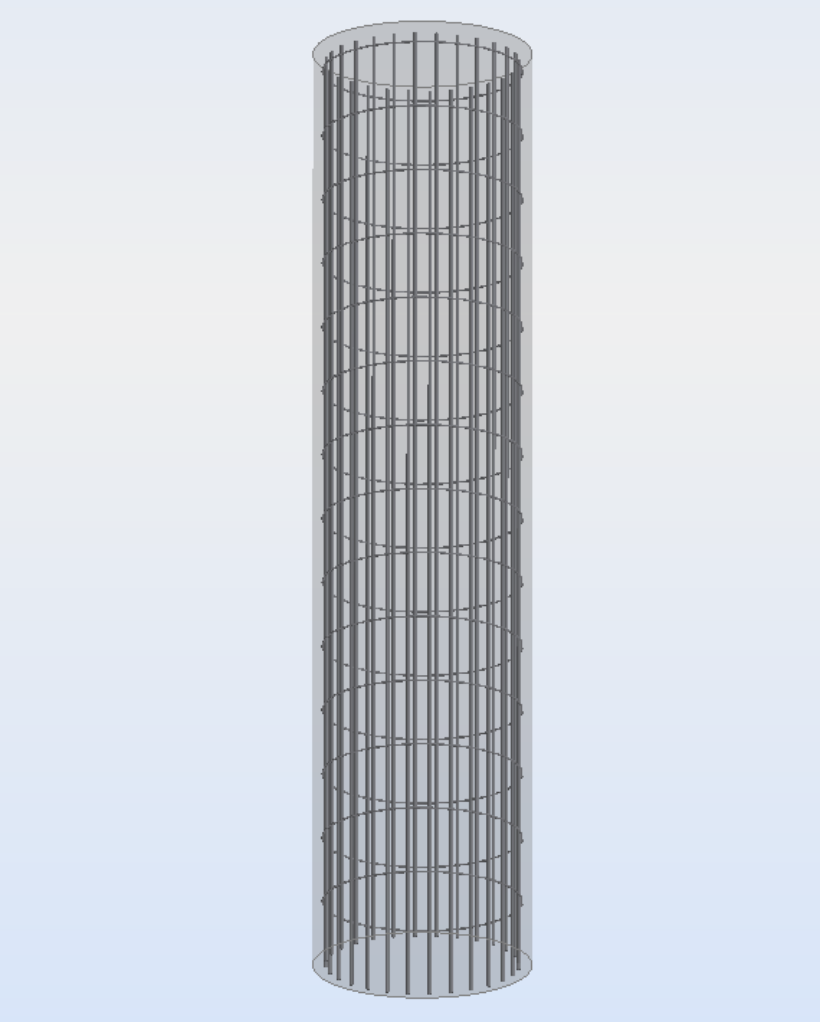
ANEXO D
MEMORIAS DE CÁLCULO
DISEÑO DEL CAISSON TIPO



CALCULATION REPORT - PILE VERIFICATION

INPUT DATA

Project

Task : DISEÑO MURO DE CONTENCION EN CONCRETO REFORZADO
Descript. : COLEGIO RURAL PALMIRA - M/PIO DE SAN VICENTE DE CHUCURÍ (S/DER)
Author : ING. GUILLERMO GALINDO GUERRERO – ING. GLAUDIA PATRICIA RINCON M.

Date : 15/10/2015

Settings

(input for current task)

Materials and standards

Concrete structures : ACI 318-11

Piles

Safety factors			
Permanent design situation			
Safety factor for compressive pile :	SF_{cp} =	2.00	[–]
Safety factor for tensile pile :	SF_{tp} =	3.00	[–]

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]	ν [–]
1	SUELO COLUVIAL		20.00	10.00	18.00	0.45
2	MACIZO ROCOSO (Ksu)		11.65	71.00	19.10	0.30

All soils are considered as cohesionless for at rest pressure analysis.

No.	Name	Pattern	E_{oed} [MPa]	E_{def} [MPa]	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	SUELO COLUVIAL		-	5.00	20.00	-	-
2	MACIZO ROCOSO (Ksu)		-	71.00	22.30	-	-

Parameters of soils to compute modulus of subsoil reaction

No.	Name	Pattern	Type of soil	n_h [MN/m³]
1	SUELO COLUVIAL		cohesive	-
2	MACIZO ROCOSO (Ksu)		cohesive	-

Soil parameters

SUELO COLUVIAL

Unit weight : γ = 18.00 kN/m³
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 10.00 kPa
Poisson's ratio : ν = 0.45
Deformation modulus : E_{def} = 5.00 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m³
Type of soil : cohesive

MACIZO ROCOSO (Ksu)

Unit weight :	γ	=	19.10 kN/m^3
Angle of internal friction :	φ_{ef}	=	11.65 °
Cohesion of soil :	c_{ef}	=	71.00 kPa
Poisson's ratio :	ν	=	0.30
Deformation modulus :	E_{def}	=	71.00 MPa
Saturated unit weight :	γ_{sat}	=	22.30 kN/m^3
Type of soil :	cohesive		

Geometry

Pile profile: circular

Dimensions

Diameter d = 1.00 m
Length l = 4.00 m

Location

Off ground height h = 0.00 m
Depth of finished grade h_z = 0.00 m

Technology

Piles with excavation of soil from a bore hole
Pile type: user-defined
Base resistance reduction = 0.80
Skin resistance reduction = 0.60

Modulus of subsoil reaction considered according to CSN 731004.

Material of structure

Unit weight γ = 24.00 kN/m^3
Analysis of concrete structures carried out according to the standard ACI 318-11.

Concrete:	Concrete ACI		
Compressive strength	$f_{c'}$	= 21.00	MPa
Tensile-bending strength	f_r	= 2.85	MPa
Elasticity modulus	E_{cm}	= 21689.22	MPa
Shear modulus	G	= 9109.47	MPa

Longitudinal steel : 3G_ACERO
Tensile strength f_y = 420.00 MPa

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	0.50	SUELO COLUVIAL	
2	5.50	MACIZO ROCOSO (Ksu)	
3	-	MACIZO ROCOSO (Ksu)	

Load

No.	Load		Name	Type	N	M_x	M_y	H_x	H_y
	new	change			[kN]	[kNm]	[kNm]	[kN]	[kN]
1	YES		CORTANTE TALUD	Design	0.00	0.00	0.00	350.00	0.00
2	YES		CARGA TRANSMITIDA	Design	400.00	0.00	0.00	333.00	0.00

Ground water table

The ground water table is at a depth of 5.00 m from the original terrain.

Negative skin friction

Terrain settlement w = 12.7 mm
Influence zone depth h = 1.83 m

Global settings

Analysis of vertical bearing capacity : spring method
Analysis type : analysis for drained conditions

Settings of the stage of construction

Design situation : permanent
Verification methodology : without reduction of soil parameters

Verification No. 1

Input data

Maximum displacement 25.0 mm
Coeff. of increase of limit skin friction due to technology 1

Depth of influence zone is post-computed.

Load transfer curve

No.	Load [kN]	Settlement [mm]
1	0.00	0.0
2	236.91	1.6
3	375.86	2.9
4	561.56	4.7
5	830.87	7.7
6	1019.10	10.1
7	1088.18	11.1
8	1101.08	11.3
9	1111.97	11.5
10	1120.86	11.8
11	1127.74	12.0
12	1388.85	25.0

Loading Q = 400.00 kN yields pile settlement 3.1 mm, depth of influence zone below the pile base is 1.23 m (1.226 x D)
Analysis for load F = 236.91 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	236.91	1.00	0.00	0.00
0.40	235.33	0.99	1.58	0.01
0.80	224.46	0.95	12.45	0.05
1.20	210.29	0.89	26.62	0.11
1.60	196.14	0.83	40.77	0.17
2.00	182.00	0.77	54.91	0.23
2.40	167.87	0.71	69.04	0.29
2.80	153.74	0.65	83.17	0.35
3.20	139.61	0.59	97.30	0.41
3.60	125.48	0.53	111.43	0.47

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
4.00	111.35	0.47	125.56	0.53

Analysis for load F = 375.86 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	375.86	1.00	0.00	0.00
0.40	372.99	0.99	2.87	0.01
0.80	362.12	0.96	13.75	0.04
1.20	336.33	0.89	39.54	0.11
1.60	310.57	0.83	65.29	0.17
2.00	284.85	0.76	91.01	0.24
2.40	259.13	0.69	116.73	0.31
2.80	233.42	0.62	142.44	0.38
3.20	207.70	0.55	168.16	0.45
3.60	181.98	0.48	193.88	0.52
4.00	156.28	0.42	219.59	0.58

Analysis for load F = 561.56 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	561.56	1.00	0.00	0.00
0.40	558.68	0.99	2.87	0.01
0.80	547.81	0.98	13.75	0.02
1.20	505.66	0.90	55.90	0.10
1.60	463.58	0.83	97.98	0.17
2.00	421.51	0.75	140.04	0.25
2.40	379.46	0.68	182.10	0.32
2.80	337.42	0.60	224.14	0.40
3.20	295.38	0.53	266.18	0.47
3.60	253.34	0.45	308.22	0.55
4.00	211.30	0.38	350.25	0.62

Analysis for load F = 830.87 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	830.87	1.00	0.00	0.00
0.40	828.00	1.00	2.87	0.00
0.80	817.12	0.98	13.75	0.02
1.20	774.97	0.93	55.90	0.07
1.60	705.81	0.85	125.06	0.15
2.00	636.68	0.77	194.19	0.23
2.40	567.58	0.68	263.29	0.32
2.80	498.48	0.60	332.39	0.40
3.20	429.37	0.52	401.50	0.48
3.60	360.25	0.43	470.61	0.57
4.00	291.17	0.35	539.69	0.65

Analysis for load F = 1019.10 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1019.10	1.00	0.00	0.00
0.40	1016.23	1.00	2.87	0.00
0.80	1005.35	0.99	13.75	0.01
1.20	963.20	0.95	55.90	0.05
1.60	894.04	0.88	125.06	0.12
2.00	803.22	0.79	215.88	0.21
2.40	712.40	0.70	306.70	0.30
2.80	621.59	0.61	397.51	0.39
3.20	530.78	0.52	488.32	0.48
3.60	439.97	0.43	579.13	0.57
4.00	349.16	0.34	669.94	0.66

Analysis for load F = 1088.18 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1088.18	1.00	0.00	0.00
0.40	1085.31	1.00	2.87	0.00
0.80	1074.43	0.99	13.75	0.01
1.20	1032.28	0.95	55.90	0.05
1.60	963.12	0.89	125.06	0.11
2.00	872.30	0.80	215.88	0.20
2.40	772.34	0.71	315.84	0.29
2.80	672.38	0.62	415.80	0.38
3.20	572.42	0.53	515.76	0.47
3.60	472.46	0.43	615.72	0.57
4.00	372.51	0.34	715.68	0.66

Analysis for load F = 1101.08 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1101.08	1.00	0.00	0.00
0.40	1098.21	1.00	2.87	0.00
0.80	1087.33	0.99	13.75	0.01
1.20	1045.18	0.95	55.90	0.05
1.60	976.02	0.89	125.06	0.11
2.00	885.20	0.80	215.88	0.20
2.40	785.24	0.71	315.84	0.29
2.80	683.30	0.62	417.78	0.38
3.20	581.36	0.53	519.72	0.47
3.60	479.42	0.44	621.66	0.56
4.00	377.48	0.34	723.60	0.66

Analysis for load F = 1111.97 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1111.97	1.00	0.00	0.00

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.40	1109.10	1.00	2.87	0.00
0.80	1098.23	0.99	13.75	0.01
1.20	1056.08	0.95	55.90	0.05
1.60	986.91	0.89	125.06	0.11
2.00	896.09	0.81	215.88	0.19
2.40	796.13	0.72	315.84	0.28
2.80	694.19	0.62	417.78	0.38
3.20	590.27	0.53	521.70	0.47
3.60	486.35	0.44	625.62	0.56
4.00	382.44	0.34	729.54	0.66

Analysis for load F = 1120.86 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1120.86	1.00	0.00	0.00
0.40	1117.99	1.00	2.87	0.00
0.80	1107.11	0.99	13.75	0.01
1.20	1064.96	0.95	55.90	0.05
1.60	995.80	0.89	125.06	0.11
2.00	904.98	0.81	215.88	0.19
2.40	805.02	0.72	315.84	0.28
2.80	703.08	0.63	417.78	0.37
3.20	599.16	0.53	521.70	0.47
3.60	493.26	0.44	627.60	0.56
4.00	387.36	0.35	733.50	0.65

Analysis for load F = 1127.74 kN

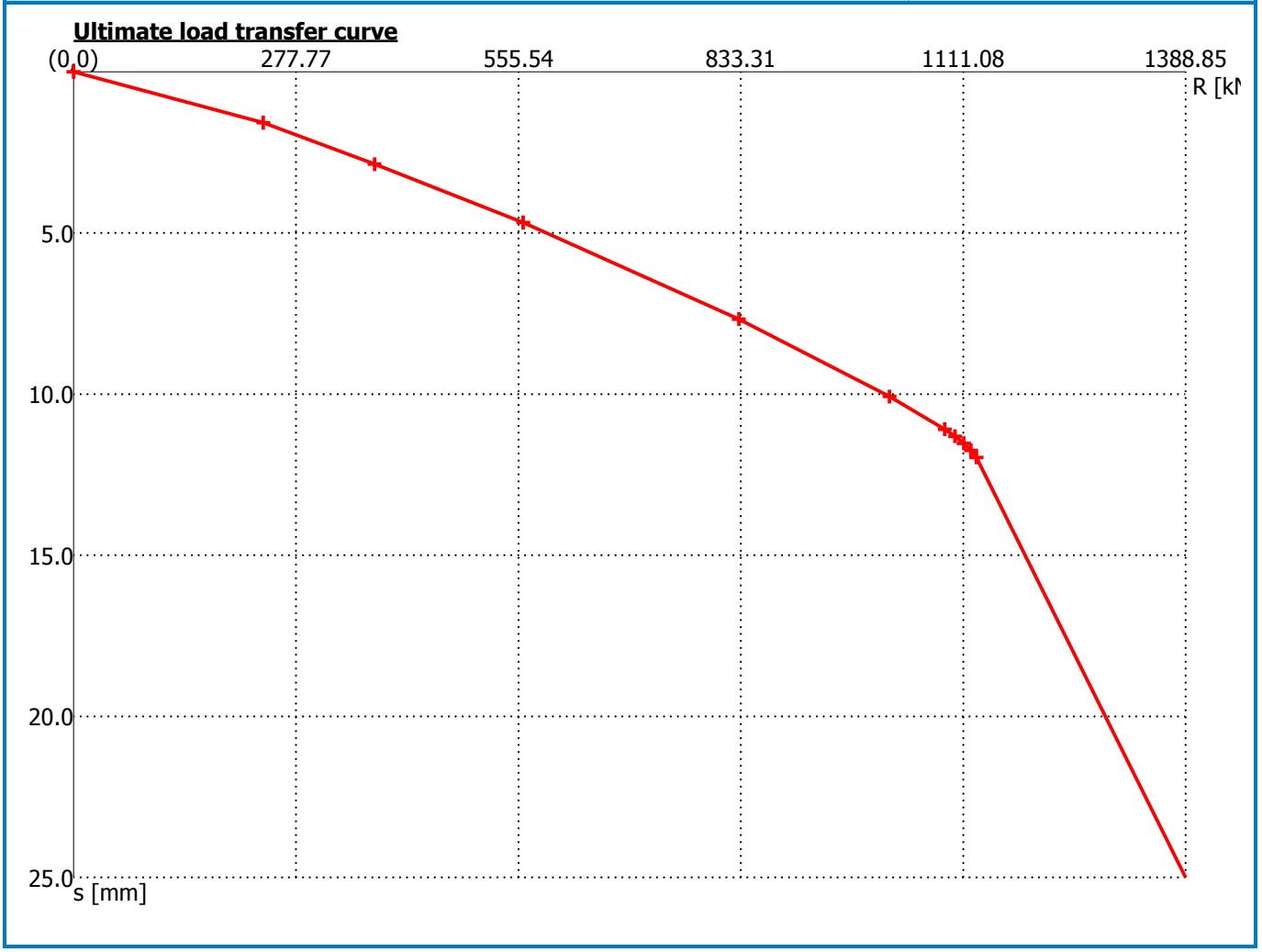
x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0.00	1127.74	1.00	0.00	0.00
0.40	1124.87	1.00	2.87	0.00
0.80	1114.00	0.99	13.75	0.01
1.20	1071.85	0.95	55.90	0.05
1.60	1002.68	0.89	125.06	0.11
2.00	911.86	0.81	215.88	0.19
2.40	811.90	0.72	315.84	0.28
2.80	709.96	0.63	417.78	0.37
3.20	606.04	0.54	521.70	0.46
3.60	500.14	0.44	627.60	0.56
4.00	392.27	0.35	735.48	0.65

Shear - deformation dependence at a depth of 4.00m

No.	Displacement [mm]	Shear [kPa]
1	0.0	0.00
2	1.6	11.24
3	2.9	20.46

No.	Displacement [mm]	Shear [kPa]
4	4.7	33.45
5	7.7	54.97
6	10.1	72.26
7	11.1	79.54
8	11.3	81.12
9	11.5	82.70
10	11.8	84.27
11	12.0	85.85
12	25.0	85.85

Name : Vert. Cap. (springs) | **Stage : 1; Verification : 1**



Verification No. 1

Input data to compute pile horizontal bearing capacity

Analysis carried out with automatic selection of the most unfavourable load cases.
Horizontal bearing capacity verified in the direction of maximum load effect.

Distributions of internal forces and displacement of pile

Pile displacements and internal forces distributions - maximum values

Dist. [m]	Modulus k [MN/m³]	Displacement [mm]	Rotat. [mRad]	Stress [kPa]	Shear Force [kN]	Moment [kNm]
0.00	0.00	12.36	4.85	41.20	350.00	0.00
0.20	3.33	11.39	4.85	37.97	342.08	69.20
0.40	3.33	10.42	4.83	149.39	334.81	136.88
0.50	3.33	9.94	4.81	246.55	309.63	167.80
0.50	47.33	9.94	4.81	246.55	309.63	167.80
0.60	47.33	9.46	4.80	343.71	284.45	198.72
0.80	47.33	8.50	4.75	402.57	199.42	246.96
1.00	47.33	7.56	4.70	357.80	123.39	279.09
1.20	47.33	6.62	4.65	313.52	56.27	296.91
1.40	47.33	5.70	4.59	269.77	2.06	302.18
1.60	47.33	4.79	4.54	226.56	51.68	296.66
1.80	47.33	3.88	4.48	183.87	92.71	282.08
2.00	47.33	2.99	4.43	141.69	125.26	260.14
2.20	47.33	2.11	4.38	99.96	149.42	232.54
2.40	47.33	1.24	4.34	58.65	165.28	200.93
2.60	47.33	0.37	4.31	17.70	172.90	166.97
2.80	47.33	0.49	4.28	22.96	172.37	132.31
3.00	47.33	1.34	4.26	63.39	163.74	98.57
3.20	47.33	2.19	4.24	103.63	147.03	67.36
3.40	47.33	3.04	4.23	143.76	122.29	40.29
3.60	47.33	3.88	4.23	183.81	89.53	18.97
3.80	47.33	4.73	4.23	223.83	48.77	5.01
4.00	47.33	5.57	4.23	263.84	0.00	0.00

Pile displacements and internal forces distributions - minimum values

Dist. [m]	Modulus k [MN/m³]	Displacement [mm]	Rotat. [mRad]	Stress [kPa]	Shear Force [kN]	Moment [kNm]
0.00	0.00	-12.36	-4.85	-41.20	-350.00	-0.00
0.20	3.33	-11.39	-4.85	-37.97	-342.08	-69.20
0.40	3.33	-10.42	-4.83	-149.39	-334.81	-136.88
0.50	3.33	-9.94	-4.81	-246.55	-309.63	-167.80
0.50	47.33	-9.94	-4.81	-246.55	-309.63	-167.80
0.60	47.33	-9.46	-4.80	-343.71	-284.45	-198.72
0.80	47.33	-8.50	-4.75	-402.57	-199.42	-246.96
1.00	47.33	-7.56	-4.70	-357.80	-123.39	-279.09
1.20	47.33	-6.62	-4.65	-313.52	-56.27	-296.91
1.40	47.33	-5.70	-4.59	-269.77	-2.06	-302.18
1.60	47.33	-4.79	-4.54	-226.56	-51.68	-296.66
1.80	47.33	-3.88	-4.48	-183.87	-92.71	-282.08
2.00	47.33	-2.99	-4.43	-141.69	-125.26	-260.14
2.20	47.33	-2.11	-4.38	-99.96	-149.42	-232.54
2.40	47.33	-1.24	-4.34	-58.65	-165.28	-200.93
2.60	47.33	-0.37	-4.31	-17.70	-172.90	-166.97
2.80	47.33	-0.49	-4.28	-22.96	-172.37	-132.31
3.00	47.33	-1.34	-4.26	-63.39	-163.74	-98.57
3.20	47.33	-2.19	-4.24	-103.63	-147.03	-67.36
3.40	47.33	-3.04	-4.23	-143.76	-122.29	-40.29
3.60	47.33	-3.88	-4.23	-183.81	-89.53	-18.97

Dist. [m]	Modulus k [MN/m3]	Displacement [mm]	Rotat. [mRad]	Stress [kPa]	Shear Force [kN]	Moment [kNm]
3.80	47.33	-4.73	-4.23	-223.83	-48.77	-5.01
4.00	47.33	-5.57	-4.23	-263.84	-0.00	-0.00

Maximum internal force and deformation :

Max. pile displacement = 12.4 mm
Max. shear force = 350.00 kN
Maximum moment = 302.18 kNm

Dimensioning of reinforcement:

Reinforcement - 28 pc bar No. 6; covering 40.0 mm
Type of structure (reinforcement ratio) : column

Reinforcement ratio ρ = 1.016 % > 1.000 % = ρ_{min}

Load : P_u = 0.00 kN (tension) ; M_u = 302.18 kNm
Bearing capacity : ϕP_n = 0.00 kN; ϕM_n = 1178.73 kNm

Designed pile reinforcement is SATISFACTORY

Name : Horizontal Cap.	Stage : 1; Verification : 1

