
Analysis of the track ropes life of a bicable
continous material ropeway.



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1 FOREWORD

Scope of this paper is an analysis of the different endurance in operation of the different sections of track ropes of the industrial ropeway "Rio Branco", considering the characteristics of the different line points. This will be made taking in account the line characteristics of the critical points of the line, where usually the track rope deteriorate first, requiring the deposal of the full line section.

The main point emerging from the analysis of the data below indicated, is the fact that the rope endurance is very different from one rope section to the other.

In some section the rope is still the original, after almost 30 years of operation and looks in good condition.

In other section it was necessary to change the rope up to three times.

Furthermore the rope was changed in the critical section due to defects appearing after some time in the same section points.

The scope of this paper is to analyze the different line parameters, trying to put in evidence the parameters common to the more critical spots, where defects induce to change the rope after some time.

The author of this paper did participate to the project, fabrication, erection, commissioning and initial operation of this ropeway.

In the occasion he lived in Brazil for a few years. Recently he had occasion to visit the installation, collecting full data of the life endurance of each section in the time of almost 30 years, thank to the accurate data collecting by the people in charge of the ropeway operation.

The bicable, continous, ropeway of Rio Branco has the following main characteristics;

- | | |
|------------------------------------|--|
| - operator: | Votorantim group |
| - transported material: | limestone |
| - site: | about 30 km from Curitiba (Paraná, Brazil) |
| - length: | about 13 km |
| - number of hauling rope sections: | three |
| - num. of track ropes second: | 7 full side + 7 empty side |
| - hourly transport capacity: | 600 t/h |
| - empty bucket mass: | 1.000 kg |
| - loaded bucket mass: | 3.000 kg |
| - hauling rope speed: | 5 m/s |
| - track rope diam.(full side) | 63 mm |
| - track rope diam (empty side) | 45 mm |
| - hauling rope diam,: | 32 mm |
| - in operation since: | continuously from 1982 |

The line calculation was made with an automatic program calculation "Cableways Design Package (CDP) unidirectional industrial ropeways 2S", elaborated by ing. Vitali (www.winsif.com) To him my deep tanking, also for the collaboration given to me in adapting this program, initially born for shorter lines, to the complex characteristics of Rio Branco line.

2 DATA COLLECTED FROM OPERATION EXPERIENCE

I have collected the following data tanks to the operating company, mainly tanks to Mr. Luiz Carlos de Lara, acting, apart from other tasks, as Operation Chief of the installation, and Dr... Shiguero Hassumi, director of all mining section, including also the ropeway section.

To them and to all the Votorantim group my great thanks. Without their collaboration this paper would not be possible.

Rope	Diam. (mm)	Critical Points Tower
Track rope - 1° Section E.S.	45	
Track rope - 1° Section F.S.	63	4,9
Track rope - 1° Section E.S.	45	
Track rope - 2° Section F.S.	63	17
Track rope - 3° Section E.S.	45	
Track rope - 3° Section F.S.	63	29, 30
Track rope - 4° Section E.S.	45	31,32
Track rope - 4° Section F.S.	63	32
Track rope - 5° Section E.S.	45	45
Track rope - 5° Section F.S.	63	45,46
Track rope - 6° Section E.S.	45	49
Track rope - 6° Section F.S.	63	47,49
Track rope - 7° Section E.S.	45	57,58
Track rope - 7° Section F.S.	63	59

(*) Client opinion

- 0 Very good
- 1 Good
- 2 Medium
- 3 Low

Data updated to December 2010

Total working hours: 79.201 h

Total transported tons: 27.049.949 t

All defects causing rope changing are found on the proximity of tower saddle, and in some case on saddles.

3 FIXED SADDLES, HIGH AND LOW ROLLERS

The ropeway towers are fitted with fixed type saddle (not oscillating) and some with “high” rollers batteries and some with “low” rollers.



Rio Branco tower with fixed saddle and “high” roller battery



Rio Branco tower with “low” rollers



Typical tower of a ropeway with oscillating saddles.

4 LINE CALCULATION

The line calculation was made separately for the three ropeway lines (each corresponding to a hauling rope ring)

The first two lines are with loads going up.

The first line starts from the loading station, reaching the first intermediary station,

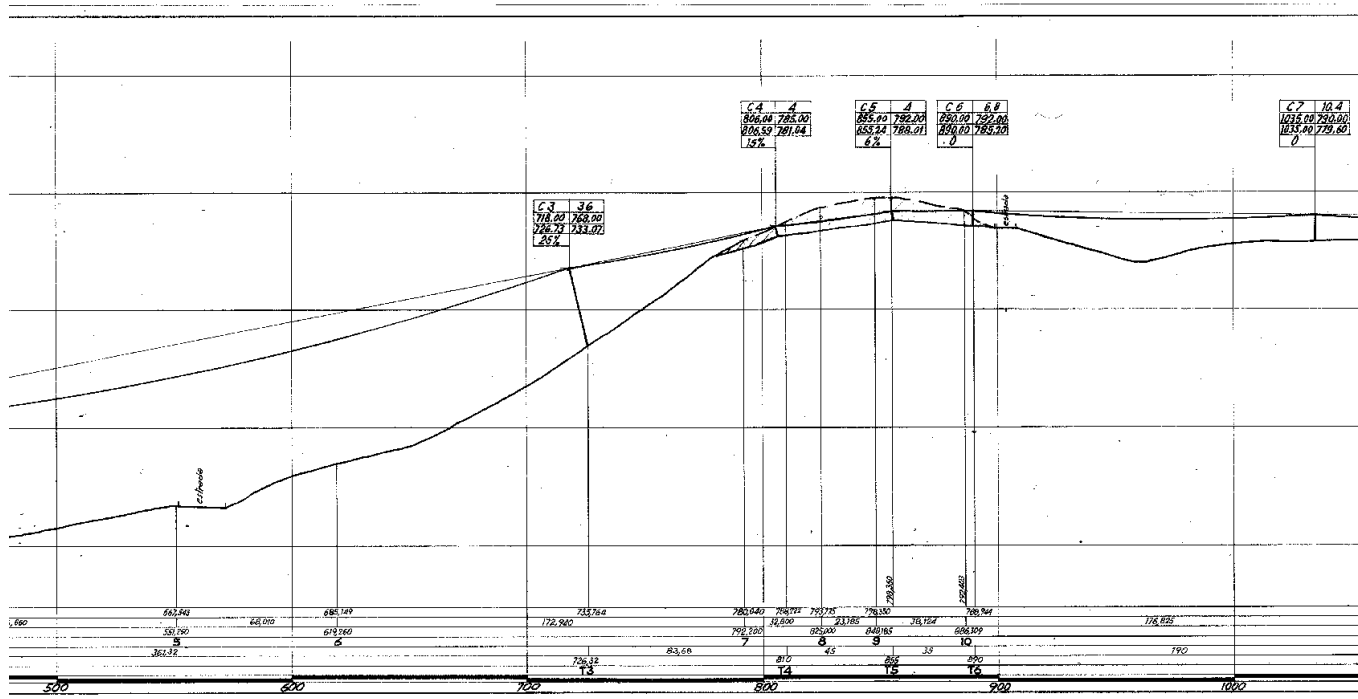
The second line links the first and second intermediary station.

Both lines are quite short (a little more than two km) and do not require track rope interruption.

Both lines have the drive station uphill and the tensioning of hauling rope downhill.

Third line has the load going slowly down, and is much longer, requiring four intermediate devices interrupting the track ropes.



The driving station of this line, as the hauling rope counterweight is downhill, the hauling rope counterweight is placed on the empty buckets side.



Example of a part of first line profile.

4.1 FIRST LINE

The incoming data to the line calculation program are the following:

DESCRIZIONE						
 	Descrizione Impianto	Teleferica Rio Branco				
	Località	Tronco n.1 Stazione di Carico - Intermediaria I				
	Comune	Rio Branco				
	Provincia	Paraná				
	Note 1	Calcolo funi portanti contrappesate				
	Note 2					
FUNE PORTANTE	45	Setip_1	Setip_2	1770 N/mm ²	1950 N/mm ²	2100 N/mm ²
Descrizione	FUNE CHIUSA FLESSIBILE \ Flexible locked coil wire rope					
Diametro	(mm)	63	45			
Peso unitario	(N/m)	209,54	112,32	<input type="radio"/> Fune_ancorata		
Sezione	(mm ²)	2537	1360			
Modulo di elasticità	(N/mm ²)	155000	155000			
Carico somma	(KN)	4237	2271	<input type="radio"/> Contrappeso_a_valle		
Carico di rottura	(KN)	3814	2044			
Coefficiente di attrito fune-scarpa	(n)	0,10	0,10	<input checked="" type="radio"/> Fune_contrappesata		
Coefficiente di dilatazione lineare	(n)	0,000012	0,000012			
Tiro di posa della fune (a valle)/contrappeso	(N)	941760	461070	<input checked="" type="radio"/> Contrappeso_a_monte		
FUNE TRAENTE	32	Setip	1770 N/mm ²	1950 N/mm ²	2100 N/mm ²	
Descrizione	FUNE SEALE 114					
Diametro	(mm)	32,00		<input checked="" type="radio"/> Contrappeso_a_valle		
Peso unitario	(N/m)	36,00				
Sezione	(mm ²)	404,50		<input type="radio"/> Contrappeso_a_monte		
Modulo di elasticità	(N/mm ²)	125.000				
Attrito % rulli-fune traente	(n)	2,00		<input type="radio"/> Traente Ancorata		
Carico somma/rottura	(KN)	793	682			
Valore tensione traente (per ramo)	(N)	53.955				
VEETTURA						
Peso del veicolo carico	(N)	29.430				
Peso del veicolo vuoto	(N)	9.810				
Equidistanza veicoli	(m)	60				
Attrito % rulli-fune portante	(n)	0,50				
	(N)					
ARGANO MOTORE						
Velocità di trasferimento in linea a regime	(m/s)	5,00		<input type="radio"/> Argano_a_valle	<input checked="" type="radio"/> Argano_a_monte	
Rendimento argano motore	(n)	0,80				
Tipo Argano motore (Fisso / Mobile)				<input checked="" type="radio"/> Argano_fisso	<input type="radio"/> Argano_mobile	
ATTRITI STAZIONI						
Pressa di forza in stazione	N	0,01				
Deviazione traente stazione di valle	rad	0,01				
Deviazione traente stazione di monte	rad	0,01				

The coordinates, absolute and relatives of tower summits, inserted in the program, are the following:

RAMO SALITA			
Sostegno N°	Codice Sostegno	Progressiva Fune (m)	Quota Fune (m)
1	S.V.	48,00	641,73
2	C1	255,00	680,00
3	C2	360,00	699,00
4	C3	718,00	768,00
5	C4	806,00	785,00
6	C5	855,00	792,00
7	C6	890,00	792,00
8	C7	1.035,00	790,00
9	C8	1.130,00	789,00
10	C9	1.510,00	799,00
11	C10	1.640,00	808,00
12	C11	1.895,00	826,00
13	C12	2.090,00	841,00
14	I1V	2.125,80	841,00

RAMO SALITA / DISCESA			
Campata N°	Codice Campata valle-monte	Campata	
		Distanza orizzontale (m)	Dislivello verticale (m)
1	S.V.-C1	207,00	38,27
2	C1-C2	105,00	19,00
3	C2-C3	358,00	69,00
4	C3-C4	88,00	17,00
5	C4-C5	49,00	7,00
6	C5-C6	35,00	0,00
7	C6-C7	145,00	-2,00
8	C7-C8	95,00	-1,00
9	C8-C9	380,00	10,00
10	C9-C10	130,00	9,00
11	C10-C11	255,00	18,00
12	C11-C12	195,00	15,00
13	C12-I1V	35,80	0,00

The output of line calculation, in uniform movement conditions is the following:

VALORI MASSIMI E MINIMI DELLE TENSIONI, FRECCIE, ANGOLI DI IMBOCCO E PRESSIONI SUI SOSTEGNI

RAMO SALITA		FUNDE PORTANTE					FUNDE TRAENTE-ZAVORRA				
Campata		Tensione Campata	Freccia Campata	Angolo valle	Angolo monte	Pressione Sostegno	Tensione Campata	Freccia Campata	Angolo valle	Angolo monte	Pressione Sostegno
Sostegno		Max Min (N)	Max Min (m)	Max Min (gradi)	Max Min (gradi)	Max Min (N)	Max Min (N)	Max Min (m)	Max Min (gradi)	Max Min (gradi)	Max Min (N)
S.V.	C1	908.024 900.005	4,41 1,41	6,75 4,88	15,86 14,18		78.715 53.955	4,41 4,06	6,01 4,88	15,86 14,63	
	C1						113.545 107.761				
C1	C2	912.005 908.024	1,15 0,36	8,79 7,01	13,48 11,71		90.181 71.238	1,15 0,95	8,42 6,99	13,49 12,05	
	C2						152.569 145.987				
C2	C3	926.463 912.005	12,41 4,16	4,07 2,11	19,21 17,54		130.259 81.942	12,41 12,20	3,79 2,11	19,21 17,67	
	C3						152.968 144.650				
C3	C4	930.026 926.463	0,85 0,25	9,83 8,07	13,83 12,06		137.086 116.653	0,85 0,57	9,73 8,06	13,83 12,15	
	C4						97.601 86.891				
C4	C5	931.492 930.026	0,41 0,08	7,81 6,09	10,19 8,45		142.014 127.877	0,41 0,04	7,75 6,09	10,19 8,51	
	C5						169.926 153.420				
C5	C6	931.492 931.492	0,28 0,04	-0,23 -2,02	2,02 0,23		142.916 131.523	0,28 0,01	-0,25 -2,02	2,02 0,25	
	C6						83.440 64.636				
C6	C7	931.492 931.073	1,99 0,65	-2,99 -4,91	3,30 1,39		143.169 130.462	1,99 1,74	-3,04 -4,91	3,30 1,48	
	C7						83.104 70.764				
C7	C8	931.073 930.864	0,91 0,28	-1,82 -3,69	2,48 0,59		144.045 129.423	0,91 0,65	-1,88 -3,69	2,48 0,65	
	C8						134.800 121.819				
C8	C9	932.959 930.864	13,32 4,46	-5,53 -7,71	10,62 8,59		152.524 129.768	13,32 13,11	-5,57 -7,71	10,62 8,64	
	C9						138.381 127.886				
C9	C10	934.845 932.959	1,56 0,52	2,11 0,25	7,64 5,79		157.766 134.009	1,56 1,37	2,07 0,25	7,64 5,84	
	C10						133.198 123.440				
C10	C11	938.617 934.845	5,90 2,00	-0,38 -2,38	10,37 8,41		166.944 141.108	5,90 5,68	-0,42 -2,38	10,37 8,41	
	C11						148.294 139.337				
C11	C12	941.760 938.617	3,56 1,17	1,32 -0,65	9,40 7,49		178.347 152.322	3,56 3,05	1,32 -0,65	9,40 7,49	
	C12						158.097 140.458				
C12	IIV	941.760 941.760	0,27 0,04	-0,23 -2,00	2,02 0,23		178.682 160.727	0,27 0,00	-0,21 -2,00	2,02 0,21	

In order to shorten this paper we are not reporting the outputs of all other lines, fully and empty sides, since the same values are listed in following table, just arranged in an order more suitable to the consideration we propose to make.

4.2 SECOND LINE

The incoming data to the line calculation program are the following for the second line:

DESCRIZIONE			
Descrizione Impianto		TELEFERICA Rio Branco	
Località		Tronco n.3 Stazione intermediaia II - Stazione di scarico	
Comune		Rio Branco	
Provincia		Paraná	
Note 1		Calcolo funi portanti contrappesate	
Note 2			
FUNE PORTANTE	44	Setip_1	Setip_2
		1770 N/mm ²	1900 N/mm ²
Descrizione		FUNI ORIGINALI	
Diametro	(mm)	63	45
Peso unitario	(N/m)	209,54	112,32
Sezione	(mm ²)	2537	1360
Modulo di elasticità	(N/mm ²)	155000	155000
Carico somma	(KN)	4237	2271
Carico di rottura	(KN)	3814	2044
Coefficiente di attrito fune-scarpa	(n)	0,10	0,10
Coefficiente di dilatazione lineare	(n)	0,000012	0,000012
Tiro di posa della fune (a valle)/contrappeso	(N)	902520	441450
FUNE TRAEANTE	36	Setip	1770 N/mm ²
			1900 N/mm ²
			2100 N/mm ²
Descrizione		FUNI SEALE 114	
Diametro	(mm)	32,00	
Peso unitario	(N/m)	36,00	
Sezione	(mm ²)	404,50	
Modulo di elasticità	(N/mm ²)	125.000	
Attrito ½ rulli-fune traente	(n)	2,00	
Carico somma/rottura	(KN)	793	863
Valore tensione traente (per ramo)	(N)	53.955	
VEETTURA			
Peso del veicolo carico	(N)	29.430	
Peso del veicolo vuoto	(N)	9.810	
Equidistanza veicoli	(m)	60	
Attrito ½ rulli-fune portante	(n)	0,50	
	(N)		
ARGANO MOTORE			
Velocità di trasferimento in linea a regime	(m/s)	5,00	
Rendimento argano motore	(n)	0,80	
Tipo Argano motore (Fisso / Mobile)			
		Argano_fisso	Argano_mobile
ATTRITI STAZIONI			
Presa di forza in stazione	N	0,01	
Deviazione traente stazione di valle	rad	0,01	
Deviazione traente stazione di monte	rad	0,01	

The towers summit coordinates are the following:

RAMO SALITA			
Sostegno N°	Codice Sostegno	Progressiva Fune (m)	Quota Fune (m)
1	I1M	2.189,20	840,70
2	C13	2.250,00	840,70
3	C14	2.503,00	841,00
4	C15	2.764,00	851,00
5	C16	3.102,00	869,00
6	C17	3.257,00	883,00
7	C18	3.497,00	913,00
8	C19	3.720,00	946,00
9	C20	3.831,00	959,00
10	C21	4.030,00	985,00
11	C22	4.294,00	1.024,00
12	C23	4.450,00	1.047,00
13	I2V	4.485,80	1.047,00

RAMO SALITA / DISCESA			
Campata N°	Codice Campata valle-monte	Campata	
		Distanza orizzontale (m)	Dislivello verticale (m)
1	I1M-C13	60,80	0,00
2	C13-C14	253,00	0,30
3	C14-C15	261,00	10,00
4	C15-C16	338,00	18,00
5	C16-C17	155,00	14,00
6	C17-C18	240,00	30,00
7	C18-C19	223,00	33,00
8	C19-C20	111,00	13,00
9	C20-C21	199,00	26,00
10	C21-C22	264,00	39,00
11	C22-C23	156,00	23,00
12	C23-I2V	35,80	0,00

4.3 THIRD LINE

The incoming data to the line calculation program are the following:

DESCRIZIONE		TELEFERICA Rio Branco					
Località	Tronco n.3 Stazione intermediaia II - Stazione di scarico						
Comune	Rio Branco						
Provincia	Paraná						
Note 1	Calcolo funi portanti contrappesate						
Note 2							
FUNE PORTANTI	44	Se Imp_1	Se Imp_2				
		1770 N/mm ²	1900 N/mm ² 2100 N/mm ²				
Descrizione	FUNI ORIGINALI						
Diametro	(mm)	63	45				
Peso unitario	(N/m)	209,54	112,32				
Sezione	(mm ²)	2537	1360				
Modulo di elasticità	(N/mm ²)	155000	155000				
Carico somma	(KN)	4237	2271				
Carico di rottura	(KN)	3814	2044				
Coefficiente di attrito fune-scarpa	(n)	0,10	0,10				
Coefficiente di dilatazione lineare	(n)	0,000012	0,000012				
Tiro di posa della fune (a valle)/contrapp.	(N)	785000	430000				
FUNE TRAEENTE	36	Se Imp	1770 N/mm ² 1900 N/mm ² 2100 N/mm ²				
Descrizione	FUNI SEALE H14						
Diametro	(mm)	32,00					
Peso unitario	(N/m)	36,00					
Sezione	(mm ²)	404,50					
Modulo di elasticità	(N/mm ²)	125.000					
Attrito % rulli-fune traente	(n)	2,00					
Carico somma/rottura	(KN)	793	863				
Valore tensione traente (per ramo)	(N)	843.660					
VEETTURA							
Peso del veicolo carico	(N)	29.430					
Peso del veicolo vuoto	(N)	9.810					
Equidistanza veicoli	(m)	60					
Attrito % rulli-fune portante	(n)	0,50					
ARGANO MOTORE							
Velocità di trasferimento in linea a regime	(m/s)	5,00					
Rendimento argano motore	(n)	0,80					
Tipo Argano motore (Fisso / Mobile)							
TRITTI STAZIONE							
Presa di forza in stazione	(N)	0,01					
Deviazione traente stazione di valle	(rad)	0,01					
Deviazione traente stazione di monte	(rad)	0,01					
DEFINIZIONE DEI TRATTI NON INTERCONNESSI DI FUNE PORTANTE (linea con fune portante a tratti e tes)							
Num.	Attivo	Inizio: "Sost. Valle"	Fine: "Sost. Monte"	Misura tiro di posa a valle	Tipo tensione fune Contrapp.	Valore tiro posa salita (N)	Valore tiro posa discesa (N)
1	XXX	DIAM	SM	XXX	XXX	922140	451126
2	XXX	I2M	D1AV	XXX	XXX	922140	451126
3	XXX	D2CM	D3AV	XXX	XXX	922140	451126
4	XXX	D3AM	D4AV	XXX	XXX	919197	449298
5	XXX	D4AM	SM	XXX	XXX	931950	456165

The towers summit coordinates are the following:

RAMO SALITA				RAMO SALITA / DISCESA			
Sostegno N°	Codice Sostegno	Progressiva Fune (m)	Quota Fune (m)	Campata N°	Codice Campata valle-monte	Campata	
						Distanza orizzontale (m)	Dislivello verticale (m)
1	I2M	4.549,20	1.047,00	1	I2M-C24	35,80	0,00
2	C24	4.585,00	1.047,00	2	C24-C25	215,00	-45,00
3	C25	4.800,00	1.002,00	3	C25-C26	232,00	-38,00
4	C26	5.032,00	964,00	4	C26-C27	458,00	-44,00
5	C27	5.490,00	920,00	5	C27-C28	160,00	-8,00
6	C28	5.650,00	912,00	6	C28-C29	350,00	0,00
7	C29	6.000,00	912,00	7	C29-C30	212,00	12,00
8	C30	6.212,00	924,00	8	C30-D1AV	249,00	23,00
9	D1AV	6.461,00	947,00	9	D1AV-DIAM	16,29	1,88
10	DIAM	6.477,29	948,88	10	DIAM-C31	158,71	20,12
11	C31	6.636,00	969,00	11	C31-C32	62,00	7,00
12	C32	6.698,00	976,00	12	C32-C33	140,00	6,00
13	C33	6.838,00	982,00	13	C33-C34	42,00	0,00
14	C34	6.880,00	982,00	14	C34-C35	44,00	-5,00
15	C35	6.924,00	977,00	15	C35-C36	75,00	-11,00
16	C36	6.999,00	966,00	16	C36-C37	288,00	-36,00
17	C37	7.287,00	930,00	17	C37-C38	223,00	-18,00
18	C38	7.510,00	912,00	18	C38-C39	390,00	-10,00
19	C39	7.900,00	902,00	19	C39-C40	50,00	0,00
20	C40	7.950,00	902,00	20	C40-D2CV	161,00	-1,88
21	D2CV	8.111,00	900,12	21	D2CV-D2CM	17,00	-0,12
22	D2CM	8.128,00	900,00	22	D2CM-C41	149,00	-0,50
23	C41	8.277,00	899,50	23	C41-C42	268,00	8,50
24	C42	8.545,00	908,00	24	C42-C43	371,00	35,00
25	C43	8.916,00	943,00	25	C43-C44	44,00	0,00
26	C44	8.960,00	943,00	26	C44-C45	162,00	-12,00
27	C45	9.122,00	931,00	27	C45-C46	397,00	-10,00
28	C46	9.519,00	921,00	28	C46-D3AV	192,00	6,00
29	D3AV	9.711,00	927,00	29	D3AV-D3AM	17,00	0,17
30	D3AM	9.728,00	927,17	30	D3AM-C47	206,00	-2,17
31	C47	9.934,00	925,00	31	C47-C48	412,00	11,00
32	C48	10.346,00	936,00	32	C48-C49	49,00	0,00
33	C49	10.395,00	936,00	33	C49-C50	342,00	-11,00
34	C50	10.737,00	925,00	34	C50-C51	36,00	-1,00
35	C51	10.773,00	924,00	35	C51-C52	387,00	-29,00
36	C52	11.160,00	895,00	36	C52-C53	90,00	-3,00
37	C53	11.250,00	892,00	37	C53-C54	244,00	-6,00
38	C54	11.494,00	886,00	38	C54-C55	395,00	15,70
39	C55	11.889,00	901,70	39	C55-D4AV	175,00	14,40
40	D4AV	12.064,00	916,10	40	D4AV-D4AM	18,00	1,80
41	D4AM	12.082,00	917,90	41	D4AM-C56	98,00	10,10
42	C56	12.180,00	928,00	42	C56-C57	110,00	9,00
43	C57	12.290,00	937,00	43	C57-C58	97,00	2,00
44	C58	12.387,00	939,00	44	C58-C59	167,00	-1,00
45	C59	12.554,00	938,00	45	C59-C60	196,00	0,00
46	C60	12.750,00	938,00	46	C60-C61	410,00	20,00
47	C61	13.160,00	958,00	47	C61-C62	50,00	2,40
48	C62	13.210,00	960,40	48	C62-C63	398,42	0,60
49	C63	13.608,42	961,00	49	C63-C64	211,58	2,00
50	C64	13.820,00	963,00	50	C64-SM	26,85	-0,01
51	SM	13.846,85	962,99				

5 REARRANGEMENT OF LINE CALCULATION OUTPUT DATA

5.1 FIRST SECTION OF TRACK ROPES – FIRSTB LINE

We list below the main data of line calculation:

		LATO SALITA																	
Campata	Sost.	PORTANTE							TRAENTE		Camp. valle	Camp. monte	N° VAG. VALLE	N° VAG. MONTE	Rulliera alta o bassa	Raggio scarpata e rulliera, se alta	Carico su carrello su scarpata	Pressione su scarpata dovuto a raggio scarpata	Sost. Critic.
		Tensione campata	Freccia campata	Angolo valle campata	Angolo monte campata	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione traente	Pressione traente su sostegno									
		Max Min (N)	Max Min (m)	Max Min (°)	Max Min (°)	(°)	(°)	Max Min (N)	Max Min (N)	Max Min (N)									
S.V. C1		908.024 900.005	4,41 1,41	6,75 4,88	15,86 14,18				78.715 53.955										
	C1					1,68	1,78	113.545 107.761		10.222 9.250	211	107	3 4	1 2	B	20	39.652	45.401	
C1 C2		912.005 908.024	1,15 0,36	8,79 7,01	13,48 11,71				90.181 71.238										
	C2					1,77	1,96	152.569 145.987		15.242 13.625	107	365	1 2	5 6	B	20	44.672	45.600	
C2 C3		926.463 912.005	12,41 4,16	4,07 2,11	19,21 17,54				130.259 81.942										
	C3					1,67	1,76	152.968 144.650		20.959 18.966	365	90	5 6	0 1	A	30	35.237	30.882	
C3 C4		930.026 926.463	0,85 0,25	9,83 8,07	13,83 12,06				137.086 116.653										
	C4					1,77	1,72	97.601 86.891		14.204 12.307	90	49	0 1	0 1	B	20	43.634	46.501	
C4 C5		931.492 930.026	0,41 0,08	7,81 6,09	10,19 8,45				142.014 127.877										
	C5					1,74	1,79	169.926 153.420		24.812 22.669	49	35	0 1	0 1	A	40	38.508	23.287	
C5 C6		931.492 931.492	0,28 0,04	-0,23 -2,02	2,02 0,23				142.916 131.523										
	C6					1,79	1,92	83.440 64.636		12.824 9.510	35	145	0 1	1 2	B	20	42.254	46.575	
C6 C7		931.492 931.073	1,99 0,65	-2,99 -4,91	3,3 1,39				143.169 130.462										
	C7					1,91	1,87	83.104 70.764		12.373 10.671	145	95	1 2	1 2	B	20	41.803	46.575	
C7 C8		931.073 930.864	0,91 0,28	-1,82 -3,69	2,48 0,59				144.045 129.423										
	C8					1,89	2,18	134.800 121.819		20.515 17.234	95	380	1 2	5 6	B	20	49.945	46.554	
C8 C9		932.959 930.864	13,32 4,46	-5,53 -7,71	10,62 8,59				152.524 129.768										
	C9					2,03	1,86	138.381 127.886		21.483 18.790	380	130	5 6	1 2	B	20	50.913	46.648	
C9 C10		934.845 932.959	1,56 0,52	2,11 0,25	7,64 5,79				157.766 134.009										
	C10					1,85	2,00	133.198 123.440		20.932 18.966	130	256	1 2	3 4	A	40	39.515	23.371	
C10 C11		938.617 934.845	5,9 2	-0,38 -2,38	10,37 8,41				166.944 141.108										
	C11					1,96	1,97	148.294 139.337		25.690 22.705	256	196	3 4	2 3	A	40	40.102	23.465	
C11 C12		941.760 938.617	3,56 1,17	1,32 -0,65	9,4 7,49				178.347 152.322										
	C12					1,91	1,77	158.097 140.458		29.806 24.224	196	36	2 3	0 1	A	50	39.631	18.835	
C12 H1V		941.760 941.760	0,27 0,04	-0,23 -2	2,02 0,23				178.682 160.727										
Val.max		941.760	13,32	9,83	19,21	2,03	2,18	169.926	178.682	29.806	380	380	6	6		50	50.913	46.648	
Val.min		900.005	0,04	-7,71	0,23	1,67	1,72	64.636	53.955	9.250	35	35	0	0		20	35.237	18.835	
Val. medi		929.319	2,32	1,11	8,05	1,83	1,88	124.707	132.998	17.832	171	157	2	2		28	42.155	36.975	

The meaning of all data, considering all columns from left to right is:

- The name of each considered span,
- The name of the considered tower,
- The maximum and minimum tension of the track rope in the considered span,
- The maximum and minimum sag of the track rope in the considered span,
- The angle between the tangent to the track rope with the horizontal line, in correspondence to downhill and uphill side of each span,
- The deviation angle range of track rope downhill and uphill of each span
- The resultant force of the pressure of the track rope on each tower saddle,
- The tension of the hauling rope on each span,
- The resultant force of the pressure of the hauling rope on each tower,
- The length of the chord of each span downhill and uphill each tower,
- The number of vehicles in the span downhill and uphill of each span,
- The type of rollers of the considered tower (A, High or B, lower) The lower rollers are put in evidence with a green mark (*),
- The considered tower saddle radius (in case of high roller batteries is also the radius of the roller battery),
- The load on the vehicle carriage at the moment on passing on the considered saddle (**),
- The linear pressure due only to the track rope on each saddle,
- The tower considered critical from the client, marked with a black mark (***)

(*) The line calculation program we used does consider all rollers as "high" type.

As a consequence the value of this column corresponds to the actual load transmitted to the roller batteries in case they are of high type.

In case of low type rollers instead, when the carriage is on line, the hauling rope can go down on the low roller. In this case the load indicated on this column corresponds to the load acting on the carriage grip, when it lifts the hauling rope, passing on the saddle.

As a simplification we consider all these loads as vertical.

(**) This column is indicating the total load on the vehicle at the moment the same is passing on the saddle. The value is corresponding:

- For towers with low rollers, to the vehicle weight plus the hauling rope pressure resultant on the tower,
- For towers with high rollers, to the weight of the vehicle, plus the component due to the effect of lifting the hauling rope from the rollers. This component is easily calculated considering that the grip lifts 82 mm the rope from the rollers, when passing on the saddle, and taking in account the rollers battery radius, considering the lifted rope tangent to the rollers battery radius.

(***) The towers indicated as critical are the towers where the ropes are subject usually to defects suggesting, in the time, the rope disposal,

On the bottom of the table are indicated for each parameter the maximum, minimum and average value in this section,

		LATO DISCESA																		
Campata	Sost.	PORTANTE							TRAENTE							Rulliera alta o bassa	Raggio scarpa e rulliera, se alta	Carico su carrello su scarpa	Pressione su scarpa dovuto a raggio scarpa	Sost. Critic.
		Tensione campata	Freccia campata	Angolo valle campata	Angolo monte campata	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione traente	Pressione traente su sostegno	Camp. valle	Camp. monte	N° VAG. VALLE	N° VAG. MONTE	[m]					
		Max Min (N)	Max Min (m)	Max Min (°)	Max Min (°)	(°)	(°)	Max Min (N)	Max Min (N)	Max Min (N)	[m]	[m]					[m]	[N]	[N/m]	
S.V. C1		442.986 438.687	3,57 1,41	7,33 6,08	14,73 13,6				62.996 53.955											
	C1					1,13	1,21	45.195 43.347		6.934 6.595	211	107	3 4	1 2	B	20	16.744	22.149		
C1	C2	445.120 442.986	0,93 0,36	8,96 7,75	12,75 11,55				67.075 60.467											
	C2					1,20	1,28	59.049 57.168		9.361 8.858	107	365	1 2	5 6	B	20	19.171	22.256		
C2	C3	452.870 445.120	10,1 4,16	5,22 3,94	17,56 16,45				81.634 64.293											
	C3					1,11	1,19	60.879 58.288		11.196 10.607	365	90	5 6	0 1	A	30	13.144	15.096		
C3	C4	454.780 452.870	0,68 0,25	9,93 8,74	13,15 11,94				83.977 77.352											
	C4					1,21	1,17	42.569 39.070		8.157 7.507	90	49	0 1	0 1	B	20	17.967	22.739		
C4	C5	455.566 454.780	0,31 0,08	7,78 6,61	9,66 8,48				85.512 80.965											
	C5					1,18	1,22	78.990 73.485		14.759 14.034	49	35	0 1	0 1	A	40	15.276	11.389		
C5	C6	455.566 455.566	0,2 0,04	-0,25 -1,47	1,47 0,25				85.374 82.048											
	C6					1,22	1,28	33.634 27.660		6.660 5.503	35	145	0 1	1 2	B	20	16.470	22.778		
C6	C7	455.566 455.341	1,63 0,65	-2,7 -3,98	2,38 1,11				85.241 81.503											
	C7					1,27	1,26	32.424 28.694		6.403 5.760	145	95	1 2	1 2	B	20	16.213	22.778		
C7	C8	455.341 455.229	0,74 0,28	-1,7 -2,96	1,75 0,48				85.148 80.971											
	C8					1,27	1,40	49.746 46.019		9.652 8.684	95	380	1 2	5 6	B	20	19.462	22.767		
C8	C9	456.352 455.229	10,87 4,46	-4,38 -5,78	8,73 7,41				87.785 80.885											
	C9					1,32	1,24	51.007 48.204		10.003 9.255	380	130	5 6	1 2	B	20	19.813	22.818		
C9	C10	457.363 456.352	1,27 0,52	2,33 1,09	6,81 5,58				89.411 82.368											
	C10					1,23	1,31	52.571 49.854		10.184 9.778	130	256	1 2	3 4	A	40	15.525	11.434		
C10	C11	459.385 457.363	4,83 2	0,3 -1,01	9,03 7,75				92.605 84.475											
	C11					1,28	1,29	58.529 56.071		12.065 11.247	256	196	3 4	2 3	A	40	15.730	11.485		
C11	C12	461.070 459.385	2,9 1,17	1,73 0,44	8,32 7,07				96.277 88.340											
	C12					1,25	1,21	68.939 63.495		14.588 13.034	196	36	2 3	0 1	A	50	15.317	9.221		
C12	11V	461.070 461.070	0,2 0,04	-0,25 -1,46	1,47 0,25				95.985 91.104											
Val.max		461.070	10,87	9,93	17,56	1,32	1,40	78.990	96.277	14.759	380	380	6	6		50	19.813	22.818		
Val.min		438.687	0,04	-5,78	0,25	1,11	1,17	27.660	53.955	5.503	35	35	0	0		20	13.144	9.221		
Val. medi		454.401	2,00	1,80	7,40	1,22	1,26	51.037	81.790	9.618	171	157	2	2		28	16.736	18.076		

5.2 SECOND SECTION OF TRACK ROPES – SECOND LINE

		RAMO SALITA																	
Campata	Sost.	FUNI PORTANTE							NE TRAENTE-ZAVOR										
		Tensione campata portante	Freccia campata	Angolo valle sost.	Angolo monte sost.	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione traente	Pressione traente su sostegno	Camp. valle	Camp. monte	N° VAG. VALLE	N° VAG. MONTE	Rulliera alta o bassa	Raggio scarpa e rulliera, se alta	Carico su carrello su scarpa	Pressione su scarpa dovuta portante	Sost. Critic.
		Max Min (N)	Max Min (m)	(°)	(°)	(°)	(°)	Max Min (N)	Max Min (N)	Max Min (N)	[m]	[m]				[m]	[N]	[N/m]	
I1M	C13	902.520 902.520	0,59 0,12						54.833 53.471										
	C13			2,22 0,47	-4,69 -6,52	1,75 1,83		109.984 107.189	7.307 7.096	61	253	0 1	3 4	A	20	34.380	45.126		
C13	C14	902.583 902.520	6,31 2,04						57.635 52.730										
	C14			6,69 4,84	-2,70 -4,56	1,85 1,86		147.894 144.282	9.888 9.301	253	261	4 5	4 5	B	20	39.318	45.129		
C14	C15	904.678 902.583	6,73 2,17						63.693 52.918										
	C15			8,93 7,10	-3,53 -5,44	1,82 1,92		197.638 192.127	14.326 13.178	261	338	4 5	6 7	B	20	43.756	45.234		
C15	C16	908.450 904.678	11,17 3,63						76.763 58.750										
	C16			11,42 9,56	2,62 0,73	1,87 1,89		139.737 134.055	12.324 10.696	338	156	6 7	3 4	B	20	41.754	45.423		
C16	C17	911.384 908.450	2,47 0,76						83.512 67.189										
	C17			9,53 7,70	2,85 0,94	1,84 1,91		107.351 101.742	10.113 9.001	156	242	3 4	4 5	B	20	39.543	45.569		
C17	C18	917.670 911.384	5,57 1,83						101.395 75.065										
	C18			13,17 11,34	4,53 2,59	1,83 1,94		140.077 133.743	15.611 13.922	242	225	4 5	4 5	B	20	45.041	45.883		
C18	C19	924.585 917.670	4,77 1,58						121.734 91.137										
	C19			14,08 12,25	5,20 3,33	1,83 1,87		143.844 137.074	19.021 16.841	225	112	4 5	2 3	A	20	40.419	46.229		
C19	C20	927.309 924.585	1,20 0,39						126.959 109.944										
	C20			9,98 8,18	4,13 2,25	1,80 1,89		95.925 88.454	13.107 11.536	112	201	2 3	3 4	B	20	42.537	46.365		
C20	C21	932.757 927.309	3,81 1,24						142.760 116.633										
	C21			12,53 10,70	3,75 1,78	1,83 1,98		145.133 135.103	21.647 19.417	201	267	3 4	4 5	A	40	38.556	23.319		
C21	C22	940.929 932.757	6,42 2,18						165.429 129.412										
	C22			14,81 12,92	6,00 4,10	1,89 1,90		144.709 133.764	24.730 21.724	267	158	4 5	3 4	A	40	40.005	23.523		
C22	C23	945.748 940.929	2,30 0,75						177.127 151.007										
	C23			12,58 10,73	-0,23 -1,95	1,85 1,72		210.895 193.737	37.739 34.126	158	36	3 4	1 2	A	50	39.561	18.915		
C23	I2V	945.748 945.748	0,27 0,04						177.528 164.523										
	Val.max	945.748	11,17	14,81	6,00	1,89	1,98	210.895	177.528	338	338	7	7			45.041	46.365		
Val.min	902.520	0,04	0,47	-6,52	1,75	1,72	88.454	52.730	7.096	61	36	0	1			34.380	18.915		
Val. medi	922.878	3,43	9,85	0,92	1,84	1,89	143.276	110.494	16.973	218	216	4	4			40.826	39.757		

RAMO DISCESA																			
Campata	Sost.	FUNDE PORTANTE							NE TRAENTE-ZAVOR										
		Tensione campata portante	Freccia campata portante	Angolo valle sost.	Angolo monte sost.	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione campata traente	Pressione su sostegno traente	Camp. valle	Camp. monte	N° VAG. VALLE	N° VAG. MONTE	Rulliera alta o bassa	Raggio scarpa e rulliera se alta	carico su carrello su scarpa	Pressione su scarpa dovuta portante	Sost. Critic.
		Max Min (N)	Max Min (m)	(°)	(°)	(°)	(°)	Max Min (N)	Max Min (N)	Max Min (N)	[m]	[m]				[m]	[N]	[N/m]	
I1M	C13	441.450 441.450	0,44 0,12						54.069 53.663										
	C13			1,68 0,49	-3,90 -5,12	1,19	1,22	43.148 42.262	5.924 5.813	61	253	0 1	3 4	A	20	14.691	22.073		
C13	C14	441.484 441.450	5,10 2,04						54.329 52.957										
	C14			5,28 4,04	-1,89 -3,13	1,24	1,23	55.209 54.149	7.379 7.216	253	261	4 5	4 5	B	20	17.189	22.074		
C14	C15	442.607 442.607	5,45 2,17						55.952 52.884										
	C15			7,50 6,29	-2,41 -3,66	1,22	1,25	76.729 75.288	10.272 9.954	261	338	4 5	6 7	B	20	20.082	22.130		
C15	C16	444.629 444.629	9,04 3,63						59.653 54.374										
	C16			9,69 8,46	2,98 1,72	1,23	1,26	52.209 50.568	7.593 7.190	338	156	6 7	3 4	B	20	17.403	22.231		
C16	C17	446.201 444.629	2,90 0,76						61.796 56.977										
	C17			8,57 7,34	3,52 2,27	1,23	1,25	39.463 37.941	6.040 5.720	156	242	3 4	4 5	B	20	15.850	22.310		
C17	C18	449.571 446.201	4,53 1,83						67.975 59.551										
	C18			11,90 10,69	5,13 3,85	1,21	1,27	53.640 52.069	8.569 8.194	242	225	4 5	4 5	B	20	18.379	22.479		
C18	C19	453.278 449.571	3,89 1,58						74.790 65.017										
	C19			12,88 11,67	5,35 4,10	1,21	1,25	59.836 57.967	10.298 9.750	225	112	4 5	2 3	A	20	16.561	22.664		
C19	C20	454.738 453.278	0,98 0,39						76.383 71.246										
	C20			9,22 8,02	4,61 3,38	1,20	1,23	36.795 34.687	6.656 6.187	112	201	2 3	3 4	B	20	16.466	22.737		
C20	C21	457.658 454.738	3,11 1,24						81.733 73.463										
	C21			11,44 10,24	4,48 3,21	1,20	1,28	56.127 53.535	10.310 9.732	201	267	3 4	4 5	A	40	15.035	11.441		
C21	C22	462.039 457.658	5,29 2,18						89.347 77.845										
	C22			13,46 12,24	6,32 5,07	1,23	1,25	57.751 54.747	11.398 10.623	267	158	4 5	3 4	A	40	15.521	11.551		
C22	C23	464.623 462.039	1,90 0,75						93.243 85.184										
	C23			11,65 10,43	-0,25 -1,42	1,22	1,17	96.273 91.018	19.129 18.154	158	36	3 4	1 2	A	50	15.143	9.292		
C23	I2V	464.623 464.623	0,20 0,04						92.868 89.240										
	Val.max	464.623	9,04	13,46	6,32	1,24	1,28	96.273	93.243	19.129	338	338	7	7		20.082	22.737		
	Val.min	441.450	0,04	0,49	-5,12	1,19	1,17	34.687	52.884	5.720	61	36	0	1		14.691	9.292		
	Val. medi	452.363	2,92	8,98	1,76	1,22	1,24	57.725	71.307	9.619	218	216	4	4		16.867	19.477		

5.3 THIRD SECTION OF TRACK ROPES – THIRD LINE SECTION BETWEEN INTERMEDIATE STATION II AND DEVICE I

RAMO SALITA																		
Campata	Sost.	FUNDE PORTANTE					TRAENTE			lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.	N° veicoli monte sos.	Tipo Rulliera alta o bassa	Raggio scarpae rulliera [m]	carico su carrello su [N]	Pressione su scarpa dovuto Raggio scarpae [N/m]	Sosteg. Critico
		Tensione campata portante Max Min (N)	Freccia campata portante Max Min (m)	Delta angolo valle sost. [°]	Delta angolo monte sost. [°]	Pressione portante su sostegno Max Min (N)	Tensione campata traente Max Min (N)	Pressione traente su sostegno Max Min (N)										
I2M	C24	922.140 922.140	0,30 0,04				108.479 106.724											
	C24			1,81	1,91	284.212 248.781		36.819	36	220	1 0	4 3	A	40	36.364	23.054		
C24	C25	922.140 912.711	4,71 1,51				108.607 75.011											
	C25			1,96	1,83	103.932 63.390		17.636	220	235	4 3	4 3	B	20	47.066	46.107		
C25	C26	912.711 904.748	5,47 1,75				85.661 50.164											
	C26			1,98	1,97	168.360 116.306		20.413	235	460	4 3	8 7	A	30	35.750	30.424		
C26	C27	904.748 895.528	21,57 6,78				66.463 26.322											
	C27			1,80	1,80	155.250 120.805		11.861	460	160	8 7	3 2	B	20	41.291	45.237		
C27	C28	895.528 893.852	2,79 0,83				44.940 26.077											
	C28			1,87	1,87	123.838 81.210		8.339	160	350	3 2	6 5	B	20	37.769	44.776		
C28	C29	893.852 893.852	12,45 3,95				41.300 22.227											
	C29			1,84	1,81	131.526 85.383		8.140	350	212	6 5	4 3	B	20	37.570	44.693		
C29	C30	896.366 893.852	4,64 1,45				42.595 18.904											
	C30			1,81	1,82	114.361 75.779		7.548	212	250	4 3	5 4	B	20	36.978	44.818		
C30	D1AV	901.186 896.366	6,24 2,00				49.717 24.967											

RAMO DISCESA																	
Campata	Sost.	FUNTE PORTANTE									TRAENTE						
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	lung. camp. valle sos.	lung. camp. monte sos.	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	Carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	Sostegno Critico
		Max Min (N)	Max Min (m)							Max Min (N)	[N]	Max Min (N)		[m]	[N]	[N/m]	
I2M	C24	451.126 451.126	0,21 0,04								108.479 107.812						
	C24			1,24	1,34	36	220	1 0	4 3	129.680 112.972		33.493	A	40	16.744	11.278	
C24	C25	451.126 446.071	3,73 1,51								108.430 95.437						
	C25			1,38	1,29	220	235	4 3	4 3	34.446 14.120		12.788	B	20	22.598	22.556	
C25	C26	446.071 441.803	4,32 1,75								99.071 85.478						
	C26			1,40	1,43	235	460	4 3	8 7	57.770 30.656		17.360	A	30	17.119	14.869	
C26	C27	441.803 436.861	17,03 6,78								91.105 75.803						
	C27			1,11	1,27	460	160	8 7	3 2	53.004 35.092		10.814	B	20	20.624	22.090	
C27	C28	436.861 435.962	2,17 0,83								81.619 76.086						
	C28			1,32	1,35	160	350	3 2	6 5	42.485 20.149		11.105	B	20	20.915	21.843	
C28	C29	435.962 435.962	9,83 3,95								79.785 74.721						
	C29			1,29	1,28	350	212	6 5	4 3	44.577 20.069		11.532	B	20	21.342	21.798	
C29	C30	437.310 435.962	3,66 1,45								79.284 72.330						
	C30			1,26	1,29	212	250	4 3	5 4	39.470 19.226		10.499	B	20	20.309	21.866	
C30	D1AV	439.894 437.310	4,94 2,00								81.403 72.468						

5.4 THOURTH SECTION OF TRACK ROPES – THIRD LINE SECTION BETWEEN DEVICE I AND DEVICE II

RAMO SALITA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE					Tipo Rulliera alta o bassa	Raggio scarpae rulliera [m]	carico su carrello su [N]	Pressione su scarpa dovuto Raggio scarpa [N/m]	Sosteg. Critico	
		Tensione campata portante Max Min (N)	Freccia campata portante Max Min (m)	Delta angolo valle sost. [°]	Delta angolo monte sost. [°]	Pressione portante su sostegno Max Min (N)	Tensione campata traente Max Min [N]	Pressione traente su sostegno Max Min (N)	lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.						N° veicoli monte sos.
DIAM	C31	936.573 932.357	2,61 0,79				63.834 39.513										
	C31			1,69	1,74	89.688 59.974		8.091	160	62	3 2	2 1	B	20	37.521	46.829	
C31	C32	938.040 936.573	0,58 0,12				75.047 57.850										
	C32			1,74	1,78	137.002 107.125		13.240	62	140	2 1	3 2	B	20	42.670	46.902	
C32	C33	939.297 938.040	1,95 0,61				78.980 62.465										
	C33			1,75	1,74	109.246 77.551		11.539	140	42	3 2	1 0	B	20	40.969	46.965	
C33	C34	939.297 939.297	0,36 0,05				82.659 68.484										
	C34			1,79	1,78	144.466 123.168		15.203	42	44	1 0	1 0	A	30	35.528	31.310	
C34	C35	939.297 938.250	0,39 0,06				82.816 64.857										
	C35			1,79	1,61	74.734 52.553		7.883	44	76	1 0	2 1	B	20	37.313	46.965	
C35	C36	938.250 935.945	0,74 0,18				80.344 59.017										
	C36			1,81	1,83	107.487 66.427		12.013	76	290	2 1	5 4	B	20	41.443	46.912	
C36	C37	935.945 928.401	8,27 2,62				72.849 35.976										
	C37			1,87	1,76	125.928 81.412		13.371	290	224	5 4	4 3	B	20	42.801	46.797	
C37	C38	928.401 924.629	4,92 1,57				56.878 24.968										
	C38			1,78	1,76	150.009 103.235		12.033	224	390	4 3	7 6	B	20	41.463	46.420	
C38	C39	924.629 922.534	15,04 4,79				48.206 20.338										
	C39			1,78	1,82	135.692 86.652		8.578	390	50	7 6	1 0	B	20	38.008	46.231	
C39	C40	922.534 922.534	0,47 0,08				44.371 20.994										
	C40			1,82	1,76	87.626 55.821		5.606	50	161	1 0	3 2	B	20	35.036	46.127	

RAMO DISCESA																	
Campata	Sost.	FUNDE PORTANTE									TRAENTE						Sostegno Critico
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	lung. camp. valle sos.	lung. camp. monte sos.	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	Carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	
		Max Min (N)	Max Min (m)							Max Min (N)	Max Min (N)		[m]	[N]	[N/m]		
DIAM	C31	458.863 456.603	2,04 0,79								86.024 77.494						
	C31			1,18	1,19	160	62	3 2	2 1	36.482 20.767		8.682	B	20	18.492	22.943	
C31	C32	459.649 458.863	0,42 0,12								89.850 84.741						
	C32			1,19	1,23	62	140	2 1	3 2	60.031 45.160		13.624	B	20	23.434	22.982	
C32	C33	460.323 459.649	1,53 0,61								91.164 86.453						
	C33			1,22	1,18	140	42	3 2	1 0	46.605 31.665		11.076	B	20	20.886	23.016	
C33	C34	460.323 460.323	0,25 0,05								92.175 88.288						
	C34			1,22	1,21	42	44	1 0	1 0	66.632 58.041		15.228	A	30	16.610	15.344	
C34	C35	460.323 459.762	0,27 0,06								92.116 86.676						
	C35			1,22	1,06	44	76	1 0	2 1	31.581 22.450		6.886	B	20	16.696	23.016	
C35	C36	459.762 458.526	0,55 0,18								91.047 83.788						
	C36			1,24	1,27	76	290	2 1	5 4	39.819 19.427		10.185	B	20	19.995	22.988	
C36	C37	458.526 454.482	6,55 2,62								88.731 74.966						
	C37			1,30	1,22	290	224	5 4	4 3	43.110 20.487		11.970	B	20	21.780	22.926	
C37	C38	454.482 452.460	3,89 1,57								81.089 70.672						
	C38			1,24	1,24	224	390	4 3	7 6	51.586 27.390		12.621	B	20	22.431	22.724	
C38	C39	452.460 451.337	11,92 4,79								77.156 68.202						
	C39			1,25	1,24	390	50	7 6	1 0	50.874 25.755		10.334	B	20	20.144	22.623	
C39	C40	451.337 451.337	0,33 0,08								74.595 68.804						
	C40			1,24	1,21	50	161	1 0	3 2	35.366 19.549		7.440	B	20	17.250	22.567	
C40	D2CV	451.337 451.126	2,14 0,82								74.527 67.800						

5.5 FIFTH SECTION OF TRACK ROPES – THIRD LINE SECTION BETWEEN DEVICE II AND DEVICE III

RAMO SALITA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE					Tipo Rulliera alta o bassa	Raggio scarpata e rulliera [m]	Carico su carrello su [N]	Pressione su scarpa dovuto Raggio scarpata [N/m]	Sosteg. Critico	
		Tensione campata portante Max Min (N)	Freccia campata portante Max Min (m)	Delta angolo valle sost. [°]	Delta angolo monte sost. [°]	Pressione portante su sostegno Max Min (N)	Tensione campata traente Max Min (N)	Pressione traente su sostegno Max Min (N)	lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.						N° veicoli monte sos.
D2CM	C41	922.140 922.035	2,35 0,69				44.155 19.300										
	C41			1,76	1,76	104.160 66.776		6.937	149	268	3 2	5 4	B	20	36.367	46.107	
	C42	923.816 922.035	7,15 2,24				44.439 16.162										
	C42			1,74	1,81	148.418 100.500		9.423	268	373	5 4	7 6	B	20	38.853	46.191	
	C43	931.150 923.816	13,40 4,30				49.913 15.755										
	C43			1,64	1,77	233.542 188.833		13.900	373	44	7 6	1 0	A	30	33.112	31.038	
	C44	931.150 931.150	0,39 0,06				69.779 40.064										
	C44			1,74	1,78	145.743 112.507		12.956	44	162	1 0	3 2	B	20	42.386	46.558	
	C45	931.150 928.636	2,74 0,81				69.935 32.707										
	C45			1,78	1,81	140.630 94.889		13.675	162	397	3 2	7 6	B	20	43.105	46.558	
	C46	928.636 926.540	15,41 4,88				64.206 26.446										
	C46			1,80	1,77	140.792 91.884		12.858	397	192	7 6	4 3	B	20	42.288	46.432	
C46	D3AV	927.798 926.540	3,72 1,14				60.390 25.490										

RAMO DISCESA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE					Tipo Rulliera alta o bassa	Raggio scarpata e rulliera [m]	Carico su carrello su [N]	Pressione su scarpa dovuto Raggio scarpata [N/m]	Sostegno Critico	
		Tensione campata portante Max Min (N)	Freccia campata portante Max Min (m)	Delta angolo valle sost. [°]	Delta angolo monte sost. [°]	lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno Max Min (N)	Tensione campata traente Max Min (N)						Pressione traente su sostegno Max Min (N)
D2CM	C41	451.126 451.070	1,83 0,69								73.869 67.435						
	C41			1,22	1,22	149	268	3 2	5 4	36.088 17.557		8.540	B	20	18.350	22.556	
	C42	452.025 451.070	5,66 2,24								73.565 65.088						
	C42			1,21	1,25	268	373	5 4	7 6	50.093 25.453		11.400	B	20	21.210	22.601	
	C43	455.956 452.025	10,68 4,30								74.890 60.282						
	C43			1,10	1,21	373	44	7 6	1 0	100.485 76.967		17.922	A	30	15.335	15.199	
	C44	455.956 455.956	0,28 0,06								81.403 72.737						
	C44			1,18	1,21	44	162	1 0	3 2	63.719 47.840		12.988	B	20	22.798	22.798	
	C45	455.956 454.608	2,15 0,81								81.345 69.132						
	C45			1,21	1,23	162	397	3 2	7 6	49.145 25.980		11.703	B	20	21.513	22.798	
	C46	454.608 453.485	12,29 4,88								78.706 65.767						
	C46			1,24	1,21	397	192	7 6	4 3	48.116 23.023		11.514	B	20	21.324	22.730	
C46	D3AV	454.159 453.485	2,96 1,14								76.135 65.329						

5.6 SIXT SECTION OF TRACK ROPES – THIRD LINE SECTION BETWEEN DEVICE III AND DEVICE IV

RAMO SALITA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE					Tipo Rulliera alta o bassa	Raggio scarpata e rulliera [m]	carico su carrello su [N]	Pressione su scarpata dovuto Raggio scarpata [N/m]	Sosteg. Critico	
		Tensione campata portante Max Min (N)	Freccia campata portante Max Min (m)	Delta angolo valle sost. [°]	Delta angolo monte sost. [°]	Pressione portante su sostegno Max Min (N)	Tensione campata traente Max Min [N]	Pressione traente su sostegno Max Min (N)	lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.						N° veicoli monte sos.
D3AM	C47	921.517 921.062	4,26 1,33				68.346 32.293										
	C47			1,74	1,79	157.943 118.777		12.760	206	412	4 3	7 6	B	20	42.190	46.076	
C47	C48	923.367 921.062	16,64 5,31				64.040 26.241										
	C48			1,78	1,80	188.781 139.174		14.984	412	49	7 6	1 0	A	30	34.155	30.779	
C48	C49	923.367 923.367	0,45 0,07				71.368 33.158										
	C49			1,82	1,91	170.972 128.588		15.374	49	342	1 0	6 5	B	20	44.804	46.168	
C49	C50	923.367 921.062	11,39 3,66				71.544 28.256										
	C50			1,82	1,83	135.484 88.100		12.739	342	36	6 5	1 0	B	20	42.169	46.168	
C50	C51	921.062 920.852	0,31 0,04				67.002 30.022										
	C51			1,82	1,89	199.739 150.503		16.522	36	388	1 0	7 6	A	30	34.373	30.702	
C51	C52	920.852 914.776	15,07 4,73				66.610 11.000										
	C52			1,86	1,77	129.889 79.003		11.908	388	90	7 6	2 1	B	20	41.338	46.043	
C52	C53	914.776 914.147	0,97 0,26				52.729 10.118										
	C53			1,82	1,82	105.857 70.714		8.106	90	244	2 1	5 4	B	20	37.536	45.739	
C53	C54	914.147 912.890	5,95 1,88				51.483 4.797										
	C54			1,77	1,85	148.755 100.058		10.980	244	395	5 4	7 6	B	20	40.410	45.707	
C54	C55	916.180 912.890	15,52 4,93				49.217 3.998										
	C55			1,77	1,77	137050,27 96820,34		7.597	395	176	7 6	3 2	B	20	37.027	45.809	
C55	D4AV	919.197 916.180	3,24 0,97				58.968 14.030										

RAMO DISCESA																	
Campata	Sost.	FUNDE PORTANTE									TRAENTE						Sostegno Critico
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	lungh. camp. valle sos.	lungh. camp. monte sos.	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	Carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	
		Max Min (N)	Max Min (m)							Max Min (N)	[N]	Max Min (N)		[m]	[N]	[N/m]	
D3AM	C47	450.541 450.298	3,40 1,33								77.067 66.499						
	C47			1,20	1,16	206	412	4	7	55.552 35.805		9.952	B	20	19.762	22.527	
C47	C48	451.533 450.298	13,31 5,31								76.351 63.995						
	C48			1,21	1,23	412	49	7	1	76.669 51.672		14.521	A	30	15.443	15.051	
C48	C49	451.533 451.533	0,32 0,07								77.980 66.390						
	C49			1,24	1,28	49	342	1	6	69.913 49.179		13.698	B	20	23.508	22.577	
C49	C50	451.533 450.298	9,15 3,66								77.911 63.212						
	C50			1,23	1,25	342	36	6	1	52.556 28.776		10.747	B	20	20.557	22.577	
C50	C51	450.298 450.185	0,22 0,04								75.223 64.445						
	C51			1,24	1,27	36	388	1	7	82.323 59.622		15.299	A	30	15.360	15.010	
C51	C52	450.185 446.928	12,01 4,73								74.968 55.591						
	C52			1,25	1,21	388	90	7	2	46.370 21.148		9.848	B	20	19.658	22.509	
C52	C53	446.928 446.591	0,75 0,26								68.601 55.917						
	C53			1,24	1,21	90	244	2	5	40.107 22.526		8.101	B	20	17.911	22.346	
C53	C54	446.591 445.917	4,76 1,88								67.866 53.570						
	C54			1,18	1,19	244	395	5	7	50.470 26.281		10.567	B	20	20.377	22.330	
C54	C55	447.681 445.917	12,45 4,93								66.316 51.003						
	C55			1,18	1,20	395	176	7	3	47.275 27.329		6.868	B	20	16.678	22.384	
C55	D4AV	449.298 447.681	2,58 0,97								68.915 53.647						

5.7 SEVENTH SECTION OF TRACK ROPES – THIRD LINE SECTION BETWEEN DEVICE IV AND UNLOADING STATION

RAMO SALITA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE		lungh. camp. valle sos. [m]	lungh. camp. monte sos. [m]	N° veicoli valle sos.	N° veicoli monte sos.	Tipo Rulliera alta o bassa	Raggio scarpata e rulliera [m]	carico su carrello su [N]	Pressione su scarpata dovuto Raggio scarpata [N/m]	Sosteg. Critico
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno									
		Max Min (N)	Max Min (m)	[°]	[°]	Max Min (N)	Max Min [N]	Max Min (N)									
D4AM	C56	934.066 931.950	1,04 0,30				68.238 23.610										
	C56			1,76	1,77	87.797 62.264		9.003	99	110	2 1	2 1	B	20	38.433	46.703	
	C56	935.952 934.066	1,24 0,37				73.928 30.840										
	C57			1,77	1,80	125.158 98.940		12.683	110	97	2 1	2 1	B	20	42.113	46.798	
	C57	936.371 935.952	1,03 0,29				79.088 38.875										
	C58			1,78	1,80	113.149 79.936		12.538	97	167	2 1	3 2	B	20	41.968	46.819	
	C58	936.371 936.162	2,82 0,85				80.511 39.338										
	C59			1,83	1,86	109.519 73.029		13.078	167	196	3 2	4 3	B	20	42.508	46.819	
	C59	936.162 936.162	3,80 1,18				80.599 37.842										
	C60			1,80	1,91	153.262 103.245		16.997	196	410	4 3	7 6	A	30	35.376	31.205	
	C60	940.353 936.162	16,05 5,16				81.315 31.851										
	C61			1,77	1,77	162.966 113.392		16.495	410	50	7 6	1 0	B	20	45.925	47.018	
	C61	940.856 940.353	0,44 0,08				93.401 45.956										
	C62			1,78	1,95	204.729 157.963		23.015	50	398	1 0	7 6	A	30	36.321	31.362	
	C62	940.981 940.856	15,21 4,84				94.853 48.336										
	C63			1,83	1,82	191.098 140.997		23.708	398	212	7 6	4 3	A	30	36.428	31.366	
	C63	941.400 940.981	4,34 1,36				96.638 50.998										
	C64			1,80	1,76	101.177 59.866		13.298	212	27	4 3	1 0	A	30	36.560	31.380	
	C64	941.400 941.398	0,22 0,02				98.473 53.629										

RAMO DISCESA																	
Campata	Sost.	FUNDE PORTANTE								TRAENTE							
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	lung. camp. valle sos.	lung. camp. monte sos.	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	Carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	Sostegno Critico
		Max Min (N)	Max Min (m)							Max Min (N)	Max Min (N)		[m]	[N]	[N/m]		
D4AM	C56	457.299 456.165	0,83 0,30								71.897 57.314						
	C56			1,19	1,19	99	110	2 1	2 1	35.510 23.340		7.639	B	20	17.449	22.865	
C56	C57	458.310 457.299	0,98 0,37								73.791 59.951						
	C57			1,20	1,22	110	97	2 1	2 1	53.905 41.719		10.769	B	20	20.579	22.916	
C57	C58	458.535 458.310	0,81 0,29								75.449 63.403						
	C58			1,20	1,20	97	167	2 1	3 2	46.048 30.237		9.710	B	20	19.520	22.927	
C58	C59	458.535 458.423	2,26 0,85								75.714 63.008						
	C59			1,22	1,22	167	196	3 2	4 3	40.975 23.104		9.511	B	20	19.321	22.927	
C59	C60	458.423 458.423	3,06 1,18								75.272 62.171						
	C60			1,20	1,24	196	410	4 3	7 6	54.014 29.886		11.767	A	30	15.363	15.281	
C60	C61	460.669 458.423	12,94 5,16								74.997 57.496						
	C61			1,15	1,20	410	50	7 6	1 0	64.346 39.905		11.996	B	20	21.806	23.033	
C61	C62	460.939 460.669	0,33 0,08								78.441 63.786						
	C62			1,21	1,24	50	398	1 0	7 6	84.584 62.277		15.952	A	30	15.597	15.365	
C62	C63	461.006 460.939	12,24 4,84								78.853 64.668						
	C63			1,19	1,20	398	212	7 6	4 3	72.713 48.220		15.466	A	30	15.628	15.367	
C63	C64	461.231 461.006	3,50 1,36								78.411 64.543						
	C64			1,18	1,20	212	27	4 3	1 0	40.255 21.678		8.452	A	30	15.595	15.374	
C64	SM	461.231 461.230	0,15 0,02								78.519 64.891						

The maximum, minimum and average value of main parameters for the third line, full side is indicated below:

RAMO SALITA																	
Campata	Sost.	FUNDE PORTANTE					TRAENTE						Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	Sostegno Critico
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	lung. camp. valle sos. [m]	lung. camp. monte sos. [m]	N° veicoli valle sos.	N° veicoli monte sos.					
		Max Min (N)	Max Min (m)	[°]	[°]	Max Min (N)	Max Min (N)	Max Min (N)									
max	3 tr	941.400	21,57	1,98	1,97	284.212	108607	36.819	460	460	8	8			47.066	47.018	
min	3 tr	893.852	0,02	1,64	1,61	52.553	3998	5.606	36	27	0	0			33.112	23.054	
media	3 tr	925.000	4,00	1,80	1,81	122.729	50969	13.730	212	216	3	3			39.485	42.455	

The maximum, minimum and average value of main parameters for the third line, empty side is indicated below:

RAMO DISCESA																	
Campata	Sost.	FUNDE PORTANTE								TRAENTE							
		Tensione campata portante	Freccia campata portante	Delta angolo valle sost.	Delta angolo monte sost.	lung. camp. valle sos.	lung. camp. monte sos.	N° veicoli valle sos.	N° veicoli monte sos.	Pressione portante su sostegno	Tensione campata traente	Pressione traente su sostegno	Tipo Rulliera alta o bassa	Raggio scarpa e rulliera	Carico su carrello su	Pressione su scarpa dovuto Raggio scarpa	Sostegno Critico
		Max Min (N)	Max Min (m)							Max Min (N)	[N]	Max Min (N)		[m]	[N]	[N/m]	
max	3 tr	461.231	17,03	1,40	1,43	460	460	8	8	129.680	108.479	33.493			23.508	23.033	
min	3 tr	435.962	0,02	1,10	1,06	36	27	0	0	14.120	51.003	6.868			15.335	11.278	
media	3 tr	452.553	3,37	1,23	1,24	212	216	3	3	45.264	74.633	12.478			19.322	20.774	

6 CONCLUSIONS

6.1 ANALYSIS OF CRITICAL TOWER PARAMETERS

Using the same denomination of the above tables we resume below the main parameters of critical towers.

	Sostegni critici		Tipo rulliera	Pressione max traente	Tensione portante	Pressione portante	Max variaz. Angolo portante	min lungh. campata adiacente	max lungh. campata adiacente	Carico su carrello su scarpa	Pressione su scarpa dovuta al raggio scarpa
				[N]	[N]	[N]	[°]	[m]	[m]	[N]	[N/m]
Lato carichi	Prima tratta	4	B	14.204	930.026	97.601	1,78	50	87	43.634	46.501
		9	B	21.483	932.959	138.381	1,96	130	380	50.913	46.648
	Seconda tratta	17	B	10.113	911.384	107.351	1,91	156	242	39.543	45.569
		24	A	33.812	922.140	284.212	1,91	36	220	36.364	23.054
	Terza tratta	29	B	8.164	893.852	131.526	1,84	212	350	37.570	44.693
		30	B	7.182	901.186	114.361	1,82	212	250	36.978	44.818
		32	B	11.555	938.040	137.002	1,78	62	140	42.670	46.902
	Quarta tratta	34	A	12.826	939.227	144.466	1,79	42	44	35.528	31.310
		45	B	11.263	931.140	140.630	1,81	162	397	43.105	46.558
	Quinta tratta	46	B	10.590	928.636	140.792	1,8	397	192	42.288	46.432
		47	B	14.037	921.517	157.943	1,79	206	412	42.190	46.076
		49	B	13.527	923.367	170.972	1,91	49	342	44.804	46.168
	Sesta tratta	51	A	14.612	921.062	199.739	1,89	36	388	34.373	30.702
		59	B	11.220	936.371	109.519	1,86	167	196	42.508	46.819
Valore massimo in tutta la linea				77.739	945.748	284.212	2,18	460	460	50.913	47.018
Valore minimo in tutta la linea				5.606	893.852	52.553	1,61	35	27	33.112	18.835
Valore medio in tutta la linea				31.271	926.622	151.503	1,92	234	230	42.369	37.121

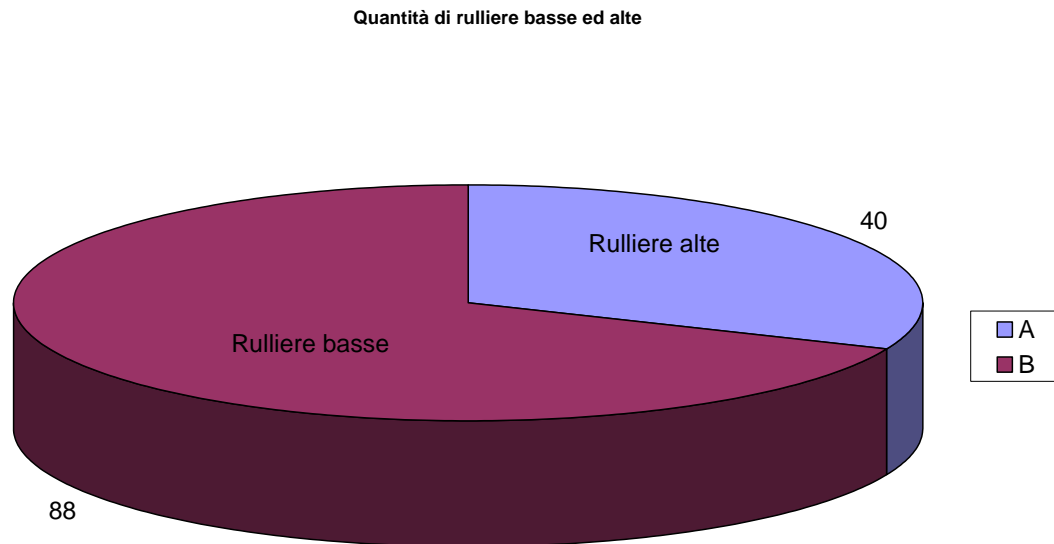
Lato vuoti	Prima tratta										
	Seconda tratta										
	Terza tratta	31	B	8.672	458.863	36.482	1,19	62	160	18.492	22.943
	Quarta tratta	32	B	13.624	459.649	60.031	1,23	62	140	23.434	22.982
		34	A	15.228	460.323	66.632	1,22	42	44	16.610	15.344
	Quinta tratta	45	B	11.703	455.956	49.145	1,23	162	397	21.513	22.798
	Sesta tratta	49	B	13.698	451.333	69.913	1,28	49	342	23.508	22.577
	Settima tratta	57	B	10.769	458.310	53.905	1,22	97	110	20.579	22.916
58		B	9.718	458.535	46.048	1,2	97	167	19.520	22.927	
Valore massimo in tutta la linea				33.493	464.623	129.680	1,43	460	460	23.508	23.033
Valore minimo in tutta la linea				5.503	435.962	14.120	1,06	35	27	13.144	9.221
Valore medio in tutta la linea				13.790	453.720	58.914	1,27	234	230	18.020	17.054

6.2 HIGH AND LOW ROLLERS

The more evident data coming out from the analysis of the previous table is that the frequency of critical toes is higher in low roller towers than in high rollers towers.

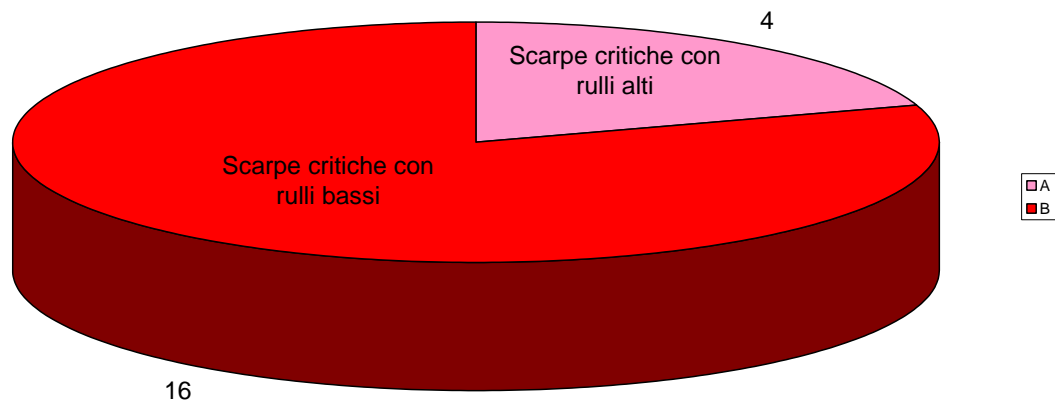
On a total population of 64 towers existing in Rio Branco, 44 towers (88 saddles) have low rollers and 20 towers (40 saddles) high rollers.

The below graphic is showing this distribution (in blue the high rollers and in violet the low ones),



On the other side, on a total of 20 saddle considered critical, 16 have low rollers and only 4 high rollers (as indicated in the below graphic, where critical saddles with low rollers are marked in red, and critical saddle with high rollers in rose,

Quantità rulliere basse su scarpe critiche



It is quite evident that the low rollers saddles are in percentage more critical than the ones with high rollers.

The fact can be explained considering what indicated previously at par. 5.1:

In case of low roller saddles when the vehicle passes on the saddle, all the vertical load due to the hauling rope goes directly on the vehicle, increasing the pressure on the track rope, due to the load transmitted to the track rope by the vehicle wheels.

Furthermore the additional component on the vehicle, due to the hauling rope, goes as a additional load also on the track rope, at the entrance and exit of saddle increasing the deflection angle and fatigue effect,

All these effects are sensibly reduced in case of high rollers saddles, considering the reduced component of hauling rope charging the vehicle

6.3 EFFECT DUE TO THE ADDITIONAL LOAD OF THE HAULING ROPE, IN CASE OF LOW ROLLERS

Below we have indicated, separately, first for full side, and then for empty side, the table with the value of the load on the vehicle, considering the hauling rope component, only for low rollers towers.

Then we have indicate the same values on a bar diagrams, marking in red all critical towers.

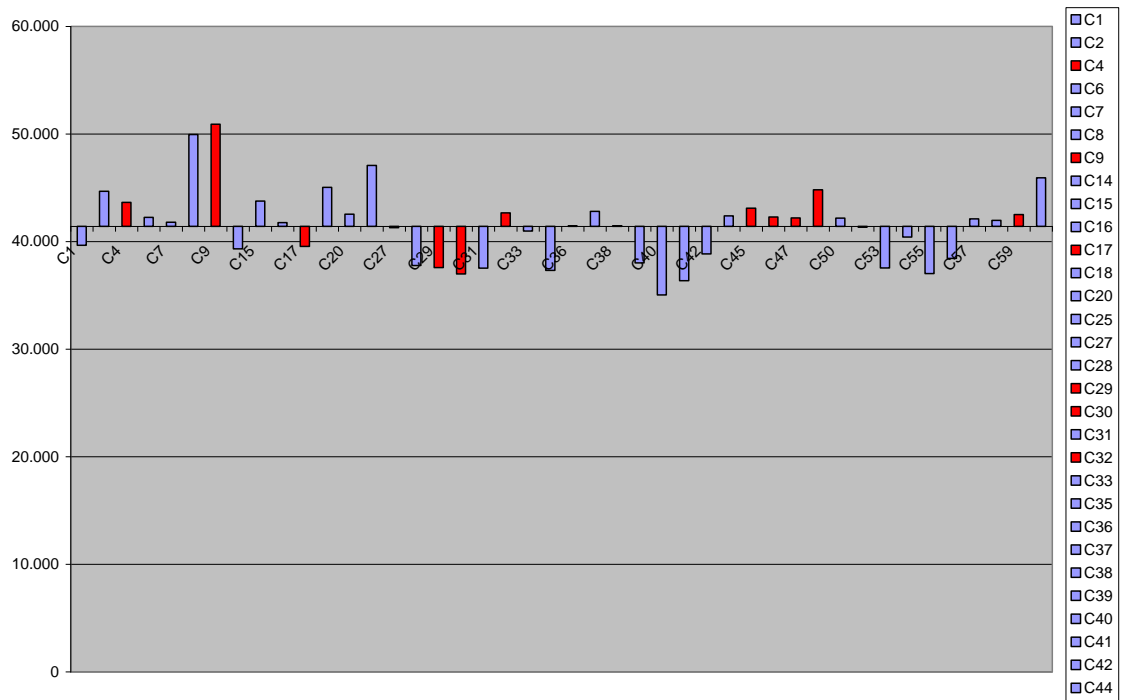
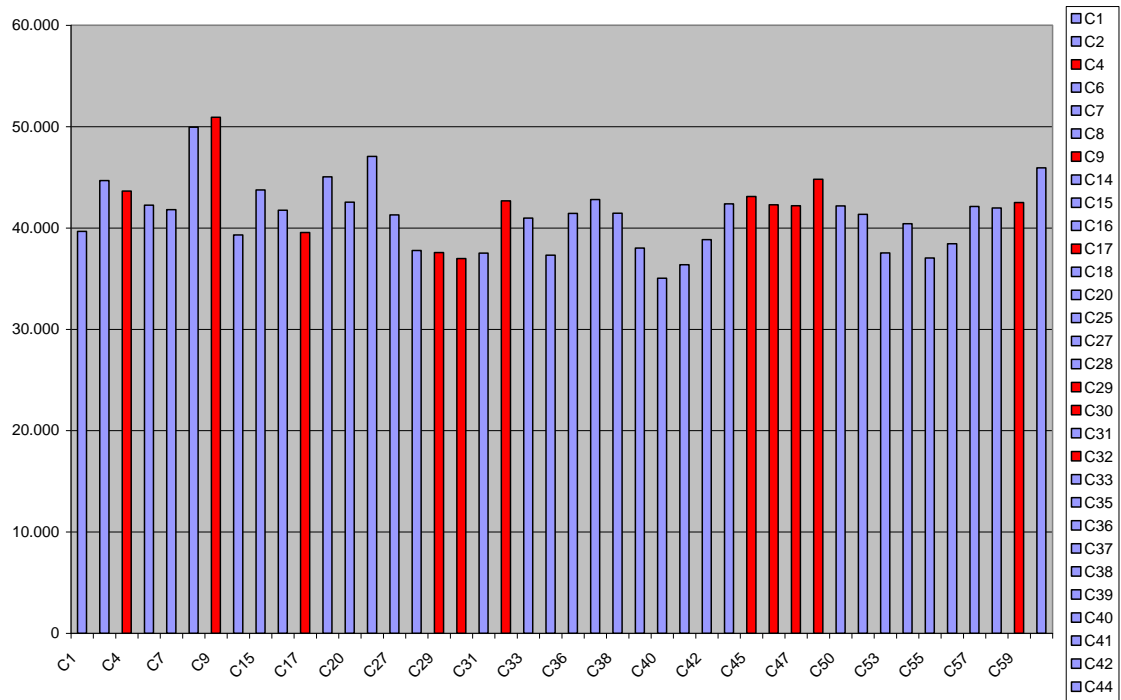
A following bar diagram compare these values with the average values on all low rollers towers.

It comes out that on the full side 8 on 11 critical tower have a value of this load superior to the average, confirming that an elevate value of this parameter has an important influence on the critical level of the tower,

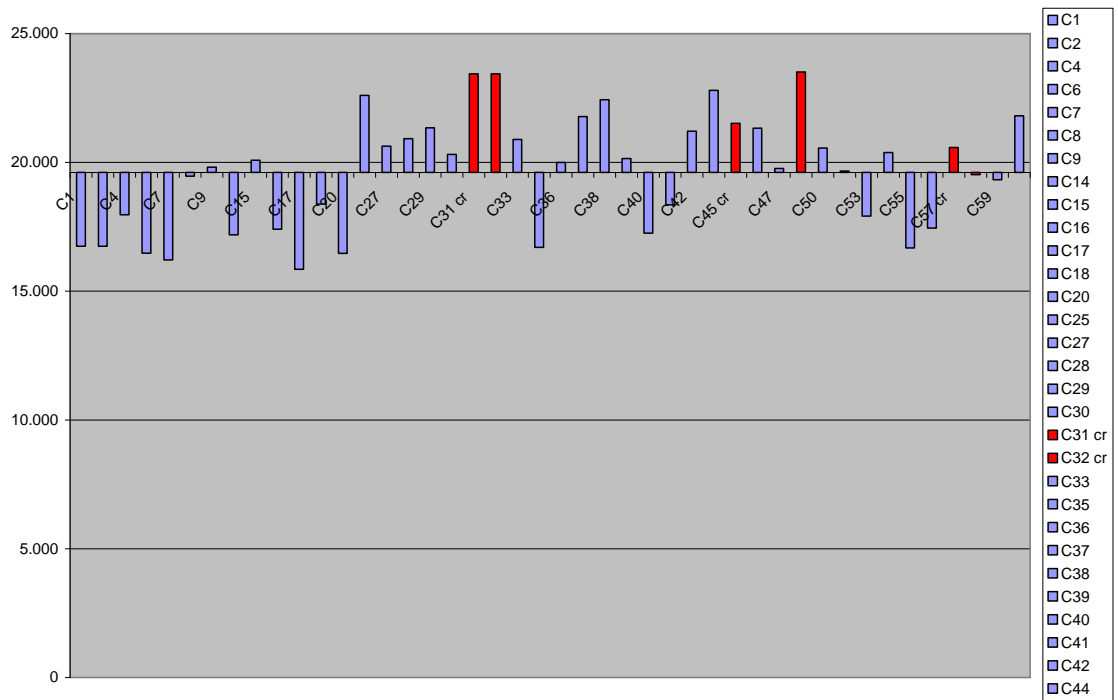
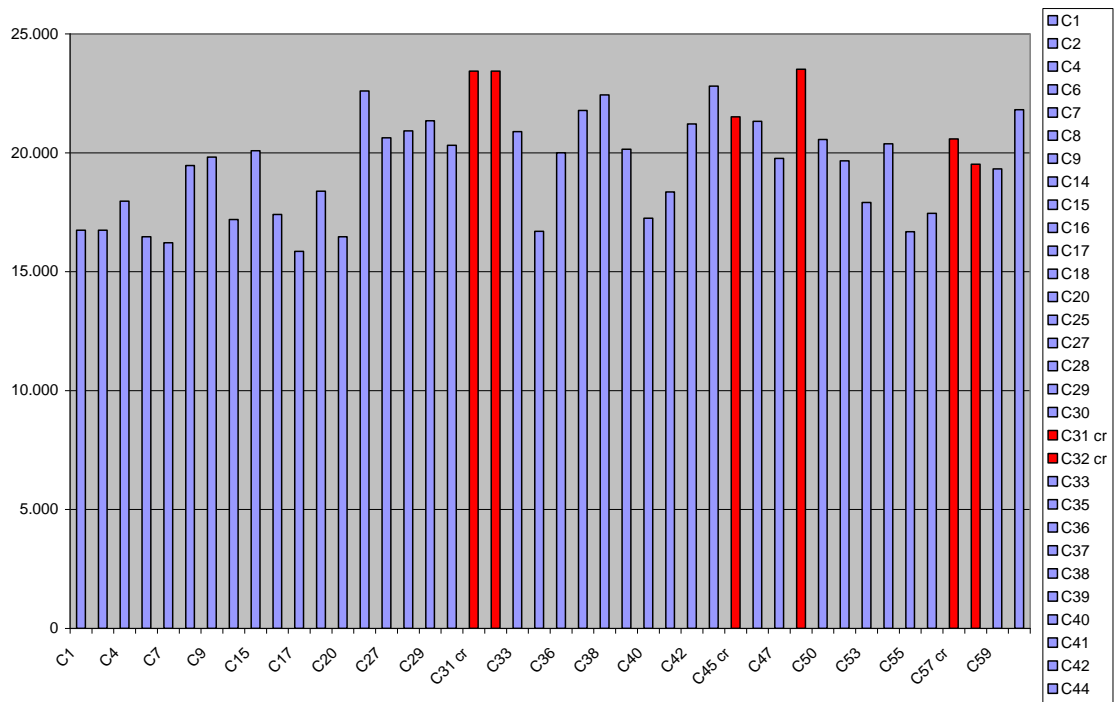
The same indication is even much more evident on the empty side, where 5 critical towers on five have low rollers,

Probably this depends from the fact that this parameter has more influence on the empty side, where the percentage of this additional load is higher.

Tratta fune portante	Tipo rulli	Sost.	Carico su carrello su scarpa [N]
Prima tratta	B	C1	39.652
	B	C2	44.672
	B	C4	43.634
	B	C6	42.254
	B	C7	41.803
	B	C8	49.945
	B	C9	50.913
Seconda tratta	B	C14	39.318
	B	C15	43.756
	B	C16	41.754
	B	C17	39.543
	B	C18	45.041
	B	C20	42.537
Terza tratta	B	C25	47.066
	B	C27	41.291
	B	C28	37.769
	B	C29	37.570
	B	C30	36.978
Quarta tratta	B	C31	37.521
	B	C32	42.670
	B	C33	40.969
	B	C35	37.313
	B	C36	41.443
	B	C37	42.801
	B	C38	41.463
	B	C39	38.008
	B	C40	35.036
Quinta tratta	B	C41	36.367
	B	C42	38.853
	B	C44	42.386
	B	C45	43.105
	B	C46	42.288
Sesta tratta	B	C47	42.190
	B	C49	44.804
	B	C50	42.169
	B	C52	41.338
	B	C53	37.536
	B	C54	40.410
	B	C55	37.027
Settima tratta	B	C56	38.433
	B	C57	42.113
	B	C58	41.968
	B	C59	42.508
	B	C61	45.925
Valore medio			41.412



			[N]
Prima tratta	B	C1	16.744
	B	C2	16.744
	B	C4	17.967
	B	C6	16.470
	B	C7	16.213
	B	C8	19.462
	B	C9	19.813
Seconda tratta	B	C14	17.189
	B	C15	20.082
	B	C16	17.403
	B	C17	15.850
	B	C18	18.379
	B	C20	16.466
Terza tratta	B	C25	22.598
	B	C27	20.624
	B	C28	20.915
	B	C29	21.342
	B	C30	20.309
Quarta tratta	B	C31 cr	23.434
	B	C32 cr	23.434
	B	C33	20.886
	B	C35	16.696
	B	C36	19.995
	B	C37	21.780
	B	C38	22.431
	B	C39	20.144
	B	C40	17.250
Quinta tratta	B	C41	18.350
	B	C42	21.210
	B	C44	22.798
	B	C45 cr	21.513
	B	C46	21.324
Sesta tratta	B	C47	19.762
	B	C49 cr	23.508
	B	C50	20.557
	B	C52	19.658
	B	C53	17.911
	B	C54	20.377
	B	C55	16.678
Settima tratta	B	C56	17.449
	B	C57 cr	20.579
	B	C58 cr	19.520
	B	C59	19.321
	B	C61	21.806
media			19.612



Considering the limited number of critical tower with high rollers, we will just note that usually these towers have a big track rope deviation and consequently a high track rope pressure resultant.

6.4 PROPOSALS

To increase the endurance of track ropes we suggest modifying the following critical saddles, today with low rollers, modifying them with high rollers batteries.

Fune	Diam. (mm)	Punti critici sostegno
Portante - 1° Tronco L.V	45	
Portante - 1° Tronco L.C	63	4,9
Portante - 2° Tronco L.V	45	
Portante - 2° Tronco L.C	63	17
Portante - 3° Tronco L.V	45	
Portante - 3° Tronco L.C	63	29, 30
Portante - 4° Tronco L.V	45	31,32
Portante - 4° Tronco L.C	63	32
Portante - 5° Tronco L.V	45	45
Portante - 5° Tronco L.C	63	45,46
Portante - 6° Tronco L.V	45	49
Portante - 6° Tronco L.C	63	47,49
Portante - 7° Tronco L.V	45	57,58
Portante - 7° Tronco L.C	63	59

Doing this we should increase sensibly the track rope endurance in the following sections:

- First section, loaded side
- Second section, loaded side
- Fifth section, empty side
- Fifth section loaded side
- Sixth section, empty side
- Seventh section, empty side
- Seventh section, loaded side

Therefore only the following section would still be critical:

- Third section loaded side
- Fourth section, empty side
- Fourth section loaded side
- Sixth section, loaded side

Therefore this suggested modification could reduce the critical sections from the actual number of eleven to only four (these where there are problems with saddles with high type rollers),