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Appendix I
Bamboo as concrete reinforcement in hydroelectric structures

The hydroelectric structures in the construction industry have a great impact on the environment as one of the main consumers of energy and materials. Hydroelectric structures consume large amounts of concrete and steel due to their big cross-sections (Figure AI.1) in slabs, walls, beams, columns and dams. After modelling and analysing several hydroelectric structures (Figures below) at the MEK engineering company, it can be concluded that the use of big dimensions (Table AI.1-AI.12) in the structural elements come mainly from the need to avoid the fluctuation of the structures and not from the applied loads. This is a possible and common solution increasing the geometrical dimensions of the structural elements (more mass). This leads to lower tension in the structural elements due to their high rigidity (Figure AI.2), and therefore less steel reinforcement is required (in more of the cases the minimum reinforcement recommended for the standard codes is required). This basic concept related to the loads, tension, fluctuation, weight and dimensions is schematically explained in Figure AI.2.

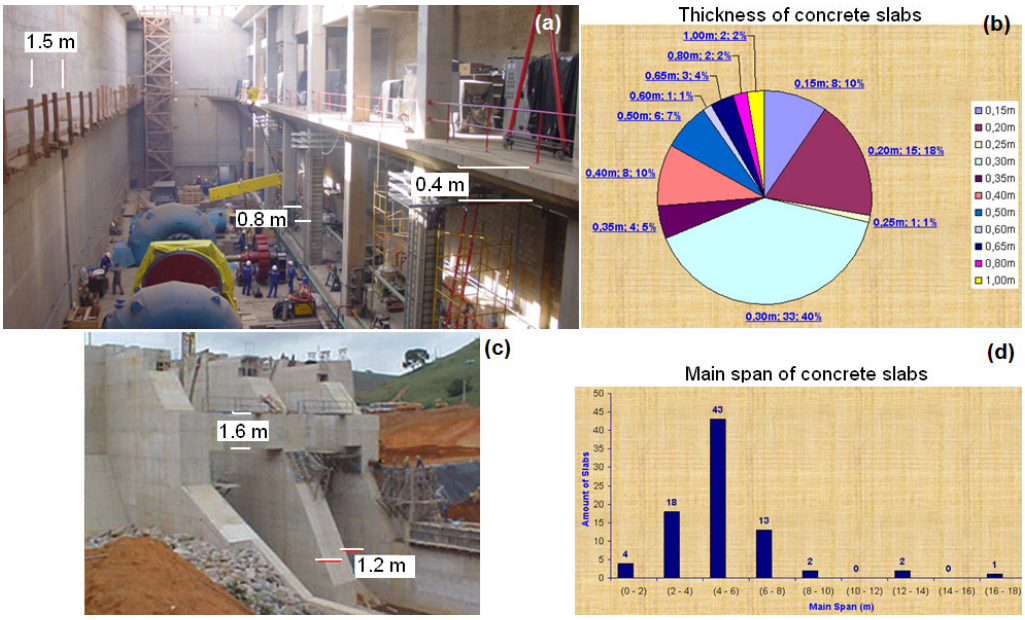

Figure AI.1- Usual cross section in (a) power houses (c) intakes and (b and d) a statistical study of thickness and main span of floor slab at power houses

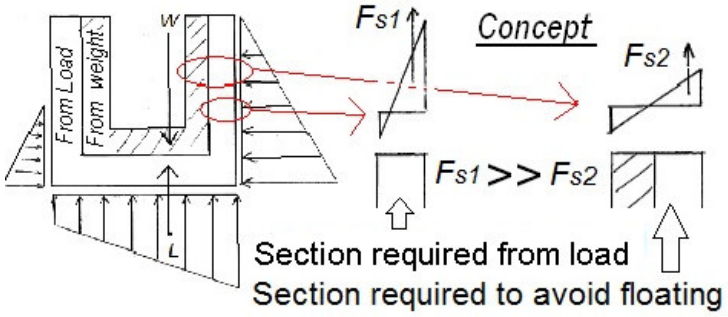

Figure A.I.2- Basic concept due the increment of cross section

Illustrated in Figures below are examples of hydroelectric structures that have been analysed using FEM and that have been built or are in process. The longitudinal steel reinforcement required for these structures is presented respectively in Tables AI.1-AI.12. Using the results in this study (treated bamboo strips), is presented in Tables AI.1-AI.12 the equivalent bmboo section required for concrete reinforcement.

The specific application of treated bamboo culm strips in hydroelectric structures is based upon the available space where the strips can be placed in the cross section of the structural elements due to the bamboo tensile strength, minimum distance between the strips and stiffness required for the reinforcement.

AI.1. Dams (Kgf/cm2)

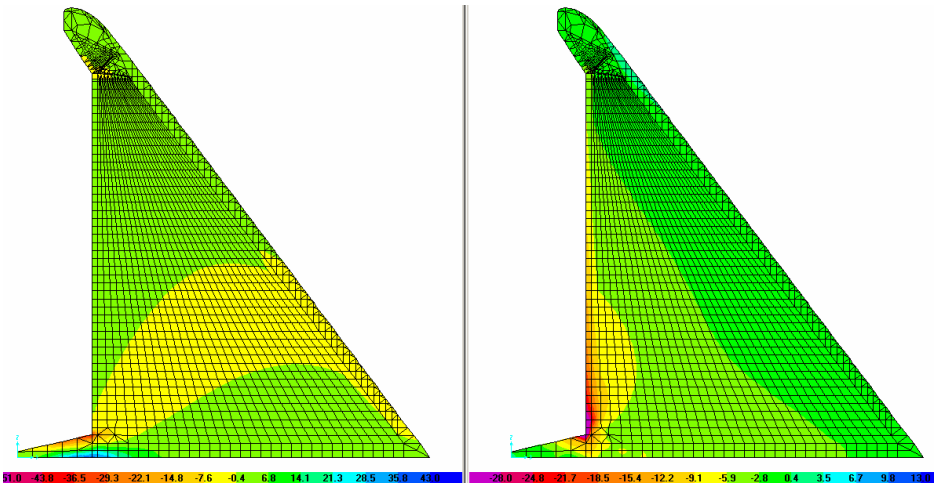

Table AI.1- Reinforcement required

Project: ARVOREDO				
	thickness (m)	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	3	Min.	Min
Slab	1	43	35	98

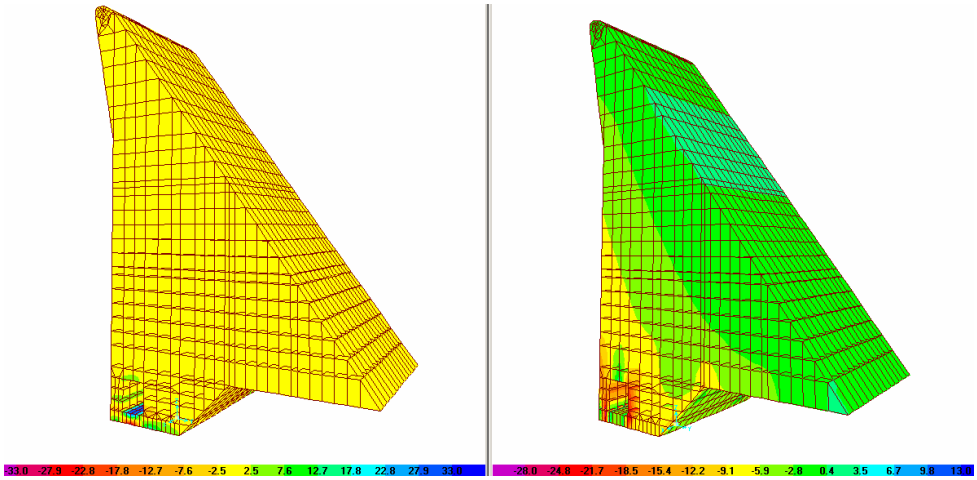

Table AI.2- Reinforcement required

Project: ARVOREDO				
	thickness (m)	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	10	Min.	
Slab	1	33	30	84

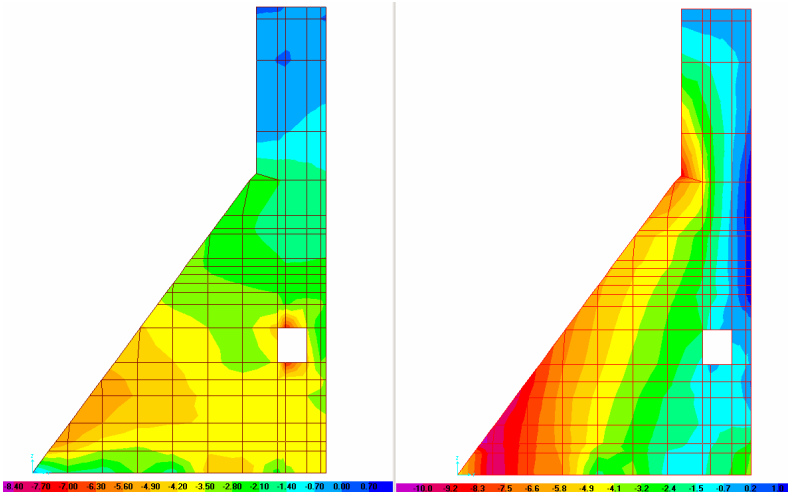

Table AI.3- Reinforcement required

Project: ARVOREDO				
	thickness (m)	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	2.4	Min.	21

AI.2. Dams and intakes (Kgf/cm2)

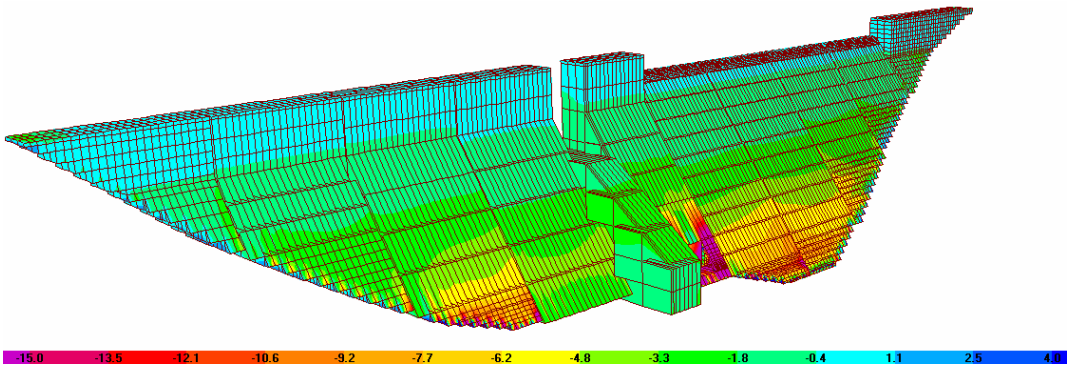

Table AI.4- Reinforcement required

Project: CAJU				
	hickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	3	Min.	21
Slab at box of water	1	29	30	84

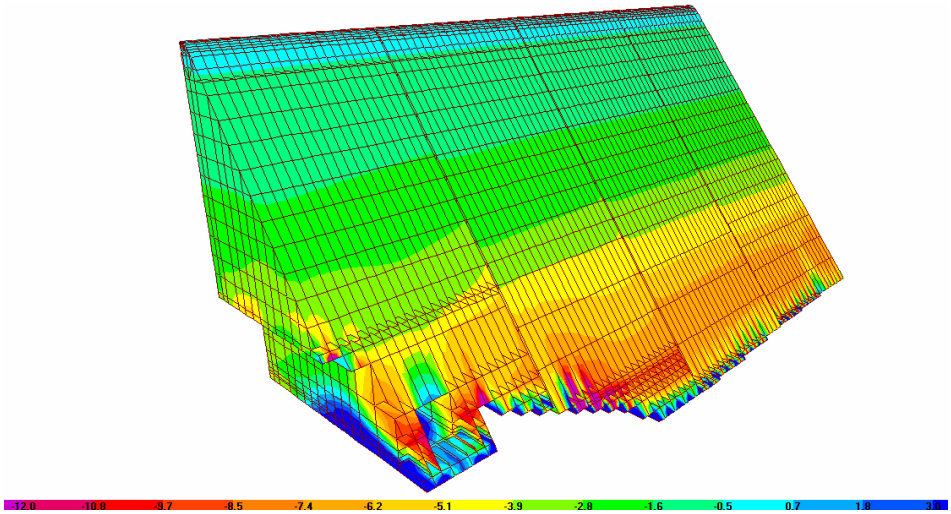

Table AI.5- Reinforcement required

Project: SANTO ANTONIO				
Vertedouro	**hickness**	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	1.3	Min.	22
Slab	1.5	33	35	99

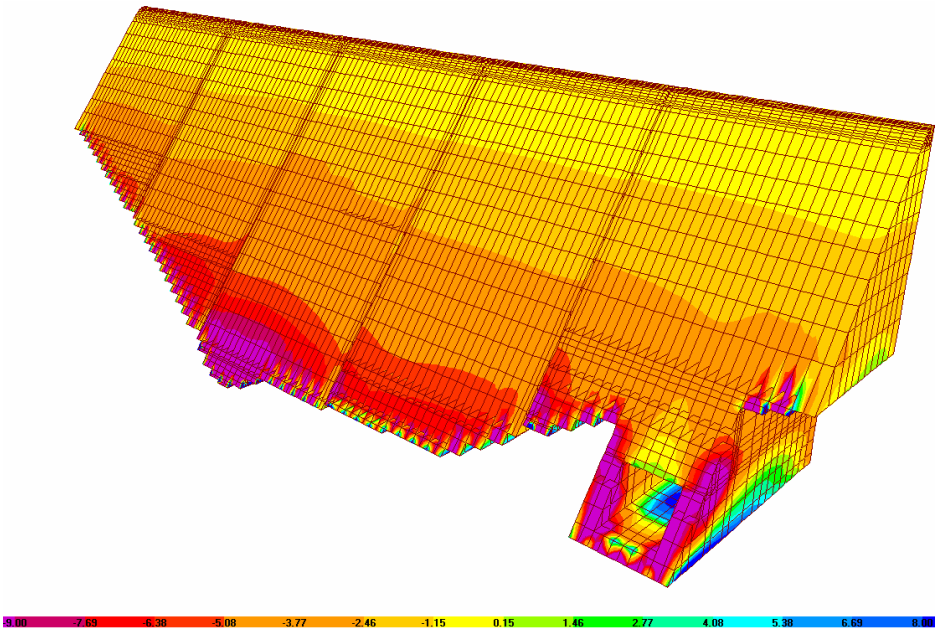

Table AI.6- Reinforcement required

Project: São Sebastião do Alto	**Barragens**			
Vertedouro	**thickness**	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Top	0.5	0.9	Min.	22
Slab	1.8	37	33	93

AI.3. Intakes (Kgf/cm2)

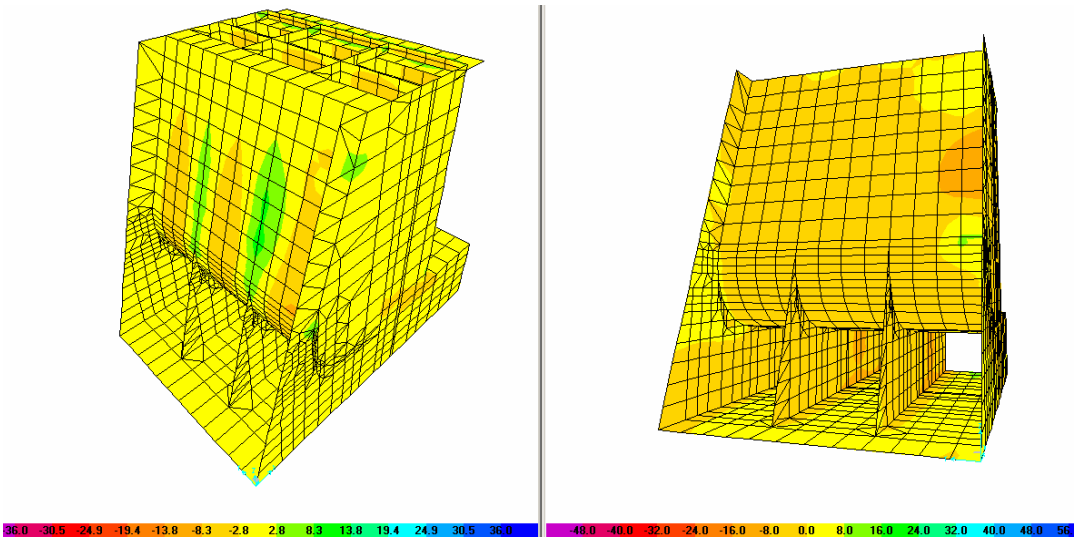

Table AI.7 Reinforcement required

Project: Arvoredo				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Front wall	0.8	27	20	57
Middle wall	0.9	17	(Min)	58
Back Wall	0.6	20	(Min)	26
Side wall	0.8	18	(Min)	34
From Slab	1	23	(Min)	43

Lower slab	1	8.3	(Min)	43

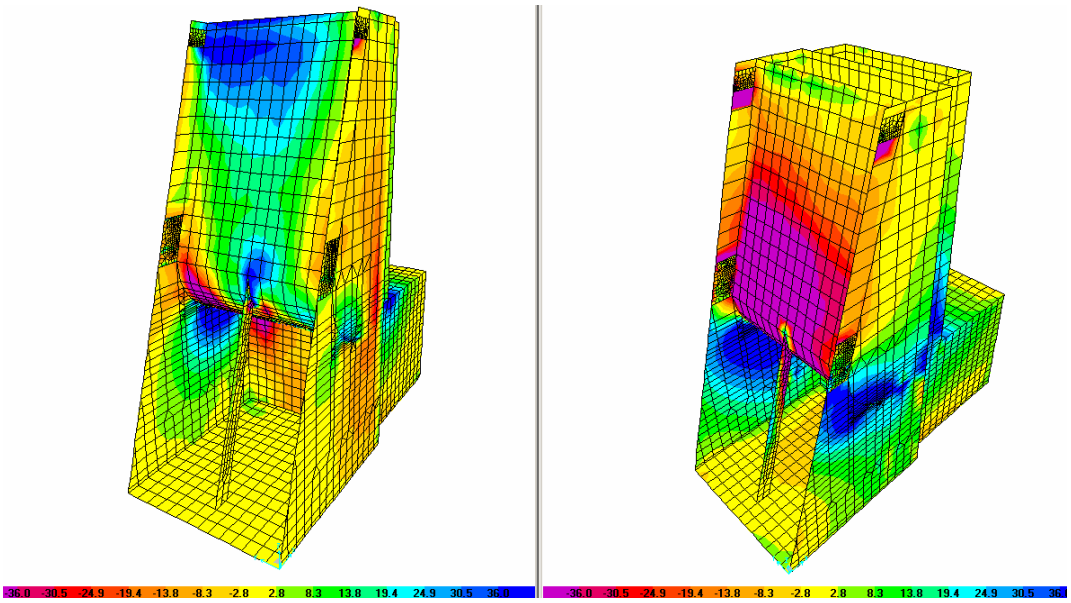

Table AI.8- Reinforcement required

Project: Autódromo				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Front wall	0.7	27	20	33
Middle wall	0.8	16	(Min)	34
Back Wall	0.8	18	(Min)	34
Side wall	1	18	(Min)	43
From Slab	1	21	(Min)	43
Lower slab	1.2	7.9	(Min)	51

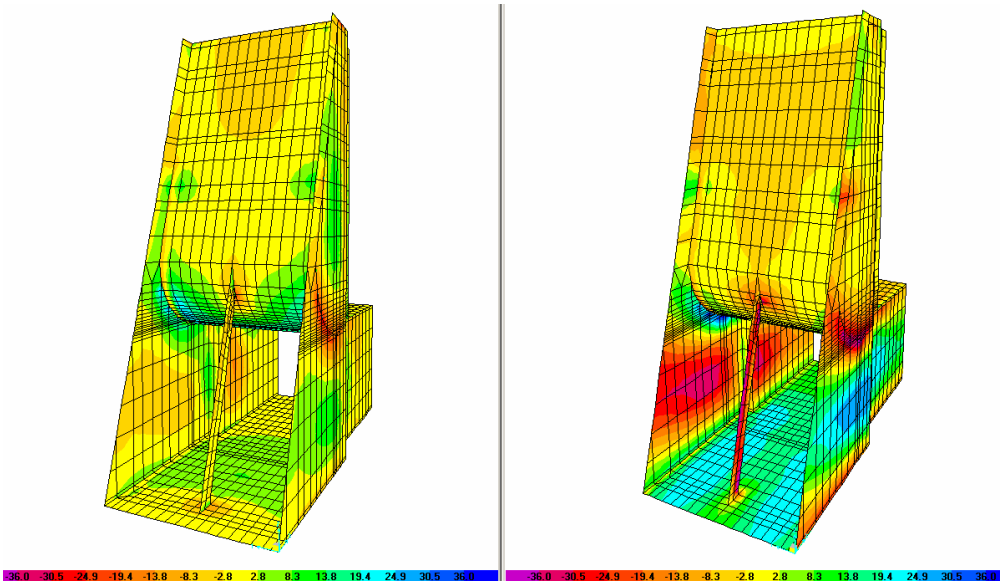

Table AI.9- Reinforcement required

Project: Boa fé				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Front wall	0.8	35	30	85
Middle wall	0.8	14	(Min)	34
Back Wall	0.8	21	(Min)	34
Side wall	1	16	(Min)	43
From Slab	1	19	(Min)	43
Lower slab	1.2	8.3	(Min)	51

AI.4. Chimineas (Kgf/cm2)

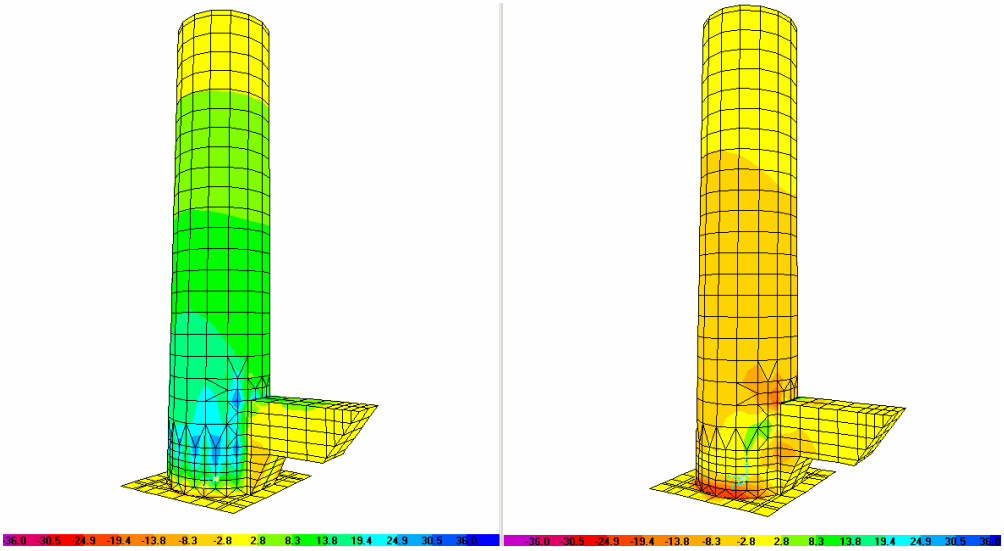

Table AI.10- Reinforcement required

Projeto: Barra da paciência				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Wall	0.65	30	25	71
Slab	0.8	37	24	70

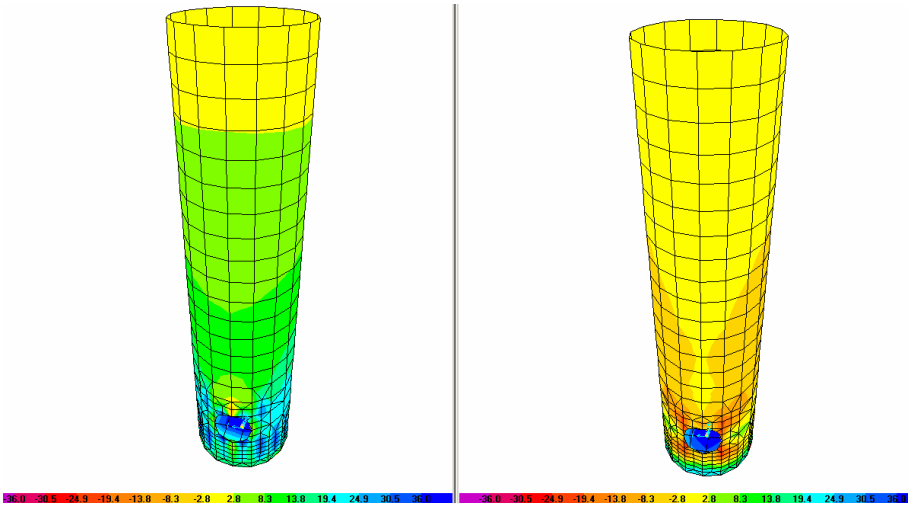

Table AI.11- Reinforcement required

Project: C. Grande				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Wall	0.65	30	25	71
Slab	0.8	40	26	72

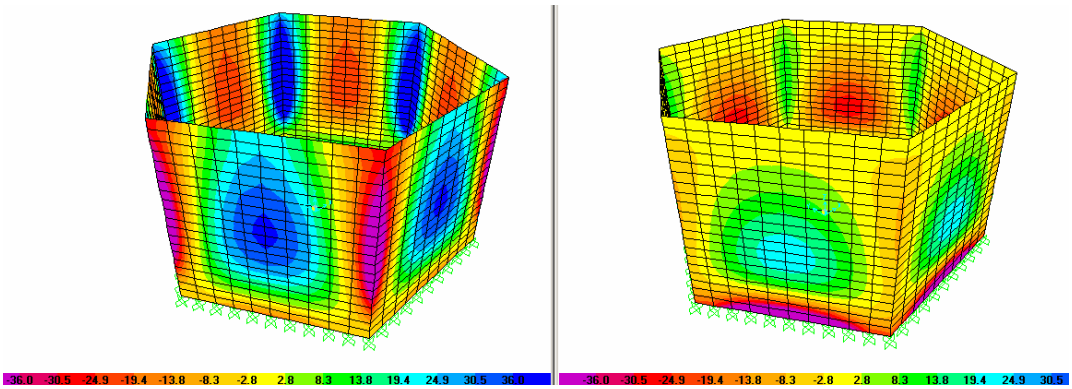

Table AI.12- Reinforcement required

Projeto: Criuva	**Chaminé**			
Chaminé	**thickness**	**Tensile strength (Kgf/cm2)**	**Steel required (cm2/m)**	**B. strips required (cm2/m)**
Wall	0.5	34	29	82
Slab	0.5	45	30	85

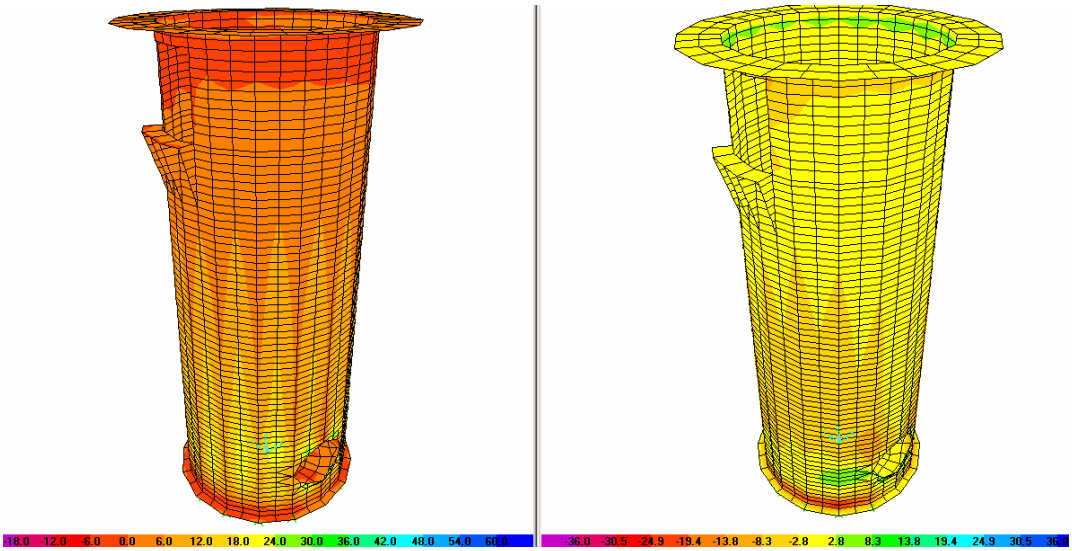

Table AI.13- Reinforcement Required

Project: Guary				
	thickness	**Tensile strength (Kgf/cm2)**	**Steel Required (cm2/m)**	**B. strips Required (cm2/m)**
Wall	0.5	31	26	73
Slab	1.5	27	18	51