

MINISTÉRIO DAS CIDADES

PROGRAMA SANEAMENTO PARA TODOS

AVANÇAR SANEAMENTO 2017

CONTRATO 0506697-36/2018
PROPONENTE : CESAMA - COMPANHIA DE SANEAMENTO MUNICIPAL

MODALIDADE - ABASTECIMENTO DE ÁGUA

**DESCRIÇÃO: AMPLIAÇÃO E OTIMIZAÇÃO DO SISTEMA DE ABASTECIMENTO
DE ÁGUA DE JUIZ DE FORA**

Intervenção 2 **Construção da 4a. Adutora de Água Tratada**

VOLUME 4– DESENHOS

PARTE 2 DE 3

Revisão	Descrição	Data
0	Emissão Inicial	29/12/2017
1	Atendimento considerações CEF	30/07/2018
2	Alteração de título da intervenção / nº contrato	10/07/2019
3	Revisão do orçamento	13/08/2020



COMPANHIA DE SANEAMENTO MUNICIPAL

JUIZ DE FORA - MG

PROJETO EXECUTIVO PARA CONSTRUÇÃO DA 4ª. ADUTORA D E ÁGUA TRATADA DE JUIZ DE FORA - MG



PROJETO ESTRUTURAL
PEÇAS GRÁFICAS (DESENHOS 01 A 05)
MEMORIAL DE CÁLCULO

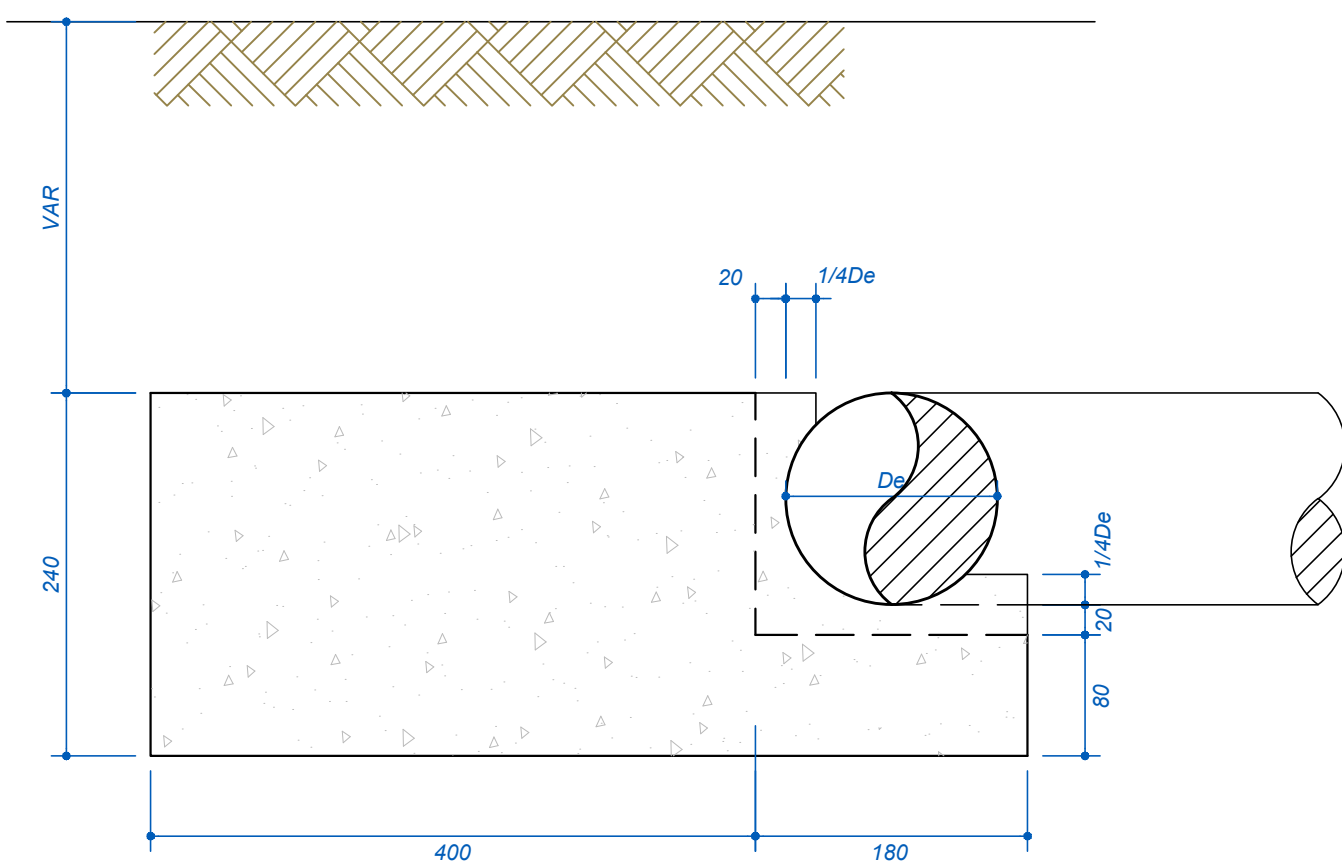
Marcelo Mello do Amaral
Engenheiro Civil – CREA MG 68770/D
ART 14201700000004001868

A intervenção em questão foi, preliminarmente, denominada Desvio da Adutora Menelick de Carvalho e Dr. João Penido, sendo alterada para Construção da 4a adutora de Água Tratada de Juiz de Fora, sem alteração dos projetos desenvolvidos

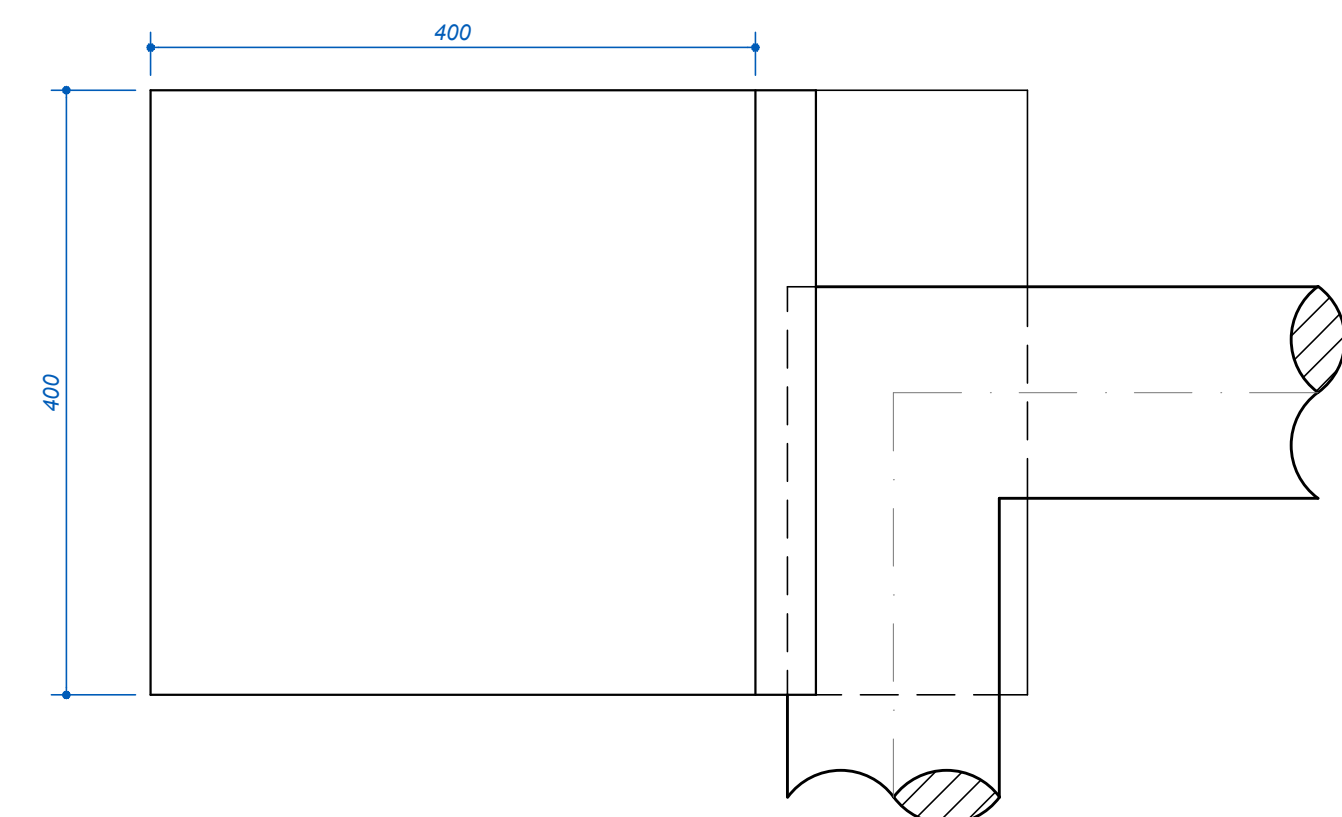


Marcelo Mello do Amaral
Engenheiro Civil – CREA MG 68770/D
ART 14201700000004001868

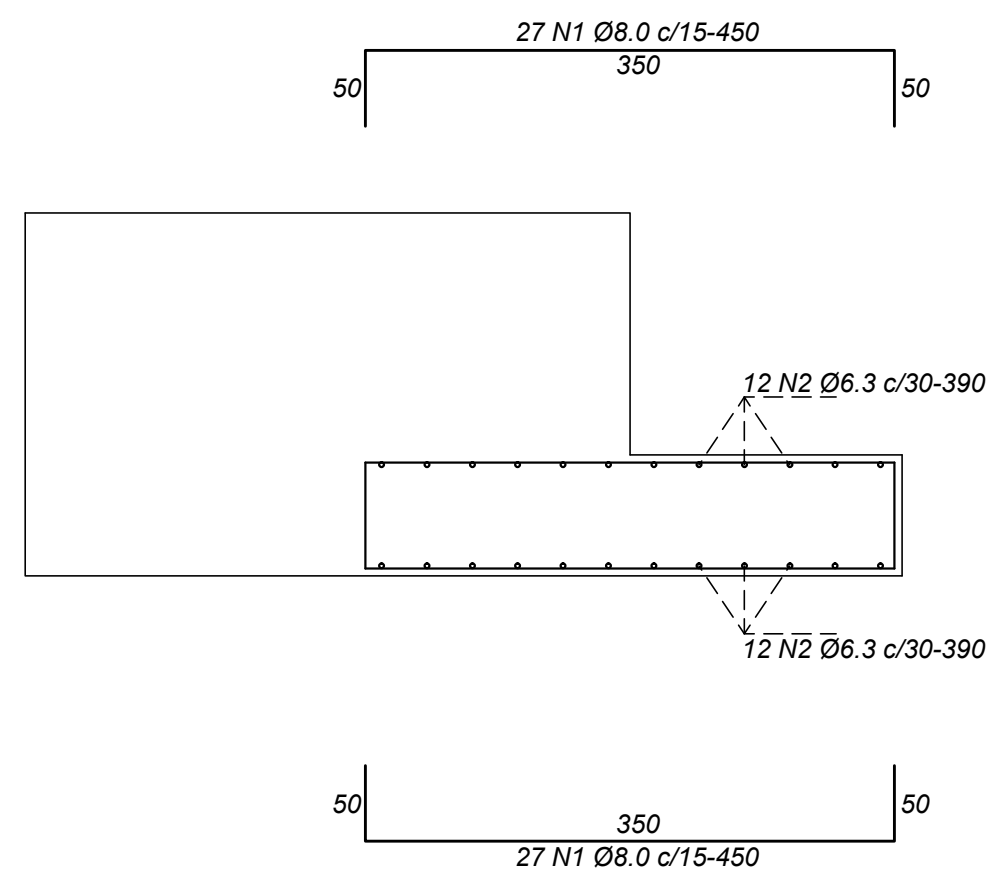
ESCALA 1 : 50



ESCALA 1 : 50

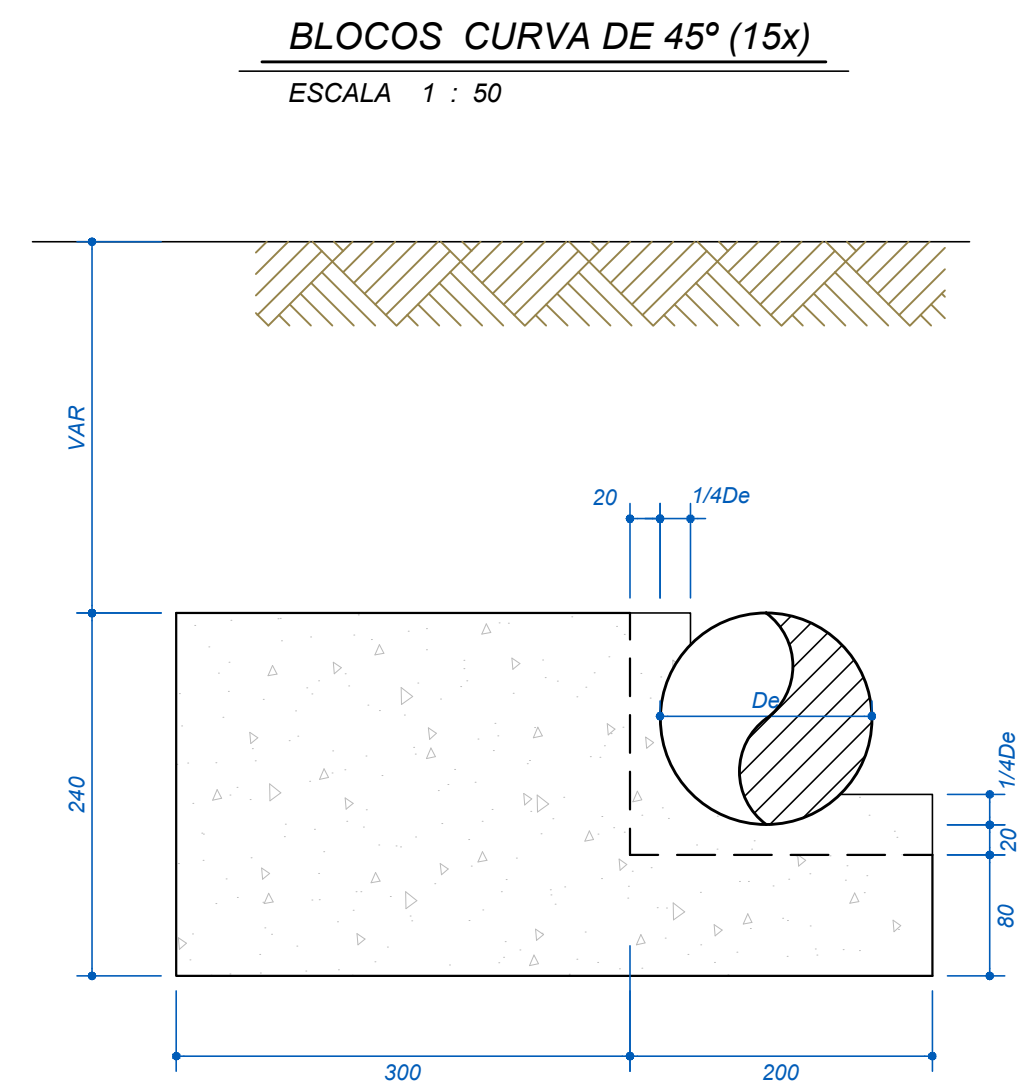


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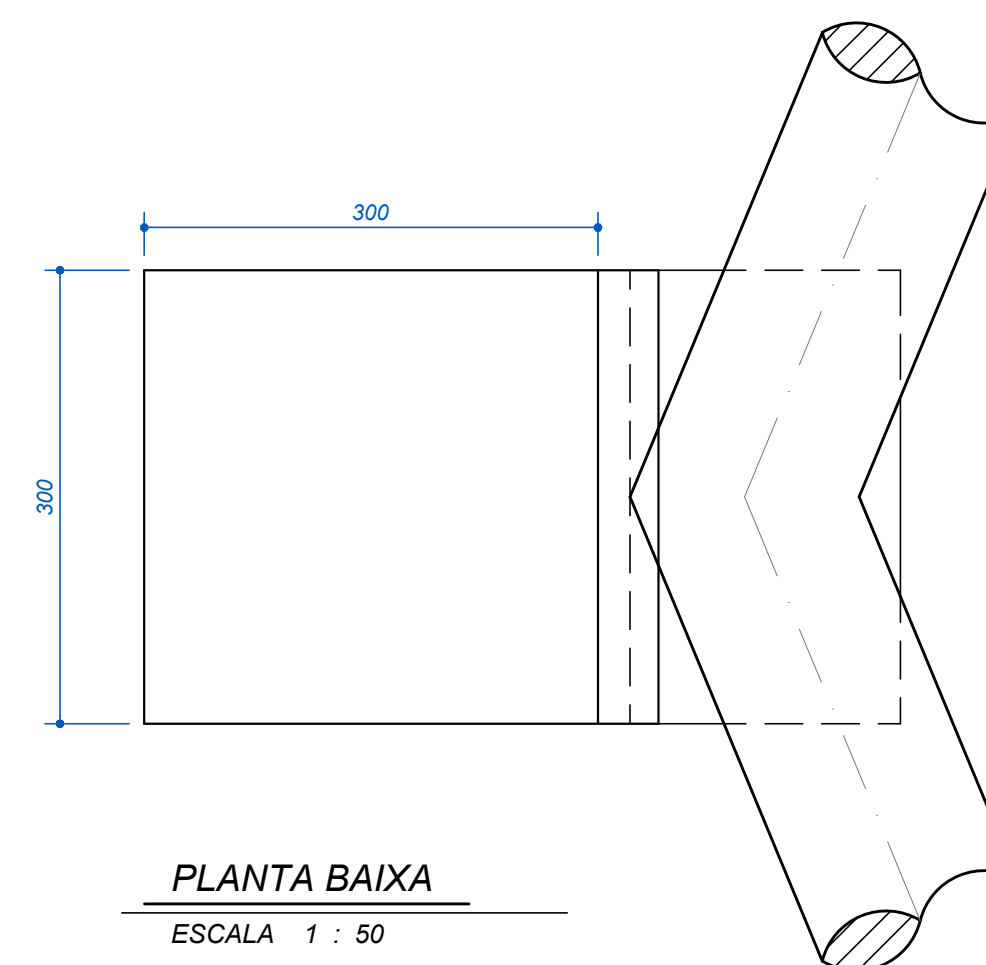


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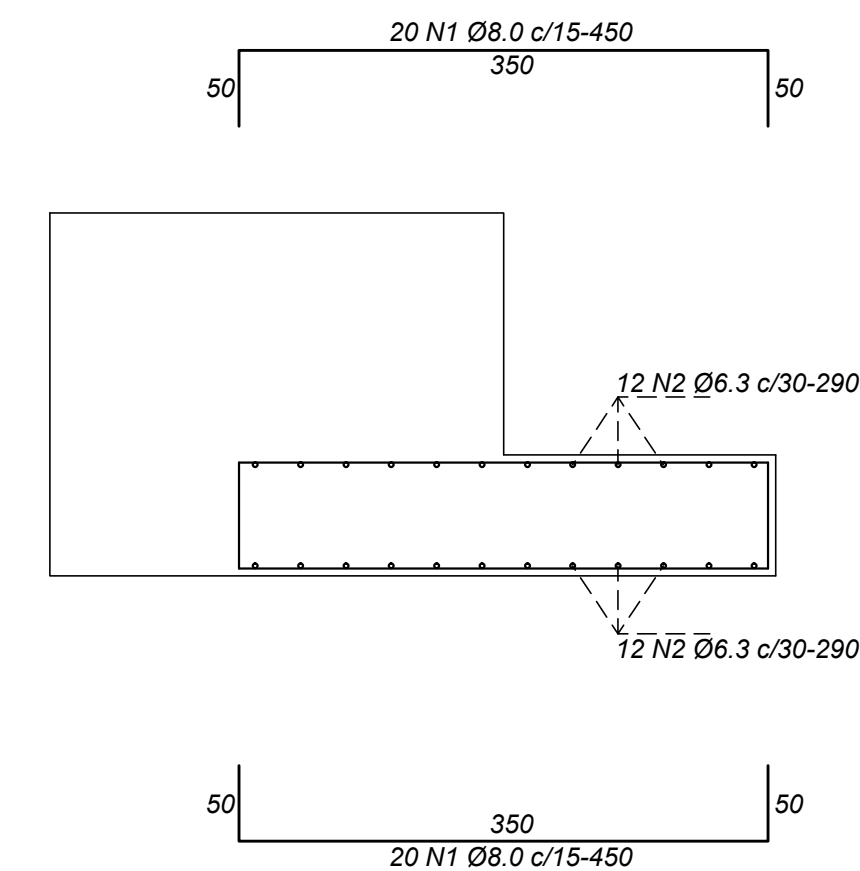
Vol. concreto total = 48 m³
Área de forma = 42.0 m²



ESCALA 1 : 50

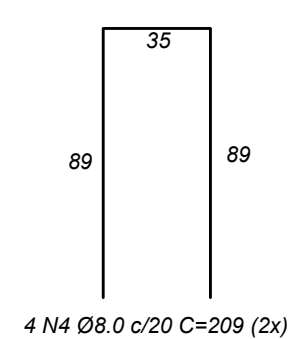
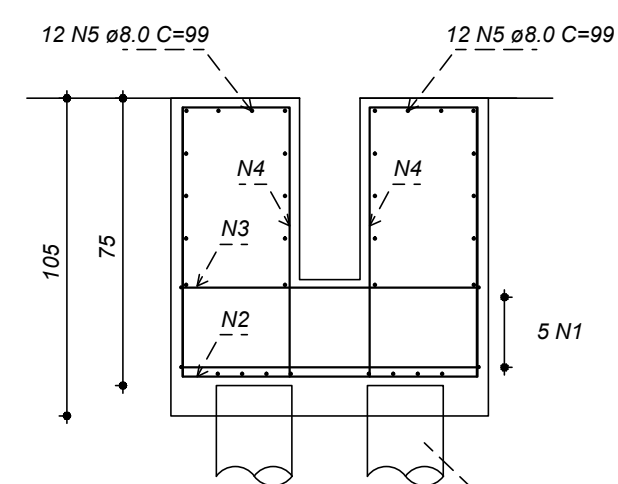
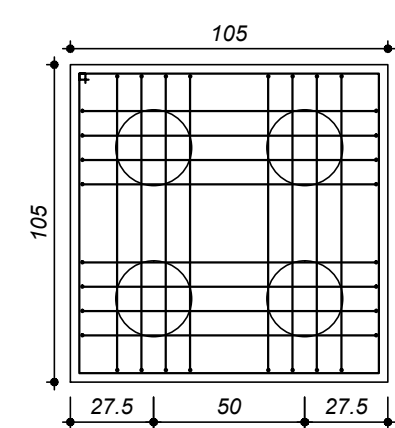


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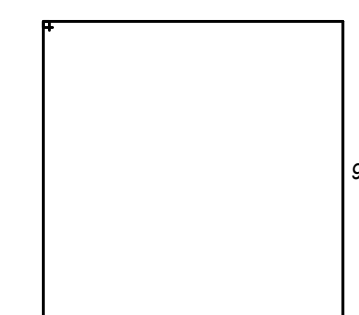
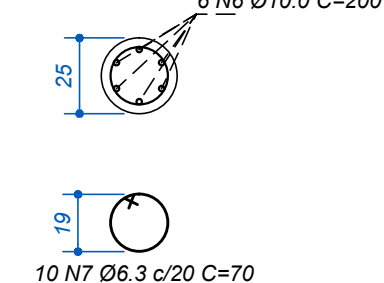
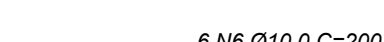


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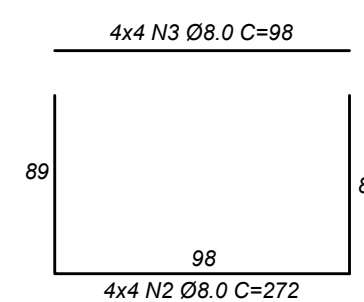
Vol. concreto total = 45 m³
Área de forma = 32.5 m²



Vol. concreto total = 1.04 m³
Área de forma total = 4.71 m²
fck = 250.00 kgf/cm²

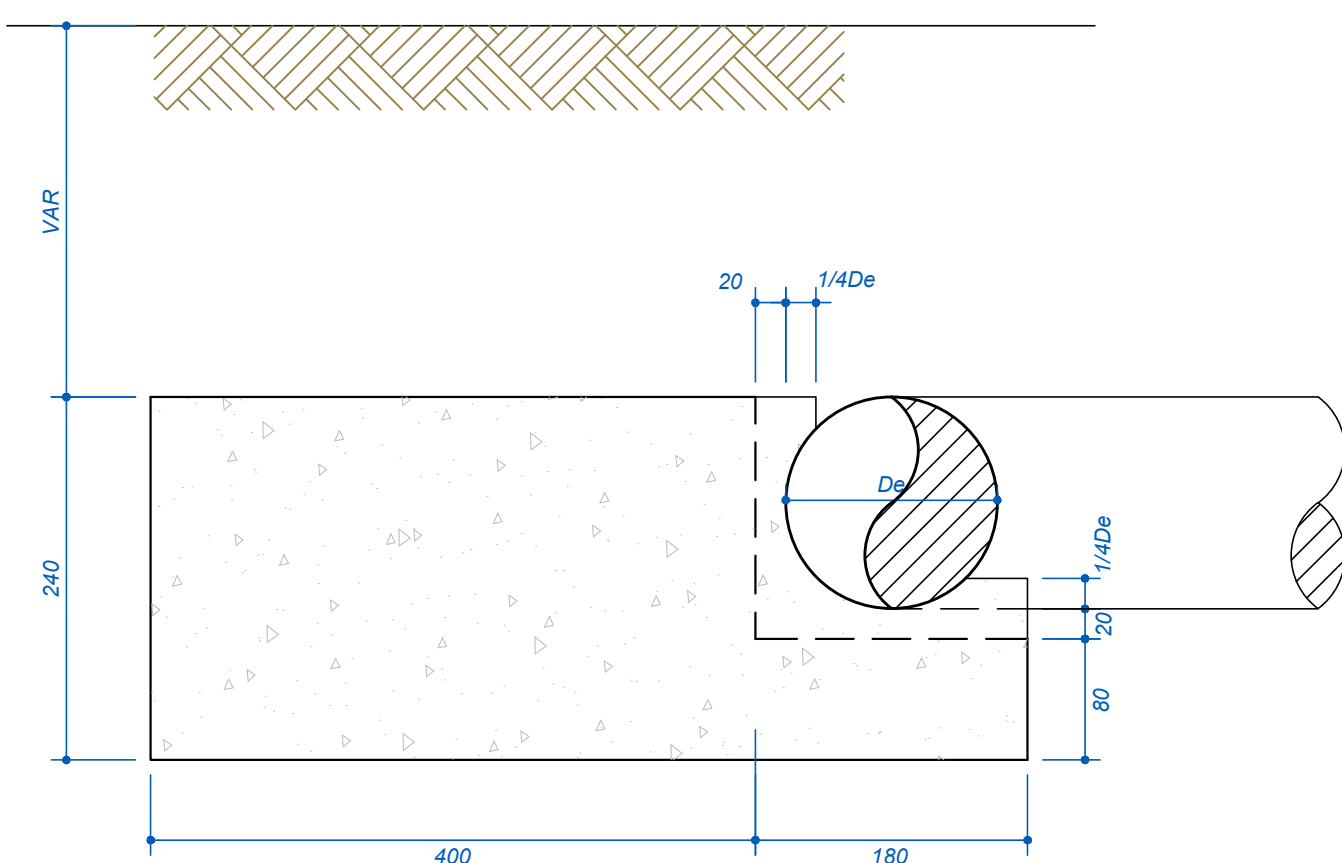


5 N1 Ø6.3 C=404

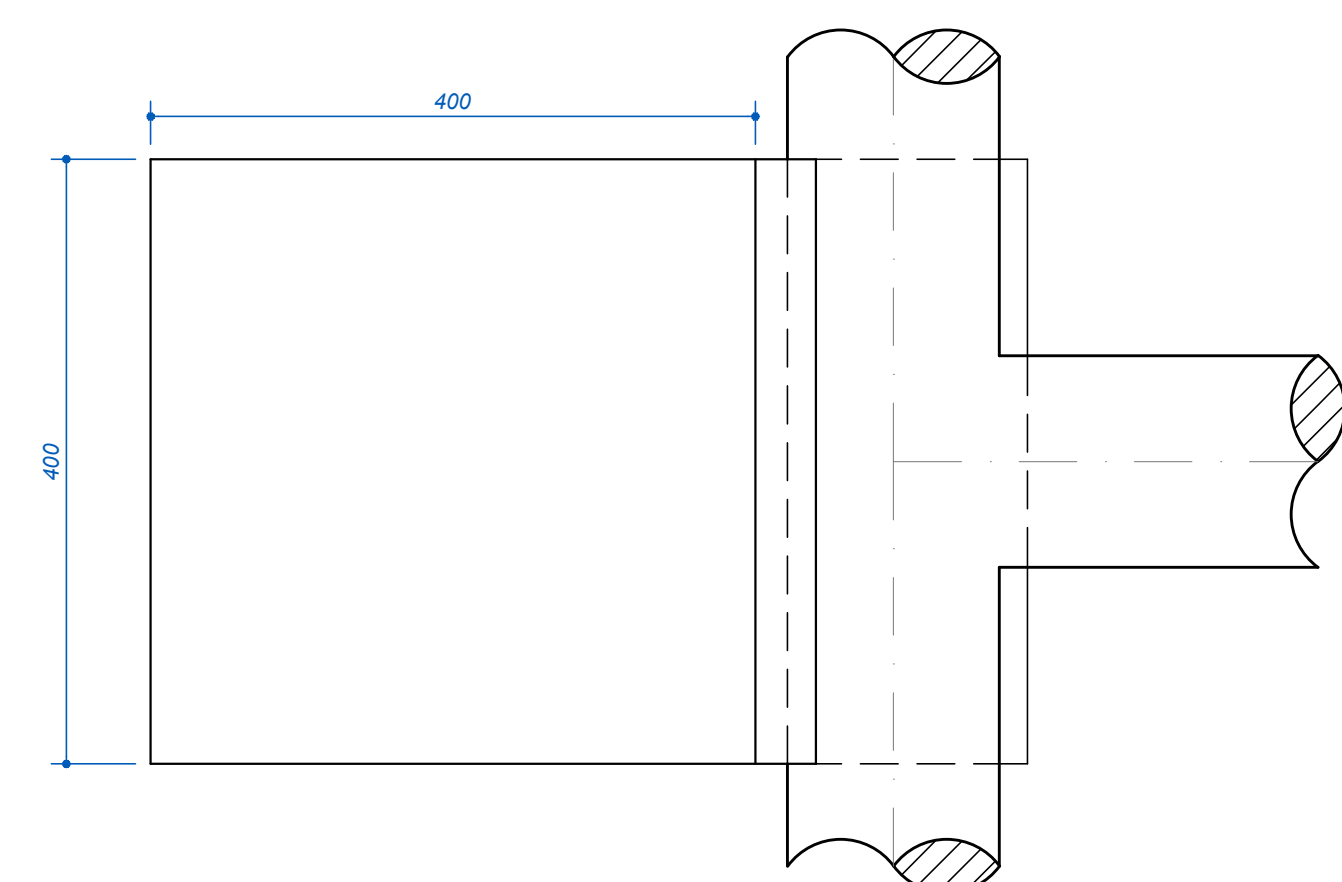


4x4 N2 Ø8.0 C=272

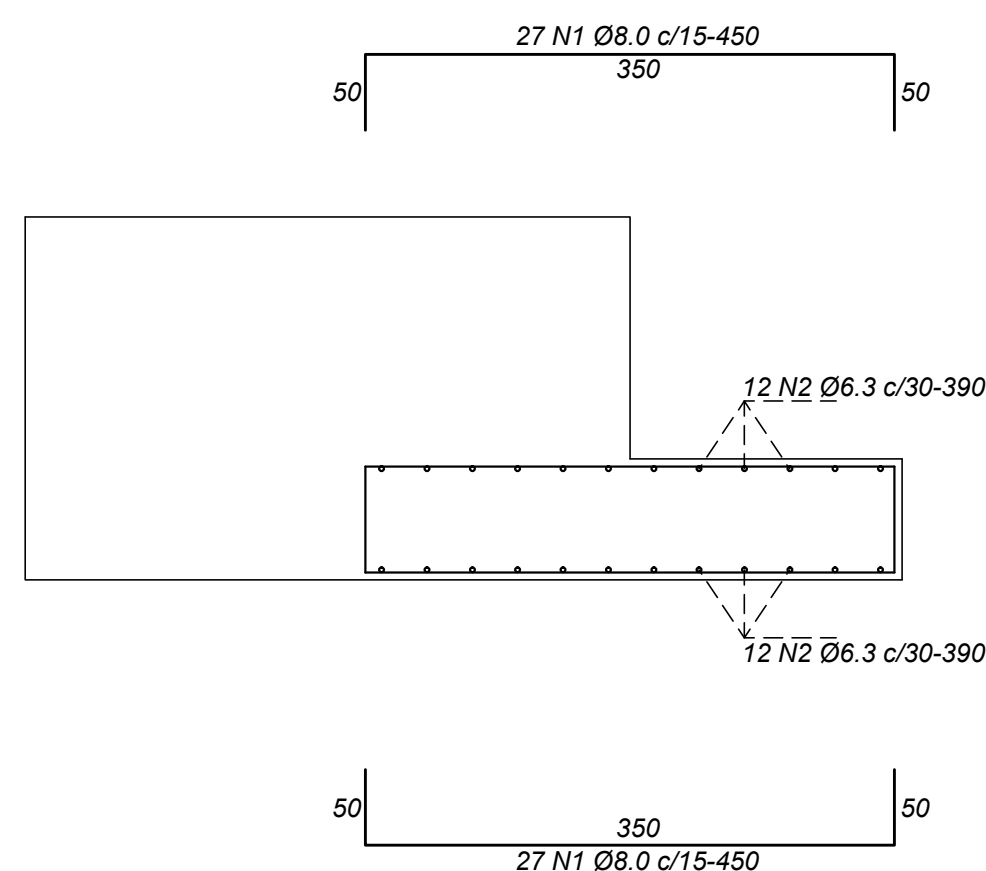
ESCALA 1 : 50



ESCALA 1 : 50



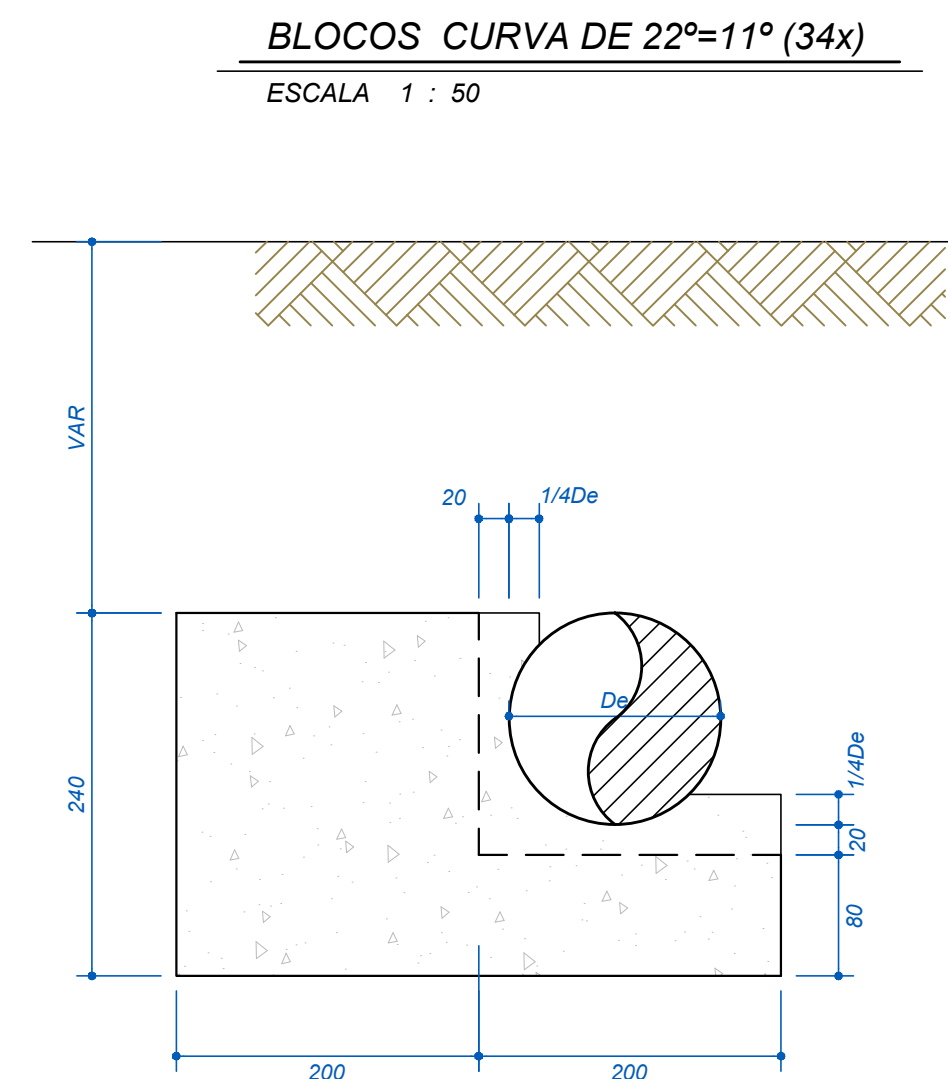
ESCALA 1 : 50



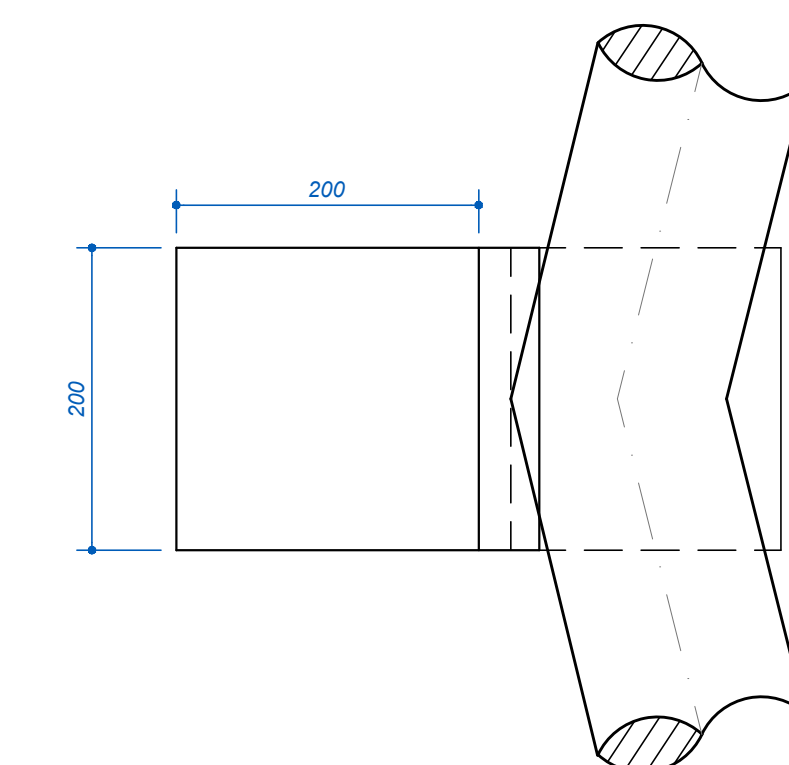
ESCALA 1 : 50

RESUMO DO AÇO/ BLOCO			
AÇO	DIAM	C.TOTAL (m)	PESO+10% (kg)
CA50	8.0	243.0	105.0
CA50	6.3	93.6	25.0
PESO TOTAL			
CA50	130.0		

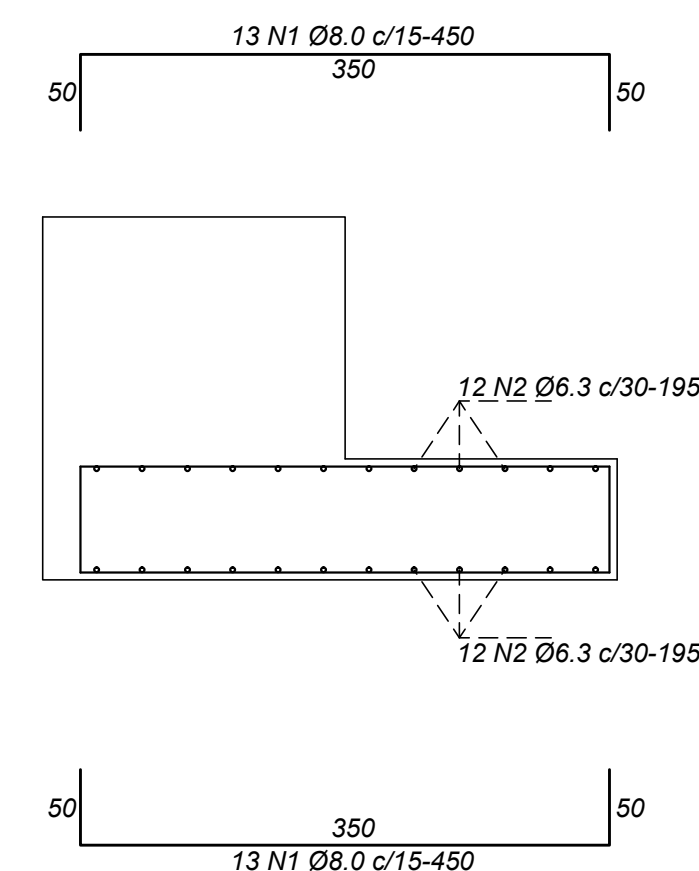
Vol. concreto total = 48 m³
Área de forma = 42.0 m²



ESCALA 1 : 50



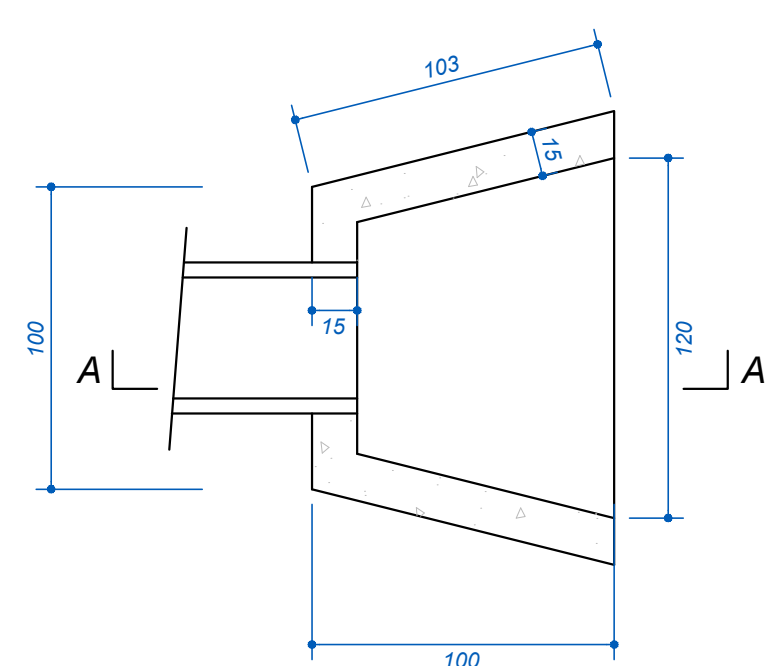
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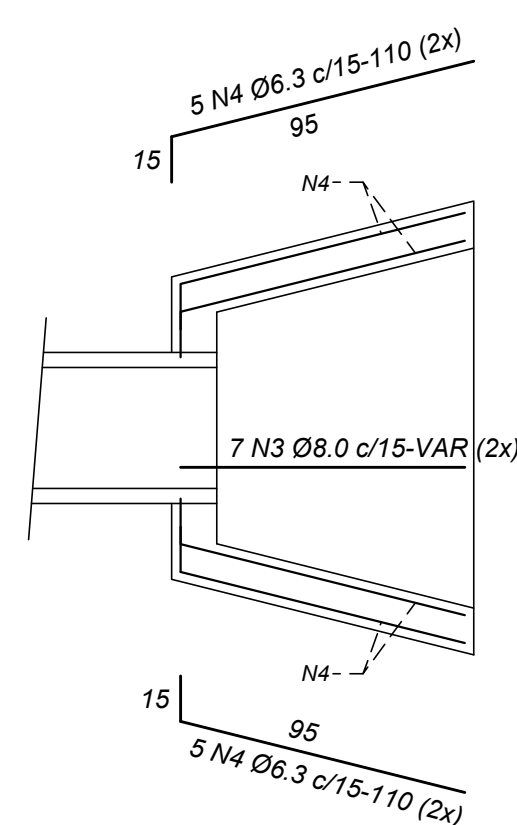
ESCALA 1 : 50

AÇO	DIAM	C.TOTAL (m)	PESO+10% (kg)
CA50	8.0	117.0	50.
CA50	6.3	47.0	12.
PESO TOTAL			
CA50	62.9		

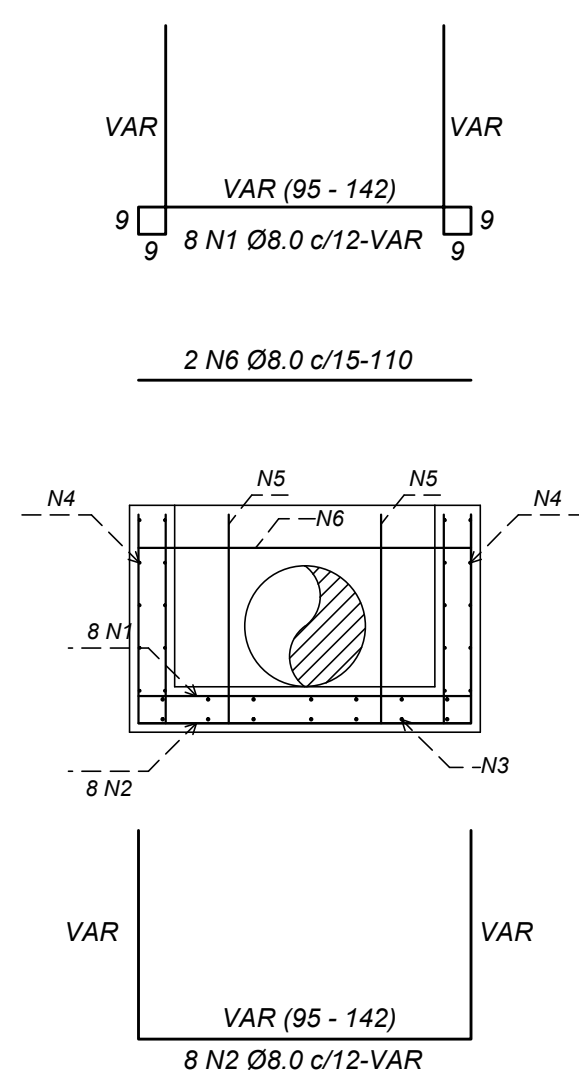
Vol. concreto total = 15 m³
Área de forma = 32.5 m²



ESCALA 1 : 25



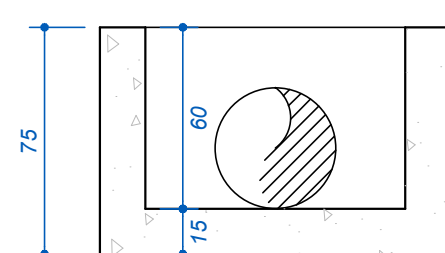
ESCALA 1 : 25



4 N5 Ø8.0 c/15 - 69 (2x)

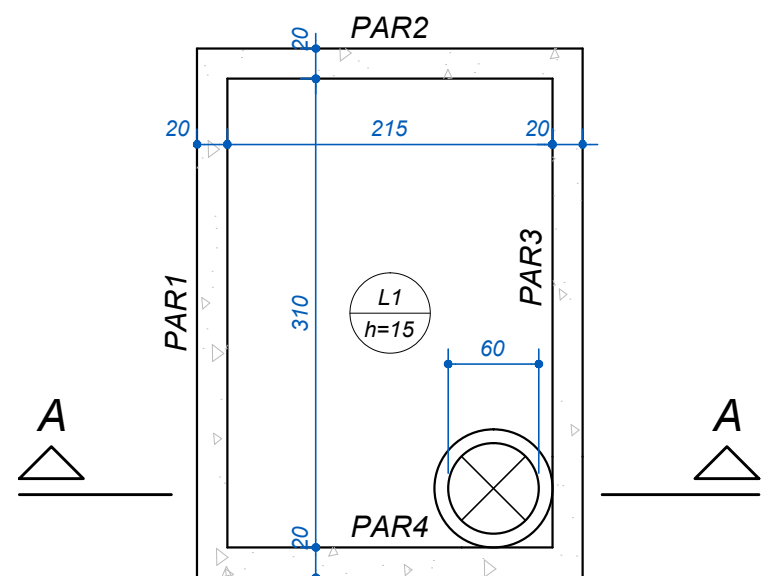
RESUMO DO AÇO/ ALA			
AÇO	DIAM	C. TOTAL (m)	PESO+10% (kg)
CA50	8.0	59.0	25.5
CA50	6.3	4.5	1.2
PESO TOTAL			
CA50	26.7		

Vol. concreto total = 0.4 m³
Área de forma = 0.50 m²

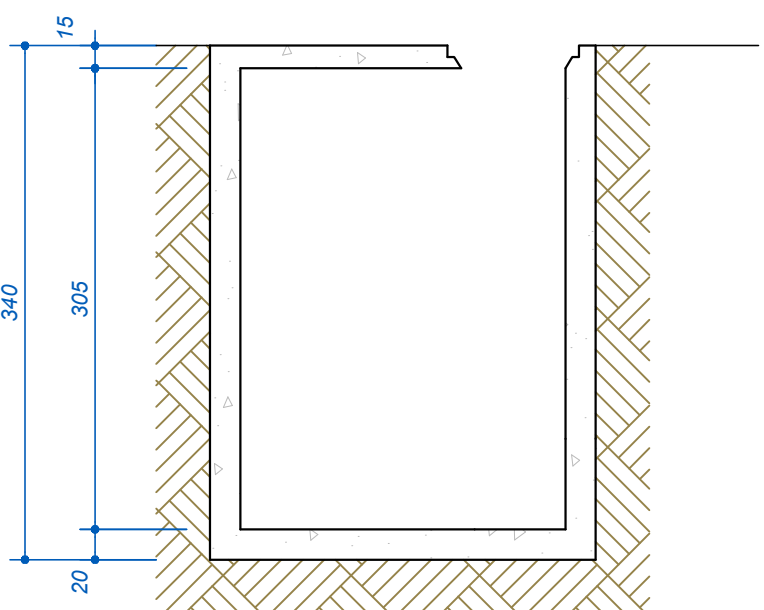


ESCALA 1 : 25

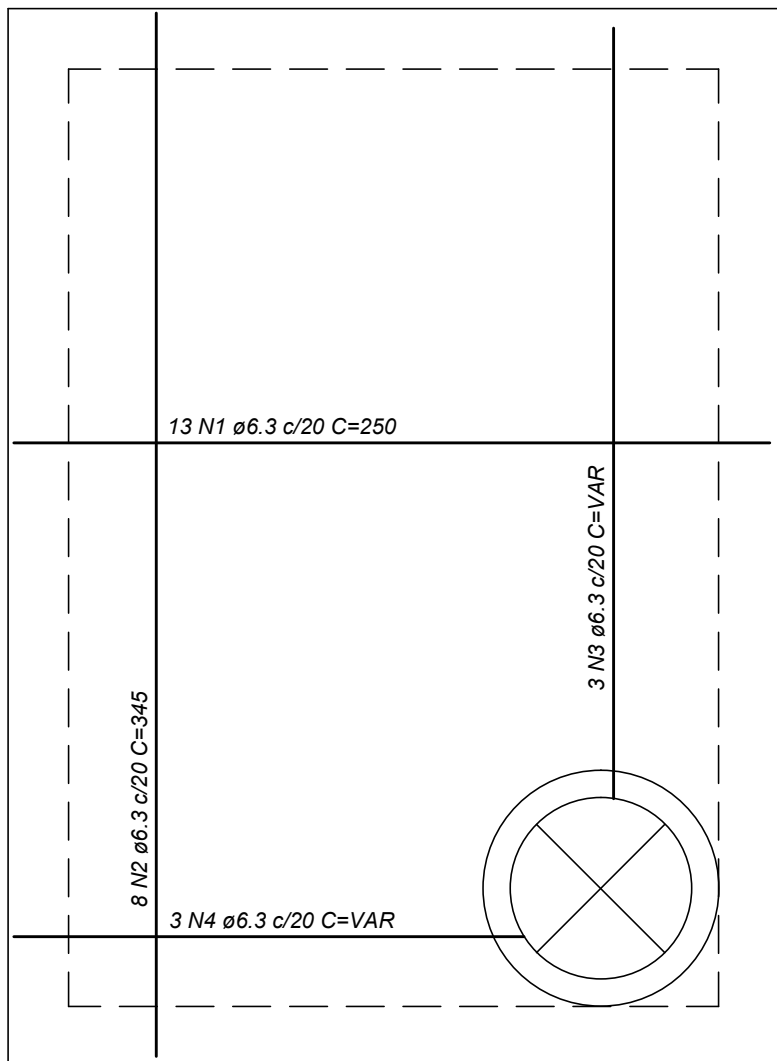
Data: 23/07/2018		Escala: Indicada	Projeto: ETU_P1047_FL01.0_BLOCOS_SERENC_R00		Rev.: R-0
Autor do Projeto: ENGETEC		Desenho: Douglas	Assinatura: Douglas Seiberlich		Assinatura: MG-99.767/D
 <p>ENGETEC-PROJETOS DE ENGENHARIA Tel.: (32) 9 9992-4411 – (32) 3017-4073 E-mail: engetecpe@gmail.com Endereço: Rua Dr. Romualdo, nº 342, São Mateus Juiz de Fora – MG</p>			Contratante: <div style="border: 1px solid black; padding: 5px; margin-top: 10px;">  <p>SERENCO Serviços de Engenharia Consultiva</p> </div>		



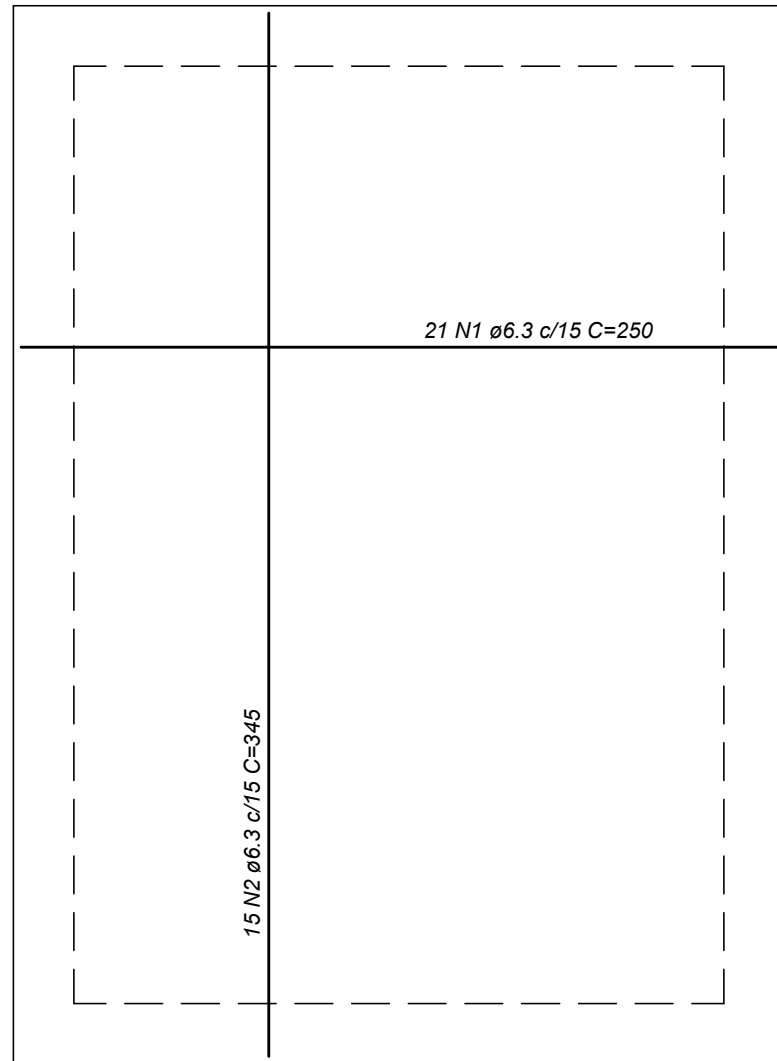
PLANTA BAIXA DO TOPO
ESCALA 1 : 50



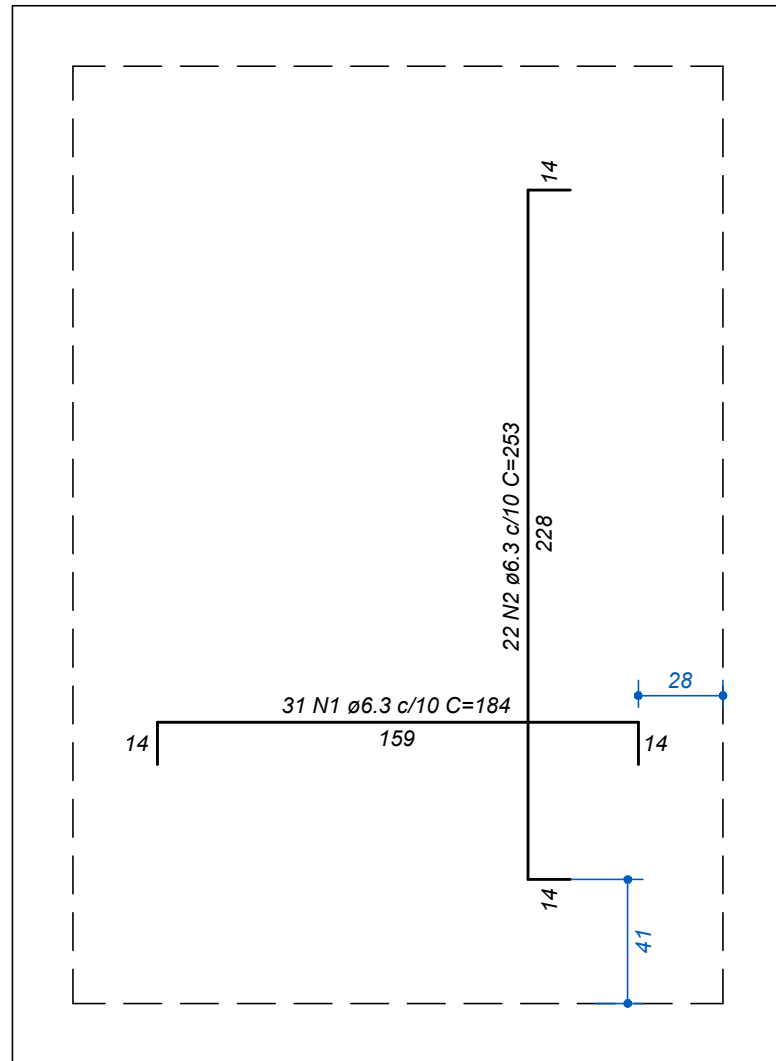
CORTE A-A
ESCALA 1 : 50



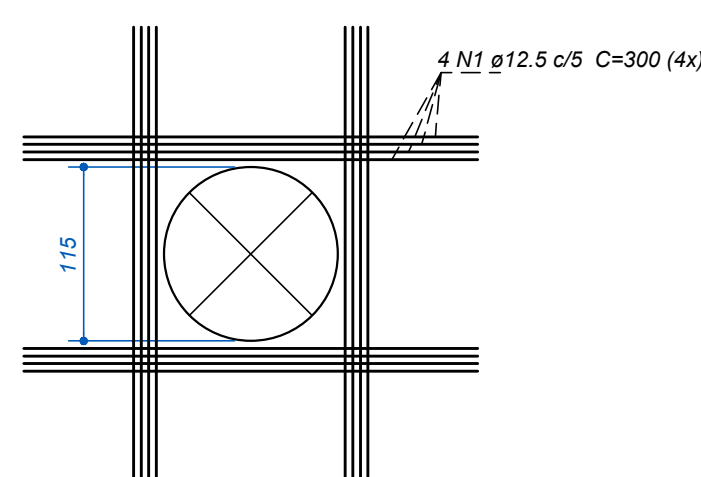
ARM. POS. LAJE DO TOPO
ESCALA 1 : 25



ARM. POS. LAJE DO FUNDO
ESCALA 1 : 25



ARM. NEG. LAJE DO FUNDO
ESCALA 1 : 25

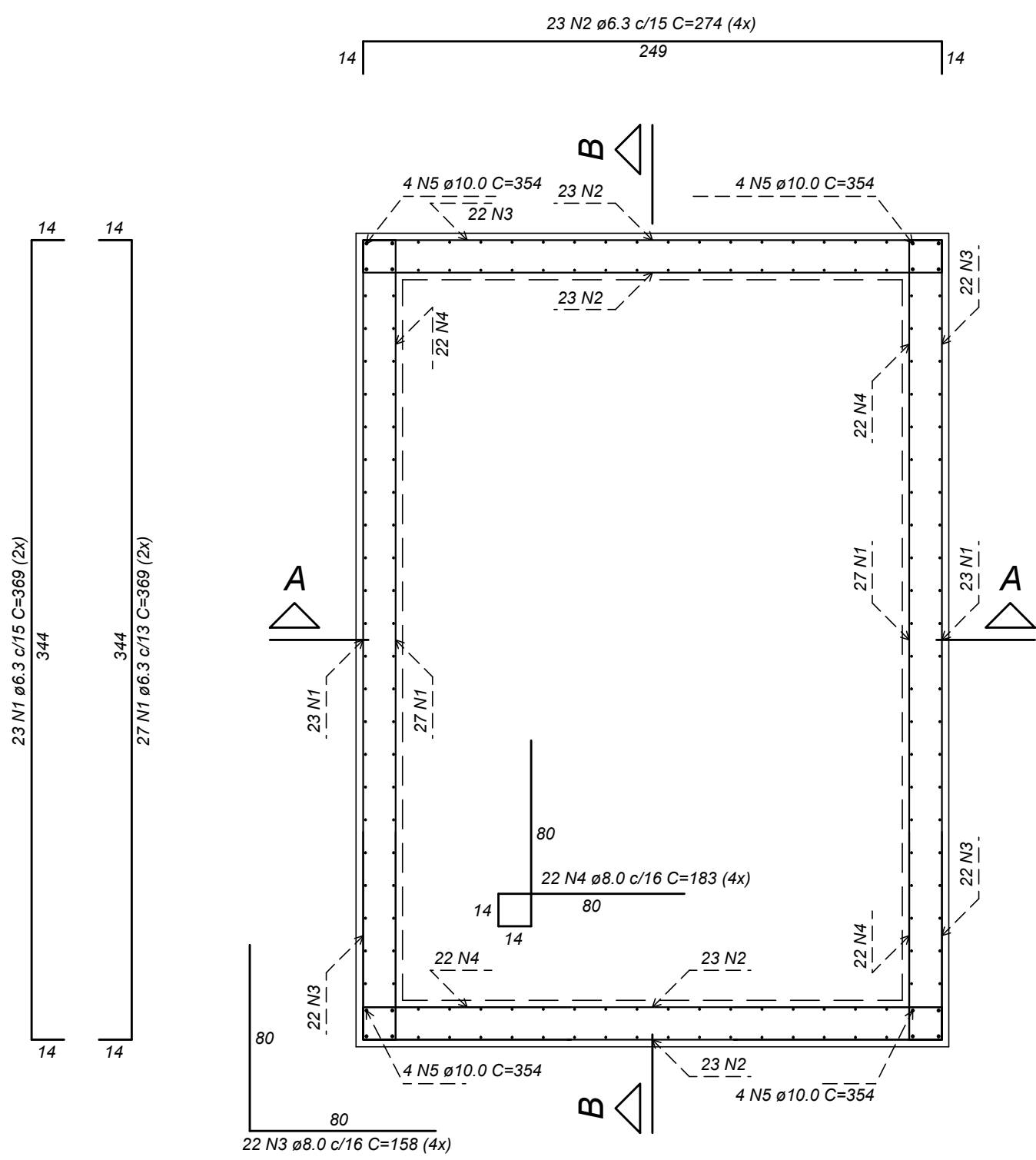


DETALHE DA ABERTURA DA PAREDE (2x)
ESCALA 1 : 50

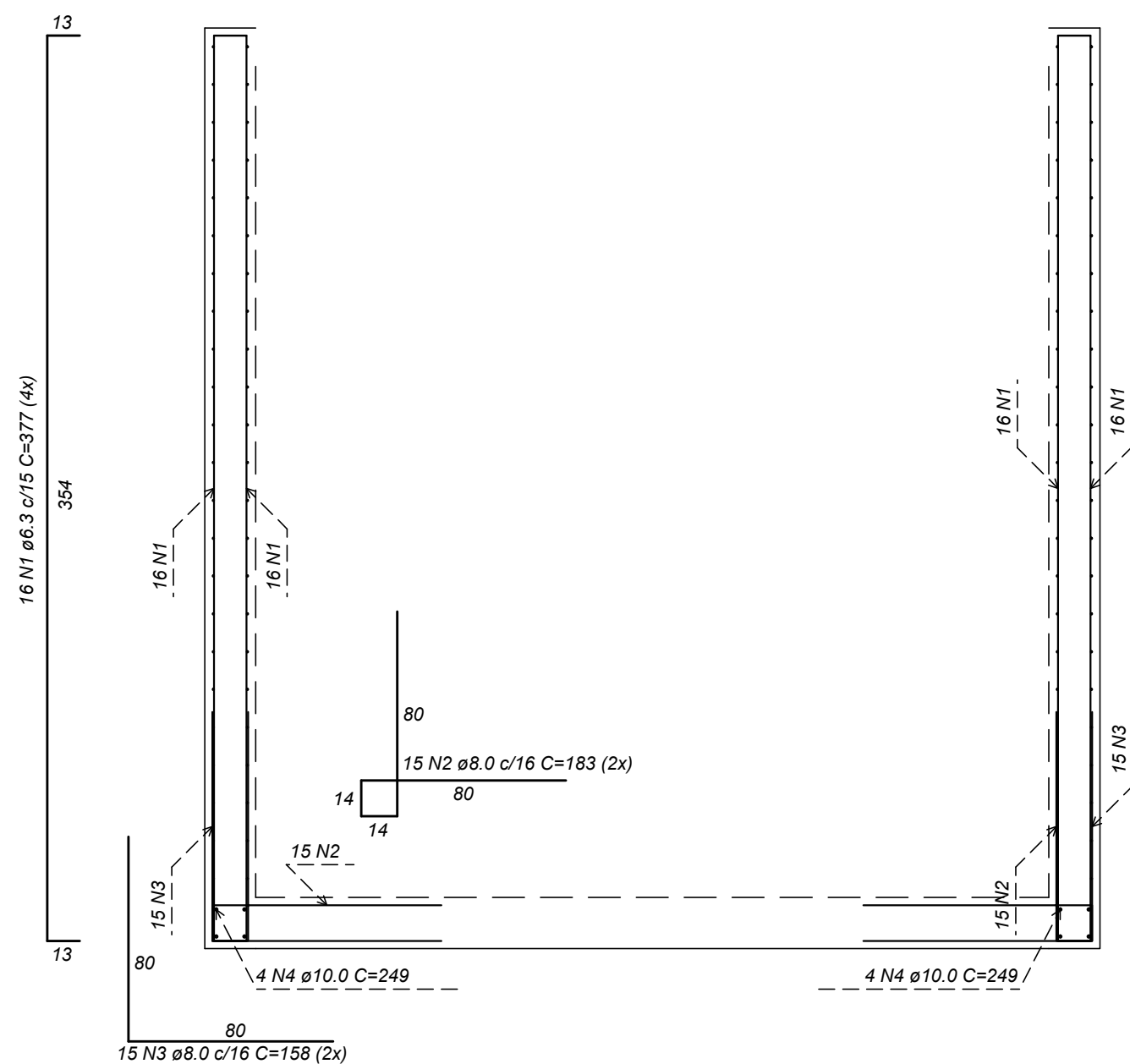
RELAÇÃO DO AÇO						
ELEMENTO	AÇO	N	DIAM (mm)	QUANT	C.UNIT (cm)	C.TOTAL (cm)
Corte A-A	CA50	1	6.3	88	377	33176
	CA50	2	8.0	42	183	7686
	CA50	3	8.0	42	158	6636
	CA50	4	10.0	8	344	2752
Corte B-B	CA50	1	6.3	64	377	24128
	CA50	2	8.0	30	183	5490
	CA50	3	8.0	30	158	4740
	CA50	4	10.0	8	249	1992
Neg. Fundo	CA50	1	6.3	31	184	5704
	CA50	2	6.3	22	253	5566
	CA50	1	6.3	100	369	36900
	CA50	2	6.3	92	274	25208
Corte Horizontal	CA50	3	8.0	88	158	13904
	CA50	4	8.0	88	183	16104
	CA50	5	10.0	16	354	5664
	CA50	1	6.3	13	250	3250
Pos. Tampo	CA50	2	6.3	8	345	2760
	CA50	3	6.3	3	VAR	VAR
	CA50	4	6.3	3	VAR	VAR
	CA50	1	6.3	21	250	5250
Pos. Fundo	CA50	2	6.3	15	345	5175
	CA50	1	12.5	32	300	9600
Abertura						

RESUMO DO AÇO			
AÇO	DIAM (mm)	C.TOTAL (m)	PESO + 10% (kg)
CA50	6.3	1498.6	400.7
	8.0	545.6	236.8
	10.0	104.1	70.6
	12.5	96.0	101.7
PESO TOTAL (kg)			
CA50		809.8	

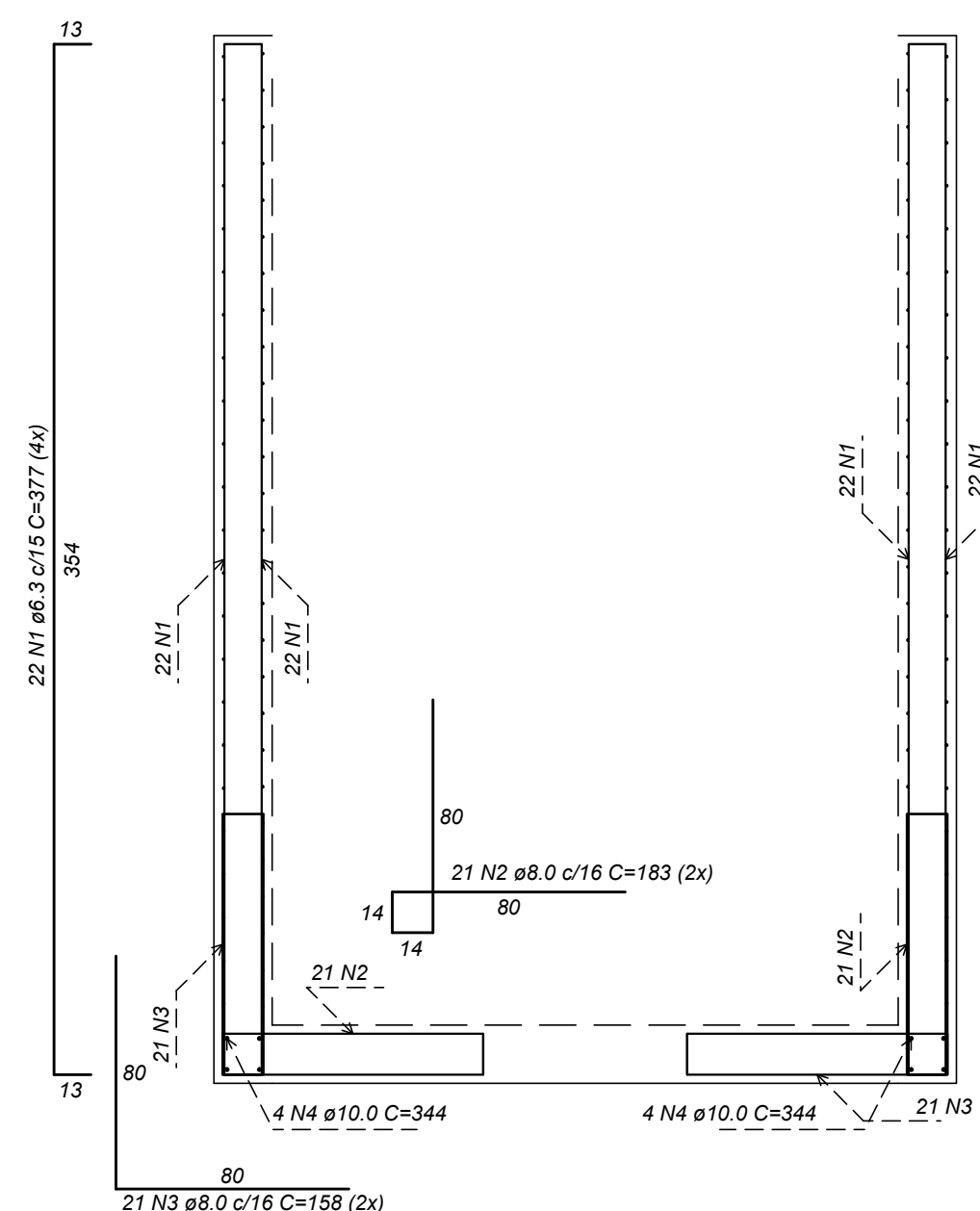
Volume de concreto (C-25) = 10.02 m³
Área de forma = 85.77 m²



ARMAÇÃO HORIZONTAL
ESCALA 1 : 25



CORTE B-B
ESCALA 1 : 25



CORTE A-A
ESCALA 1 : 25

Projeto Executivo

PROJETO EXECUTIVO

Projeto Estrutural

ESTRUTURAL DA CAIXA DA TRAVESSIA

03

Data: 23/07/2018

Escala: Indicada

ETU_P1047_FL01.0_BLOCOS_SERENC_R00

Desenho: Douglas

Douglas Seiberlich

MG-99.767/D

Folha: 03

Rev: R-0

Autore: Douglas Seiberlich

Contratante: SERENCO

Cliente: CESAMA



RESUMO DO AÇO

Volume de concreto (C-25) = 8.92 m³
Área de forma = 78.07 m²

[illegible]

0.50mm	
0.10mm	
0.30mm	
0.20mm	
0.10mm	
0.10mm	

MEMORIAL DE CÁLCULO

ESTRUTURA EM CONCRETO ARMADO

Cliente: Serenço Serviços de Engenharia Consultiva

Local: Juiz de Fora-MG

Obra: Caixa de Descarga

1. NORMAS ADOTADAS

Foram utilizadas as seguintes normas para a realização deste projeto estrutural:

- NBR 6118:2003 – Projeto de estruturas de concreto
- NBR 6120:1980 – Cargas para o cálculo de estruturas de edificações
- NBR 6122:1986 – Projeto e execução de fundações

2. PARÂMETROS ADOTADOS

a) Materiais:

- Concreto: C25 ($f_{ck} = 25 \text{ MPa}$) (demais elementos estruturais)

Módulo de elasticidade inicial do concreto:

$$E_{cs} = 5600\sqrt{f_{ck}} = 5600\sqrt{25} = 28000 \text{ MPa} \cong 2.800.000.000 \text{ kgf} / \text{m}^2$$

Peso específico do concreto armado = 2500 kgf/m^3

$\gamma_c = 1,4$ (coeficiente de majoração do concreto)

- Aço: CA-50A ($f_{yk} = 500 \text{ MPa}$)

$\gamma_s = 1,15$ (coeficiente de majoração do aço)

3. DADOS

Seção (cm)				Cargas Verticais (kgf/m²)				Cargas Horizontais (kgf/m²)	
Elemento	H	Elevação	Nível	Peso Próprio	Acidental Revestimento	Paredes Outras	Total	Base	Topo
L1 (R1)	20.00	0.00	0.00	500.00 kgf/m²	300.00 150.00	0.00 0.00	4350.00 kgf/m²		
L2 (R1)	20.00	-60.00	-60.00	500.00 kgf/m²	300.00 150.00	0.00 0.00	4350.00 kgf/m²		
PAR1 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	509.62 kgf/m	555.00	125.00
PAR2 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	560.51 kgf/m	2845.00	125.00
PAR3 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	509.62 kgf/m	555.00	125.00
PAR4 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	278.12 kgf/m	555.00	125.00
PAR5 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	222.64 kgf/m	555.00	125.00
PAR6 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	222.64 kgf/m	555.00	125.00
PAR7 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	282.39 kgf/m	555.00	125.00

4. RESULTADOS

ARMADURAS NA LAJE									
Esforços					Resultados				
Trecho	Ndx Rdx (tf)	Ndy Rdy (tf)	Mdx (kgf.m/m)	Mdy (kgf.m/m)	Armadura inferior		Armadura superior		Flecha (cm)
					Asx	Asy	Asx	Asy	
L1	3.23 - 1.56	2.45 - 2.05	984	713	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 3.00 cm²/m ø8.0 c/16 (3.14 cm²/m)	A's = 3.00 cm²/m ø8.0 c/16 (3.14 cm²/m)	-0.08
L2	2.11 - 2.18	1.29 - 1.35	415	500	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)			-0.03
PAR1	2.70 - 2.93	9.42 - 2.72	817	727	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.29 cm²/m ø6.3 c/13 (2.40 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	0.31
PAR2	4.69 - 0.64	3.91 - 1.13	452	427	As = 3.00 cm²/m ø6.3 c/10	As = 1.50 cm²/m ø6.3 c/20	A's = 3.00 cm²/m ø6.3 c/10	A's = 1.50 cm²/m ø6.3 c/20	0.31

					(3.12 cm ² /m)	(1.56 cm ² /m)	(3.12 cm ² /m)	(1.56 cm ² /m)	
PAR3	2.70 - 2.93	9.41 - 2.82	817	726	As = 2.01 cm ² /m ø6.3 c/15 (2.08 cm ² /m)	As = 2.01 cm ² /m ø6.3 c/15 (2.08 cm ² /m)	A's = 2.29 cm ² /m ø6.3 c/13 (2.40 cm ² /m)	A's = 2.01 cm ² /m ø6.3 c/15 (2.08 cm ² /m)	0.31
PAR4	3.57 - 0.69	6.88 0.00	337	348	As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	As = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	A's = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	A's = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	0.31
PAR5	2.35 - 2.38	7.67 0.00	388	342	As = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	As = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	A's = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	A's = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	0.30
PAR6	2.34 - 2.50	7.90 0.00	383	380	As = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	As = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	A's = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	A's = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	0.31
PAR7	2.29 - 0.85	3.59 0.00	440	342	As = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	As = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	A's = 3.00 cm ² /m ø6.3 c/10 (3.12 cm ² /m)	A's = 1.50 cm ² /m ø6.3 c/20 (1.56 cm ² /m)	0.30

ARMADURAS NA CONTINUIDADE					
Viga Trecho	Laje 1 Laje 2	Momentos fletores (kgf.m/m)		Armaduras	
		Md negativo	Md positivo	As (superior)	A's (inferior)
Barra	L1 PAR3	-949		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR3 L1	-802		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L1 PAR2	-501		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR2 L2	-258		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L2 L1	-119		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L1 PAR1	-951		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR1 L1	-802		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L1 PAR4	-713		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR4 L1	-35		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L2	-474		As = 3.00 cm ² /m	

	PAR5			ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR5 L2	-316		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L2 PAR6	-500		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR6 L2	-314		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	L2 PAR7	-342		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR7 L2	-190		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR2 PAR5	-1033		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR5 PAR1	-1489		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR1 PAR2	-2		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR4 PAR1	-152		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR1 PAR4	-1241		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR6 PAR2	-1026		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR2 PAR3	-4		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR3 PAR6	-1496		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR3 PAR4	-151		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR4 PAR3	-1241		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR7 PAR5	-687		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR5 PAR7	-96		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR7 PAR6	-96		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	
Barra	PAR6 PAR7	-681		As = 3.00 cm ² /m ø8.0 c/16 (3.14 cm ² /m)	

MEMORIAL DE CÁLCULO

ESTRUTURA EM CONCRETO ARMADO

Cliente: Serenço Serviços de Engenharia Consultiva

Local: Juiz de Fora-MG

Obra: Caixa de Travessia

1. NORMAS ADOTADAS

Foram utilizadas as seguintes normas para a realização deste projeto estrutural:

- NBR 6118:2003 – Projeto de estruturas de concreto
- NBR 6120:1980 – Cargas para o cálculo de estruturas de edificações
- NBR 6122:1986 – Projeto e execução de fundações

2. PARÂMETROS ADOTADOS

a) Materiais:

- Concreto: C25 ($f_{ck} = 25 \text{ MPa}$) (demais elementos estruturais)

Módulo de elasticidade inicial do concreto:

$$E_{cs} = 5600\sqrt{f_{ck}} = 5600\sqrt{25} = 28000 \text{ MPa} \cong 2.800.000.000 \text{ kgf} / \text{m}^2$$

Peso específico do concreto armado = 2500 kgf/m^3

$\gamma_c = 1,4$ (coeficiente de majoração do concreto)

- Aço: CA-50A ($f_{yk} = 500 \text{ MPa}$)

$\gamma_s = 1,15$ (coeficiente de majoração do aço)

3. DADOS

Seção (cm)				Cargas Verticais (kgf/m²)				Cargas Horizontais (kgf/m²)	
Elemento	H	Elevação	Nível	Peso Próprio	Acidental Revestimento	Paredes Outras	Total	Base	Topo
L1 (R1)	20.00	0.00	0.00	500.00 kgf/m²	300.00 150.00	0.00 0.00	4350.00 kgf/m²		
PAR1 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	564.51 kgf/m	555.00	125.00
PAR2 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	370.57 kgf/m	555.00	125.00
PAR3 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	564.49 kgf/m	555.00	125.00
PAR4 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	370.53 kgf/m	555.00	125.00

4. RESULTADOS

ARMADURAS POSITIVAS (LAJE)										
Trec ho	Direç ão	Momento positivo			Momento negativo			Armad ura inferior	Armad ura superior	Cisalham ento
		Flexã o	Verificaç ão axial (compress ão)	Verifica ção axial (tração)	Flexã o	Verificaç ão axial (compress ão)	Verifica ção axial (tração)			
L1	X	Md = 1192 kgf.m /m As = 1.67 cm²/m A's = 0.00 cm²/m	Fd = 3.10 tf Situação: GE As = 1.20 cm²/m A's = 0.00 cm²/m	Fd = 2.00 tf Situaçã o: GE As = 1.89 cm²/m A's = 0.00 cm²/m	Md = 859 kgf.m /m As = 1.20 cm²/m A's = 0.00 cm²/m	Fd = 3.10 tf Situação: GE As = 0.78 cm²/m A's = 0.00 cm²/m	Fd = 2.00 tf Situaçã o: GE As = 1.48 cm²/m A's = 0.00 cm²/m	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m) fiss = 0.10 mm	A's = 3.00 cm²/m ø6.3 c/10 (3.12 cm²/m)	vsd = 3.95 tf/m vrd1 = 9.58 tf/m Modelo I vrd2 = 70.23 tf/m vsw = 0.00 tf/m asw = 0.00 cm²/m
	Y	Md = 1192 kgf.m /m As = 1.73 cm²/m A's = 0.00 cm²/m	Fd = 1.45 tf Situação: GE As = 0.57 cm²/m A's = 0.00 cm²/m	Fd = 3.05 tf Situaçã o: GE As = 1.21 cm²/m A's = 0.00 cm²/m	Md = 624 kgf.m /m As = 0.91 cm²/m A's = 0.00 cm²/m	Fd = 1.45 tf Situação: GE As = 0.70 cm²/m A's = 0.00 cm²/m	Fd = 3.05 tf Situaçã o: GE As = 1.34 cm²/m A's = 0.00 cm²/m	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m) fiss = 0.03 mm	A's = 3.00 cm²/m ø6.3 c/10 (3.12 cm²/m)	vsd = 3.01 tf/m vrd1 = 9.28 tf/m vrd2 = 67.50 tf/m vsw = 0.00 tf/m asw = 0.00 cm²/m

PAR 1	X	Md = 1192 kgf.m /m As = 1.67 cm ² / m A's = 0.00 cm ² / m	Fd = 2.94 tf Situa�� o: GE As = 0.73 cm ² / m A's = 0.00 cm ² / m	Md = 1192 kgf.m /m As = 1.67 cm ² / m A's = 0.00 cm ² / m	Fd = 2.84 tf Situa��o: GE As = 0.75 cm ² / m A's = 0.00 cm ² / m	Fd = 2.94 tf Situa�� o: GE As = 1.54 cm ² / m A's = 0.00 cm ² / m	As = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) fiss = 0.01 mm	A's = 2.29 cm ² / m �6.3 c/13 (2.40 cm ² / m) 	vsd = 3.48 tf/m vrd1 = 9.75 tf/m Modelo I vrd2 = 71.52 tf/m vsw = 0.00 tf/m asw = 0.00 cm ² / m
	Y	Md = 1192 kgf.m /m As = 1.73 cm ² / m A's = 0.00 cm ² / m	Fd = 3.51 tf Situa�� o: PE As = 0.54 cm ² / m A's = 0.27 cm ² / m	Md = 1192 kgf.m /m As = 1.73 cm ² / m A's = 0.00 cm ² / m		Fd = 3.51 tf Situa�� o: GE As = 1.55 cm ² / m A's = 0.00 cm ² / m	As = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) fiss = 0.01 mm	A's = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) 	vsd = 4.02 tf/m vrd1 = 9.44 tf/m vrd2 = 68.74 tf/m vsw = 0.00 tf/m asw = 0.00 cm ² / m
PAR 2	X	Md = 1192 kgf.m /m As = 1.67 cm ² / m A's = 0.00 cm ² / m	Fd = 2.09 tf Situa�� o: PE As = 0.44 cm ² / m A's = 0.04 cm ² / m	Md = 1192 kgf.m /m As = 1.67 cm ² / m A's = 0.00 cm ² / m	Fd = 3.60 tf Situa��o: GE As = 0.10 cm ² / m A's = 0.00 cm ² / m	Fd = 2.09 tf Situa�� o: GE As = 0.87 cm ² / m A's = 0.00 cm ² / m	As = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) fiss = 0.00 mm	A's = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) 	vsd = 3.18 tf/m vrd1 = 9.75 tf/m Modelo I vrd2 = 71.52 tf/m vsw = 0.00 tf/m asw = 0.00 cm ² / m
	Y	Md = 1192 kgf.m /m As = 1.73 cm ² / m A's = 0.00 cm ² / m	Fd = 1.07 tf Situa�� o: PE As = 0.18 cm ² / m A's = 0.06 cm ² / m	Md = 1192 kgf.m /m As = 1.73 cm ² / m A's = 0.00 cm ² / m		Fd = 1.07 tf Situa�� o: GE As = 0.79 cm ² / m A's = 0.00 cm ² / m	As = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) fiss = 0.00 mm	A's = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) 	vsd = 1.80 tf/m vrd1 = 9.44 tf/m vrd2 = 68.74 tf/m vsw = 0.00 tf/m asw = 0.00 cm ² / m
PAR 3	X	Md = 1192 kgf.m /m As = 1.67 cm ² / m	Fd = 2.94 tf Situa�� o: GE As = 0.73 cm ² / m	Md = 1192 kgf.m /m As = 1.67 cm ² / m	Fd = 3.02 tf Situa��o: GE As = 0.73 cm ² / m A's = 0.00 cm ² / m	Fd = 2.94 tf Situa�� o: GE As = 1.54 cm ² / m	As = 2.01 cm ² / m �6.3 c/15 (2.08 cm ² / m) 	A's = 2.29 cm ² / m �6.3 c/13 (2.40 cm ² / m) 	vsd = 3.48 tf/m vrd1 = 9.75 tf/m Modelo I vrd2 = 71.52 tf/m

		A's = 0.00 cm²/ m	A's = 0.00 cm²/m	A's = 0.00 cm²/ m		A's = 0.00 cm²/m		A's = 0.00 cm²/m	fiss = 0.01 mm		vsw = 0.00 tf/m asw = 0.00 cm²/m
	Y	Md = 1192 kgf.m /m As = 1.73 cm²/ m A's = 0.00 cm²/ m	Fd = 3.57 tf Situaçã o: PE As = 0.54 cm²/m A's = 0.28 cm²/m	Md = 1192 kgf.m /m As = 1.73 cm²/ m A's = 0.00 cm²/ m		Fd = 3.57 tf Situaçã o: GE As = 1.56 cm²/m A's = 0.00 cm²/m		As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m) fiss = 0.01 mm	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)		vsd = 4.02 tf/m vrd1 = 9.44 tf/m vrd2 = 68.74 tf/m vsw = 0.00 tf/m asw = 0.00 cm²/m
	X	Md = 1192 kgf.m /m As = 1.67 cm²/ m A's = 0.00 cm²/ m	Fd = 2.08 tf Situaçã o: PE As = 0.43 cm²/m A's = 0.05 cm²/m	Md = 1192 kgf.m /m As = 1.67 cm²/ m A's = 0.00 cm²/ m		Fd = 2.08 tf Situaçã o: GE As = 0.87 cm²/m A's = 0.00 cm²/m		As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m) fiss = 0.00 mm	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)		vsd = 3.18 tf/m vrd1 = 9.75 tf/m Modelo I vrd2 = 71.52 tf/m vsw = 0.00 tf/m asw = 0.00 cm²/m
PAR 4	Y	Md = 1192 kgf.m /m As = 1.73 cm²/ m A's = 0.00 cm²/ m	Fd = 1.23 tf Situaçã o: PE As = 0.19 cm²/m A's = 0.09 cm²/m	Md = 1192 kgf.m /m As = 1.73 cm²/ m A's = 0.00 cm²/ m		Fd = 1.23 tf Situaçã o: GE As = 0.81 cm²/m A's = 0.00 cm²/m		As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m) fiss = 0.00 mm	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)		vsd = 1.79 tf/m vrd1 = 9.44 tf/m vrd2 = 68.74 tf/m vsw = 0.00 tf/m asw = 0.00 cm²/m

ARMADURAS NEGATIVAS (NA CONTINUIDADE)							
Viga	Laje 1	Momento negativo		Momento positivo			Armaduras finais
Trecho	Laje 2	Flexão	Flexo compressão	Flexo tração	Flexão	Flexo compressão	
Barra	L1	Md = 1778 kgf.m/m	Fd = 7.68 tf Situação: GE As = 0.61 cm²/m	Fd = 3.49 tf Situação: GE As = 2.12 cm²/m A's = 0.00 cm²/m			As = 3.00 cm²/m (ø8.0 c/16 - 3.14 cm²/m) fiss = 0.06 mm
	PAR3	As = 2.52 cm²/m A's = 0.00 cm²/m	A's = 0.00 cm²/m	A's = 0.00 cm²/m			
Barra	PAR3	Md = 1778 kgf.m/m		Fd = 3.49 tf			As = 3.00 cm²/m
	L1						

		As = 2.52 cm ² /m A's = 0.00 cm ² /m		Situação: GE As = 1.49 cm ² /m A's = 0.00 cm ² /m				(ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.03 mm
Barra	L1 PAR2	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 1.46 tf Situação: GE As = 1.07 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.02 mm
Barra	PAR2 L1	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 1.46 tf Situação: GE As = 0.35 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	L1 PAR1	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m	Fd = 7.70 tf Situação: GE As = 0.61 cm ² /m A's = 0.00 cm ² /m	Fd = 3.44 tf Situação: GE As = 2.12 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.06 mm
Barra	PAR1 L1	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 3.44 tf Situação: GE As = 1.48 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.03 mm
Barra	L1 PAR4	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 1.45 tf Situação: GE As = 1.07 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.02 mm
Barra	PAR4 L1	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 1.45 tf Situação: GE As = 0.34 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	PAR2 PAR1	Md = 1778 kgf.m/m As = 2.52 cm ² /m	Fd = 3.38 tf Situação: GE As = 1.53 cm ² /m A's = 0.00 cm ² /m	Fd = 0.27 tf Situação: GE As = 2.02 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.07 mm

		A's = 0.00 cm ² /m		A's = 0.00 cm ² /m				
Barra	PAR1 PAR2	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 0.27 tf Situação: GE As = 0.20 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	PAR4 PAR1	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 0.27 tf Situação: GE As = 0.20 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	PAR1 PAR4	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m	Fd = 3.38 tf Situação: GE As = 1.53 cm ² /m A's = 0.00 cm ² /m	Fd = 0.27 tf Situação: GE As = 2.02 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.07 mm
Barra	PAR2 PAR3	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 0.28 tf Situação: GE As = 0.21 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	PAR3 PAR2	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m	Fd = 3.26 tf Situação: GE As = 1.54 cm ² /m A's = 0.00 cm ² /m	Fd = 0.28 tf Situação: GE As = 2.02 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.07 mm
Barra	PAR3 PAR4	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m		Fd = 0.27 tf Situação: GE As = 0.20 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.00 mm
Barra	PAR4 PAR3	Md = 1778 kgf.m/m As = 2.52 cm ² /m A's = 0.00 cm ² /m	Fd = 3.38 tf Situação: GE As = 1.53 cm ² /m A's = 0.00 cm ² /m	Fd = 0.27 tf Situação: GE As = 2.02 cm ² /m A's = 0.00 cm ² /m				As = 3.00 cm ² /m (ø8.0 c/16 - 3.14 cm ² /m) fiss = 0.07 mm

MEMORIAL DE CÁLCULO

ESTRUTURA EM CONCRETO ARMADO

Cliente: Serenço Serviços de Engenharia Consultiva

Local: Juiz de Fora-MG

Obra: Caixa de Ventosa

1. NORMAS ADOTADAS

Foram utilizadas as seguintes normas para a realização deste projeto estrutural:

- NBR 6118:2003 – Projeto de estruturas de concreto
- NBR 6120:1980 – Cargas para o cálculo de estruturas de edificações
- NBR 6122:1986 – Projeto e execução de fundações

2. PARÂMETROS ADOTADOS

a) Materiais:

- Concreto: C25 ($f_{ck} = 25 \text{ MPa}$) (demais elementos estruturais)

Módulo de elasticidade inicial do concreto:

$$E_{cs} = 5600\sqrt{f_{ck}} = 5600\sqrt{25} = 28000 \text{ MPa} \cong 2.800.000.000 \text{ kgf} / \text{m}^2$$

Peso específico do concreto armado = 2500 kgf/m^3

$\gamma_c = 1,4$ (coeficiente de majoração do concreto)

- Aço: CA-50A ($f_{yk} = 500 \text{ MPa}$)

$\gamma_s = 1,15$ (coeficiente de majoração do aço)

3. DADOS

Seção (cm)				Cargas Verticais (kgf/m²)				Cargas Horizontais (kgf/m²)	
Elemento	H	Elevação	Nível	Peso Próprio	Acidental Revestimento	Paredes Outras	Total	Base	Topo
L1 (R1)	20.00	0.00	0.00	500.00 kgf/m²	300.00 150.00	0.00 0.00	4350.00 kgf/m²		
PAR1 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	509.62 kgf/m	555.00	125.00
PAR2 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	278.12 kgf/m	555.00	125.00
PAR3 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	509.62 kgf/m	555.00	125.00
PAR4 (R1)	20.00	0.00	340.00	1700.00 kgf/m	0.00 0.00	0.00 0.00	278.12 kgf/m	555.00	125.00

4. RESULTADOS

ARMADURAS NA LAJE									
Esforços					Resultados				
Trecho	Ndx Rdx (tf)	Ndy Rdy (tf)	Mdx (kgf.m/m)	Mdy (kgf.m/m)	Armadura inferior		Armadura superior		Flecha (cm)
					Asx	Asy	Asx	Asy	
L1	3.02 - 1.27	0.64 - 2.11	799	816	As = 3.00 cm²/m ø6.3 c/10 (3.12 cm²/m)	As = 1.50 cm²/m ø6.3 c/20 (1.56 cm²/m)	A's = 3.00 cm²/m ø8.0 c/16 (3.14 cm²/m)	A's = 3.00 cm²/m ø8.0 c/16 (3.14 cm²/m)	-0.09
PAR1	2.48 - 2.39	6.56 - 2.53	873	768	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.29 cm²/m ø6.3 c/13 (2.40 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	0.03
PAR2	3.54 - 0.70	6.45 0.00	126	352	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	0.03
PAR3	2.64 - 2.39	6.54 - 2.57	873	767	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.29 cm²/m ø6.3 c/13 (2.40 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	0.03
PAR4	3.56 - 0.70	5.91 0.00	128	349	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	As = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	A's = 2.01 cm²/m ø6.3 c/15 (2.08 cm²/m)	0.03

ARMADURAS NA CONTINUIDADE					
Viga Trecho	Laje 1 Laje 2	Momentos fletores (kgf.m/m)		Armaduras	
		Md negativo	Md positivo	As (superior)	A's (inferior)
Barra	L1	-1089		As = 3.00 cm²/m	

	PAR3			$\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR3 L1	-554		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	L1 PAR2	-816		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR2 L1	-40		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	L1 PAR1	-1089		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR1 L1	-552		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	L1 PAR4	-812		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR4 L1	-39		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR2 PAR1	-1308		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR1 PAR2	-112		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR4 PAR1	-113		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR1 PAR4	-1307		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR2 PAR3	-114		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR3 PAR2	-1305		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR3 PAR4	-114		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	
Barra	PAR4 PAR3	-1307		$A_s = 3.00 \text{ cm}^2/\text{m}$ $\varnothing 8.0 \text{ c}/16$ $(3.14 \text{ cm}^2/\text{m})$	



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