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Analysis Of The Existing Geometric Design Conditions Of The Bypass Of The City Of San Juan De Pasto – Nariño – Colombia

Luis Armando Merino Chamorro[1*], Jorge Luis Argoty Burbano[2]

[1*]luismerino@udenar.edu.co Universidad de Nariño
[2]jlargoty@udenar.edu.co Universidad de Nariño https://orcid.org/0000-0001-6661-1398

***Corresponding Author:** Luis Armando Merino Chamorro
*luismerino@udenar.edu.co Universidad de Nariño

Abstract
The present work written in the development, summarizes and describes the theoretical foundation, accompanied by the analysis procedure for one of the routes under study that constitute the variant of the city of San Juan de Pasto, this for each parameter object of analysis, at the end some conclusions and recommendations are presented, as well as comparative statistical graphs of the most important parameters and on plans critical points of the design are indicated as an annex. This is done both for the actual design speed (the speed with which the design was carried out) and for the minimum theoretical design speed (the speed that, due to the conditions under which the project is developed, should have been chosen based on the provisions of the Manual for the Geometric Design of Roads). This analysis aims to generate conclusions and some recommendations regarding the existing design of the bypass of the city of San Juan de Pasto, which begins in the township of Catambuco and ends in the sector of the Daza tunnel.

Keywords: Development, Analysis, Design

1. Introduction
The geometric design is perhaps the most important stage in the development of a road project since it provides a concrete idea of what the road will be and it must adhere to a set of current standards established for this purpose, with the aim of satisfying the demand for transport as much as possible while guaranteeing its functionality. its efficiency, its safety, and other important aspects of it.
In this paper, a comparative analysis of the geometric design of the bypass of the city of San Juan de Pasto will be carried out, referenced to the 1998 and 2008 Manuals of Geometric Design of Roads of INVIAS. This design was proposed by the road concession DESARROLLO VIAL DE NARIÑO - DEVINAR S.A. Controls for geometric design will be studied, such as: design speed, design vehicle, visibility distances; the design in plan and profile of the axis of the road together with its respective elements and the design of the cross-section of the road together with the components that make it up.
Finally, depending on the inconsistencies identified with the comparative analysis regarding the current regulations of the Geometric Design of Roads, recommendations and suggestions will be made in the sectors that require it.

PROJECT IDENTIFICATION
Scope and delimitation:
In this research, geometric design will be studied and analyzed. This study will not take into account the route corridor where the route is located. This is due to the fact that detailed information on the geotechnical part and slopes is not available.
Through the study and analysis of the existing geometric layout, it will be verified that the elements that make up the geometric design comply with the minimum and maximum requirements proposed by INVIAS in its 2008 Geometric Road Design Manual. For sectors that do not comply with current regulations, suggestions or recommendations will be proposed as alternative solutions.
This research will include the study and analysis of the following parameters that make up geometric design:

A. Controls for geometric design
- Design Speed
- Design Vehicle
- Sight distances

B. Plan design of the road axis
- Horizontal curves
- Superelevation Transition
- Spiral curves

- Horizontal intertangency
- Relationship Between Radii of Contiguous Horizontal Curves

C. Profile design of the road axis
- Vertical tangent
- Vertical Curves

D. Road cross-section design
- Zone gauge or right-of-way
- Crown (Causeway & Berm)
- Overwidth in curves
- Arrow value (m) to provide cornering sight distance

Because the information available is limited, this applied research will not include:
- *Design and/or verify the pavement structure.*
- *Check the angle of inclination and/or the stability of slopes.*
- *Develop a new route for the road.*
- *Verify and design drainage works.*
- *Verify and design containment works.*

PROBLEM UNDER STUDY

Problem description:

Taking into account that the "RUMICHACA – PASTO – CHACHAGÜI – AIRPORT VARIANT CONCESSION", made the geometric designs of "SECTION 5" referenced to the 1998 Geometric Design Manual of Roads and that this route is influenced by factors such as topography, hydrology, geology, etc. that make the geometric design of greater care and professionalism, there may be discrepancies with the current standard, which requires the detailed study of each and every one of the the elements that make up the geometric design, in such a way that they comply with current regulations in order to provide the user with a comfortable, safe, economical and efficient transit.

Problem formulation:

Do the existing geometric design (controls for geometric design, road centerline plan and profile design, and cross-section design) of the Pasto city bypass meet the minimum requirements of the 2008 Geometric Road Design Manual?

2. Objectives

2.1 General objective

Verify compliance with current regulations for the geometric design of roads through a comparative analysis between standards from 1998 and 2008 of the Rumichaca - Pasto - Chachagüi - Airport - Pasto City Bypass project.

2.2 Specific objectives

- Review compliance with the parameters for horizontal geometric design of the Pasto City Bypass in accordance with the regulations for the Geometric Design of Roads issued by INVIAS in 1998 and 2008.
- Review compliance with the parameters for vertical geometric design of the Pasto City Bypass in accordance with the regulations for Geometric Design of Roads issued by INVIAS in 1998 and 2008.
- Review the design of the cross-section of the Pasto City Bypass in accordance with the regulations for the Geometric Design of Roads issued by INVIAS in 1998 and 2008.
- Carry out a comparative analysis based on the results obtained in previous stages of the existing design with the standards of the Geometric Design Manual of Roads of the years 1998 and 2008.
- Propose recommendations and suggestions in sections of the designed project, which contribute to the optimization of the design.
- Present in an orderly and coherent manner the basic and indispensable aspects to carry out the comparative analysis of the project.
- Elaborate, present and technically support the comparative analysis of the project in plant, in profile and cross-section according to the regulations of the years 1998 and 2008.

3. Methodology

For the development and subsequent fulfillment of the proposed objectives, this work will be based on the analysis and compilation of existing information regarding this design, using standards for Geometric Design of Roads issued by the National Institute of Roads _INVIAS in the years 1998 and 2008.

Tools from the knowledge of subjects such as Drawing, Descriptive Geometry, Topography, Geology, Geotechnics will be used and combined to determine control points and important aspects that from the beginning limit the design and its subsequent execution.

Once the possible restrictive parameters have been determined, all the technical knowledge of the geometric design will be applied in the comparative analysis of the proposed design in plan, profile, cross-section and in general everything that has been previously limited within the content of this project.
The final result of the analysis will allow us to draw conclusions regarding the design and design standards in force, suggestions and recommendations in relation to the proposed design and a general view of the design from the technical point of view and relate it to social, economic, cultural issues, among others.
Regarding the development of the comparative analysis, we will use knowledge tools previously exposed, computer equipment, software for the administration of designs on drawings and other computer tools required during the process of development of our work and finally material resources will be used such as sheets, scales, design plans presented in . DWG, among other basic tools for the application of geometric design criteria.

4. Results
4.1 General
4.1.1 Location and description of the Pasto City Bypass.
The Pasto City Bypass is part of the RUMICHACA - PASTO - CHACHAGÜI - AIRPORT BYPASS CONCESSION and begins in the township of Catambuco and ends at the Daza intersection. For ease of analysis, this path will be divided into subpaths T5-1, T5-2 and T5-3. The design is made for the left carriageway. Each subpath is then specified with its respective delimitation. (see Table 1).

Route	Road	Beginning		Termination	
		Abscissa	Locality	Abscissa	Locality
T5-1	Left	*PR0 + 000*	CATAMBUCO	*PR10 + 760*	BOTANILLA
S5-2	Left	*PR10 + 760*	BOTANILLA	*PR18 + 400*	TUNNEL
T5-3	Right	K16+255	ARANDA	K18+166	LA MERCED

Table 1. Description: Variant of the city of Pasto.

In the abscissa K16 + 255 a right carriageway is detached due to the fact that further on there is an intersection that aims to improve the road specifications and the level of service to generate benefits to users, this roadway ends at the K18 + 166 abscissa and will be analyzed as the T5-3 subpath.

4.1.2 Horizontal alignment
4.1.2.1 Description of horizontal curves
In the Pasto City Bypass, there are mostly spiral curves with Spiral-Circle-Spiral (E-C-E) type splicing, in a smaller number spiral-spiral curves (E-E) and circular curves.
The following table presents the start and end abscissae as well as the splice type of each horizontal curve:

PI N°	Splice Type	Abscissa Input	Abscissa Exit
1	E-C-E	PR0 + 4.19	PR0 + 200.86
2	E-C-E	PR0 + 341.00	PR0 + 482.94
3	E-E	PR0 + 715.08	PR0 + 865.08
4	E-C-E	PR1 + 134.14	PR1 + 287.72
5	E-C-E	PR1 + 699.21	PR1 + 965.90
6	E-C-E	PR2 + 581.55	PR2 + 972.25
7	Circular	PR3 + 446.67	PR3 + 606.52
8	E-C-E	PR3 + 829.25	PR4 + 9.51
9	Circular	PR4 + 171.95	PR4 + 278.89
10	E-C-E	PR4 + 828.44	PR5 + 107.10
11	E-C-E	PR5 + 233.02	PR5 + 423.92
12	E-C-E	PR5 + 425.64	PR5 + 606.68
13	E-C-E	PR5 + 638.83	PR5 + 818.55
14	E-C-E	PR6 + 229.50	PR6 + 467.38
15	E-C-E	PR6 + 494.20	PR6 + 847.92
16	E-C-E	PR6 + 980.50	PR7 + 159.34
17	E-C-E	PR7 + 274.31	PR7 + 635.41
18	E-C-E	PR7 + 643.22	PR7 + 989.29
19	E-C-E	PR8 + 18.18	PR8 + 416.13
20	E-C-E	PR8 + 641.38	PR9 + 179.37
21	E-C-E	PR9 + 312.33	PR9 + 467.75
22	E-C-E	PR9 + 501.55	PR9 + 668.49
23	E-C-E	PR9 + 821.65	PR10 + 50.41
24	E-C-E	PR10 + 51.83	PR10 + 224.62

Table 2. Description T5-1 horizontal curves.

PI N°	Splice Type	Abscissa Input	Abscissa Exit
1	E-C-E	PR10 + 594.97	PR10 + 877.32
2	Circular	PR11 + 189.45	PR11 + 630.31
3	E-C-E	PR11 + 862.63	PR12 + 116.45
4	Circular	PR12 + 396.58	PR12 + 725.73
5	E-C-E	PR13 + 8.90	PR13 + 249.30
6	E-C-E	PR13 + 467.30	PR13 + 665.19
7	E-C-E	PR14 + 16.74	PR14 + 353.48
8	E-C-E	PR14 + 377.07	PR14 + 662.08
9	E-C-E	PR14 + 690.33	PR14 + 972.76
10	E-C-E	PR14 + 992.54	PR15 + 534.72
11	E-C-E	PR15 + 594.30	PR15 + 700.36
12	E-C-E	PR15 + 714.26	PR16 + 11.31
13	E-C-E	PR16 + 31.00	PR16 + 196.54
14	E-C-E	PR16 + 282.02	PR16 + 459.05
15	Circular	PR16 + 518.20	PR16 + 647.31
16	Circular	PR16 + 819.25	PR16 + 969.70
17	E-C-E	PR17 + 99.19	PR17 + 366.15
18	Circular	PR17 + 780.88	PR17 + 928.29
19	Circular	PR18 + 138.44	PR18 + 242.30
20	Circular	PR18 + 286.49	PR18 + 424.30

Table 3. Description T5-2 horizontal curves.

PI N°	Splice Type	Abscissa Input	Abscissa Exit
1	E-C-E	PR0+000	PR0 + 211.96
2	E-C-E	PR0 + 416.18	PR0 + 713.98
3	E-C-E	PR0 + 856.54	PR1 + 181.71
4	E-C-E	PR1 + 580.81	PR1 + 719.47
5	E-C-E	PR1 + 883.90	PR2 + 032.49

Table 4. Description T5-3 horizontal curves.

4.1.2.2 Description of horizontal tangencies.

The following table shows the beginning and end abscissae of each horizontal intertangency and their corresponding length:

Entretangencia N°	ET Abscissa	Abscissa TE	Length Intertangency (m)
1	PR0 + 200.86	PR0 + 341.00	140.14
2	PR0 + 482.94	PR0 + 715.08	232.14
3	PR0 + 865.08	PR1 + 134.14	268.92
4	PR1 + 287.72	PR1 + 699.21	411.49
5	PR1 + 965.90	PR2 + 581.55	615.65
6	PR2 + 972.25	PR3 + 446.67	474.42
7	PR3 + 606.52	PR3 + 829.25	222.73
8	PR4 + 9.51	PR4 + 171.95	162.44
9	PR4 + 278.89	PR4 + 828.44	549.55
10	PR5 + 107.10	PR5 + 233.02	125.92
11	PR5 + 423.92	PR5 + 425.64	1.72
12	PR5 + 606.68	PR5 + 638.83	32.15
13	PR5 + 818.55	PR6 + 229.50	410.95
14	PR6 + 467.38	PR6 + 494.20	26.82
15	PR6 + 847.92	PR6 + 980.50	132.58
16	PR7 + 159.34	PR7 + 274.31	114.97
17	PR7 + 635.41	PR7 + 643.22	7.81
18	PR7 + 989.29	PR8 + 18.18	28.89
19	PR8 + 416.13	PR8 + 641.38	225.25
20	PR9 + 179.37	PR9 + 312.33	132.96
21	PR9 + 467.75	PR9 + 501.55	33.8
22	PR9 + 668.49	PR9 + 821.65	153.16
23	PR10 + 50.41	PR10 + 51.83	1.42
24	PR10 + 224.62	PR10 + 594.97	370.35

Table 5. Description of horizontal tangencies T5-1.

Entretangencia N°	ET Abscissa	Abscissa TE	Length Intertangency (m)
1	PR10 + 224.62	PR10 + 594.97	370.35
2	PR10 + 877.32	PR11 + 189.45	312.13
3	PR11 + 630.31	PR11 + 862.63	232.32
4	PR12 + 116.45	PR12 + 396.58	280.13
5	PR12 + 725.73	PR13 + 8.90	355.17
6	PR13 + 249.30	PR13 + 467.30	218
7	PR13 + 665.19	PR14 + 16.74	351.55
8	PR14 + 353.48	PR14 + 377.07	23.59
9	PR14 + 662.08	PR14 + 690.33	28.25
10	PR14 + 972.76	PR14 + 992.54	19.78
11	PR15 + 534.72	PR15 + 594.30	59.58
12	PR15 + 700.36	PR15 + 714.26	13.9
13	PR16 + 11.31	PR16 + 31.00	19.69
14	PR16 + 196.54	PR16 +282.02	85.48
15	PR16 + 459.05	PR16 + 518.20	59.15
16	PR16 + 647.31	PR16 + 819.25	171.94
17	PR16 + 969.70	PR17 + 99.19	129.49
18	PR17 + 366.15	PR17 + 780.88	414.73
19	PR17 + 928.29	PR18 + 138.44	210.15
20	PR18 + 242.30	PR18 + 286.49	44.19

Table 6. Description of T5-2 horizontal tangencies.

Entretangencia N°	ET Abscissa	Abscissa TE	Length Intertangency (m)
1	PR16 + 196.54	PR0 + 000	196.54
2	PR0 + 211.96	PR0 + 416.18	207.22
3	PR0 + 713.98	PR0 + 856.54	142.56
4	PR1 + 181.71	PR1 + 580.81	399.1
5	PR1 + 719.47	PR1 + 883.90	164.43

Table 7. Description of horizontal tangencies T5-3.

4.1.3 Vertical alignment

4.1.3.1 Description of vertical curves

The following table presents the start and end abscissae as well as their inflection shape of each vertical curve:

PIV N°	Inflection Shape	Curve Length (m)	PCV Abscissa	PTV abscissa
1	Convex	110.00	PR0 + 015,000	PR0 + 125,000
2	Concave	130.00	PR0 + 125,000	PR0 + 255,000
3	Convex	320.00	PR0 + 360.484	PR0 + 680.484
4	Concave	500.00	PR1 + 445.078	PR1 + 945.078
5	Convex	300.00	PR2 + 806.260	PR3 + 106,260
6	Concave	140.00	PR3 + 306,260	PR3 + 446,260
7	Concave	120.00	PR3 + 756.256	PR3 + 876.256
8	Convex	440.00	PR4 + 186.256	PR4 + 626.256
9	Concave	180.00	PR4 + 786.256	PR4 + 966.256
10	Concave	100.00	PR5 + 596.256	PR5 + 696.256
11	Convex	260.00	PR6 + 108,737	PR6 + 368,737
12	Concave	340.00	PR6 + 768,737	PR7 + 108,737
13	Convex	440.00	PR7 + 210,637	PR7 + 650.637
14	Concave	90.00	PR8 + 357,711	PR8 + 447,711
15	Concave	120.00	PR8 + 739.228	PR8 + 859.228
16	Convex	250.00	PR8 + 912,675	PR9 + 162,675
17	Concave	360.00	PR9 + 739,921	PR10 + 099.921

Table 8. Description of T5-1 vertical curves.

PIV N°	Inflection Shape	Curve Length (m)	PCV Abscissa	PTV abscissa
1	Convex	360.00	PR11 + 127.11	PR11 + 487.11
2	Concave	290.00	PR11 + 506.18	PR11 + 796.18
3	Convex	400.00	PR12 + 38.19	PR12 + 438.19
4	Convex	50.00	PR12 + 906.18	PR12 + 956.18

5	Concave	320.00	PR13 + 100	PR13 + 420
6	Convex	140.00	PR13 + 710	PR13 + 850
7	Convex	260.00	PR14 + 550	PR14 + 810
8	Concave	260.00	PR15+ 070	PR15 + 330
9	Convex	280.00	PR15 + 351.18	PR15 + 560.68
10	Concave	180.00	PR16 + 402.01	PR16 + 582.01
11	Concave	160.00	PR17+080	PR17+024
12	Convex	250.00	PR18 + 146.86	PR18 + 396.86

Table 9. Description T5-2 vertical curves.

For subpath T5-3, no description or analysis of the vertical alignment will be made, since the necessary information is not available, i.e. plans of the profile of this subpath.

4.2 Comparative analysis of the geometric design of the Pasto city bypass referenced to the 1998 manual

In this section, the different parameters that make up the geometric design of a road will be analyzed, specifically the route under study. In other words, a relationship will be made between the parameters that characterize the geometric design presented by the Concessionaire DEVINAR S.A. and the minimum and maximum parameters specified by INVIAS in its 1998 manual.

Some of these parameters are very close to the minimum or maximum value (below or above respectively) required by the regulations, but theoretically they do not comply, so the analyses that will be carried out below will be limited to saying whether they COMPLY or NOT COMPLY and not to accept those values that are very close, but outside that range. This is also due to the fact that a good geometric design of a road, the parameters that characterize it must be above the minimum values and below the maximum required values and not too close to the limit.

4.2.1 Controls for geometric design

4.2.1.1 Design speed

The design speed depends on the type of terrain and the category of the road.

Type of terrain: to determine this parameter, it is necessary to establish the slope both longitudinally and transversely with respect to the design axis, obtained from the topography of the terrain. The type of terrain is characterized by sections depending on the degree of variation it presents.

"Longitudinal slope of the terrain is the natural slope of the terrain, measured in the direction of the axis of the road.

A transverse slope of the terrain is the natural slope of the terrain, usually measured at the center of the road.

Terrain	**Average Maximum Slope of Maximum Slope Lines (%)**	**Earthworks**
Flat (P)	0 to 5	Minimal earthworks, so it does not present difficulties either in the layout or in the leveling of a road.
Wavy (O)	5 to 25	Moderate earthworks, which allow more or less straight alignments, without major difficulties in the layout and leveling of a road.
Mountainous (M)	25 to 75	The longitudinal and transverse slopes are steep, although not the maximum that can be presented in a given direction; There are difficulties in the layout and levelling of a road.
Steep (E)	> 75	Maximum earthworks, with many difficulties for the layout and levelling, as the alignments are practically defined by watersheds along the route of a road.

Table 10. Type of terrain

From the analysis of the longitudinal slopes and transverse slopes of the terrain, the average maximum slope is obtained, and from this the one that predominates in the T5-1 and T5-2 routes, as follows:

LONGITUDINAL SLOPE				**TRANSVERSE SLOPE**				**AVERAGE MAXIMUM GRADIENT (%)**	**TERRAIN**
Stretch	**Horizontal Distance (m)**	**Elevation gain (m)**	**Slope (%)**	**Abscissa**	**Horizontal Distance (m)**	**Elevation gain (m)**	**Slope (%)**		
K0 + 000 to 100	100	2,51	2,51	K0 + 100	50	3,7	7,4	4,955	Flat
100 to 200	100	7,34	7,34	K0 + 200	50	0,3	0,6	3,97	Flat
200 to 300	100	2,71	2,71	K0 + 300	50	3,7	7,4	5,055	Wavy

300 to 400	100	7,18	7,18	K0 + 400	50	3,7	7,4	7,29	Wavy
400 to 500	100	0,82	0,82	K0 + 500	50	3,1	6,2	3,51	Flat
500 to 600	100	3,27	3,27	K0 + 600	50	4,2	8,4	5,835	Wavy
600 to 700	100	6,77	6,77	K0 + 700	50	3,6	7,2	6,985	Wavy
700 to 800	100	7,48	7,48	K0 + 800	50	2,7	5,4	6,44	Wavy
800 to 900	100	6,69	6,69	K0 + 900	50	0,9	1,8	4,245	Flat
900 to K1 +000	100	5,49	5,49	K1+000	50	2,1	4,2	4,845	Flat
K1 + 000 to 100	100	3,3	3,3	K1 + 100	50	1,3	2,6	2,95	Flat
100 to 200	100	8,22	8,22	K1 + 200	50	4,5	9	8,61	Wavy
200 to 300	100	8,84	8,84	K1 + 300	50	3,4	6,8	7,82	Wavy
300 to 400	100	7,06	7,06	K1 + 400	50	10,7	21,4	14,23	Wavy
400 to 500	100	12,45	12,45	K1 + 500	50	16,3	32,6	22,525	Wavy
500 to 600	100	14,91	14,91	K1 + 600	50	5,6	11,2	13,055	Wavy
600 to 700	100	10,75	10,75	K1 + 700	50	7,25	14,5	12,625	Wavy
700 to 800	100	1,87	1,87	K1 + 800	50	5,7	11,4	6,635	Wavy
800 to 900	100	9,5	9,5	K1 + 900	50	5,3	10,6	10,05	Wavy
900 to K2 + 000	100	3,09	3,09	K2+000	50	1,3	2,6	2,845	Flat
K2 + 000 to 100	100	8,47	8,47	K2 + 100	50	1,7	3,4	5,935	Wavy
100 to 200	100	0,28	0,28	K2 + 200	50	1,9	3,8	2,04	Flat
200 to 300	100	7,5	7,5	K2 + 300	50	0,4	0,8	4,15	Flat
300 to 400	100	2,37	2,37	K2 + 400	50	3,7	7,4	4,885	Flat
400 to 500	100	5,68	5,68	K2 + 500	50	1,9	3,8	4,74	Flat
500 to 600	100	6,58	6,58	K2 + 600	50	1,5	3	4,79	Flat
600 to 700	100	5,74	5,74	K2 + 700	50	8,1	16,2	10,97	Wavy
700 to 800	100	4,63	4,63	K2 + 800	50	1,7	3,4	4,015	Flat
800 to 900	100	7,84	7,84	K2 + 900	50	3,9	7,8	7,82	Wavy
900 to K3+000	100	0,99	0,99	K3+000	50	4,5	9	4,995	Flat
K3 + 000 to 100	100	2,17	2,17	K3 + 100	50	3,4	6,8	4,485	Flat
100 to 200	100	2,92	2,92	K3 + 200	50	5,2	10,4	6,66	Wavy
200 to 300	100	5,47	5,47	K3 + 300	50	4,1	8,2	6,835	Wavy
300 to 400	100	4,95	4,95	K3 + 400	50	1,1	2,2	3,575	Flat
400 to 500	100	11,97	11,97	K3 + 500	50	1,6	3,2	7,585	Wavy
500 to 600	100	1,33	1,33	K3+600	50	1,4	2,8	2,065	Flat
600 to 700	100	0,19	0,19	K3 + 700	50	2,8	5,6	2,895	Flat
700 to 800	100	7,4	7,4	K3+800	50	11,7	23,4	15,4	Wavy
800 to 900	100	3,35	3,35	K3 + 900	50	11,6	23,2	13,275	Wavy
900 to K4+000	100	4,72	4,72	K4+000	50	7,8	15,6	10,16	Wavy
K4 + 000 to 100	100	6,35	6,35	K4 + 100	50	7,4	14,8	10,575	Wavy
100 to 200	100	9,03	9,03	K4 + 200	50	6,9	13,8	11,415	Wavy
200 to 300	100	9,7	9,7	K4 + 300	50	7,6	15,2	12,45	Wavy
300 to 400	100	9,71	9,71	K4 + 400	50	5,3	10,6	10,155	Wavy
400 to 500	100	1,37	1,37	K4 + 500	50	12,4	24,8	13,085	Wavy
500 to 600	100	12,43	12,43	K4 + 600	50	10,2	20,4	16,415	Wavy
600 to 700	100	7,88	7,88	K4+700	50	10,5	21	14,44	Wavy
700 to 800	100	11,25	11,25	K4+800	50	14,8	29,6	20,425	Wavy
800 to 900	100	5,06	5,06	K4+900	50	4,8	9,6	7,33	Wavy
900 to K5+000	100	2,71	2,71	K5+000	50	1,2	2,4	2,555	Flat
K5 + 000 to 100	100	5,3	5,3	K5 + 100	50	8,8	17,6	11,45	Wavy
100 to 200	100	3,39	3,39	K5 + 200	50	9,3	18,6	10,995	Wavy
200 to 300	100	17,4	17,4	K5 + 300	50	4,8	9,6	13,5	Wavy
300 to 400	100	1,19	1,19	K5+400	50	3,1	6,2	3,695	Flat
400 to 500	100	6,1	6,1	K5 + 500	50	0,6	1,2	3,65	Flat
500 to 600	100	10,38	10,38	K5 + 600	50	3,2	6,4	8,39	Wavy
600 to 700	100	0,34	0,34	K5 + 700	50	5,6	11,2	5,77	Wavy
700 to 800	100	1,38	1,38	K5+800	50	13,9	27,8	14,59	Wavy
800 to 900	100	0,85	0,85	K5+900	50	4,9	9,8	5,325	Wavy
900 to K6+000	100	0,6	0,6	K6+000	50	22,9	45,8	23,2	Wavy

K6 + 000 to 100	100	14,68	14,68	K6 + 100	50	4,1	8,2	11,44	Wavy
100 to 200	100	0,55	0,55	K6 + 200	50	5,2	10,4	5,475	Wavy
200 to 300	100	1,69	1,69	K6 + 300	50	4,6	9,2	5,445	Wavy
300 to 400	100	2,37	2,37	K6 + 400	50	10,1	20,2	11,285	Wavy
400 to 500	100	15,91	15,91	K6 + 500	50	11,6	23,2	19,555	Wavy
500 to 600	100	15,33	15,33	K6 + 600	50	25,4	50,8	33,065	Mountainous
600 to 700	100	31,57	31,57	K6 + 700	50	24,2	48,4	39,985	Mountainous
700 to 800	100	7,53	7,53	K6+800	50	12,5	25	16,265	Wavy
800 to 900	100	8,07	8,07	K6 + 900	50	10,7	21,4	14,735	Wavy
900 to K7+000	100	15,07	15,07	K7+000	50	7,2	14,4	14,735	Wavy
K7 + 000 to 100	100	0,85	0,85	K7 + 100	50	10,2	20,4	10,625	Wavy
100 to 200	100	2,32	2,32	K7 + 200	50	18,7	37,4	19,86	Wavy
200 to 300	100	36,85	36,85	K7 + 300	50	24,4	48,8	42,825	Mountainous
300 to 400	100	17,62	17,62	K7+400	50	19,1	38,2	27,91	Wavy
400 to 500	100	20,86	20,86	K7 + 500	50	13,1	26,2	23,53	Wavy
500 to 600	100	24,95	24,95	K7+600	50	15,3	30,6	27,775	Mountainous
600 to 700	100	7,12	7,12	K7 + 700	50	3,1	6,2	6,66	Wavy
700 to 800	100	21,77	21,77	K7+800	50	3,6	7,2	14,485	Wavy
800 to 900	100	9,73	9,73	K7+900	50	3,9	7,8	8,765	Wavy
900 to K8+000	100	9,1	9,1	K8+000	50	2,7	5,4	7,25	Wavy
K8 + 000 to 100	100	8,39	8,39	K8 + 100	50	4,1	8,2	8,295	Wavy
100 to 200	100	0,24	0,24	K8 + 200	50	2,9	5,8	3,02	Flat
200 to 300	100	20,04	20,04	K8 + 300	50	4,9	9,8	14,92	Wavy
300 to 400	100	6,01	6,01	K8+400	50	2,1	4,2	5,105	Wavy
400 to 500	100	7,05	7,05	K8 + 500	50	4,9	9,8	8,425	Wavy
500 to 600	100	5,14	5,14	K8 + 600	50	3,4	6,8	5,97	Wavy
600 to 700	100	1,74	1,74	K8+700	50	5,7	11,4	6,57	Wavy
700 to 800	100	23,12	23,12	K8+800	50	4,3	8,6	15,86	Wavy
800 to 900	100	6,05	6,05	K8+900	50	7,7	15,4	10,725	Wavy
900 to K9+000	100	8,92	8,92	K9+000	50	7,4	14,8	11,86	Wavy
K9 + 000 to 100	100	5,86	5,86	K9 + 100	50	1,9	3,8	4,83	Flat
100 to 200	100	14,2	14,2	K9+200	50	2,6	5,2	9,7	Wavy
200 to 300	100	14,31	14,31	K9+300	50	3,2	6,4	10,355	Wavy
300 to 400	100	13,06	13,06	K9+400	50	1,5	3	8,03	Wavy
400 to 500	100	4,7	4,7	K9+500	50	3,8	7,6	6,15	Wavy
500 to 600	100	6,59	6,59	K9 + 600	50	4,5	9	7,795	Wavy
600 to 700	100	5,32	5,32	K9+700	50	16,5	33	19,16	Wavy
700 to 800	100	8,46	8,46	K9 + 800	50	7,1	14,2	11,33	Wavy
800 to 900	100	7	7	K9+900	50	0,9	1,8	4,4	Flat
900 to K10+000	100	2,74	2,74	K10+000	50	3,2	6,4	4,57	Flat
K10 + 000 to 100	100	7,49	7,49	K10 + 100	50	9,2	18,4	12,945	Wavy
100 to 200	100	10,14	10,14	K10 + 200	50	6,4	12,8	11,47	Wavy
200 to 300	100	8,84	8,84	K10 + 300	50	4,9	9,8	9,32	Wavy
300 to 400	100	8,9	8,9	K10+400	50	3,5	7	7,95	Wavy
400 to 500	100	12,56	12,56	K10 + 500	50	2,3	4,6	8,58	Wavy
500 to 600	100	11,12	11,12	K10 + 600	50	10,4	20,8	15,96	Wavy
600 to 700	100	4,9	4,9	K10+700	50	10,9	21,8	13,35	Wavy
700 to 800	100	6,81	6,81	K10 + 800	50	12,1	24,2	15,505	Wavy

Table 11. Longitudinal, transverse and average maximum slope-type of terrain T5-1.

The predominant terrain type for the T5-1 course is UNDULATING

LONGITUDINAL SLOPE				**TRANSVERSE SLOPE**				**AVERAGE MAXIMUM GRADIENT (%)**	**TERRAIN**
Stretch	**Horizontal Distance (m)**	**Elevation gain (m)**	**Slope (%)**	**Abscissa**	**Horizontal Distance (m)**	**Elevation gain (m)**	**Slope (%)**		
800 to 900	100	8,01	8,01	K10 + 900	50	4,4	8,8	8,405	Wavy
900 to K11+000	100	4,1	4,1	K11+000	50	14,8	29,6	16,85	Wavy
K11+ 000 to 100	100	12,62	12,62	K11 + 100	50	0,9	1,8	7,21	Wavy
100 to 200	100	6,96	6,96	K11 + 200	50	6,1	12,2	9,58	Wavy
200 to 300	100	6,12	6,12	K11 + 300	50	8,6	17,2	11,66	Wavy
300 to 400	100	3,93	3,93	K11+400	50	10,5	21	12,465	Wavy
400 to 500	100	9,34	9,34	K11 + 500	50	7,3	14,6	11,97	Wavy
500 to 600	100	2,28	2,28	K11 + 600	50	7,1	14,2	8,24	Wavy
600 to 700	100	5,66	5,66	K11 + 700	50	11,7	23,4	14,53	Wavy
700 to 800	100	9,56	9,56	K11 + 800	50	5,9	11,8	10,68	Wavy
800 to 900	100	16,21	16,21	K11+900	50	11,4	22,8	19,505	Wavy
900 to K12+000	100	20,96	20,96	K12+000	50	4,7	9,4	15,18	Wavy
K12 + 000 to 100	100	9,95	9,95	K12 + 100	50	3,8	7,6	8,775	Wavy
100 to 200	100	5,28	5,28	K12 + 200	50	1,9	3,8	4,54	Flat
200 to 300	100	1,07	1,07	K12 + 300	50	2,7	5,4	3,235	Flat
300 to 400	100	10,92	10,92	K12+400	50	1,2	2,4	6,66	Wavy
400 to 500	100	16,84	16,84	K12 + 500	50	5,9	11,8	14,32	Wavy
500 to 600	100	4,45	4,45	K12 + 600	50	7,9	15,8	10,125	Wavy
600 to 700	100	4,81	4,81	K12+700	50	8,8	17,6	11,205	Wavy
700 to 800	100	5,57	5,57	K12+800	50	8,9	17,8	11,685	Wavy
800 to 900	100	4,28	4,28	K12+900	50	7,4	14,8	9,54	Wavy
900 to K13+000	100	3,01	3,01	K13+000	50	6,2	12,4	7,705	Wavy
K13 + 000 to 100	100	16,59	16,59	K13 + 100	50	5,4	10,8	13,695	Wavy
100 to 200	100	23,1	23,1	K13 + 200	50	3,9	7,8	15,45	Wavy
200 to 300	100	9,7	9,7	K13 + 300	50	8,2	16,4	13,05	Wavy
300 to 400	100	4,45	4,45	K13+400	50	3,9	7,8	6,125	Wavy
400 to 500	100	6,89	6,89	K13+500	50	3,4	6,8	6,845	Wavy
500 to 600	100	1,46	1,46	K13 + 600	50	4,5	9	5,23	Wavy
600 to 700	100	16,1	16,1	K13+700	50	12,6	25,2	20,65	Wavy
700 to 800	100	0,03	0,03	K13+800	50	10,3	20,6	10,315	Wavy
800 to 900	100	1,95	1,95	K13 + 900	50	3,1	6,2	4,075	Flat

900 to K14+000	100	3,11	3,11	K14+000	50	7,8	15,6	9,355	Wavy
K14+000 to 100	100	12,3	12,3	K14 + 100	50	4,9	9,8	11,05	Wavy
100 to 200	100	6,33	6,33	K14+200	50	9,4	18,8	12,565	Wavy
200 to 300	100	2	2	K14 + 300	50	13,4	26,8	14,4	Wavy
300 to 400	100	4,87	4,87	K14+400	50	10,7	21,4	13,135	Wavy
400 to 500	100	18,07	18,07	K14+500	50	9,7	19,4	18,735	Wavy
500 to 600	100	9,88	9,88	K14+600	50	3,4	6,8	8,34	Wavy
600 to 700	100	13,05	13,05	K14+700	50	4,3	8,6	10,825	Wavy
700 to 800	100	5,6	5,6	K14+800	50	2,8	5,6	5,6	Wavy
800 to 900	100	13,52	13,52	K14+900	50	2,7	5,4	9,46	Wavy
900 to K15+000	100	13,21	13,21	K15+000	50	1,9	3,8	8,505	Wavy
K15 + 000 to 100	100	5,48	5,48	K15 + 100	50	0,6	1,2	3,34	Flat
100 to 200	100	13,24	13,24	K15 + 200	50	11,2	22,4	17,82	Wavy
200 to 300	100	13,18	13,18	K15 + 300	50	7,2	14,4	13,79	Wavy
300 to 400	100	14,13	14,13	K15+400	50	6,1	12,2	13,165	Wavy
400 to 500	100	6,13	6,13	K15 + 500	50	2,7	5,4	5,765	Wavy
500 to 600	100	12,04	12,04	K15+600	50	12,7	25,4	18,72	Wavy
600 to 700	100	18,83	18,83	K15+700	50	10,2	20,4	19,615	Wavy
700 to 800	100	12	12	K15+800	50	19,5	39	25,5	Mountainous
800 to 900	100	4,12	4,12	K15+900	50	15,4	30,8	17,46	Wavy
900 to K16+000	100	10,25	10,25	K16+000	50	13,6	27,2	18,725	Wavy
K16 + 000 to 100	100	16,46	16,46	K16 + 100	50	8,7	17,4	16,93	Wavy
100 to 200	100	10,39	10,39	K16 + 200	50	20,3	40,6	25,495	Mountainous
200 to 300	100	6,05	6,05	K16+300	50	10,3	20,6	13,325	Wavy
300 to 400	100	10,5	10,5	K16+400	50	19,9	39,8	25,15	Mountainous
400 to 500	100	11,22	11,22	K16 + 500	50	22,8	45,6	28,41	Mountainous
500 to 600	100	1,08	1,08	K16+600	50	3,2	6,4	3,74	Flat
600 to 700	100	0,84	0,84	K16+700	50	1,1	2,2	1,52	Flat
700 to 800	100	2	2	K16+800	50	1,4	2,8	2,4	Flat
800 to 900	100	1,99	1,99	K16+900	50	2,4	4,8	3,395	Flat
900 to K17+000	100	0,5	0,5	K17+000	50	1,6	3,2	1,85	Flat
K17 + 000 to 100	100	0,55	0,55	K17 + 100	50	0,9	1,8	1,175	Flat
100 to 200	100	4,44	4,44	K17 + 200	50	0,4	0,8	2,62	Flat
200 to 300	100	5,26	5,26	K17+300	50	0,3	0,6	2,93	Flat
300 to 400	100	9,13	9,13	K17+400	50	8,9	17,8	13,465	Wavy

400 to 500	100	10,18	10,18	K17 + 500	50	8,8	17,6	13,89	Wavy
500 to 600	100	7,63	7,63	K17+600	50	7,6	15,2	11,415	Wavy
600 to 700	100	12,94	12,94	K17+700	50	13,8	27,6	20,27	Wavy
700 to 800	100	0,09	0,09	K17+800	50	16,2	32,4	16,245	Wavy
800 to 900	100	4,67	4,67	K17+900	50	5,9	11,8	8,235	Wavy
900 to K18+000	100	6,76	6,76	K18+000	50	3,9	7,8	7,28	Wavy
K18 + 000 to 100	100	2,96	2,96	K18 + 100	50	1,7	3,4	3,18	Flat
100 to 200	100	2,57	2,57	K18+200	50	4,9	9,8	6,185	Wavy
200 to 300	100	6,53	6,53	K18+300	50	1,9	3,8	5,165	Wavy
300 to 400	100	12,63	12,63	K18 + 400	50	3,8	7,6	10,115	Wavy

Table 12. Longitudinal, transverse and average maximum slope-type of terrain T5-2.

The predominant terrain for the T5-2 route is UNDULATING.

Since the necessary information is not available for the calculation of the longitudinal slope in subpath T5-3, the transverse slope will be described and the type of terrain will be determined

TRANSVERSE SLOPE				**TERRAIN**
Abscissa	**Horizontal Distance (m)**	**Elevation gain (m)**	**Slope (%)**	
K0 + 100	50	15,2	32,6	Mountainous
K0 + 200	50	32,2	41,10	Mountainous
K0 + 300	50	27,7	38,85	Mountainous
K0 + 400	50	18,5	34,25	Mountainous
K0 + 500	50	10,2	30,10	Mountainous
K0 + 600	50	4,6	27,3	Mountainous
K0 + 700	50	0,6	25,30	Mountainous
K0 + 800	50	0,7	25,35	Mountainous
K0 + 900	50	1,2	25,60	Mountainous
K1+000	50	0,8	25,40	Mountainous
K1 + 100	50	1,9	25,95	Mountainous
K1 + 200	50	19,1	34,55	Mountainous
K1 + 300	50	17,2	33,60	Mountainous
K1 + 400	50	7,9	28,95	Mountainous
K1 + 500	50	16,2	33,10	Mountainous
K1 + 600	50	18,8	34,40	Mountainous
K1 + 700	50	6,9	28,45	Mountainous
K1 + 800	50	2,5	26,25	Mountainous
K1 + 900	50	2,2	26,10	Mountainous
K2+000	50	6,1	28,05	Mountainous

Table 13. Cross slope - terrain type T5-3.

The predominant terrain type for the T5-3 route is MOUNTAINOUS.
The following is a breakdown of the terrain type percentages of sub-paths T5-1, T5-2 and T5-3 and defines the terrain that predominates in them:

Route	**Road**	**Rugged terrain %**	**Mountainous Terrain %**	**Undulating Terrain %**	**Flat Terrain %**	**Predominant Terrain Type**
T5-1	Left	0,00	3,7	73,15	23,15	Wavy
S5-2	Left	0,00	5,26	77,63	17,11	Wavy
T5-3	Right	0,00	100	0,00	0,00	Mountainous

Table 14. Percentages of predominant terrain type.

Road Category: The Rumichaca-Pasto-Chachagüi-Airport Bypass Road Concession project of the city of Pasto, is classified as a Main Highway of a Causeway because it is a Trunk (going from South to North) and is the main access to the city of San Juan de Pasto.

Type of Road	**Type of Terrain**	**Design Speed Vd (km/h)**									
		30	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Two-Carriageway Main Road	Flat										
	Wavy										
	Mountainous										
	Steep										
Main Road of a Carriageway	Flat										
	Wavy										
	Mountainous										
	Steep										
Secondary Road	Flat										
	Wavy										
	Mountainous										
	Steep										
Tertiary Highway	Flat										
	Wavy										
	Mountainous										
	Steep										

Table 15. Design speeds according to road type and terrain

Based on the parameters previously defined in terms of type of terrain and category of the road and entering with these to Table 15 it is determined that the Design Speed is between 60 km/h and 100 km/h for all the routes under study, from the above it is identified that the minimum value of Vd corresponds to 60 km/h.
Comparing this value Vd, determined based on the parameters established by INVIAS in its 1998 manual, and the value of Vd equal to 50 km/h used by DEVÍNAR S.A. for the Geometric Design of this route, it is identified that the latter value does not meet the minimum needs in the design of this road.

4.3 Comparative analysis of the geometric design of the Pasto city bypass referenced to the 2008 manual
4.3.1 Controls for geometric design:
4.3.1.1 Design speed

"In the process of assigning design speed, the safety of users must be given the highest priority. For this reason, the design speed along the route must be such that drivers are not surprised by sudden and/or very frequent changes in the speed at which they can safely complete the route.
In order to ensure consistency in speed, the designer must identify homogeneous sections along the route corridor to which, due to topographical conditions, the same speed can be assigned. This speed, called the design speed of the homogeneous section (VTR), is the basis for defining the characteristics of the geometric elements included in that section.
In order to identify homogeneous sections and establish their design speed (VTR), the following criteria must be taken into account:

- The minimum length of a stretch of road with a given design speed shall be three (3) kilometers for speeds between twenty and fifty kilometers per hour (20 and 50 km/h) and four (4) kilometers for speeds between sixty and one hundred and ten kilometers per hour (60 and 110 km/h).
- The difference in design speed between adjacent sections may not be more than twenty kilometers per hour (20 km/h).

Notwithstanding the above, if due to a marked change in the type of terrain in a short sector of the route corridor it is necessary to establish a section with a shorter length than that specified, the difference between its design speed and that of the adjacent sections may not be greater than ten kilometers per hour (10 km/h)
The Geometric Design of the "PASTO CITY BYPASS (T5-1, T5-2 and T5-3) OF THE RUMICHACA – PASTO – CHACHAGÜI – AIRPORT BYPASS CONCESSION", consists of 3 sub-routes (for analysis and design purposes, the routes are equivalent to homogeneous sections). It should be noted that in the T5-3 subpath there is no vertical design information, so the parameters that imply this design will not be analyzed.

4.3.1.2 Homogeneous span design speed (VTR).

Categoria de la Carretera	Tipo de Terreno	Velocidad de Diseño de un Tramo Homogeneo VTR (Km/h)									
		20	30	40	50	60	70	80	90	100	110
Primaria de Dos Calzadas	Plano										
	Ondulado										
	Montañoso										
	Escarpado										
Primaria de Una Calzada	Plano										
	Ondulado										
	Montañoso										
	Escarpado										
Secundaria	Plano										
	Ondulado										
	Montañoso										
	Escarpado										
Terciaria	Plano										
	Ondulado										
	Montañoso										
	Escarpado										

Table 16. Homogeneous section design speed (VTR) values as a function of road category and terrain type". In original Spanish language

On the basis of the category of the road and the type of terrain previously defined in the study carried out in the 1998 manual, the following VTRs are available for each particular route:

Trayecto	Calzada	Tipo de Terreno	Categoria de la Via	VTR (Km/h)
T5-1	Izquierda	Ondulado	Principal de Una Calzada	70
T5-2	Izquierda	Ondulado		70
T5-3	Derecha	Montañoso		60

Table 17. Speed assignment by homogeneous sections (Pasto City Bypass). In original Spanish language

According to the design presented by DEVINAR S.A., the actual design speed is 50 km/h (in this case corresponding to the actual design VTR) for all the sub-routes that make up the Pasto City Bypass, which allows us to determine a great difference with respect to the minimum theoretical speeds of homogeneous sections (minimum theoretical design VTR) that should have been used for the conditions of the category of Route and type of terrain. Therefore, from now on, the analysis of each parameter will be carried out for the actual design VTR presented by DEVINAR S.A. for the project, in this case corresponding to a VTR = 50 km/h, and for the minimum theoretical design VTR, corresponding to the value of the VTR determined for each subpath, which is shown in Table 18.
Next, the length of each route is described, as well as the start and end abscissa, and observations regarding the length parameter based on the indications made by the 2008 Manual for the Geometric Design of Roads.

Trayecto	Calzada	Abscisa Inicio	Abscisa Fin	Longitud (m)	VTR (Km/h)	Longitud Minima (m)	Chequeo
T5-1	Izquierda	PR0 + 000	PR10 + 760	10760	70	3000	CUMPLE
T5-2	Izquierda	PR10 + 760	PR18 + 400	7640	70	3000	CUMPLE
T5-3	Derecha	PR16 + 255	PR18 + 166	1911	60	3000	NO CUMPLE

Table 18. Minimum homogeneous span lengths for real VTR design

Trayecto	Calzada	Abscisa Inicio	Abscisa Fin	Longitud (m)	VTR (Km/h)	Longitud Minima (m)	Chequeo
T5-1	Izquierda	PR0 + 000	PR10 + 760	10760	70	4000	CUMPLE
T5-2	Izquierda	PR10 + 760	PR18 + 400	7640	70	4000	CUMPLE
T5-3	Derecha	PR16 + 255	PR18 + 166	1911	60	4000	NO CUMPLE

Table 19. Minimum Homogeneous Span Lengths for VTR Minimum Theoretical Design. In original Spanish language

Regarding the minimum homogeneous section length parameter, we have: For the actual design VTR, the T5-3 is the only one that does not meet this condition, determining in a general way that the lengths presented to maintain a constant speed of 50 km/h are adequate. For the minimum theoretical design VTR, this parameter is non-compliant with what is stated in the INVIAS manual also in the T5-3 route.
Specific speed of the elements that make up the layout in plan and profile: "The most likely maximum speed with which each geometric element would be approached is precisely its specific speed and it is with which that element should be designed. The value of the specific velocity of a geometric element essentially depends on the following parameters:

- From the value of the design speed of the homogeneous span (VTR) in which the element is included. The desirable condition is that most of the geometric elements that make up the homogeneous span can be assigned the design speed (VTR) value as a specific speed.
- From the geometry of the route immediately before the element under consideration, taking into account the direction in which the vehicle travels.

In order to ensure the greatest possible homogeneity in the specific speed of curves and intertangencies, which necessarily translates into greater safety for users, it is mandatory that the specific speeds of the elements that make up a homogeneous section are at least equal to the design speed of the section (VTR) and do not exceed this speed by more than twenty kilometers per hour (VTR + 20 km/h)."

"The general sequence for assigning the specific velocity of geometrical elements in plan and profile is as follows:
To. In the process of designing the shaft in the plant:

- Starting from the adopted homogeneous section design speed (VTR), assign the Specific Speed to each of the horizontal curves (VCH).
- Starting from the specific velocity assigned to horizontal curves (VCH), assign the specific velocity to horizontal intertangencies (VETH).

B. In the design process of the shaft in profile:

- Starting from the specific velocity assigned to horizontal curves (VCH) and horizontal intertangencies (VETH), assign the specific velocity to vertical curves (VCV).
- Starting from the specific velocity assigned to horizontal intertangencies (VETH), assign the specific velocity to vertical tangents (VTV)."
- Horizontal Curve Specific Velocity (VCH): "The specific velocity of each of the horizontal curves must be established according to the following criteria:
- The specific speed of a horizontal curve (VCH) may not be less than the design speed of the section (VCH ≥ VTR) or greater than it by twenty kilometres per hour (VCH ≤ VTR + 20).
- The specific velocity of a horizontal curve must be assigned taking into account the specific velocity of the anterior horizontal curve and the length of the anterior straight segment."

It has been established that drivers, depending on the speed at which they travel through a horizontal curve and the length of the straight segment they encounter when exiting the curve, adopt the pattern of behavior that is typified in five cases. Such cases are illustrated for the situation of relatively high design speeds (VTR between 60 and 110 km/h) and are reported in Table 116.
When the Section Design Speed (VTR) is relatively low (between 30 and 50 km/h), the length of the Straight Segment, based on which drivers make the decision to adjust their speed, is shorter, as can be seen in Table 20.

Velocidad Especifica de la Curva Horizontal	Velocidad de Diseño del Tramo (VTR) ≤ 50 Km/h					Velocidad de Diseño del Tramo (VTR) > 50 Km/h				
	Longitud del Segmento Recto Anterior (m)					Longitud del Segmento Recto Anterior (m)				
	L ≤ 70	70 < L ≤ 250		250 < L ≤ 400	L > 400	L ≤ 150	150 < L ≤ 400		400 < L ≤ 600	L > 600
		Δ < 45°	Δ ≥ 45°				Δ < 45°	Δ ≥ 45°		
VTR	VTR	VTR	VTR	VTR + 10	VTR + 20	VTR	VTR	VTR	VTR + 10	VTR + 20
VTR + 10	VTR + 10	VTR + 10	VTR	VTR + 10	VTR + 20	VTR + 10	VTR + 10	VTR	VTR + 10	VTR + 20
VTR + 20	VTR + 20	VTR + 20	VTR + 10	VTR + 10	VTR + 20	VTR + 20	VTR + 20	VTR + 10	VTR + 10	VTR + 20
CASO	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**

Table 20. Specific Speed of a Horizontal Curve (VCH) Included in a Homogeneous Span with Design Speed (VTR). In original Spanish language

"The difference between the specific speeds of the last horizontal curve of one section and the first of the next is shown in Table 21. Those differences are a function of the design speed of the contiguous sections and the length of the straight segment between those curves. In addition, they are consistent with the criteria established for the assignment of the specific speed of horizontal curves within the same section."

Velocidad de Diseño de los Tramos Contiguos (Km/h)		Longitud del Segmento Recto Anterior (m)(1)					Longitud del Segmento Recto Anterior (m)				
		L ≤ 70	70 < L ≤ 250		250 < L ≤ 400	L > 400	L ≤ 150	150 < L ≤ 400		400 < L ≤ 600	L > 600
Anterior	Analizado		Δ < 45°	Δ ≥ 45°				Δ < 45°	Δ ≥ 45°		
20	30	0	0	0	10	20	N.A (2)	N.A	N.A	N.A	N.A
20	40	0	0	0	10	20	N.A	N.A	N.A	N.A	N.A
30	20	0	0	-10	10	NOTA (3)	N.A	N.A	N.A	N.A	N.A
30	40	0	0	0	10	20	N.A	N.A	N.A	N.A	N.A
30	50	0	0	0	10	20	N.A	N.A	N.A	N.A	N.A
40	20	0	0	-10	NOTA (5)	NOTA (3)	N.A	N.A	N.A	N.A	N.A
40	30	0	0	-10	10	NOTA (3)	N.A	N.A	N.A	N.A	N.A
40	50	0	0	0	10	20	N.A	N.A	N.A	N.A	N.A
40	60	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
50	30	0	0	-10	NOTA (5)	NOTA (3)	N.A	N.A	N.A	N.A	N.A
50	40	0	0	-10	10	NOTA (3)	N.A	N.A	N.A	N.A	N.A
50	60	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
50	70	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
60	40	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
60	50	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)
60	70	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
60	80	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
70	50	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
70	60	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)
70	80	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
70	90	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
80	60	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
80	70	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)
80	90	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
80	100	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
90	70	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
90	80	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)
90	100	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
90	110	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
100	80	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
100	90	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)
100	110	N.A	N.A	N.A	N.A	N.A	0	0	0	10	20
110	90	N.A	N.A	N.A	N.A	N.A	0	0	-10	NOTA (6)	NOTA (4)
110	100	N.A	N.A	N.A	N.A	N.A	0	0	-10	10	NOTA (4)

NOTA

(1) Longitud del Segmento Recto entre la última Curva Horizontal del Tramo Anterior y la Primera Curva Horizontal del Tramo Analizado

(2) No Aplica

(3) Si la Longitud del Segmento Recto Anterior es mayor de Cuatroscientos metros (400m) es necesario revisar las Velocidades Asignadas a los Tramos Homogeneos (VTR)

(4) Si la Longitud del Segmento Recto Anterior es mayor de Seiscientos metros (600m) es necesario revisar las Velocidades Asignadas a los Tramos Homogeneos (VTR)

(5) Si la Longitud del Segmento Recto Anterior se encuentra entre Doscientos Cincuenta y Cuatroscientos metros (250m - 400m) es necesario revisar las Velocidades Asignadas a los Tramos Homogeneos (VTR)

(6) Si la Longitud del Segmento Recto Anterior se encuentra entre Cuatroscientos y Seiscientos metros (400m - 600m) es necesario revisar las Velocidades Asignadas a los Tramos Homogeneos (VTR)

Table 21. Difference between the specific speed of the last horizontal curve of the previous section and the first horizontal curve of the analysed section, in km/h". In original Spanish language

The assignment of the specific speed of horizontal curves (VCH) must be done by simulating first the movement of a vehicle in one direction of traffic and then in the other. The specific velocity assigned to a curve as definitive must be the highest resulting from the simulation in both directions. In this particular case, the design corresponds to a dual carriageway with two lanes in each direction of vehicular flow, therefore, the analysis is carried out in a single direction corresponding to the direction of traffic.

4.4 Analysis of the geometric design for roads of the Pasto City Bypass referenced to manuals for the years 1998 and 2008. Comparative Table - Percentage Main Parameters

Once the analysis of the Geometric Design of Route 6 belonging to the "RUMICHACA - PASTO - CHACHAGÜI - AEROPUERTO" variant concession has been carried out, a comparative table is presented with the results of these analyses carried out through the manuals of the years 1998 and 2008. The following table summarizes the most important parameters that can be compared, and they are also the parameters with the most design information, which provides a large margin of safety in their study and analysis. The following comparative table presents the percentages of non-compliance of the element or parameter under analysis for the actual design speed (either as Vd = 50 km/h for the 1998 manual or as VTR = 50 km/h for the 2008 manual), since this is the reference speed for the study and analysis developed.

For the minimum theoretical design speed, whose study and analysis was carried out in parallel to the actual design speed, it was presented only in order to indicate the values with which the design had to be developed and the percentages of compliance or not with respect to the design presented, but no comparison is established because they are theoretical values; It is clarified that the above does not constitute a new design, but was made for academic purposes for the development of this article.

Parámetros Objeto de Análisis			Porcentaje No Cumple Manual Año 1998	Porcentaje No Cumple Manual Año 2008
Diseño en Planta del Eje de la Carretera	Distancia de Visibilidad de Parada DVP en Planta		0,00	0,00
	Radios Mínimos Curvas Horizontales		0,00	0,00
	Sobreancho Curvas Horizontales		100,00	100,00
	Longitud Entretangencia Horizontal		2,08	2,08
	Relacion entre Radios de Curvas Contiguas		-	40,91
	Curvas Espirales	Longitud Circular Mínima Empalme E - C - E	6,25	10,42
		Deflexiones Límite Empalme E - E	0,00	0,00
		Longitud Espiral Le	0,00	0,00
	Peralte	Peralte Curvas Horizontales	0,00	100,00
		Longitud de Transición	11,63	11,63
		Rampa de Peralte	16,67	16,67
Diseño Vertical	Pendiente Tangente Vertical		-	-
	Longitud Mínima y Máxima Curva Vertical		0,00	0,00
	Distancia de Visibilidad de Parada DVP en Perfil		0,00	0,00
Sección Transversal	Ancho de Zona Mínimo		0,00	0,00
	Ancho de Calzada		0,00	0,00
	Ancho de Berma		26,42	26,42

Table 22. Comparative-percentage table of main parameters. In original Spanish language

In general, the geometric design of the Pasto City Bypass is more compliant with the 1998 Geometric Road Design Manual. In addition, it has 100% compliance, with respect to some parameters such as: DVP stop visibility distance in plan, DVP stop visibility distance in profile, E-E splice limit deflections, Spiral Length Le, Minimum and maximum length of vertical curves and for the cross-section in area width and roadway width, this applies both to the analysis carried out through the manual of the years 1998 and 2008.

However, there are some parameters in the design that are not met with respect to what is stated in the manuals in percentages of 100%, such is the case of Overwidth of the Road in horizontal curves.

Regarding the parameter of slopes of vertical tangents (vertical section), comparative values are not established because for the actual design speed equal to 50 Km/h, for a main road of a roadway and the predominant types of terrain along the Bypass of the city of Pasto (either Undulating or Mountainous), There are no slope values associated with such conditions, this applies to both the analysis carried out by the manual for the years 1998 and 2008.

For the parameter relationship between radii of contiguous horizontal curves, no percentage value of relationships is established for the analysis carried out by means of the 1998 manual since it is not contemplated as a design parameter. However, the percentage value of relationships that do not comply with the analysis carried out by the 2008 manual is presented due to the importance it has in the design.

The remaining parameters are more in line with the theoretical-conceptual basis set forth in the 1998 manual for the Geometric Design of Roads. For values of percentages that do not meet the same, they indicate that there is no variation in terms of the procedure of study and analysis of that parameter. In general, a design will be said to be fully adequate if it is 100% compliant with all the parameters involved in the design.

5. Conclusions

The project: Design and construction of the "RUMICHACA - PASTO - CHACHAGÜI - AEROPUERTO" bypass is the most important road infrastructure work currently being developed in the Department of Nariño and will bring many benefits to users.

In general, the geometric design of the Pasto City Bypass presents a greater compliance with respect to the theoretical-conceptual support of the different parameters presented in the 1998 manual; since in fact the design made by DEVINAR S.A. was made based on this.

The design of the Pasto City Bypass has 100% compliance with some parameters, such as: DVP stop visibility distance in plan, DVP stop visibility distance in profile, E-E splice limit deflections, Spiral Length Le, Minimum and maximum length of vertical curves and for the cross-section in area width and roadway width, This applies to both the analysis carried out by the 1998 and 2008 manuals.

But there are also some parameters in the design that are not met with respect to what is exposed in the manuals in percentages of 100%, such is the case of Overwidth of the Roadway in horizontal curves that becomes critical parameters of the design of the Bypass of the city of Pasto, which can generate operational problems. Safety, economy and speed in the project, this applies both to the analysis carried out through the manual of 1998 and 2008.

The design object of the study and analysis is classified as Inadequate under the conditions developed in terms of design and construction of the "RUMICHACA – PASTO – CHACHAGÜI - AIRPORT" bypass, for the Pasto city bypass.

Below are conclusions for the analysis of both the 1998 Geometric Road Design Manual and the 2008 Manual, as follows:

- CONCLUSIONS: COMPARATIVE ANALYSIS REFERENCED TO THE MANUAL FOR THE GEOMETRIC DESIGN OF ROADS IN 1998.

By contrasting the value of design speed Vd minimum equal to 60 km/h, established based on the parameters indicated by INVIAS in its manual of 1998 and the value of Vd equal to 50 km/h used by DEVINAR S.A. for this design, it is concluded that the latter value satisfies in the vast majority the minimum needs required by the geometric design of this route.
For the existing DVP stop visibility distances in the convex vertical curves of the Pasto City Bypass, studied with the 1998 regulations, for the actual design speed (50 km/h) they comply satisfactorily. While for the stipulated minimum theoretical design speed of (60 km/h) there are a total of 14 curves, of which 1 of them does not comply, this being (7.14%) of those that do not meet the criterion.

Once the classification of the road is taken into account, the overtaking visibility distances Da for horizontal curves under consideration are analyzed, measured in planes in relation to the minimum theoretical Da, established in the 1998 regulations. For a real design speed (50 km/h) 40 of them curves, their overtaking visibility distance is less than 250 m (83.33%) and for the minimum theoretical design speed (60 km/h), it does not meet almost all of them (45 curves – 93.75%), which indicates that this criterion is totally inadequate. It shows that it is difficult and expensive to achieve overtaking visibility over an entire track.

The DVP stop visibility distances on horizontal curves of the Pasto City Bypass, measured in plans in relation to the minimum theoretical DVP, analyzed with the 1998 regulations, it is necessary for the actual design speed (50 km/h), and the minimum theoretical design speed (60 km/h) fully comply with this criterion.

Taking into account that in the Variant of the city of Pasto for its geometric design there are 48 horizontal curves, which analyzed with the regulations of the year 1998. For the actual design speed (50 km/h) it complies in its entirety and for the minimum theoretical design speed (60 km/h) it is found that only 1 of the 48 curves studied has a design radius of less than 120 meters for a (2.08%).

For the geometric design of the Pasto City Bypass, none of the horizontal curves have an overwidth. Once the analysis has been carried out for the 1998 regulations and with the criterion that the minimum overwidth that is constructively adequate is 0.6 meters (values corresponding to radii not greater than 117 meters or except in curves with deflection angle greater than 120°) therefore this criterion constructively does not apply overwidth.

The criterion of the Arrow M in horizontal curves of the Bypass of the city of Pasto based on the Regulations of 1998, is taken as a reference for an adequate and correct construction for the start-up of the road; therefore, compliance with this parameter is not studied because there is no information on lateral obstacles that restrict the visibility of the user along its route. It must be taken into account that its analysis is of great importance since it is related to the safety of the operator and must always guarantee that during the construction processes and in general during the operation and maintenance stages the road is free of obstacles that limit visibility.

The Geometric Design of the Variant of the city of Pasto with a total number of 48 horizontal curves analyzed, for the criterion of minimum circular length to the Manual of the year 1998, it has that for the actual design speed (50 km/h) 3 curves do not comply (6.25%) and the minimum theoretical design speed (60 km/h) again 3 curves do not fully comply with this criterion to obtain a (6.25%).

The geometric design of the Pasto City Bypass, analyzed with the 1998 regulations, shows only 1 horizontal curve designed with a Spiral - Symmetrical Spiral type joint, which does not exceed the limitations of deflections (ΔT and θe greater than 20º and 10º degrees respectively).

The Geometric Design of the Pasto City Bypass with a total number of 48 horizontal curves analyzed, for the maximum cant criterion referenced to the 1998 manual, fully complies with this criterion.

The Geometric Design of the Bypass of the city of Pasto with a total number of 43 horizontal curves analyzed, for the transition length criterion referenced to the 1998 Manual, it has to be found that for Circular type joints they comply with this criterion in their entirety; for E-C-E splices they do not comply with 4 curves being the (9.30%) and for E-E splices they do not comply with 1 curve (2.33%).

In the Geometric Design of the Variant of the city of Pasto with a total number of 48 horizontal curves, for the superelevation ramp criterion referenced to the 1998 manual, for real design speed of (50 km/h) they do not comply with 8 curves to obtain a (41.74%) of curves that do not comply and for minimum theoretical speed of (60 km/h) they do not comply with 17 curves to have a (35.42%).

In the geometric design of the Pasto City Bypass with 48 horizontal intertangencies, analyzed with the 1998 regulations. For the actual design speed (50 km/h), and the minimum theoretical design speed (60 km/h) only one (1) of them does not meet the minimum theoretical horizontal length, in order to have (2.08%) that does not meet the criterion.

The criterion of minimum slope length of the Pasto City Bypass based on the 1998 regulations, is taken as a reference so that the speed is not reduced considerably, since this causes delays for vehicles traveling behind and that could go faster. To avoid the formation of delays and overtaking manoeuvres that pose greater risk, the possibility of designing a second ascent lane will be evaluated, since in many cases the length of the slope is greater than the critical one.

In the Geometric Design of the Variant of the city of Pasto with a total of 29 vertical curves, for the criterion of minimum length referenced to the manual of the year 1998, for real design speed of (50 km/h) it complies in its entirety and for minimum theoretical speed of (60 Km/h) only one (1) curve does not comply to obtain a (3.45%).

For the Geometric Design of the Variant of the city of Pasto, a total number of 53 abscissas in cross-section were analyzed, in order to determine the criterion of minimum zone width referenced to the 1998 manual, it fully complies with the 53 abscissa taken randomly, for which it is said that the criterion is totally adequate.

For the Geometric Design of the Bypass of the city of Pasto with a total number of 53 abscissae analyzed in cross-section, for the criterion of road width referenced to the manual of the year 1998, they comply in their (100%) of the abscissa, so the criterion is totally adequate.

In the Geometric Design of the Bypass of the city of Pasto with a total number of 53 abscissae analyzed in cross-section, for the berm width criterion referenced to the 1998 manual, 14 do not meet to obtain a (26.42%) abscissa that do not comply.

- CONCLUSIONS: COMPARATIVE ANALYSIS REFERENCED TO THE MANUAL FOR THE GEOMETRIC DESIGN OF ROADS IN 2008

When comparing the value of the actual VTR of design equal to 50 km/h, used by DEVINAR SA, with the value of VTR according to the parameters determined by INVIAS in its 2008 manual for the Bypass of the city of Pasto, this value of VTR (50 km/h) mostly satisfies the minimum needs required by the Geometric Design of this route.

In the Geometric Design of the Bypass of the city of Pasto with a total number of 14 vertical curves analyzed, for the criterion of visibility distance of DVP stop in profile referenced to the manual of the year 2008, for real VTR design of (50 km/h) this parameter complies favorably and for minimum theoretical VTR of 70 km/h does not meet a total number of 4 curves to obtain a percentage of (28.57%).

Once the classification of the road is taken into account, the overtaking visibility distances Da for horizontal curves under consideration are analyzed, measured in planes in relation to the minimum theoretical Da, established in the 2008 regulations. For a real design speed (50 km/h) 40 of them curves, its overtaking visibility distance is less than 250 m (83.33%) and for the minimum theoretical design speed (60 km/h), it does not fully comply (45 curves – 93.75%) which indicates that this criterion is totally inadequate. It shows that it is difficult and expensive to achieve overtaking visibility over an entire track.

The DVP stop visibility distances in horizontal curves of the Pasto City Bypass, measured in planes in relation to the minimum theoretical DVP, analyzed with the 2008 regulations, it has to be necessary for the actual design speed (50 km/h), and the minimum theoretical design speed (70 km/h) to fully comply with this criterion.

In the Geometric Design of the Variant of the city of Pasto with a total number of 48 horizontal curves analyzed, for the criterion of minimum curvature radii referenced to the 2008 manual, for real VTR design of (50 km/h) it satisfactorily complies in its entirety, while for minimum theoretical VTR of (70 km/h) 4 curves (8.33%) present problems.

In the Geometric Design of the Variant of the city of Pasto, none of the horizontal curves presents overwidth, however the following analysis is carried out with a total number of 48 horizontal curves analyzed, for the criterion of overwidth for rigid vehicles referenced to the manual of the year 2008, this parameter is applicable, but of which 100% of curves do not comply.

In the Geometric Design of the Bypass of the city of Pasto, the analysis of the Arrow M parameter is presented as a theoretical, because it is not possible to establish a comparison with values used in the design due to the fact that there is no information regarding lateral obstacles that limit the visibility of the user during his journey.

In the Geometric Design of the Variant of the city of Pasto with a total number of 48 horizontal curves designed with Spiral - Circle - Spiral agreement, for the criterion of Minimum circular length referenced to the 2008 manual, for real VTR design of (50 km/h) they do not comply with 5 curves (10.41%) and for minimum theoretical VTR of (70 km/h) they do not comply with 7 curves (14.58%).

The geometric design of the Pasto City Bypass analyzed with the 2008 regulations, shows only 1 horizontal curve designed with a Spiral - Symmetrical Spiral type splice, which does not exceed the limitations of deflections (ΔT and θe greater than 20° and 10° degrees respectively).

In the Geometric Design of the Bypass of the city of Pasto with a total number of 48 horizontal curves analyzed, for the cant criterion referenced to the 2008 manual, for real VTR design of (50 km/h) they do not comply in one (100%) while for minimum theoretical VTR of (70 km/h) they do not comply with 44 curves (91.67%). However, these high percentages of superelevation that do not meet the design values are very close to the theoretical ones.

The Geometric Design of the Bypass of the city of Pasto with a total number of 43 horizontal curves analyzed, for the transition length criterion referenced to the 2008 Manual, it has to be found that for Circular type joints they comply with this criterion in their entirety; For E-C-E splices they do not comply with 4 curves being the (9.30%) and for E-E splices they do not comply with 1 curve (2.33%).

In the Geometric Design of the Variant of the city of Pasto with a total number of 48 horizontal curves, for the superelevation ramp criterion referenced to the 2008 manual, for real design speed of (50 km/h) they do not comply with 8 curves to obtain a (41.74%) of curves that do not comply and for minimum theoretical speed of (60 km/h) they do not comply with 17 curves to have a (35.42%).

In the geometric design of the Pasto City Bypass with 48 horizontal intertangencies, analyzed with the 1998 regulations, it has to be found that for the actual design speed (50 km/h), and the minimum theoretical design speed (70 km/h) only one (1) of them does not comply with horizontal length less than the minimum theoretical intertangency. to have (2.08%) that does not meet the criteria.

In the Geometric Design of the Variant of the city of Pasto with a total number of 48 curves analyzed, for the criterion of relationship between radii of contiguous horizontal curves referenced to the 2008 manual, for real VTR design of (50 km/h) they do not comply with 18 relationships (40.90%) and for minimum theoretical VTR of (70 km/h) they do not meet 20 relationships (45.45%).

In the Geometric Design of the Bypass of the city of Pasto with a total number of 28 intertangencies in profile section, for the slope criterion in Vertical Tangents referenced to the 2008 manual, for real VTR design of (50 km/h) it complies (100%) satisfactorily and for VTR theoretical minimum of (70 km/h) it does not comply with 6 curves (21.43%).

In the Geometric Design of the Variant of the city of Pasto for a total number of 28 intertangencies in profile section, for the criterion of minimum length referenced to the 2008 manual, both for real VTR design of (50 km/h) and for minimum theoretical VTR of (70 km/h) only does not comply with a curve (7.14%).

In the Geometric Design of the Variant of the city of Pasto with a total number of 28 vertical curves, for the criterion of maximum and minimum length of vertical curves referenced to the manual of the year 2008, for real VTR design of (50 km/h) it fully complies with this criterion while for minimum theoretical VTR of (70 km/h) 6 curves (21.43%) do not meet.

For the Geometric Design of the Variant of the city of Pasto, a total number of 53 abscissas were analyzed in cross-section, in order to determine the criterion of minimum zone width referenced to the 2008 manual, it fully complies with the 53 abscissa taken randomly, for which it is said that the criterion is totally adequate.

In the Geometric Design of the Bypass of the city of Pasto with a total number of 53 abscissas analyzed in cross-section, for the criterion of road width referenced to the 2008 manual, they comply with (100%) of the abscissa, so the criterion is totally adequate.

In the Geometric Design of the Variant of the city of Pasto with a total number of 53 abscissae analyzed in cross-section, for the berm width criterion referenced to the 2008 manual, 14 do not comply to obtain a (26.42%) abscissa that do not comply.

6. Recommendations

Assigning speeds to the different elements that make up the geometric design to comply with the imposed specifications, as in the case of Da, which presents very inadequate values, therefore indicates that it is a criterion that is totally inadequate. And so it is in accordance with the conditions under which the project is developed based on the exposition of the Manual for the Geometric Design of Roads.

Implement, as far as possible, overwidths in horizontal curves that require it and whose value is higher than the limit established by the standard from the construction point of view, in order to maintain the same safety conditions as straight sections, in terms of the crossing of vehicles from the opposite direction.

Generate a more in-depth study of those criteria that can be called "critical" based on this analysis, because in the future these may generate problems of functionality, operability and safety during vehicular circulation.

Make adjustments to parameters that require and allow it in order to optimize the geometric design of roads of the Pasto City Bypass of the "RUMICHACA – PASTO – CHACHAGÜI – AIRPORT" bypass.

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