

**OBRA: "PROTECCION SECTORIZADA CONTRA EROSIONES DE LA MARGEN SUR DEL RIO CUARTO". LOCALIDAD DE LA CARLOTA
Dpto. JUAREZ CELMAN -PROVINCIA DE CÓRDOBA**

Generalidades

Las obras propuestas tienen como funciones básicas prevenir el desplazamiento lateral de los márgenes del río en las curvas y estabilizar estructuralmente las obras de infraestructura.

El diseño de las obras tuvo como premisa fundamental estabilizar los taludes sujetos a la continua erosión hidráulica y proteger zonas puntuales a lo largo del tramo urbano del Río Cuarto en la localidad de La Carlota.

MEMORIA TÉCNICA

El proyecto prevé la estabilización del cauce del río en los sitios en donde se han producido erosiones o desplazamientos laterales de los márgenes mediante la construcción de un muro lateral de gaviones y de esta forma fijar en forma definitiva la orilla a proteger.

Para realizar el análisis de estabilidad del muro de gaviones propuesto se utilizó el programa GAWAC WIN 2003- Maccaferri, modelando diferentes alternativas de solución.

Se consideró asimismo la protección contra la erosión local requerida en el pie de los mencionados muros, se adoptó un revestimiento con gaviones colchonetas de 0.30m de espesor de 4.0m de largo, en forma de delantal sobre el fondo del cauce, que resulta eficiente para las solicitaciones en el pie del muro.

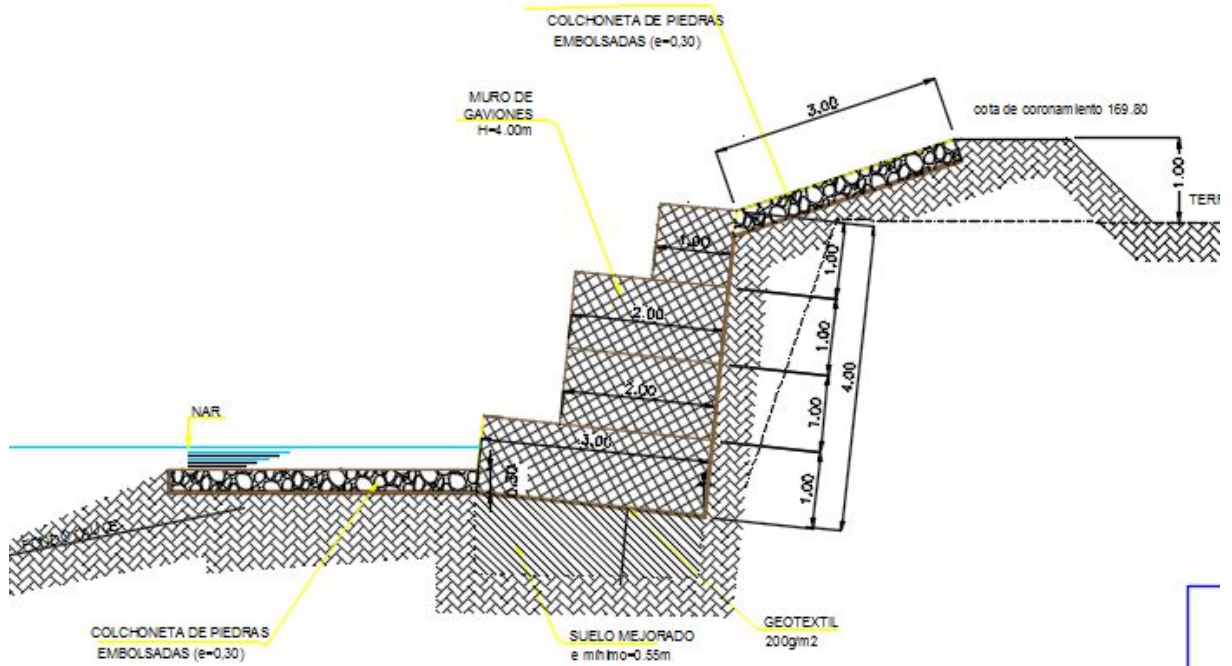
Muros de contención

Se considera la estructura como un muro de gravedad, prescindiendo de la contribución de la parte metálica que proporciona un ulterior coeficiente de seguridad.

Se adjuntan resultados para los muros de 4.0m y 5.0m de altura proyectados.

Las geometrías propuestas verifican las condiciones de servicio. Las secciones originales no verificaron la estabilidad global (Se adjuntan resultados al final del informe).

MURO h = 4.00m Progresivas 0+90.00- 0+400.00



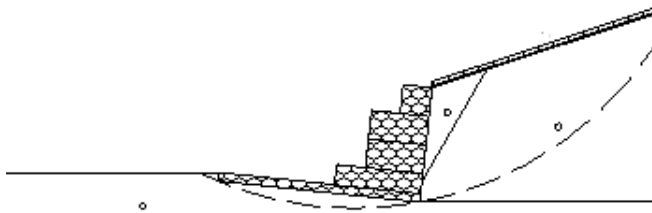
INPUT DATA

Wall data

Wall batter : 6,00 deg
 Rockfill unit weight : 24,20 kN/m³
 Porosity of gabions : 30,00 %
 Geotextile in the backfill : Yes
 Friction reduction : 5,00 %
 Geotextile on the base : Yes
 Friction reduction : 5,00 %

Layer	Length m	Width m	Offset m
1	7,00	0,30	-
2	3,00	0,70	4,00
3	2,00	1,00	5,00
4	2,00	1,00	5,00
5	1,00	1,00	6,00

+



Backfill soil data

Inclination of Stretch 1 : 18,43 deg
 Length of stretch 1 : 10,00 m
 Inclination of Stretch 2 : 0,00 deg
 Soil unit weight : 18,00 kN/m³
 Soil friction angle : 28,00 deg
 Soil cohesion : 0,00 kN/m²

Additional Backfill Layers

Layer	Initial height m	Incl. angle deg	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
1	0,00	60,00	20,00	5,00	28,00

Is not responsible for the reliability of the geotechnical parameters assumed, or the
 improper use of the software. The program takes into account the physical characteristics of materials as
 manufactured by the Maccaferri group. Its results will not be realistic if a different material is used.

Project: pro la carlotta 4
 File: LA_CARLOTTA 4m

Date: 30/12/1899

Foundation data

Top surface height : 0,25 m
 Top surface init. length : 10,00 m
 Top surface incl. angle : 0,00 deg
 Soil unit weight : 18,00 kN/m³
 Soil friction angle : 30,00 deg
 Soil cohesion : 0,00 kN/m²
 Foundation allowable pressure : kN/m²
 Water table height : m

Additional Foundation Layers

Layer	Depth m	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
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Water profile data

Initial height : m
 Inclination of the 1st stretch : deg
 Length of the 1st stretch : m
 Inclination of the 2nd stretch : deg
 Length of the 2nd stretch : m

Loads data

Distributed loads on backfill
 First stretch : 2,00 kN/m²
 Second stretch : 0,00 kN/m²

Distributed loads on wall
 Load : kN/m²

Line loads on backfill

Load 1 : kNm Distance from wall face : m
 Load 2 : kNm Distance from wall face : m
 Load 3 : kNm Distance from wall face : m

Line load on wall

Load : kNm Distance from wall face : m

Seismic action data

Horizontal coefficient : Vertical coefficient :

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Project: pro la carlota 4
 File: LA CARLOTA 4m

Date: 30/12/1899

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	:	32,22 kNm
Point of application ref. to X axis	:	7,13 m
Point of application ref. to Y axis	:	0,87 m
Direction of the thrust ref. to X axis	:	20,80 deg
Passive Thrust	:	2,27 kNm
Point of application ref. to X axis	:	0,01 m
Point of application ref. to Y axis	:	0,10 m
Direction of the thrust ref. to X axis	:	0,00 deg

Sliding

Normal force on the base	:	189,15 kNm
Point of application ref. to X axis	:	5,37 m
Point of application ref. to Y axis	:	-0,58 m
Shear force on the base	:	10,28 kNm
Resisting force on the base	:	95,31 kNm
Sliding Safety Coefficient	:	3,87

Overturning

Overturning Moment	:	26,37 kNm x m
Restoring Moment	:	936,85 kNm x m
Overturning Safety Coefficient	:	35,52

Stresses Acting on Foundation

Eccentricity	:	-1,85 m
Normal stress on outer border	:	21,08 kN/m ²
Normal stress on inner border	:	0,00 kN/m ²
Max. allowable stress on the foundation	:	347,73 kN/m ²
Warning: Not all base is used!		

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Project: pro la carlota 4
 File: LA_CARLOTA 4m

Date: 30/12/1899

Overall Stability

Initial distance at pivot leftside : 3,75 m
 Initial distance at pivot rightside : 5,97 m
 Initial depth referred to base : 0,00 m
 Max. depth allowed in calculation : m
 Center of the arch referred to X axis : 4,65 m
 Center of the arch referred to Y axis : 11,43 m
 Radius of the arch : 12,35 m
 Number of search surfaces : 41

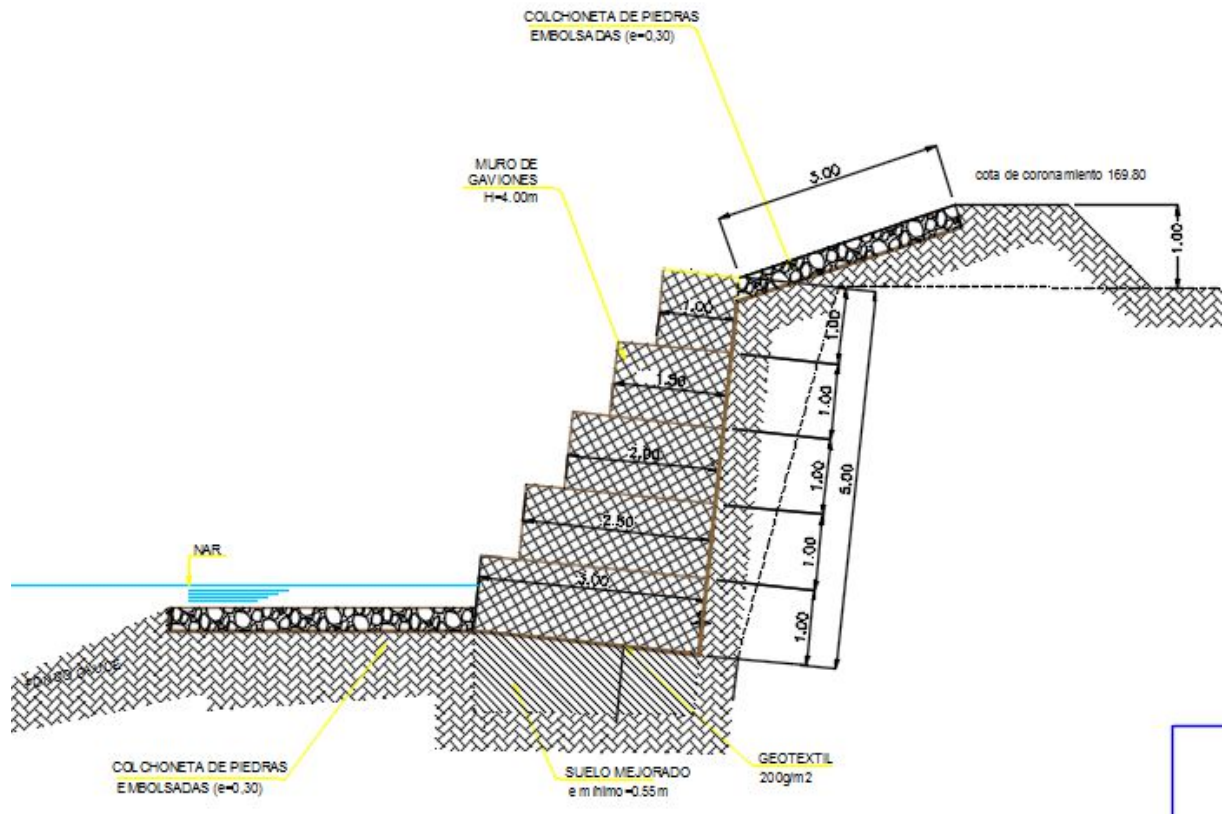
Overall Stability Safety Coefficient : 1,66

Internal Stability

Layer	H m	N kNm	T kNm	M kNm x m	τ_{Max} kN/m ²	τ_{All} kN/m ²	q_{Max} kN/m ²	q_{All} kN/m ²
1	3,68	818,49	-59,89	-906,52	-19,96	198,23	-369,50	
2	2,98	95,74	14,13	104,20	7,06	51,12	43,99	552,79
3	1,99	54,31	2,22	65,91	1,11	37,57	22,38	
4	0,99	16,85	-1,77	9,31	-1,77	30,83	15,24	

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MURO h = 5.00m



 File:

 Project: pro la carlota 5
 File: LA_CARLOTA 5m

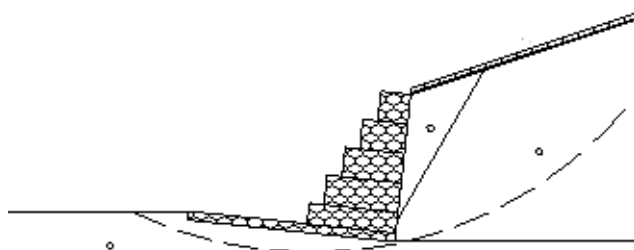
Date: 30/12/1899

INPUT DATA

Wall data

 Wall batter : 6,00 deg
 Rockfill unit weight : 24,20 kN/m³
 Porosity of gabions : 30,00 %
 Geotextile in the backfill : Yes
 Friction reduction : 5,00 %
 Geotextile on the base : Yes
 Friction reduction + : 5,00 %

Layer	Length m	Width m	Offset m
1	7,00	0,30	-
2	3,00	0,70	4,00
3	2,50	1,00	4,50
4	2,00	1,00	5,00
5	1,50	1,00	5,50
6	1,00	1,00	6,00



Backfill soil data

 Inclination of Stretch 1 : 18,43 deg
 Length of stretch 1 : 10,00 m
 Inclination of Stretch 2 : 0,00 deg
 Soil unit weight : 18,00 kN/m³
 Soil friction angle : 28,00 deg
 Soil cohesion : 0,00 kN/m²

Additional Backfill Layers

Layer	Initial height m	Incl. angle deg	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
1	0,00	60,00	20,00	5,00	28,00

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Project: pro la carlotta 5
 File: LA_CARLOTTA 5m

Date: 30/12/1899

Foundation data

Top surface height : 0,25 m
 Top surface init. length : 10,00 m
 Top surface incl. angle : 0,00 deg
 Soil unit weight : 18,00 kN/m³
 Soil friction angle : 30,00 deg
 Soil cohesion : 0,00 kN/m²
 Foundation allowable pressure : kN/m²
 Water table height : m

Additional Foundation Layers

Layer	Depth m	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
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Water profile data

Initial height : m
 Inclination of the 1st stretch : deg
 Length of the 1st stretch : m
 Inclination of the 2nd stretch : deg
 Length of the 2nd stretch : m

Loads data

Distributed loads on backfill
 First stretch : 2,00 kN/m²
 Second stretch : 0,00 kN/m²

Distributed loads on wall
 Load : kN/m²

Line loads on backfill
 Load 1 : kNm Distance from wall face : m
 Load 2 : kNm Distance from wall face : m
 Load 3 : kNm Distance from wall face : m

Line load on wall
 Load : kNm Distance from wall face : m

Seismic action data

Horizontal coefficient : Vertical coefficient :

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Project: pro la carlota 5
 File: LA CARLOTA 5m

Date: 30/12/1899

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	:	57,00 kNm
Point of application ref. to X axis	:	7,15 m
Point of application ref. to Y axis	:	1,05 m
Direction of the thrust ref. to X axis	:	20,60 deg
Passive Thrust	:	2,27 kNm
Point of application ref. to X axis	:	0,01 m
Point of application ref. to Y axis	:	0,10 m
Direction of the thrust ref. to X axis	:	0,00 deg

Sliding

Normal force on the base	:	213,97 kNm
Point of application ref. to X axis	:	5,37 m
Point of application ref. to Y axis	:	-0,56 m
Shear force on the base	:	26,87 kNm
Resisting force on the base	:	119,86 kNm
Sliding Safety Coefficient	:	2,74

Overtuning

Overtuning Moment	:	57,90 kNm \times m
Restoring Moment	:	1209,56 kNm \times m
Overtuning Safety Coefficient	:	20,89

Stresses Acting on Foundation

Eccentricity	:	-1,90 m
Normal stress on outer border	:	26,62 kN/m ²
Normal stress on inner border	:	0,00 kN/m ²
Max. allowable stress on the foundation	:	323,45 kN/m ²
Warning: Not all base is used!		

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 improper use of the software. The program takes into account the physical characteristics of materials as
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Project: pro la carlota 5
 File: LA CARLOTA 5.m

Date: 30/12/1899

Overall Stability

Initial distance at pivot leftside	:	m
Initial distance at pivot rightside	:	m
Initial depth referred to base	:	m
Max depth allowed in calculation	:	m
Center of the arch referred to X axis	:	4,15 m
Center of the arch referred to Y axis	:	12,85 m
Radius of the arch	:	13,95 m
Number of search surfaces	:	43
Overall Stability Safety Coefficient	:	1,53

Internal Stability

Layer	H m	N kNm	T kNm	M kNm x m	τ_{Max} kN/m ²	τ_{All} kN/m ²	σ_{Max} kN/m ²	σ_{All} kN/m ²
1	4,67	861,28	-45,26	-844,53	-15,09	207,56	-439,19	
2	3,98	137,74	27,17	198,25	10,87	55,84	47,85	552,79
3	2,98	85,91	12,21	100,77	6,10	47,90	36,63	
4	1,99	44,54	0,41	40,19	0,27	39,23	24,68	
5	0,99	16,85	-1,77	9,31	-1,77	30,83	15,24	

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Protección erosión local al pie del muro

Ref: "Manual de Ingeniería de ríos- Cap. 13 EROSION EN RIOS Y OBRAS DE PROTECCION- Cap.14- ESTABILIZACION Y RECTIFICACIÓN DE RIOS "- UNAM-1996.

Se considera a la erosión que tiene lugar al pie y en el extremo de las obras que están unidas a la orilla como consecuencia de la deflexión de las líneas de corriente, la turbulencia y vórtices provocados por la presencia del obstáculo.

En este caso se ha protegido la margen construyendo un muro longitudinal, se adopta como solución colocar un delantal de gaviones al pie del muro y sobre el fondo con un ancho no menor que una vez el tirante de la corriente.

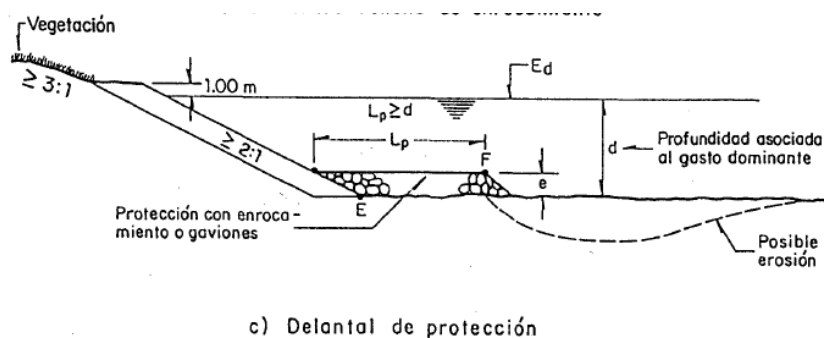


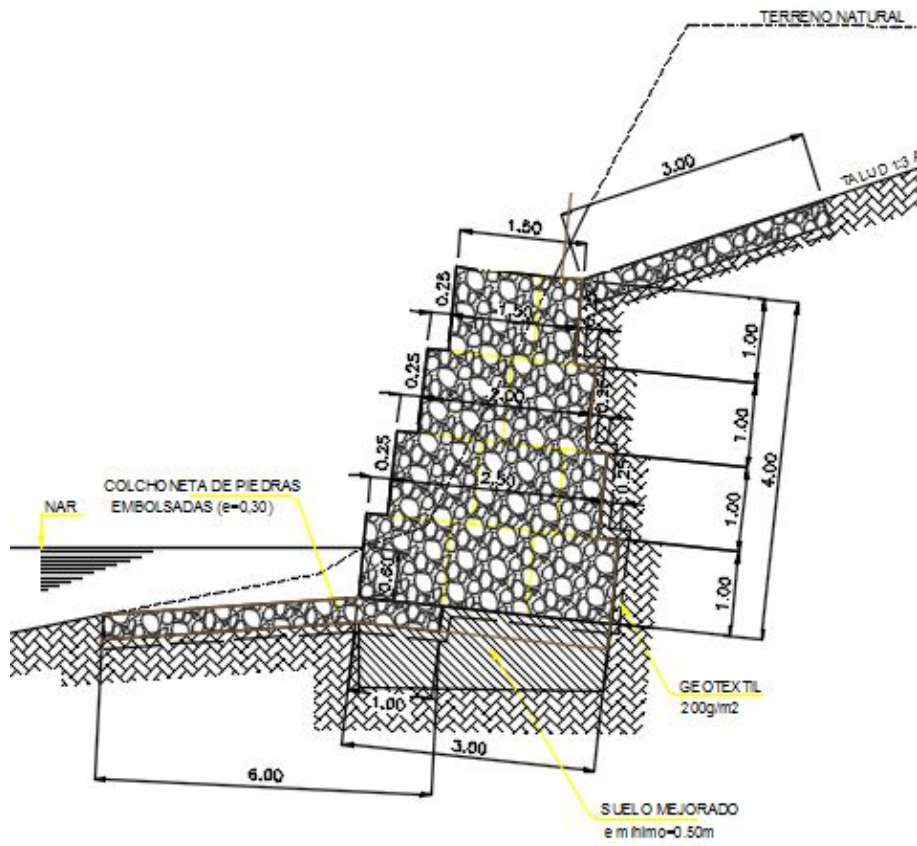
Fig 14.31 Formas de proteger un recubrimiento marginal contra la erosión

Se recomienda D50 de la piedra para el relleno $\approx 0.15m$. Colocado en dos capas como mínimo.

CONCLUSIONES

- Toda obra lineal en márgenes se debe proteger contra la erosión local que puede ocurrir al pie del talud y que es causada por la erosión general y en curvas del propio río.
- La colocación de gaviones colchonetas, actuarán limitando el proceso de socavación del pie del muro, dándoles protección frente a dichos procesos.

Anexo. Verificación muros originales h=4.0m

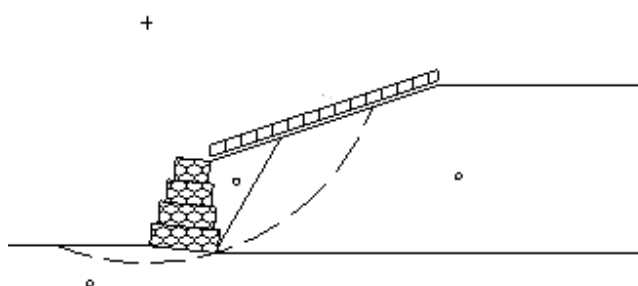


INPUT DATA

Wall data

Wall batter	:	6,00 deg
Rockfill unit weight	:	24,20 kN/m ³
Porosity of gabions	:	30,00 %
Geotextile in the backfill	:	Yes
Friction reduction	:	5,00 %
Geotextile on the base	:	Yes
Friction reduction	:	5,00 %

Layer	Length m	Width m	Offset m
1	3,00	1,00	-
2	2,50	1,00	0,25
3	2,00	1,00	0,50
4	1,50	1,00	0,75



Backfill soil data

Inclination of Stretch 1	:	18,43 deg
Length of stretch 1	:	10,00 m
Inclination of Stretch 2	:	0,00 deg
Soil unit weight	:	18,00 kN/m ³
Soil friction angle	:	28,00 deg
Soil cohesion	:	0,00 kN/m ²

Additional Backfill Layers

Layer	Initial height m	Incl. angle deg	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
1	0,00	60,00	20,00	5,00	28,00

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STABILITY ANALYSIS RESULTS**Active and Passive Thrust**

Active Thrust	:	58,33 kNm
Point of application ref. to X axis	:	2,86 m
Point of application ref. to Y axis	:	1,21 m
Direction of the thrust ref. to X axis	:	31,22 deg
Passive Thrust	:	0,00 kNm
Point of application ref. to X axis	:	0,00 m
Point of application ref. to Y axis	:	0,00 m
Direction of the thrust ref. to X axis	:	0,00 deg

Sliding

Normal force on the base	:	186,90 kNm
Point of application ref. to X axis	:	1,50 m
Point of application ref. to Y axis	:	-0,16 m
Shear force on the base	:	30,51 kNm
Resisting force on the base	:	102,51 kNm
Sliding Safety Coefficient	:	2,55

Overtuning

Overtuning Moment	:	60,33 kNm x m
Restoring Moment	:	340,75 kNm x m
Overtuning Safety Coefficient	:	5,65

Stresses Acting on Foundation

Eccentricity	:	-0,01 m
Normal stress on outer border	:	62,27 kN/m ²
Normal stress on inner border	:	62,33 kN/m ²
Max. allowable stress on the foundation	:	124,82 kN/m ²

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 Program released in license to: MUNICIPALIDAD DE CORDOBA

 Project: pro la carlota 4 m original
 File: LA CARLOTA 4 m original

Date: 30/12/1899

Overall Stability

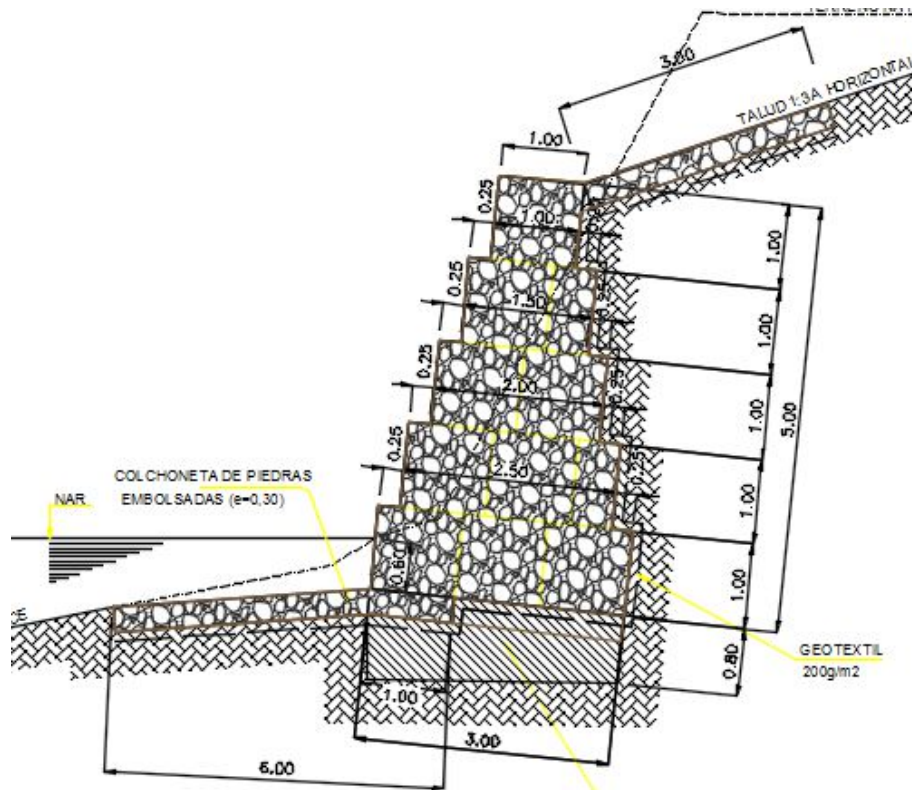
Initial distance at pivot leftside : 3,75 m
 Initial distance at pivot rightside : 7,46 m
 Initial depth referred to base : 0,00 m
 Max depth allowed in calculation : m
 Center of the arch referred to X axis : -0,10 m
 Center of the arch referred to Y axis : 9,82 m
 Radius of the arch : 10,60 m
 Number of search surfaces : 44
Overall Stability Safety Coefficient : 1,47

Internal Stability

Layer	H m	N kNm	T kNm	M kNm x m	q_{MAX} kN/m ²	τ_{All} kN/m ²	q_{MAX} kN/m ²	τ_{All} kN/m ²
1	3,04	121,84	17,81	159,95	7,04	51,63	46,25	552,79
2	2,02	62,33	-1,16	67,71	-0,58	40,19	28,69	
3	0,99	25,27	-2,66	20,28	-1,77	30,83	15,74	

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Verificación muros originales h=5.0m



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Project: pro la carlota 5 moriginal
File: LA CARLOTA 5.moriginal

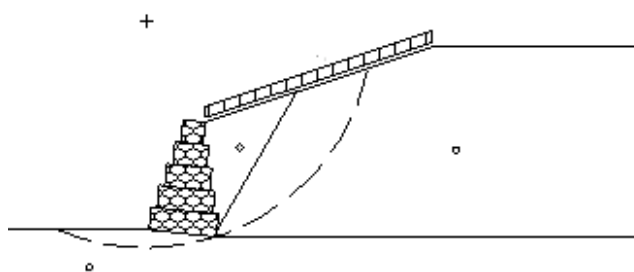
Date: 30/12/1899

INPUT DATA

Wall data

Wall batter : 6,00 deg
Rockfill unit weight : 24,20 kN/m³
Porosity of gabions : 30,00 %
Geotextile in the backfill : Yes
Friction reduction : 5,00 %
Geotextile on the base : Yes
Friction reduction : 5,00 %

Layer	Length m	Width m	Offset m
1	3,00	1,00	-
2	2,50	1,00	0,25
3	2,00	1,00	0,50
4	1,50	1,00	0,75
5	1,00	1,00	1,00



Backfill soil data

Inclination of Stretch 1 : 18,43 deg
Length of stretch 1 : 10,00 m
Inclination of Stretch 2 : 0,00 deg
Soil unit weight : 18,00 kN/m³
Soil friction angle : 28,00 deg
Soil cohesion : 0,00 kN/m²

Additional Backfill Layers

Layer	Initial height m	Incl. angle deg	Unit weight kN/m ³	Cohesion kN/m ²	Friction angle deg
1	0,00	60,00	20,00	5,00	28,00

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Program released in license to: MUNICIPALIDAD DE COCOCOA

Project: pro la carlota 5 moriginal

File: LA CARLOTA 5.moriginal

Date: 30/12/1899

Overall Stability

Initial distance at pivot leftside : 3,75 m
 Initial distance at pivot rightside : 7,46 m
 Initial depth referred to base : 0,00 m
 Max depth allowed in calculation : m
 Center of the arch referred to X axis : -0,06 m
 Center of the arch referred to Y axis : 9,21 m
 Radius of the arch : 10,06 m
 Number of search surfaces : 45

Overall Stability Safety Coefficient : **1,31**

Internal Stability

Layer	H m	N kNm	T kNm	M kNm x m	T_{Max} kNm/m	T_{All} kNm/m	Q_{Max} kNm/m	C_{All} kNm/m
1	4,06	159,16	41,88	187,56	16,75	61,44	67,53	
2	3,04	92,41	14,83	93,33	7,42	50,03	45,76	552,79
3	2,02	44,92	-0,22	36,64	-0,15	39,40	27,54	
4	0,99	16,85	-1,77	9,31	-1,77	30,83	15,24	

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