Sociedad Colombiana de Geotecnia
XII CONGRESO COLOMBIANO DE GEOTECNIA

Bogotá 3 - 4 Septiembre 2008

Taludes de corte estabilizados en Venezuela mediante pantallas de concreto proyectado ancladas

Gianfranco Perri


2 m
2 m

Technical Data

Bar Diameter mm	Steel Grade N/mm²	Ultimate Strength kN (F_m)	Yield Strength* kN (F_y)
	Prestressing Steel		
15	900/1100	195	159
20	900/1100	345	283
26.5	950/1050	575	523
32	950/1050	844	764
36	950/1050	1059	967
40	950/1050	1320	1194
47	950/1050	1822	1648
	Cast Steel		
16	500/600	121	100
20	500/600	188	157
25	500/600	295	245
28	500/600	370	308
32	500/600	482	402
40	500/600	756	630
50	500/600	1176	980
63.5	555/700	2217	1758

Corrosion Protection for Permanent Bar Anchors

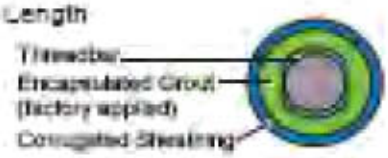
Permanent Anchors (lifespans in excess of 2 years) require sufficient corrosion protection to ensure durability throughout the working life of each anchor.

Double Corrosion Protection, featuring factory pregrouted encapsulation of the bar within a corrugated plastic sheath, ensures comprehensive protection to all parts of the anchor. Protection at the anchor head is provided by a fully enclosed assembly.

Borehole Grout is not recognised by current anchor standards (BS8081 or EN1537) as a corrosion protection barrier.

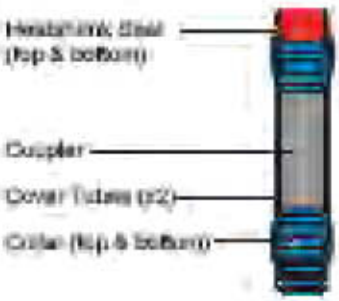
Double Corrosion Protection Detail:

Bond Length

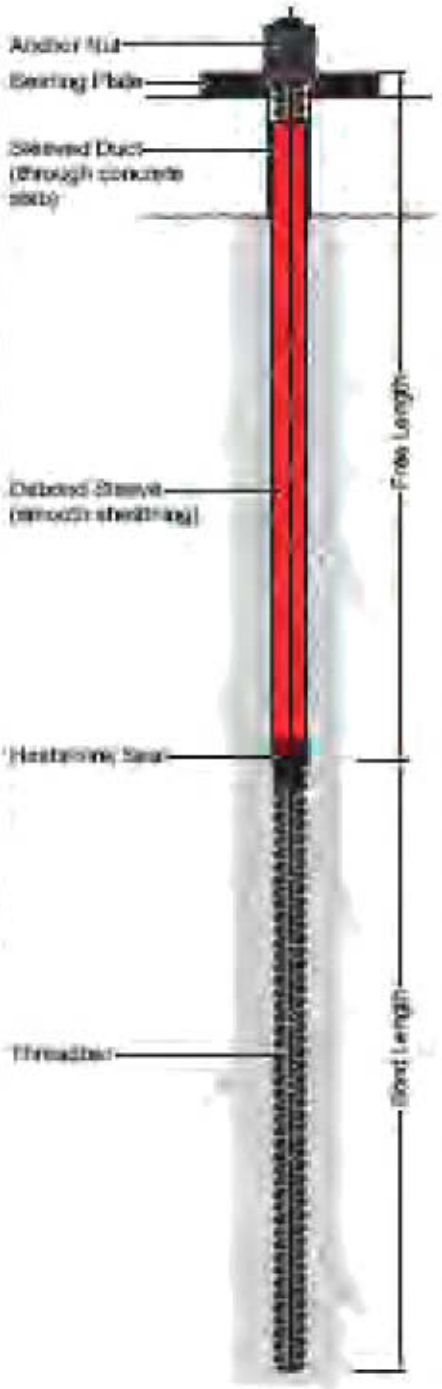


Free Length

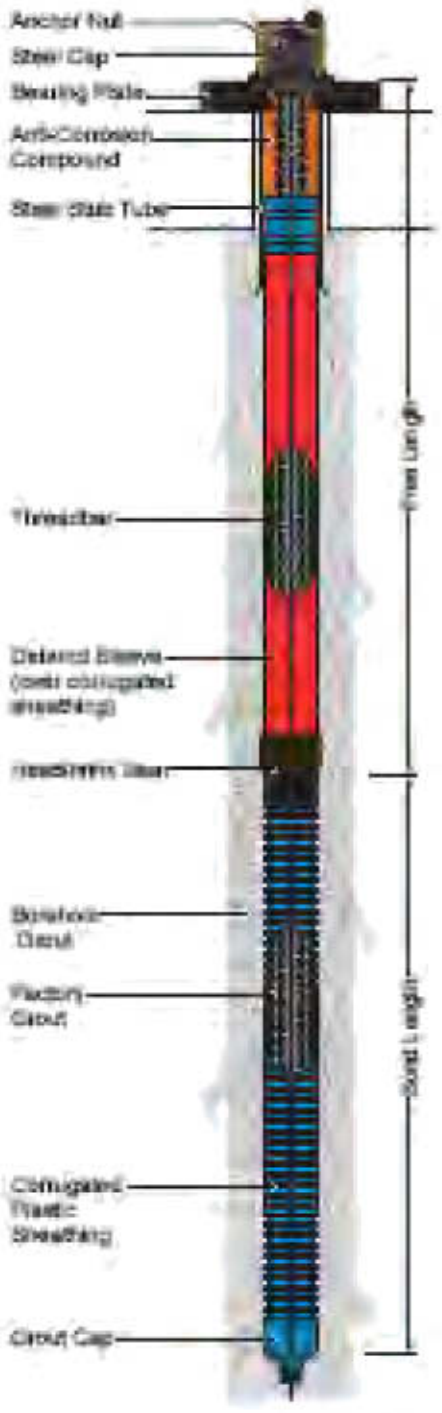
Coupler



Temporary Bar Anchor
(Lifespan: up to 2 years)



Permanent Bar Anchor with Double Corrosion Protection
(Lifespan: up to 120 years)



Lantern Spacer - plain bar (soil or rock)

Lantern Spacer (cased boreholes, soil)

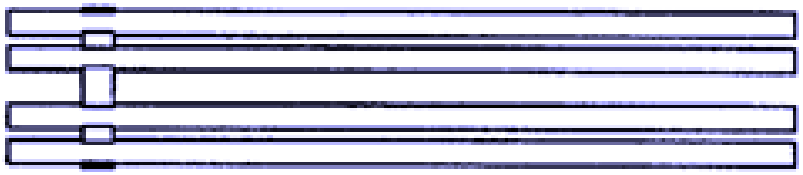
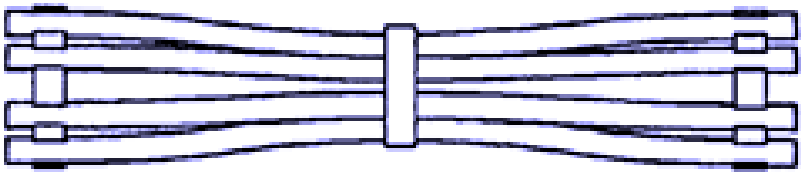
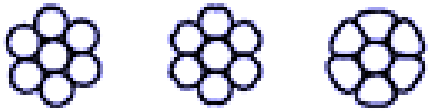
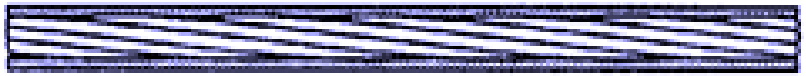
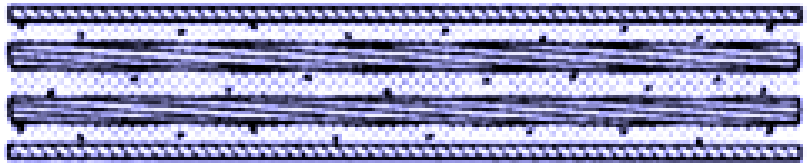
Wrap-around Spacer (stable boreholes, rock)


45 m


URB. COLINAS
DE TURUMO


17 10:47AM

TORONES O GUAYAS PARA ANCLAJES

TYPE	LONGITUDINAL SECTION	CROSS SECTION
Multi-wire tendon (Clifford, 1974)		
Birdcaged multi-wire tendon (Jirovec, 1978)		 Antinode Node
Single strand (Hunt & Askew, 1977)		 Normal Indented Drawn
Coated single strand (Hunt & Askew, 1977)		 Sheathed Coated Encapsulated
High capacity shear dowel (Mathews et al, 1986)		 Steel tube Concrete

Technical Data

Strand Anchors are constructed from compacted strand, grade 1660 / 1820 N/mm².

Number of Strands	Ultimate Strength kN (T_{uts})	0.1% Proof (Yield Strength) kN (T_y)
1	300	255
2	600	510
3	900	765
4	1200	1020
5	1500	1275
6	1800	1530
7	2100	1785
8	2400	2040
9	2700	2295
10	3000	2550
11	3300	2805
12	3600	3060

Higher capacity anchors are available through the addition of further strands.

Corrosion Protection for Permanent Strand Anchors

The same principles of corrosion protection for Permanent Bar Anchors apply for Permanent Strand Anchors, to ensure durability throughout the lifespan.

For Permanent Strand Anchors, Double Corrosion Protection is achieved by two independent layers of plastic sheathing as follows:

Bond Length

Two concentric corrugated plastic sheaths (typically factory pregrouted).

Free Length

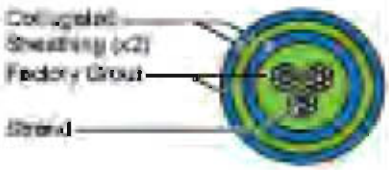
Individual plastic sheaths (smooth) for each strand, all enclosed within a common external corrugated plastic sheath. Protection at the anchor head is provided by a fully enclosed assembly.

Anchors are factory assembled and coiled (except for pregrouted bond length), prior to delivery.

Borehole grout is not recognised by current anchor standards (BS8081 or EN1537) as a corrosion protection barrier.

Double Corrosion Protection Detail:

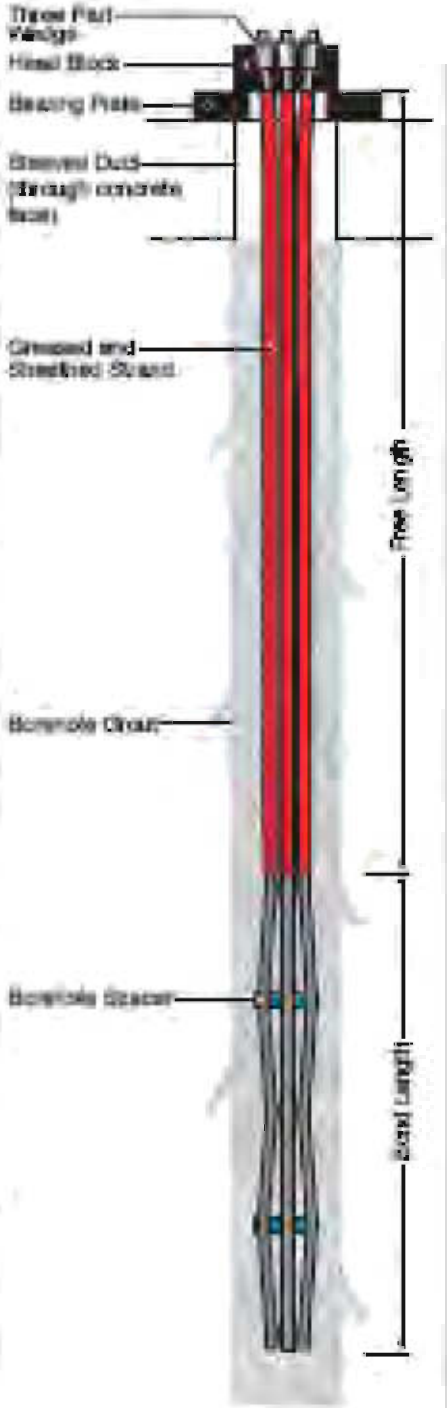
Bond Length



Free Length

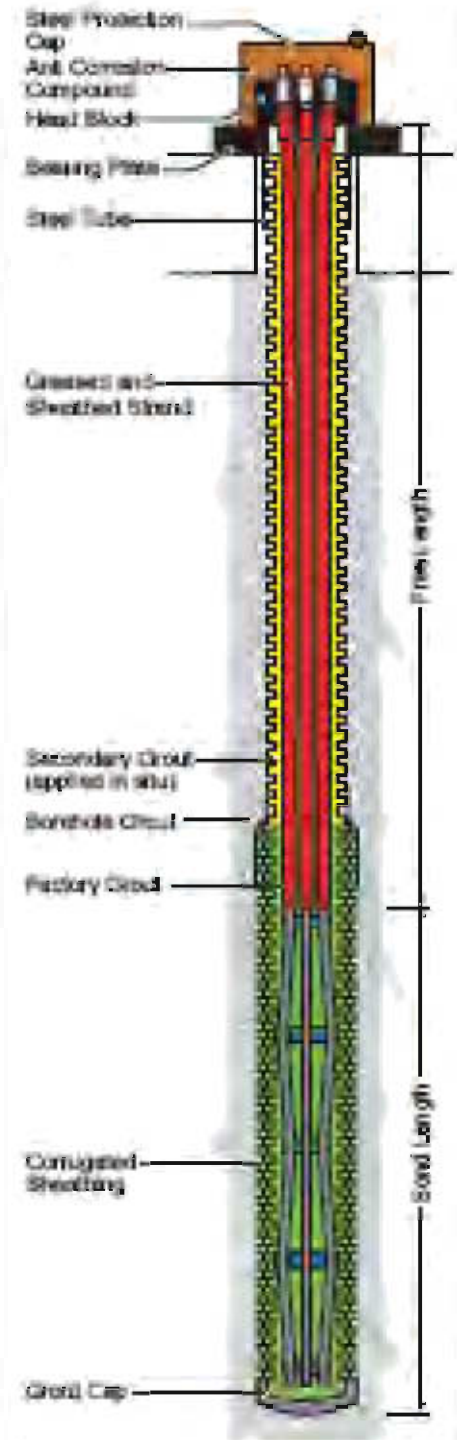
Temporary Strand Anchor

(Lifespan: up to 2 years)



Permanent Strand Anchor with Double Corrosion Protection

(Lifespan: up to 120 years)



Permanent Strand Anchors, Head Assemblies

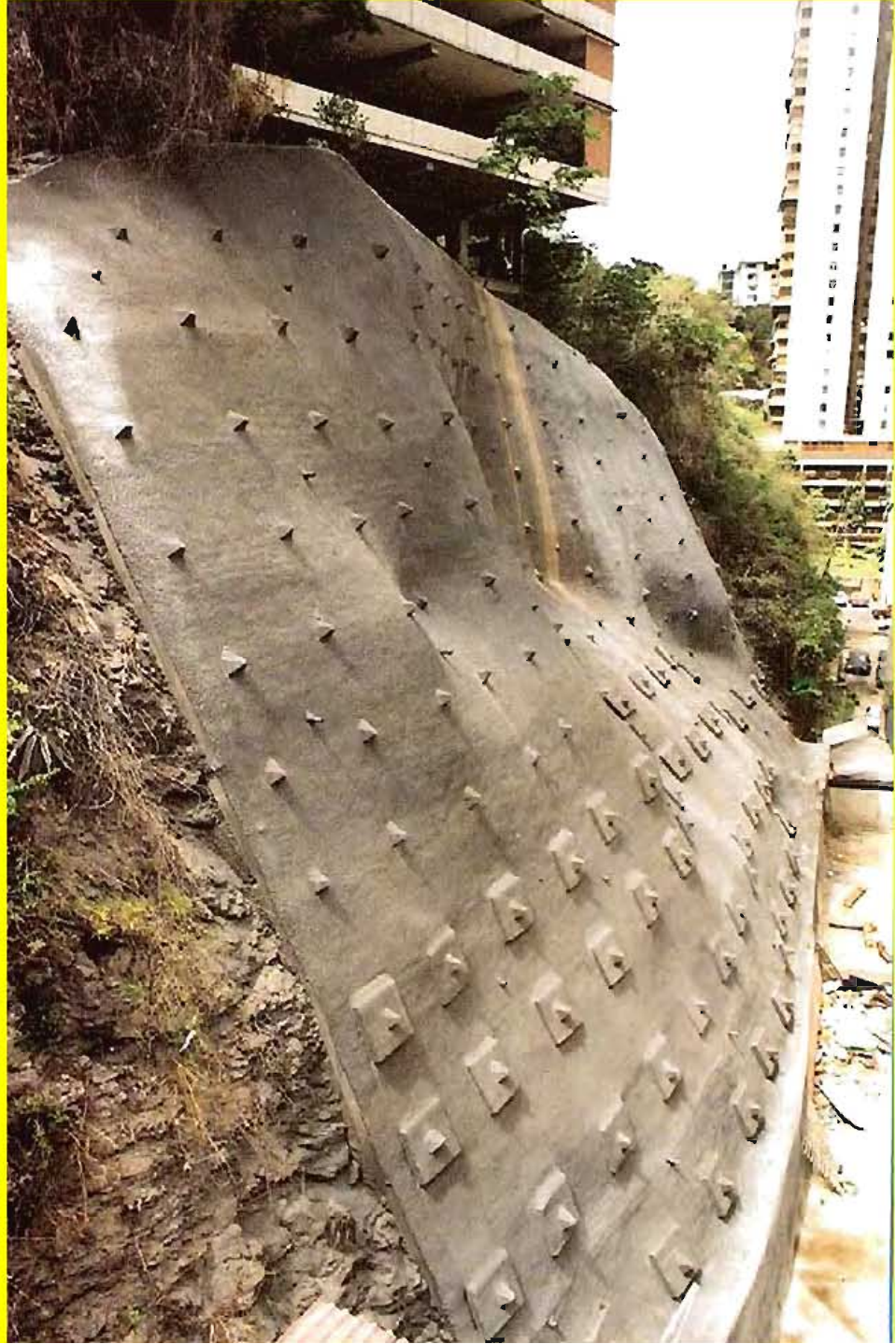
Standard (non-restressable)

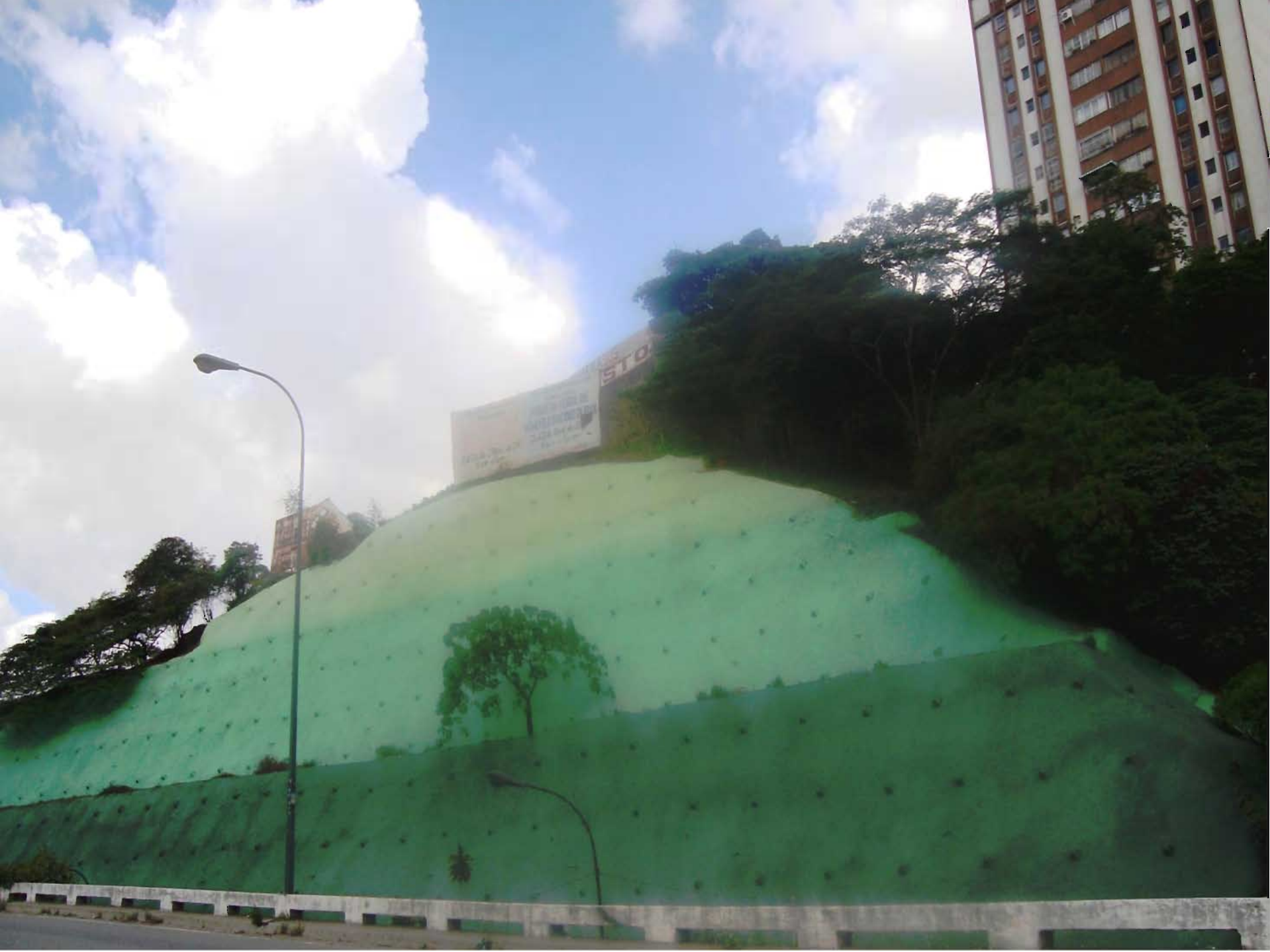
Threaded Headblock (restressable)

Long End Cap (restressable)


24 m


26 m





Pantallas de Concreto Proyectado en Seco Ancladas y Claveteadas

Concreto Proyectado Armado:

10 a 40 cm de espesor

250 a 350 Kg/cm2 de Resistencia a 28 días

350 a 450 Kg/m3 de Cemento Portland Tipo I

Pernos de Alta Resistencia:

0.5" a 1" de Diámetro

6 a 18 m de Longitud

20 a 50 t de Capacidad

Clavos Metálicos:

1" y 1+3/8" de Diámetro

3 a 12 m de Longitud

20 a 30 t de Capacidad

Anclajes de Torones:

7 y 9 Hilos de 2 a 4 mm de Diámetro

1/2" y 5/8" de Diámetro por Torón

6 a 60 m de Longitud

10 y 15 t de Capacidad por Torón

2 a 6 Torones por Anclaje

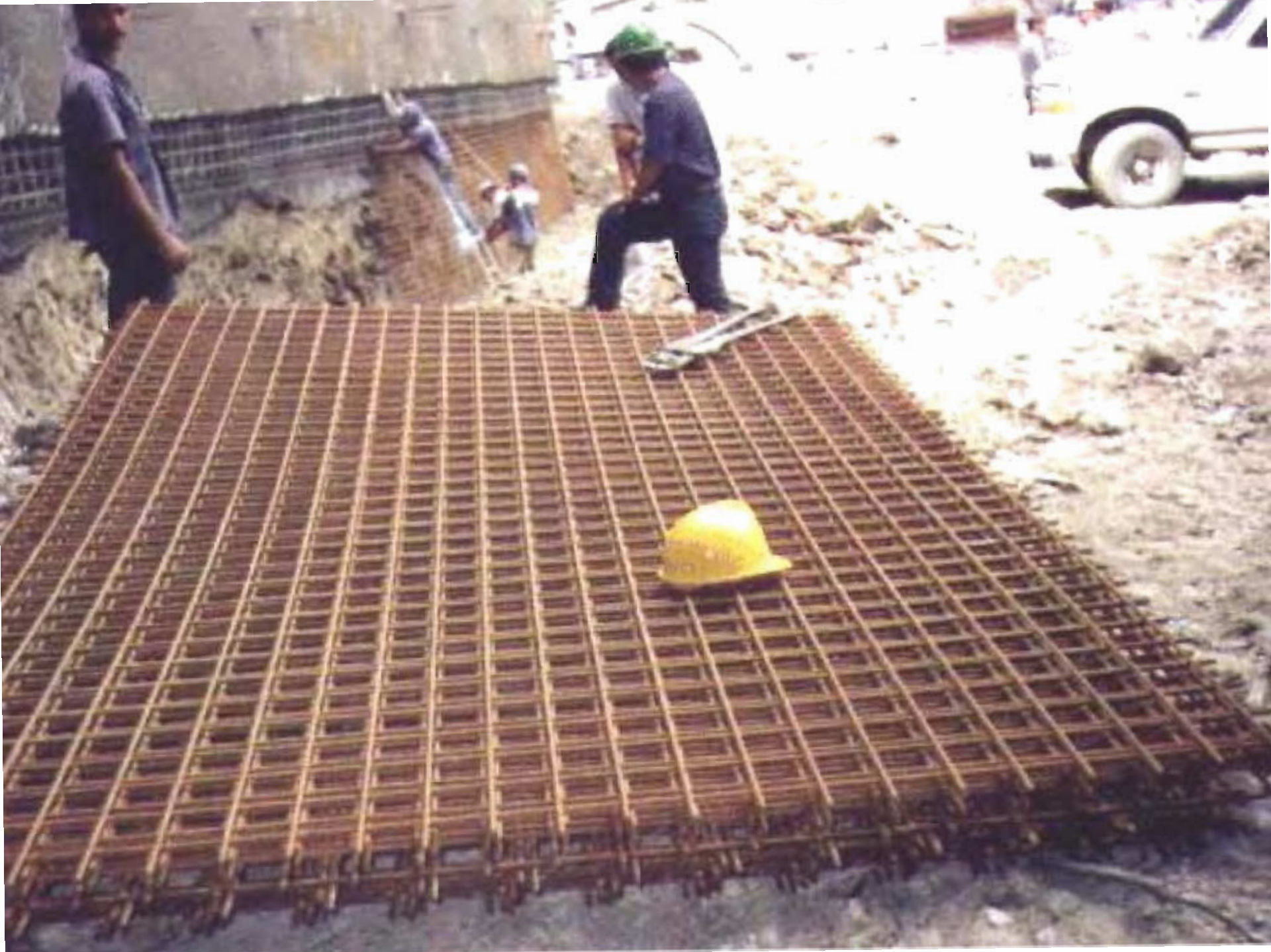
3 a 12 m Longitud Bulbo

20 a 90 t de Capacidad por Anclaje

Mortero de Inyección:

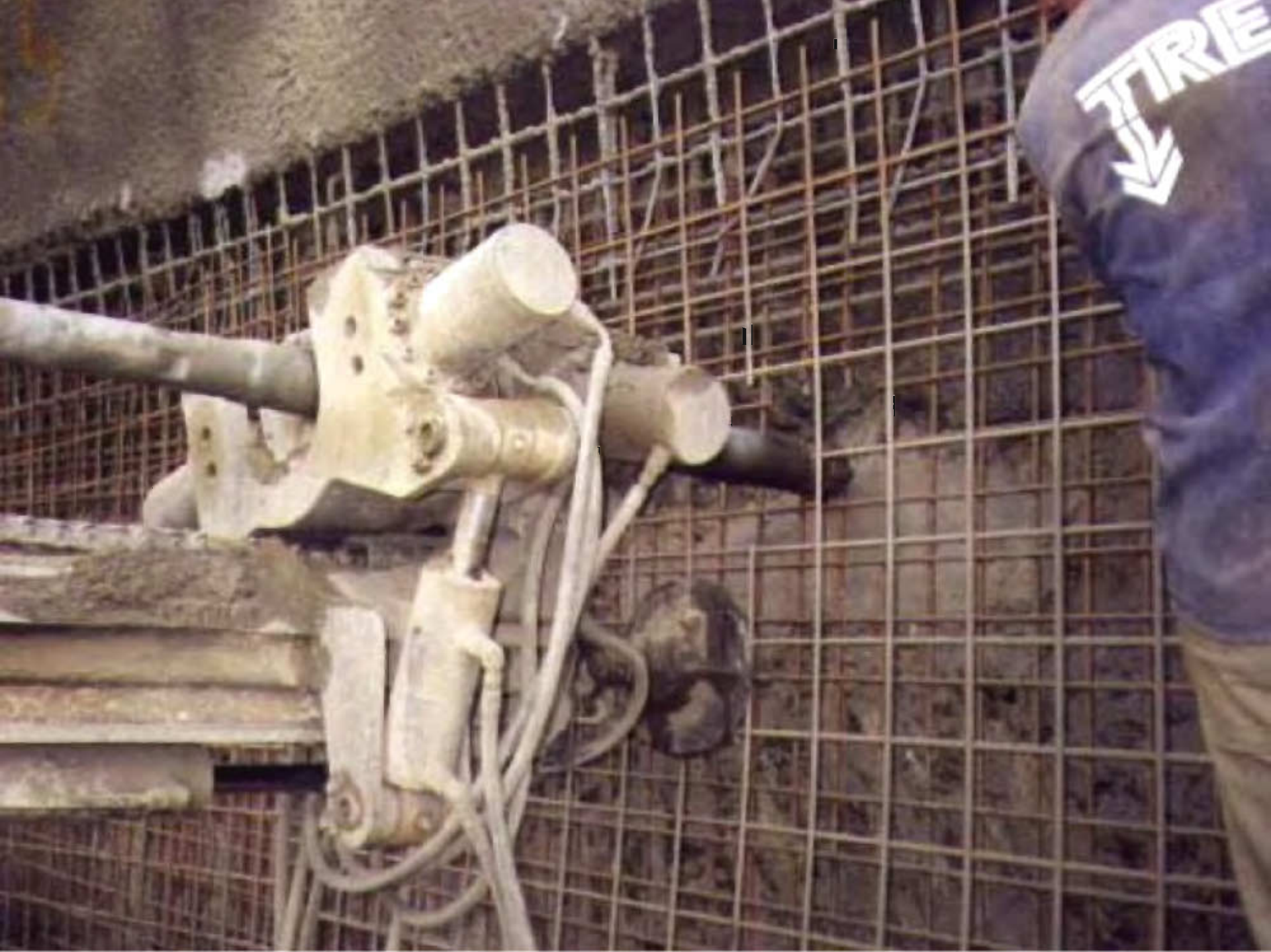
0.4 a 0.8 Agua/Cemento en peso

2 a 6 Kg/cm2 de Presión

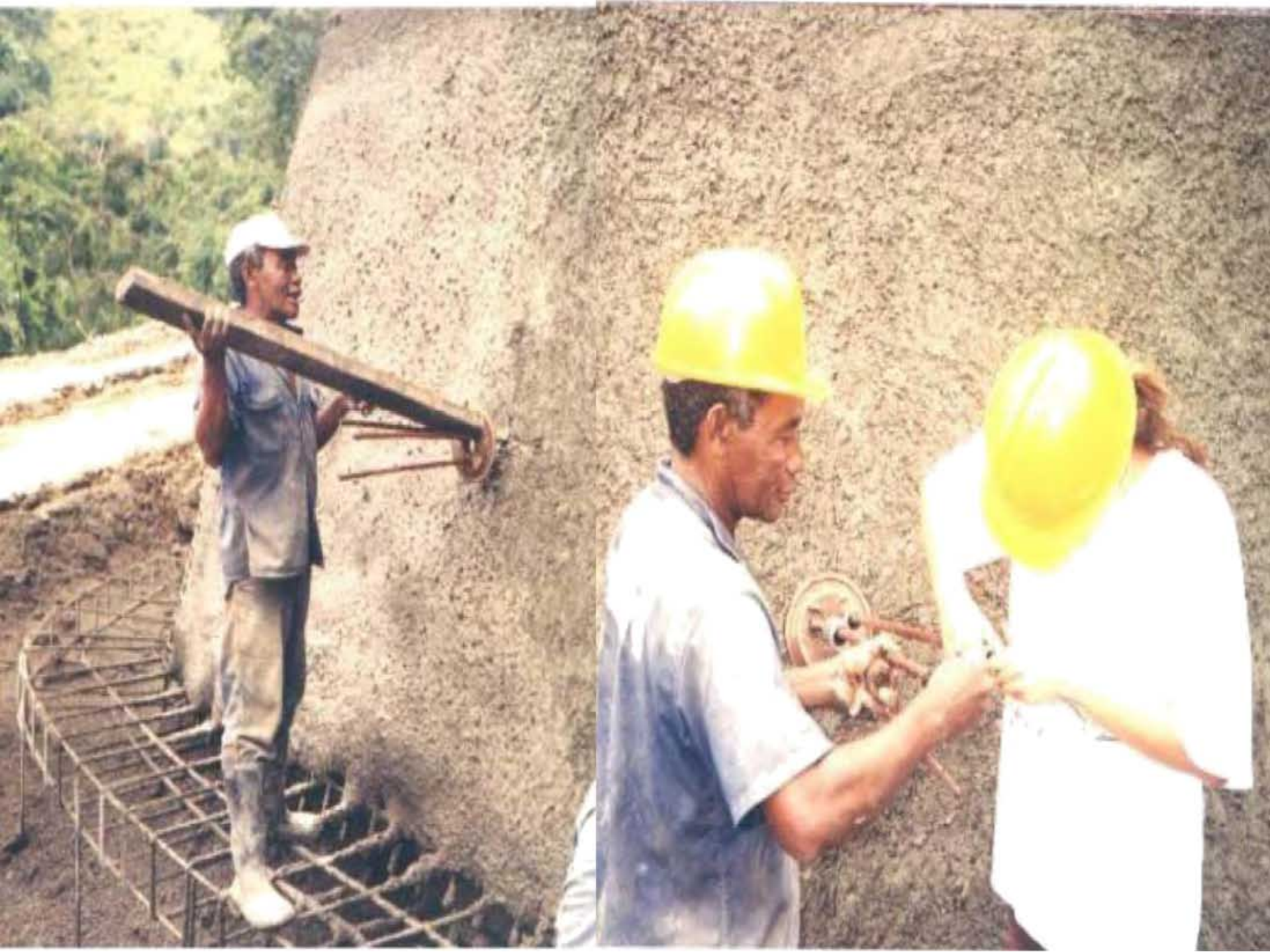



Máquina Proyectadora de Rotor


MERL




15
2:56 PM




15 2:53PM


15 2:53PM


1000
2000
200
300
500
600
700
kg/cm²
psi
10000
17 11:03AM

Tiempo (min)	Presión (bares)	Tensión por Toron (ton)	Tensión por Anclaje (ton)	Elongación (mm)		
				Gato 1	Gato 2	Gato 3
1	60	3	9	50	45	55
1	130	6	18	65	65	70
1	190	9	27	80	80	90
1	260	12	36	100	95	105
1	320	15	45	115	110	120
1	390	18	54	135	130	140
2	390	18	54	135	130	140
4	390	18	54	135	130	140
8	390	18	54	135	130	140
12	390	18	54	135	130	140
16	390	18	54	135	130	140
1	60	3	9	100	110	125
1	320	15	45	120	110	130

Tensado del Anclaje G-2 de la pantalla Palmarito: tres torones de 15 ton cada uno

Rigid micro-slotted drainage pipe

Physical characteristics

Material		HDPE (PP on request)
Outer diameter	mm	62
Inner diameter	mm	50
Outer surface		corrugated
Slot width	mm	0.5 – 0.7
Slot layout		4 arranged at 90°
Bar length	m	1.5 – 3.00 – 6.00

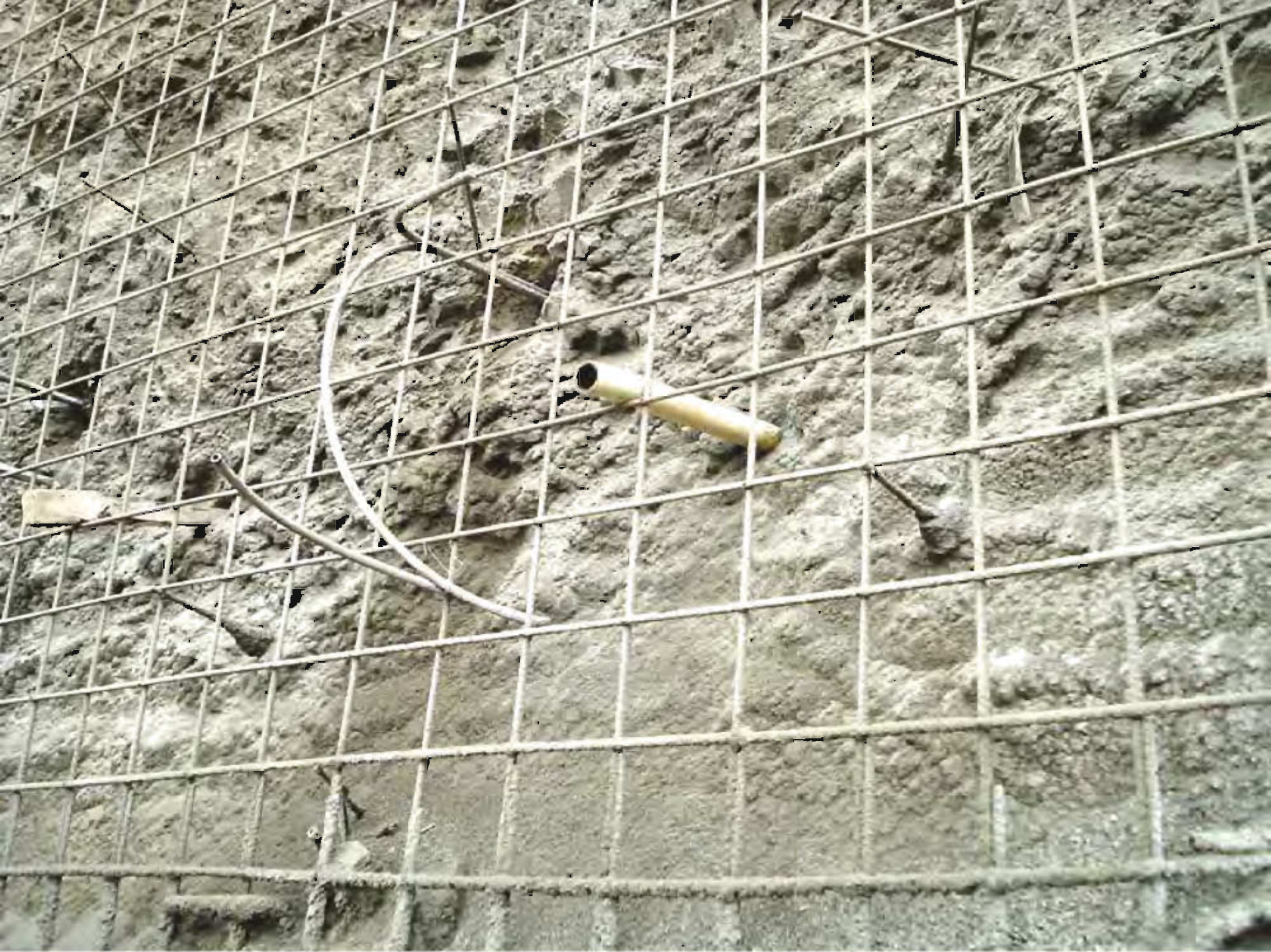
Filtering geo-fabric characteristics (TNT)

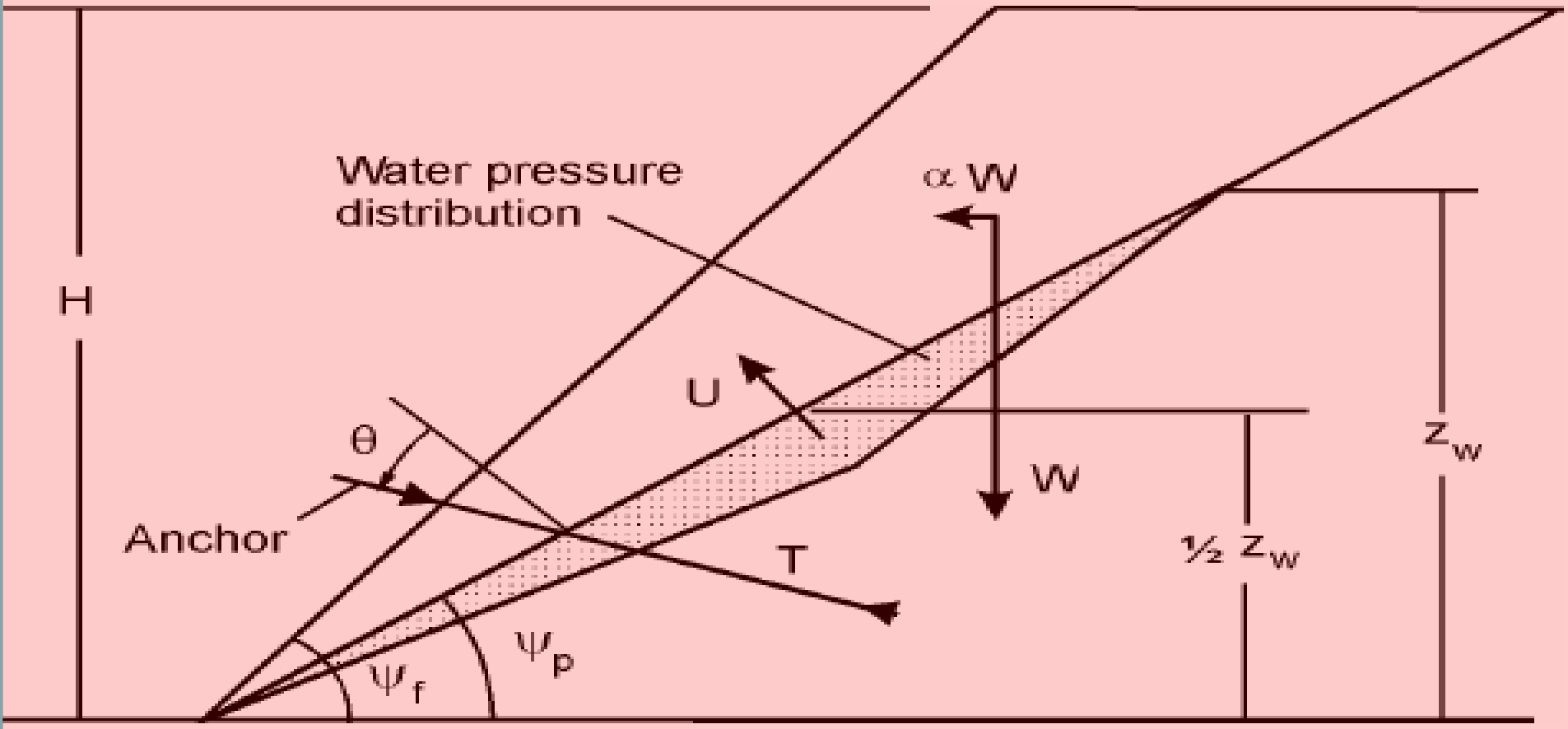
Material			Polypropylene	
Mass in air		g/m^2	120	150
Traction resistance		kN/m	7.5	9
Perforation resistance	N		1300	1600
Filtering diameter		micron	130	130
Permeability		m/s	1.18×10^{-3}	1.15×10^{-3}

PRODUCT PATENTED BY ELAS GEOTECNICA s.r.l.


FH240.3


AREA RESTRINGIDA





Fs vs. Pf

$$F = \frac{cA + \left(W(\cos\psi_p - \alpha\sin\psi_p) - U + T\cos\theta\right)\tan\phi}{W(\sin\psi_p + \alpha\cos\psi_p) - T\sin\theta}$$

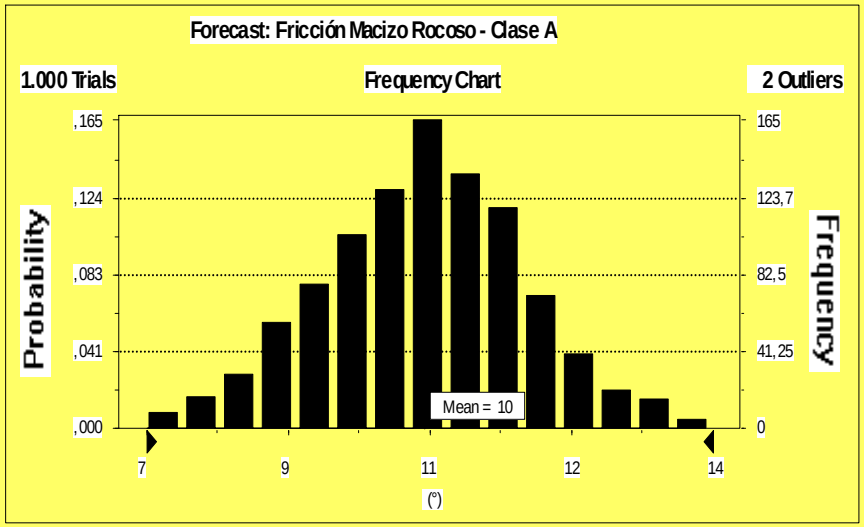
=C/D

Ángulo de fricción (°)

Summary:

Display Range is from 7 to 14 (°)
Entire Range is from 7 to 14 (°)
After 1.000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	1000
Mean	10
Median	10
Mode	---
Standard Deviation	1
Variance	2
Skewness	-0,10
Kurtosis	2,93
Coeff. of Variability	0,12
Range Minimum	7
Range Maximum	14
Range Width	7
Mean Std. Error	0,04

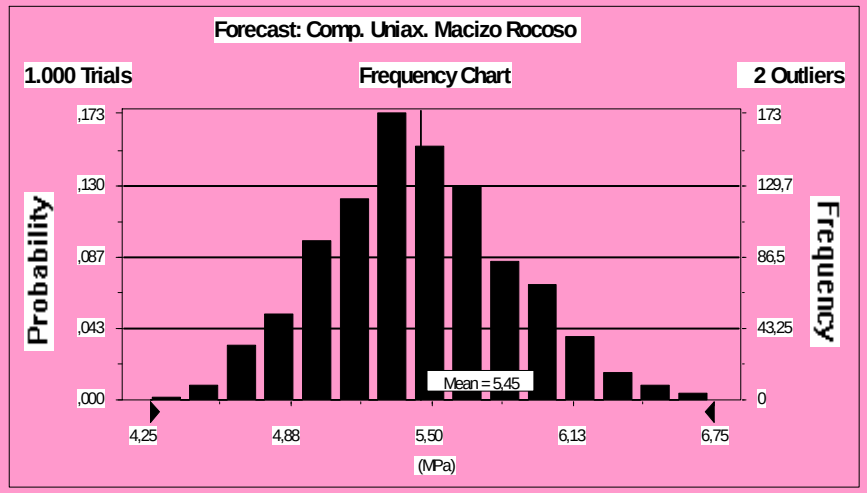


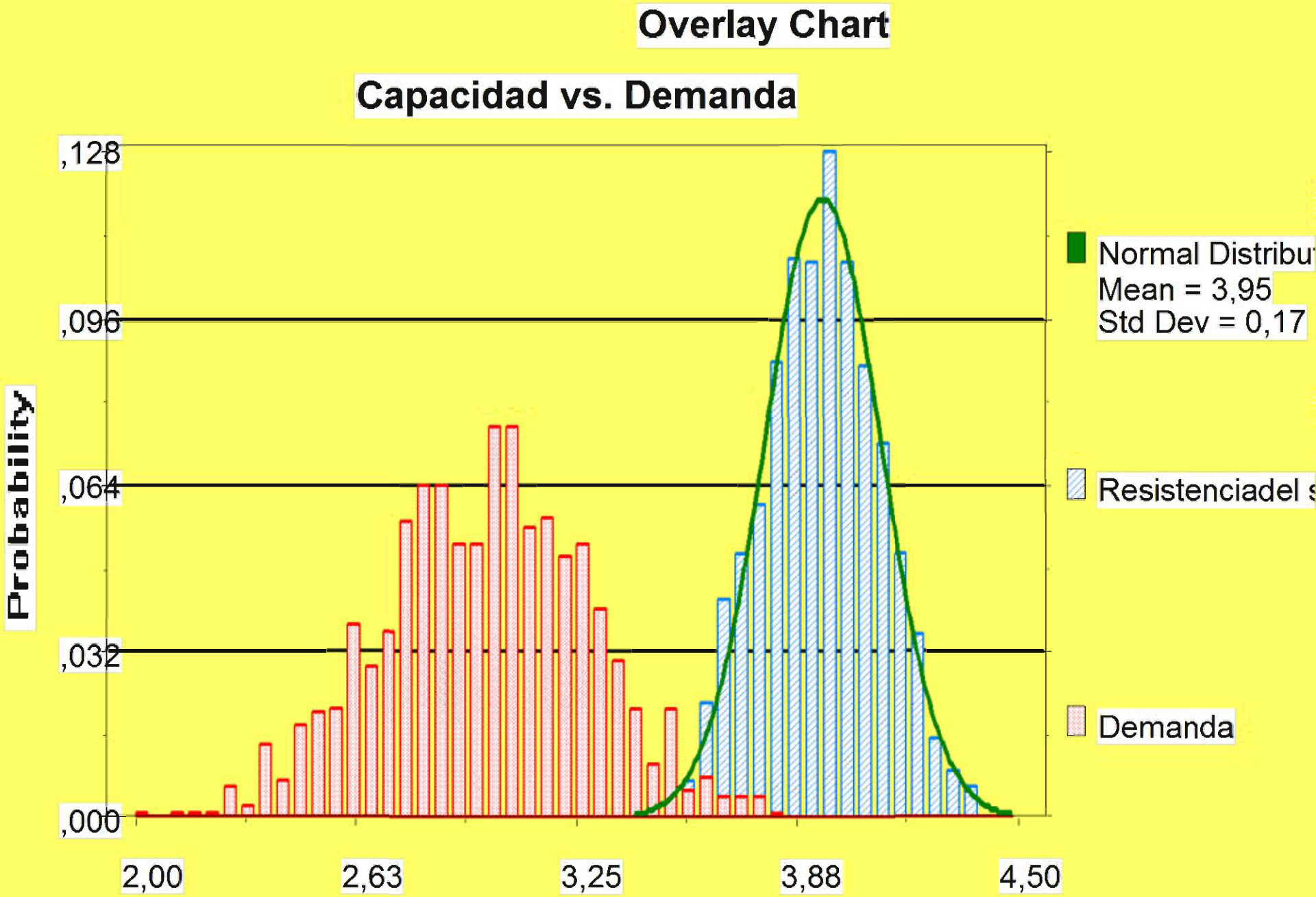
Cohesión (MPa)

Summary:

Display Range is from 4,25 to 6,75 (MPa)
Entire Range is from 4,28 to 6,86 (MPa)
After 1.000 Trials, the Std. Error of the Mean is 0,01

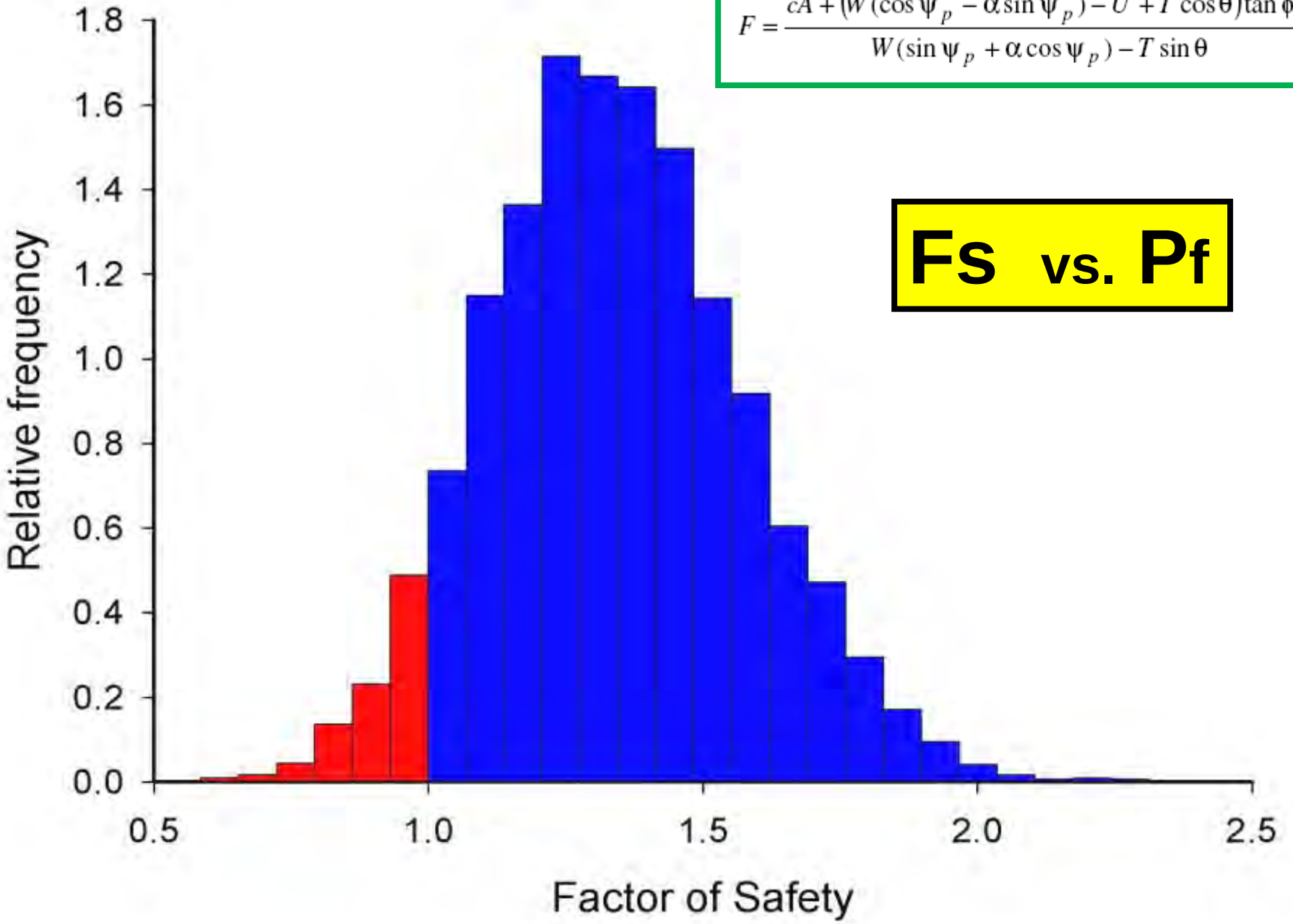
Statistics:	Value
Trials	1000
Mean	5,45
Median	5,43
Mode	---
Standard Deviation	0,42
Variance	0,18
Skewness	0,23
Kurtosis	2,94
Coeff. of Variability	0,08
Range Minimum	4,28
Range Maximum	6,86
Range Width	2,58
Mean Std. Error	0,01

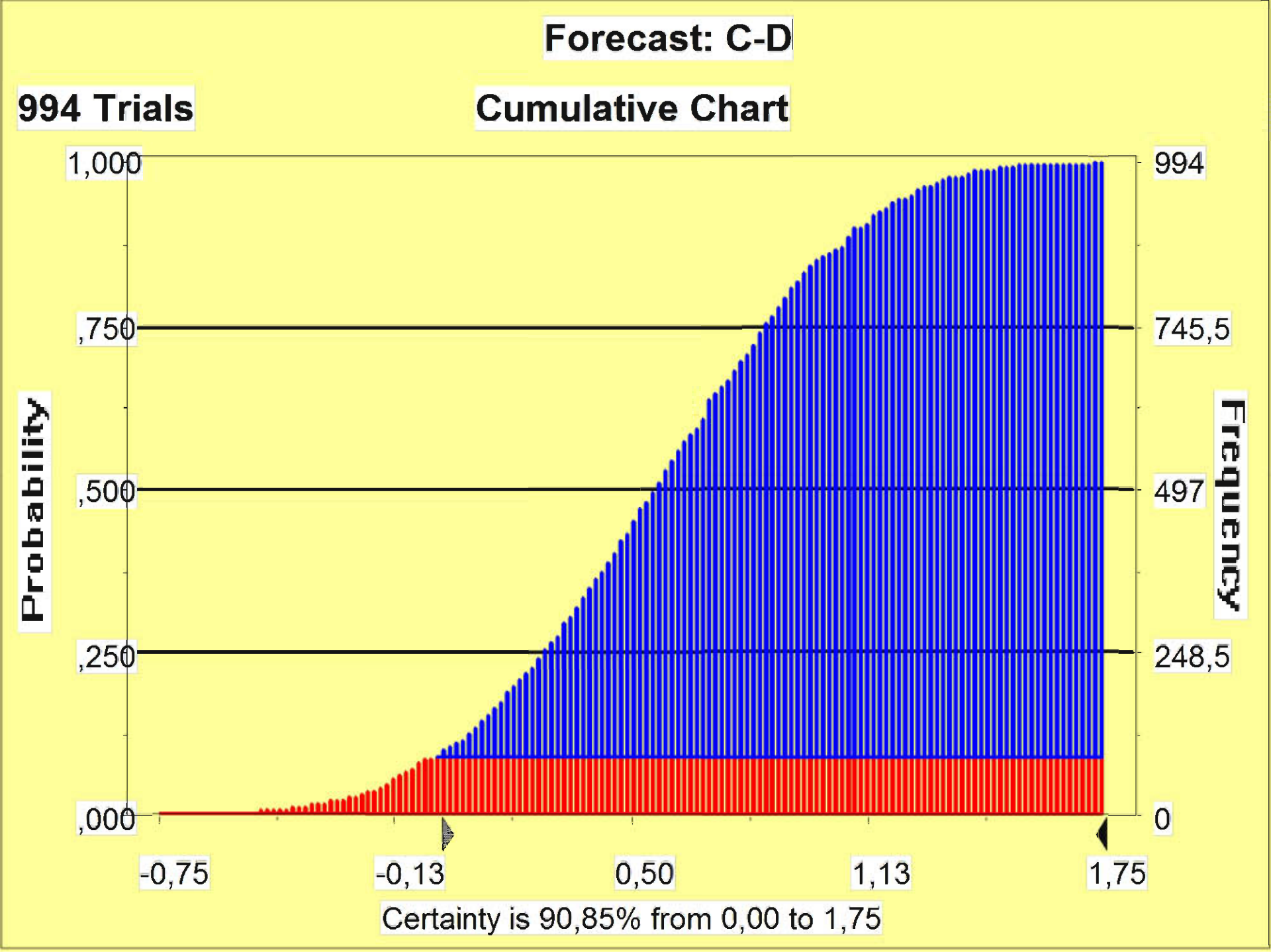



Overlay Chart
Capacidad vs. Demanda
Probability
,128
,096
,064
,032
,000
2,00
2,63
3,25
3,88
4,50
Normal Distribu
Mean = 3,95
Std Dev = 0,17
Resistenciadel s
Demanda

$$F = \frac{cA + \left(W(\cos\psi_p - \alpha\sin\psi_p) - U + T\cos\theta\right)\tan\phi}{W(\sin\psi_p + \alpha\cos\psi_p) - T\sin\theta}$$

Fs vs. Pf



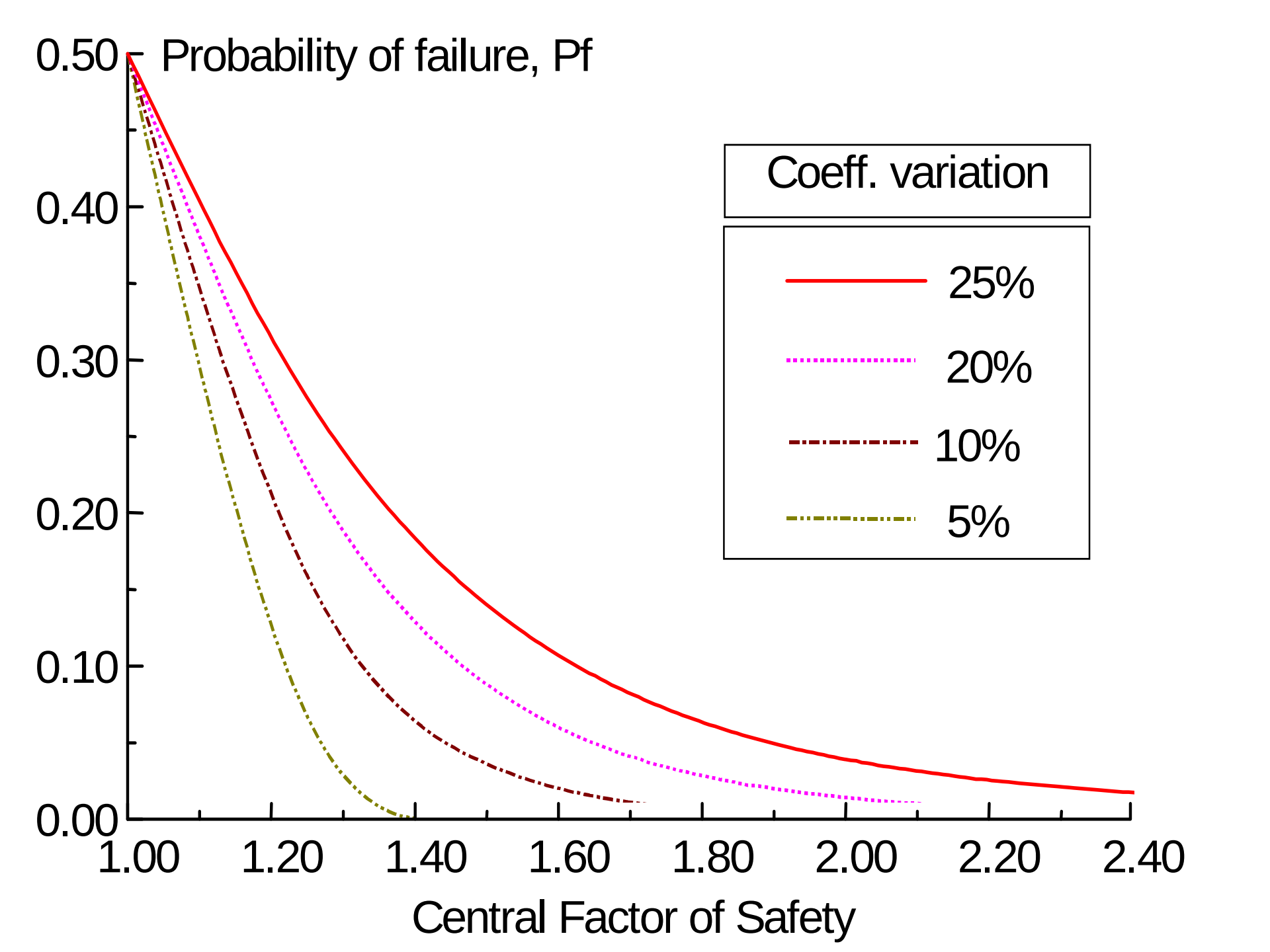

Forecast: C-D
994 Trials
Cumulative Chart
1,000
,750
,500
,250
,000
Probability
994
745,5
497
248,5
0
Frequency
-0,75
-0,13
0,50
1,13
1,75
Certainty is 90,85% from 0,00 to 1,75

EJEMPLO N°1

Ø	δ	c (t/m²)	δ	F.S. Determinístico	F.S. Estadístico	F.S. < 1 p (%)	F.S.<1,4 p(%)
25	0	10	0	1.569	1.569	0	0
25	2.5	10	2	1.569	1.411	1	48
25	2.5	15	5	2.147	1.743	2	--
25	2.5	20	8	2.703	2.120	2	--
25	2.5	20	10	2.703	1.973	6	--
25	2.5	10	3	1.569	1.325	9	65
25	2.5	15	8	2.147	1.544	13	--
25	2.5	10	4	1.569	1.228	21	75
25	2.5	15	10	2.147	1.398	23	--
25	2.5	10	5	1.569	1.136	34	77

EJEMPLO N°3

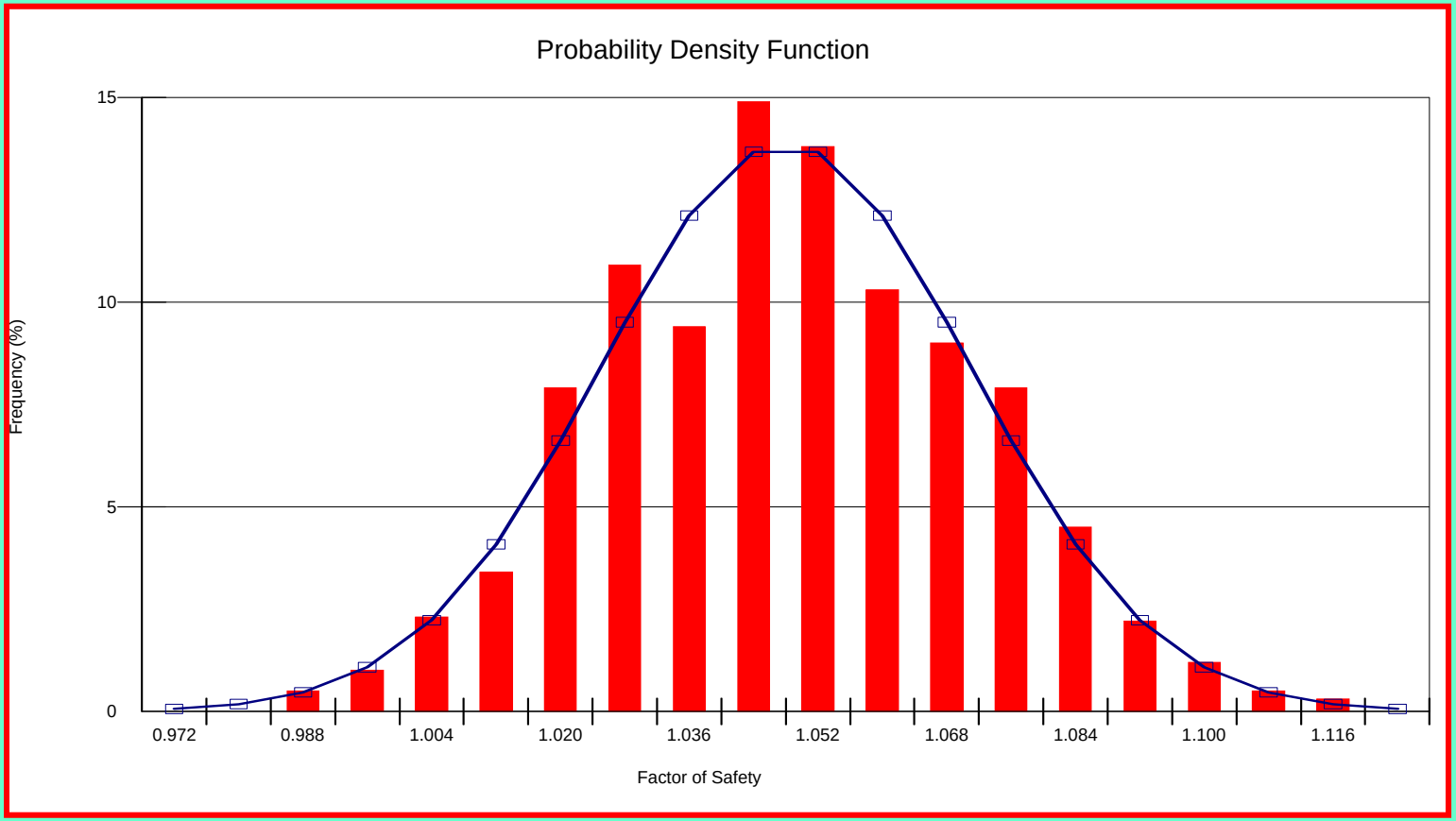
Ø	δ	c (t/m²)	δ	F.S. Determinístico	F.S. Estadístico	F.S. < 1 p (%)	F.S.<1,4 p (%)
25	2.5	7	0	1.584	1.587	0	0
25	2.5	7	2.5	1.584	1.579	2	34
25	2.5	7	3	1.584	1.573	4	35
25	2.5	15	8	2.400	2.445	4	--
25	2.5	15	10	2.400	2.456	7	--


Probability of failure, Pf
0.50
0.40
0.30
0.20
0.10
0.00
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
Central Factor of Safety
Coeff. variation
25%
20%
10%
5%

Fs Vs. Pf

No hay dudas que constituye un salto cualitativo importante y positivo el pasar del concepto *"Factor de Seguridad"* al concepto *"Probabilidad de Falla"*, aunque debe reconocerse que "*el impacto emocional*" de proponer al público no especialista que existe siempre un riesgo finito (aunque pequeño) de falla asociado al diseño de un talud, es tal que dificulta la propuesta de reemplazar el factor de seguridad estándar con la probabilidad de falla o con el índice de confiabilidad de un talud" (Hoek, 1998).

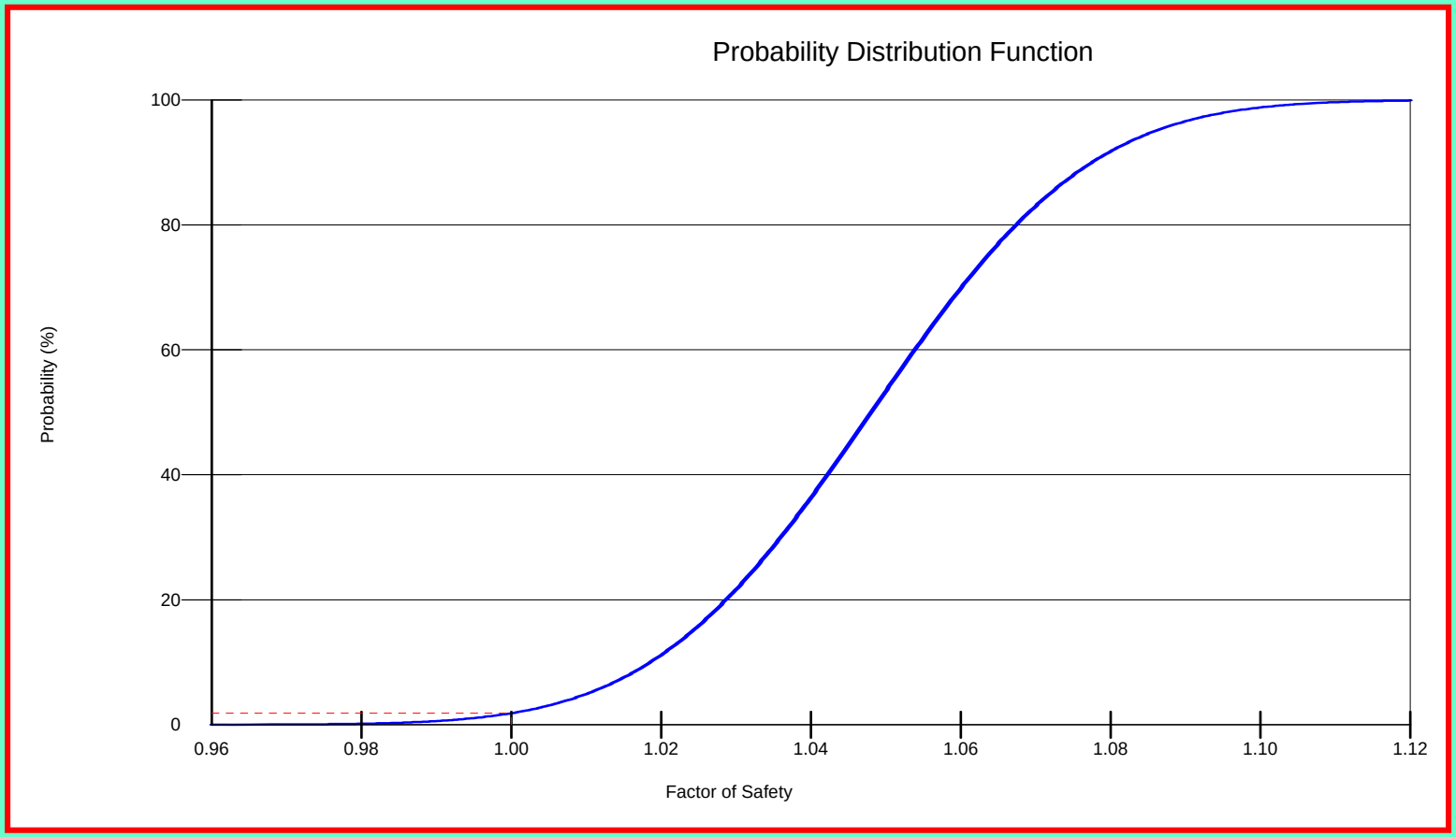
Portal Palmarito Norte **Talud sin Estabilizar** **H = 15m** **Ru = 0,25**



Mean FS=1.048 **Reliability Index=2.088** **P(Failure) (%)=1.829**

Standard Dev=0.0230 **Min FS=0.9840** **Max FS=1.119**

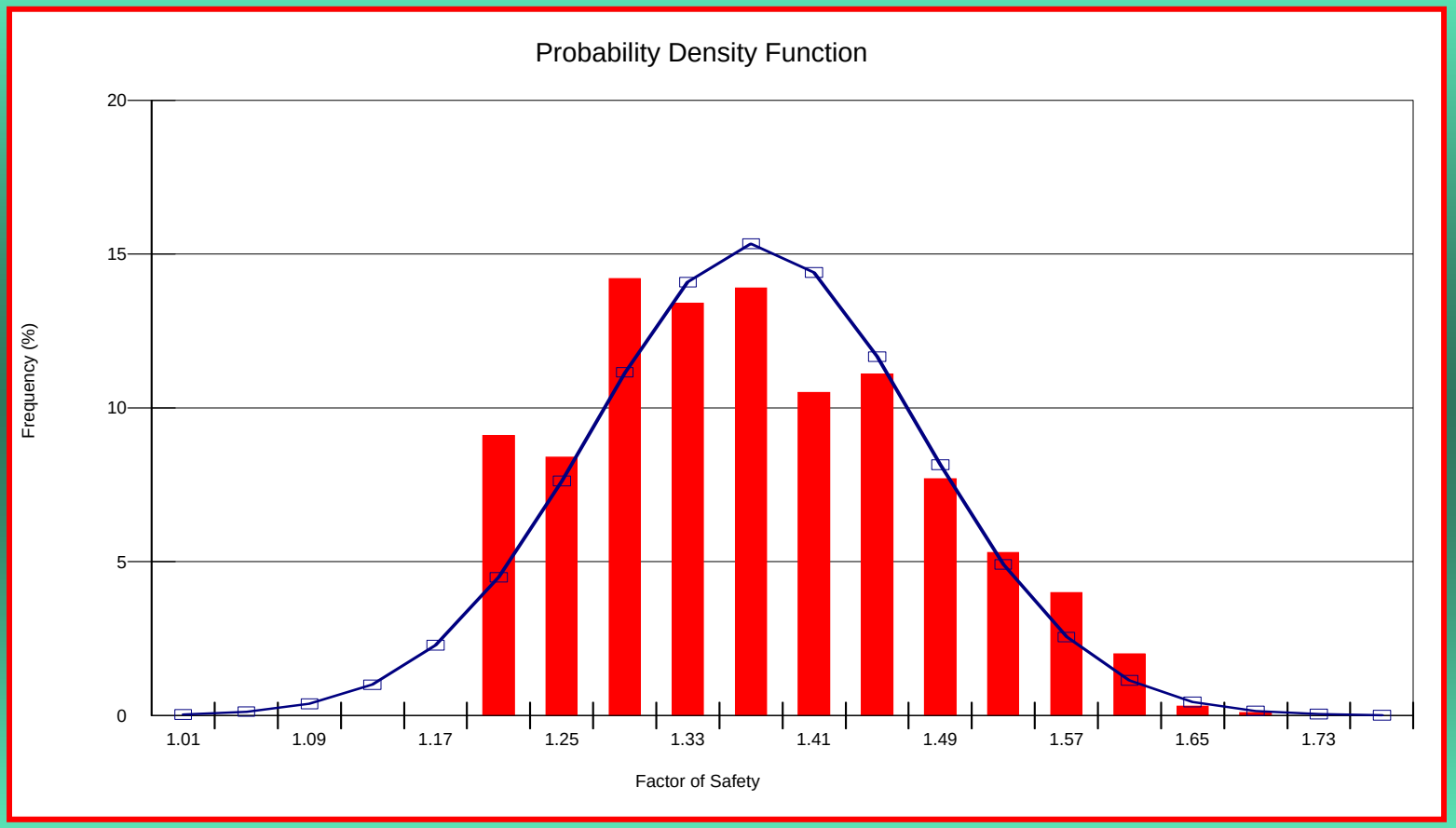
Portal Palmarito Norte **Talud sin Estabilizar** **H = 15m** **Ru = 0,25**



Mean FS=1.048 **Reliability Index=2.088** **P(Failure) (%)=1.829**

Standard Dev=0.0230 **Min FS=0.9840** **Max FS=1.119**

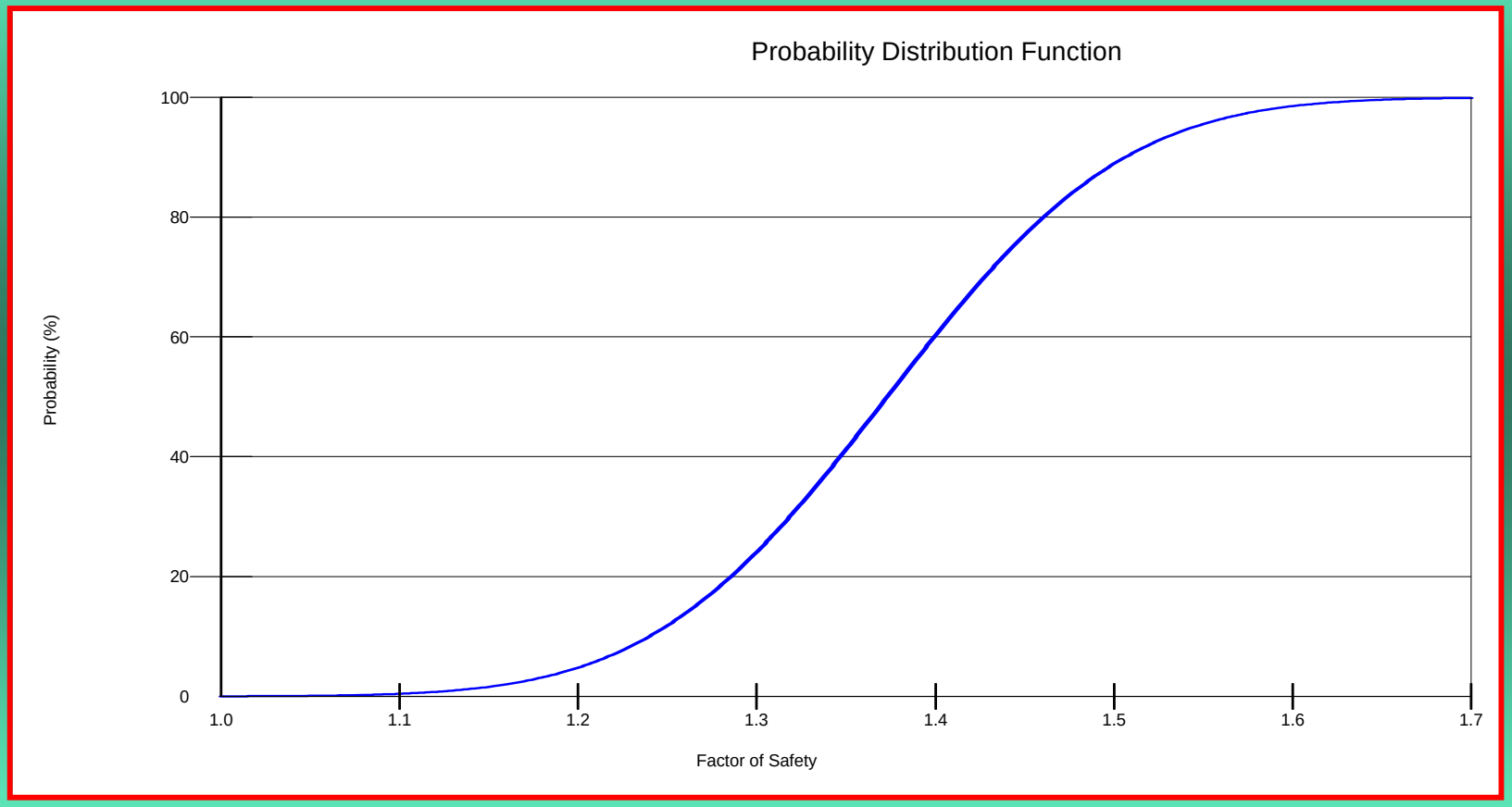
Portal Palmarito Norte **Talud Estabilizado con anclajes de 30 t (2x 2 m)** **H = 15m** **Ru = 0,25**



Mean FS=1.373 **Reliability Index=3.586** **P(Failure) (%)=0.017**

Standard Dev=0.1040 **Min FS=1.210** **Max FS=1.671**

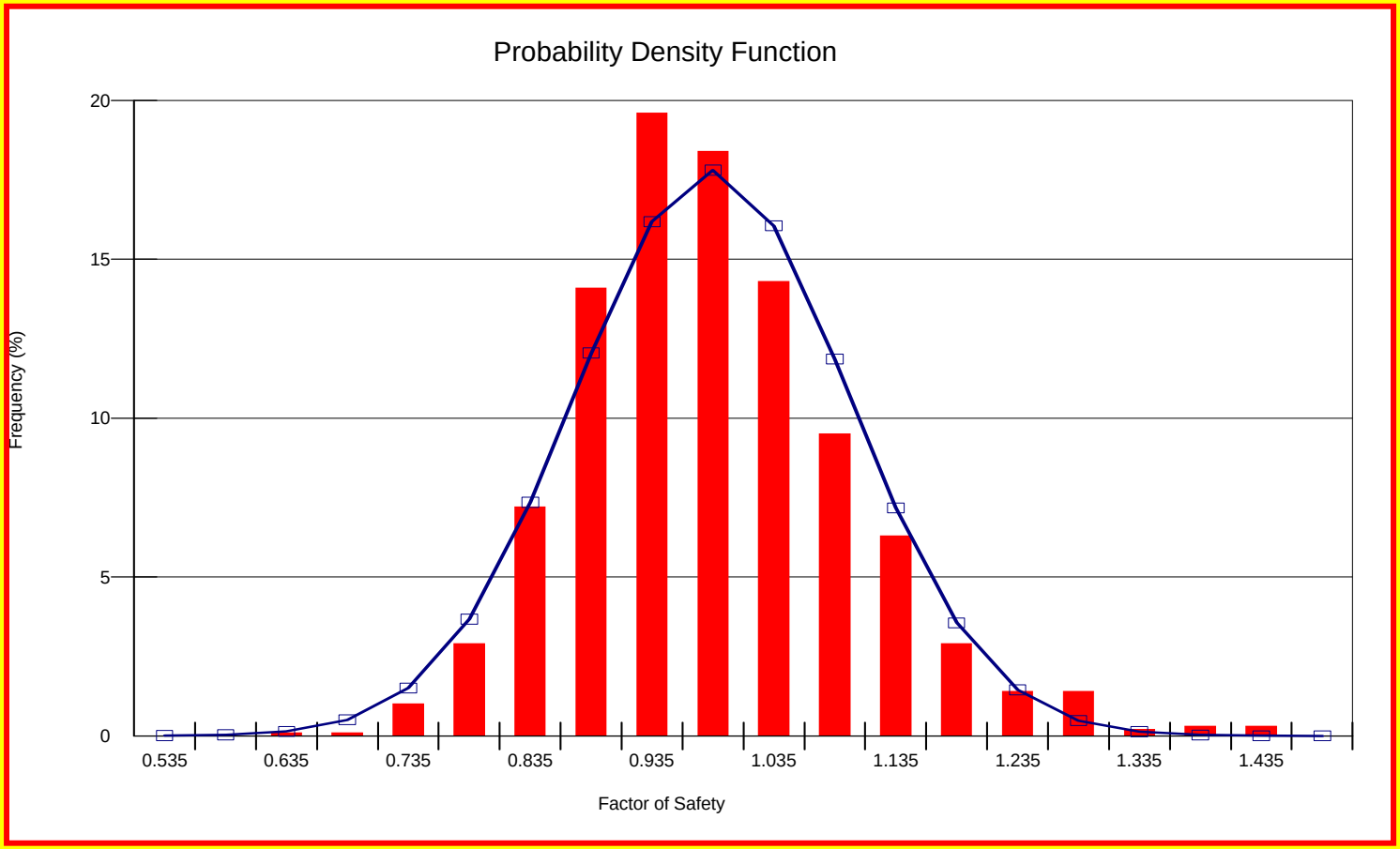
Portal Palmarito Norte **Talud Estabilizado con anclajes de 30 t (2x 2 m)** **H = 15m** **Ru = 0,25**



Mean FS=1.373 **Reliability Index=3.586** **P(Failure) (%)=0.017**

Standard Dev=0.1040 **Min FS=1.210** **Max FS=1.671**

Portal Palmarito Norte Talud con Sismo sin Estabilizar H = 15m S_h =0,3

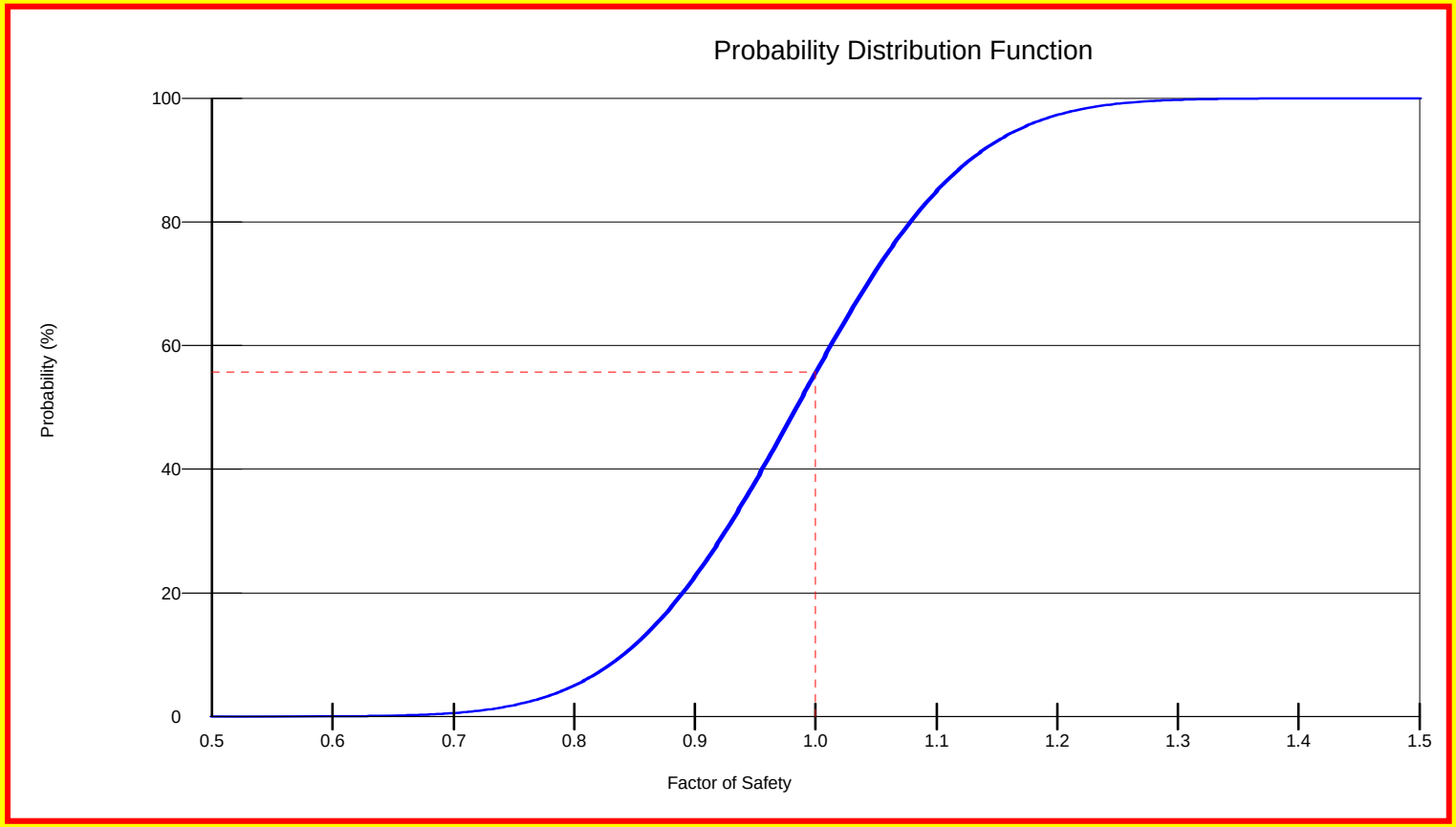


Mean FS=0.984
Standard Dev=0.1120

Reliability Index=0.1440
Min FS=0.653

P(Failure) (%)=45.736
Max FS=1.438

Portal Palmarito Norte Talud con Sismo sin Estabilizar H = 15m S_h =0,3

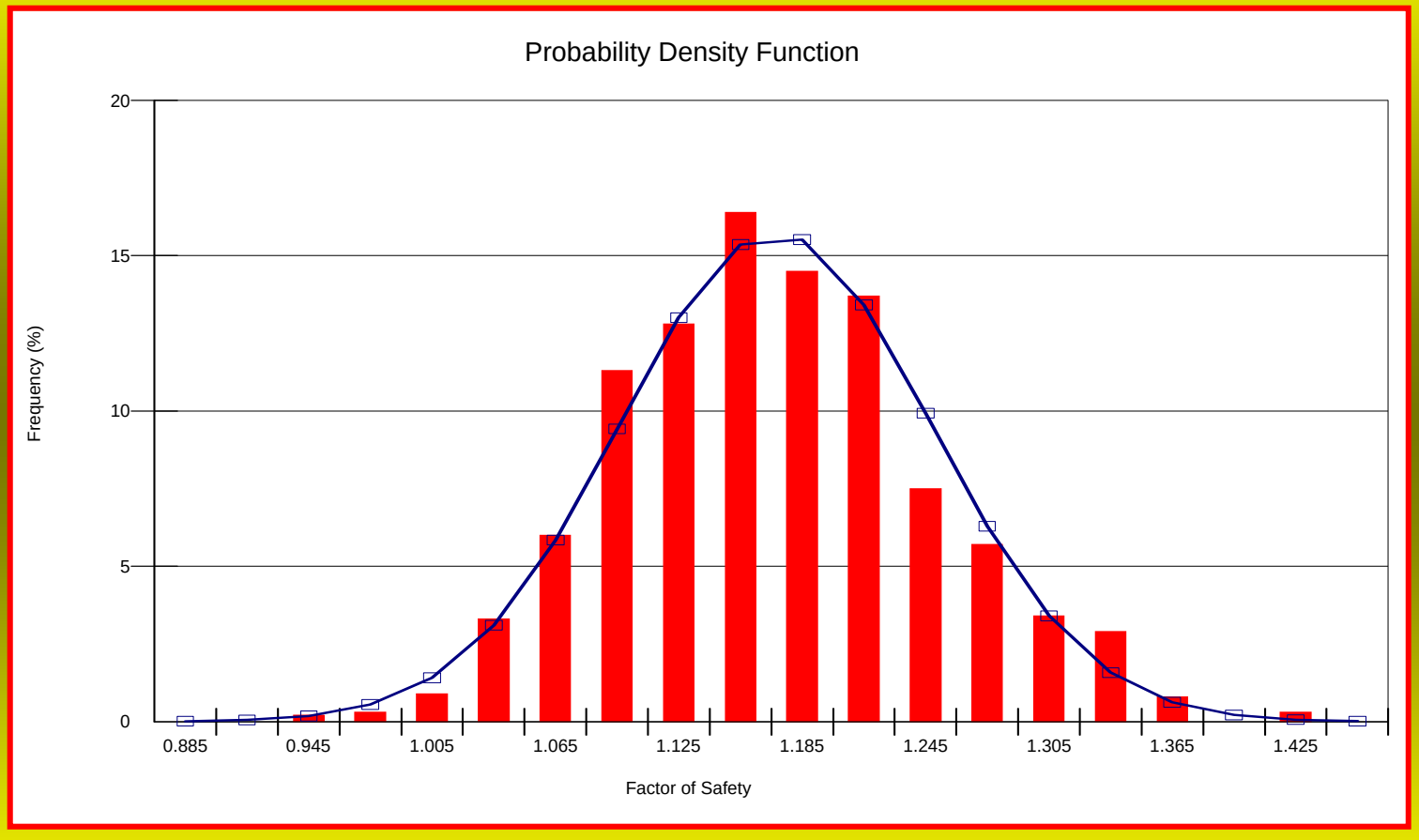


Mean FS=0.984
Standard Dev=0.1120

Reliability Index=0.1440
Min FS=0.653

P(Failure) (%)=45.736
Max FS=1.438

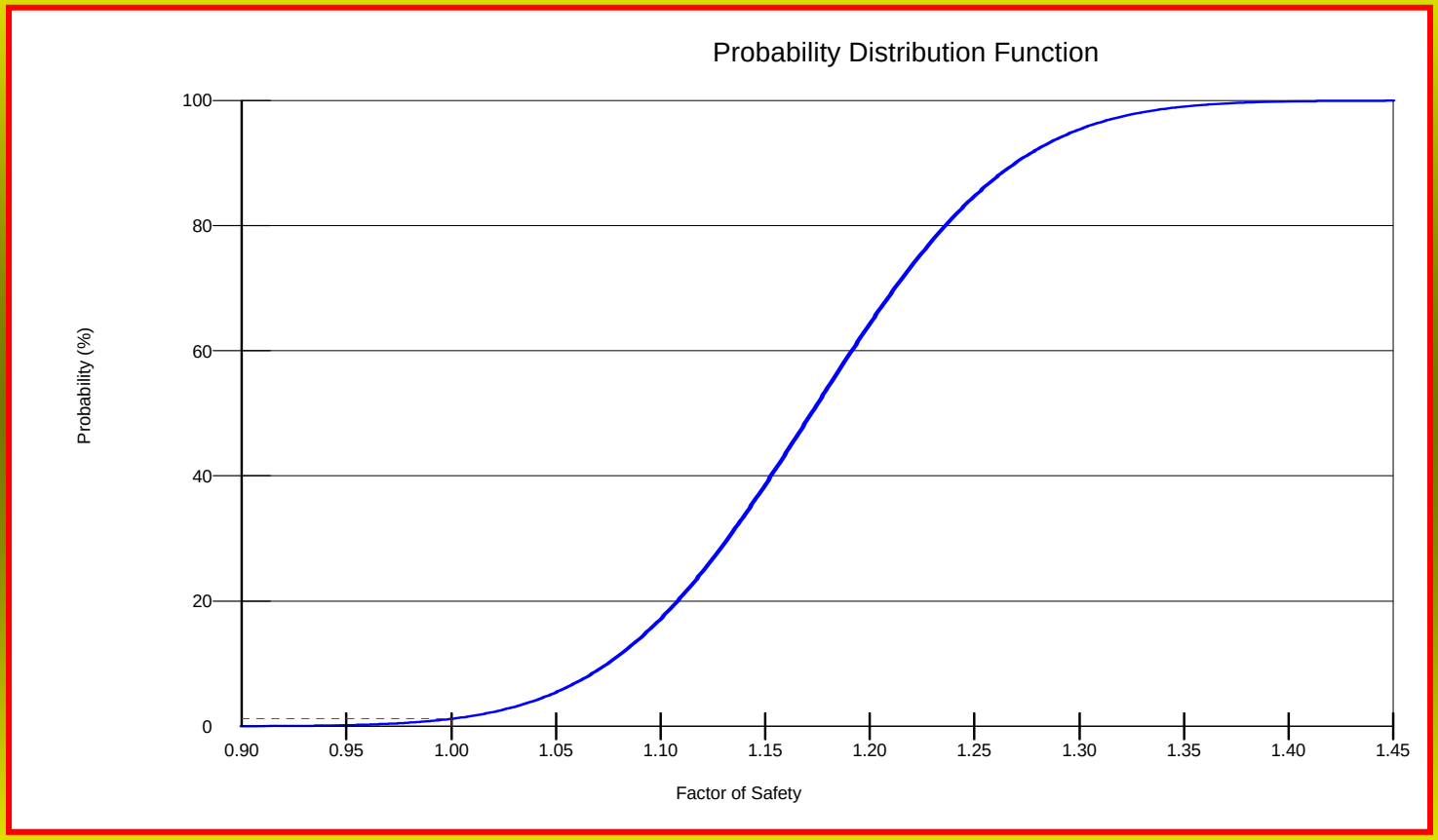
Portal Palmarito Norte Talud con Sismo Estabilizado con anclajes de 30 t (2x 2 m) H = 15m S_h = 0,3



Mean F S=1.172 **Reliability Index=2.245** **P (Failure) (%)=1.232**

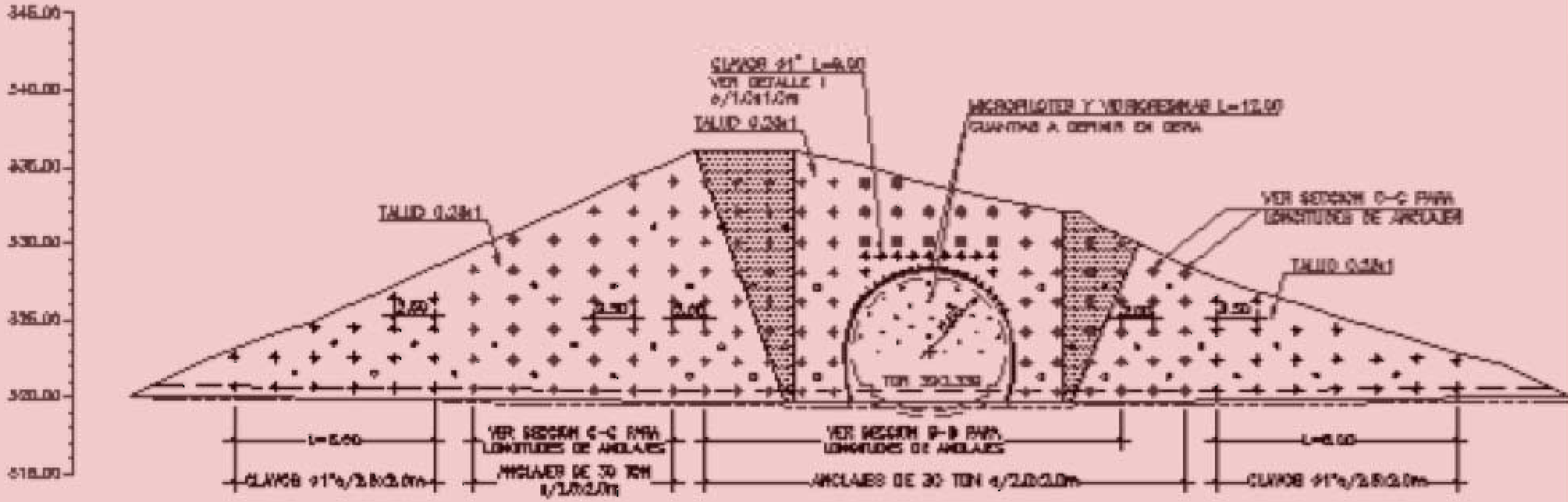
Standard Dev=0.0760 **Min F S=0.941** **Max FS=1.438**

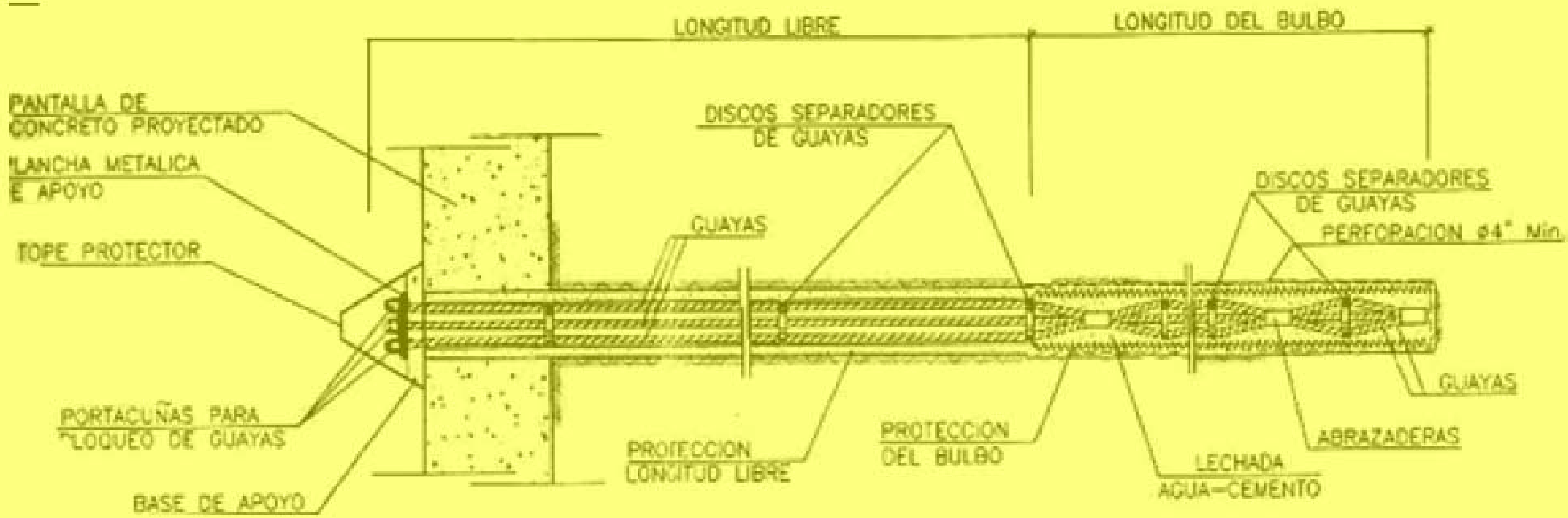
Portal Palmarito Norte Talud con Sismo Estabilizado con anclajes de 30 t (2x 2 m) H = 15m S_h = 0,3



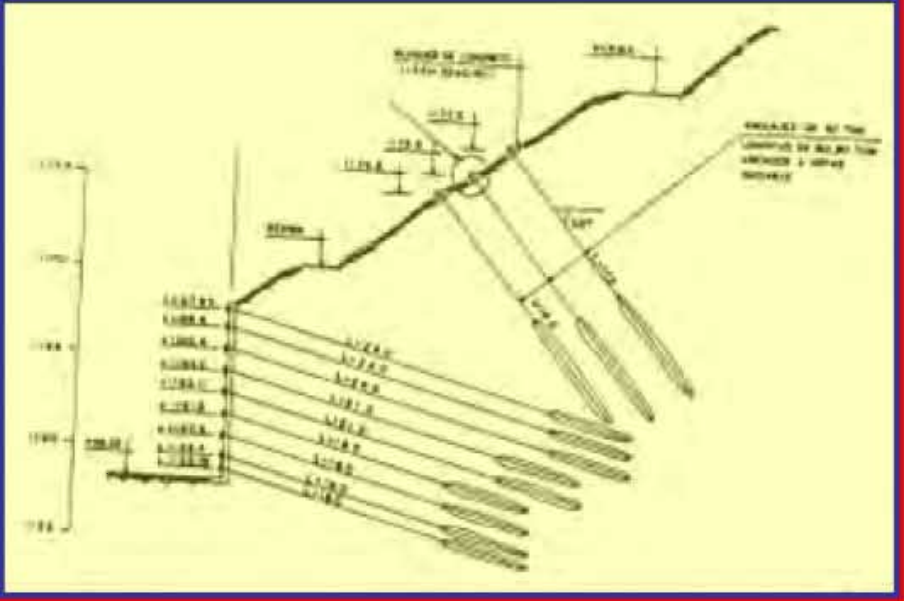
Mean F S=1.172 **Reliability Index=2.245** **P (Failure) (%)=1.232**

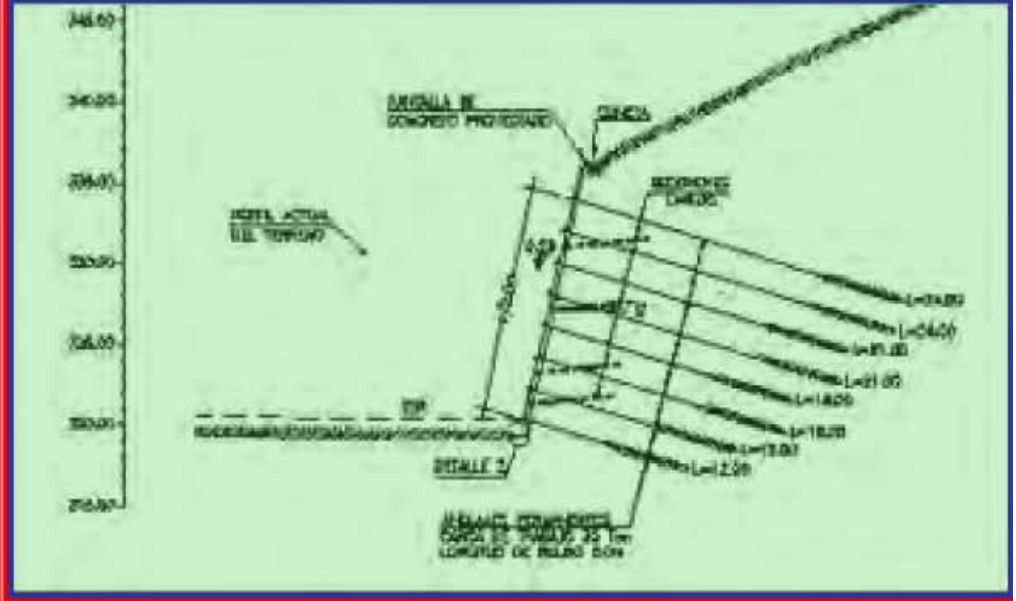
Standard Dev=0.0760 **Min F S=0.941** **Max FS=1.438**

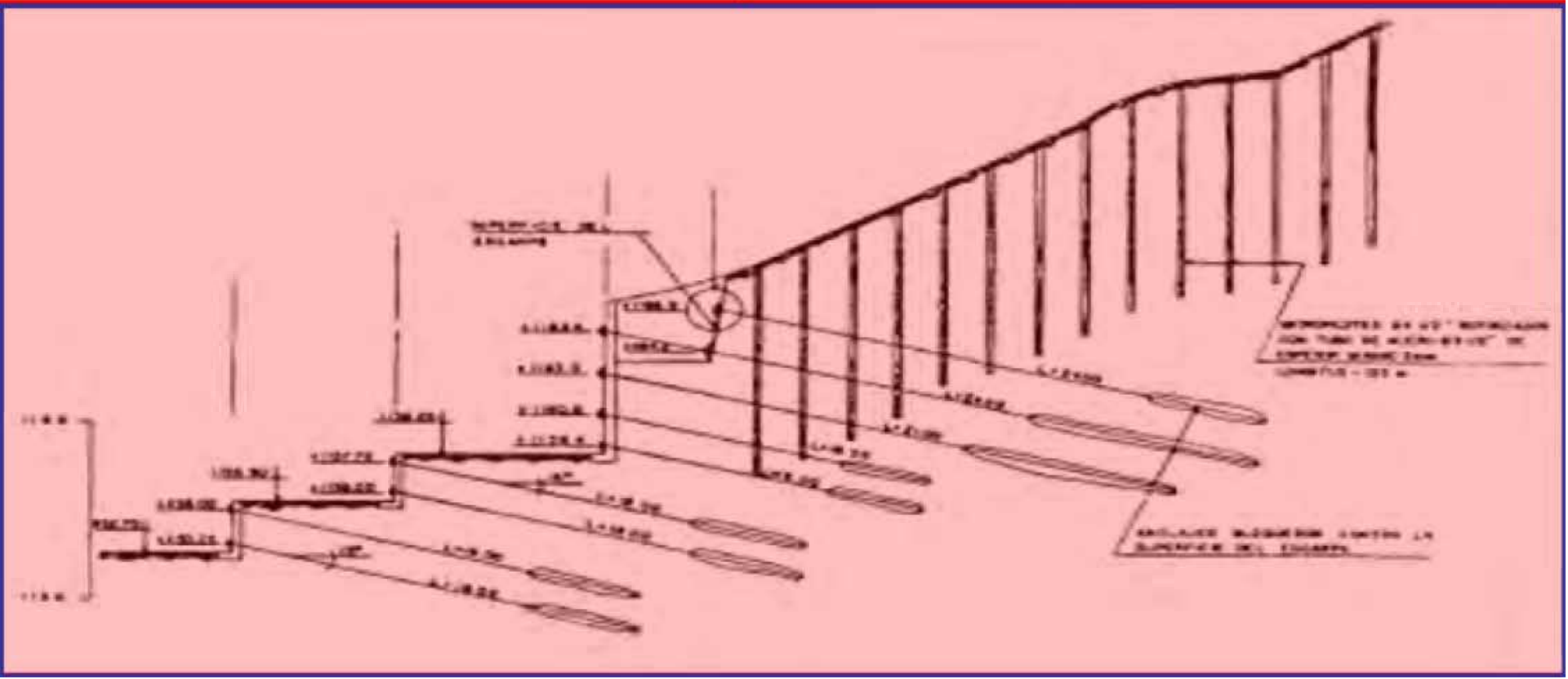


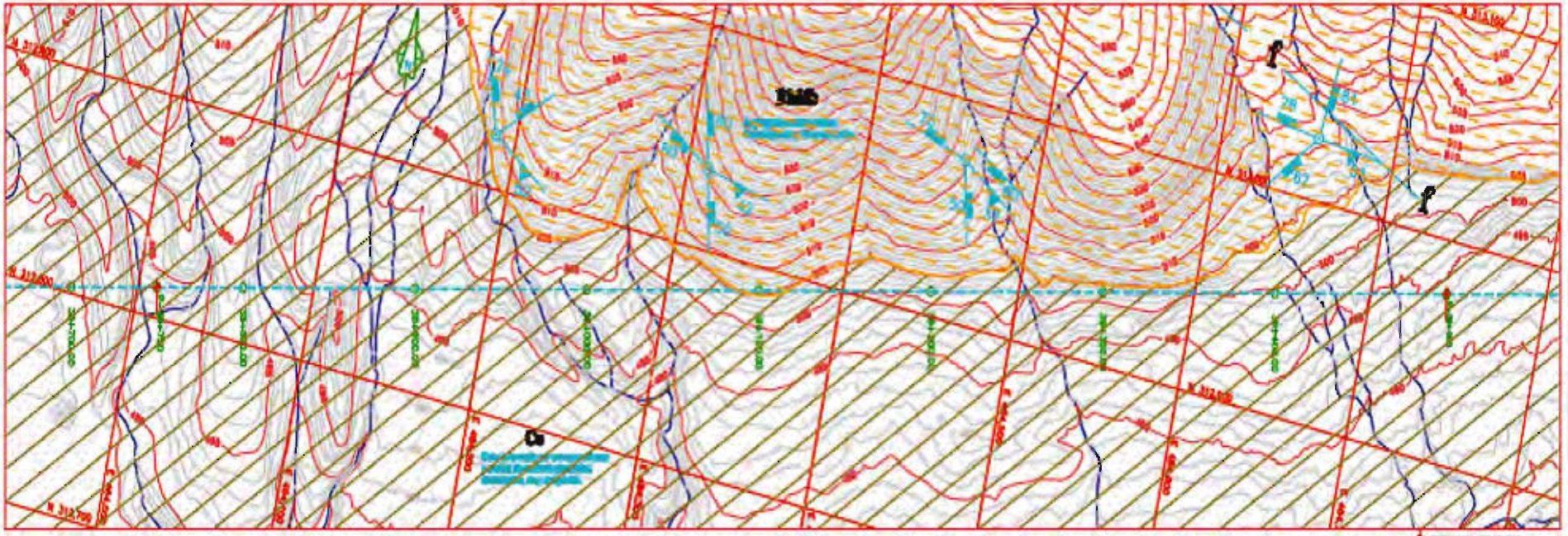


LONGITUD LIBRE
LONGITUD DEL BULBO
PANTALLA DE CONCRETO PROYECTADO
PLANCHA METALICA DE APOYO
TOPE PROTECTOR
DISCOS SEPARADORES DE GUAYAS
GUAYAS
DISCOS SEPARADORES DE GUAYAS
PERFORACION Ø4" Min.
GUAYAS
PORTACUÑAS PARA BLOQUEO DE GUAYAS
BASE DE APOYO
PROTECCION LONGITUD LIBRE
PROTECCION DEL BULBO
LECHADA AGUA-CEMENTO
ABRAZADERAS

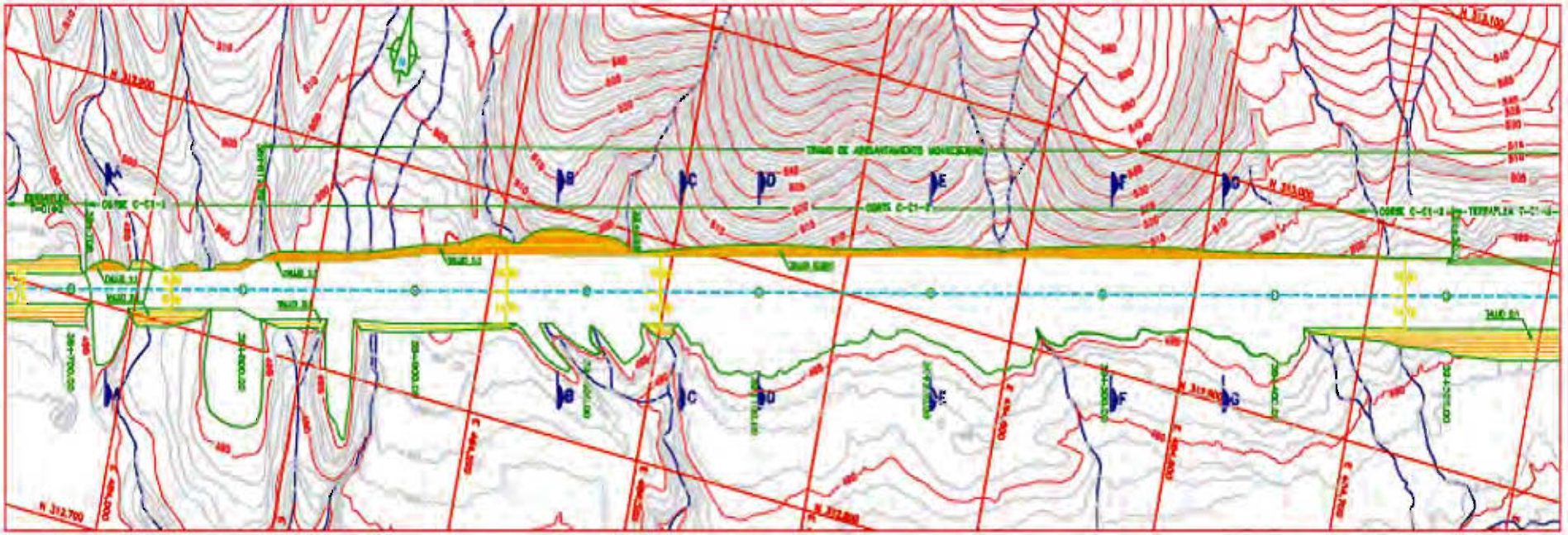




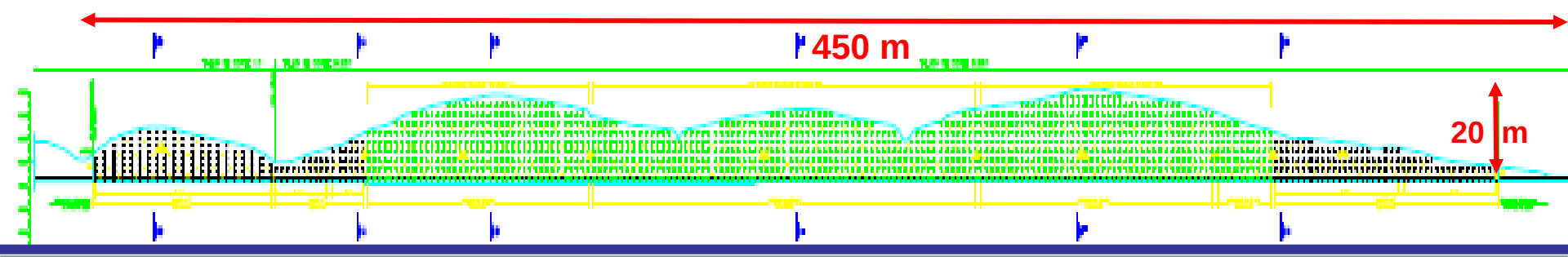


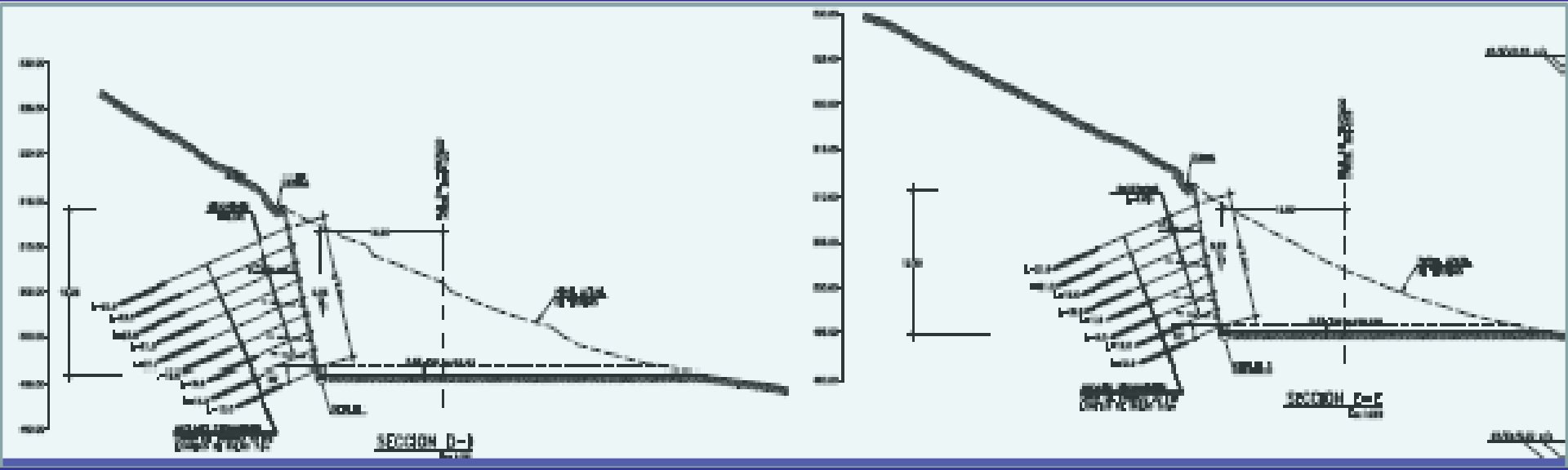


TOPOGRAFIA ACTUAL



TOPOGRAFIA MODIFICADA


450 m
20 m

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