DIÁRIO OFICIAL DO ESTADO DE SÃO PAULO

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PORTARIA Nº 080/25, DE 16 DE JUNHO DE 2025

Processo SEI nº 139.00064959/2024-57

Portaria PR/DER-080/2025

Homologa a Norma Técnica - NT-DE-COO-001- REV-B - conforme especifica. (2.1)

O Presidente do Departamento de Estradas de Rodagem do Estado de São Paulo, em conformidade com os incisos I, III e IX do artigo 33 do Decreto n° 69.322, de 22 de janeiro de 2025, resolve:

Artigo 1º - Fica homologada, de conformidade com o disposto na Portaria SUP/DER-035-01/06/2011, a Norma Técnica de Avaliação de Segurança para a passagem de guindastes de 7 (sete) eixos e 84 (oitenta e quatro) toneladas para 8 (oito) eixos e 96 (noventa e seis) toneladas em Obras de Arte Especiais (OAEs), conforme descrição abaixo:
NT-DE-COO-001- REV-B.

Artigo 2º - A Norma Técnica a que se refere o artigo anterior encontra-se no anexo parte integrante desta portaria

Artigo 3°- Esta portaria entra em vigor na data de sua publicação, ficando revogada a Portaria PR/DER-033/2025.

TÍTULO

AVALIAÇÃO DE SEGURANÇA PARA A PASSAGEM DE GUINDASTES AUTOPROPELIDOS DE 7 E 8 EIXOS (12TF/EIXO) EM OBRAS DE ARTE ESPECIAIS

ÓRGÃO

DIRETORIA DE ENGENHARIA

ELABORAÇÃO	RESP. TÉCNICO	VERIFICAÇÃO	LIBERAÇÃO DO DER	APROVAÇÃO DER
ÍRIS BEATRIZ DUARTE	JOSÉ CARLOS DE M. R. ALVES	PAULO EDUARDO DE OLIVEIRA		

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Verifique em https://validar.iti.gov.br

DOCUMENTOS DE REFERÊNCIA

DOCUMENTOS RESULTANTES

OBSERVAÇÕES

REVISÃO	DATA	RESP. TÉCNICO	VERIFICAÇÃO	LIBERAÇÃO	APROVAÇÃO
A	Set/2025	José Carlos De M. R. Alves			

ÍNDICE

1. OBJETIVO

O presente estudo tem como objetivo comparar os esforços gerados pela passagem de um guindaste de 8 eixos e 96 toneladas, calculado com os critérios atuais do trem-tipo TB-45, com os esforços de projeto calculados com os trem-tipos TB-24 e TB-36 em OAEs – Obras de Arte Especial, isto com o intuito de analisar e verificar quais pontes são capazes de suportar a passagem do guindaste.

O TB-24 começou a ser utilizado em 1943 e durou até 1960 (NB6-43), o TB-36 a partir de 1960 até 1984 (NB6-60) e o TB-45 a partir de 1984 até os dias atuais (NBR 7188/24).

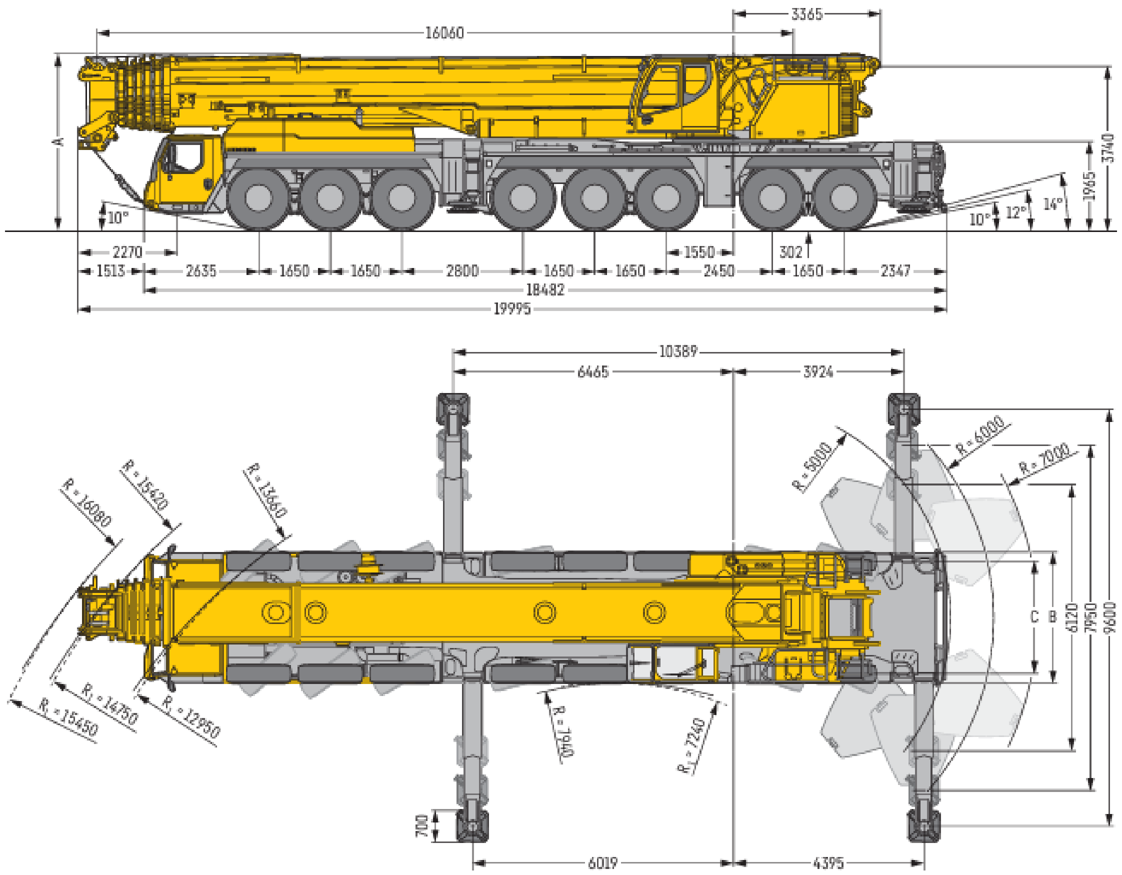
2. METODOLOGIA

Foram elaborados 90 modelos para obras calculadas com TB-36 e 24 modelos para o TB-24.

As larguras dos tabuleiros para os modelos TB-36, variam de acordo com os PP´s do DER, e assumem valores de 11,20; 12,60; 14,10; 16,10; 16,90 e 19,60 metros, com os comprimentos de 20, 25, 30, 35 e 40 metros. Para cada tabuleiro, três casos foram estudados: cargas permanentes, cargas acidentais TB-36 e cargas acidentais do guindaste.

Já para os tabuleiros do TB-24, as larguras da época eram praticamente padronizadas, por isso foram estudadas larguras de 8,30; 10,00 e 10,30 metros, com os comprimentos de 20, 25, 30 e 35 metros. Para cada tabuleiro, estudamos dois casos: cargas acidentais TB-24 e cargas acidentais de guindaste.

3. DESCRIÇÃO DO GUINDASTE



Maße · Dimensions · Encombrement · Dimensioni · Dimensiones · Размеры mm

(tyre)	A	A *	B	C
385/95 R 25 (14.00 R 25)	4000	3850	3000	2610
445/95 R 25 (16.00 R 25)	4000	3900	3000	2550
525/80 R 25 (20.5 R 25)	4000	3900	3100	2570

* **abgesenkt** · lowered · abaissé · abbassato · suspensión abajo · шасси осажено

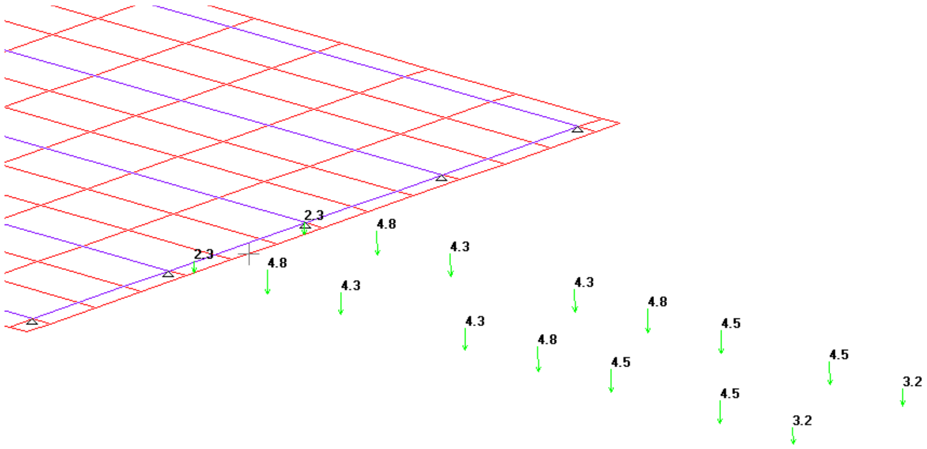
As medidas das imagens acima foram utilizadas para o cálculo do estudo.

O primeiro passo foi realizar a homogenização do guindaste, o seus eixos precisam ser aliviados proporcionalmente pela área de influência do eixo com a carga de multidão de 0,50 tf/m².

Segue abaixo a tabela utilizada para o cálculo da homogenização:

EIXOS	DISTÂNCIAS (m)	DIST. INFL (m)	LARG (m)	ÁREA DE INFL. (m²)	MULTIDÃO (tf/m²)	ALÍVIO EIXO (tf)	CARGA EIXO (tf)	COM ALIÍVIO (tf)	RODA COM ALÍVIO (tf)
0	4,15	-	-	-	-	-	-	-	-
1	1,65	4,97	3,00	14,92	0,50	7,46	12,00	4,54	2,27
2	1,65	1,65	3,00	4,95	0,50	2,48	12,00	9,53	4,76
3	2,80	2,23	3,00	6,68	0,50	3,34	12,00	8,66	4,33
4	1,65	2,23	3,00	6,68	0,50	3,34	12,00	8,66	4,33
5	1,65	1,65	3,00	4,95	0,50	2,48	12,00	9,53	4,76
6	2,40	2,03	3,00	6,09	0,50	3,05	12,00	8,96	4,48
7	1,65	2,03	3,00	6,09	0,50	3,05	12,00	8,96	4,48
8	2,85	3,67	3,00	11,02	0,50	5,51	12,00	6,49	3,25

- **Eixos:** Listagem da quantidade de eixos.
- **Distâncias (m):** Informa a distância que há de um eixo para o outro.
- **Distância de influência (m):** Representa a distância entre os pontos de apoio do guindaste.
- **Largura (m):** A largura sobre a qual a carga está sendo aplicada.
- **Área de influência (m²):** É o produto da distância de influência pela largura.
- **Multidão (tf/m²):** Representa a carga distribuída por metro quadrado.
- **Alívio eixo (tf):** É o total de carga que está sendo aliviada pelo guindaste sobre o eixo específico.
- **Carga eixo (tf):** Representa a carga total teórica que seria suportada pelo eixo sem considerar qualquer alívio. Para todos os eixos é constante, aqui indicado como 12,00 tfeladas.
- **Com alívio (tf):** É a carga real no eixo após o alívio ser aplicado.
- **Roda com alívio (tf):** O guindaste tem duas rodas por eixo, então a carga é dividida igualmente entre as duas rodas.



LTM1500-C-HOAlpu

CONC -2.27 C 0.00 1.305

CONC -2.27 C 0.00 -1.305

CONC -4.76 C 1.65 1.305

CONC -4.76 C 1.65 -1.305

CONC -4.33 C 3.30 1.305

CONC -4.33 C 3.30 -1.305

CONC -4.33 C 6.10 1.305

CONC -4.33 C 6.10 -1.305

CONC -4.76 C 7.75 1.305

CONC -4.76 C 7.75 -1.305

CONC -4.48 C 9.40 1.305

CONC -4.48 C 9.40 -1.305

CONC -4.48 C 11.85 1.305

CONC -4.48 C 11.85 -1.305

CONC -3.25 C 13.50 1.305

CONC -3.25 C 13.50 -1.305

4. DESENVOLVIMENTO: TB-36

4.1. Introdução

A partir dos Projetos Padrão (PPs) do DER, foram desenvolvidos os 90 modelos estruturais listados abaixo, permitindo a obtenção dos momentos de inércia reais das vigas longarinas.

- tabuleiro 11,20 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 11,20 - 20,00 m - permanantes
- tabuleiro 11,20 - 20,00 m - TB-36
- tabuleiro 11,20 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL
- tabuleiro 11,20 - 25,00 m - permanentes
- tabuleiro 11,20 - 25,00 m - TB-36
- tabuleiro 11,20 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 11,20 - 30,00 m - permanentes
- tabuleiro 11,20 - 30,00 m - TB-36
- tabuleiro 11,20 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 11,20 - 35,00 m - permanentes
- tabuleiro 11,20 - 35,00 m - TB-36
- tabuleiro 11,20 - 40,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 11,20 - 40,00 m - permanentes
- tabuleiro 11,20 - 40,00 m - TB-36

- tabuleiro 12.60 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 12.60 - 20,00 m - permanentes
- tabuleiro 12.60 - 20,00 m - TB-36
- tabuleiro 12.60 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 12.60 - 25,00 m - permanentes
- tabuleiro 12.60 - 25,00 m - TB-36
- tabuleiro 12.60 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 12.60 - 30,00 m - permanentes
- tabuleiro 12.60 - 30,00 m - TB-36
- tabuleiro 12.60 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 12.60 - 35,00 m - permanentes
- tabuleiro 12.60 - 35,00 m - TB-36
- tabuleiro 12.60 - 40,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 12.60 - 40,00 m - permanentes
- tabuleiro 12.60 - 40,00 m - TB-36

- tabuleiro 16.10 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.10 - 20,00 m - permanentes
- tabuleiro 16.10 - 20,00 m - TB-36
- tabuleiro 16.10 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.10 - 25,00 m - permanentes
- tabuleiro 16.10 - 25,00 m - TB-36
- tabuleiro 16.10 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.10 - 30,00 m - permanentes
- tabuleiro 16.10 - 30,00 m - TB-36
- tabuleiro 16.10 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.10 - 35,00 m - permanentes
- tabuleiro 16.10 - 35,00 m - TB-36
- tabuleiro 16.10 - 40,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.10 - 40,00 m - permanentes
- tabuleiro 16.10 - 40,00 m - TB-36

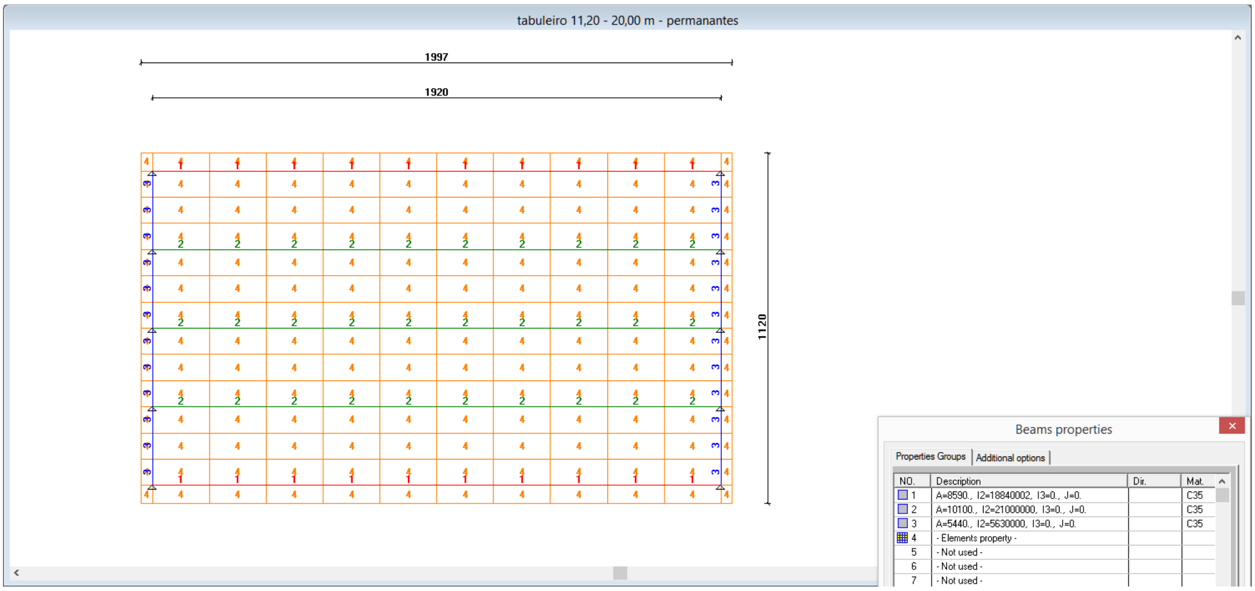
- tabuleiro 14.10 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 14.10 - 20,00 m - permanentes
- tabuleiro 14.10 - 20,00 m - TB-36
- tabuleiro 14.10 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 14.10 - 25,00 m - permanentes
- tabuleiro 14.10 - 25,00 m - TB-36
- tabuleiro 14.10 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 14.10 - 30,00 m - permanentes
- tabuleiro 14.10 - 30,00 m - TB-36
- tabuleiro 14.10 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 14.10 - 35,00 m - permanentes
- tabuleiro 14.10 - 35,00 m - TB-36
- tabuleiro 14.10 - 40,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 14.10 - 40,00 m - permanentes
- tabuleiro 14.10 - 40,00 m - TB-36

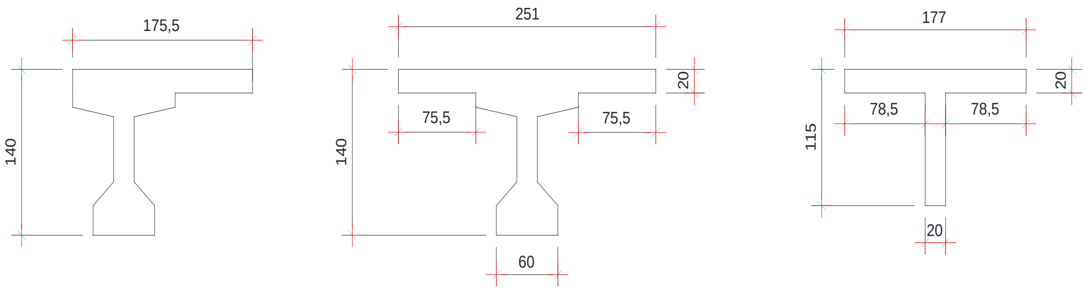
- tabuleiro 16.90 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.90 - 20,00 m - permanentes
- tabuleiro 16.90 - 20,00 m - TB-36
- tabuleiro 16.90 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.90 - 25,00 m - permanentes
- tabuleiro 16.90 - 25,00 m - TB-36
- tabuleiro 16.90 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.90 - 30,00 m - permanentes
- tabuleiro 16.90 - 30,00 m - TB-36
- tabuleiro 16.90 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.90 - 35,00 m - permanentes
- tabuleiro 16.90 - 35,00 m - TB-36
- tabuleiro 16.90 - 40,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 16.90 - 40,00 m - permanentes
- tabuleiro 16.90 - 40,00 m - TB-36

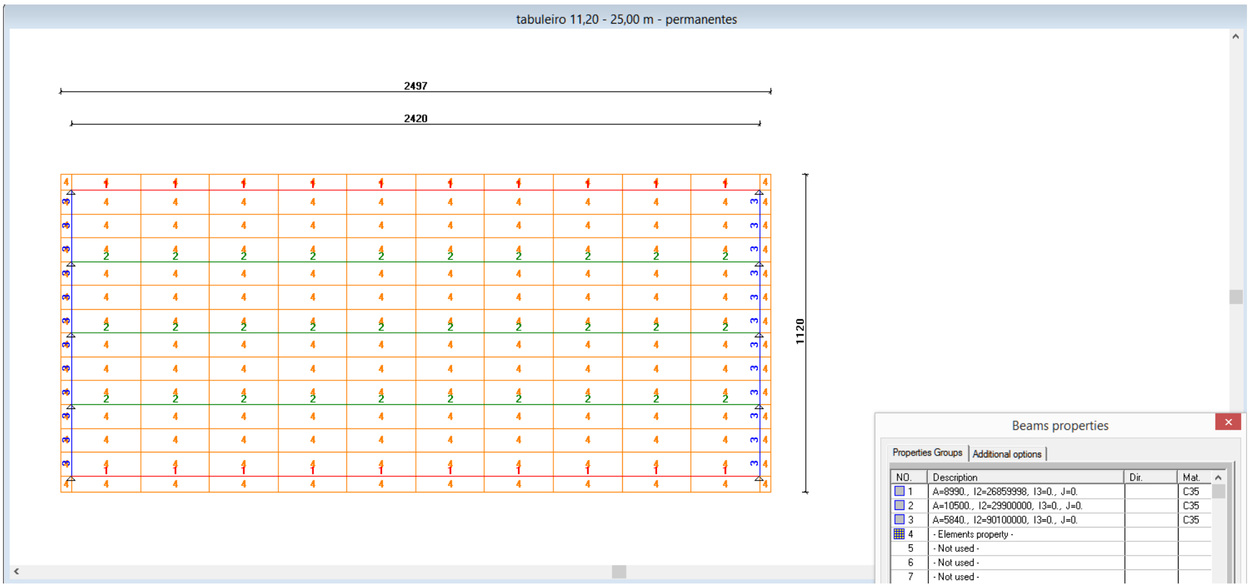
- tabuleiro 19.60 - 20,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 19.60 - 20,00 m - permanentes
- tabuleiro 19.60 - 20,00 m - TB-36
- tabuleiro 19.60 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 19.60 - 25,00 m - permanentes
- tabuleiro 19.60 - 25,00 m - TB-36
- tabuleiro 19.60 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 19.60 - 30,00 m - permanentes
- tabuleiro 19.60 - 30,00 m - TB-36
- tabuleiro 19.60 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 19.60 - 35,00 m - permanentes
- tabuleiro 19.60 - 35,00 m - TB-36
- tabuleiro 19.60 - 40 ,00 m - Leibherr LTM 1500 HOMO A.INFL.
- tabuleiro 19.60 - 40 ,00 m - permanentes
- tabuleiro 19.60 - 40 ,00 m - TB-36

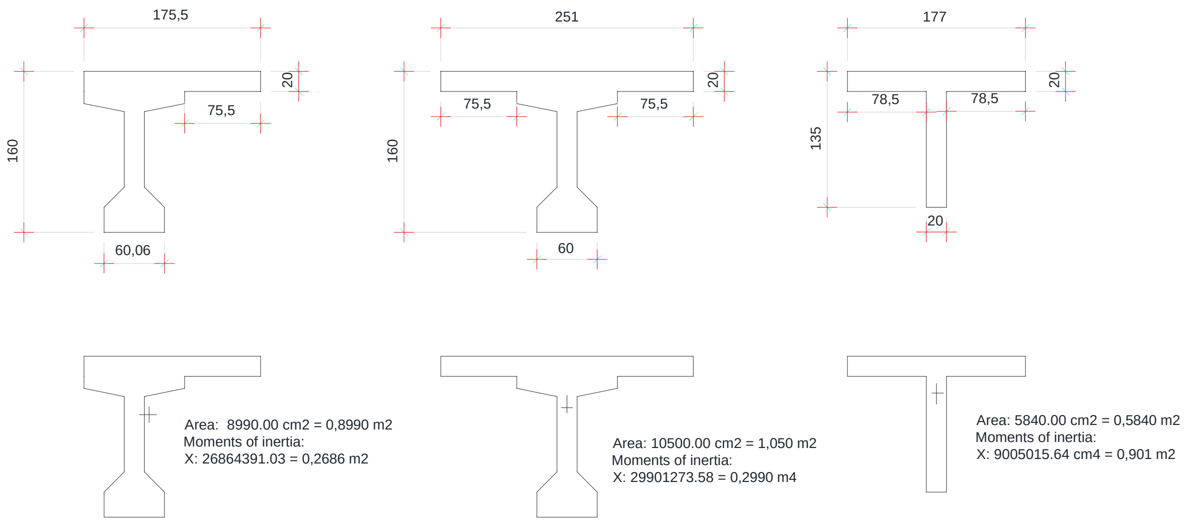
4.2. Momento de inércia e geometria

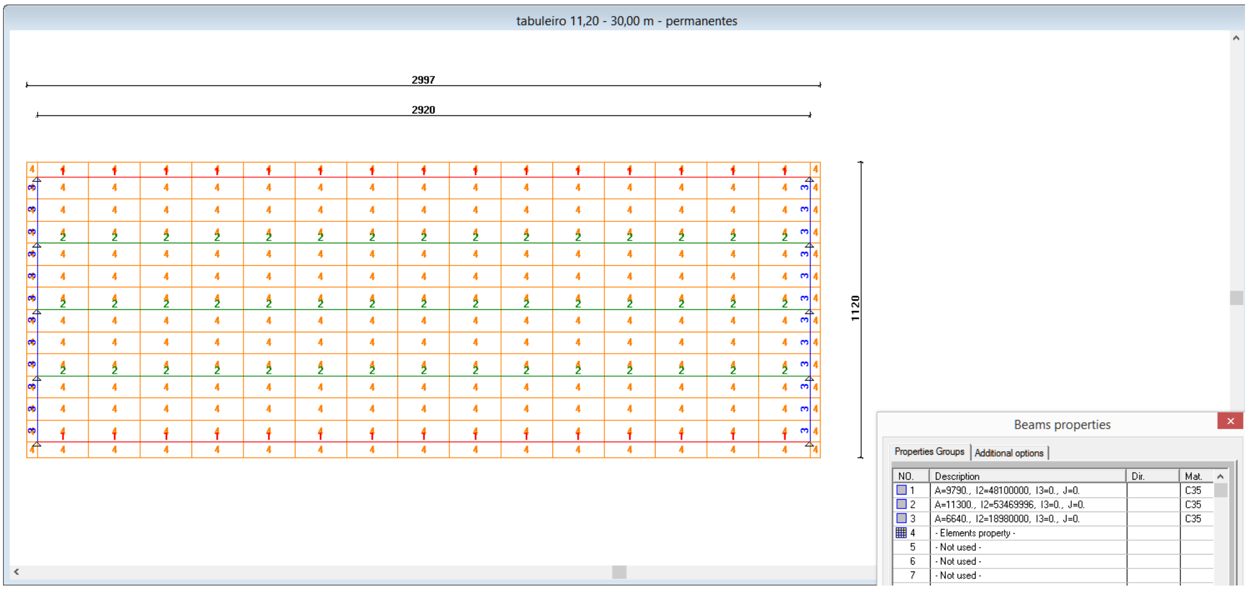
4.2.1. Tabuleiro 11,20 m

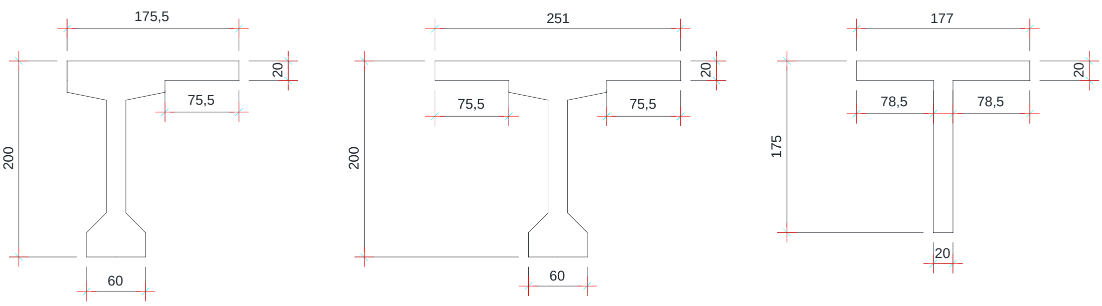




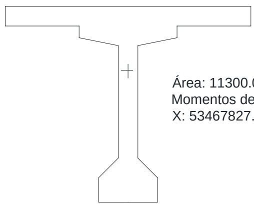

tabuleiro 11,20 - 25,00 m - permanentes
2497
2420
1120
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=8990., I2=26859998, I3=0., J=0. C35
2 A=10500., I2=29900000, I3=0., J=0. C35
3 A=5840., I2=90100000, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -


175,5
20
75,5
160
60,06
251
20
75,5
75,5
160
60
177
20
78,5
78,5
135
20
Area: 8990.00 cm2 = 0,8990 m2
Moments of inertia:
X: 26864391.03 = 0,2686 m2
Area: 10500.00 cm2 = 1,050 m2
Moments of inertia:
X: 29901273.58 = 0,2990 m4
Area: 5840.00 cm2 = 0,5840 m2
Moments of inertia:
X: 9005015.64 cm4 = 0,901 m2

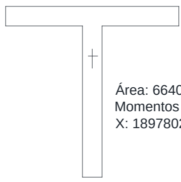




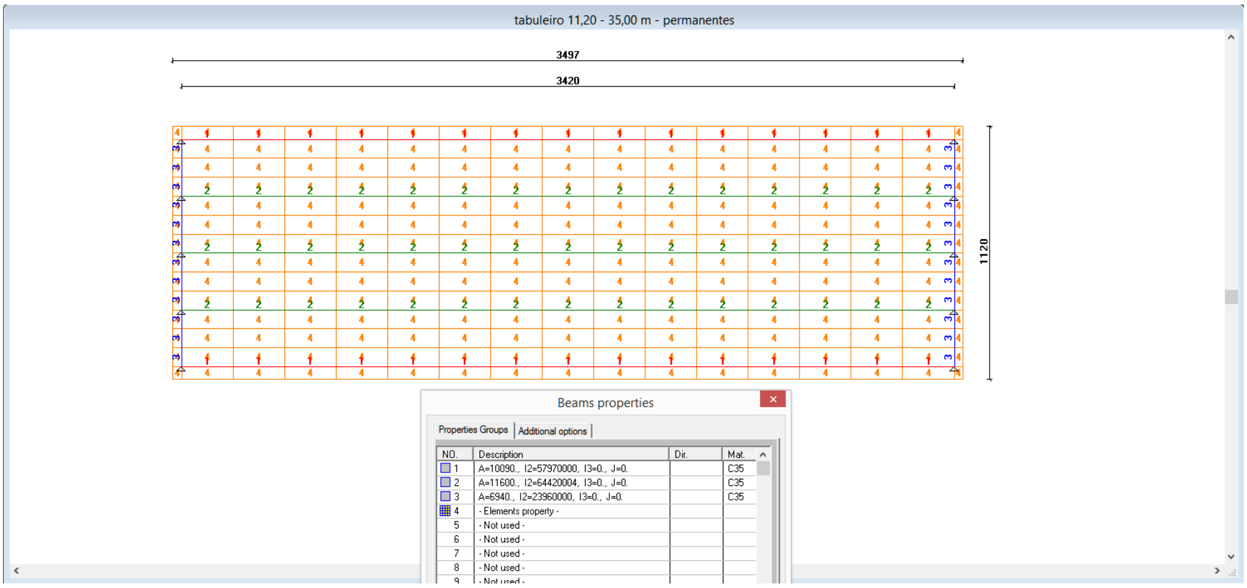
Área: 9790.00 cm2 = 0,9790 m2
Momentos de inércia:
X: 48101241.87 cm2 = 0,4810 m4

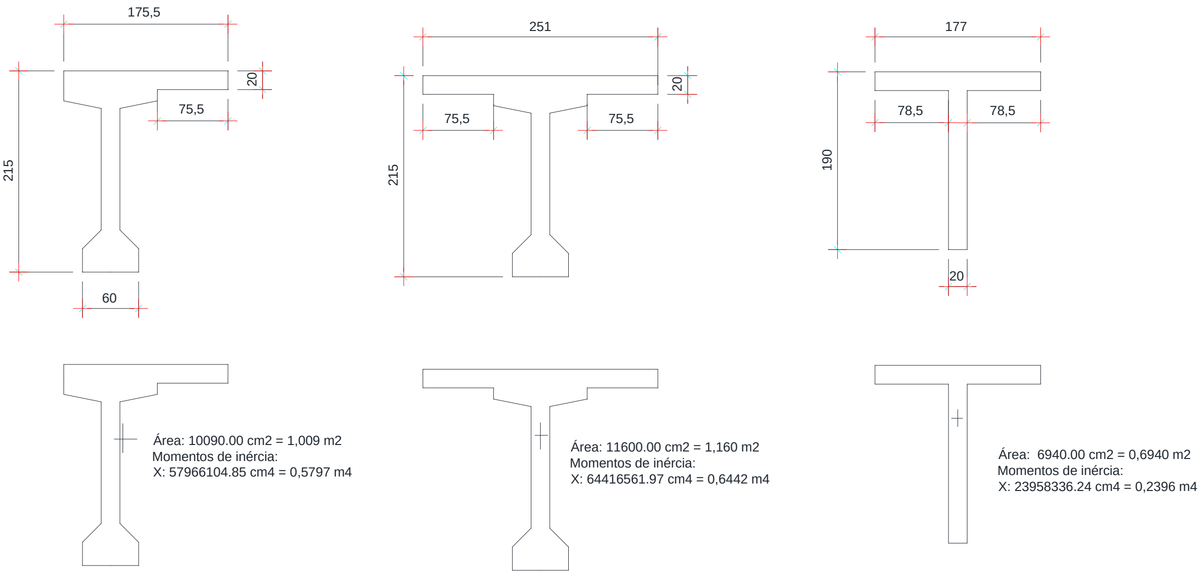


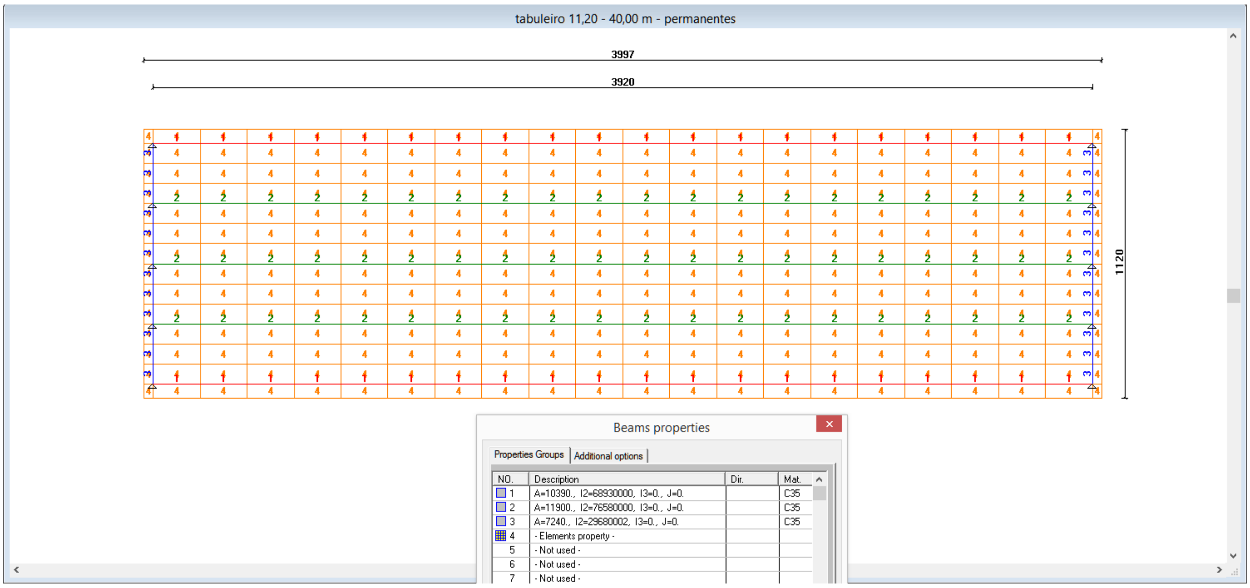
Área: 11300.00 cm2 = 1,130 m2
Momentos de inércia:
X: 53467827.90 cm4 = 0,5347 m4

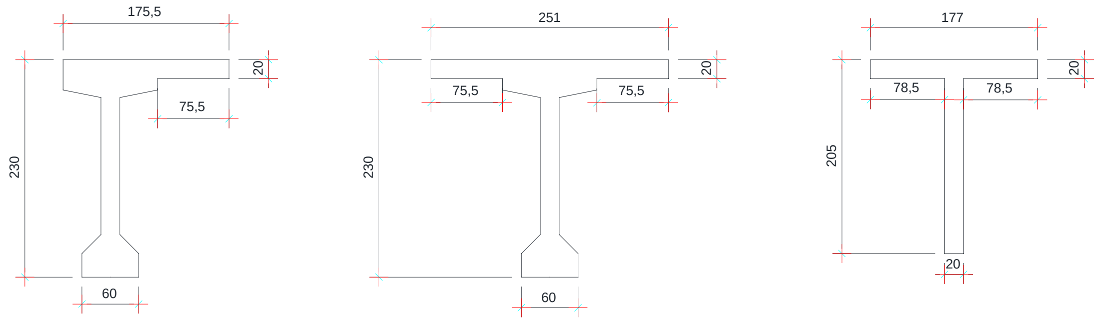


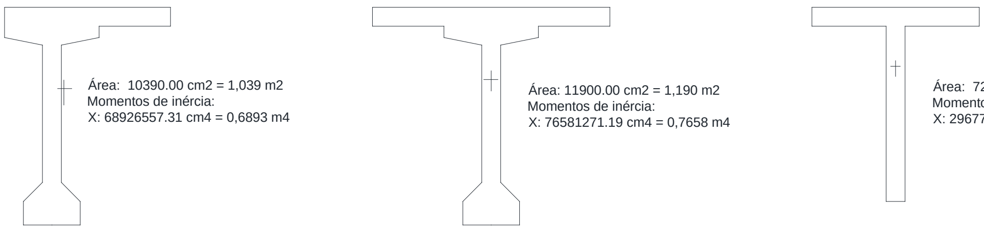
Área: 6640.00 cm2 =0,6640 m2
Momentos de inércia:
X: 18978025.73 cm4 = 0,1898 m4


tabuleiro 11,20 - 35,00 m - permanentes
3497
3420
1120
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10090., I2=57970000, I3=0., J=0. | | C35
2 | A=11600., I2=64420004, I3=0., J=0. | | C35
3 | A=6940., I2=23960000, I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -
7 | - Not used -
8 | - Not used -


175,5
20
75,5
215
60
251
20
75,5
75,5
215
177
78,5
78,5
190
20
Área: 10090.00 cm2 = 1,009 m2
Momentos de inércia:
X: 57966104.85 cm4 = 0,5797 m4
Área: 11600.00 cm2 = 1,160 m2
Momentos de inércia:
X: 64416561.97 cm4 = 0,6442 m4
Área: 6940.00 cm2 = 0,6940 m2
Momentos de inércia:
X: 23958336.24 cm4 = 0,2396 m4





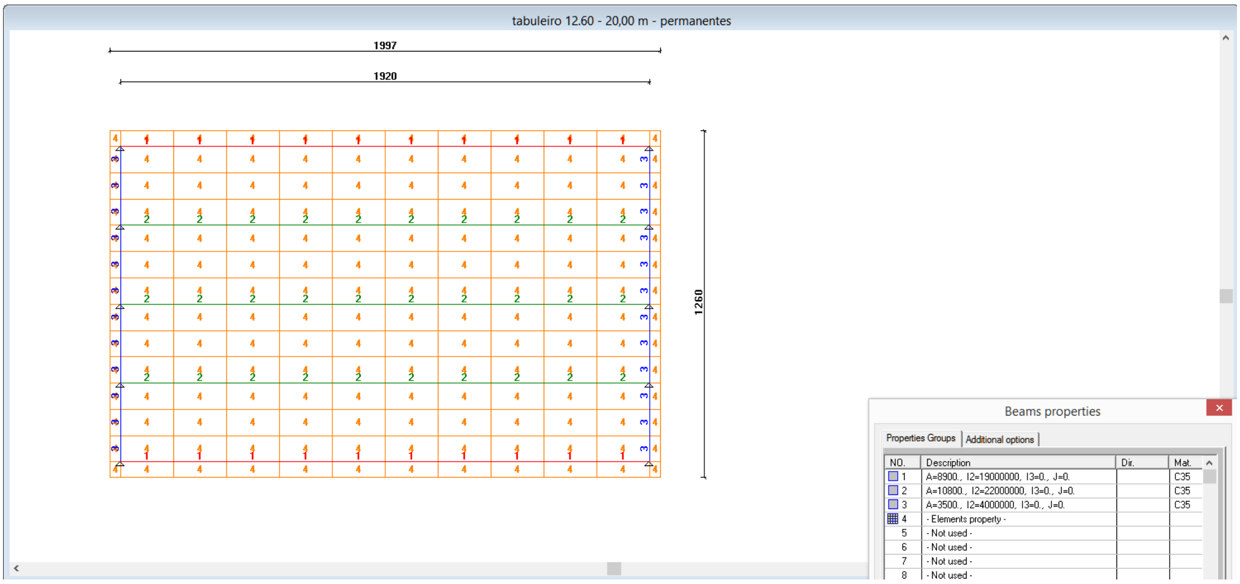


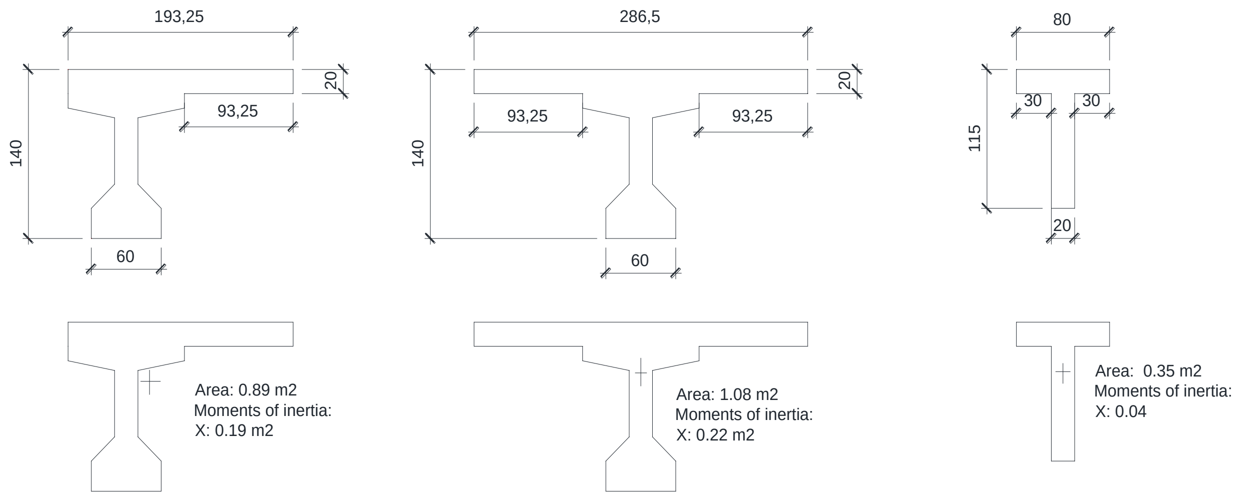
Área: 10390.00 cm2 = 1,039 m2
Momentos de inércia:
X: 68926557.31 cm4 = 0,6893 m4

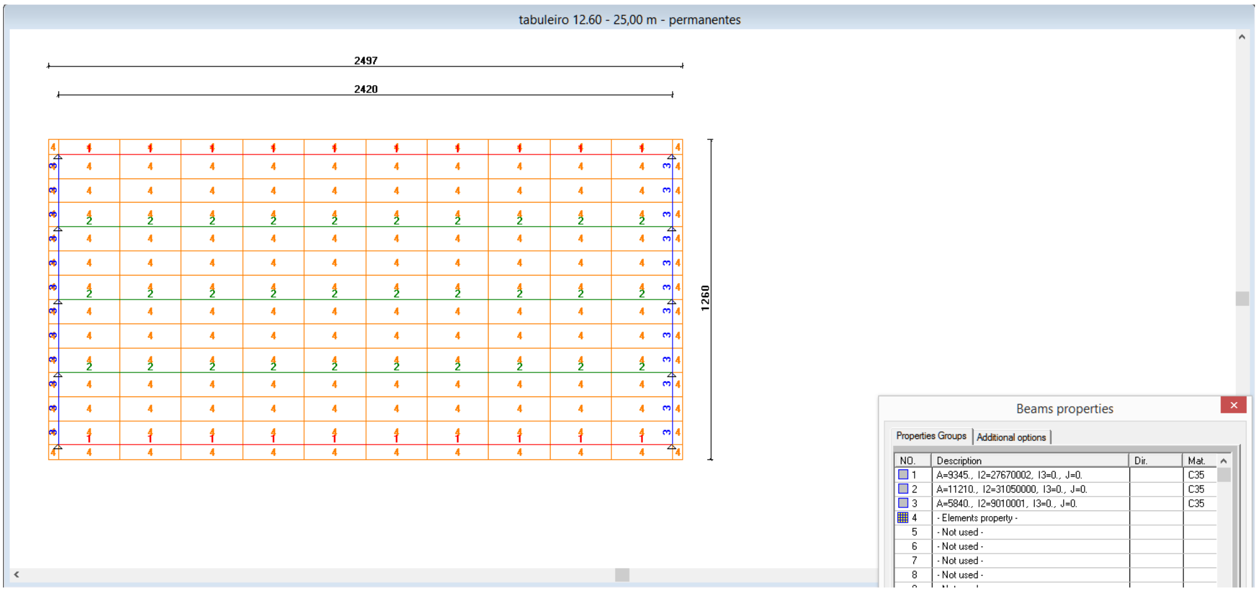
Área: 11900.00 cm2 = 1,190 m2
Momentos de inércia:
X: 76581271.19 cm4 = 0,7658 m4

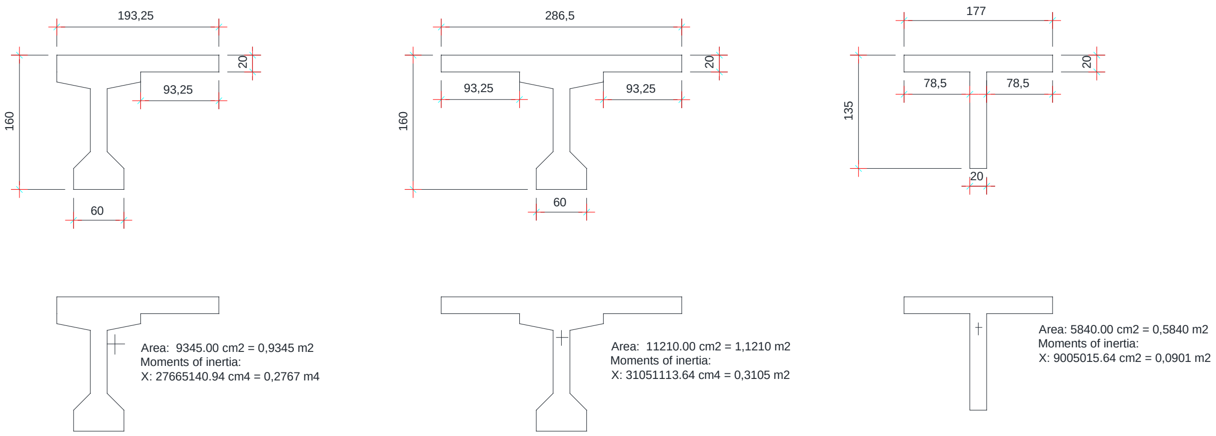
Área: 7240.00 cm2 = 0,724 m2
Momentos de inércia:
X: 29677733.59 cm4 = 0,2968 m4

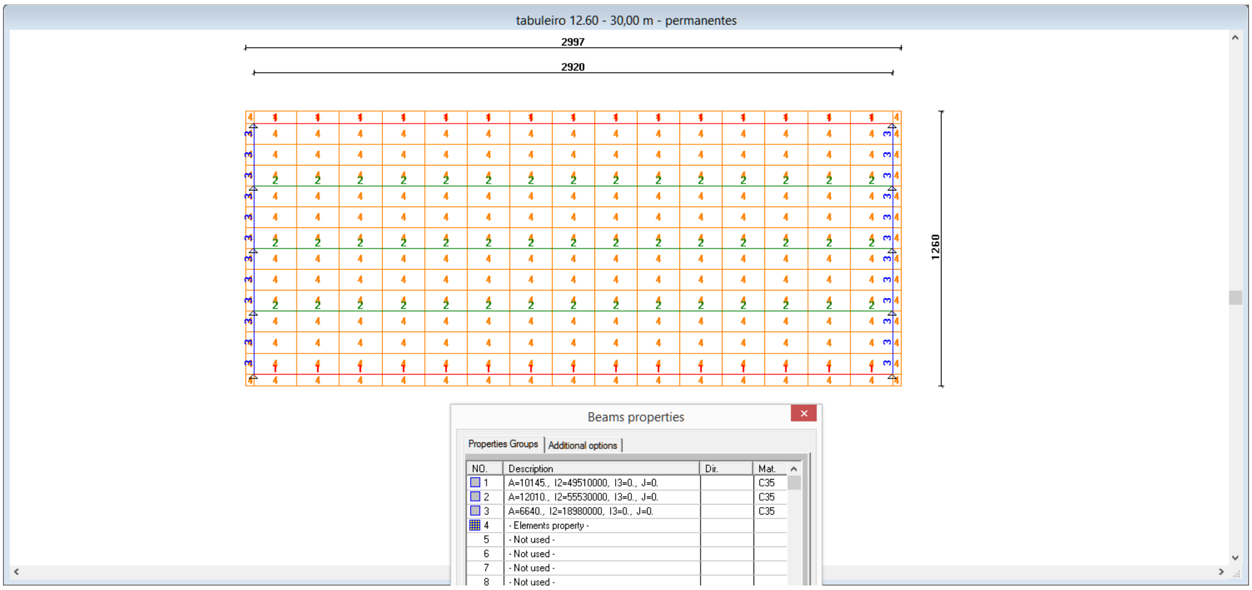
4.2.2. Tabuleiro 12,60 m

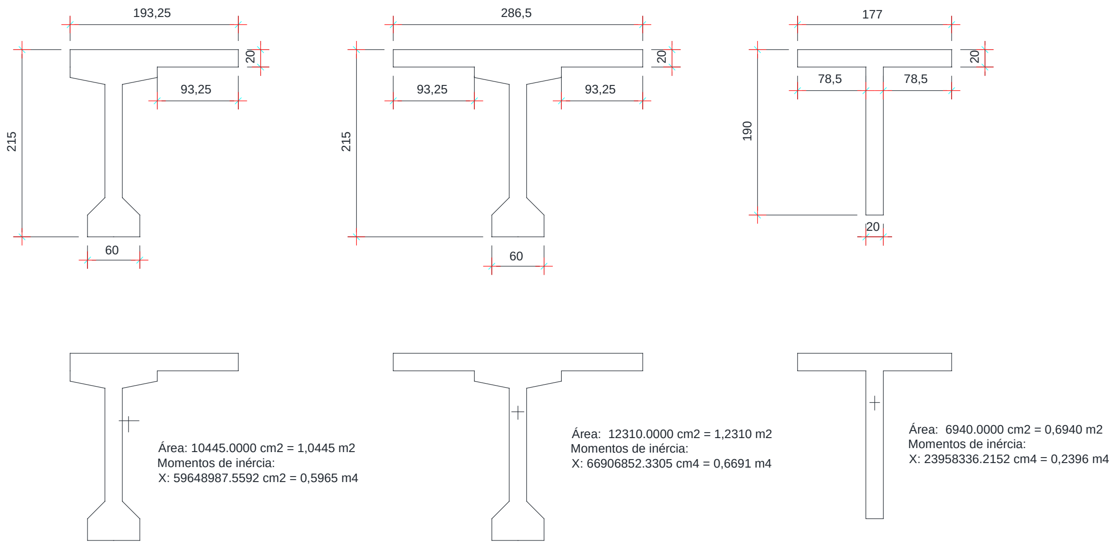


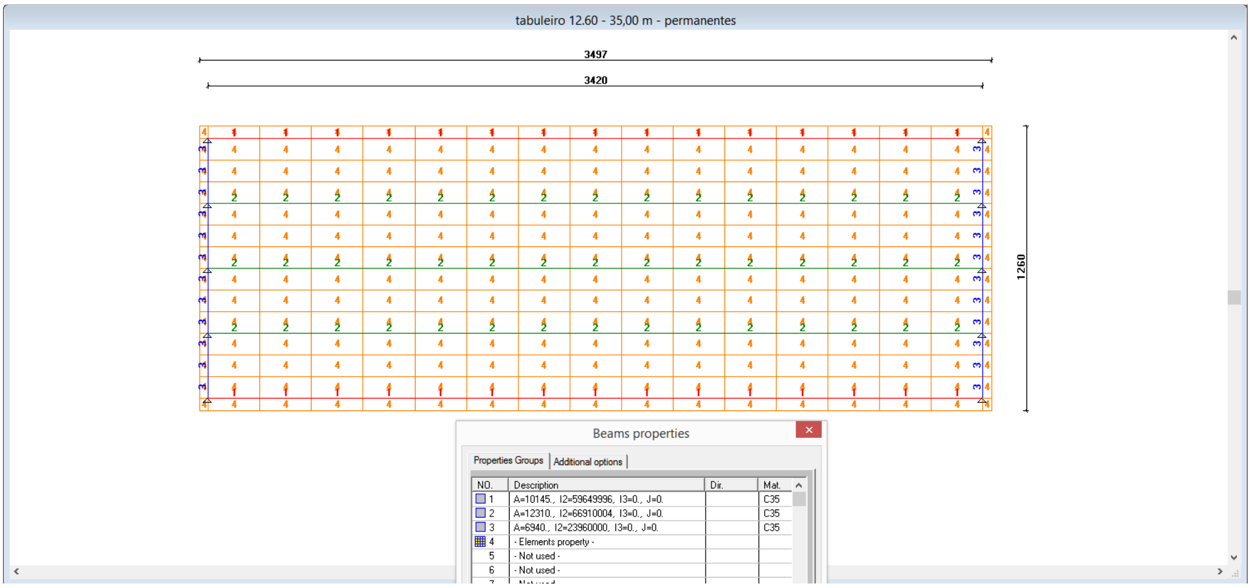


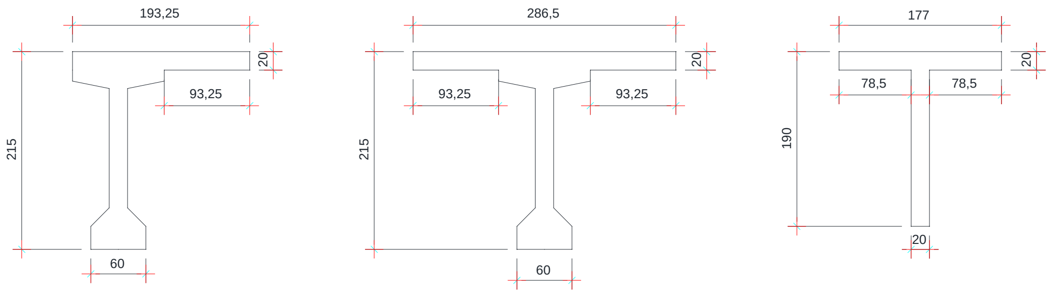

tabuleiro 12.60 - 25,00 m - permanentes
2497
2420
1260
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=9345., I2=27670002, I3=0., J=0. | | C35
2 | A=11210., I2=31050000, I3=0., J=0. | | C35
3 | A=5840., I2=9010001, I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -
7 | - Not used -
8 | - Not used -

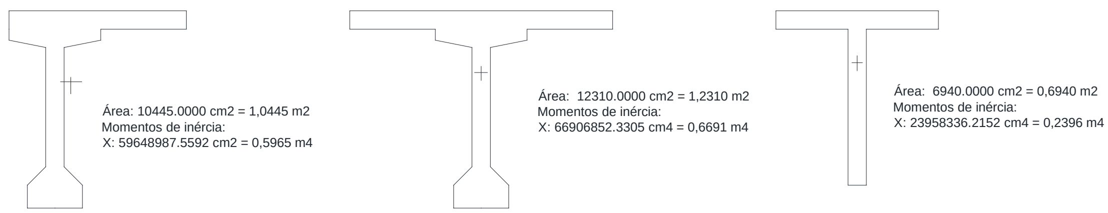

193,25
20
93,25
160
60
286,5
20
93,25
93,25
160
60
177
20
78,5
78,5
135
20
Area: 9345.00 cm2 = 0,9345 m2
Moments of inertia:
X: 27665140.94 cm4 = 0,2767 m4
Area: 11210.00 cm2 = 1,1210 m2
Moments of inertia:
X: 31051113.64 cm4 = 0,3105 m2
Area: 5840.00 cm2 = 0,5840 m2
Moments of inertia:
X: 9005015.64 cm2 = 0,0901 m2

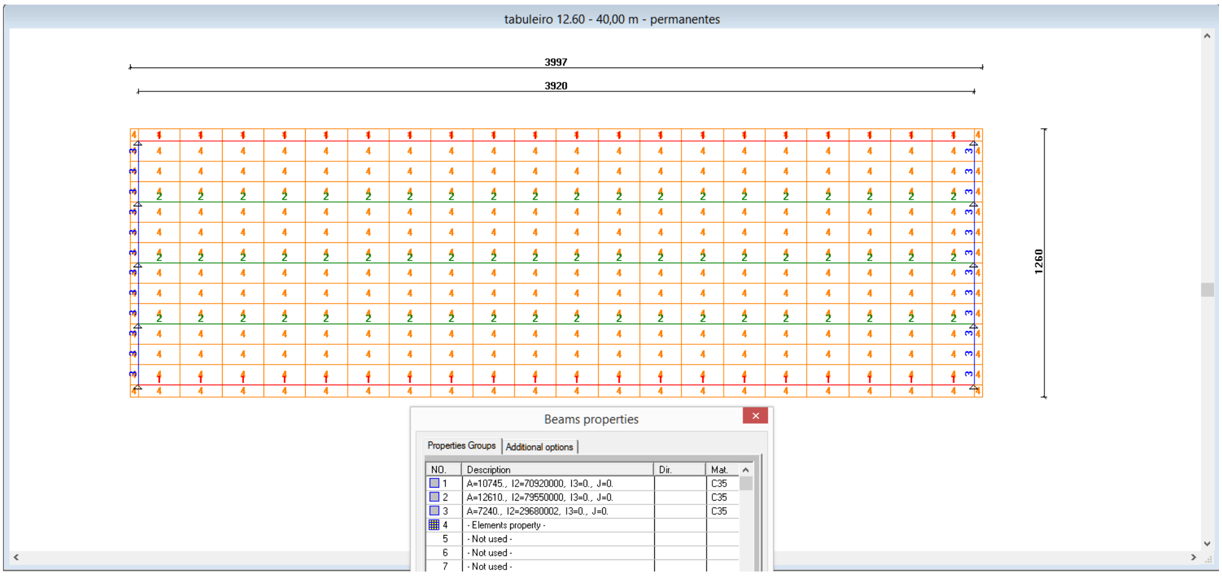

tabuleiro 12.60 - 30,00 m - permanentes
2997
2920
1260
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10145., I2=49510000, I3=0., J=0. | | C35
2 | A=12010., I2=55530000, I3=0., J=0. | | C35
3 | A=6640., I2=18980000, I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -
7 | - Not used -
8 | - Not used -

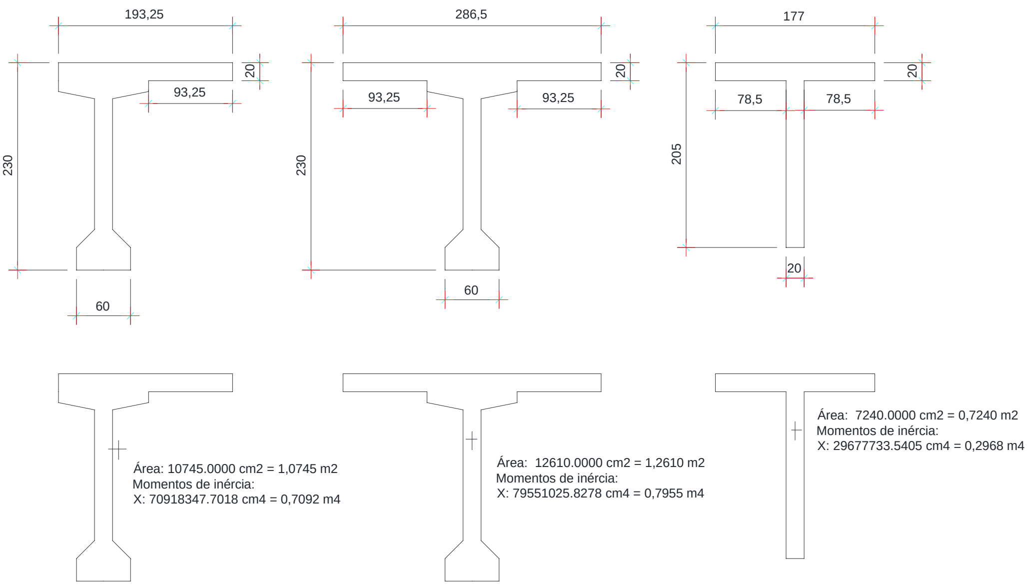

193,25
20
93,25
215
60
286,5
20
93,25
93,25
215
60
177
20
78,5
78,5
190
20
Área: 10445.0000 cm2 = 1,0445 m2
Momentos de inércia:
X: 59648987.5592 cm2 = 0,5965 m4
Área: 12310.0000 cm2 = 1,2310 m2
Momentos de inércia:
X: 66906852.3305 cm4 = 0,6691 m4
Área: 6940.0000 cm2 = 0,6940 m2
Momentos de inércia:
X: 23958336.2152 cm4 = 0,2396 m4


tabuleiro 12.60 - 35,00 m - permanentes
3497
3420
1260
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=10145., I2=59649996, I3=0., J=0. C35
2 A=12310., I2=66910004, I3=0., J=0. C35
3 A=6940., I2=23960000, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -

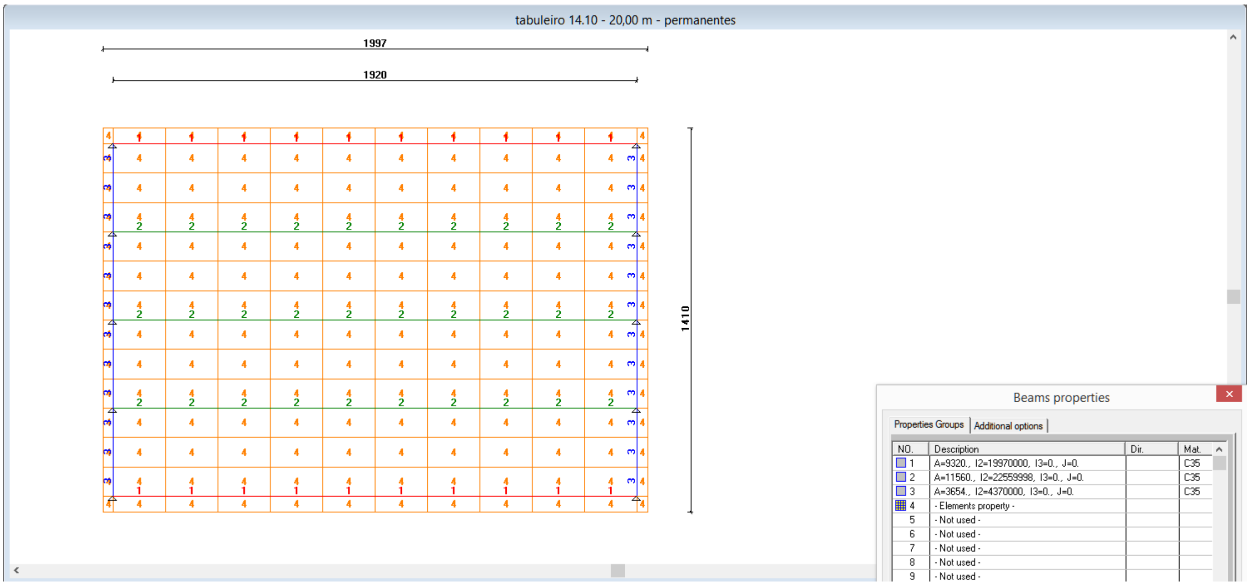

193,25
20
93,25
215
60
286,5
20
93,25
93,25
215
60
177
20
78,5
78,5
190
20

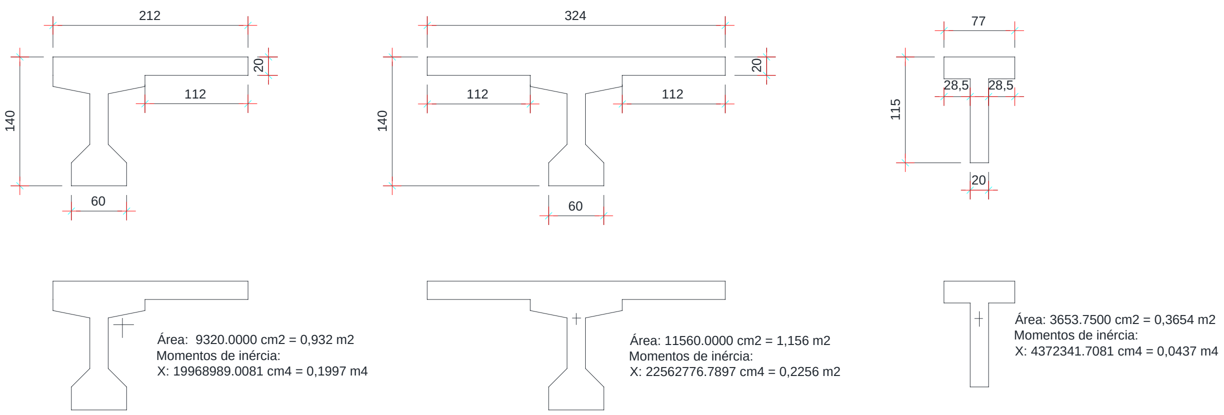

Área: 10445.0000 cm2 = 1,0445 m2
Momentos de inércia:
X: 59648987.5592 cm2 = 0,5965 m4
Área: 12310.0000 cm2 = 1,2310 m2
Momentos de inércia:
X: 66906852.3305 cm4 = 0,6691 m4
Área: 6940.0000 cm2 = 0,6940 m2
Momentos de inércia:
X: 23958336.2152 cm4 = 0,2396 m4

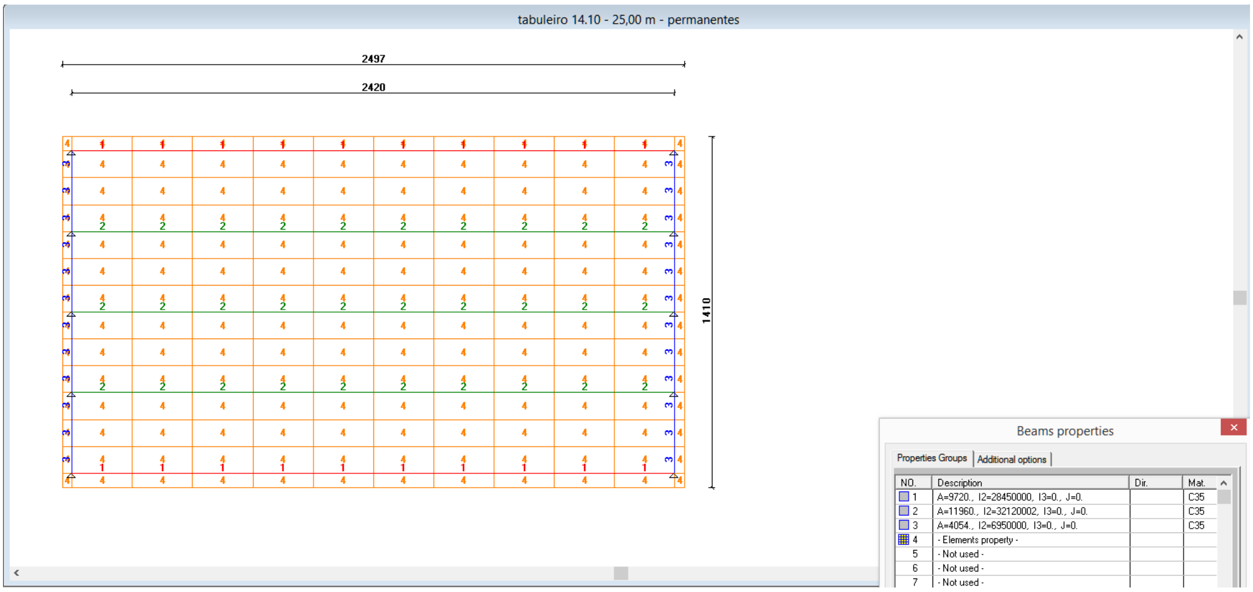

tabuleiro 12.60 - 40,00 m - permanentes
3997
3920
1260
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=10745., I2=70920000, I3=0., J=0. C35
2 A=12610., I2=79550000, I3=0., J=0. C35
3 A=7240., I2=29680002, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -

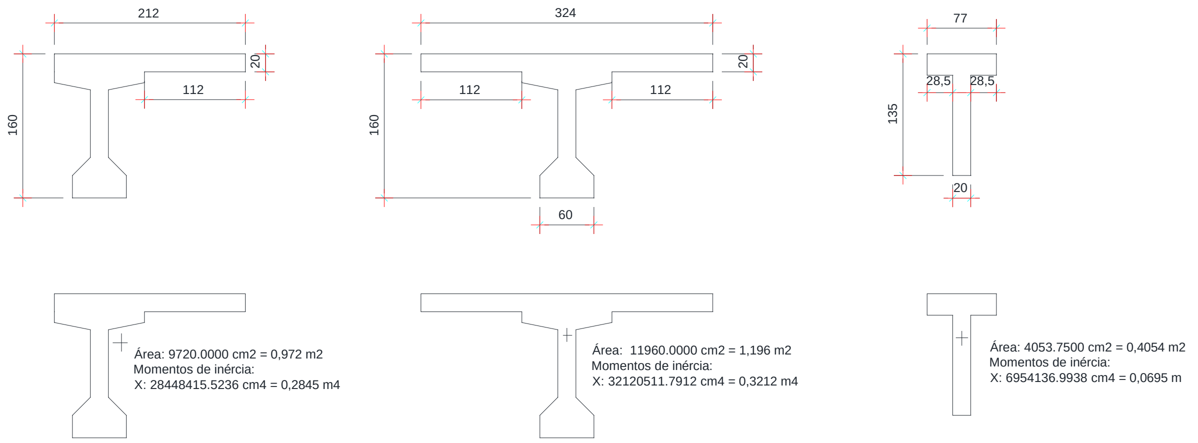

193,25
93,25
20
230
60
286,5
93,25
93,25
20
230
60
177
78,5
78,5
20
205
20
Área: 10745.0000 cm2 = 1,0745 m2
Momentos de inércia:
X: 70918347.7018 cm4 = 0,7092 m4
Área: 12610.0000 cm2 = 1,2610 m2
Momentos de inércia:
X: 79551025.8278 cm4 = 0,7955 m4
Área: 7240.0000 cm2 = 0,7240 m2
Momentos de inércia:
X: 29677733.5405 cm4 = 0,2968 m4

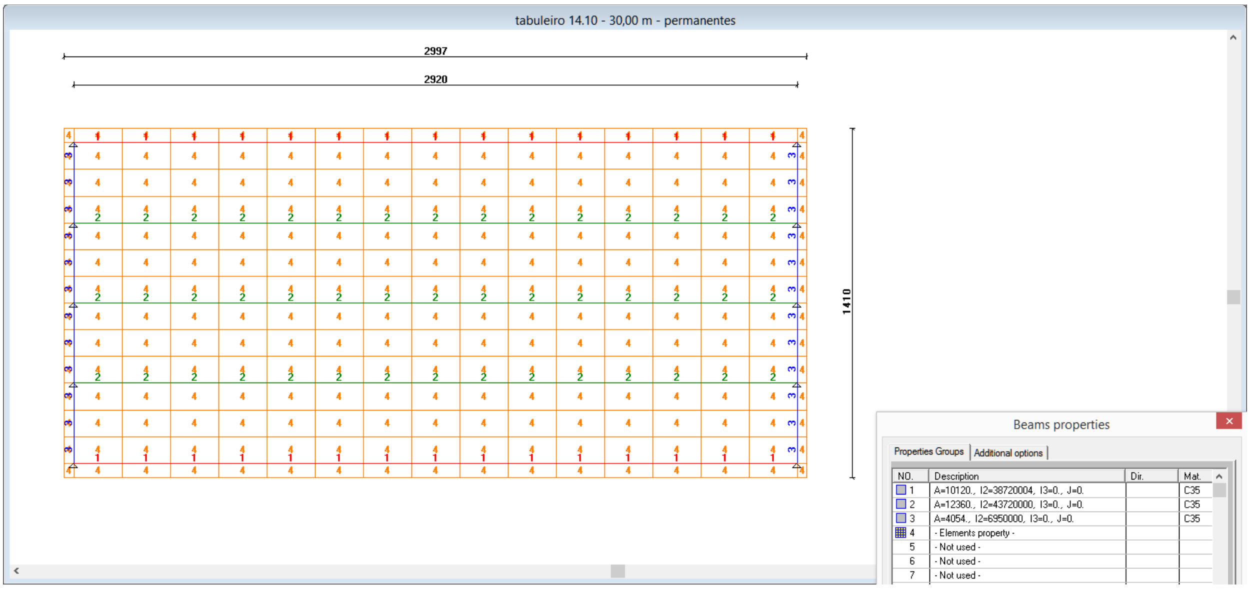
4.2.3. Tabuleiro 14,10 m

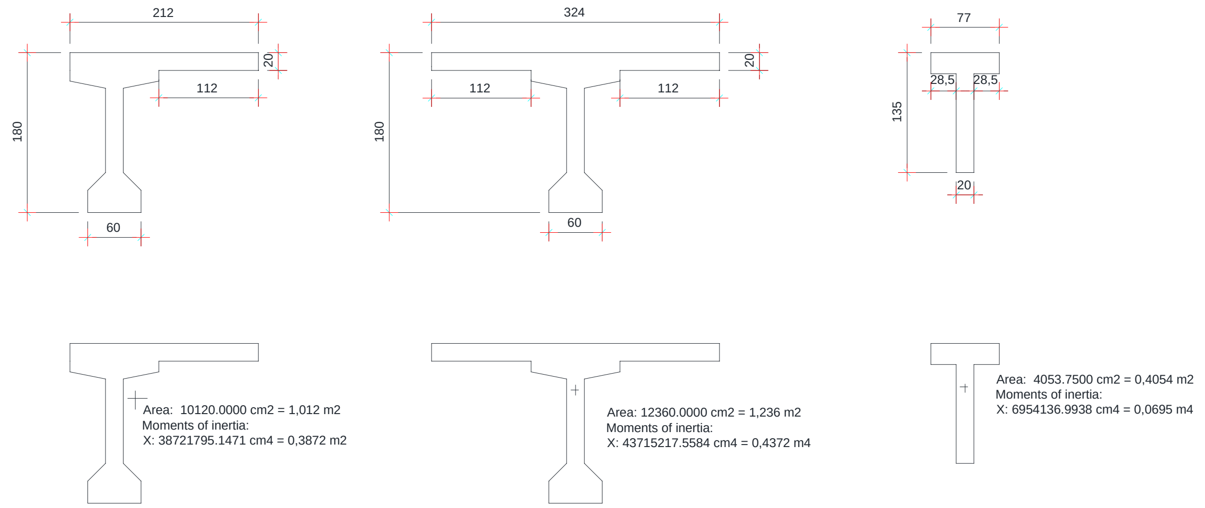


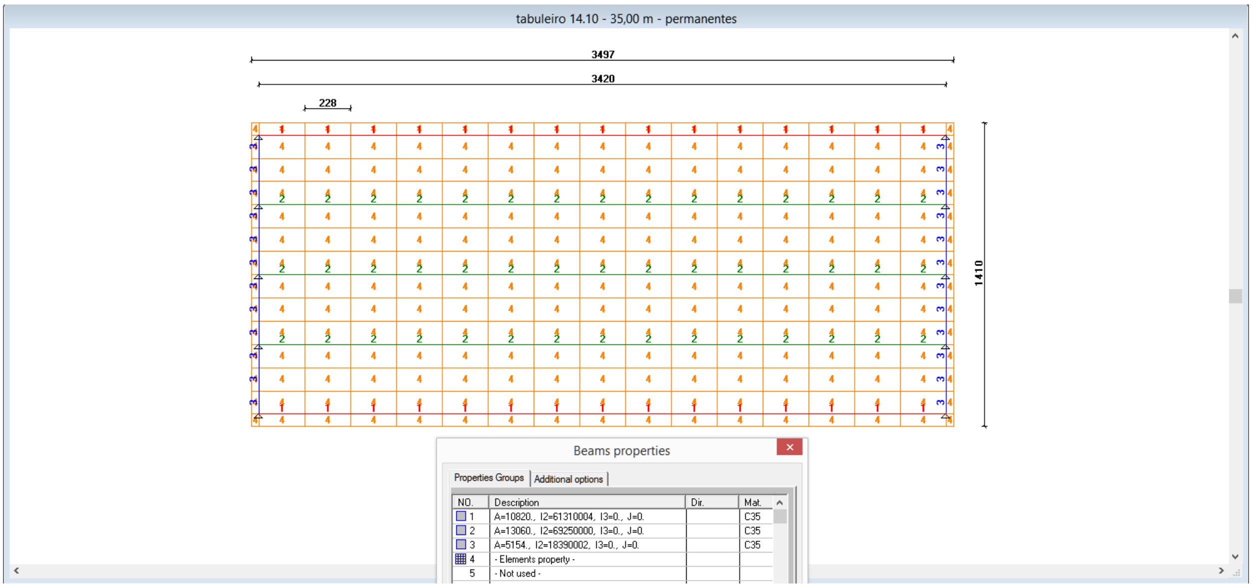


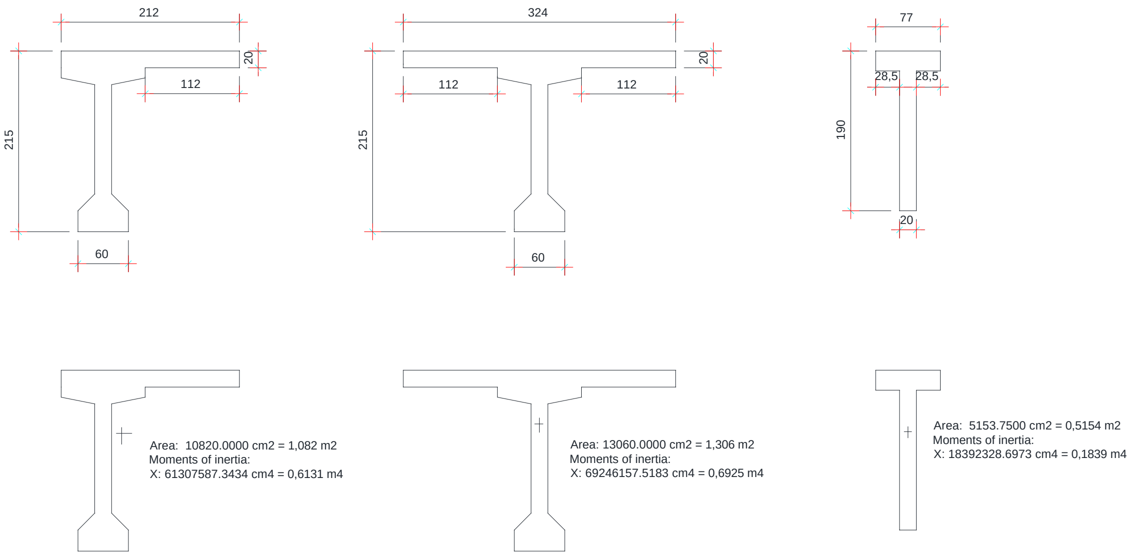

tabuleiro 14.10 - 25,00 m - permanentes
2497
2420
1410
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=9720., I2=28450000., I3=0., J=0. | | C35
2 | A=11960., I2=32120002., I3=0., J=0. | | C35
3 | A=4054., I2=6950000., I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -
7 | - Not used -

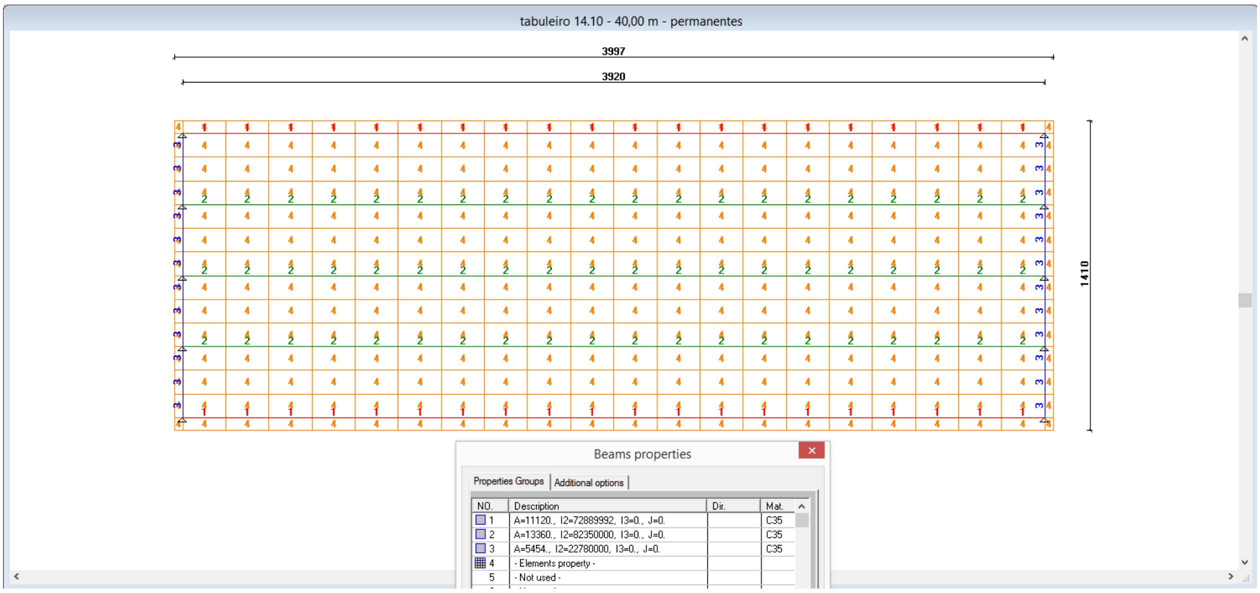

212
20
112
160
324
112
112
20
160
60
77
28,5
28,5
135
20
Área: 9720.0000 cm2 = 0,972 m2
Momentos de inércia:
X: 28448415.5236 cm4 = 0,2845 m4
Área: 11960.0000 cm2 = 1,196 m2
Momentos de inércia:
X: 32120511.7912 cm4 = 0,3212 m4
Área: 4053.7500 cm2 = 0,4054 m2
Momentos de inércia:
X: 6954136.9938 cm4 = 0,0695 m

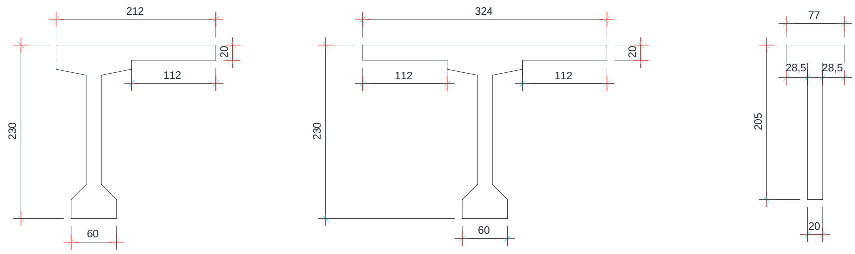

tabuleiro 14.10 - 30,00 m - permanentes
2997
2920
1410
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=10120., I2=38720004, I3=0., J=0. C35
2 A=12360., I2=43720000, I3=0., J=0. C35
3 A=4054., I2=6950000, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -

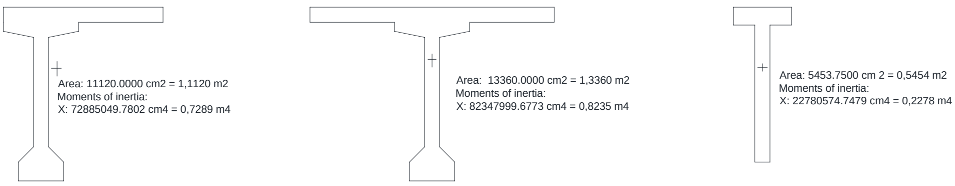

212
20
112
180
60
324
112
112
20
180
60
77
28,5
28,5
135
20
Area: 10120.0000 cm2 = 1,012 m2
Moments of inertia:
X: 38721795.1471 cm4 = 0,3872 m2
Area: 12360.0000 cm2 = 1,236 m2
Moments of inertia:
X: 43715217.5584 cm4 = 0,4372 m4
Area: 4053.7500 cm2 = 0,4054 m2
Moments of inertia:
X: 6954136.9938 cm4 = 0,0695 m4


tabuleiro 14.10 - 35,00 m - permanentes
3497
3420
228
1410
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10820., I2=61310004, I3=0., J=0. | | C35
2 | A=13060., I2=69250000, I3=0., J=0. | | C35
3 | A=5154., I2=18390002, I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -

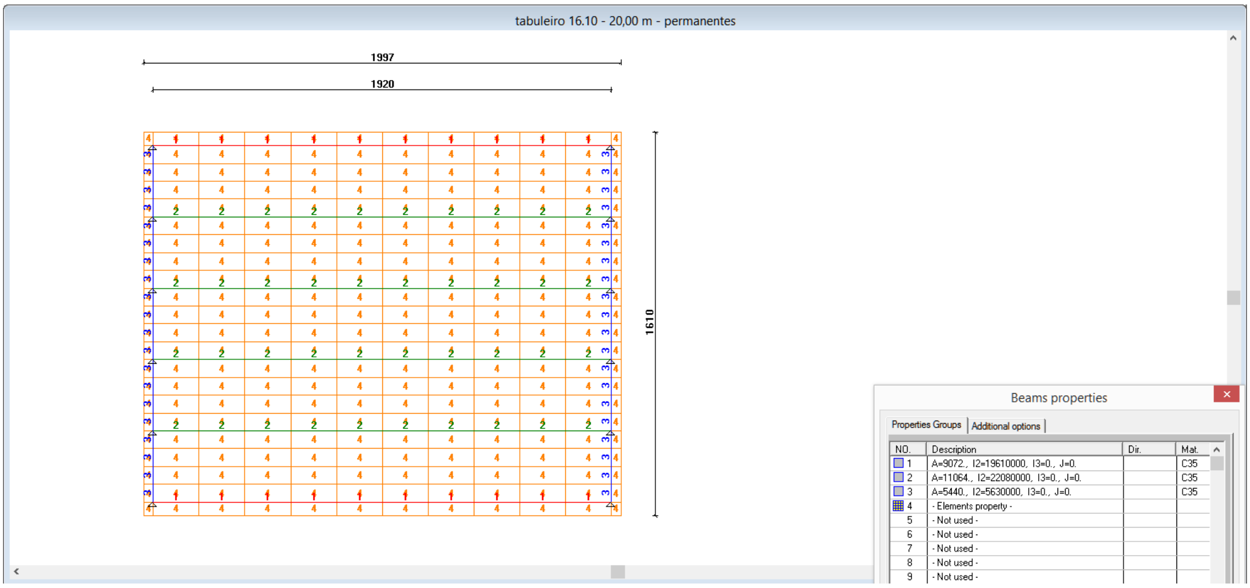

212
20
112
215
60
324
112
112
20
215
60
77
28,5
28,5
190
20
Area: 10820.0000 cm2 = 1,082 m2
Moments of inertia:
X: 61307587.3434 cm4 = 0,6131 m4
Area: 13060.0000 cm2 = 1,306 m2
Moments of inertia:
X: 69246157.5183 cm4 = 0,6925 m4
Area: 5153.7500 cm2 = 0,5154 m2
Moments of inertia:
X: 18392328.6973 cm4 = 0,1839 m4

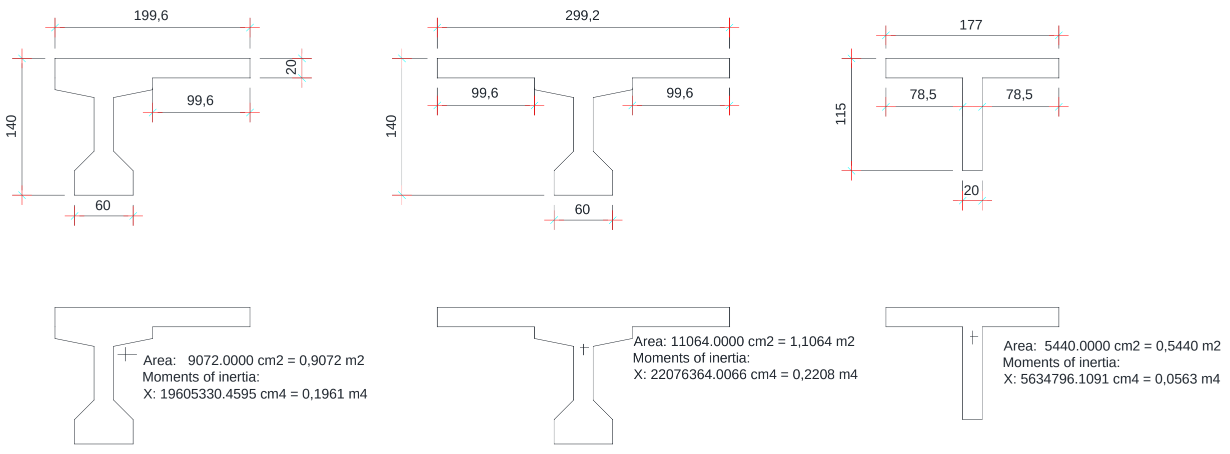

tabuleiro 14.10 - 40,00 m - permanentes
3997
3920
1410
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=11120., I2=72889992, I3=0., J=0. | C35
2 | A=13360., I2=82350000, I3=0., J=0. | C35
3 | A=5454., I2=22780000, I3=0., J=0. | C35
4 | - Elements property -
5 | - Not used -

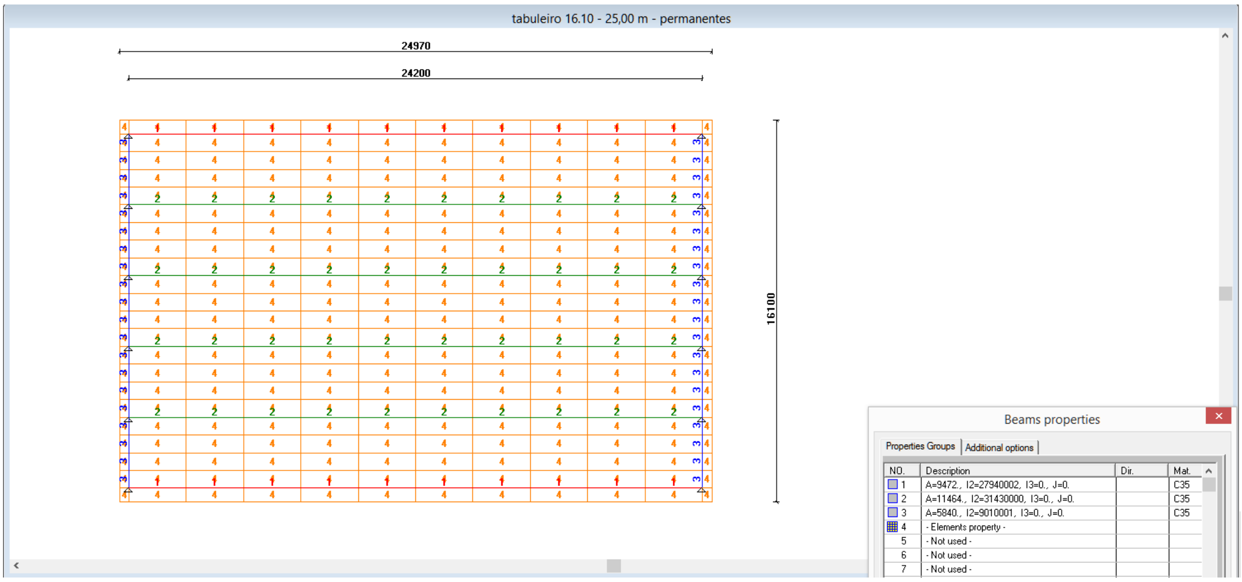

212
20
112
230
60
324
20
112
112
230
60
77
28,5
28,5
205
20

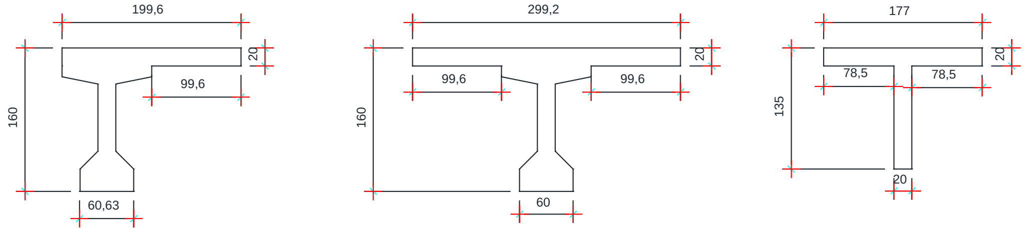

Area: 11120.0000 cm2 = 1,1120 m2
Moments of inertia:
X: 72885049.7802 cm4 = 0,7289 m4
Area: 13360.0000 cm2 = 1,3360 m2
Moments of inertia:
X: 82347999.6773 cm4 = 0,8235 m4
Area: 5453.7500 cm 2 = 0,5454 m2
Moments of inertia:
X: 22780574.7479 cm4 = 0,2278 m4

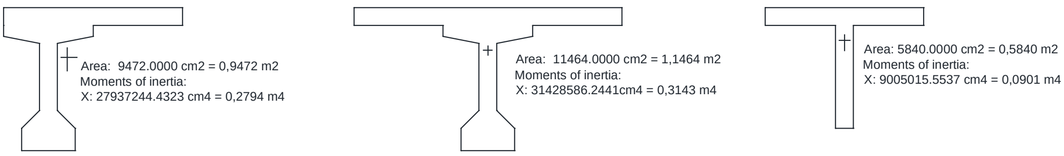
4.2.4. Tabuleiro 16,10 m

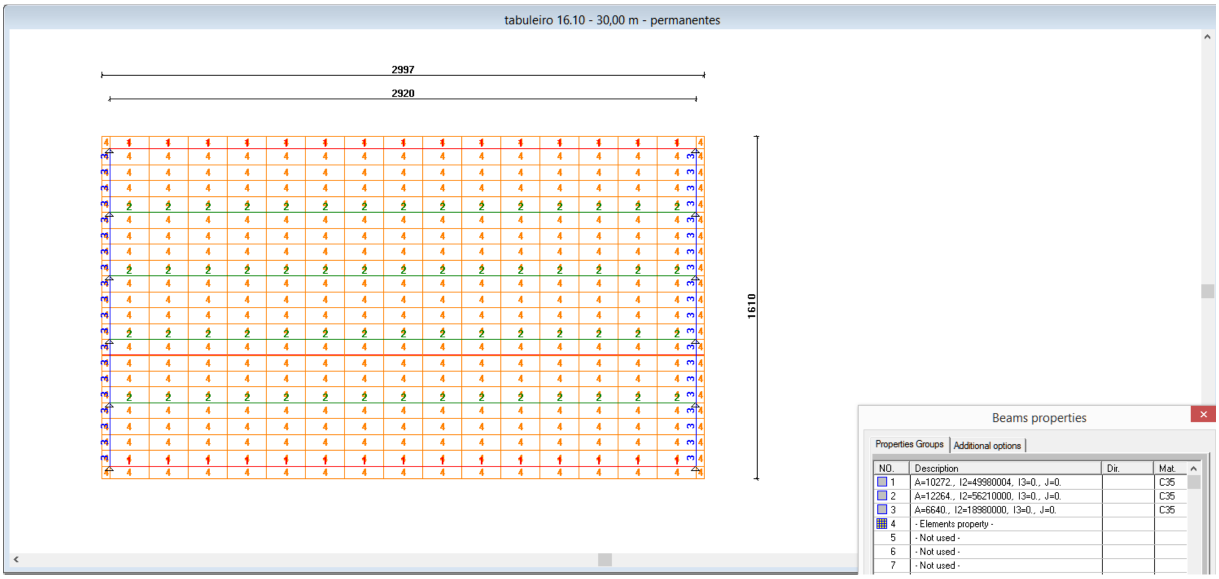


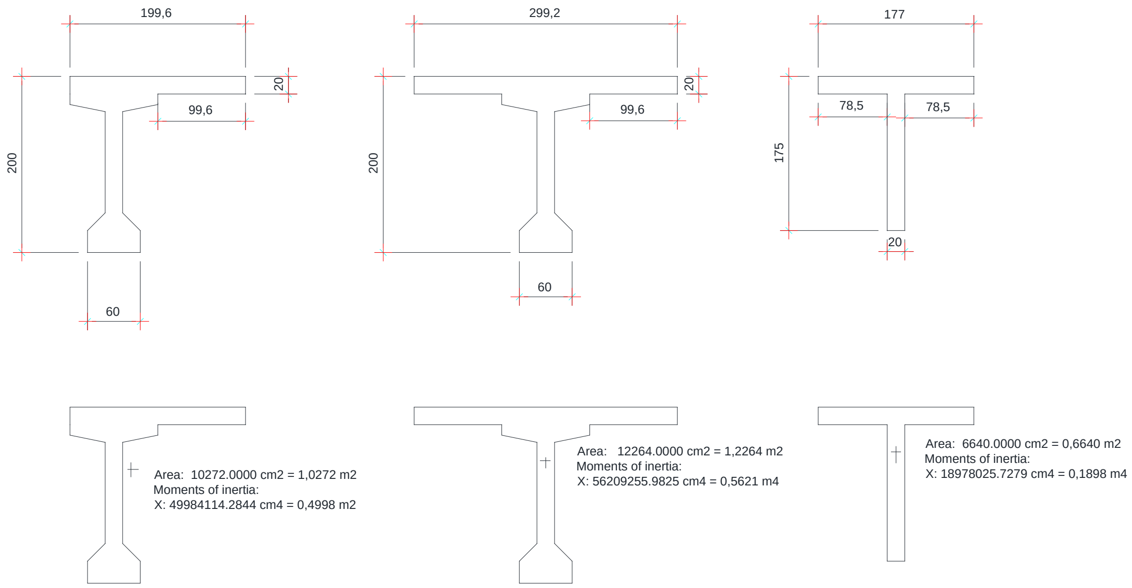


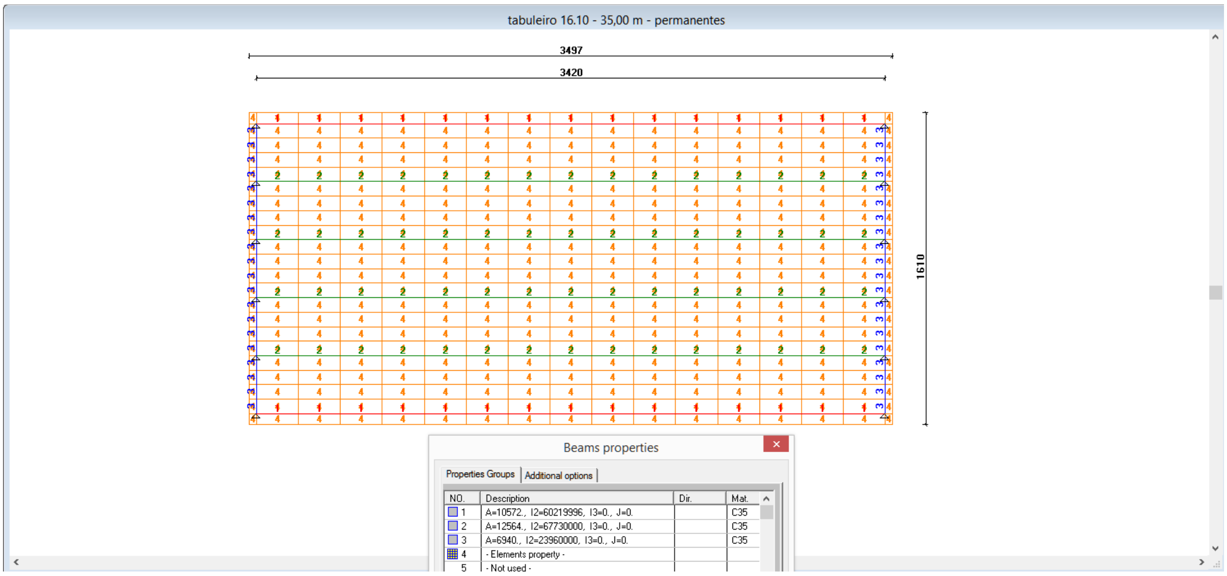

tabuleiro 16.10 - 25,00 m - permanentes
24970
24200
16100
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=9472., I2=27940002, I3=0., J=0. C35
2 A=11464., I2=31430000, I3=0., J=0. C35
3 A=5840., I2=9010001, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -

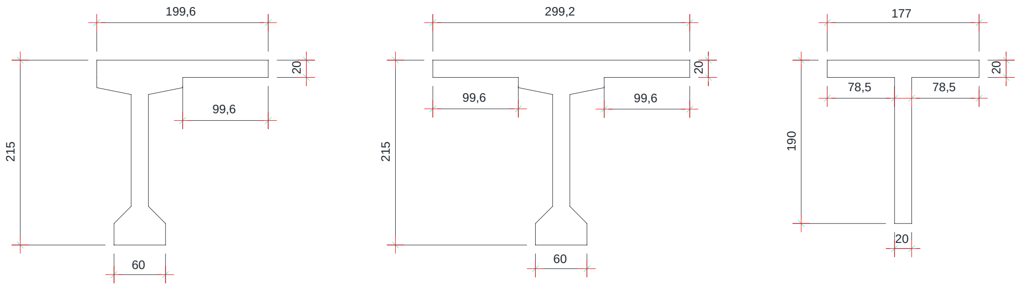

199,6
20
99,6
160
60,63
299,2
20
99,6
99,6
160
60
177
20
78,5
78,5
135
20

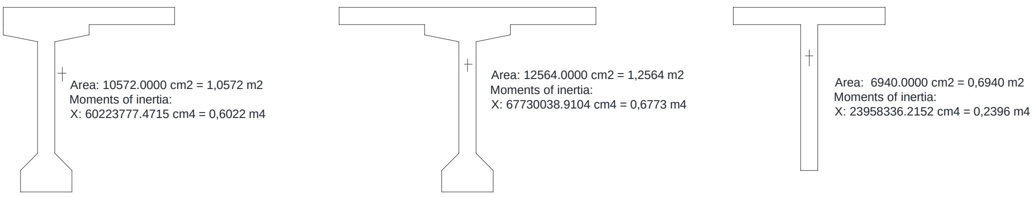

Area: 9472.0000 cm2 = 0,9472 m2
Moments of inertia:
X: 27937244.4323 cm4 = 0,2794 m4
Area: 11464.0000 cm2 = 1,1464 m2
Moments of inertia:
X: 31428586.2441cm4 = 0,3143 m4
Area: 5840.0000 cm2 = 0,5840 m2
Moments of inertia:
X: 9005015.5537 cm4 = 0,0901 m4

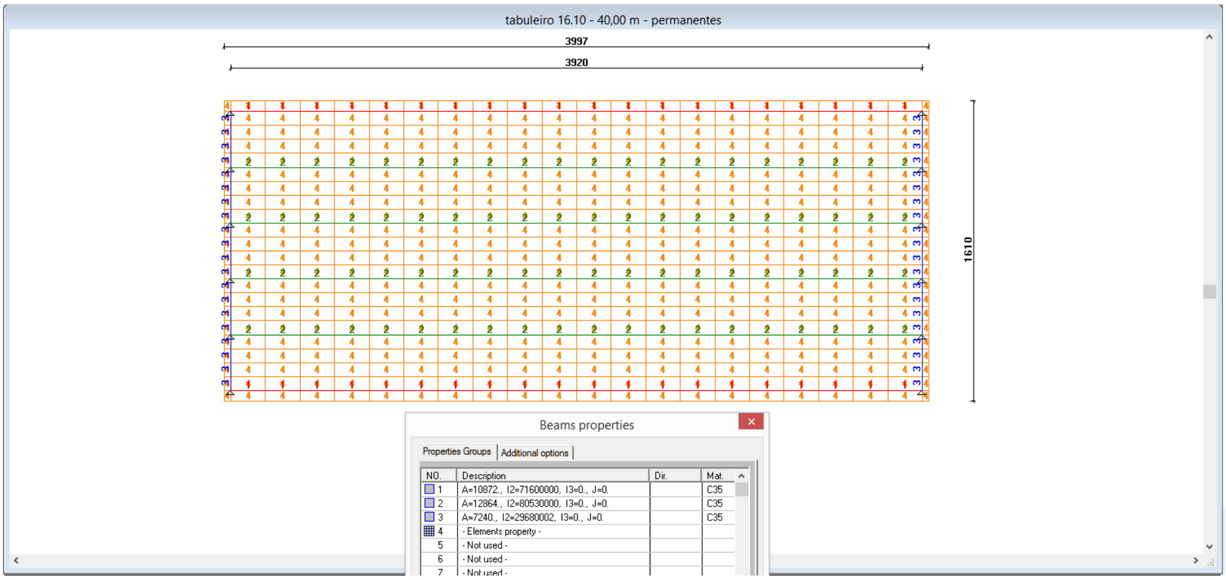

tabuleiro 16.10 - 30,00 m - permanentes
2997
2920
1610
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1
A=10272., I2=49980004, I3=0., J=0.
C35
2
A=12264., I2=56210000, I3=0., J=0.
C35
3
A=6640., I2=18980000, I3=0., J=0.
C35
4
- Elements property -
5
- Not used -
6
- Not used -
7
- Not used -

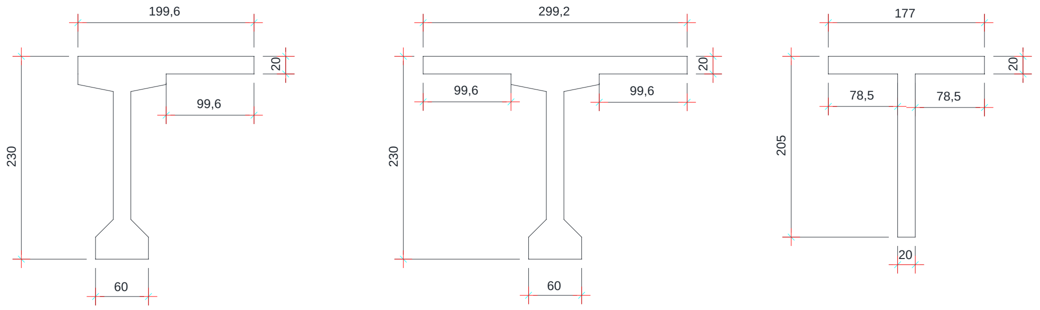

199,6
20
99,6
200
60
299,2
20
99,6
200
60
177
78,5
78,5
175
20
Area: 10272.0000 cm2 = 1,0272 m2
Moments of inertia:
X: 49984114.2844 cm4 = 0,4998 m2
Area: 12264.0000 cm2 = 1,2264 m2
Moments of inertia:
X: 56209255.9825 cm4 = 0,5621 m4
Area: 6640.0000 cm2 = 0,6640 m2
Moments of inertia:
X: 18978025.7279 cm4 = 0,1898 m4

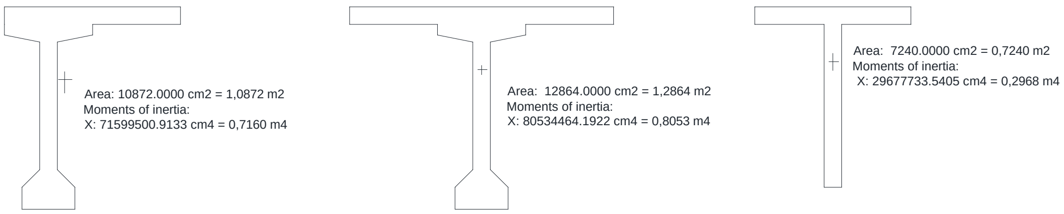

tabuleiro 16.10 - 35,00 m - permanentes
3497
3420
1610
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=10572., I2=60219996, I3=0., J=0. C35
2 A=12564., I2=67730000, I3=0., J=0. C35
3 A=6940., I2=23960000, I3=0., J=0. C35
4 - Elements property -
5 - Not used -


199,6
20
99,6
215
60
299,2
20
99,6
99,6
215
60
177
20
78,5
78,5
190
20

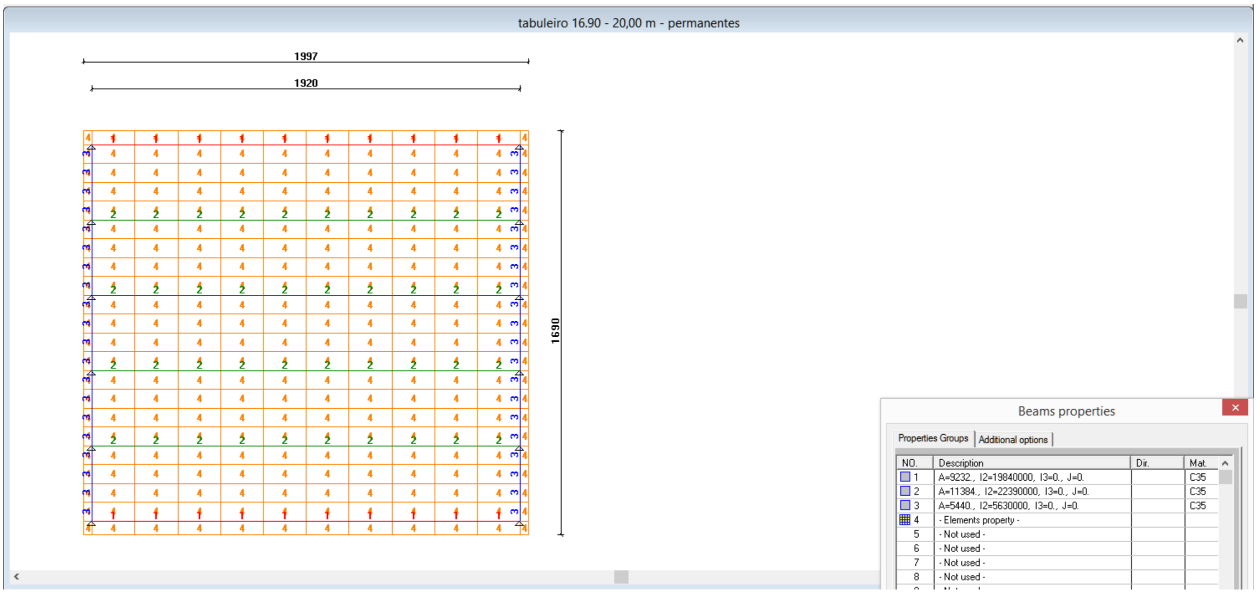

Area: 10572.0000 cm2 = 1,0572 m2
Moments of inertia:
X: 60223777.4715 cm4 = 0,6022 m4
Area: 12564.0000 cm2 = 1,2564 m2
Moments of inertia:
X: 67730038.9104 cm4 = 0,6773 m4
Area: 6940.0000 cm2 = 0,6940 m2
Moments of inertia:
X: 23958336.2152 cm4 = 0,2396 m4

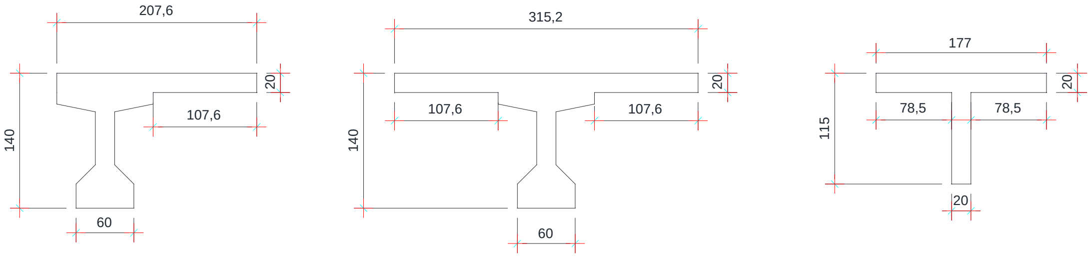

tabuleiro 16.10 - 40,00 m - permanentes
3997
3920
1610
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1
A=10872., I2=71600000, I3=0., J=0.
C35
2
A=12864., I2=80530000, I3=0., J=0.
C35
3
A=7240., I2=29680002, I3=0., J=0.
C35
4
- Elements property -
5
- Not used -
6
- Not used -

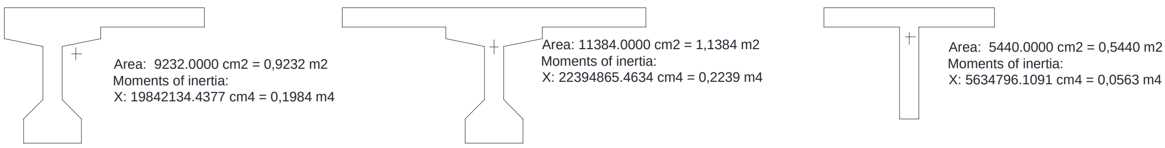

199,6
20
99,6
230
60
299,2
20
99,6
99,6
230
60
177
20
78,5
78,5
205
20

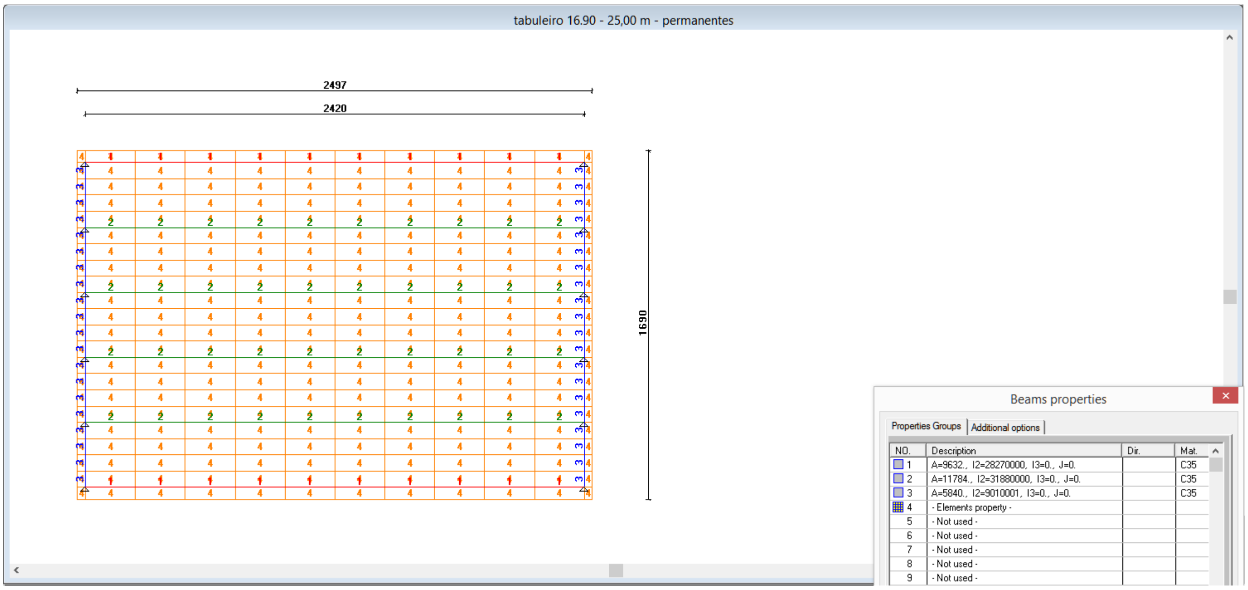

Area: 10872.0000 cm2 = 1,0872 m2
Moments of inertia:
X: 71599500.9133 cm4 = 0,7160 m4
Area: 12864.0000 cm2 = 1,2864 m2
Moments of inertia:
X: 80534464.1922 cm4 = 0,8053 m4
Area: 7240.0000 cm2 = 0,7240 m2
Moments of inertia:
X: 29677733.5405 cm4 = 0,2968 m4

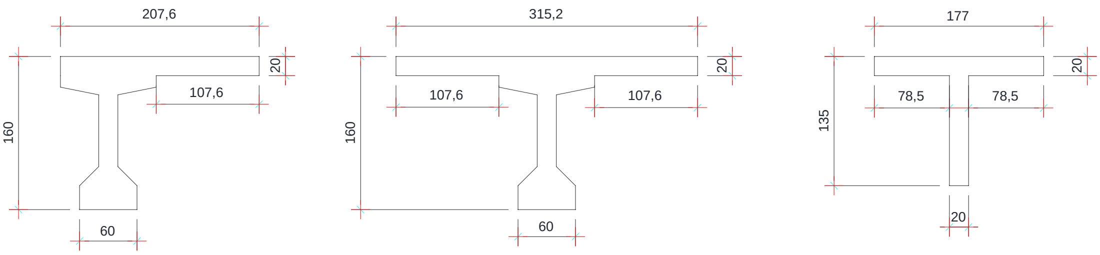
4.2.5. Tabuleiro 16,90 m

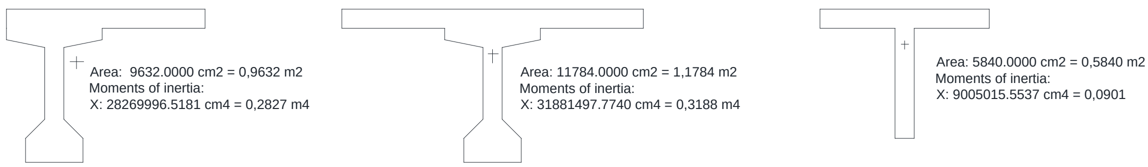


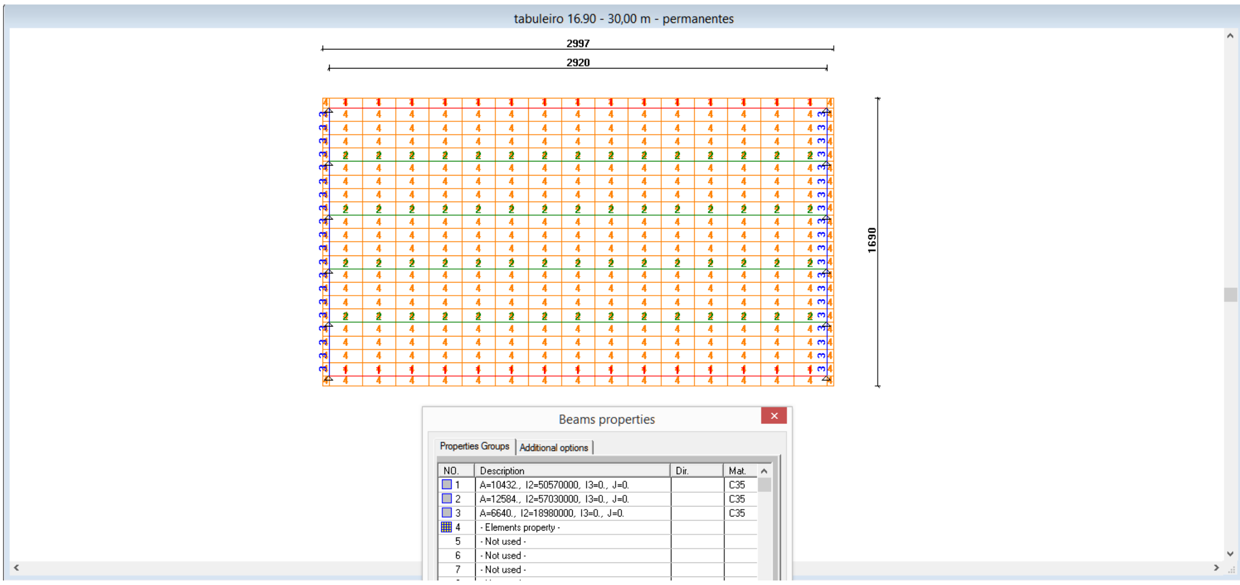


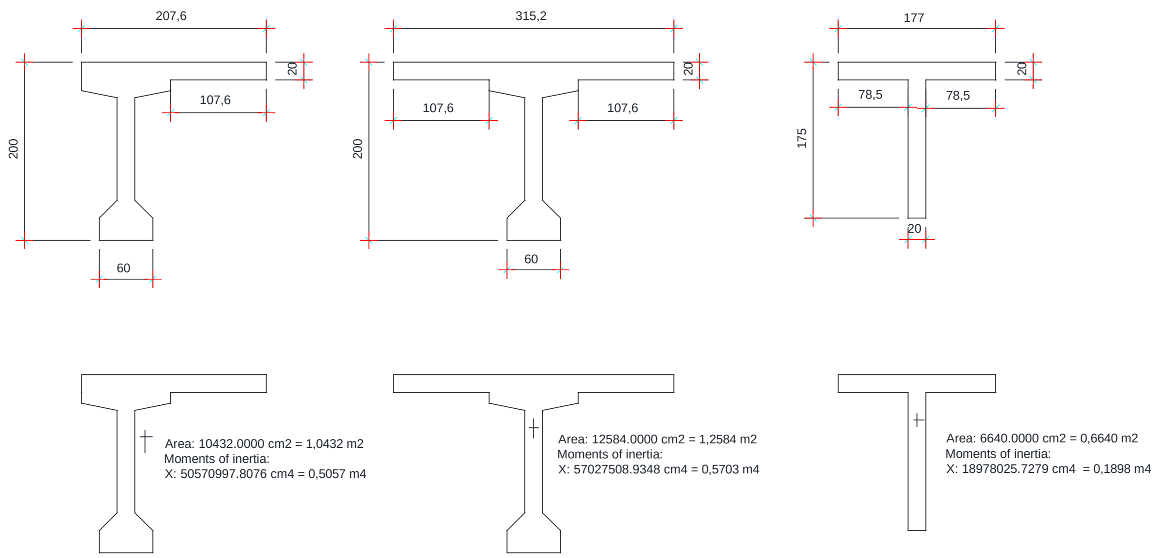


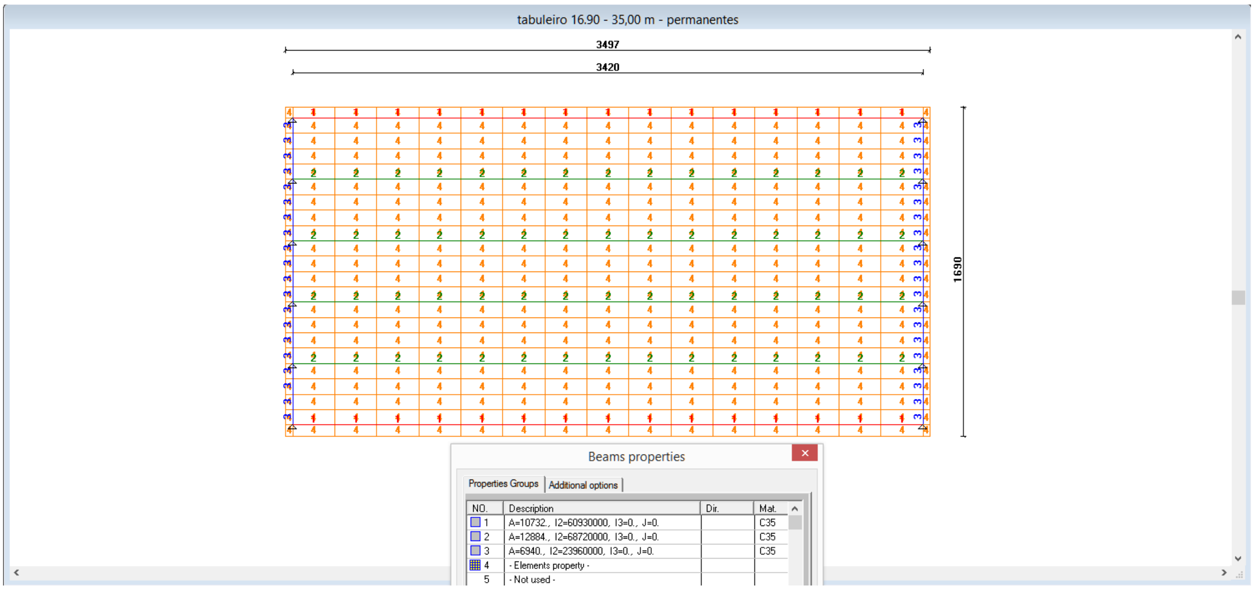

tabuleiro 16.90 - 25,00 m - permanentes
2497
2420
1690
Beams properties
Properties Groups
Additional options
NO. Description Dir. Mat.
1 A=9632., I2=28270000., I3=0., J=0. C35
2 A=11784., I2=31880000., I3=0., J=0. C35
3 A=5840., I2=9010001., I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -
8 - Not used -
9 - Not used -

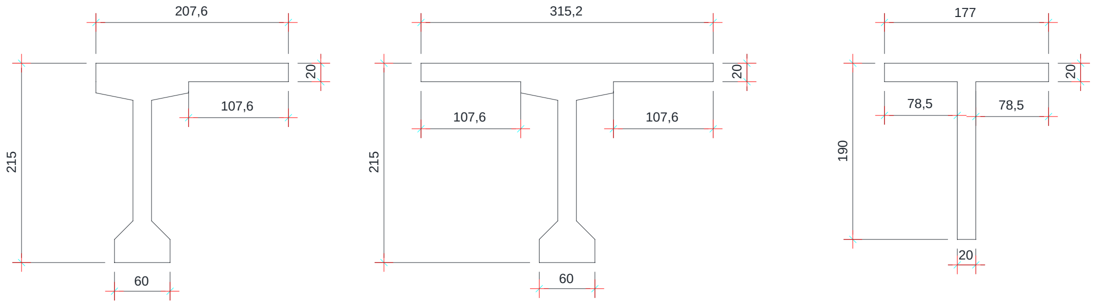

207,6
20
107,6
160
60
315,2
107,6
107,6
20
160
60
177
20
78,5
78,5
135
20

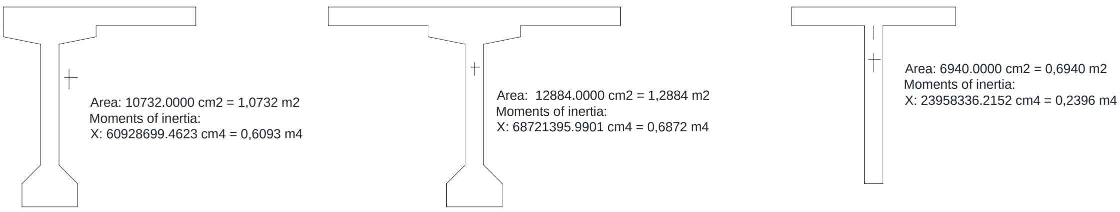

Area: 9632.0000 cm2 = 0,9632 m2
Moments of inertia:
X: 28269996.5181 cm4 = 0,2827 m4
Area: 11784.0000 cm2 = 1,1784 m2
Moments of inertia:
X: 31881497.7740 cm4 = 0,3188 m4
Area: 5840.0000 cm2 = 0,5840 m2
Moments of inertia:
X: 9005015.5537 cm4 = 0,0901

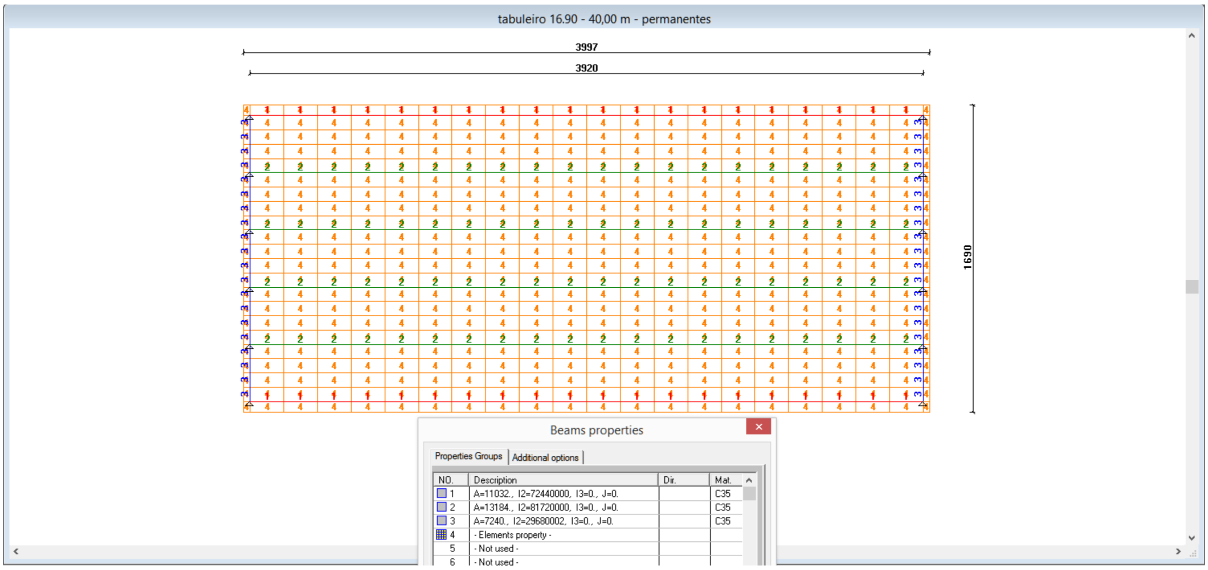

tabuleiro 16.90 - 30,00 m - permanentes
2997
2920
1690
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 A=10432., I2=50570000, I3=0., J=0. C35
2 A=12584., I2=57030000, I3=0., J=0. C35
3 A=6640., I2=18980000, I3=0., J=0. C35
4 - Elements property -
5 - Not used -
6 - Not used -
7 - Not used -

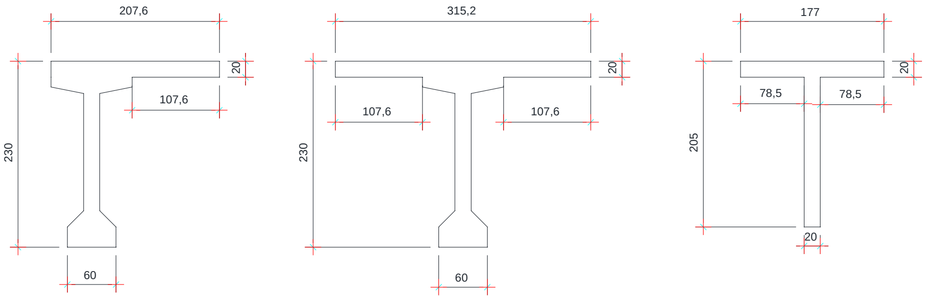

207,6
20
107,6
200
60
315,2
20
107,6
107,6
200
60
177
20
78,5
78,5
175
20
Area: 10432.0000 cm2 = 1,0432 m2
Moments of inertia:
X: 50570997.8076 cm4 = 0,5057 m4
Area: 12584.0000 cm2 = 1,2584 m2
Moments of inertia:
X: 57027508.9348 cm4 = 0,5703 m4
Area: 6640.0000 cm2 = 0,6640 m2
Moments of inertia:
X: 18978025.7279 cm4 = 0,1898 m4

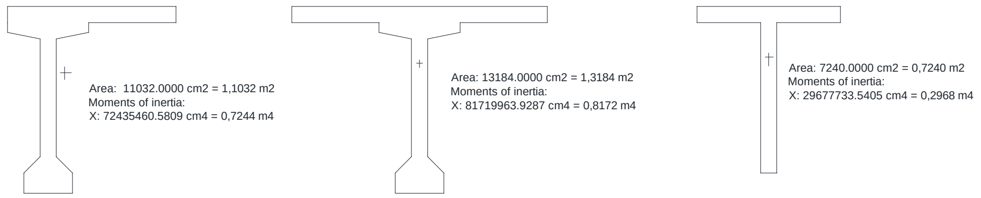

tabuleiro 16.90 - 35,00 m - permanentes
3497
3420
1690
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10732., I2=60930000., I3=0., J=0. | | C35
2 | A=12884., I2=68720000., I3=0., J=0. | | C35
3 | A=6940., I2=23960000., I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -


207,6
20
107,6
215
60
315,2
20
107,6
107,6
215
60
177
20
78,5
78,5
190
20

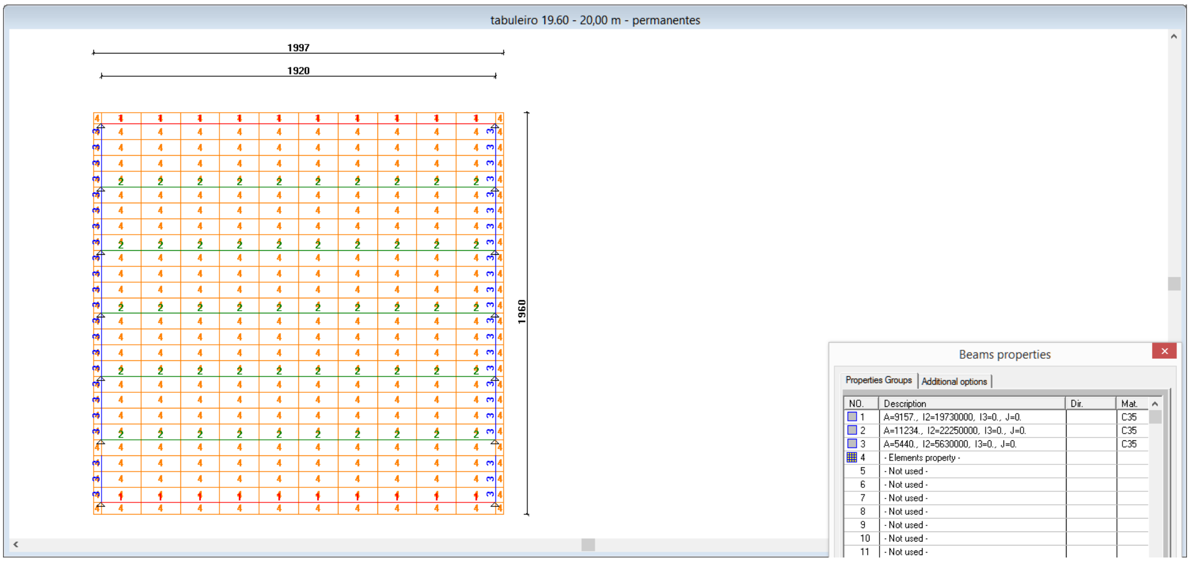

Area: 10732.0000 cm2 = 1,0732 m2
Moments of inertia:
X: 60928699.4623 cm4 = 0,6093 m4
Area: 12884.0000 cm2 = 1,2884 m2
Moments of inertia:
X: 68721395.9901 cm4 = 0,6872 m4
Area: 6940.0000 cm2 = 0,6940 m2
Moments of inertia:
X: 23958336.2152 cm4 = 0,2396 m4

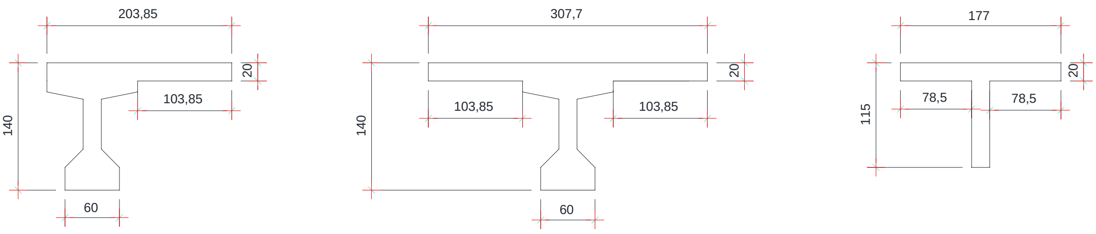

tabuleiro 16.90 - 40,00 m - permanentes
3997
3920
1690
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=11032., I2=72440000., I3=0., J=0. | | C35
2 | A=13184., I2=81720000., I3=0., J=0. | | C35
3 | A=7240., I2=29680002., I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -

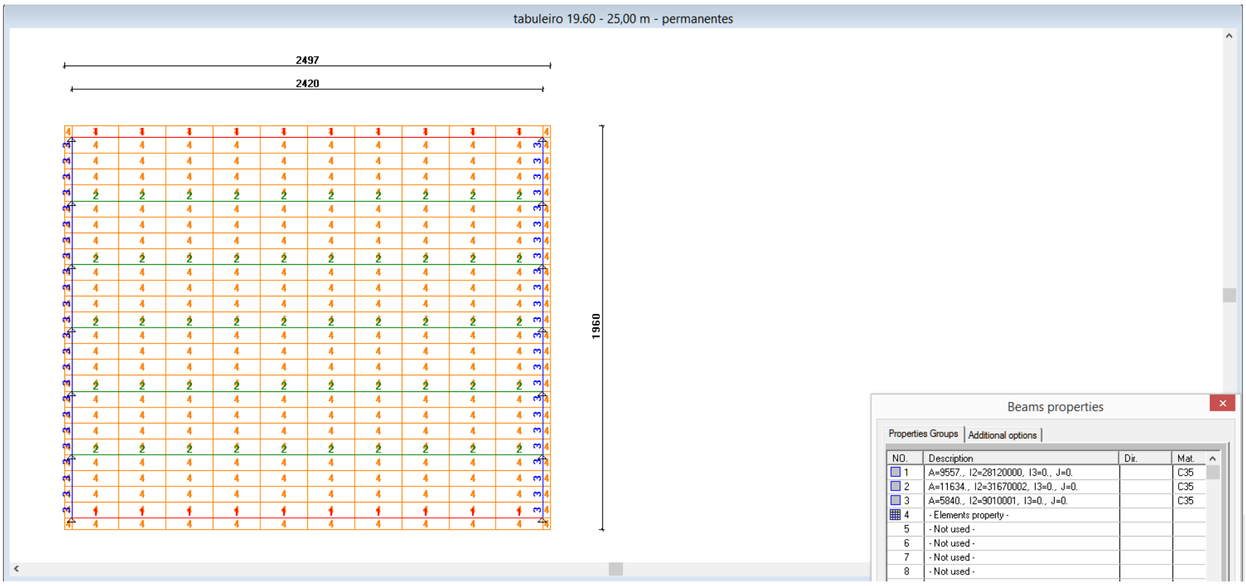

207,6
20
107,6
230
60
315,2
20
107,6
107,6
230
60
177
20
78,5
78,5
205
20

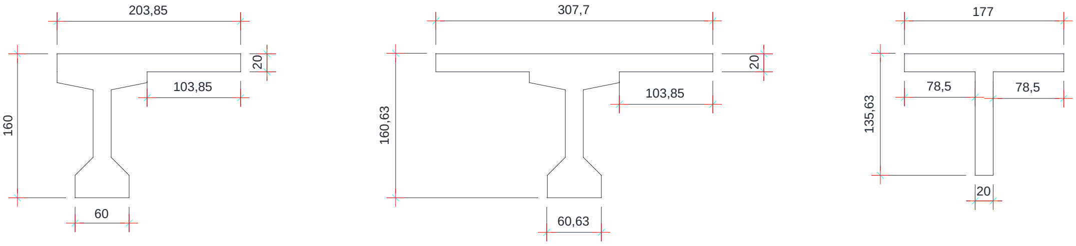

Area: 11032.0000 cm2 = 1,1032 m2
Moments of inertia:
X: 72435460.5809 cm4 = 0,7244 m4
Area: 13184.0000 cm2 = 1,3184 m2
Moments of inertia:
X: 81719963.9287 cm4 = 0,8172 m4
Area: 7240.0000 cm2 = 0,7240 m2
Moments of inertia:
X: 29677733.5405 cm4 = 0,2968 m4

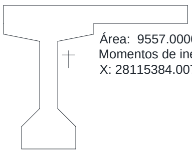
4.2.6. Tabuleiro 19,60 m



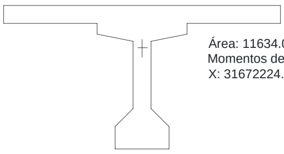




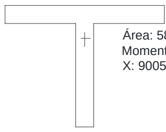




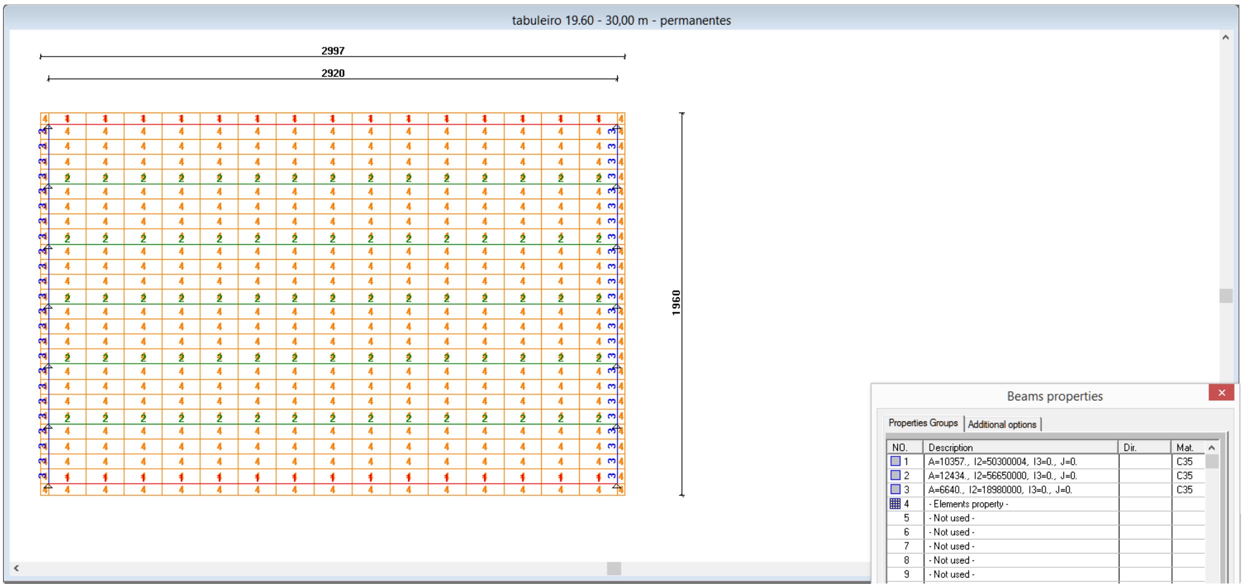
Área: 9557.0000 cm2 = 0,9557 m2
Momentos de inércia:
X: 28115384.0078 cm4 = 0,2812 m4

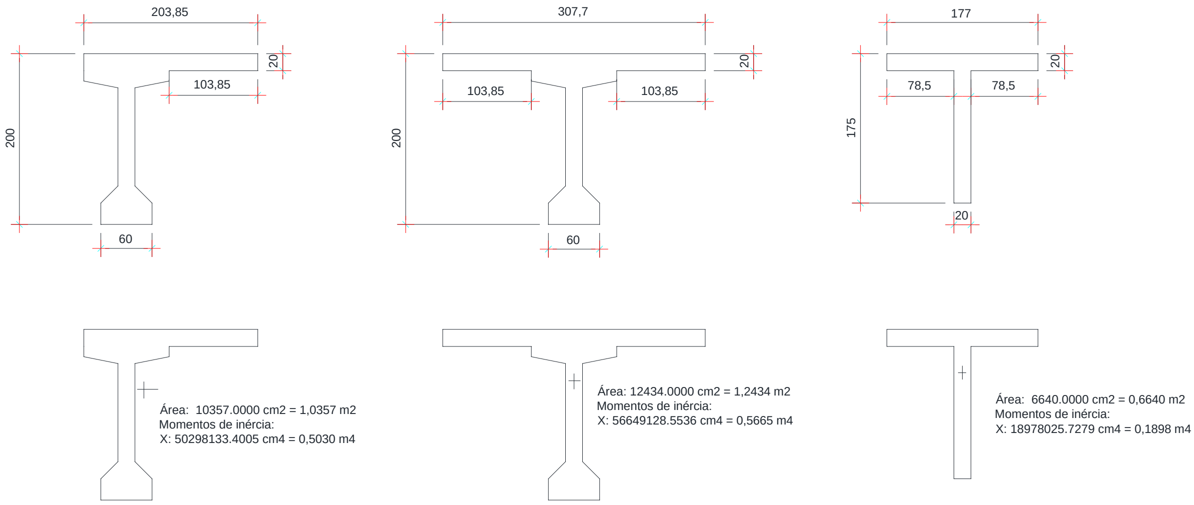


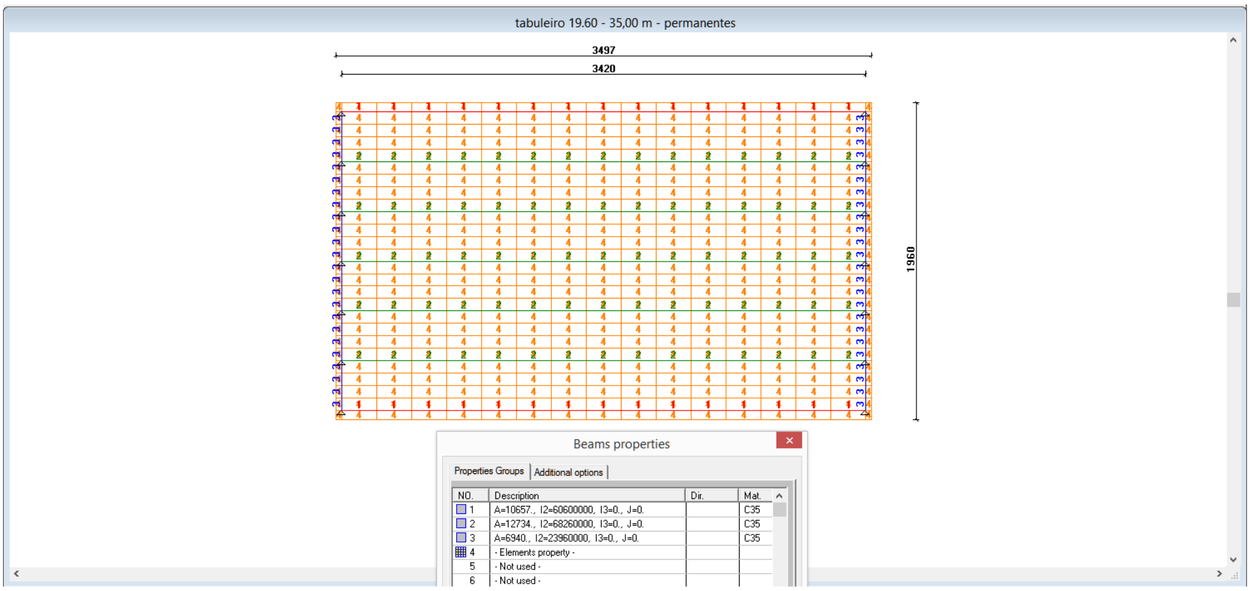
Área: 11634.0000 cm2 = 1,1634 m2
Momentos de inércia:
X: 31672224.6664 cm4 = 0,3167 m4

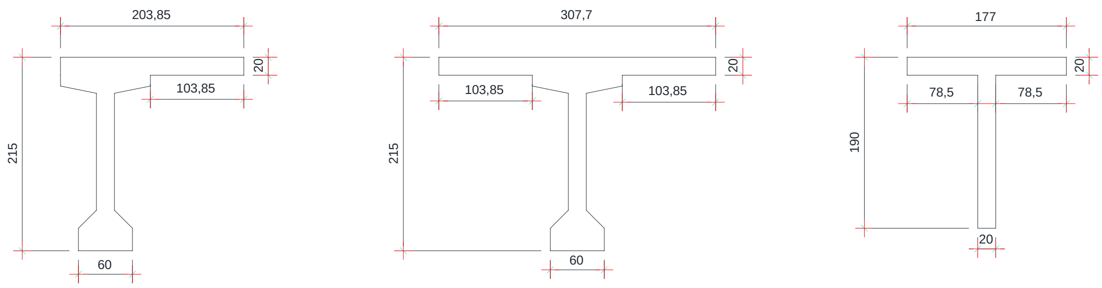


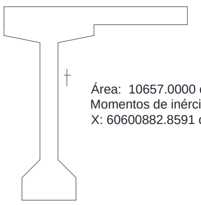
Área: 5840.0000 cm2 = 0,5840 m2
Momentos de inércia:
X: 9005015.5537 cm4 = 0,0901 m4


tabuleiro 19.60 - 30,00 m - permanentes
2997
2920
1960
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10357., I2=50300004, I3=0., J=0. | | C35
2 | A=12434., I2=56650000, I3=0., J=0. | | C35
3 | A=6640., I2=18980000, I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -
7 | - Not used -
8 | - Not used -
9 | - Not used -

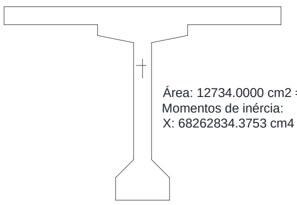

203,85
20
103,85
200
60
307,7
20
103,85
103,85
200
60
177
20
78,5
78,5
175
20
Área: 10357.0000 cm2 = 1,0357 m2
Momentos de inércia:
X: 50298133.4005 cm4 = 0,5030 m4
Área: 12434.0000 cm2 = 1,2434 m2
Momentos de inércia:
X: 56649128.5536 cm4 = 0,5665 m4
Área: 6640.0000 cm2 = 0,6640 m2
Momentos de inércia:
X: 18978025.7279 cm4 = 0,1898 m4



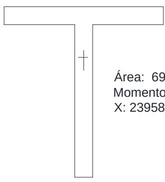




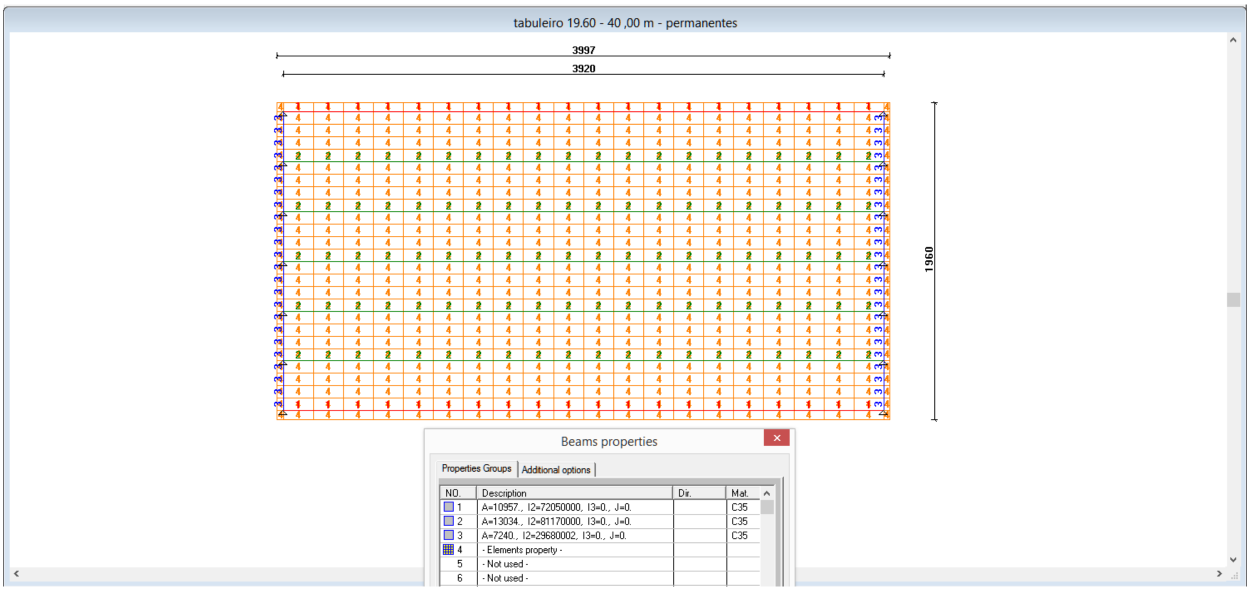
Área: 10657.0000 cm2 = 1,0657 m2
Momentos de inércia:
X: 60600882.8591 cm4 = 0,6060 m4

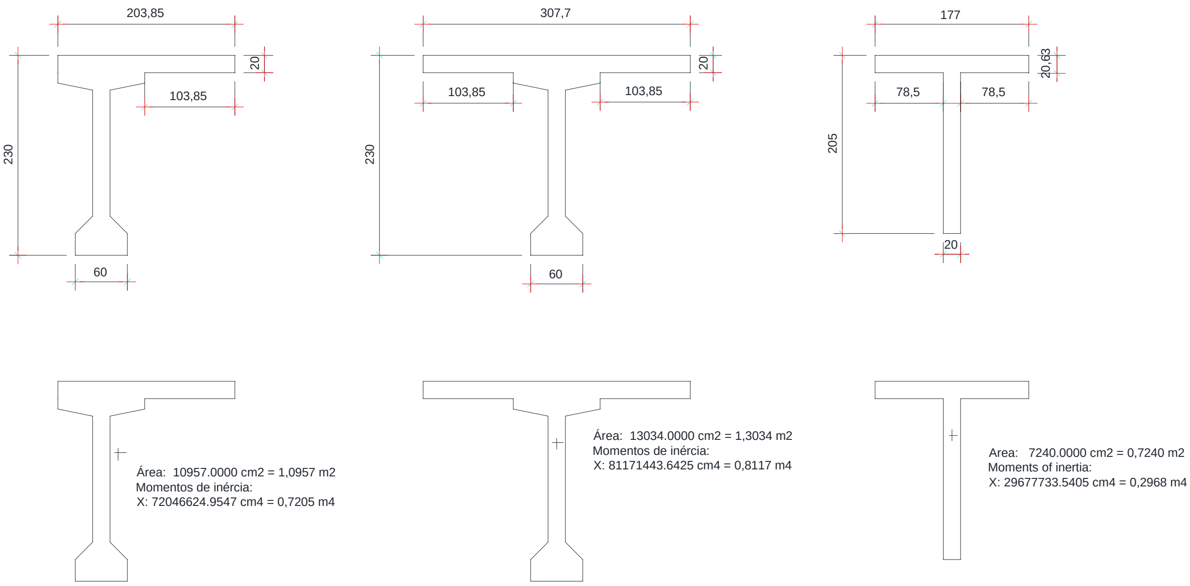


Área: 12734.0000 cm2 = 1,2734 m2
Momentos de inércia:
X: 68262834.3753 cm4 = 0,6826 m4



Área: 6940.0000 cm2 = 0,6940 m2
Momentos de inércia:
X: 23958336.2152 cm4 = 0,2396 m4


tabuleiro 19.60 - 40 ,00 m - permanentes
3997
3920
1960
Beams properties
Properties Groups
Additional options
NO. | Description | Dir. | Mat.
1 | A=10957., I2=72050000., I3=0., J=0. | | C35
2 | A=13034., I2=81170000., I3=0., J=0. | | C35
3 | A=7240., I2=29680002., I3=0., J=0. | | C35
4 | - Elements property -
5 | - Not used -
6 | - Not used -


203,85
20
103,85
230
60
307,7
20
103,85
103,85
230
60
177
20,63
78,5
78,5
205
20
Área: 10957.0000 cm2 = 1,0957 m2
Momentos de inércia:
X: 72046624.9547 cm4 = 0,7205 m4
Área: 13034.0000 cm2 = 1,3034 m2
Momentos de inércia:
X: 81171443.6425 cm4 = 0,8117 m4
Area: 7240.0000 cm2 = 0,7240 m2
Moments of inertia:
X: 29677733.5405 cm4 = 0,2968 m4

4.3. Cargas permanentes

O peso próprio considerado para o pavimento e a recapa é de:

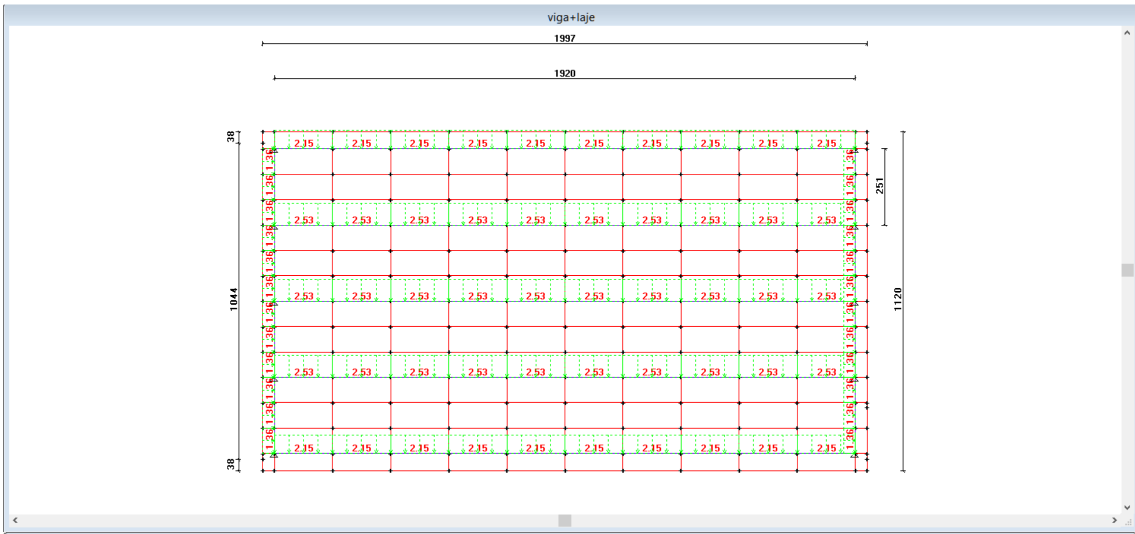
$$g_{peso\ próprio} = (2,40 \times 0,10) + 0,20 = 0,44\ tf/m^2$$

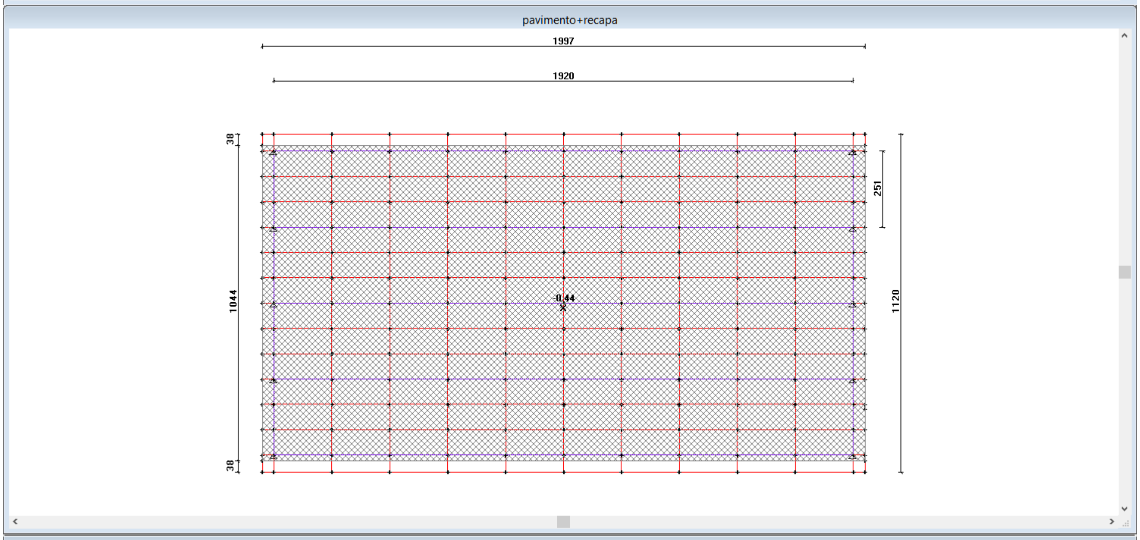
Foi adotada uma espessura de pavimento de 10 cm.

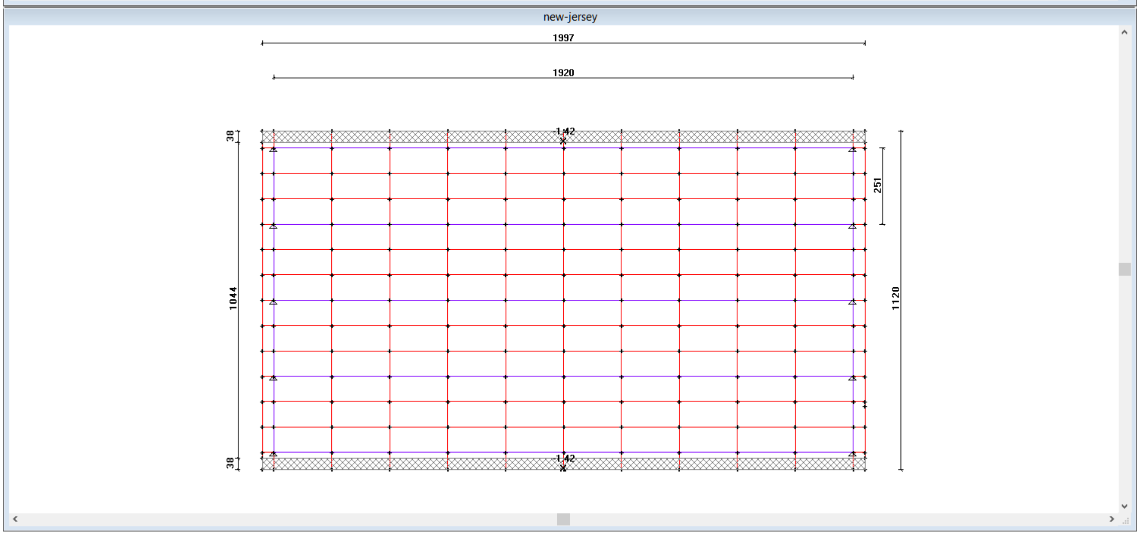
Para o New Jersey, realizamos o cálculo da área da defensa com a placa, que resultou em 0,2158 m² e multiplicamos pelo peso próprio do concreto armado, que é igual a 2,5 tf/m². Por fim, distribuímos o resultado em 0,38 metros e obtivemos uma pressão de 1,42 tf/m².

$$g_{new\ jersey} = \frac{0,2158 \times 2,50}{0,38} = 1,42\ tf/m^2$$

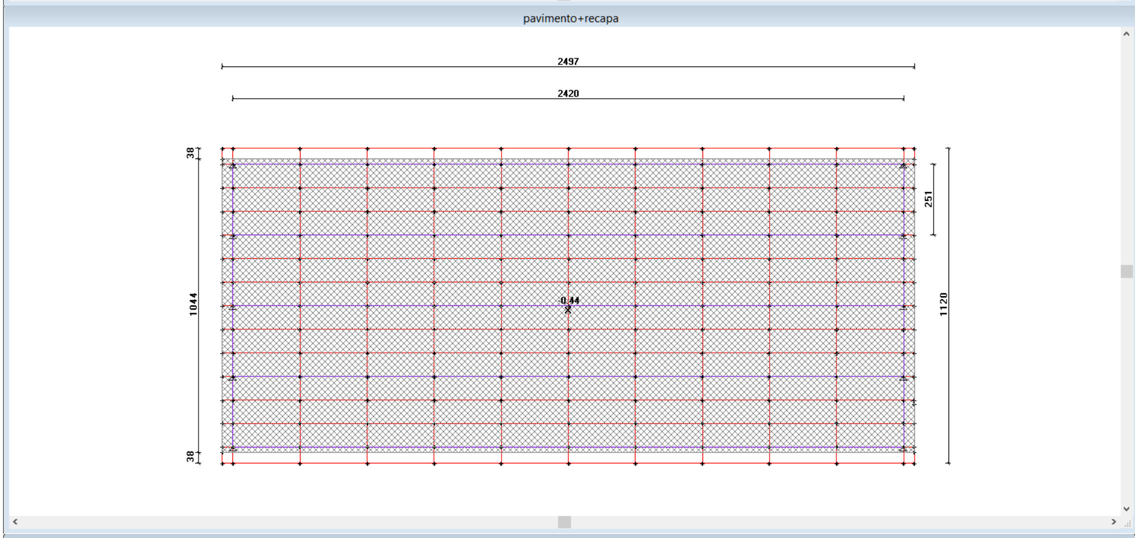
4.3.1. Tabuleiro 11,20 m

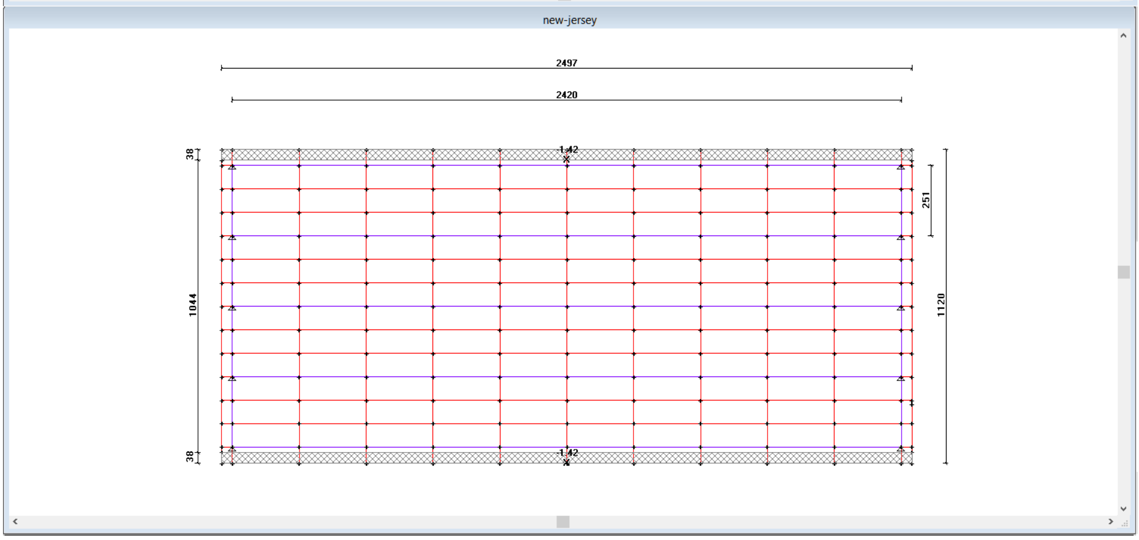


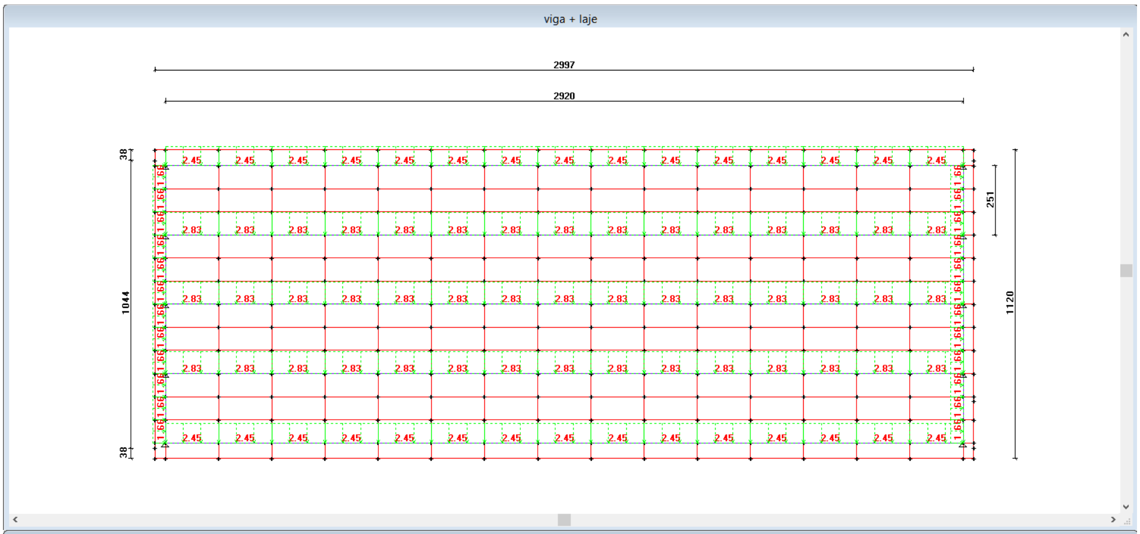


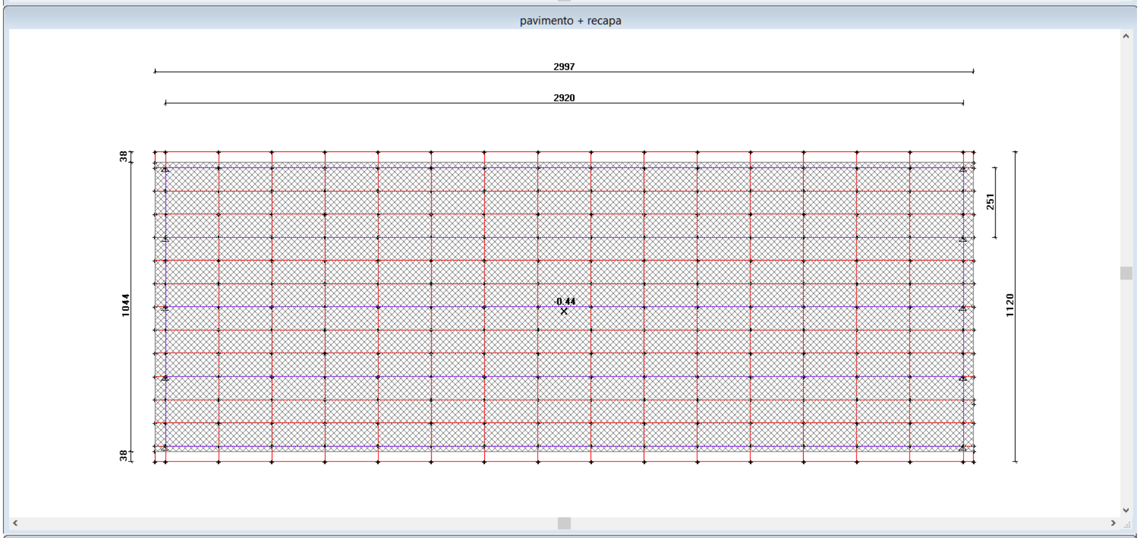


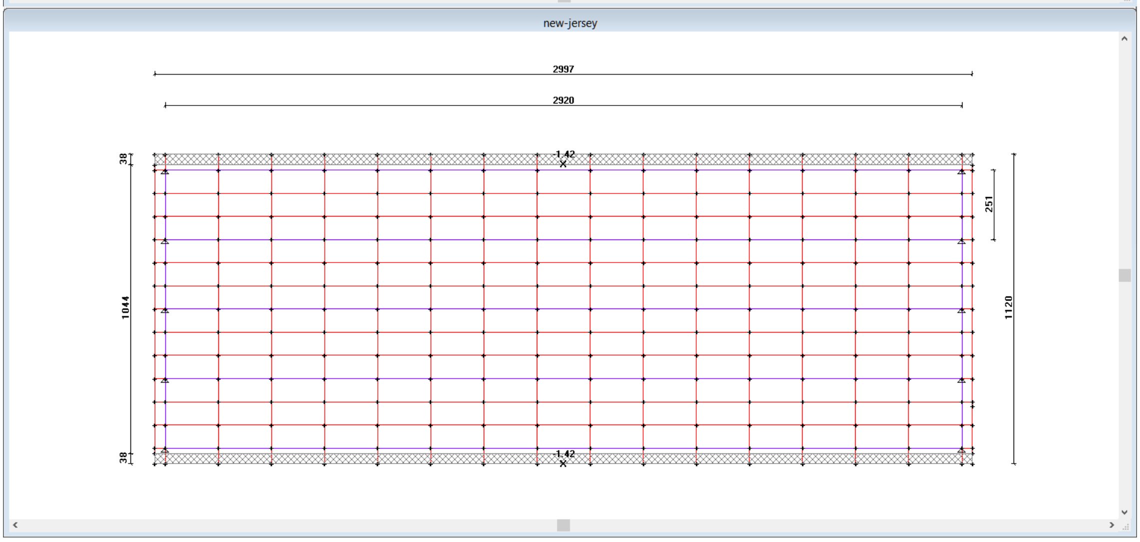

viga+laje
2497
2420
38
1044
38
251
1120
2.25
2.62
1.46


pavimento+recapa
2497
2420
38
1044
38
251
1120
-0.44

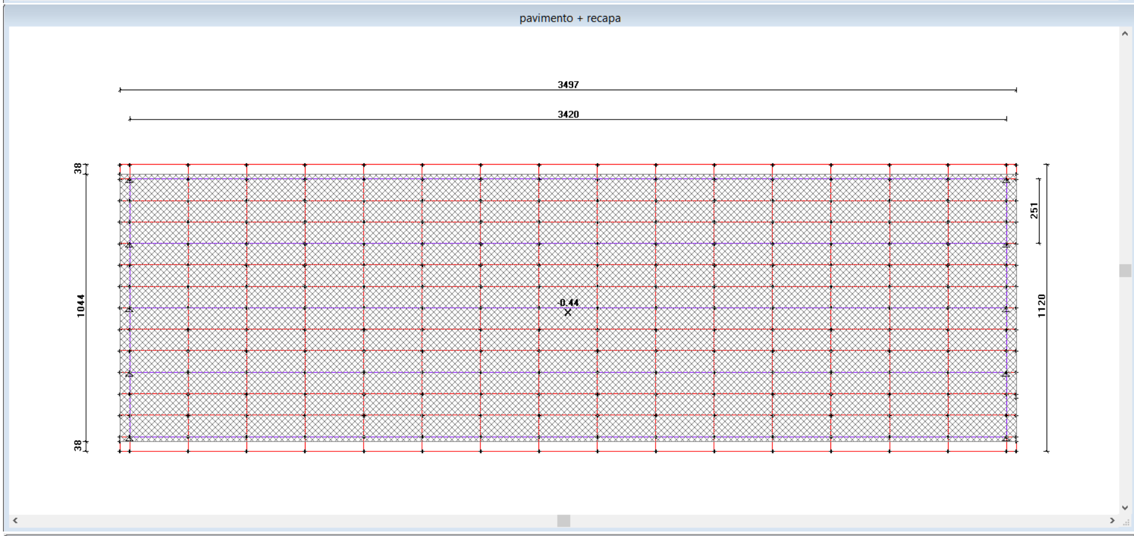

new-jersey
2497
2420
38
1044
38
251
1120
-1.42
-1.42

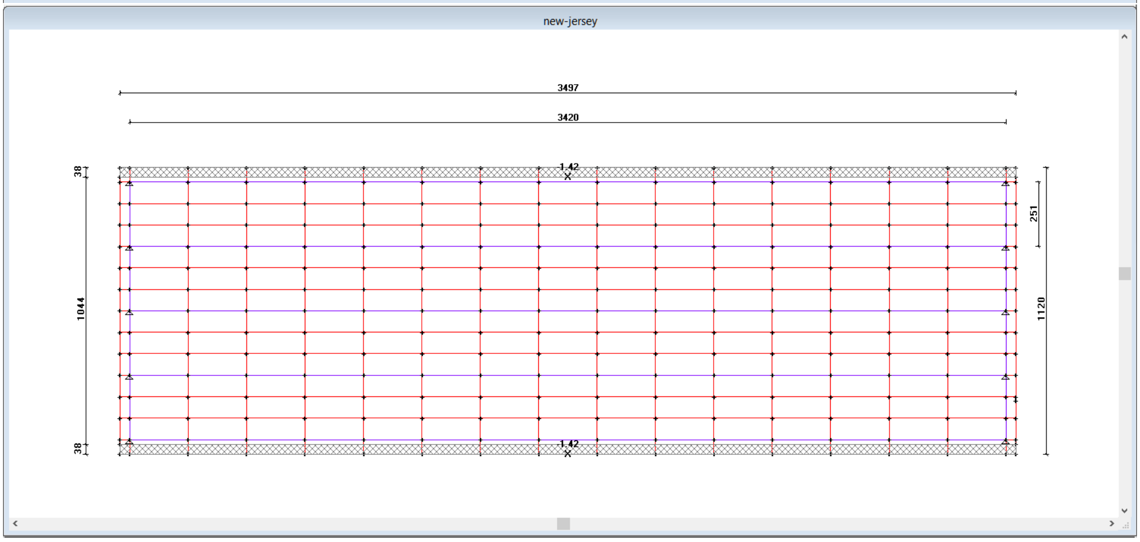

viga + laje
2997
2920
38
1044
38
251
1120


pavimento + recapa
2997
2920
38
1044
38
251
1120
-0.44

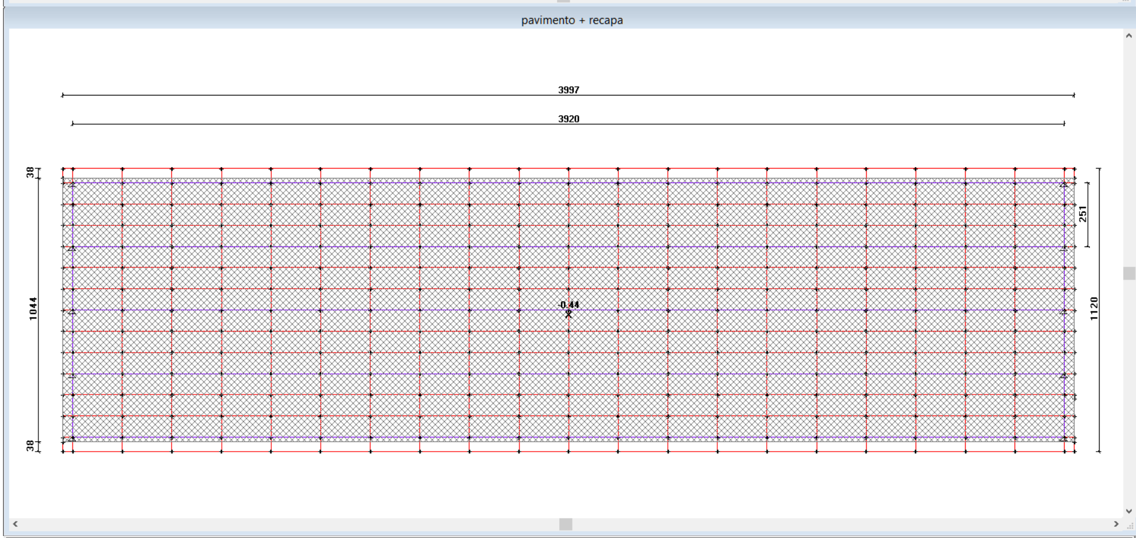

new-jersey
2997
2920
38
1044
38
251
1120
-1.42
-1.42

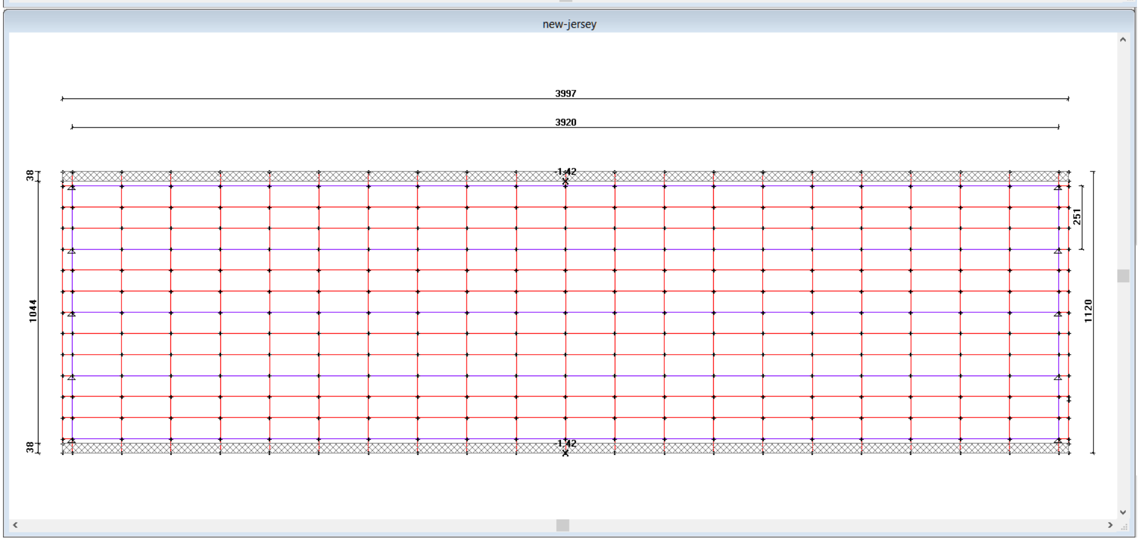

viga + laje
3497
3420
38
1044
38
251
1120
2.52
2.9


pavimento + recapa
3497
3420
38
1044
38
251
1120
-0.44

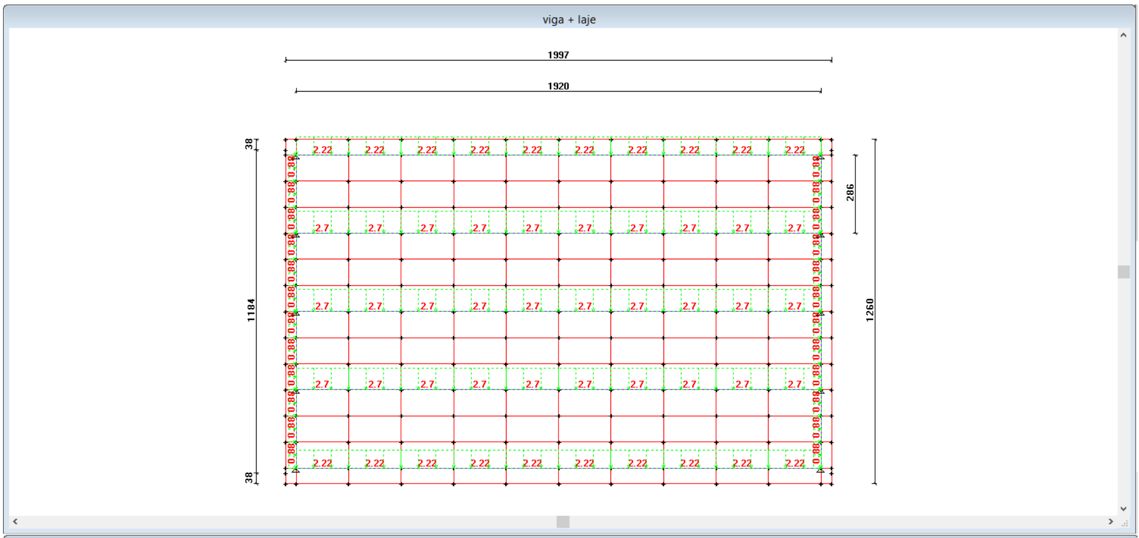

new-jersey
3497
3420
38
1044
38
251
1120
-1.42
-1.42

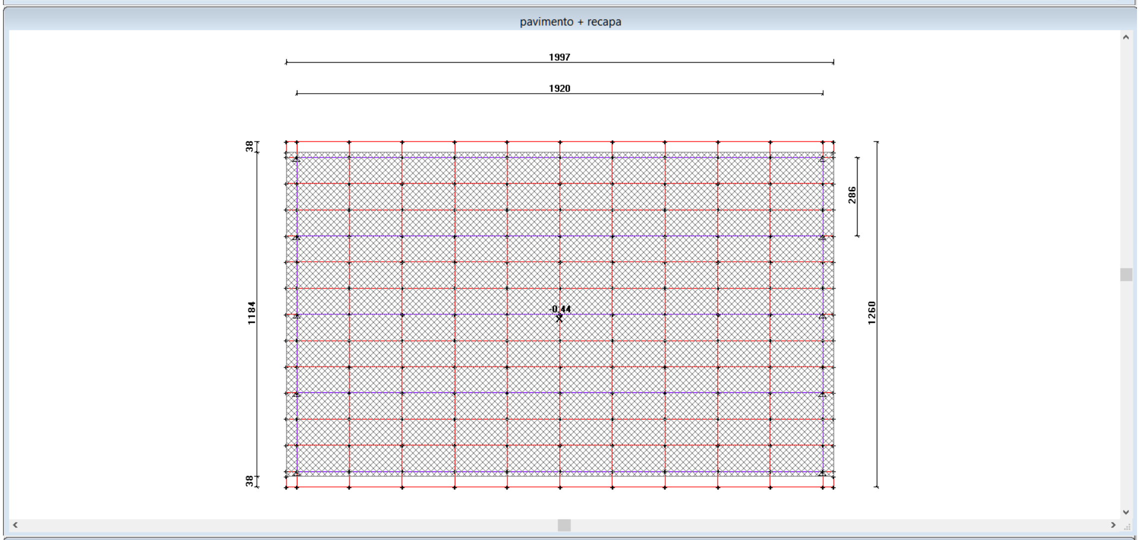

viga + laje
3997
3920
38
1044
38
251
1120
2.6
2.98
1.81

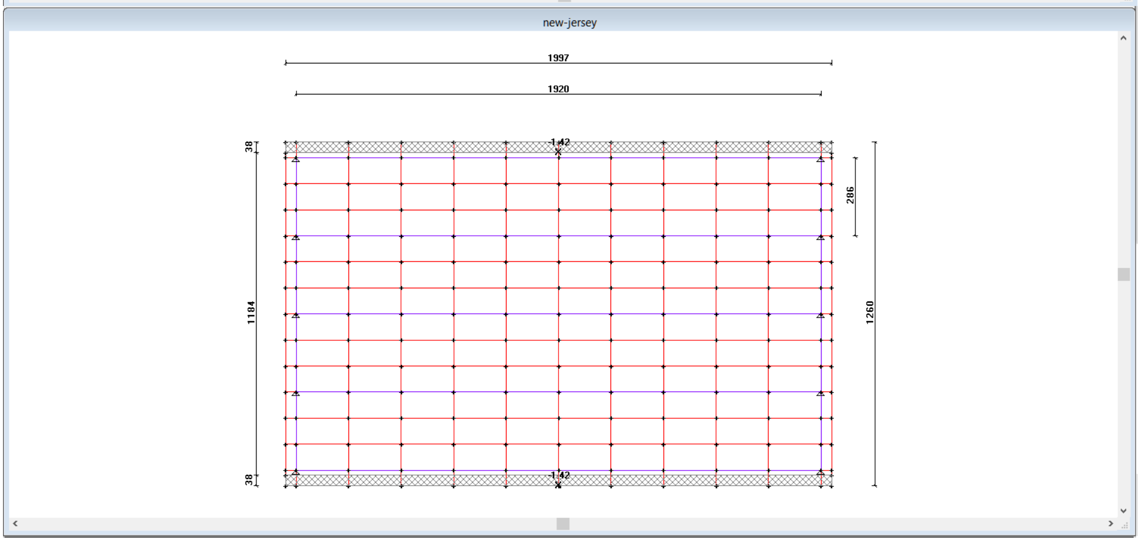

pavimento + recapa
3997
3920
38
1044
38
251
1120
-0.44


new-jersey
3997
3920
38
1044
38
251
1120
-1.42
-1.42

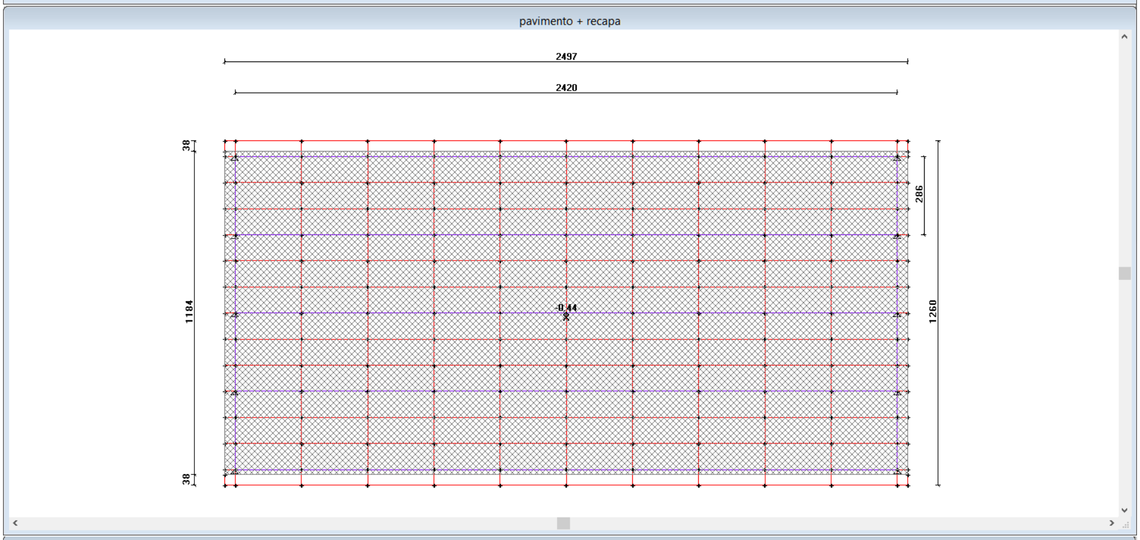
4.3.2. Tabuleiro 12,60 m

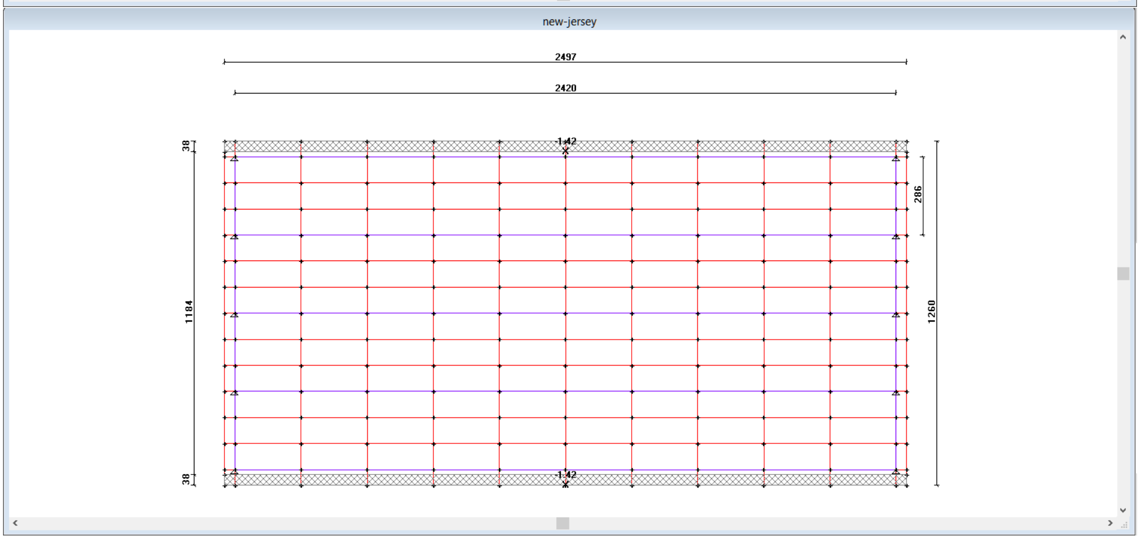


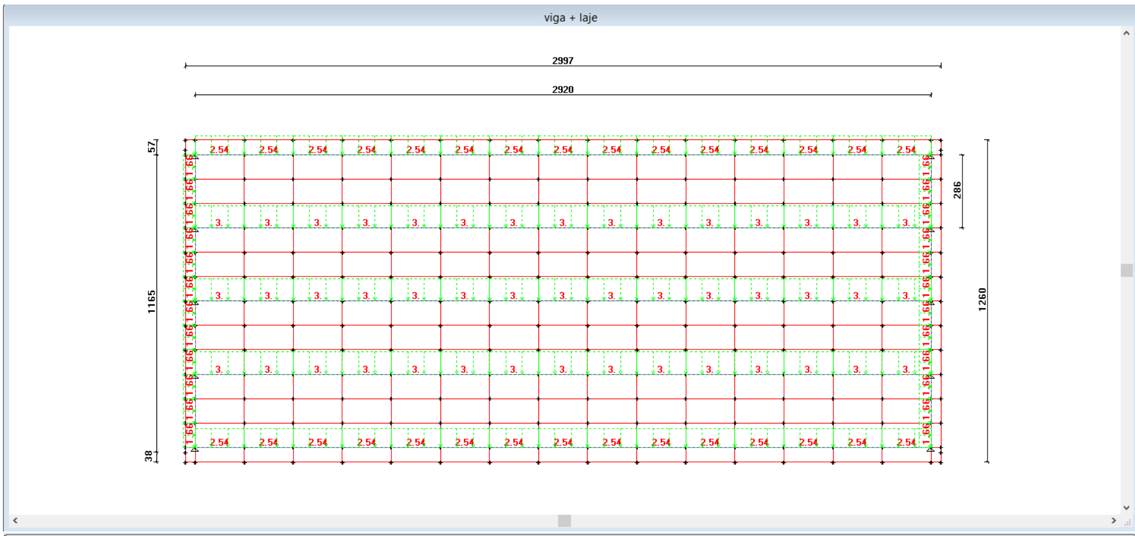


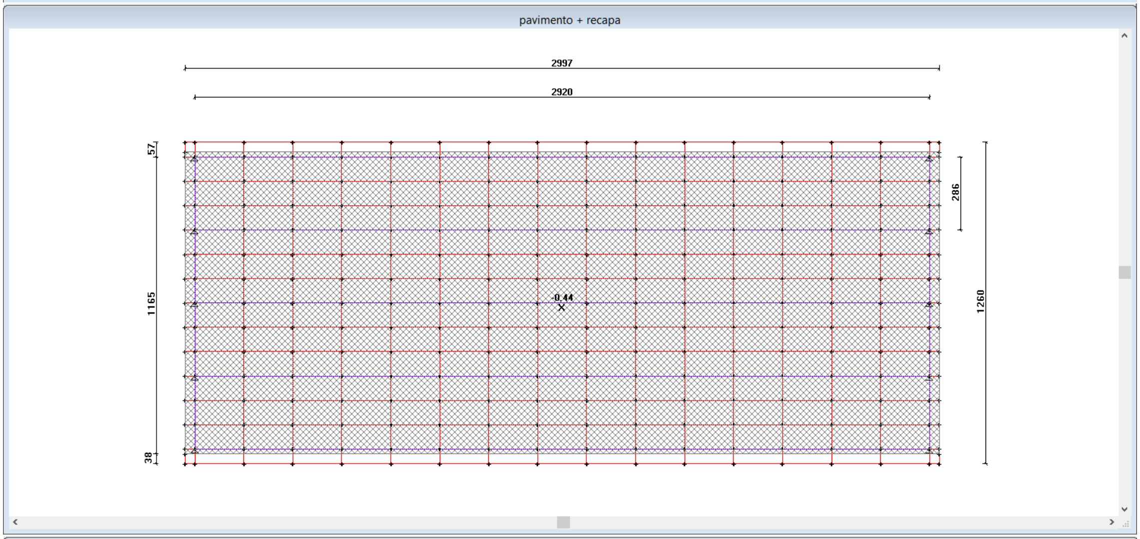


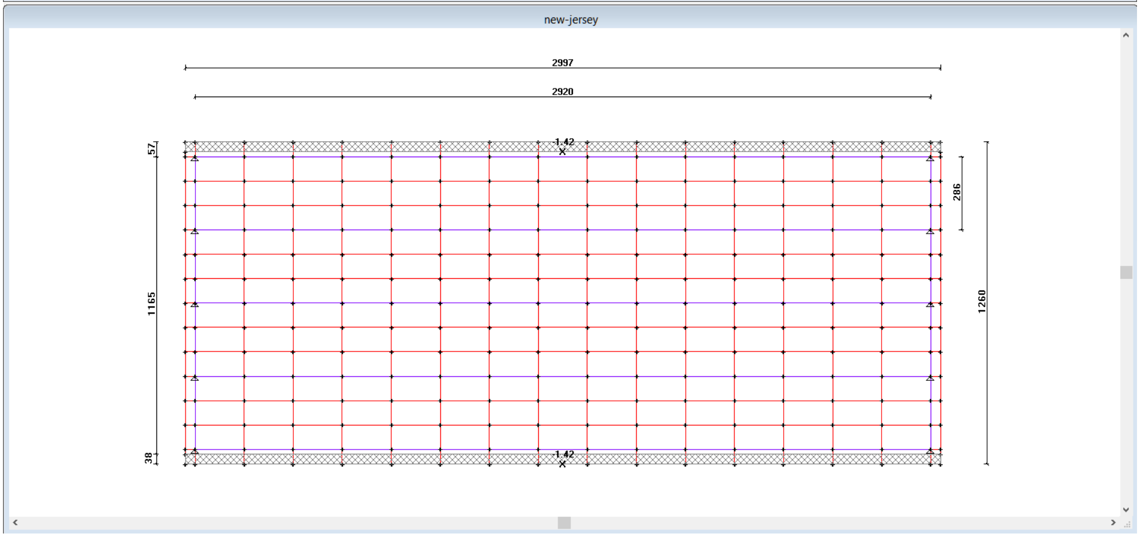

viga + laje
2497
2420
38
1184
38
286
1260
2.34
2.8
1.46

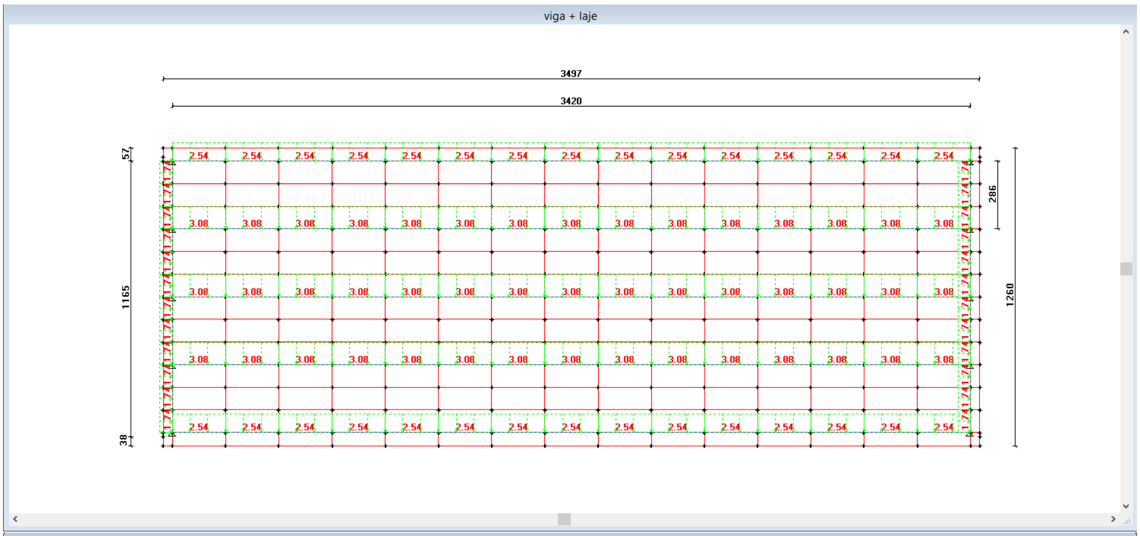

pavimento + recapa
2497
2420
38
1184
38
286
1260
-0.44

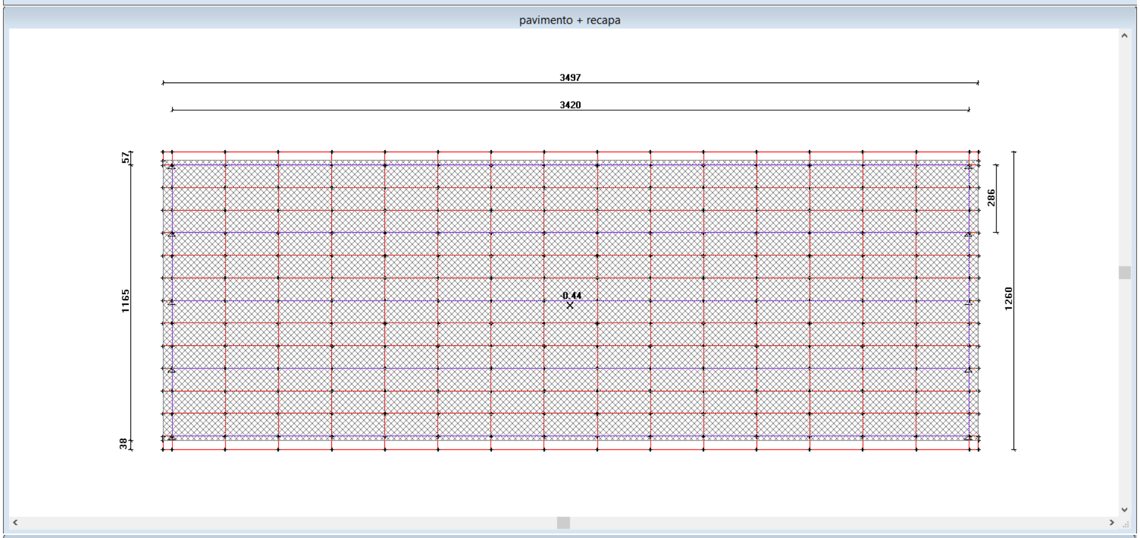

new-jersey
2497
2420
38
1184
38
286
1260
-1.42
-1.42

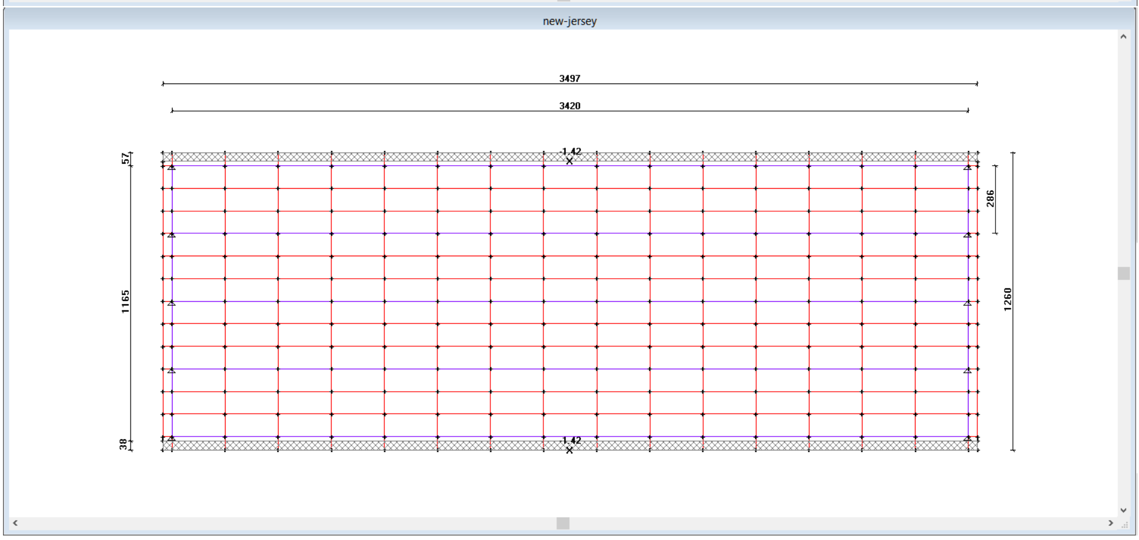

viga + laje
2997
2920
57
1165
38
286
1260


pavimento + recapa
2997
2920
57
1165
38
286
1260
-0.44

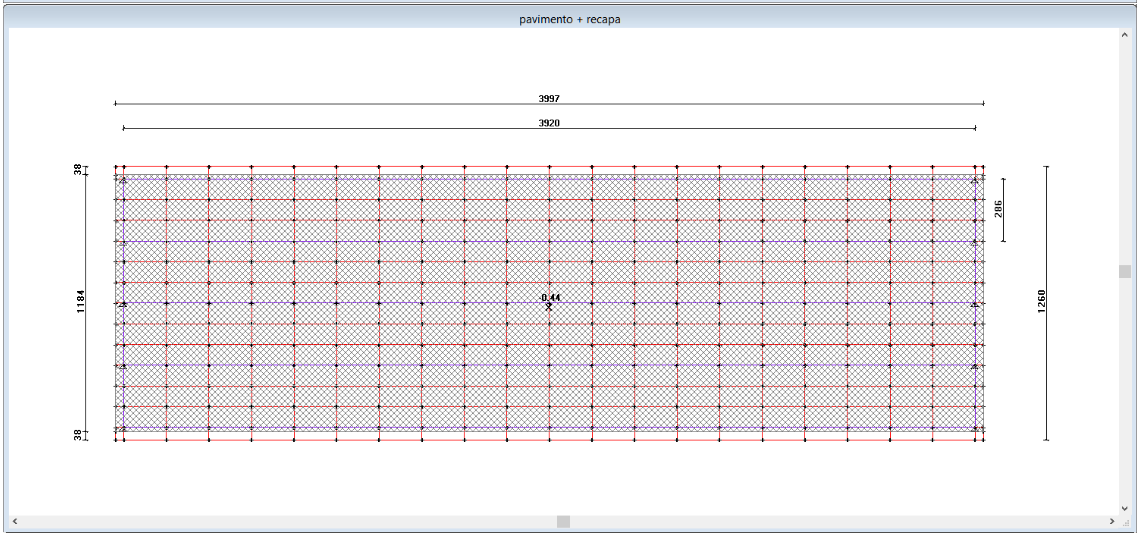

new-jersey
2997
2920
57
1165
38
286
1260
-1.42
-1.42

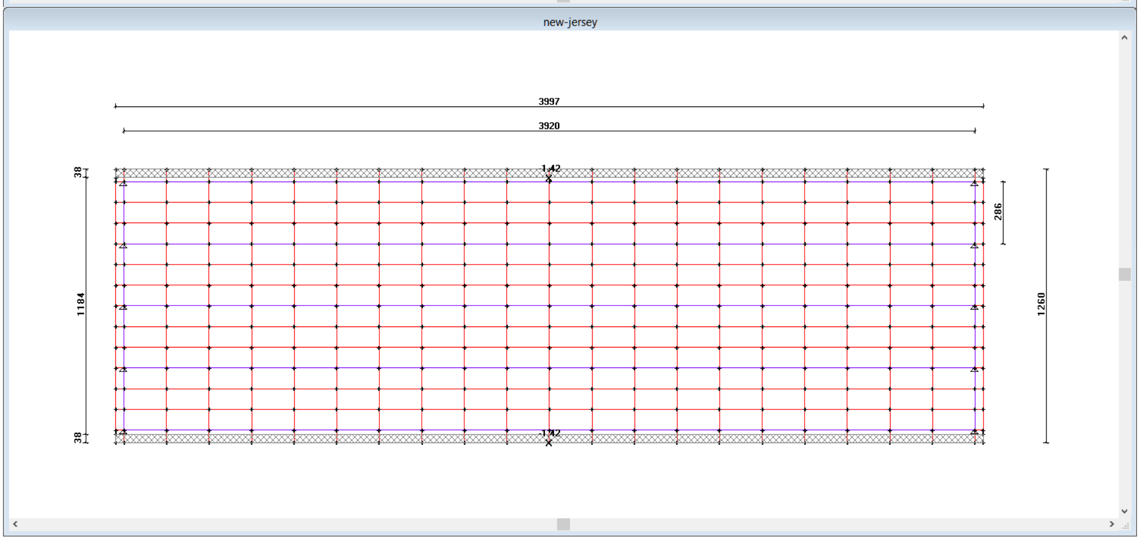

viga + laje
3497
3420
57
1165
38
286
1260
2.54
3.08


pavimento + recapa
3497
3420
57
1165
38
286
1260
-0.44

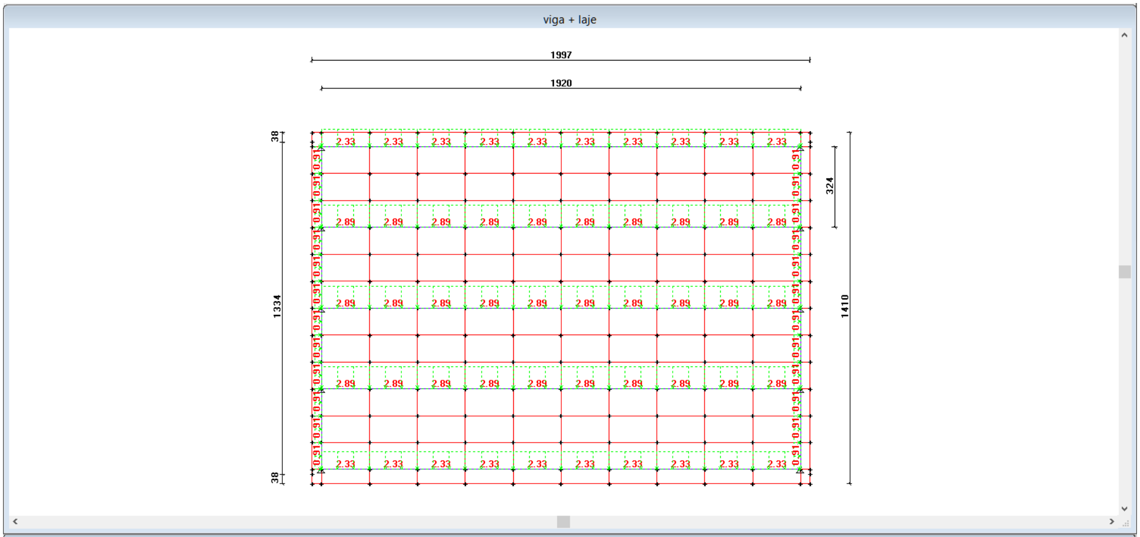

new-jersey
3497
3420
57
1165
38
286
1260
-1.42
-1.42

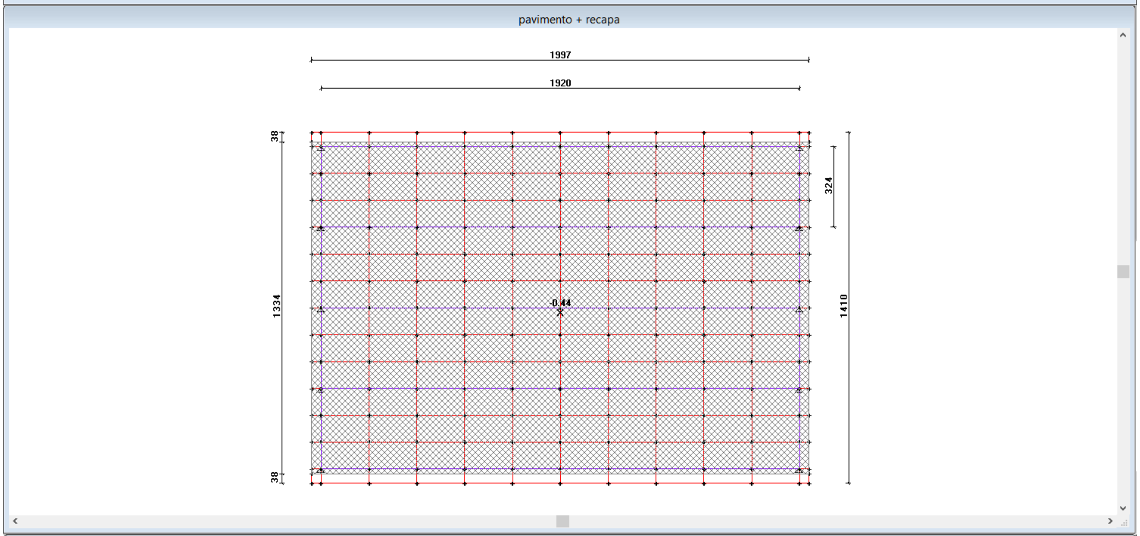

viga + laje
3997
3920
38
1184
38
286
1260
2.69
3.15
1.81

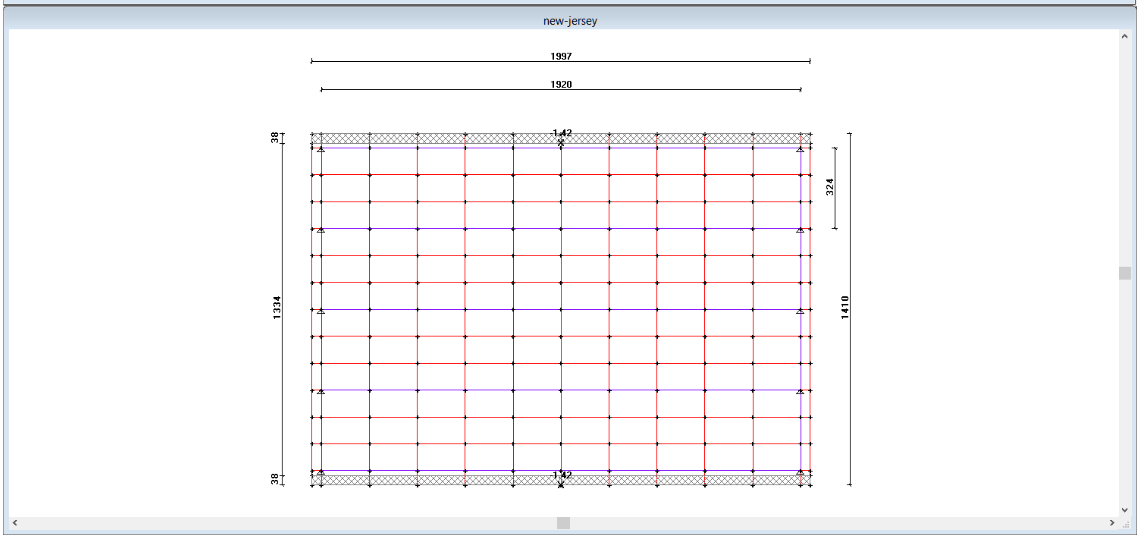

pavimento + recapa
3997
3920
38
1184
38
286
1260
-0.44

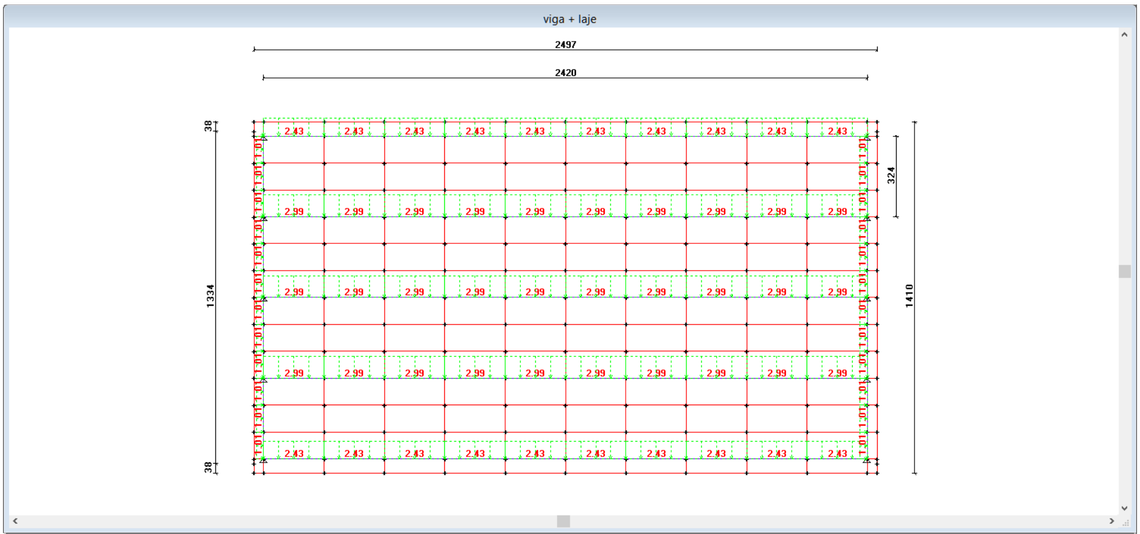

new-jersey
3997
3920
38
1184
38
286
1260
-1.42
-1.42

4.3.3. Tabuleiro 14,10 m





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2420
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324
1410
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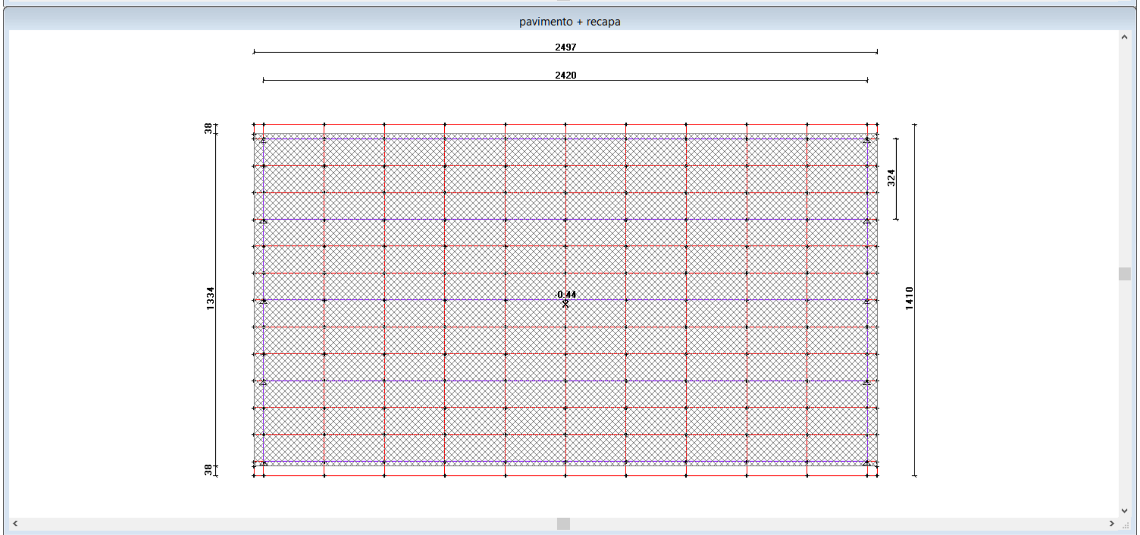
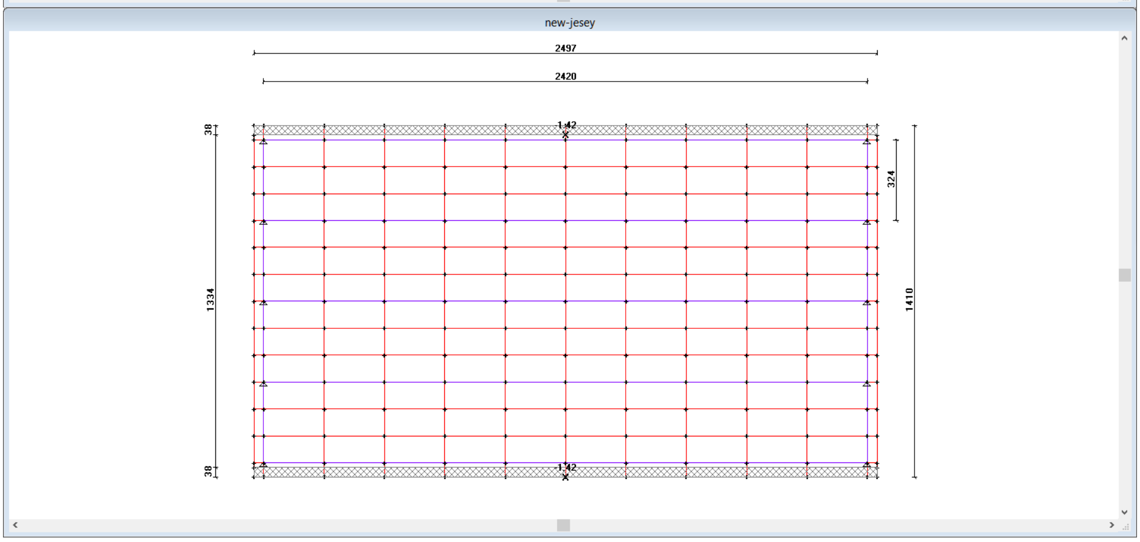
2.99
1.01


pavimento + recapa
2497
2420
38
1334
38
324
1410
-0.44


new-jesey
2497
2420
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1334
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1410
-1.42
-1.42


2997
2920
324
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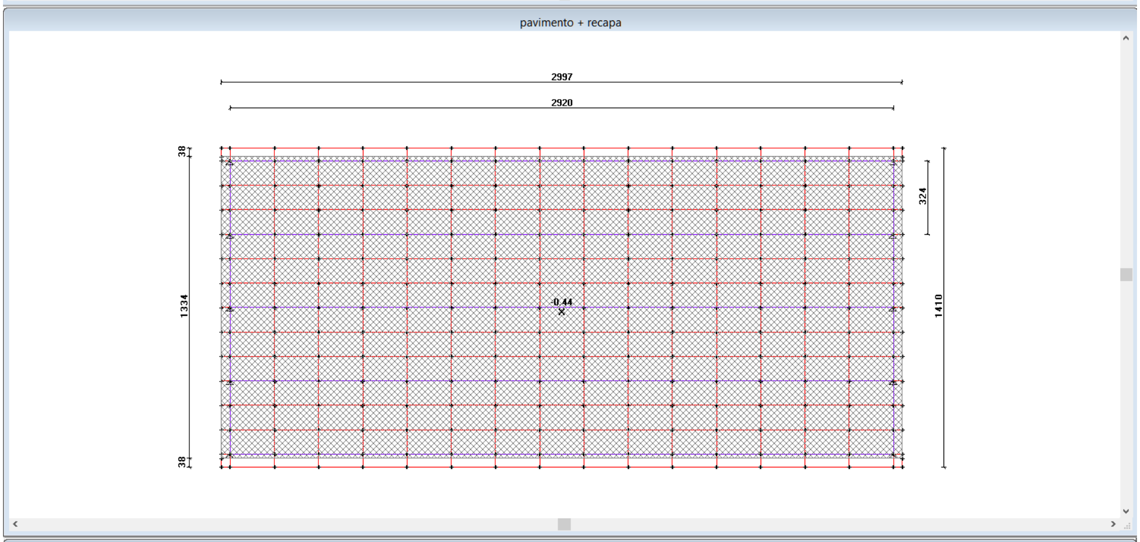
3.09
1.01
300
1410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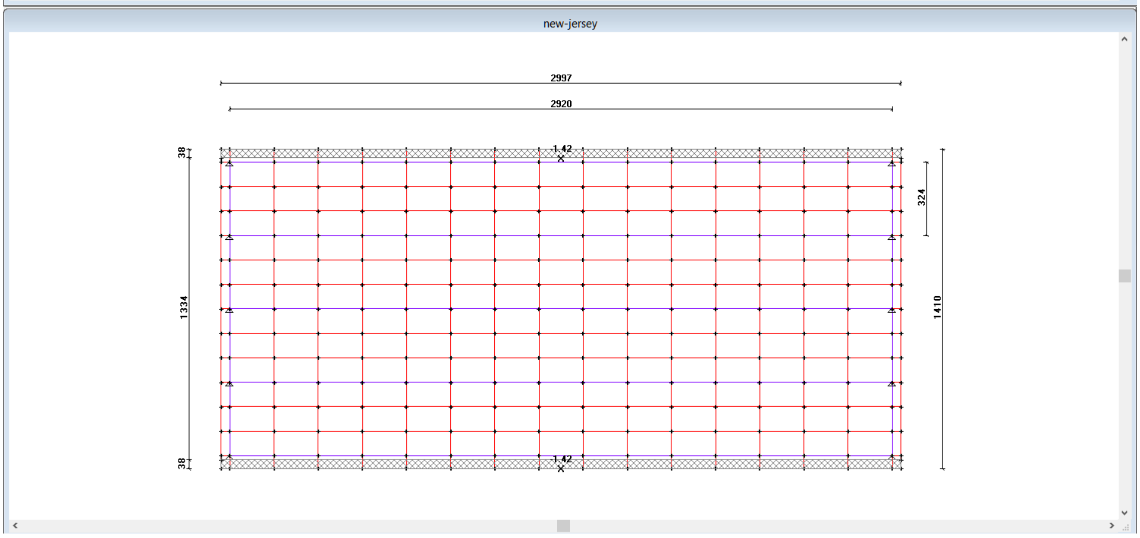
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2920
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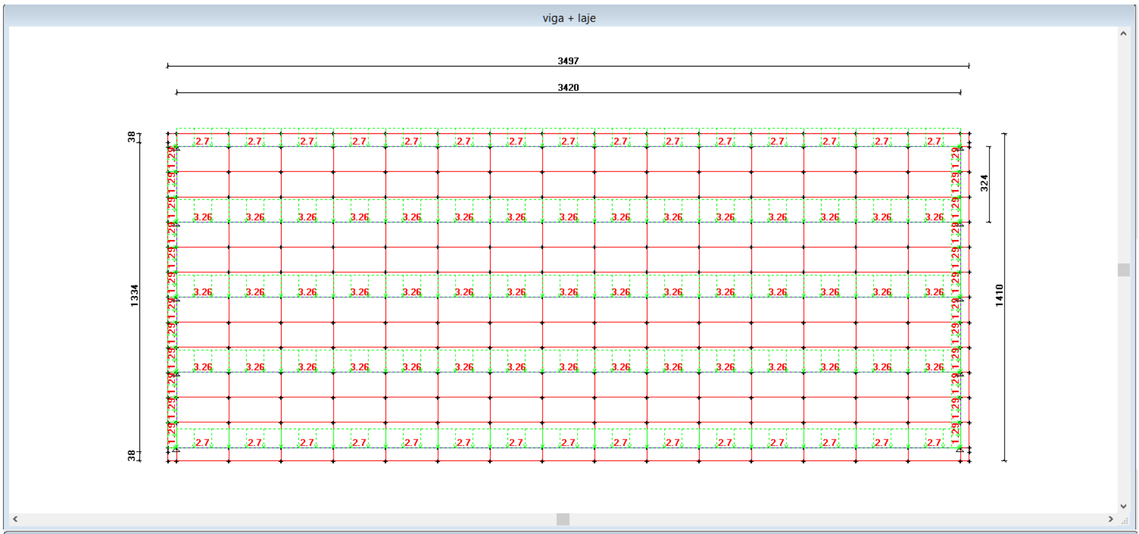
38
1334
324
1410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324
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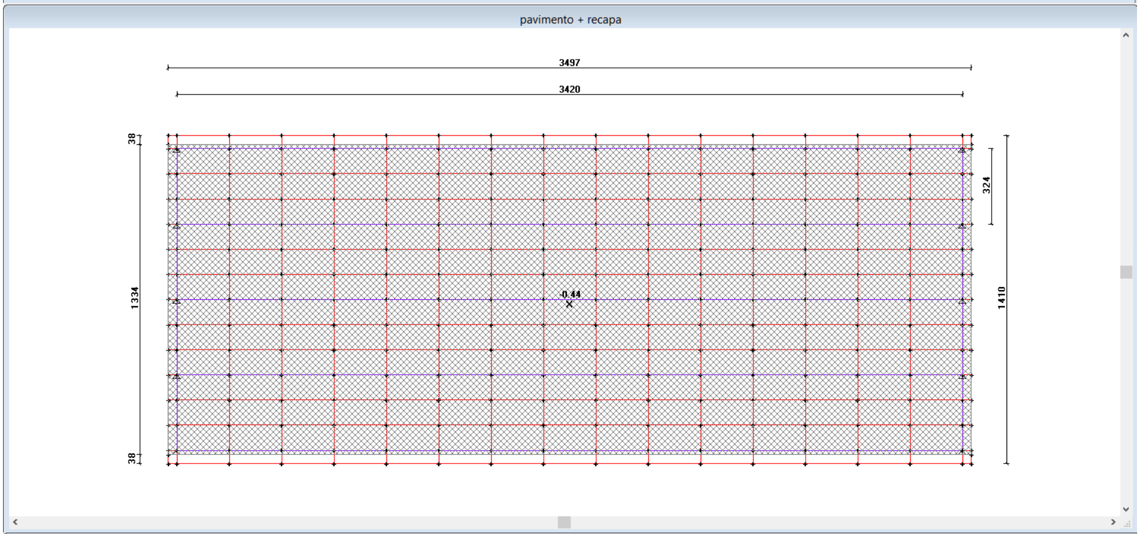
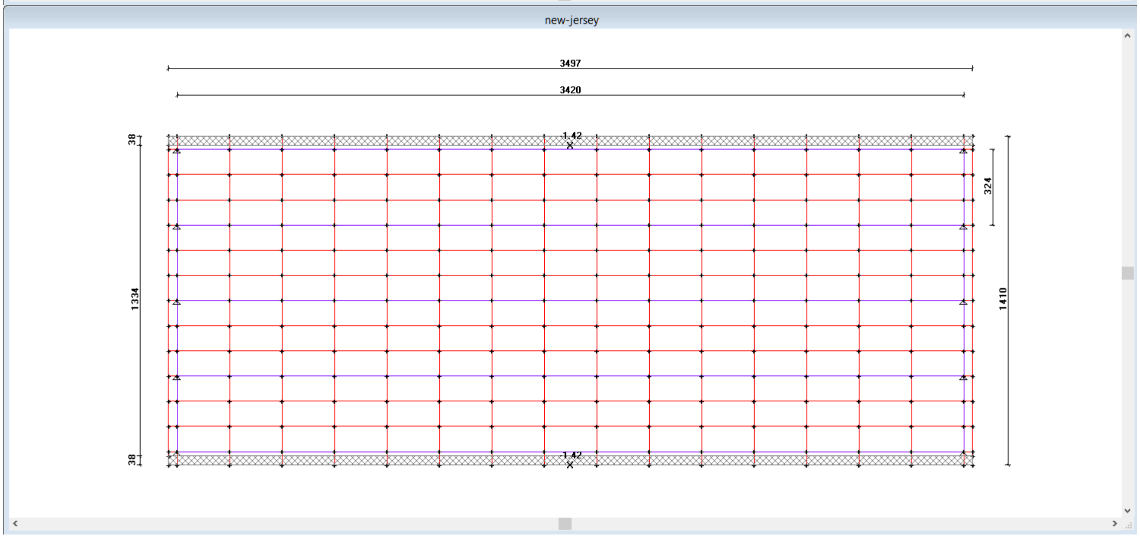
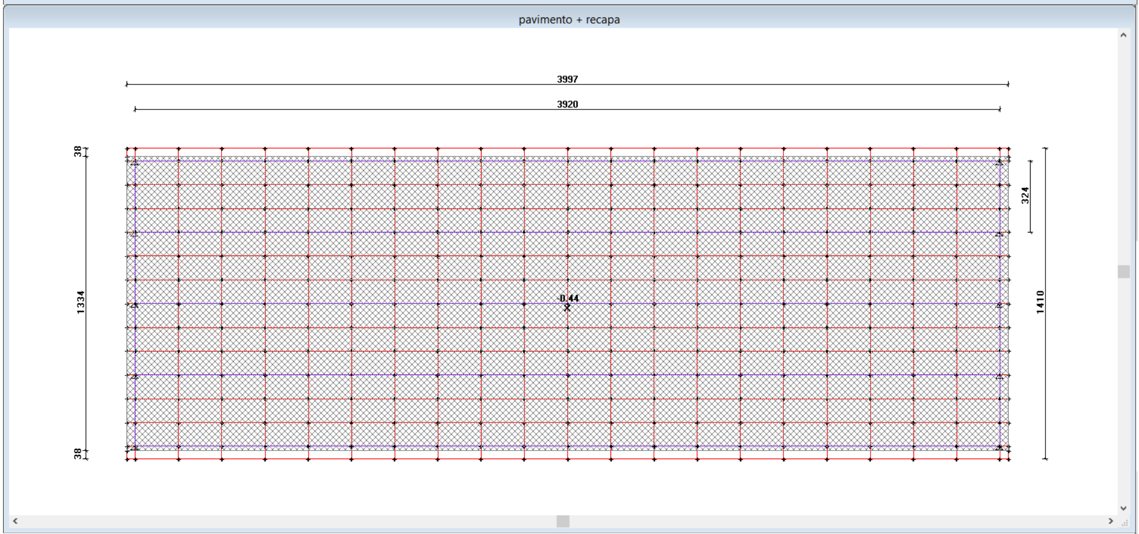
2.7
3.26
1.29


pavimento + recapa
3497
3420
38
1334
38
324
1410
-0.44


new-jersey
3497
3420
38
1334
38
324
1410
-1.42
-1.42


viga + laje
3997
3920
38
1334
38
324
1410
2.78
3.34
1.36


pavimento + recapa
3997
3920
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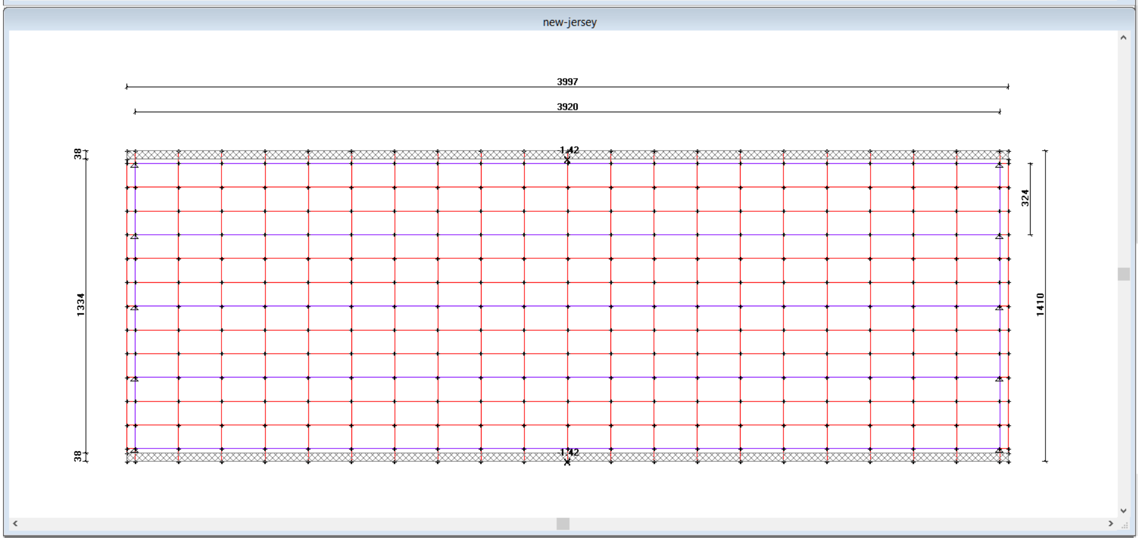
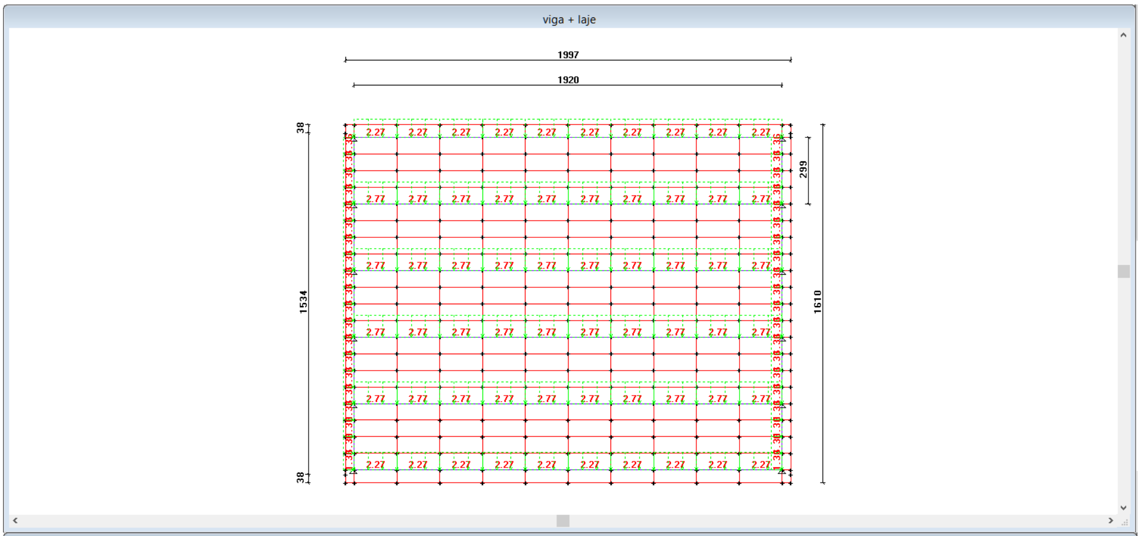
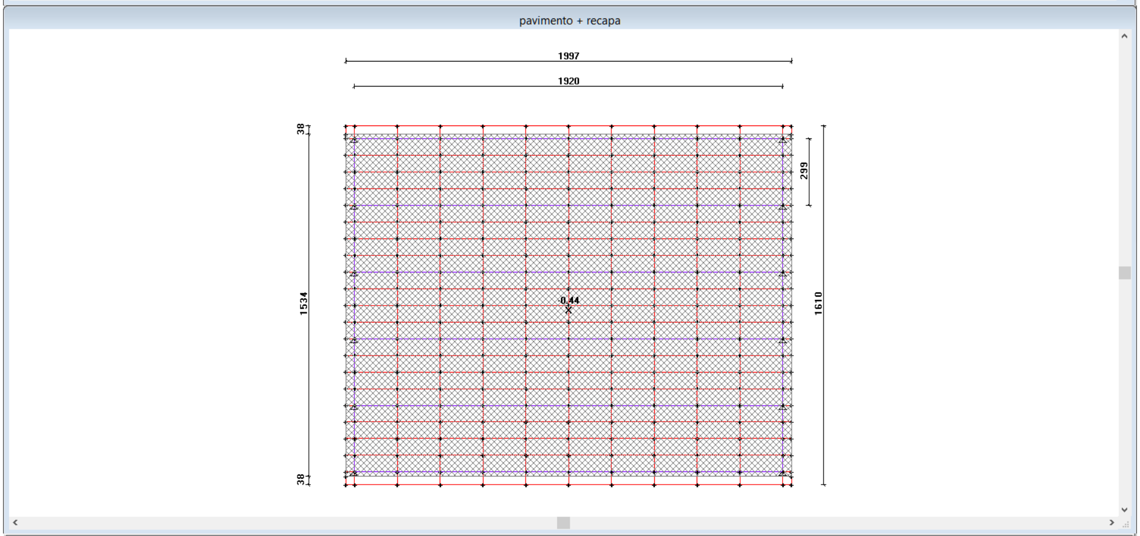
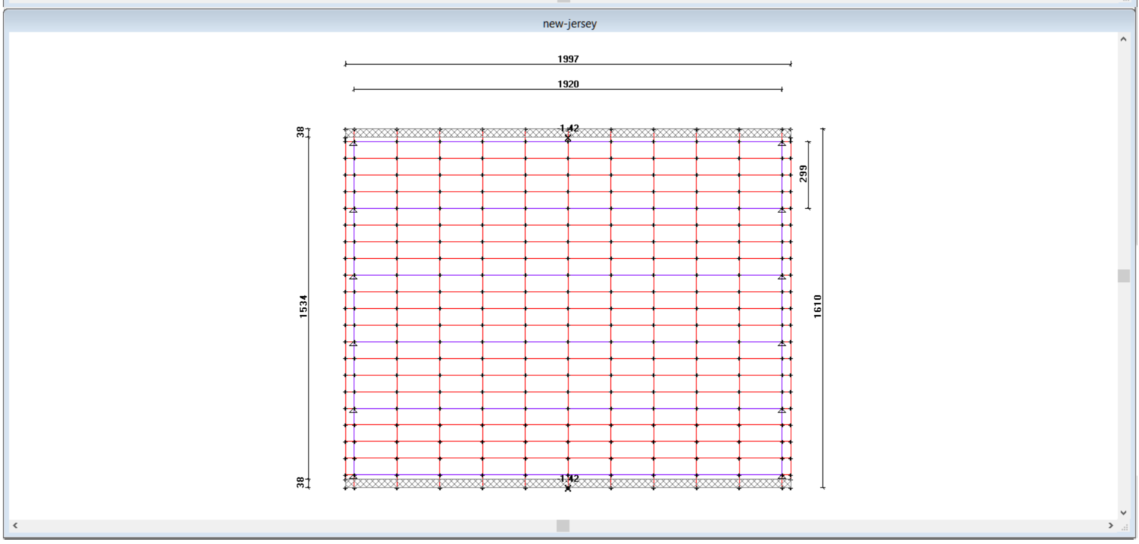
1334
38
324
1410
0.44

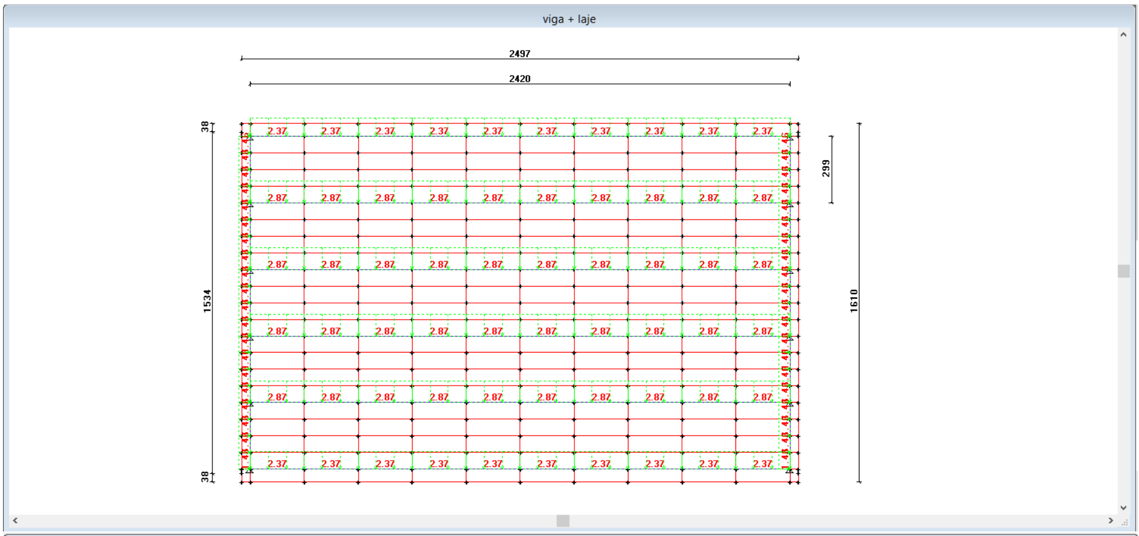

new-jersey
3997
3920
38
1334
38
324
1410
1.42
1.42

4.3.4. Tabuleiro 16,10 m





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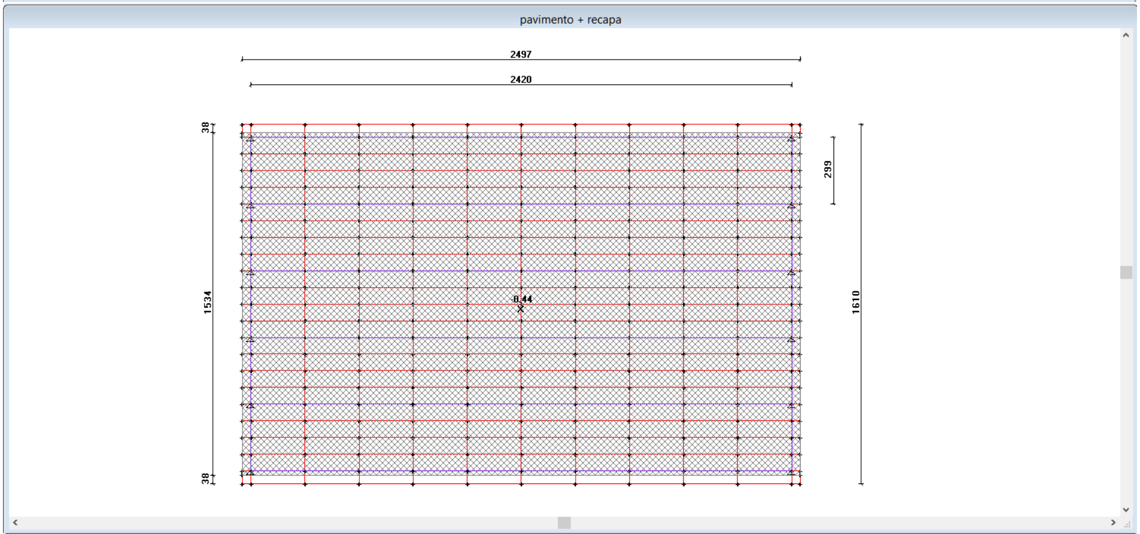
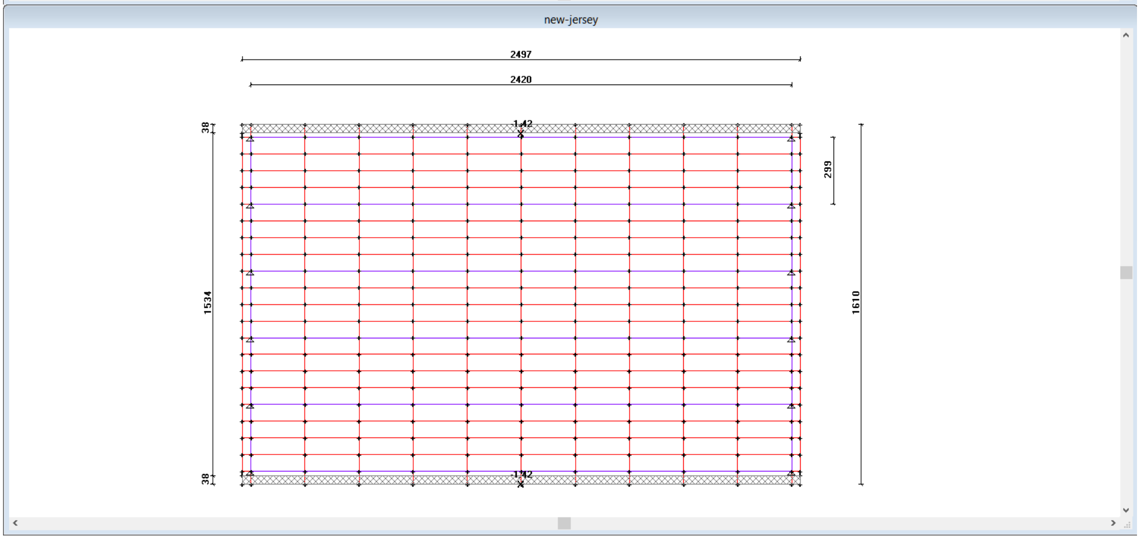
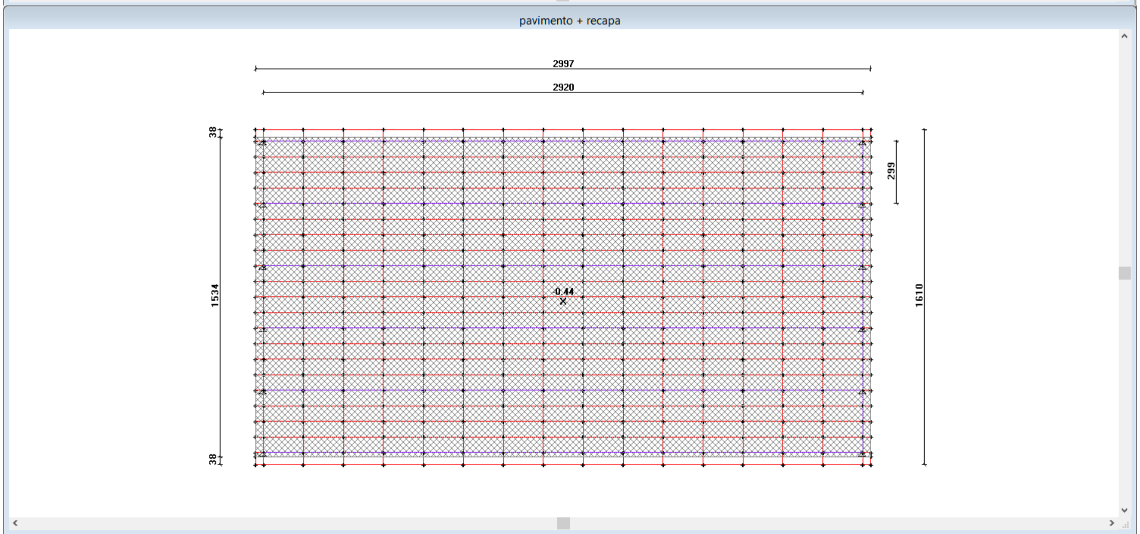
2497
2420
1534
1610
299
38
2.37
2.87


pavimento + recapa
2497
2420
1534
1610
299
38
-0.44


new-jersey
2497
2420
1534
1610
299
38
-1.42


viga + laje
2997
2920
1534
1610
299
38
2.57
3.07


pavimento + recapa
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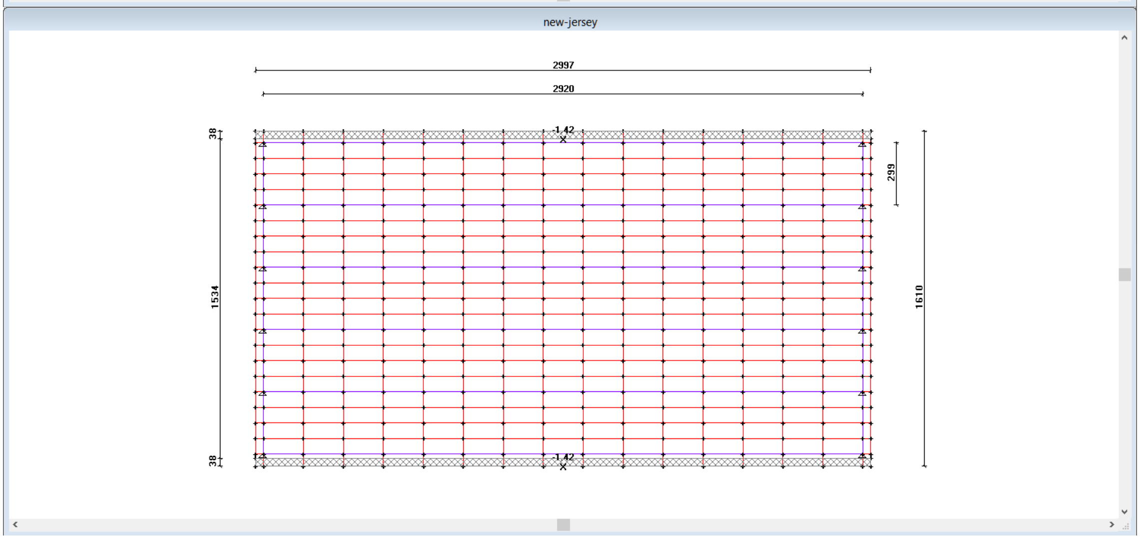
2920
1534
1610
299
38
-0.44


new-jersey
2997
2920
1534
1610
299
38
-1.42


viga + laje
3497
3420
38
1534
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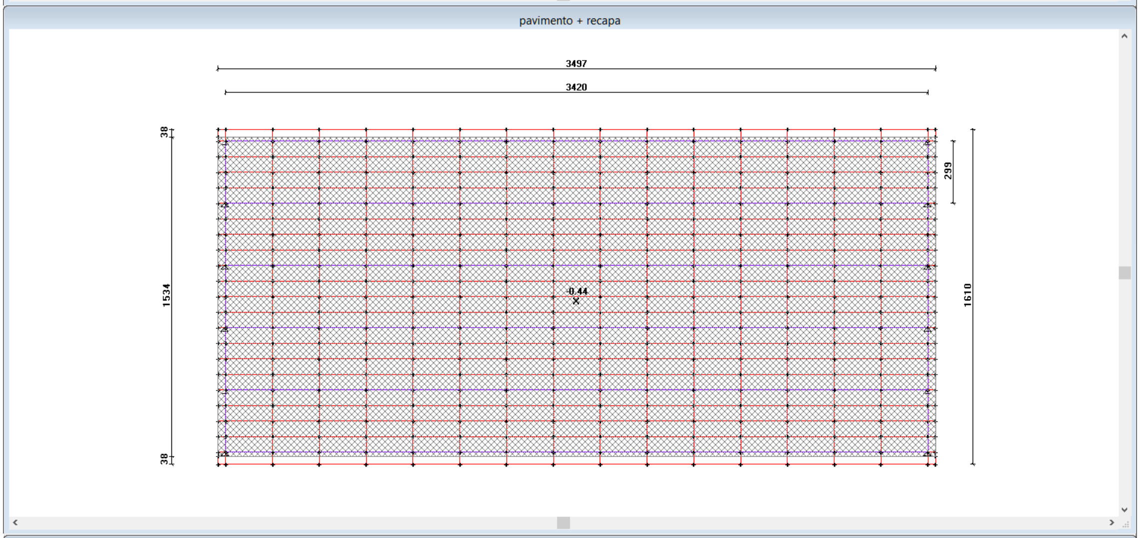
299
1610
2.64
3.14


pavimento + recapa
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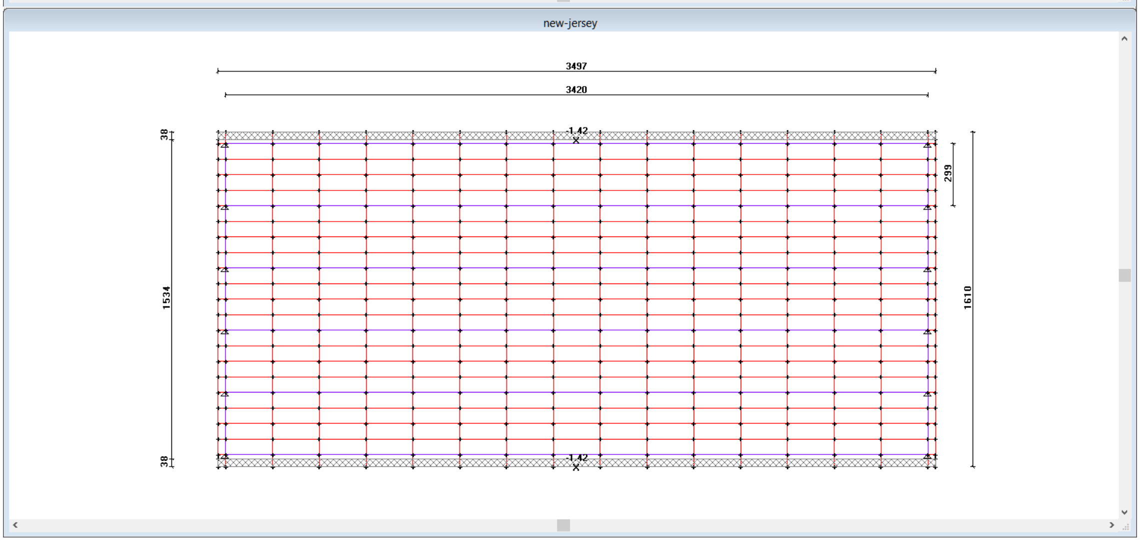
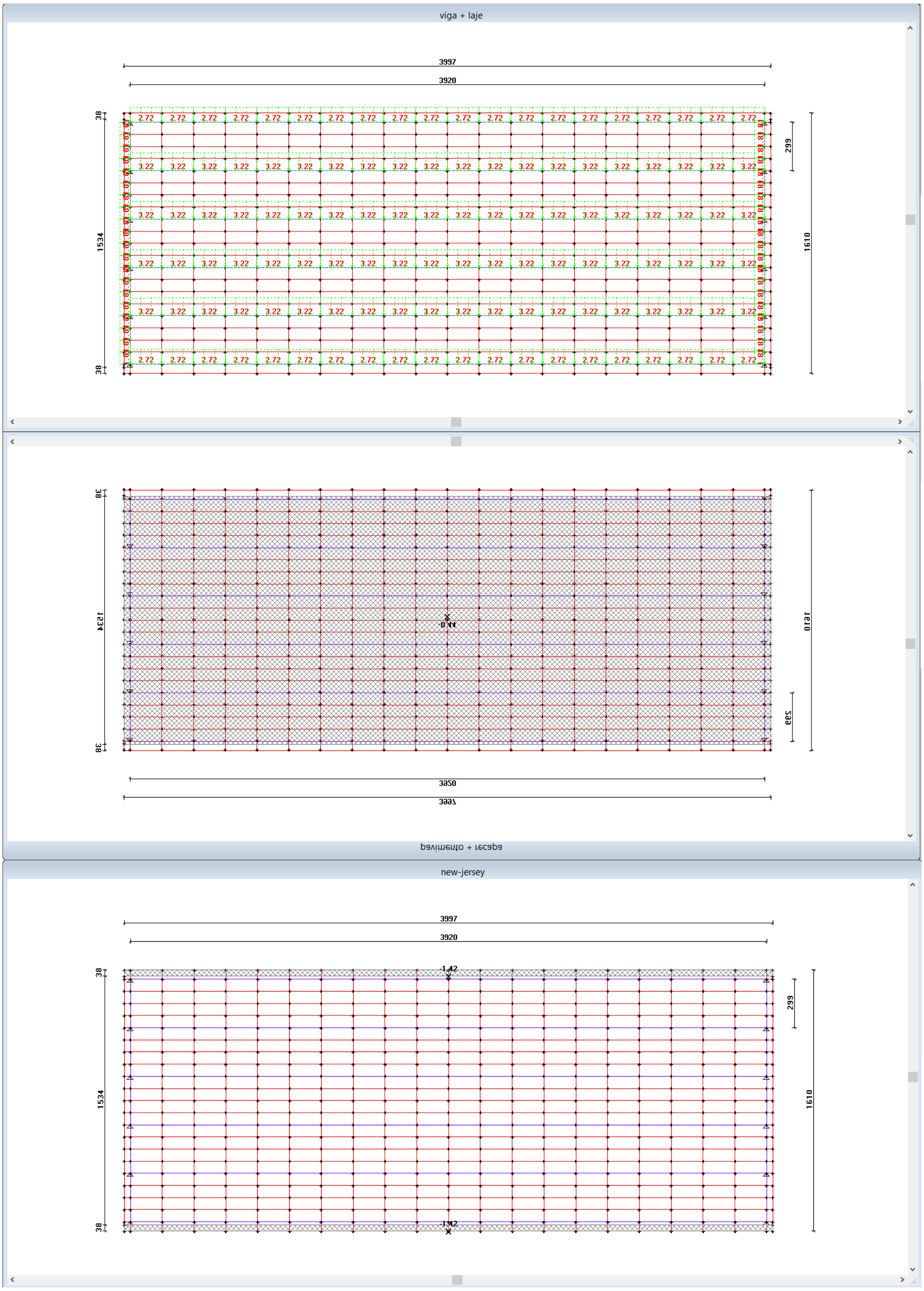
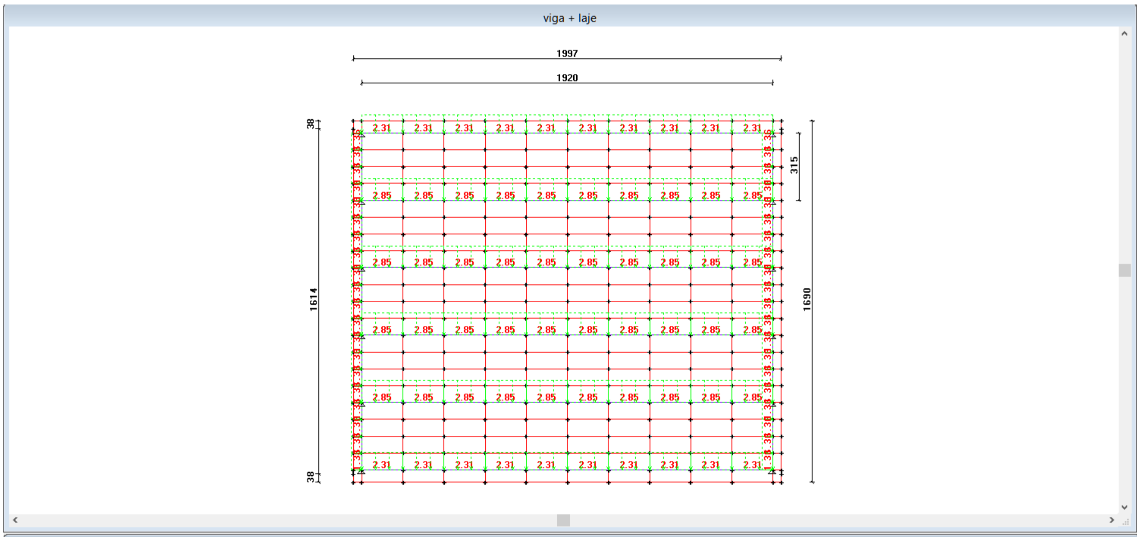
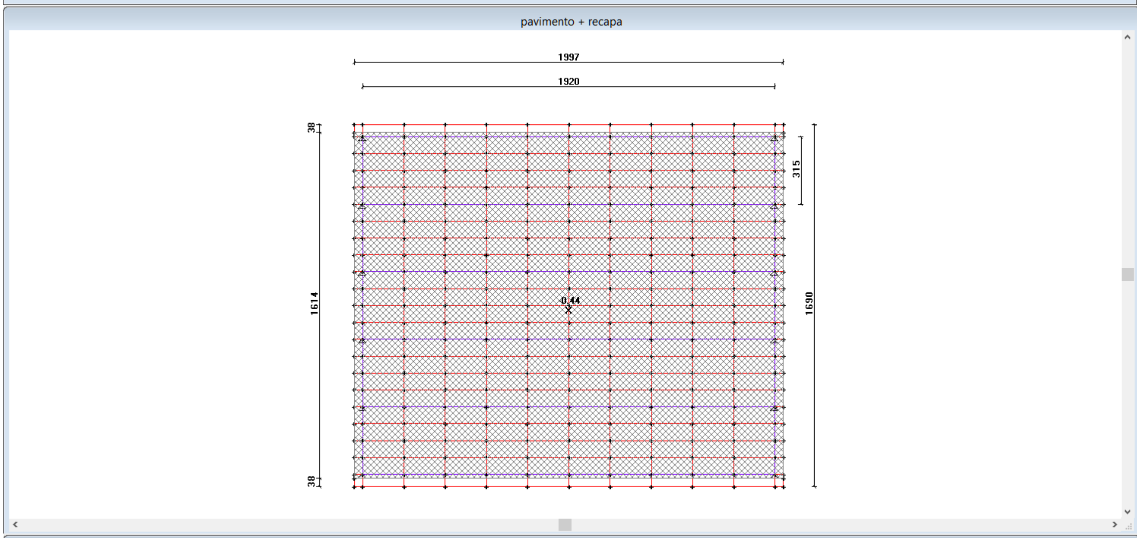
3420
38
1534
38
299
1610
-0.44

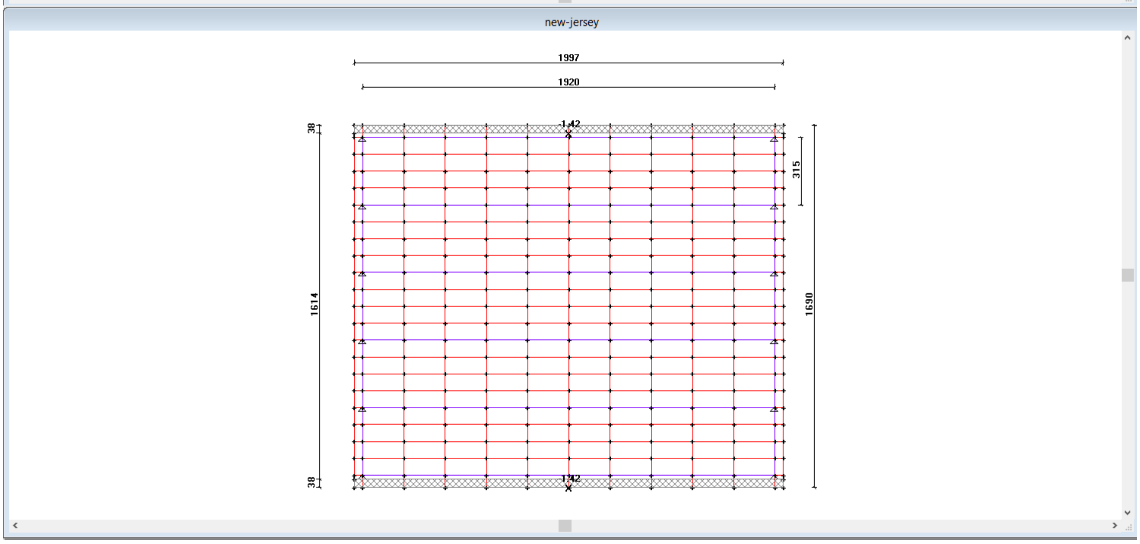

new-jersey
3497
3420
38
1534
38
299
1610
-1.42
-1.42

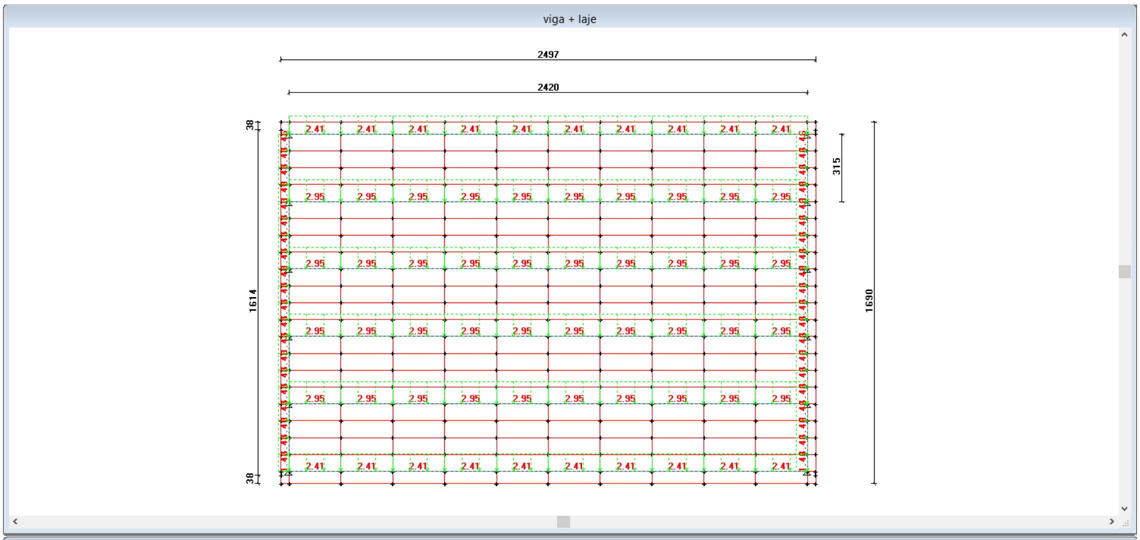

viga + laje
3997
3920
38
1534
38
299
1610
pavimento + recapa
new-jersey
3997
3920
38
1534
38
299
1610

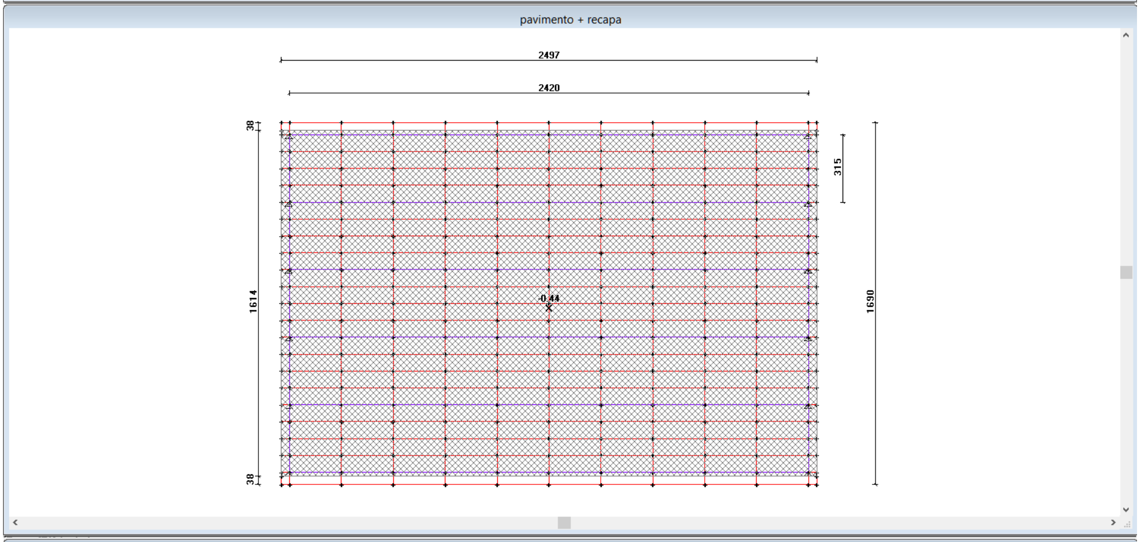
4.3.5. Tabuleiro 16,90 m

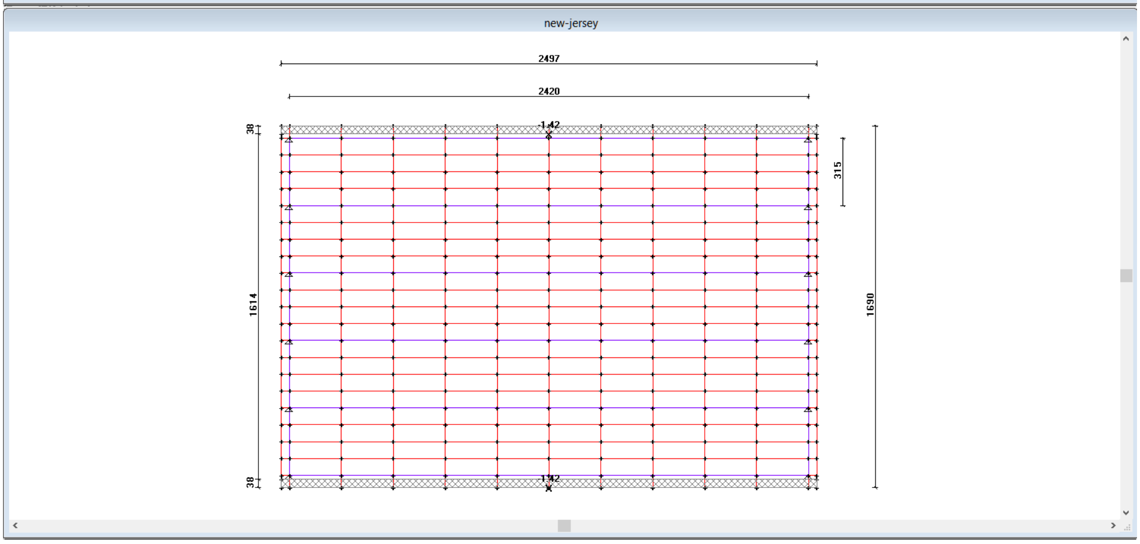




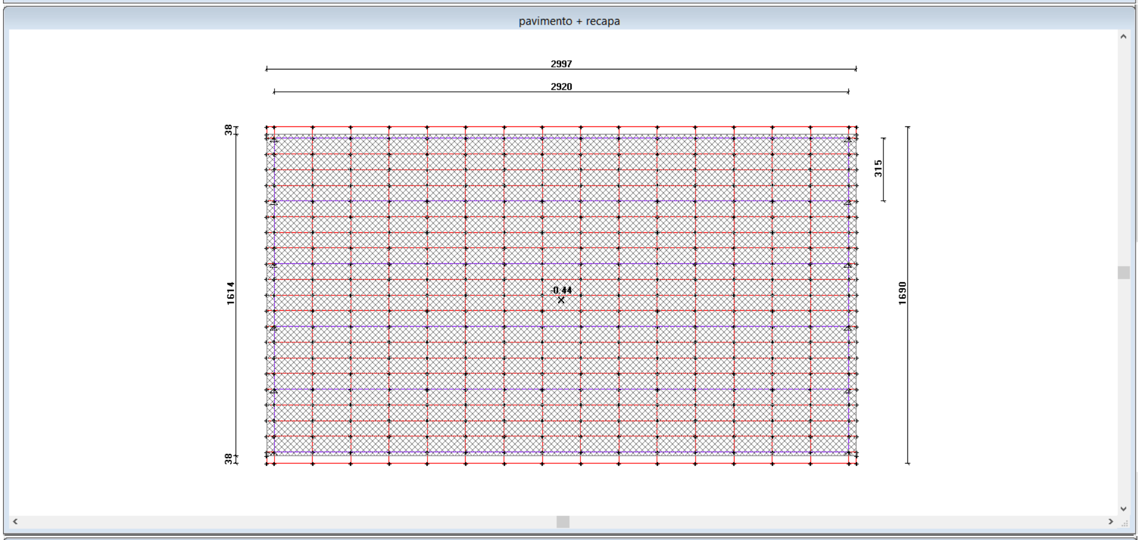


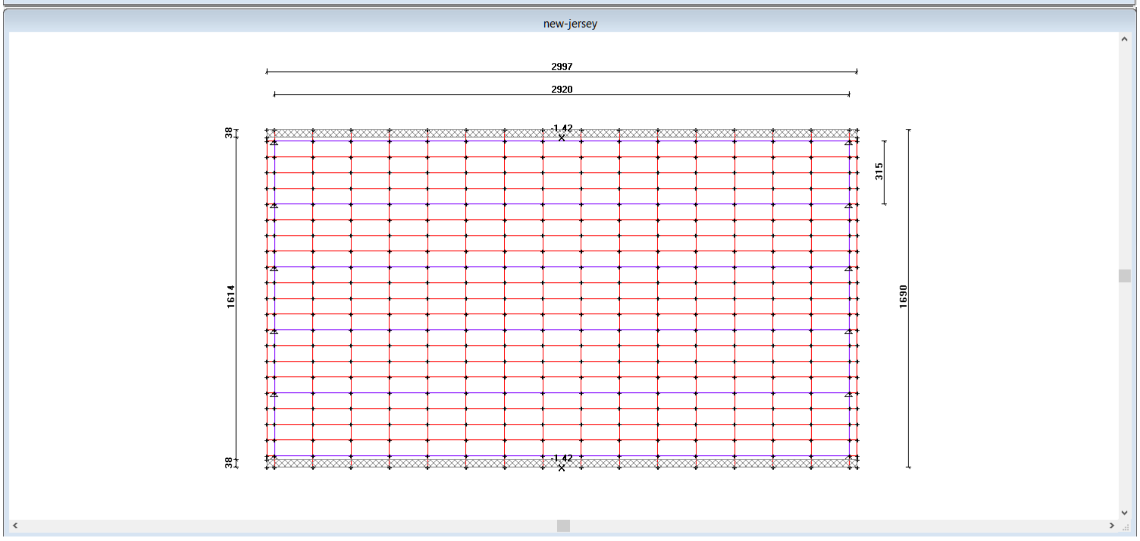

viga + laje
2497
2420
38
1614
38
315
1690
2.41
2.95
40


pavimento + recapa
2497
2420
38
1614
38
315
1690
-0.44

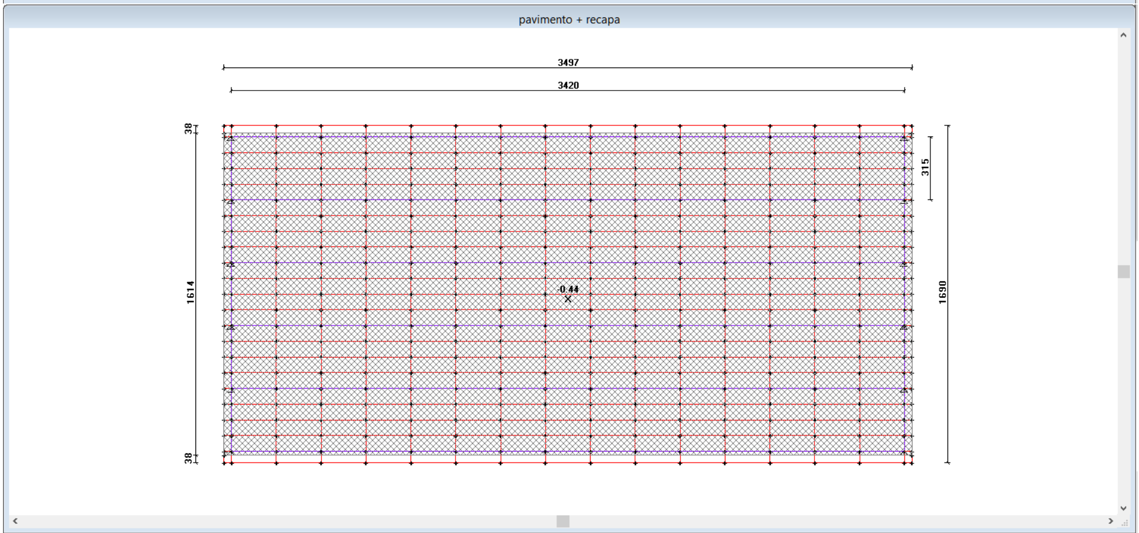

new-jersey
2497
2420
38
1614
38
315
1690
-1.42
-1.42


viga + laje
2997
2920
38
1614
38
315
1690
2.61
3.15


pavimento + recapa
2997
2920
38
1614
38
315
1690
-0.44


new-jersey
2997
2920
38
1614
38
315
1690
-1.42
-1.42


viga + laje
3497
3420
38
1614
38
315
1690
2.68
3.22


pavimento + recapa
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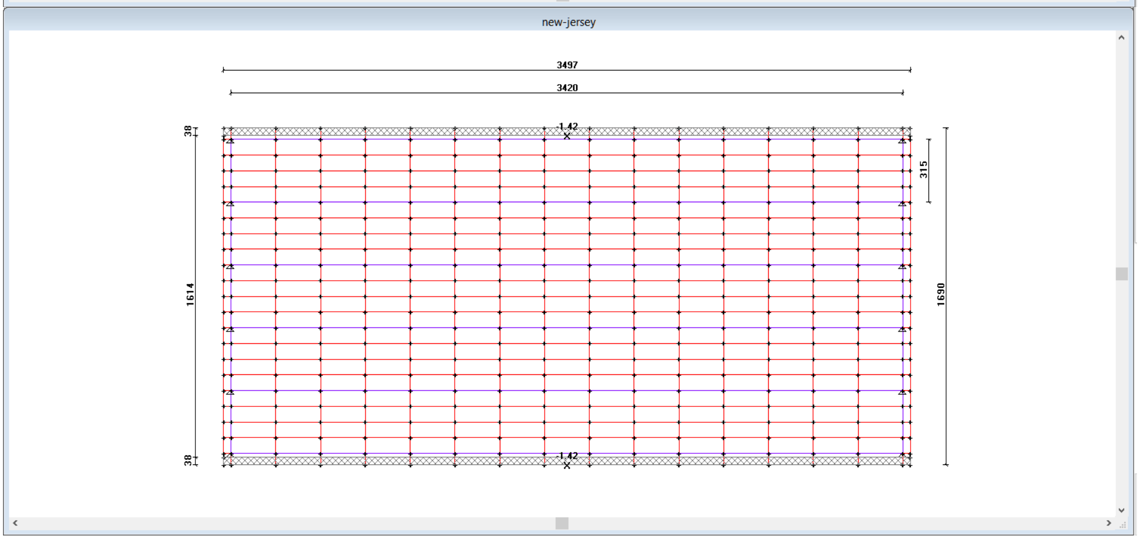
38
1614
38
315
1690
-0.44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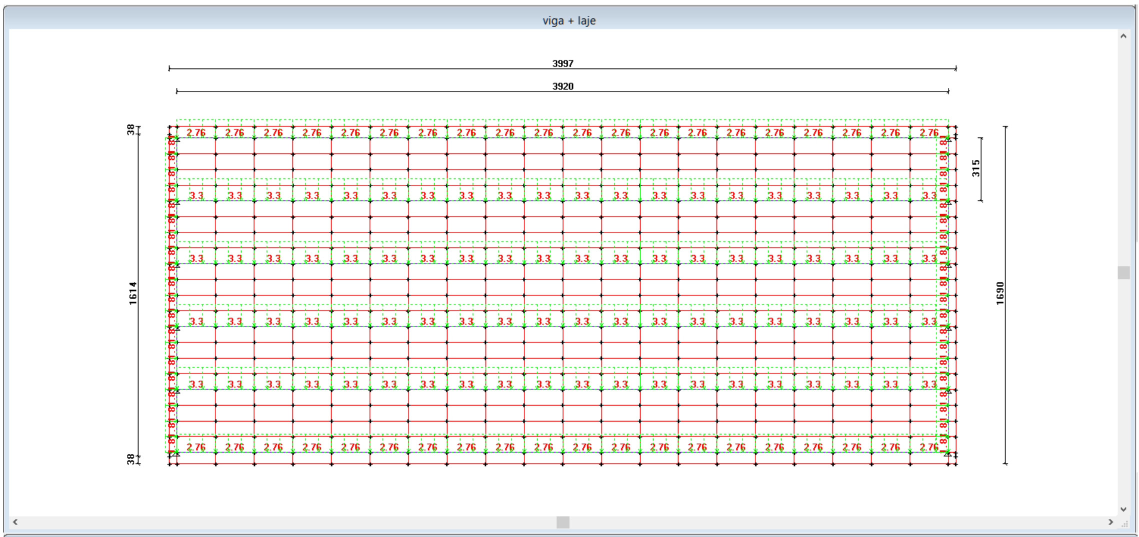
1614
38
315
1690
-1.42
-1.42


viga + laje
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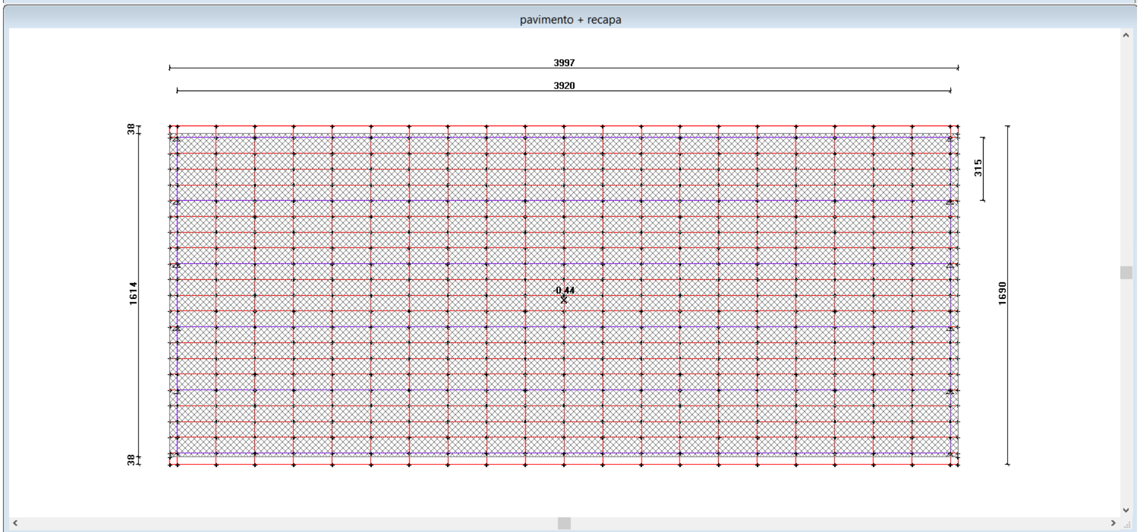
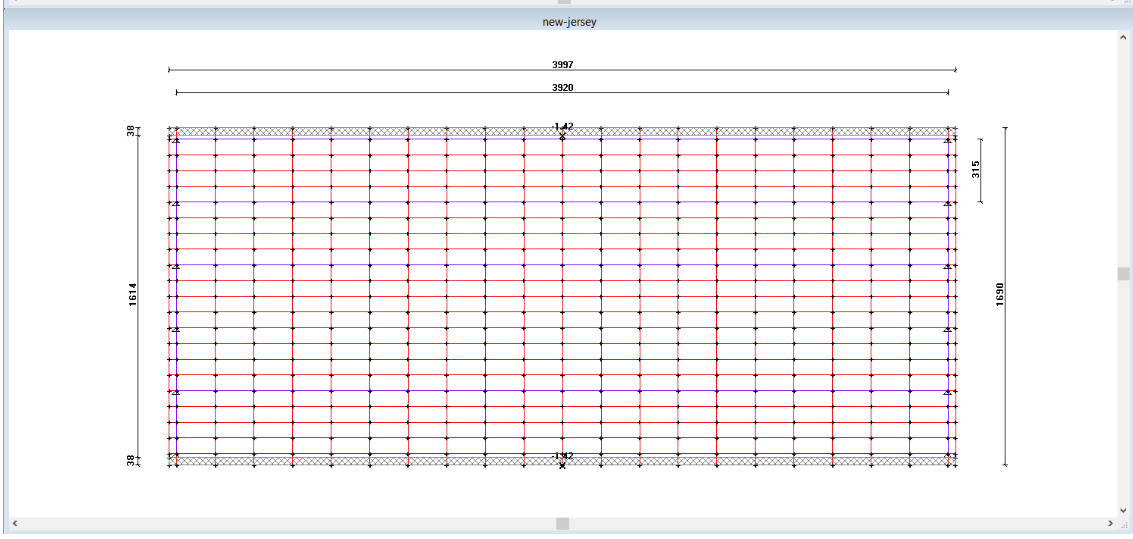
3920
38
1614
38
2.76
3.3
81
315
1690


pavimento + recapa
3997
3920
38
1614
38
-0.44
315
1690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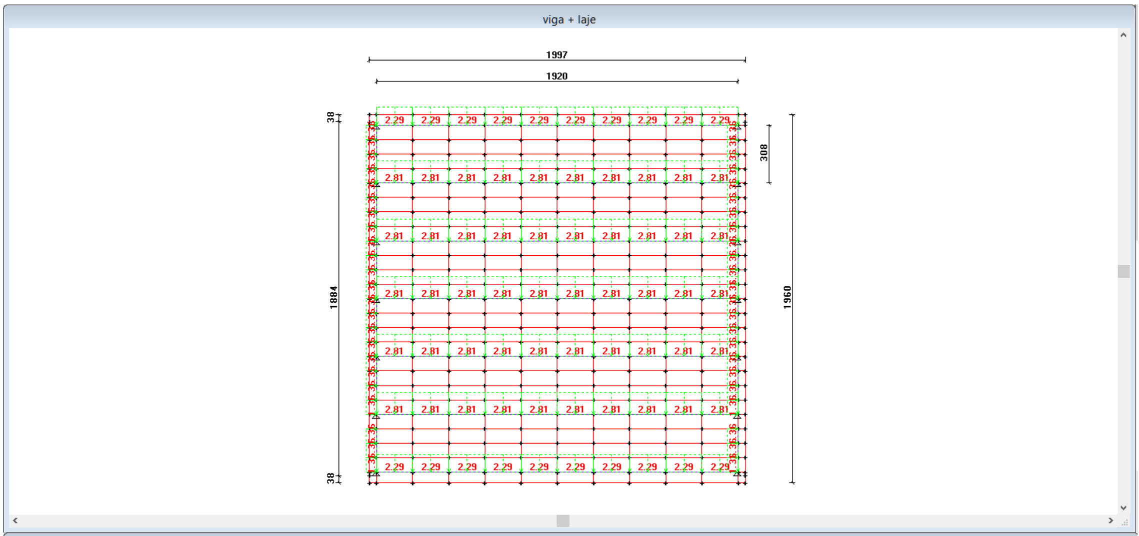
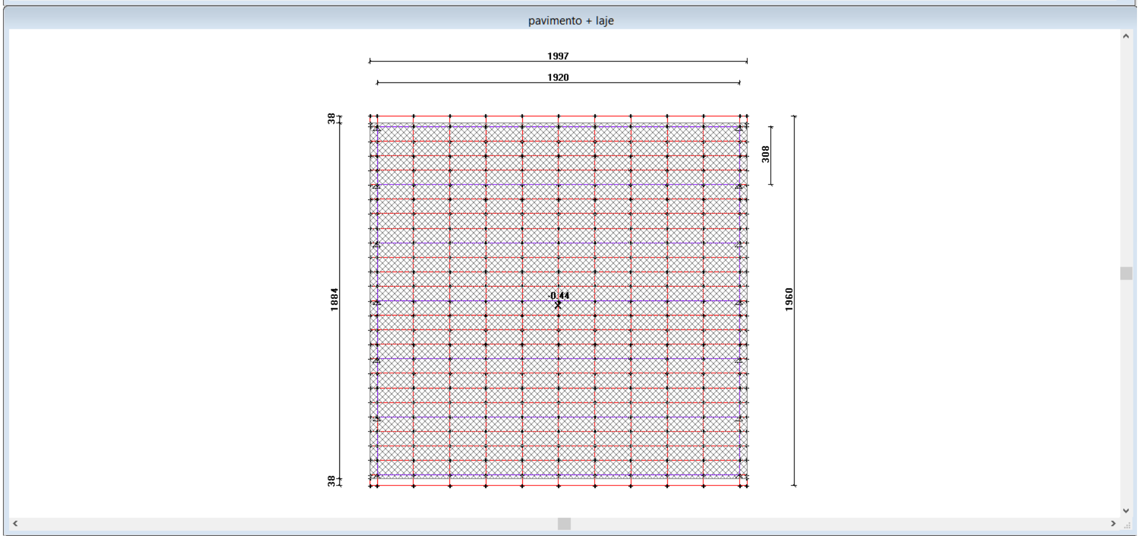
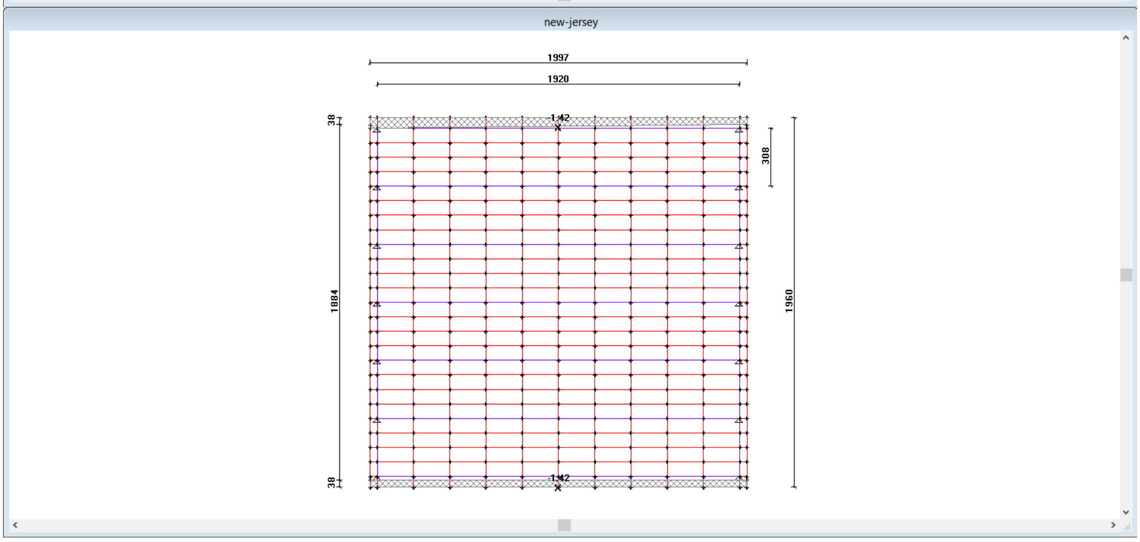
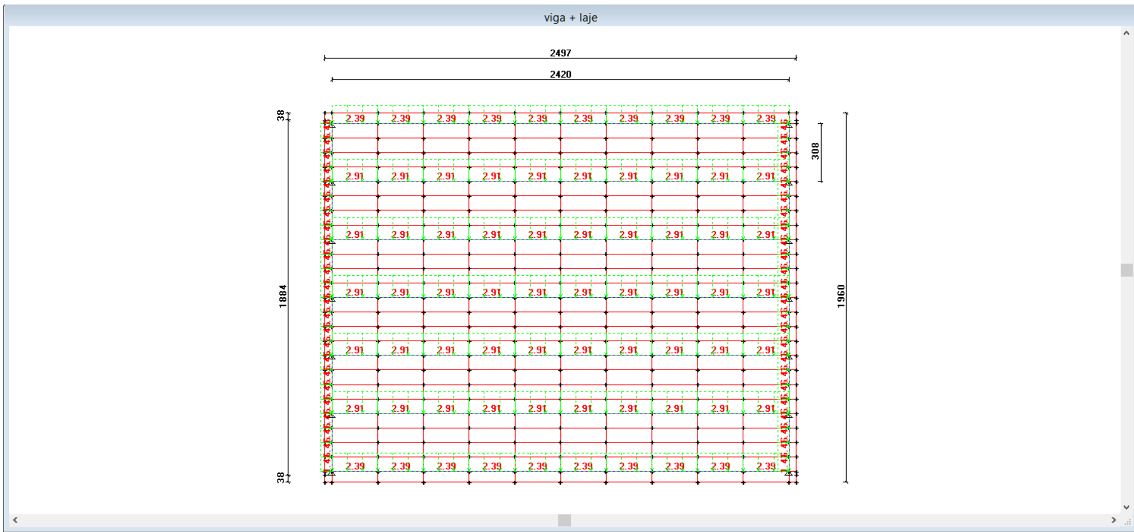
3920
38
1614
38
-1.42
-1.42
315
1690

4.3.6. Tabuleiro 19,60 m





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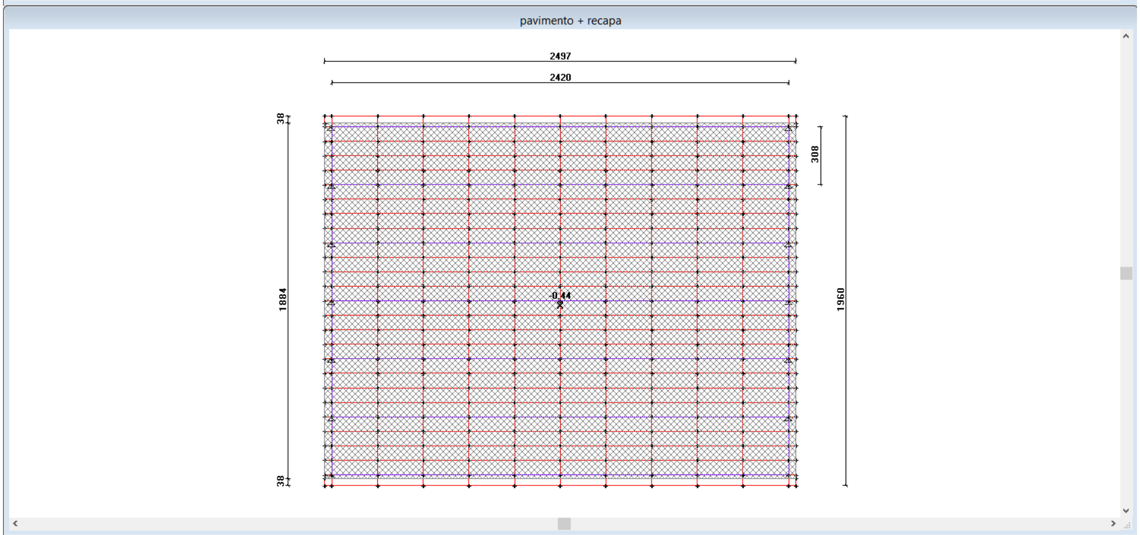
2497
2420
38
1884
38
308
1960
2.39
2.91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2420
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1884
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308
1960
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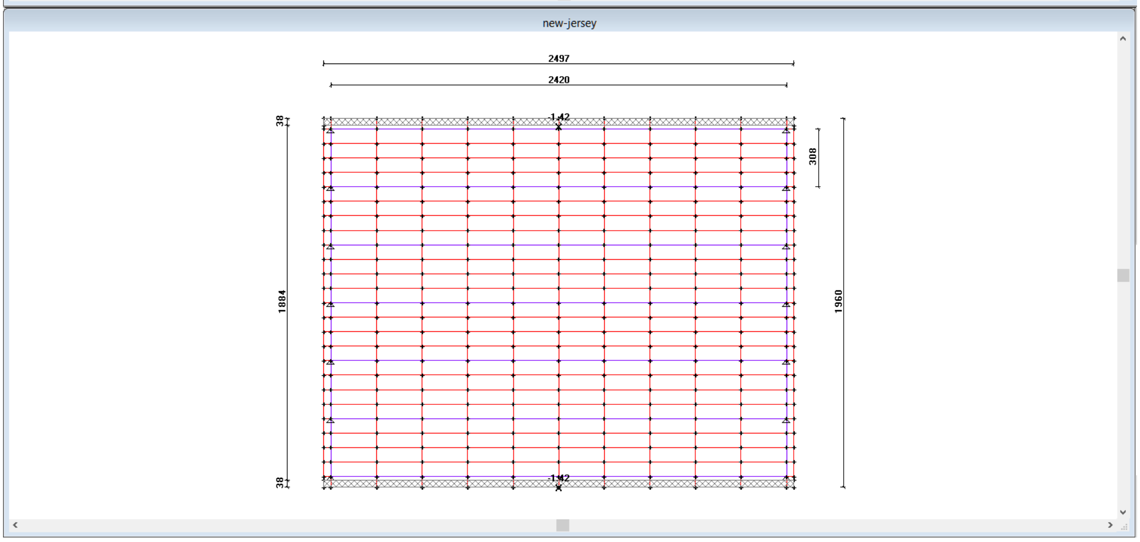
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2497
2420
38
1884
38
308
1960
-1.42
-1.42


viga + laje
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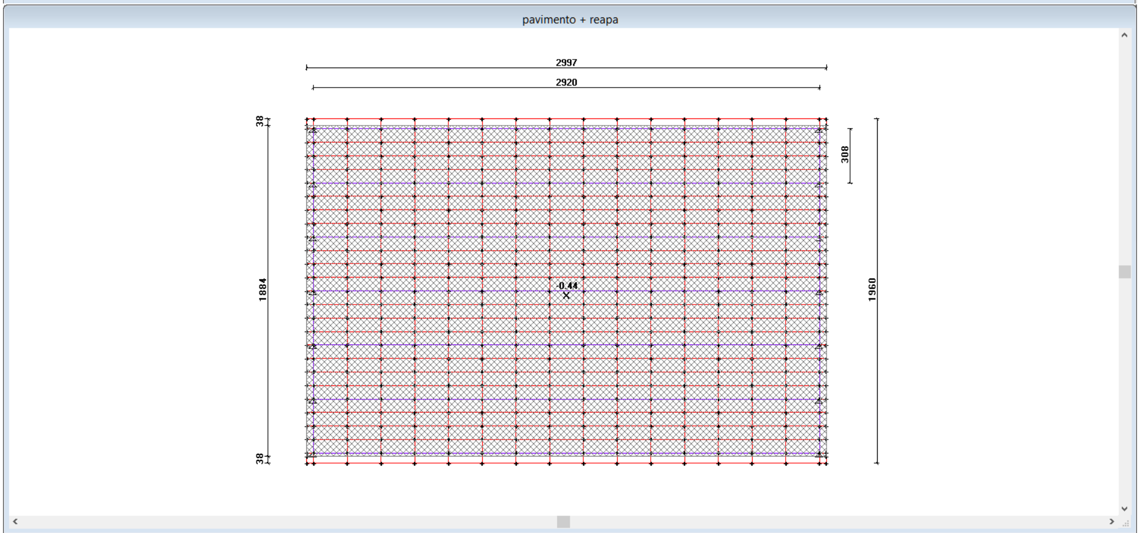
38
1884
38
308
1960
2.59
3.11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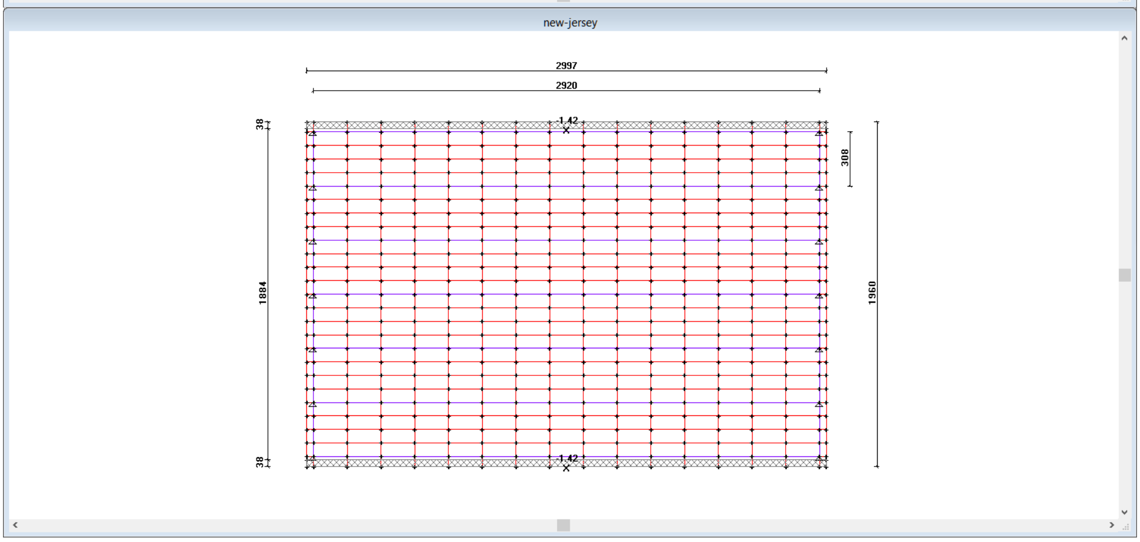
2920
38
1884
38
308
1960
-0.44


new-jersey
2997
2920
38
1884
38
308
1960
-1.42
-1.42


viga + laje
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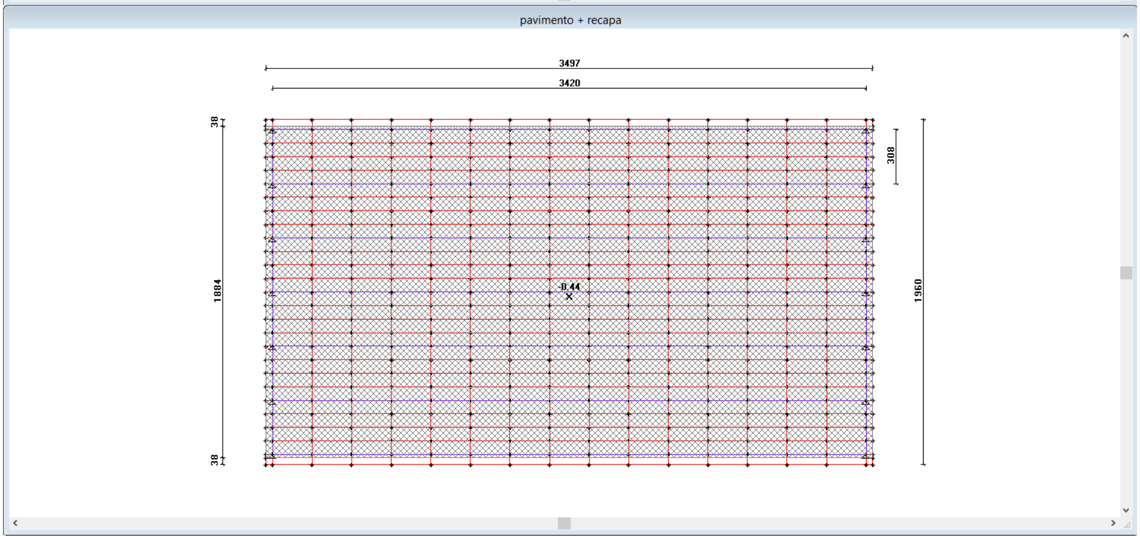
38
1884
38
308
1960
2.66
3.18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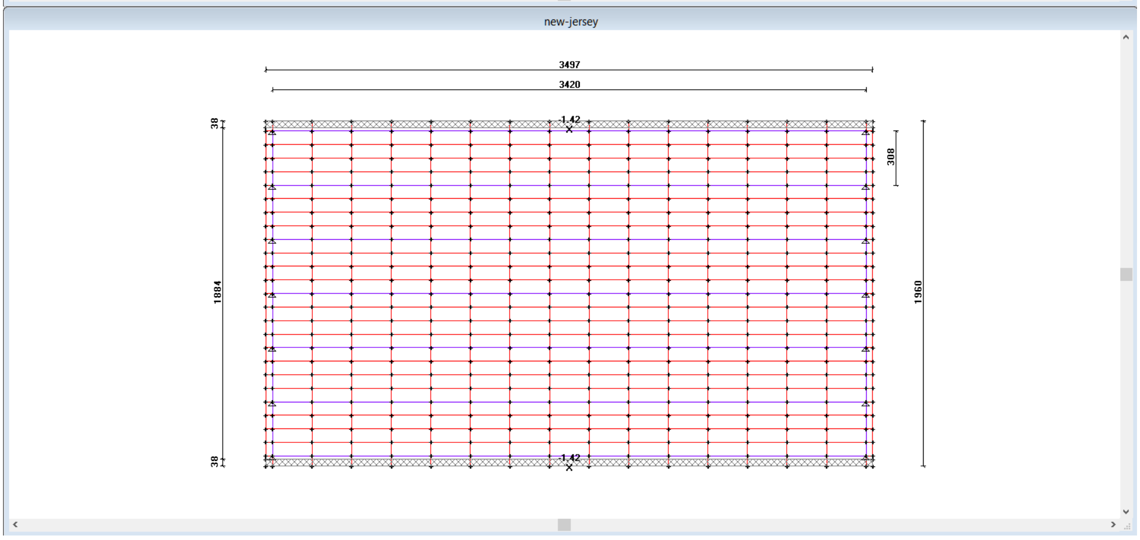
38
1884
38
308
1960
-0.44


new-jersey
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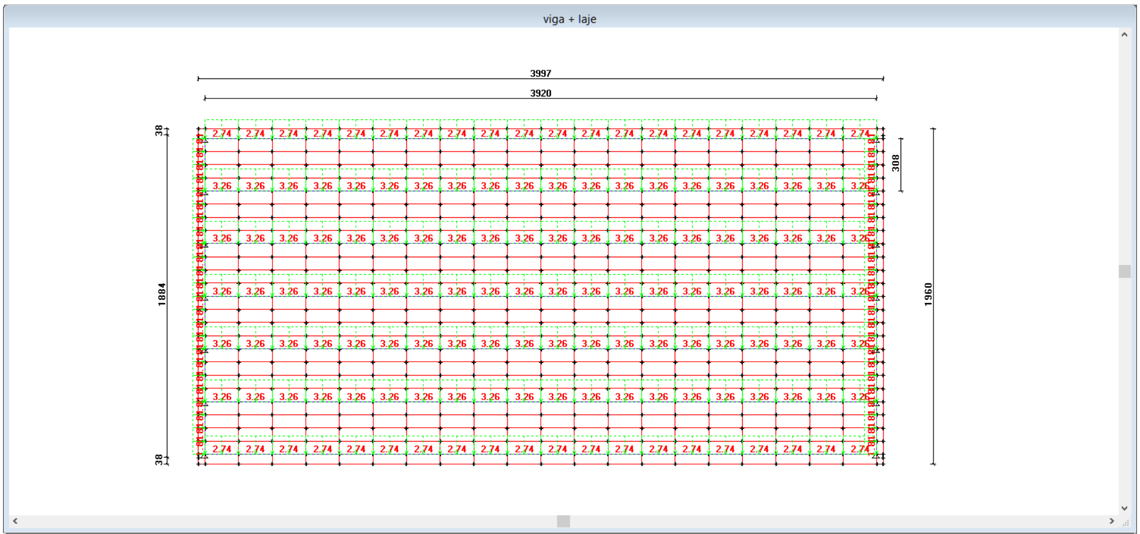
3420
38
1884
38
308
1960
-1.42
-1.42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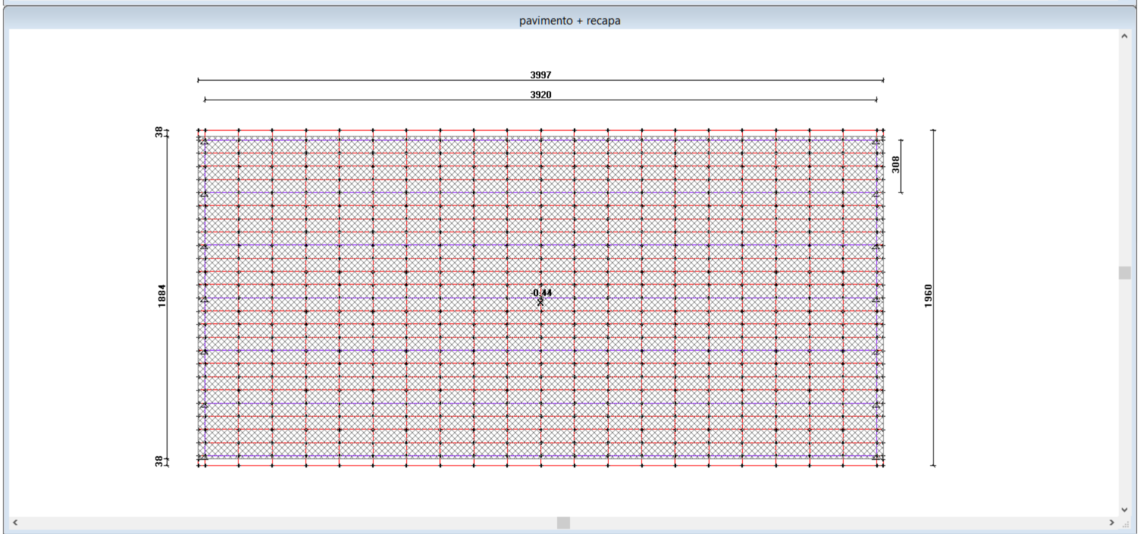
38
1884
38
308
1960
2.74
3.26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3997
3920
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1884
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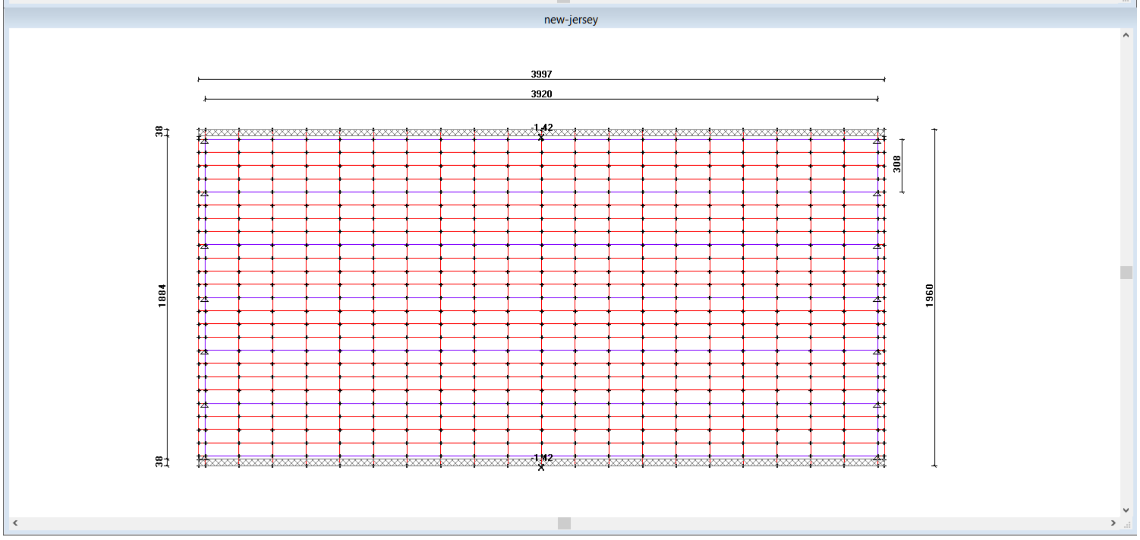
308
1960
-0.44


new-jersey
3997
3920
38
1884
38
308
1960
-1.42
-1.42

4.4. Cargas acidentais – TB-36

Para multidão, inserimos os valores no STRAP multiplicados pelo CIV – Coeficiente de Impacto Vertical:

$$\mathbf{20\ m \rightarrow \varphi = 1,40 - (0,007 \times 20) = 1,26}$$
$$\mathbf{25\ m \rightarrow \varphi = 1,40 - (0,007 \times 25) = 1,23}$$
$$\mathbf{30\ m \rightarrow \varphi = 1,40 - (0,007 \times 30) = 1,19}$$
$$\mathbf{35\ m \rightarrow \varphi = 1,40 - (0,007 \times 35) = 1,16}$$
$$\mathbf{40\ m \rightarrow \varphi = 1,40 - (0,007 \times 40) = 1,12}$$

Adotando a multidão de norma de 0,30 e 0,50 tf/m, a multiplicação resulta em:

$$\mathbf{20\ m \rightarrow 1,26 \times 0,30 = 0,38\ tf/m}$$
$$\mathbf{1,26 \times 0,50 = 0,63\ tf/m}$$

$$\mathbf{25\ m \rightarrow 1,23 \times 0,30 = 0,37\ tf/m}$$
$$\mathbf{1,23 \times 0,50 = 0,62\ tf/m}$$

$$\mathbf{30\ m \rightarrow 1,19 \times 0,30 = 0,36\ tf/m}$$
$$\mathbf{1,19 \times 0,50 = 0,60\ tf/m}$$

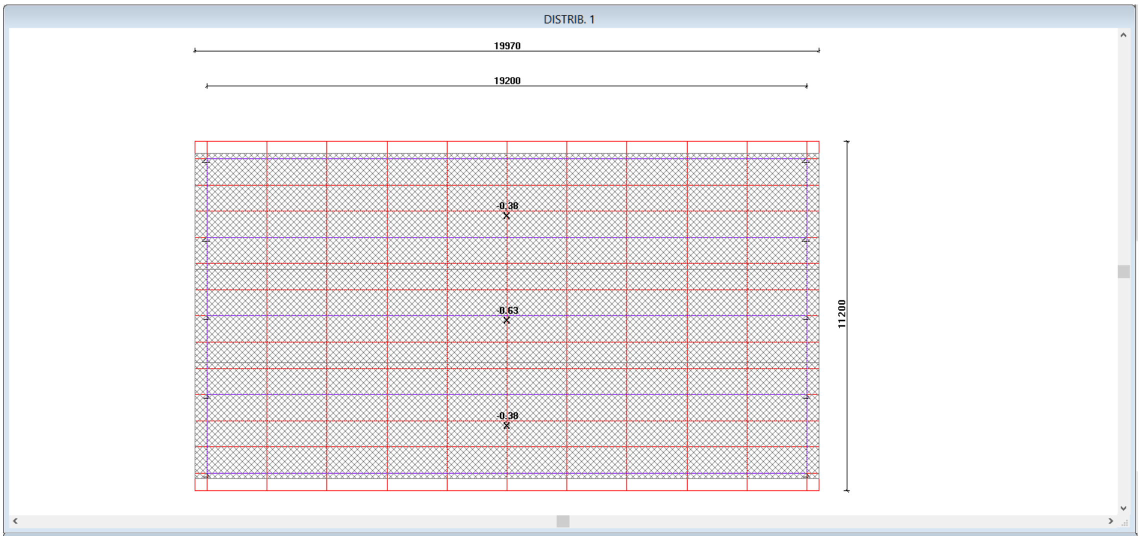
$$\mathbf{35\ m \rightarrow 1,16 \times 0,30 = 0,35\ tf/m}$$
$$\mathbf{1,16 \times 0,50 = 0,58\ tf/m}$$

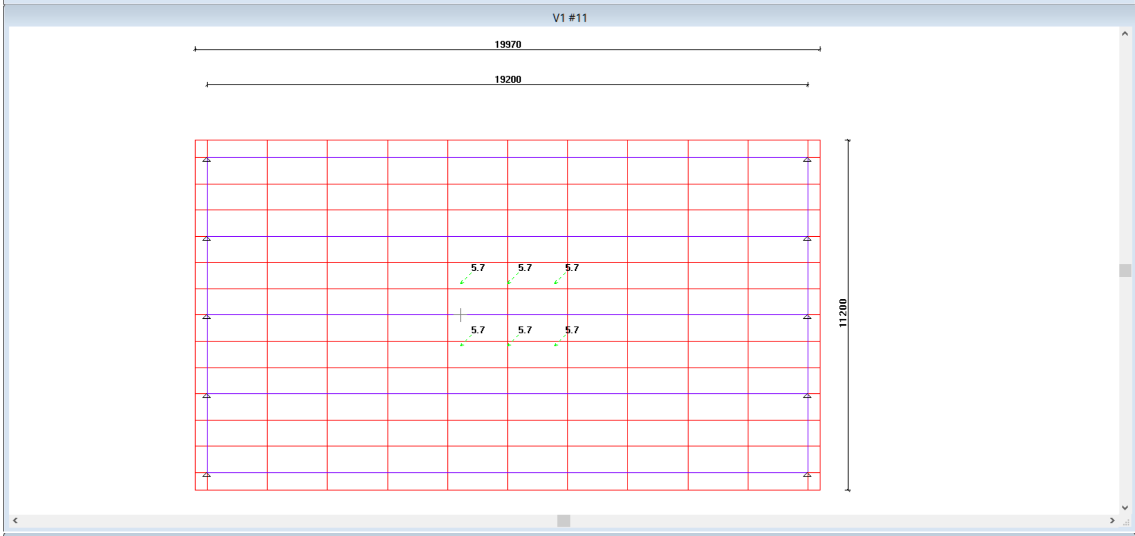
$$\mathbf{40\ m \rightarrow 1,12 \times 0,30 = 0,34\ tf/m}$$
$$\mathbf{1,12 \times 0,50 = 0,56\ tf/m}$$

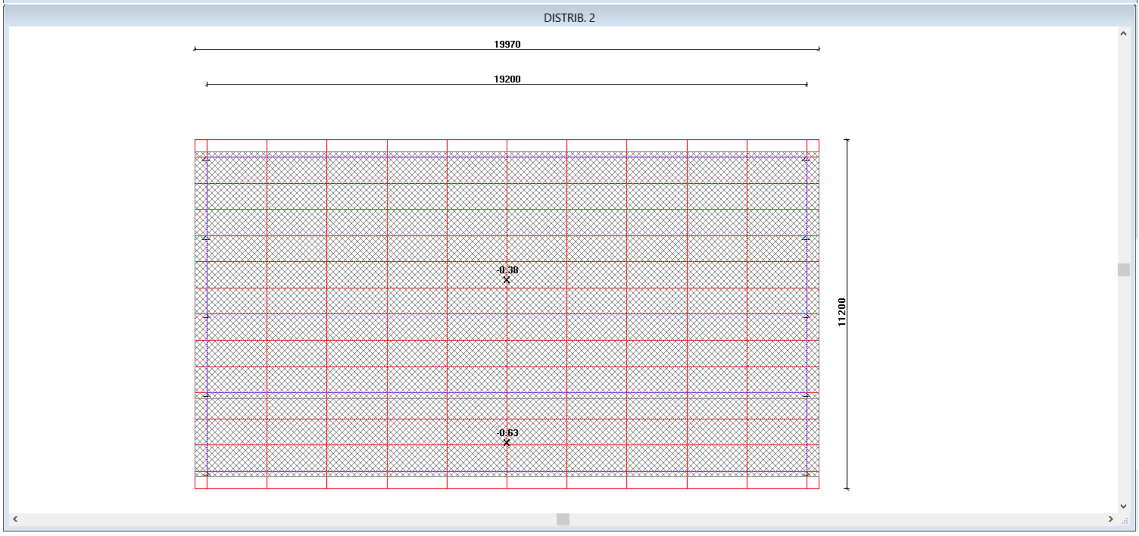
O veículo TB-36 foi homogeneizado com um coeficiente de 0,945, o que resultou em:

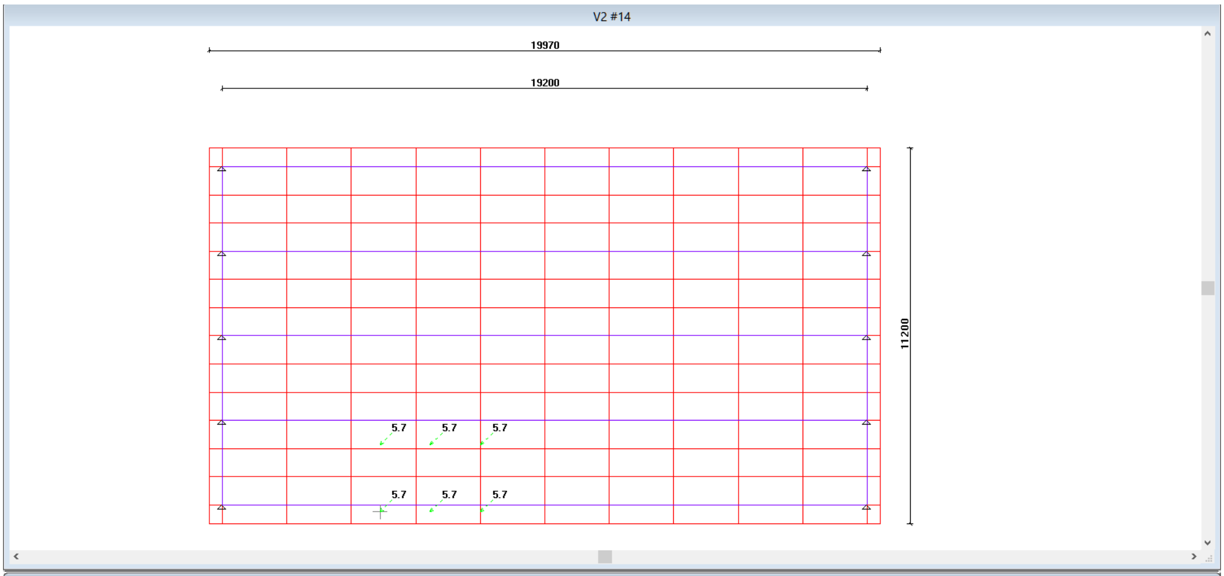
$$\mathbf{6 \times 0,945 = 5,67\ tf\ por\ roda\ do\ veículo}$$

4.4.1. Tabuleiro 11,20 m








V2 #14
19970
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11200
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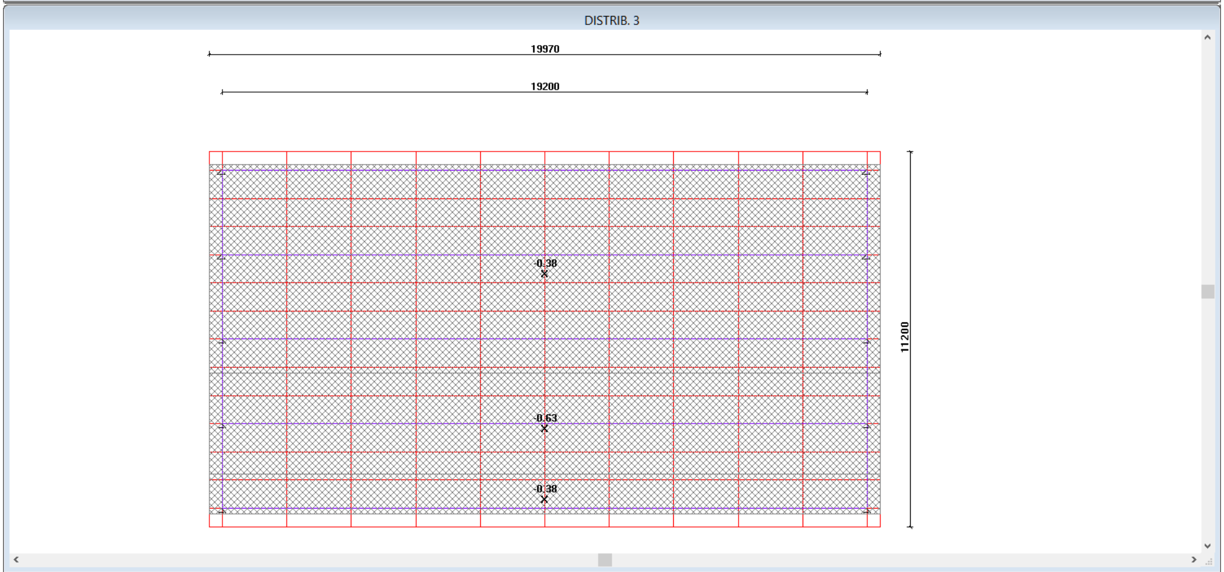
5.7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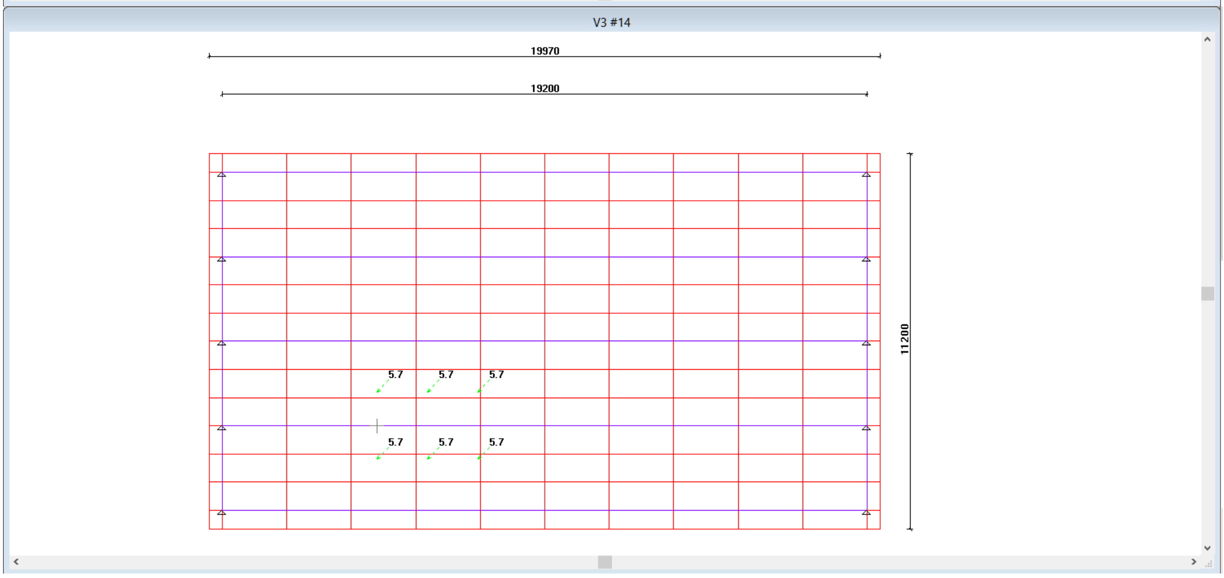
V3 #14
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11200
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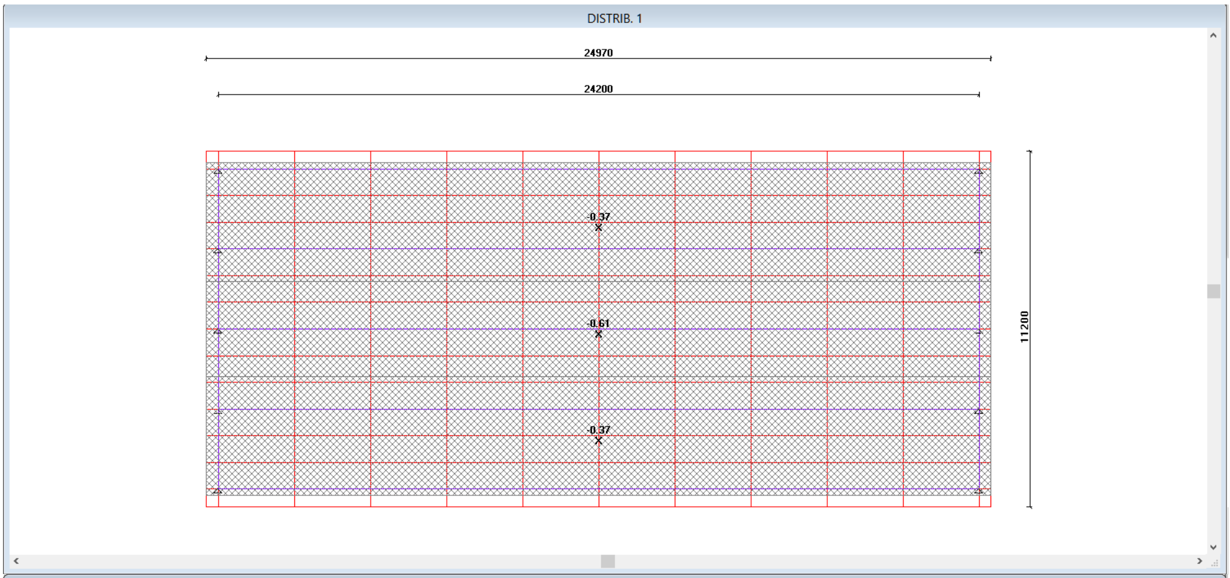
5.7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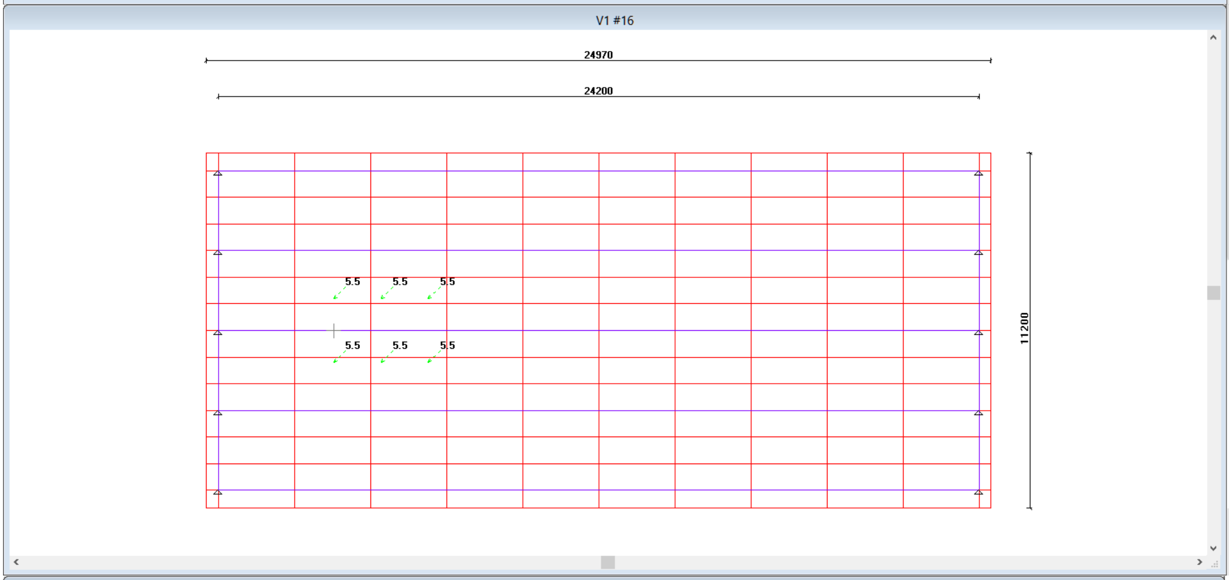
-0.37
11200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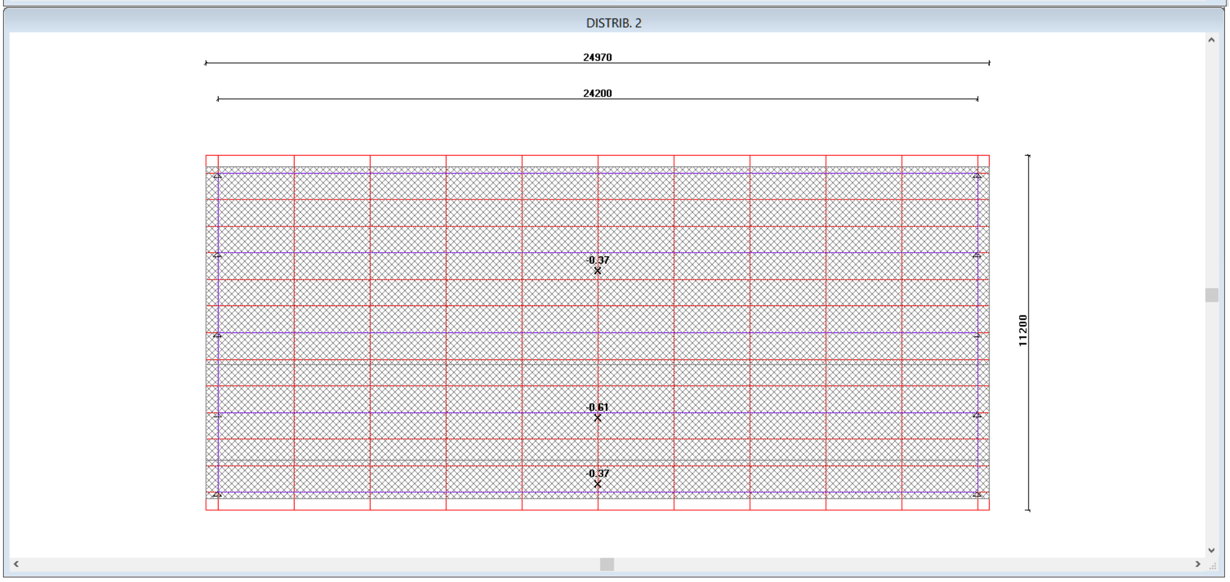
11200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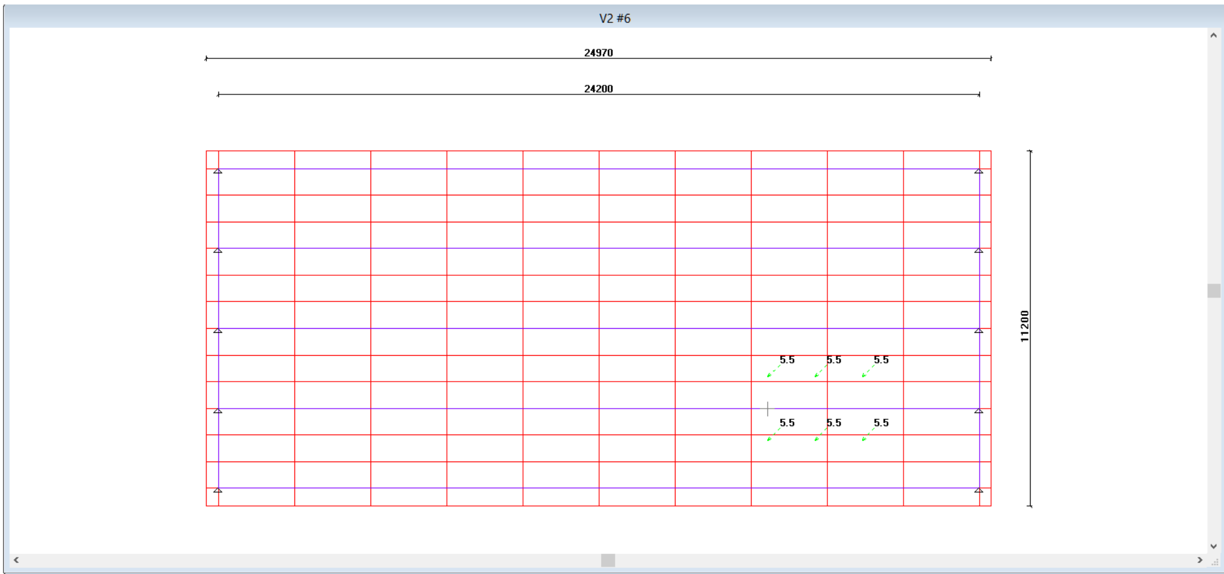
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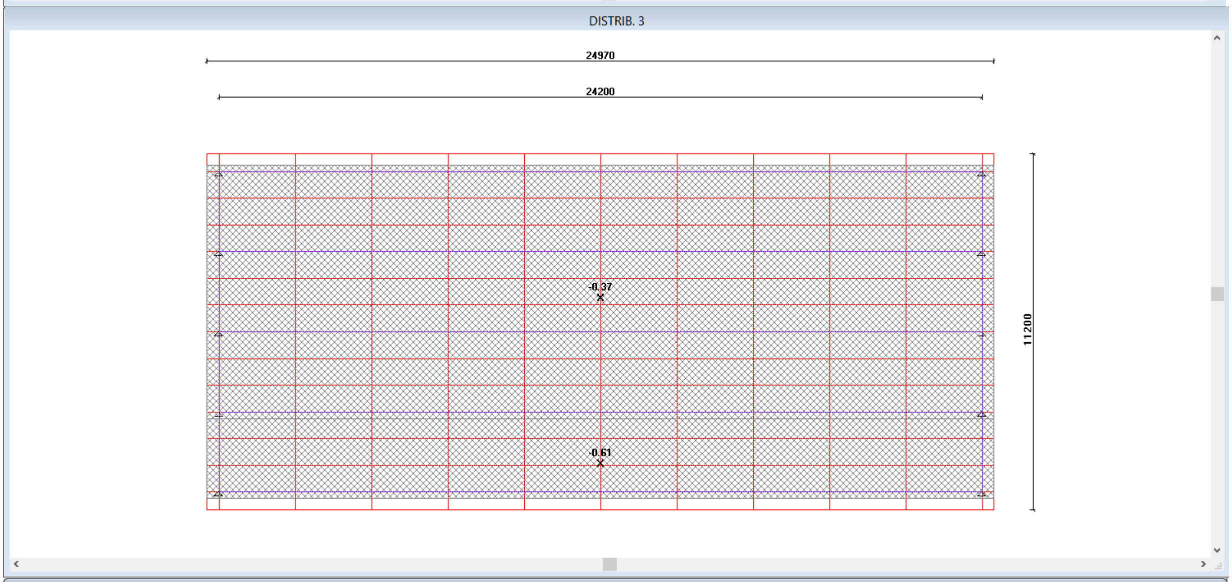
5.5
5.5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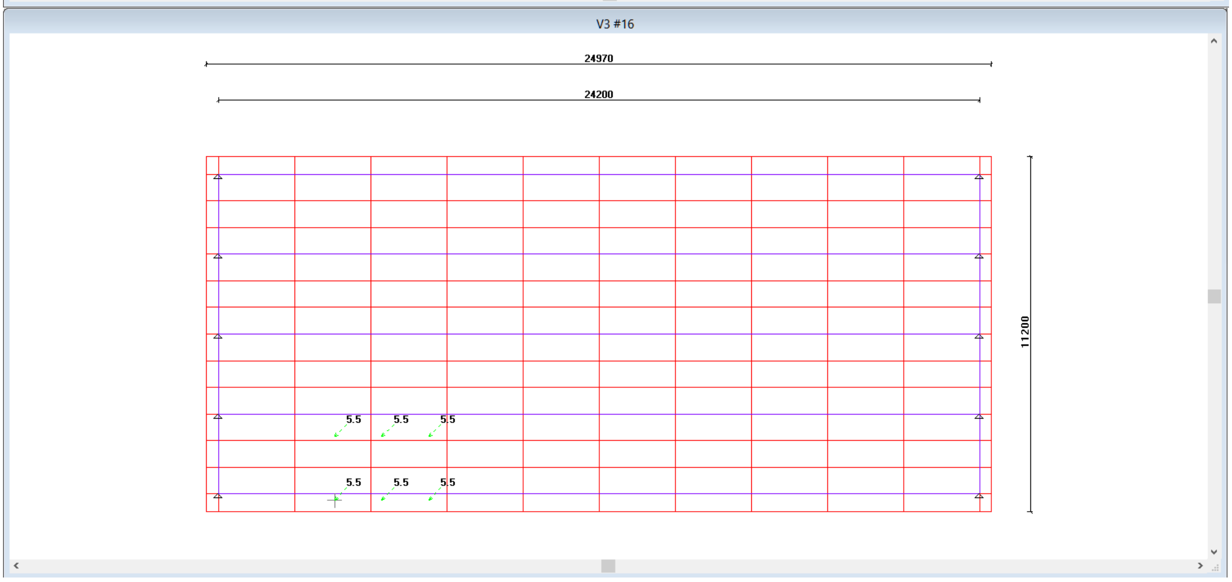
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24200
11200
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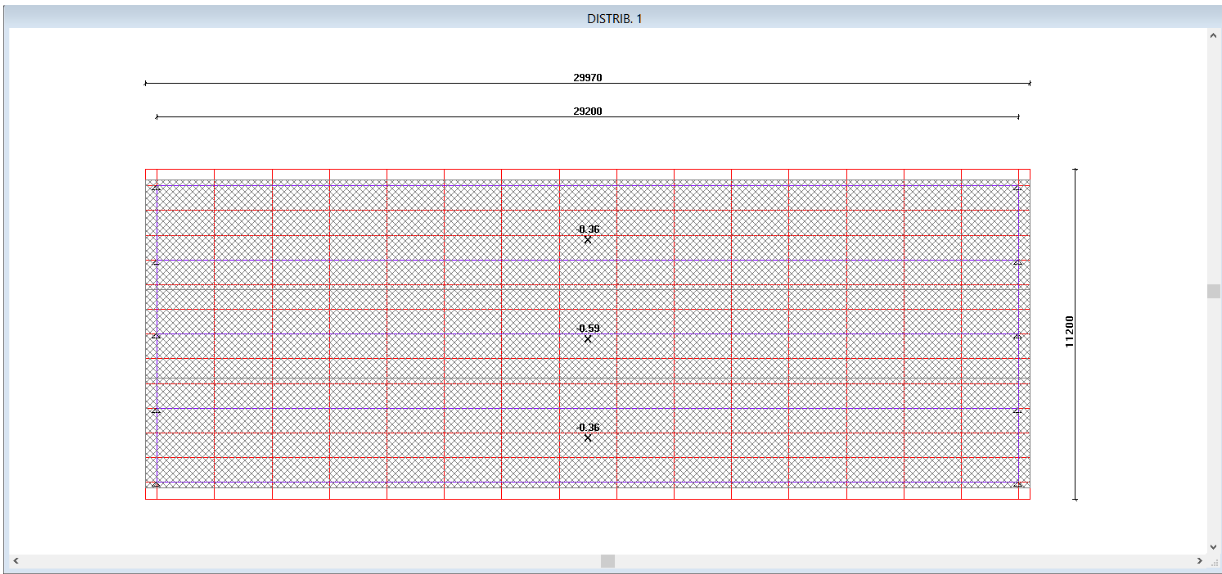
5.5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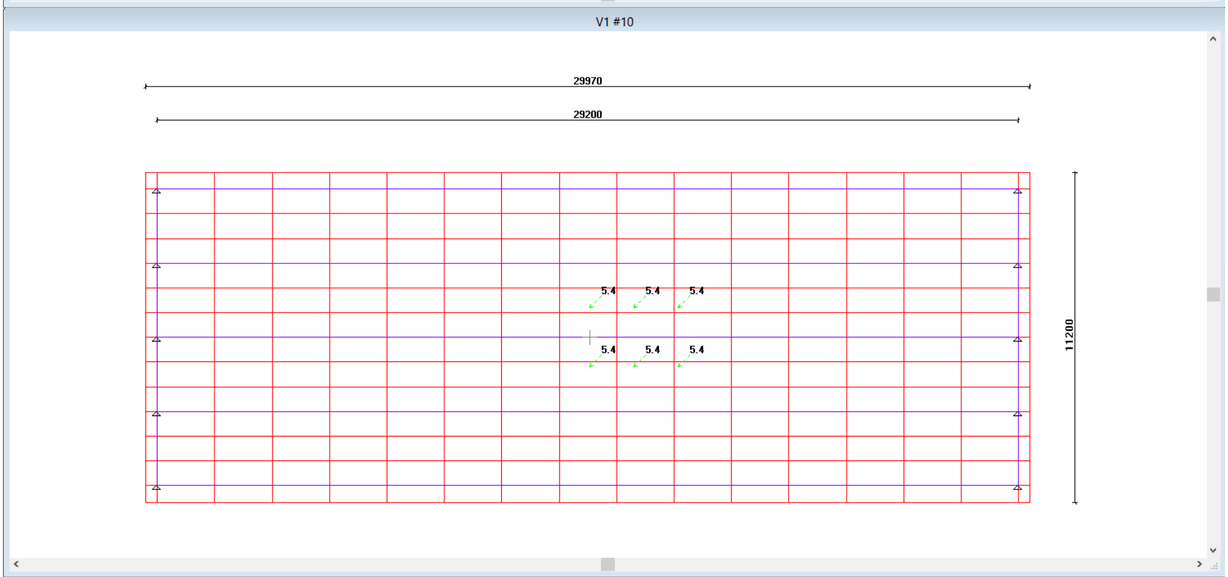
-0.36
11200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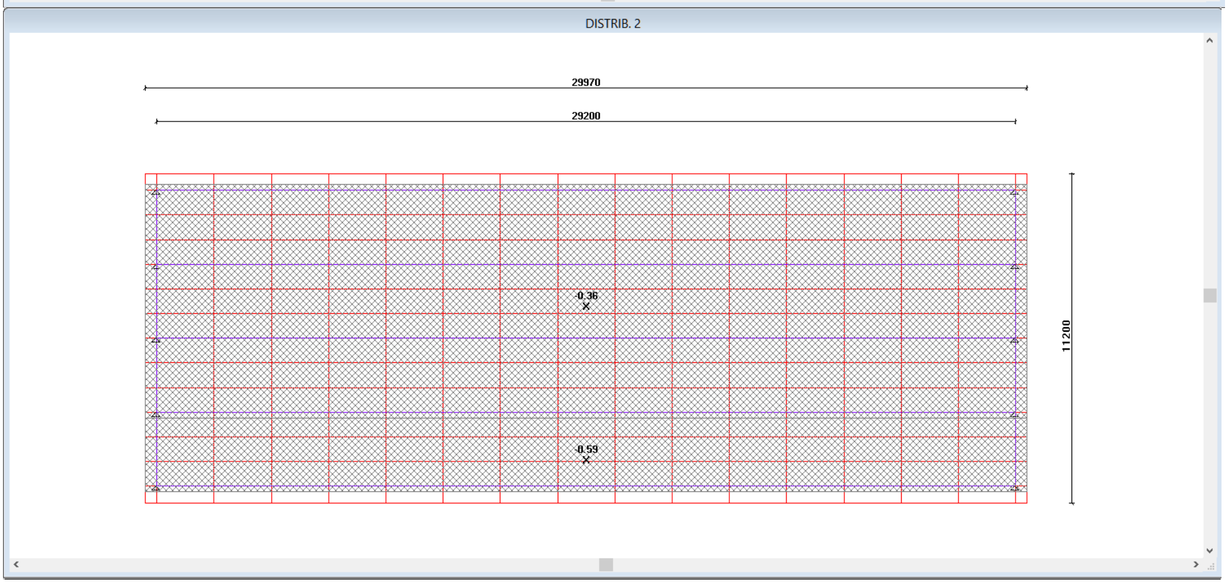
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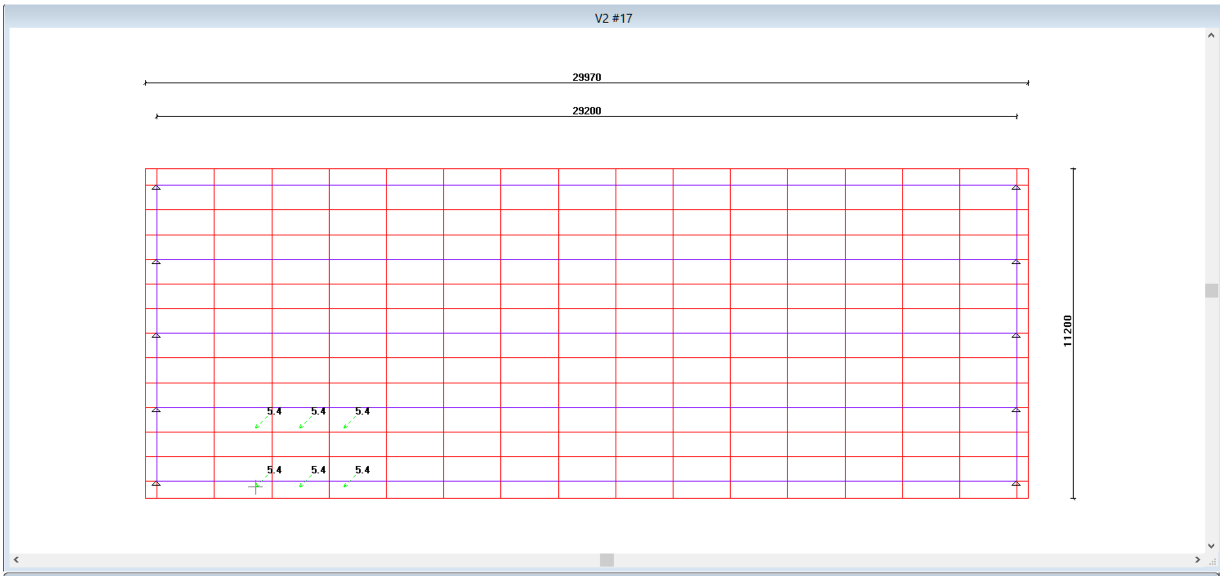
V2 #17
29970
29200
11200
5.4
5.4
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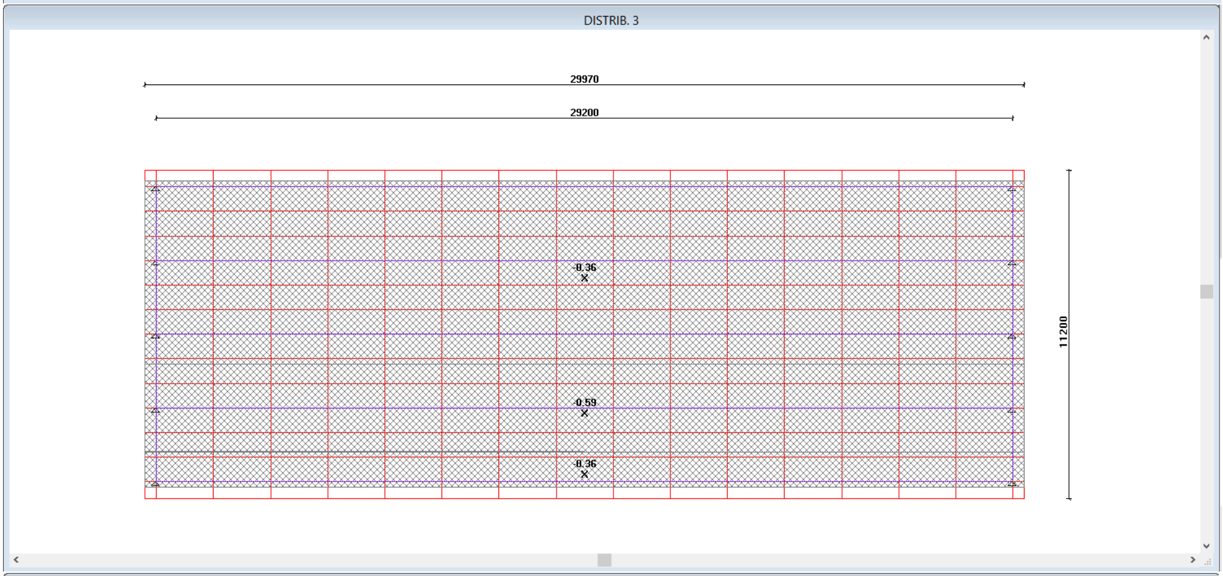
5.4
5.4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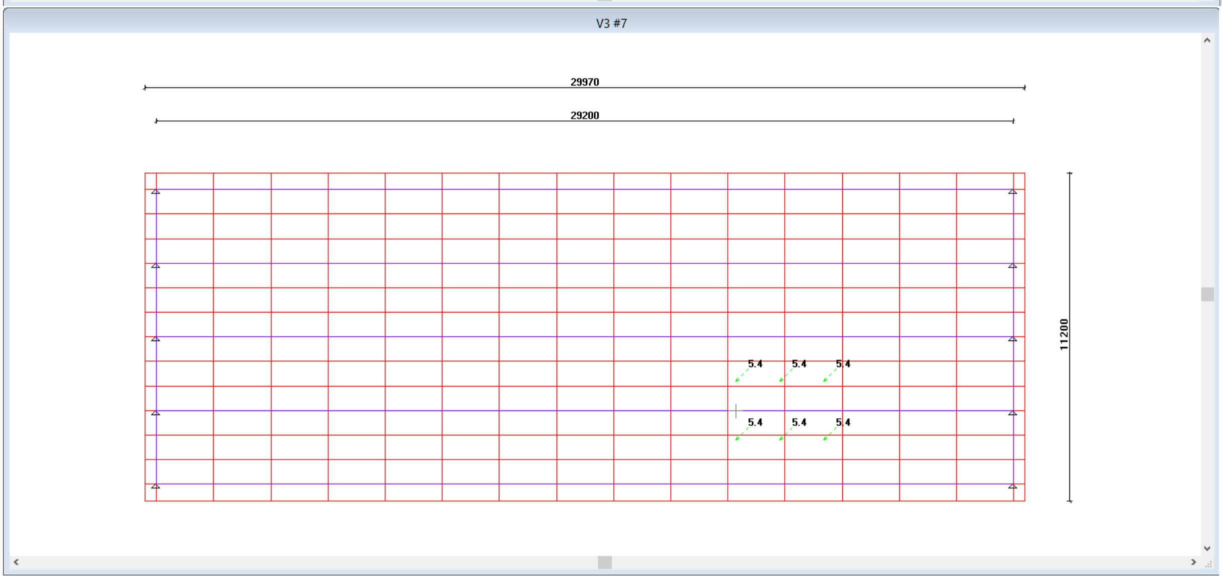
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29970
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11200
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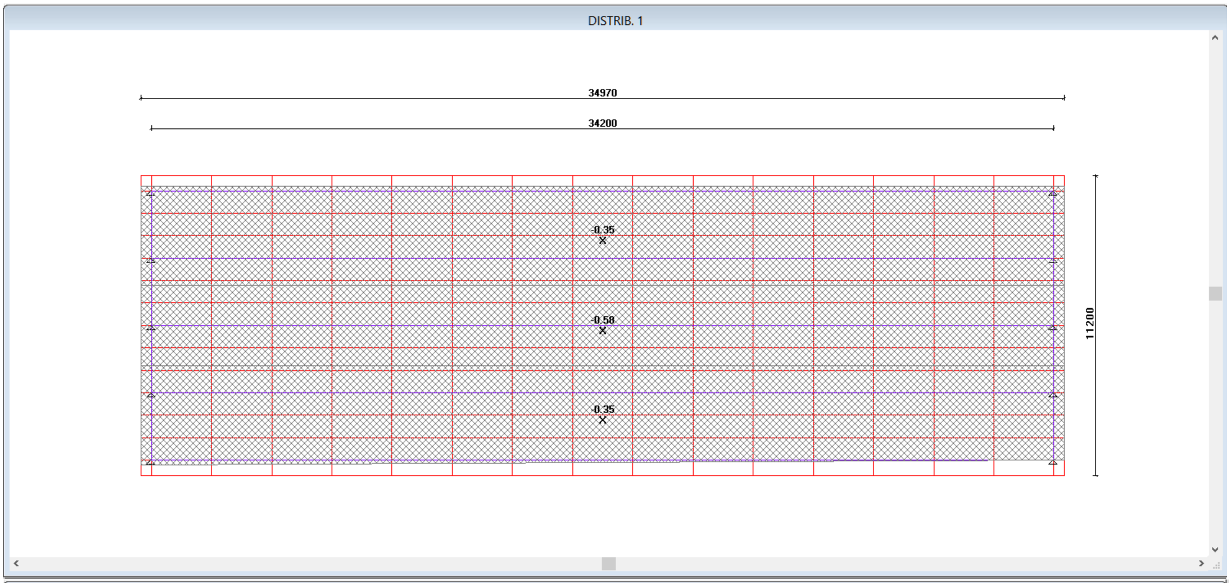
5.4
5.4
5.4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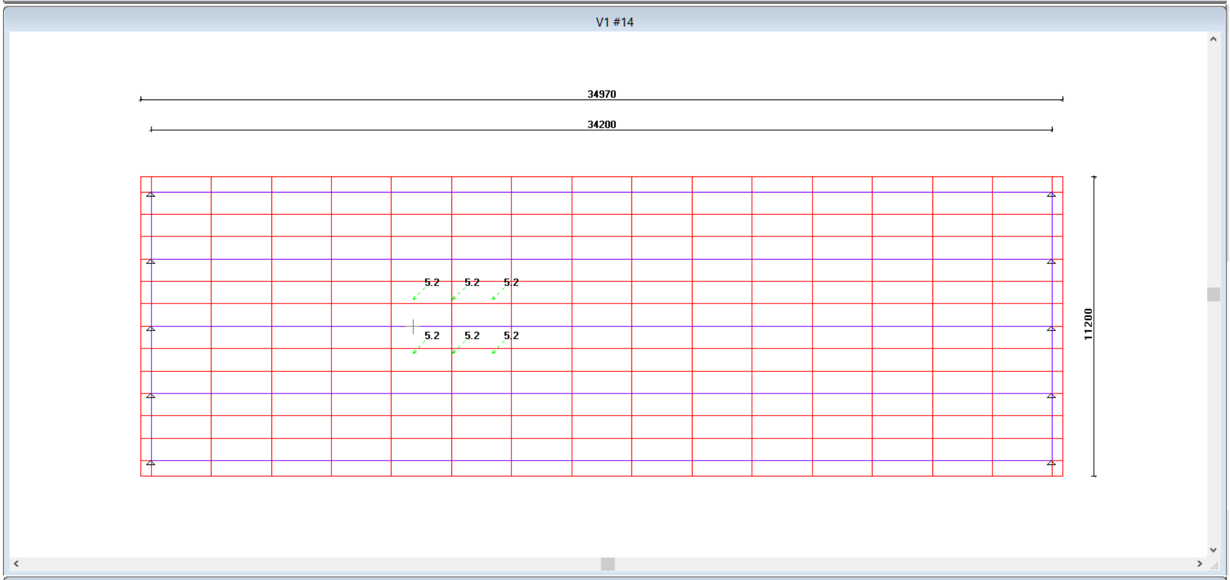
-0.35
11200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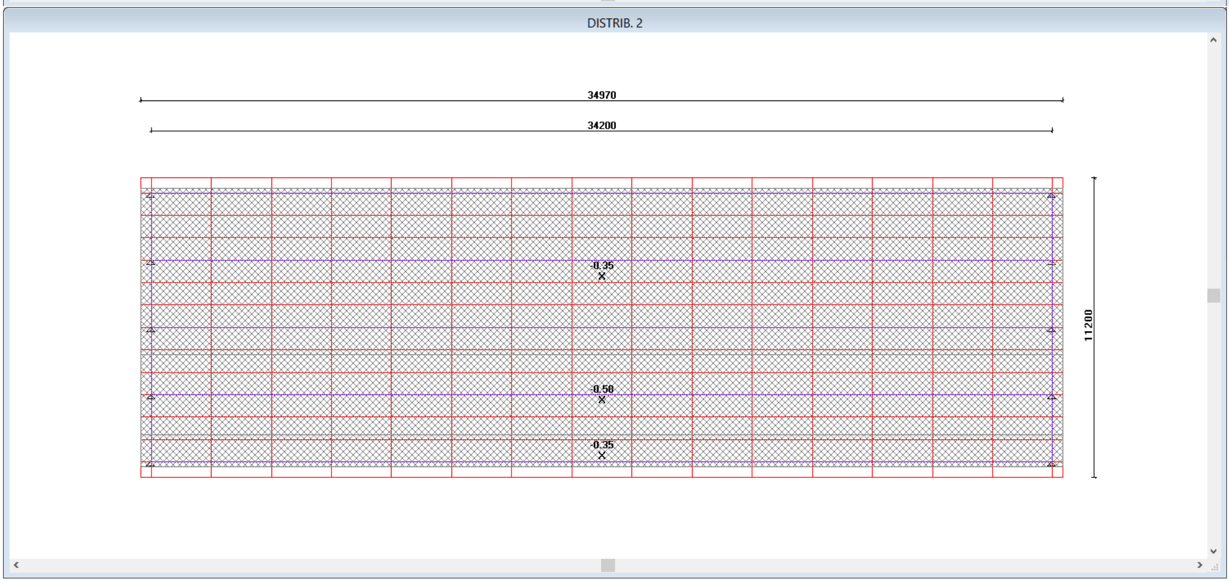
34200
5.2
5.2
5.2
5.2
5.2
5.2
11200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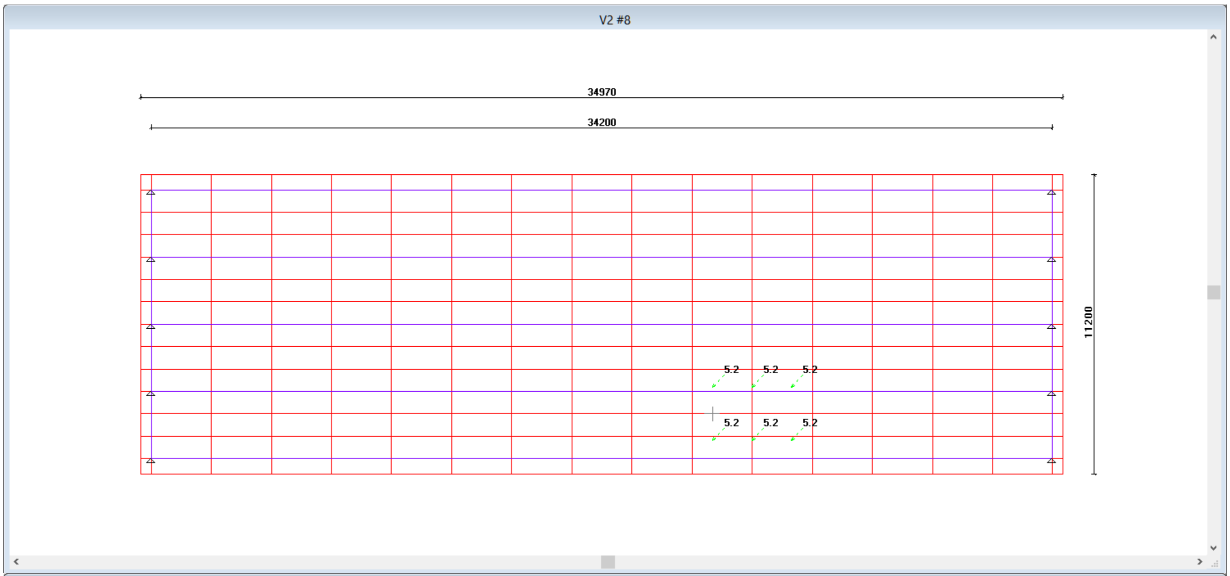
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34200
11200
5.2
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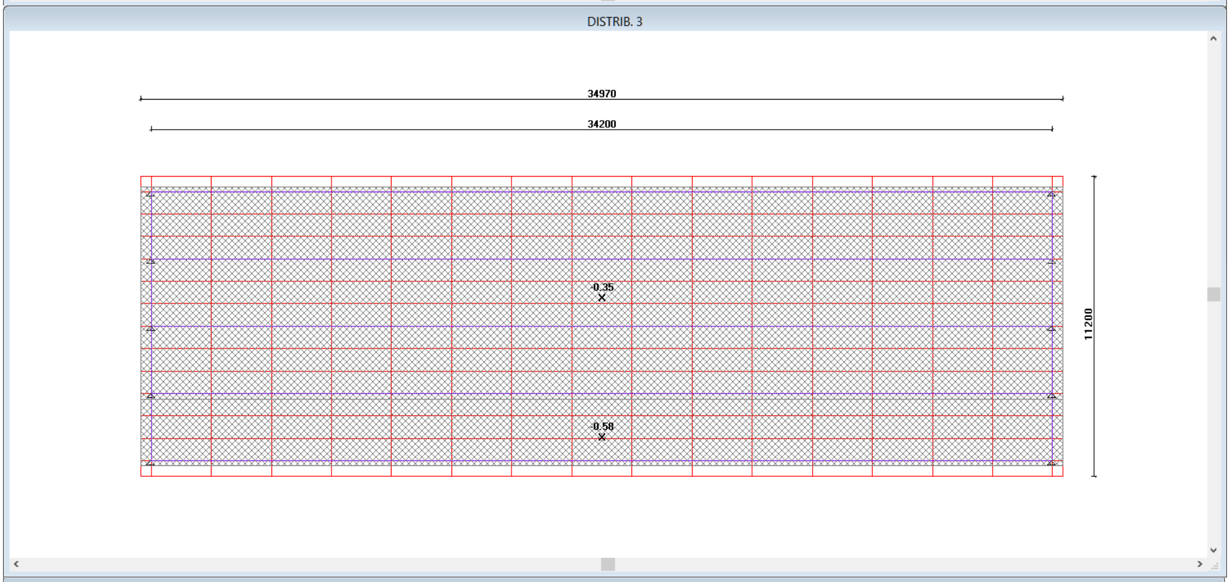
5.2
5.2
5.2
5.2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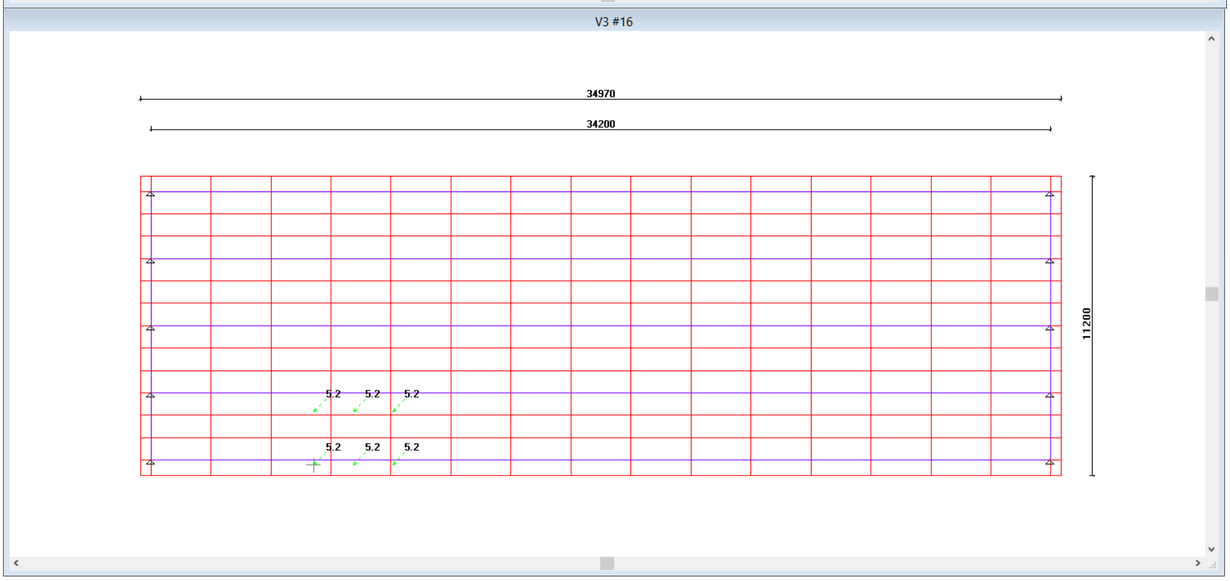
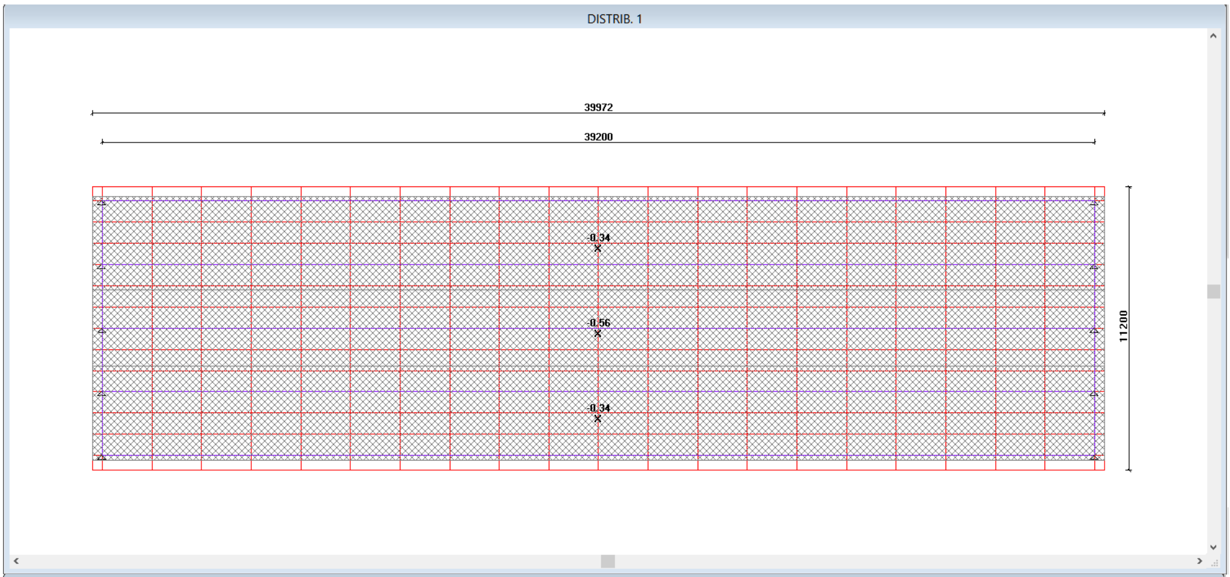
-0.58


V3 #16
34970
34200
11200
5.2
5.2
5.2
5.2
5.2
5.2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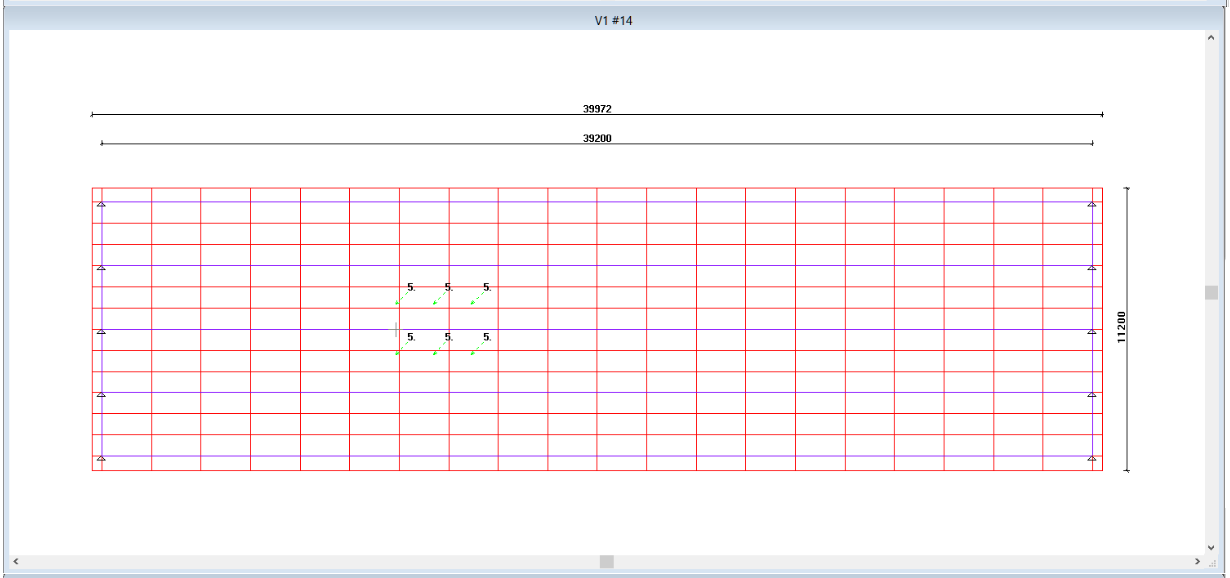
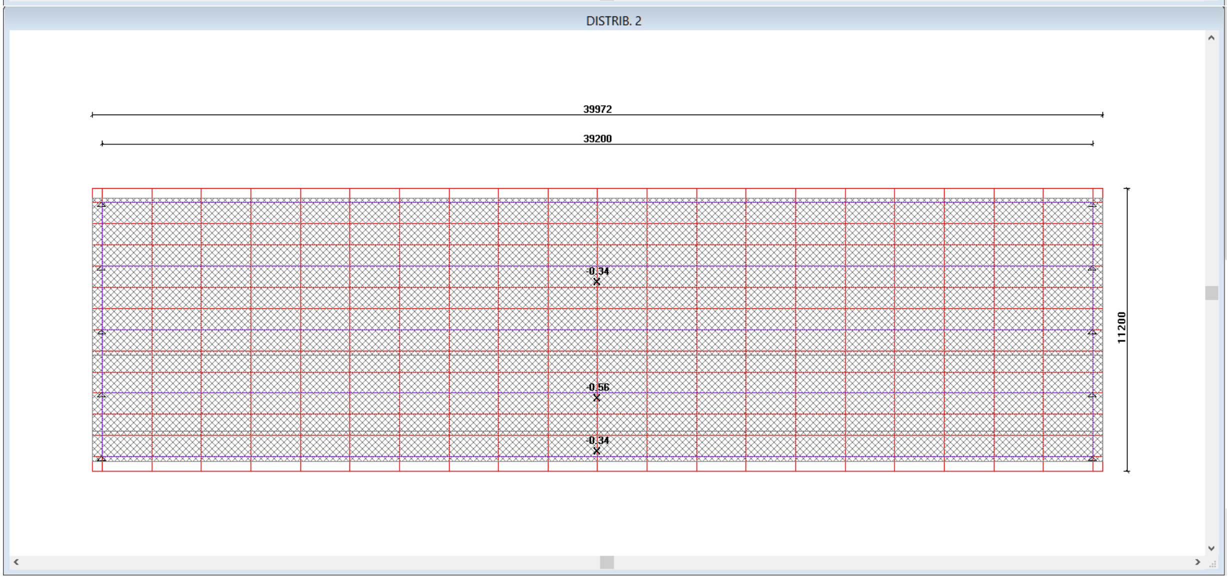
-0.34
11200


V1 #14
39972
39200
11200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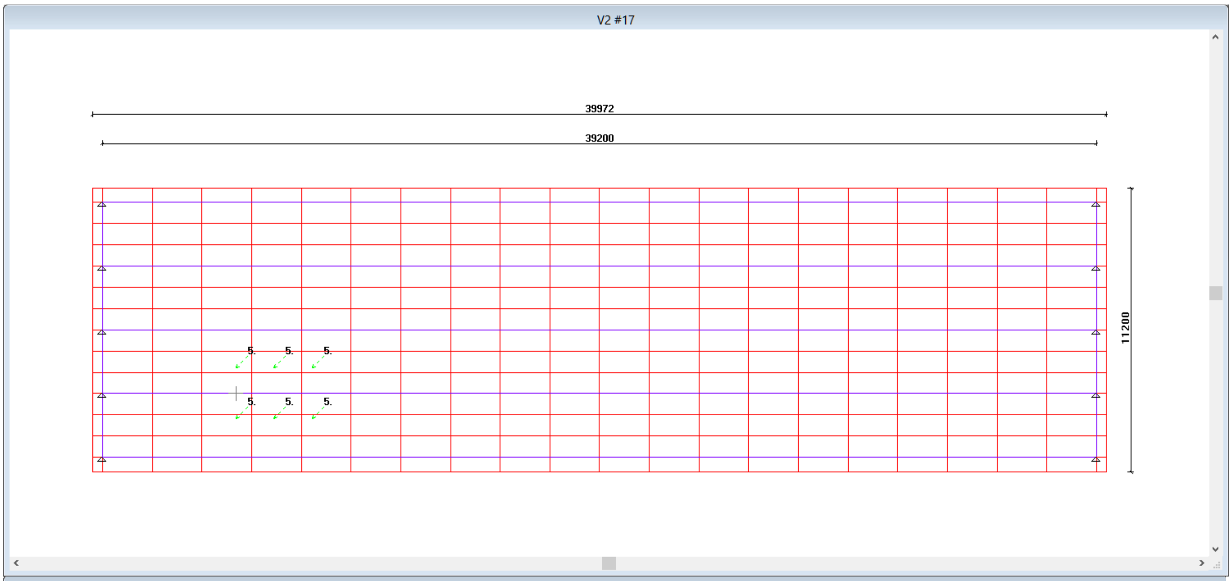
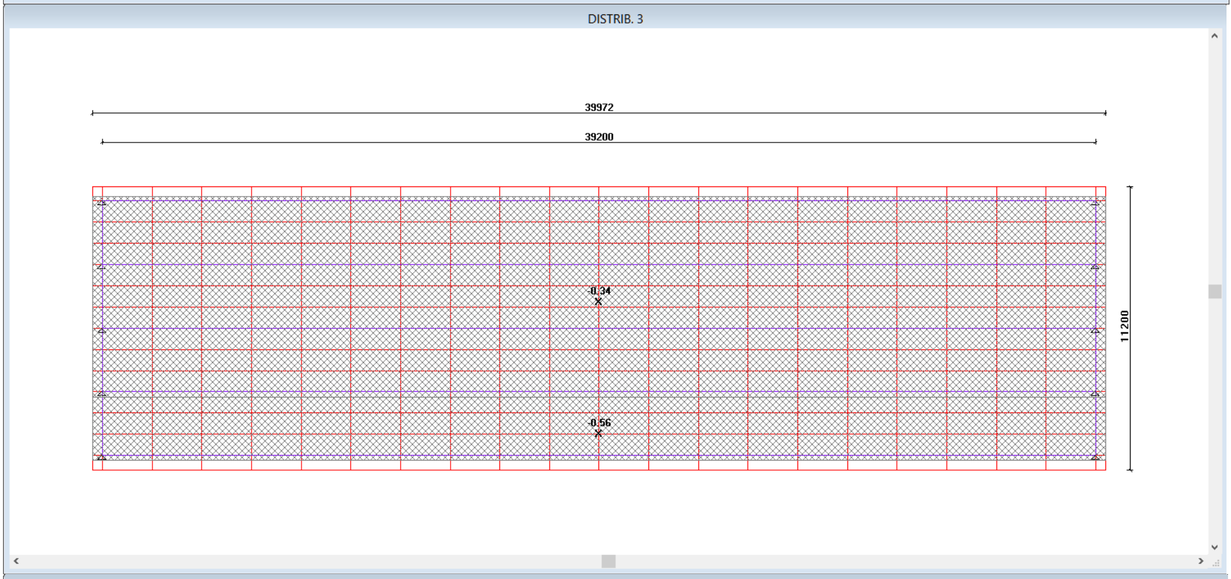
11200


V2 #17
39972
39200
11200
5.
5.
5.
5.
5.
5.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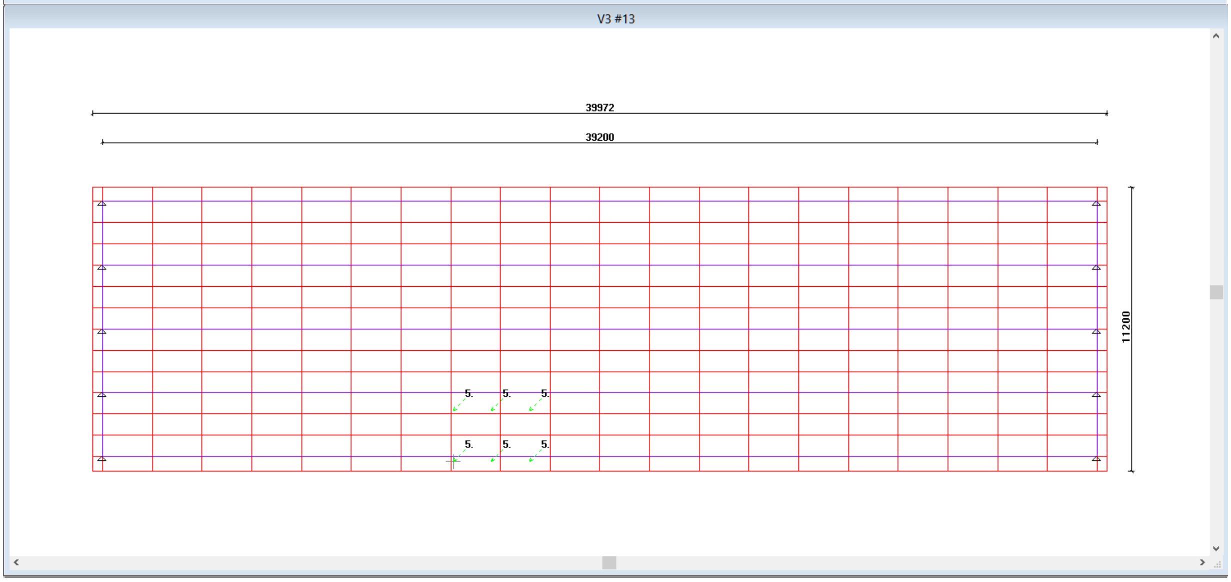
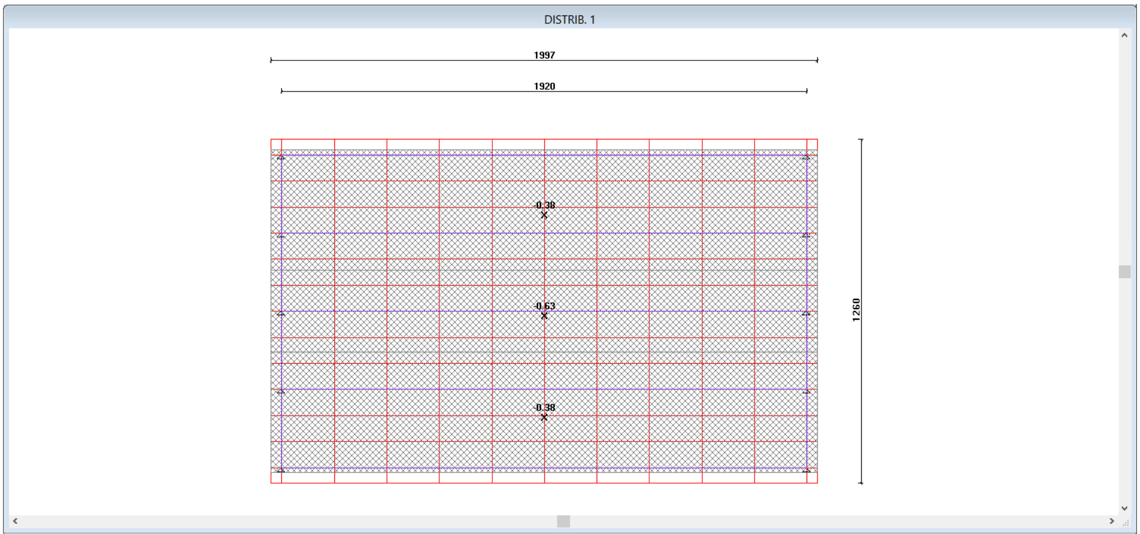
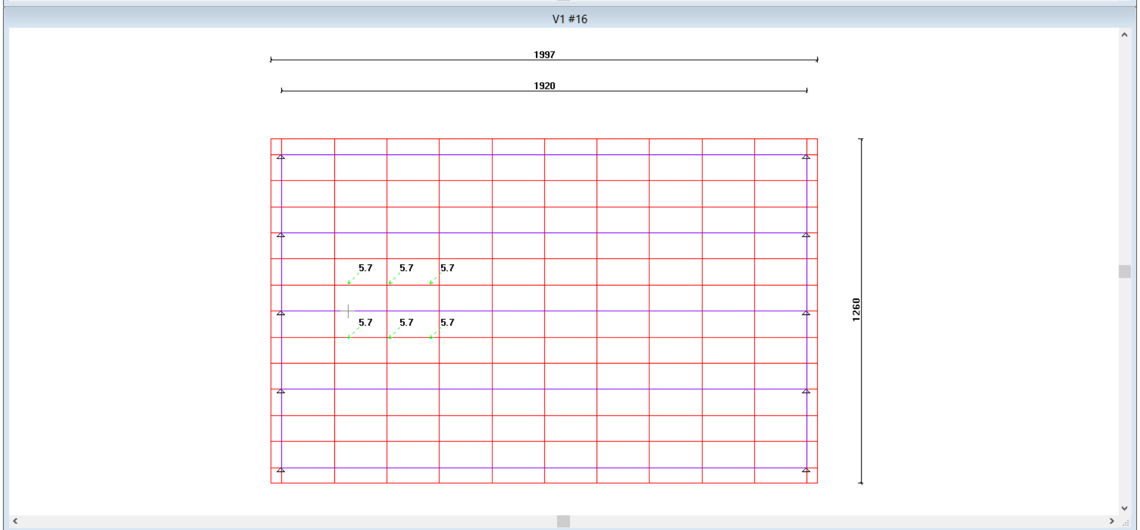
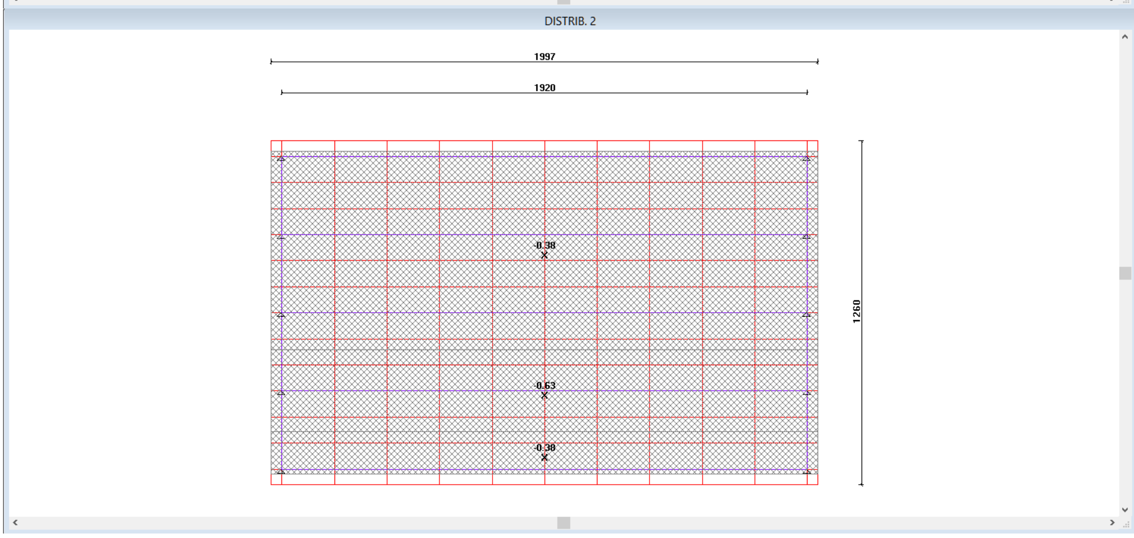
-0.56

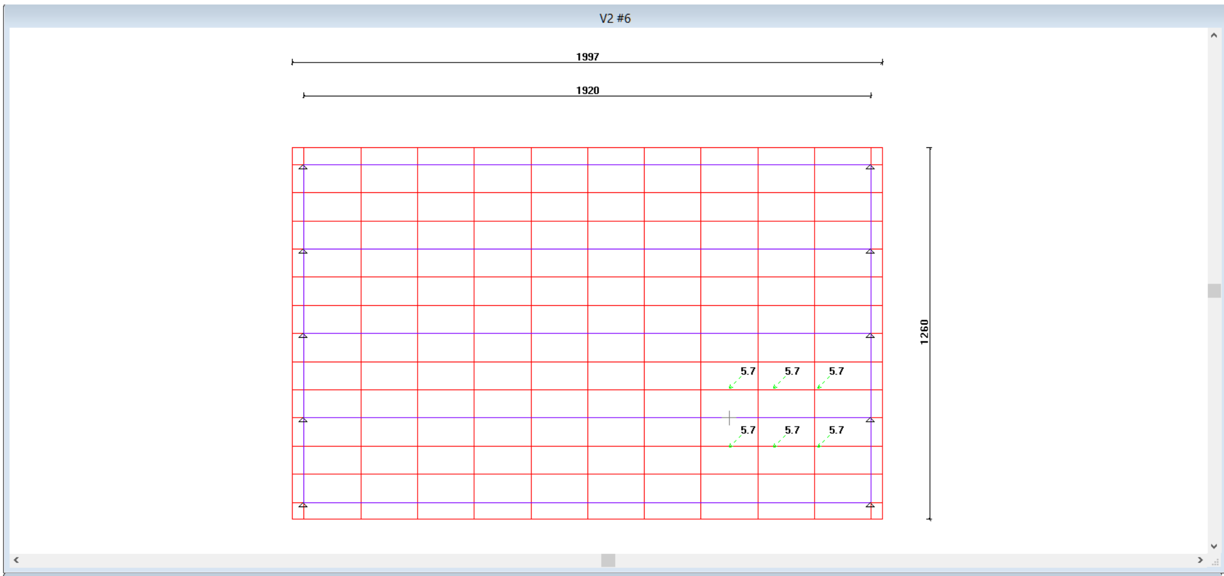

V3 #13
39972
39200
11200
5.
5.
5.
5.
5.
5.

4.4.2. Tabuleiro 12,60 m





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1920
1260
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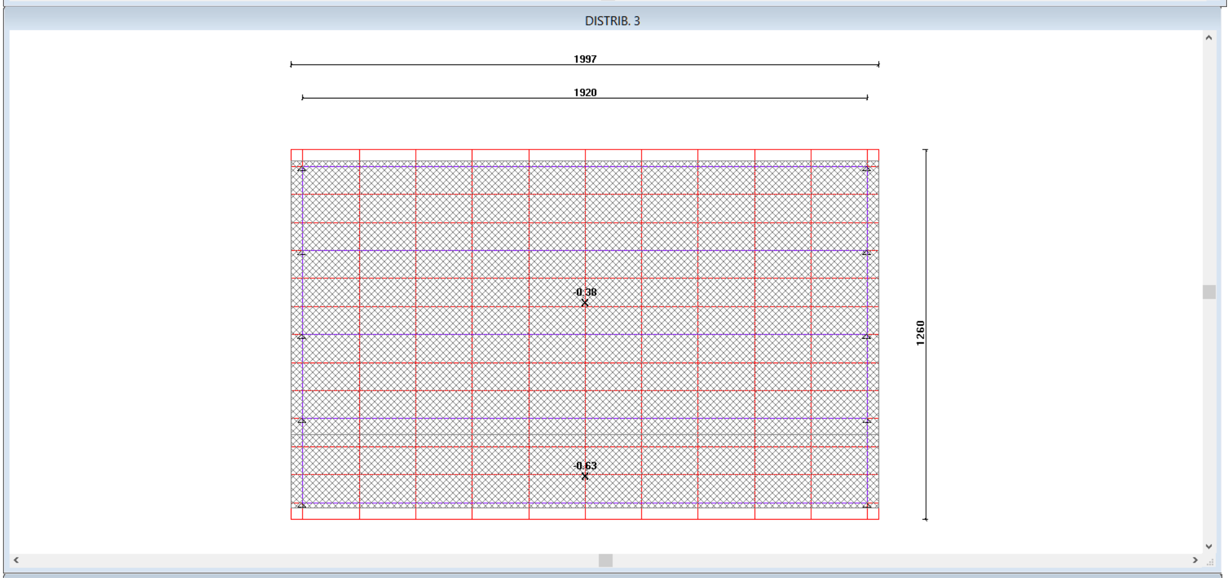
5.7
5.7
5.7
5.7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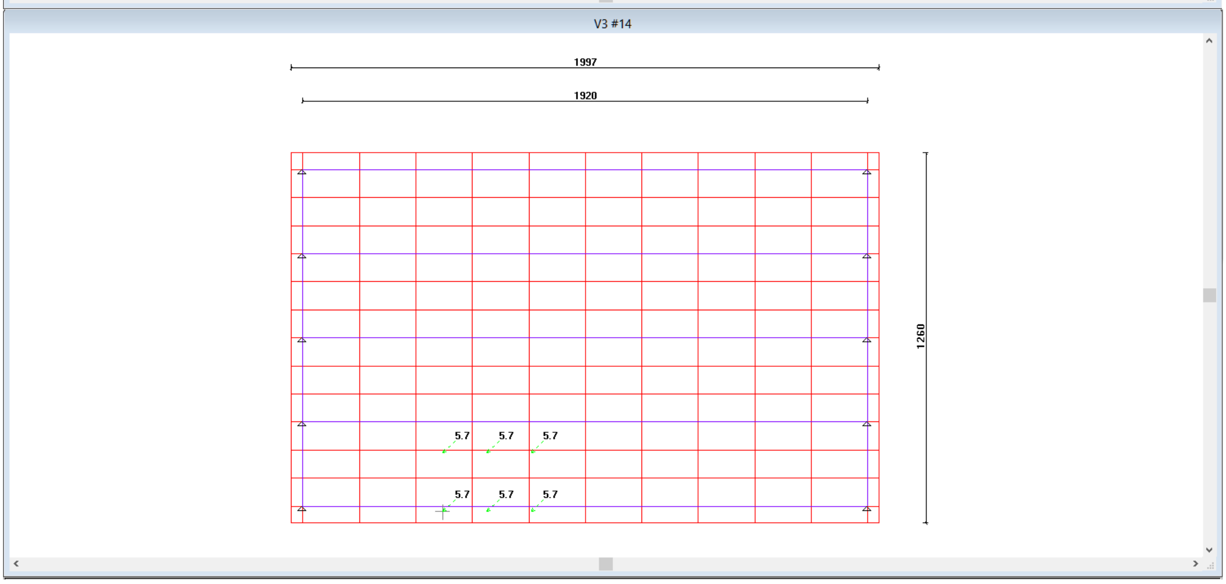
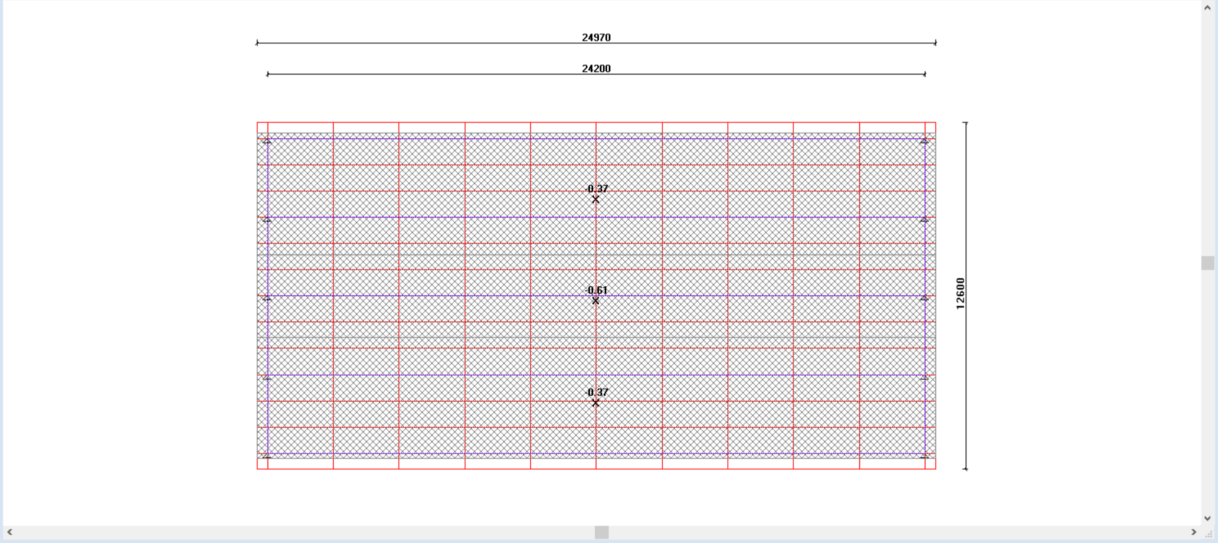
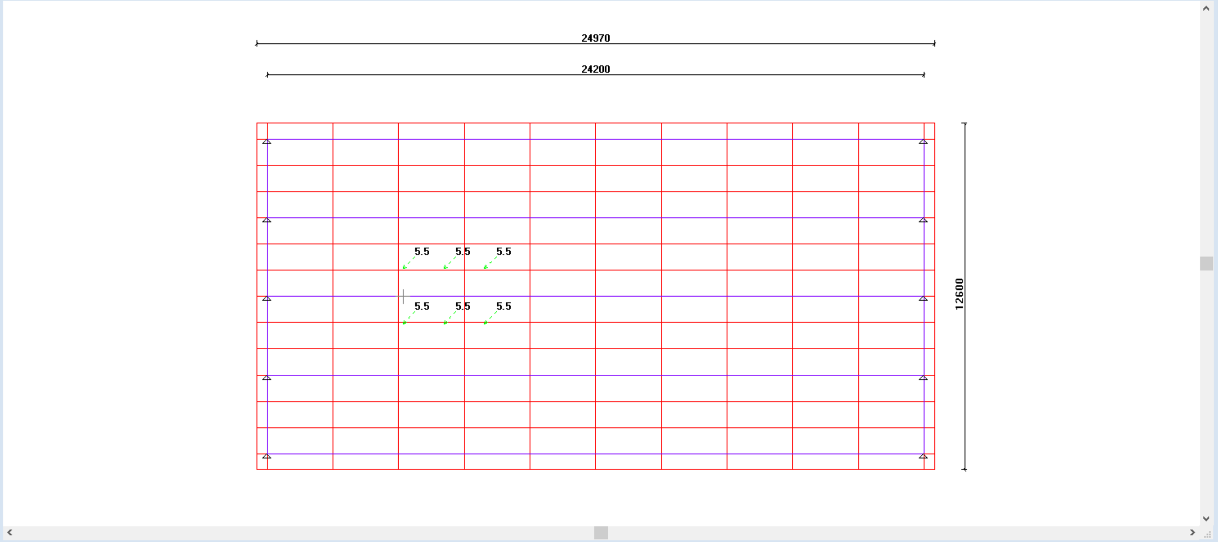
1997
1920
1260
-0.38
-0.63


V3 #14
1997
1920
1260
5.7
5.7
5.7
5.7
5.7
5.7

DISTRIB. 1



V1 #15



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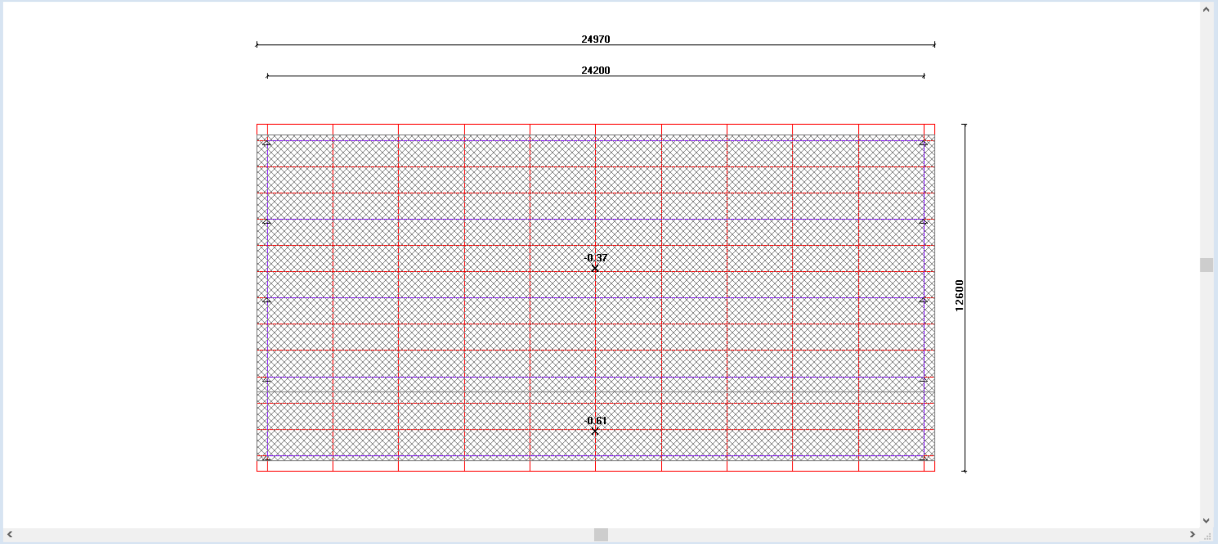
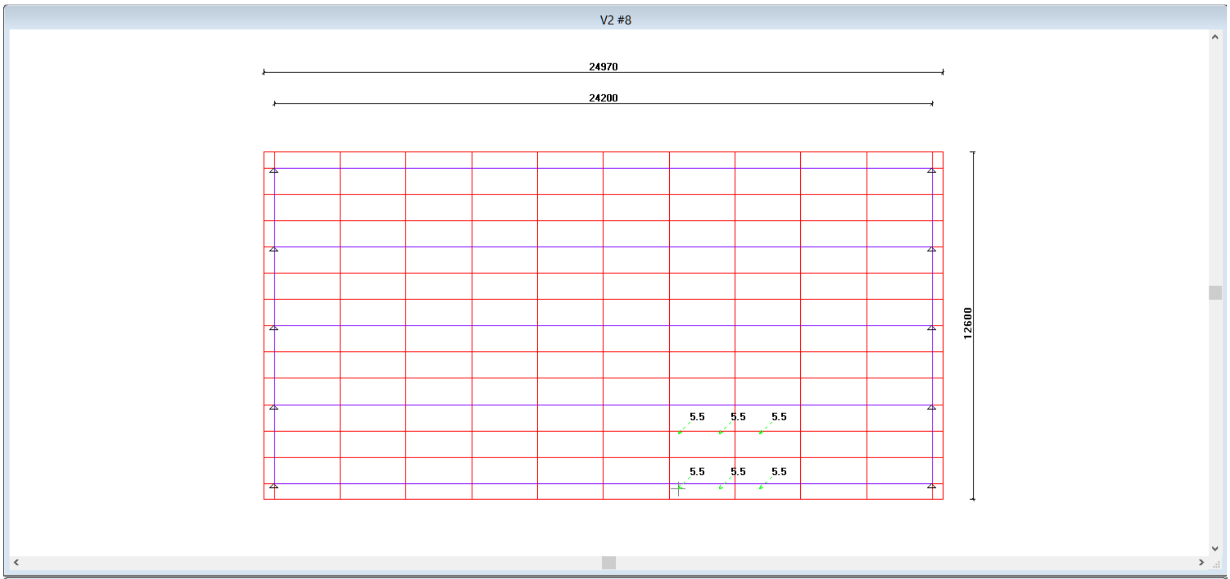
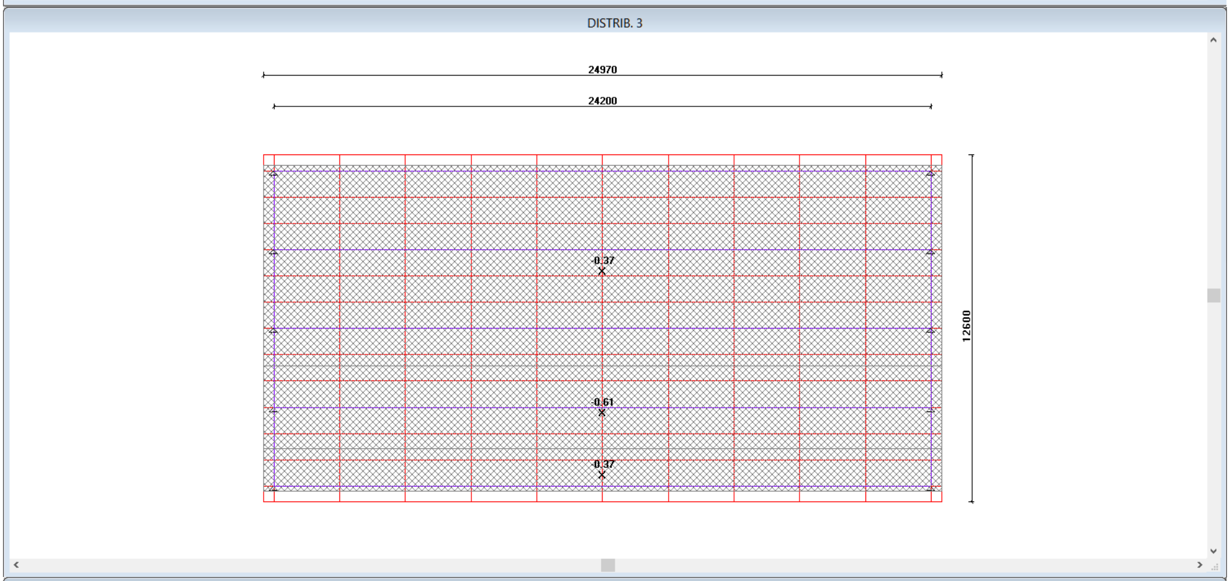



V2 #8
24970
24200
12600
5.5
5.5
5.5
5.5
5.5
5.5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12600
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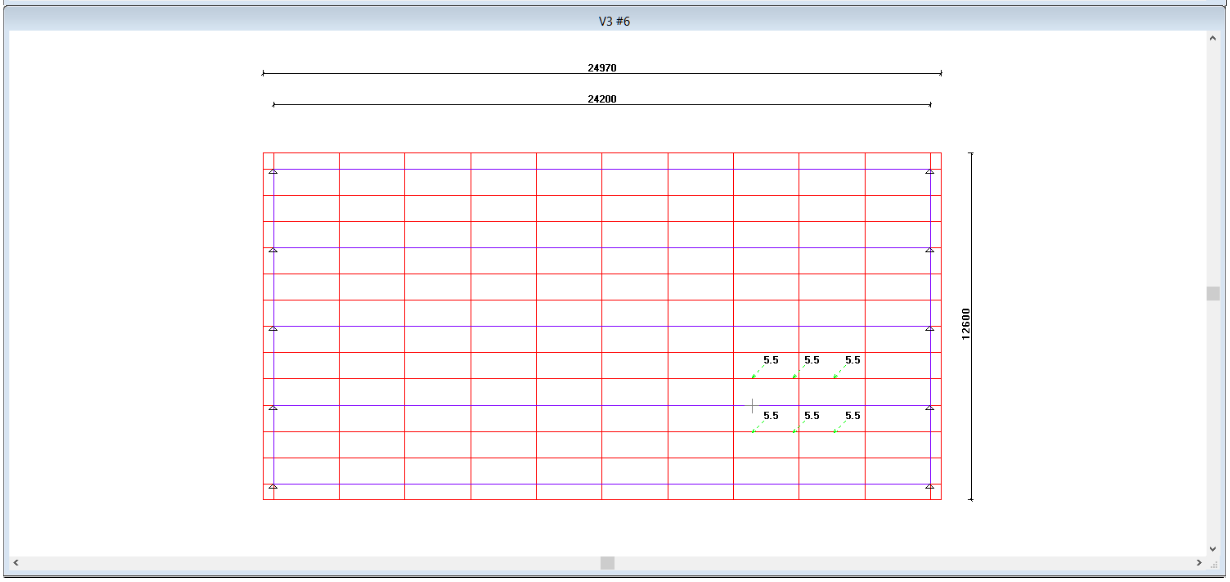
-0.37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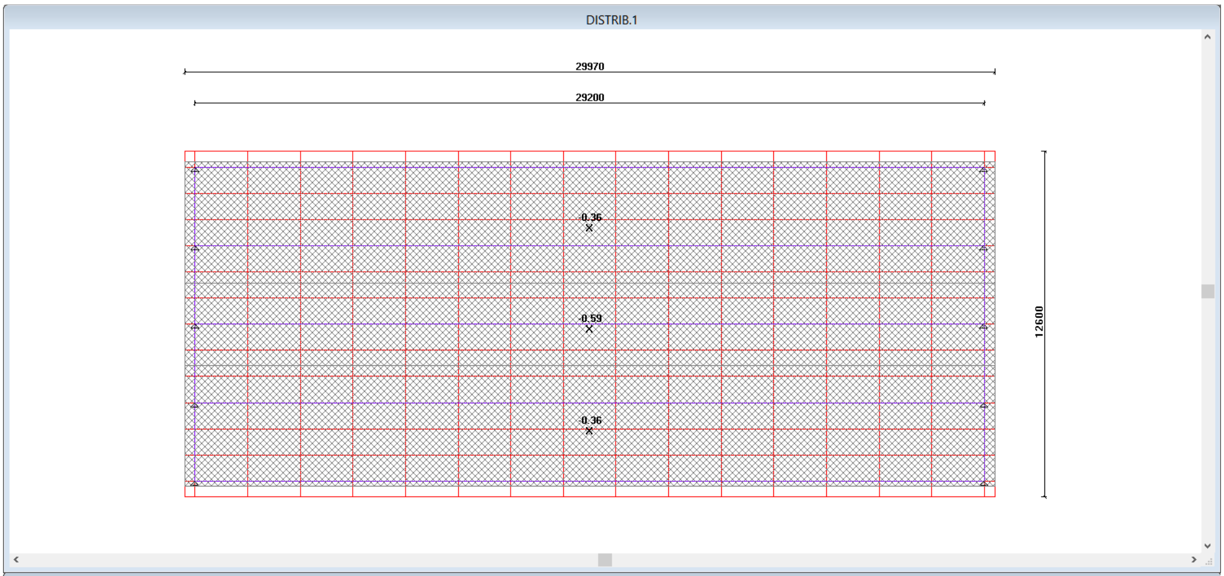
5.5
5.5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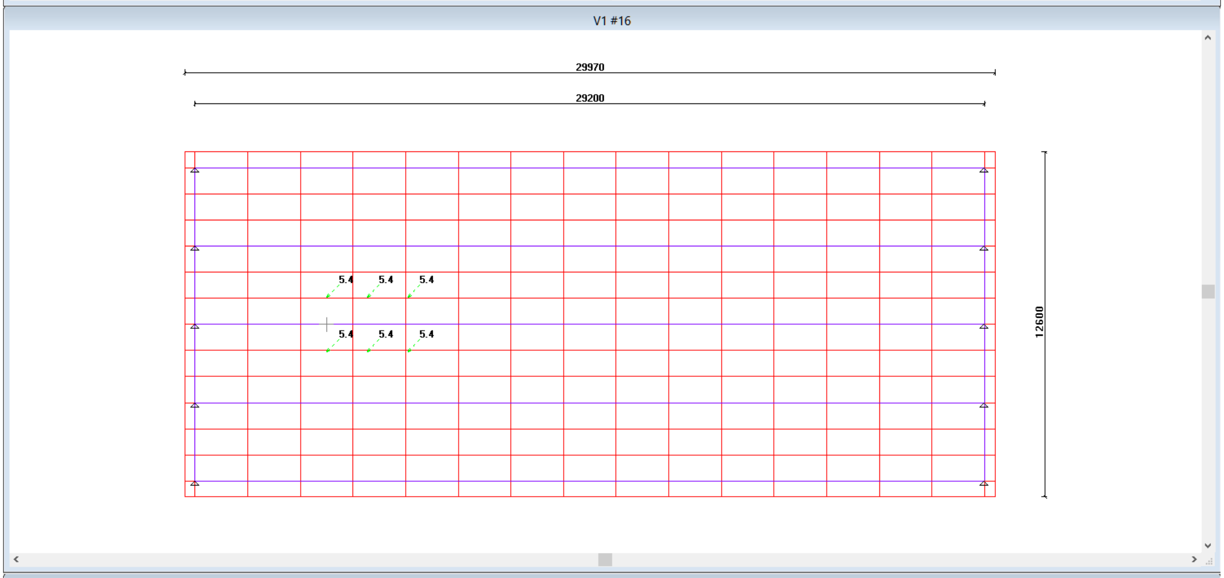
V1 #16
29970
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5.4
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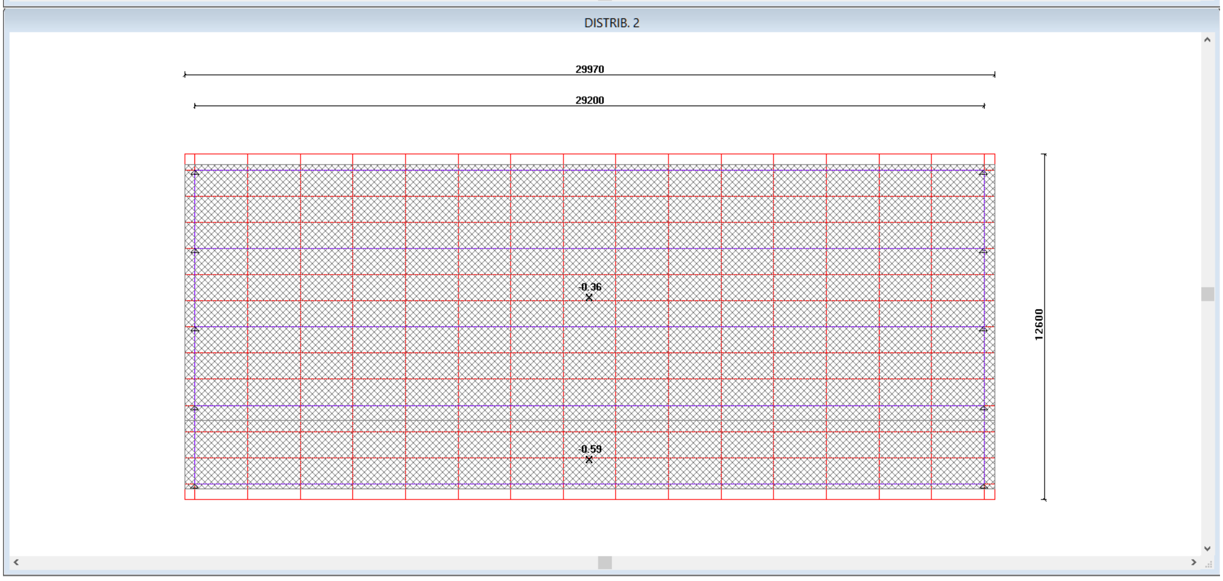
5.4
5.4
5.4
5.4
12600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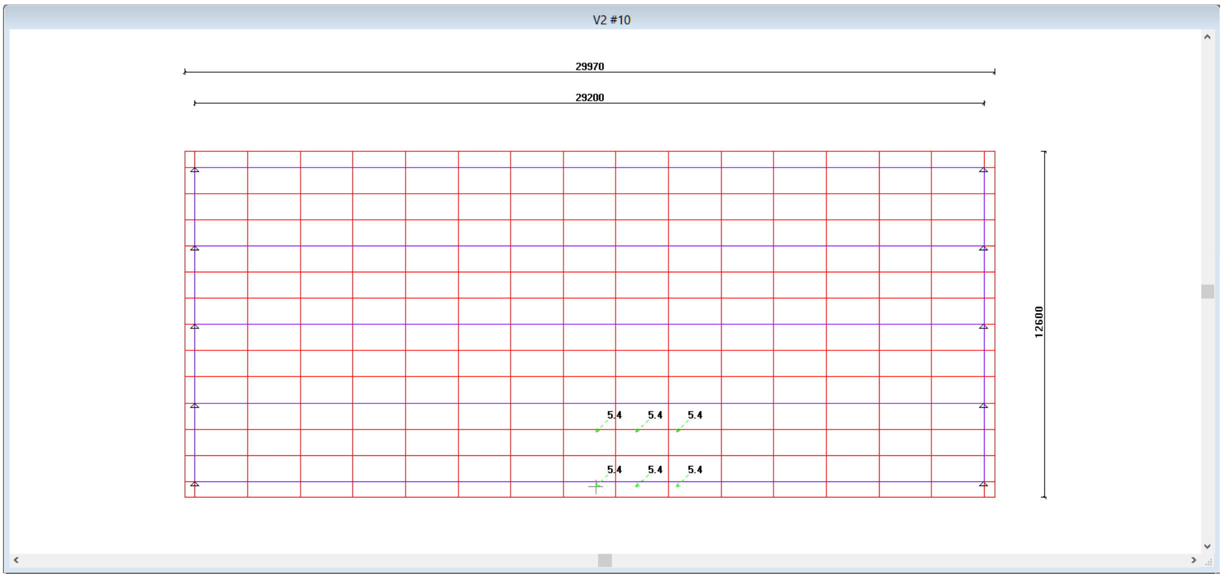
V2 #10
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29200
12600
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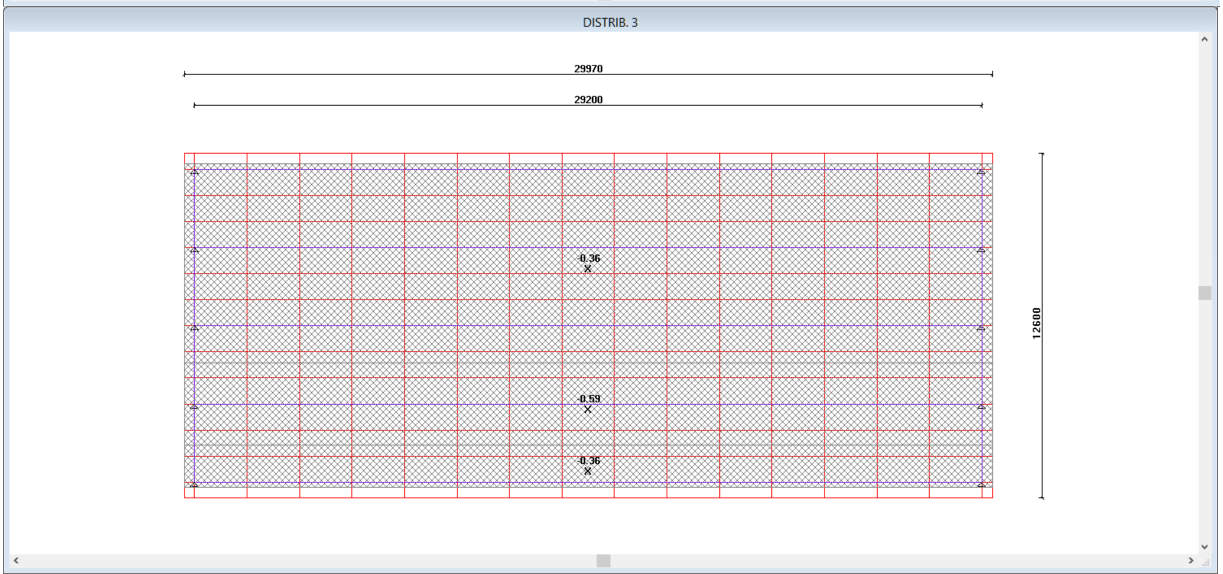
5.4
5.4
5.4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12600
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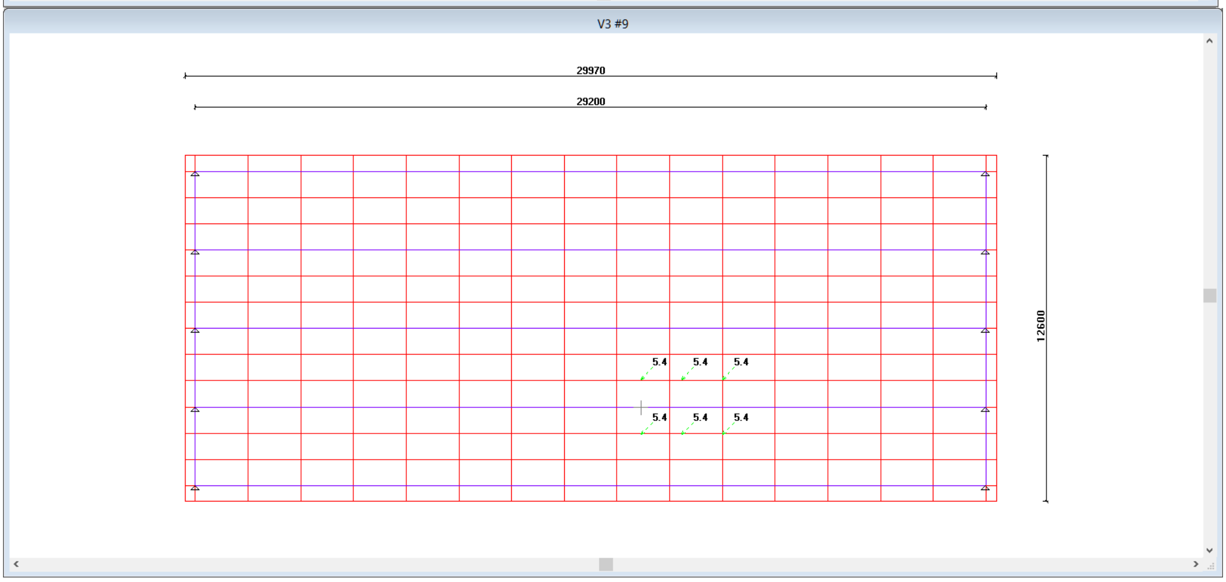
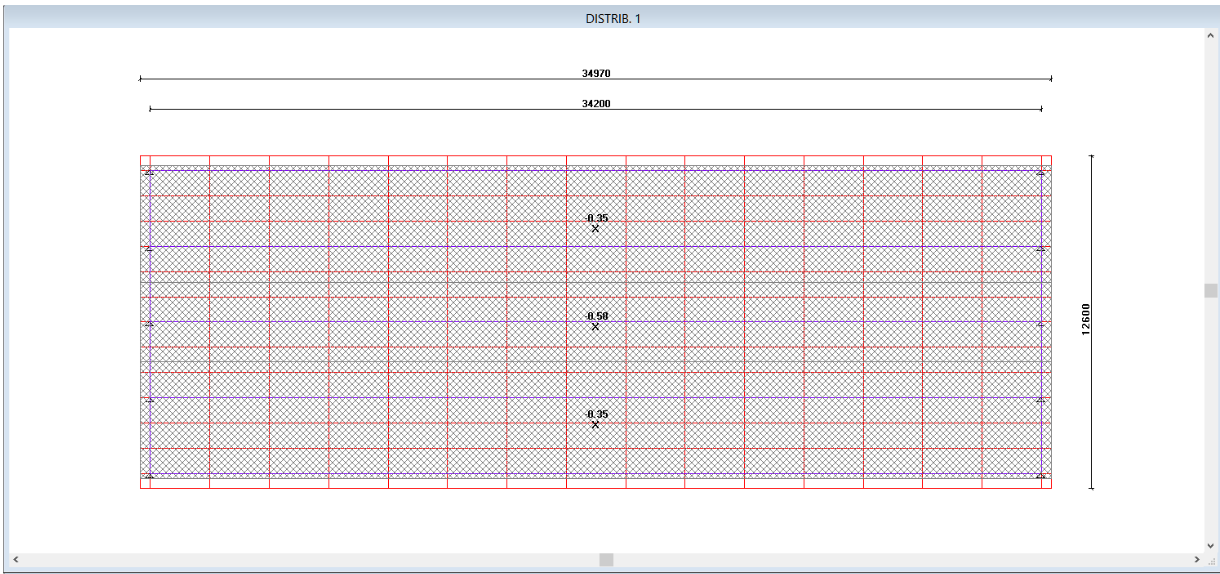
-0.59
-0.36


V3 #9
29970
29200
12600
5.4
5.4
5.4
5.4
5.4
5.4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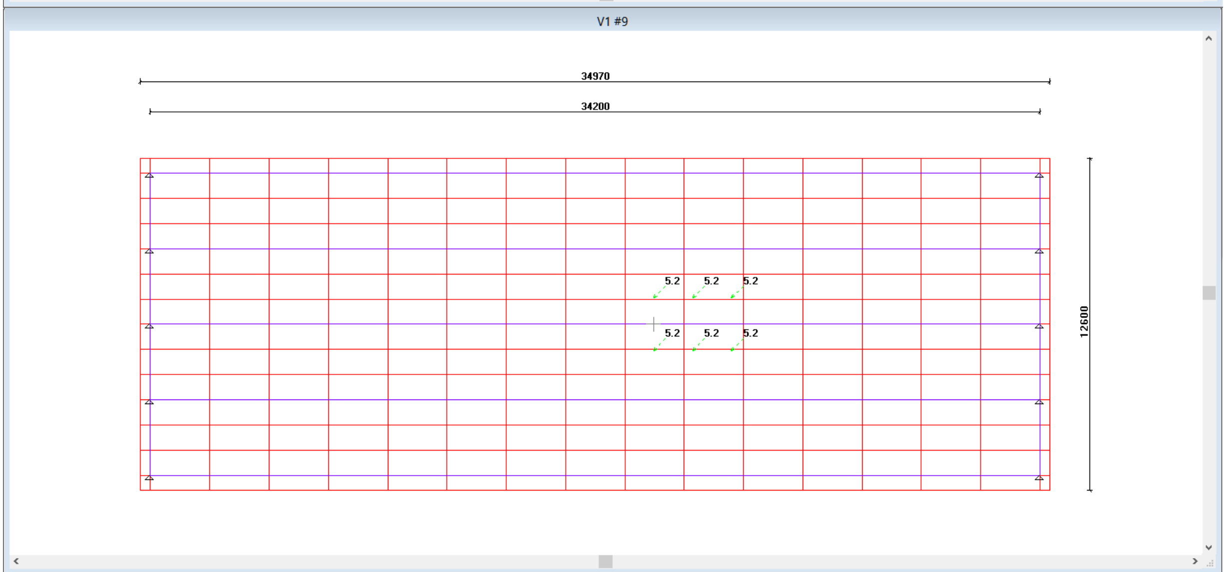
34200
-0.35
-0.58
-0.35
12600


V1 #9
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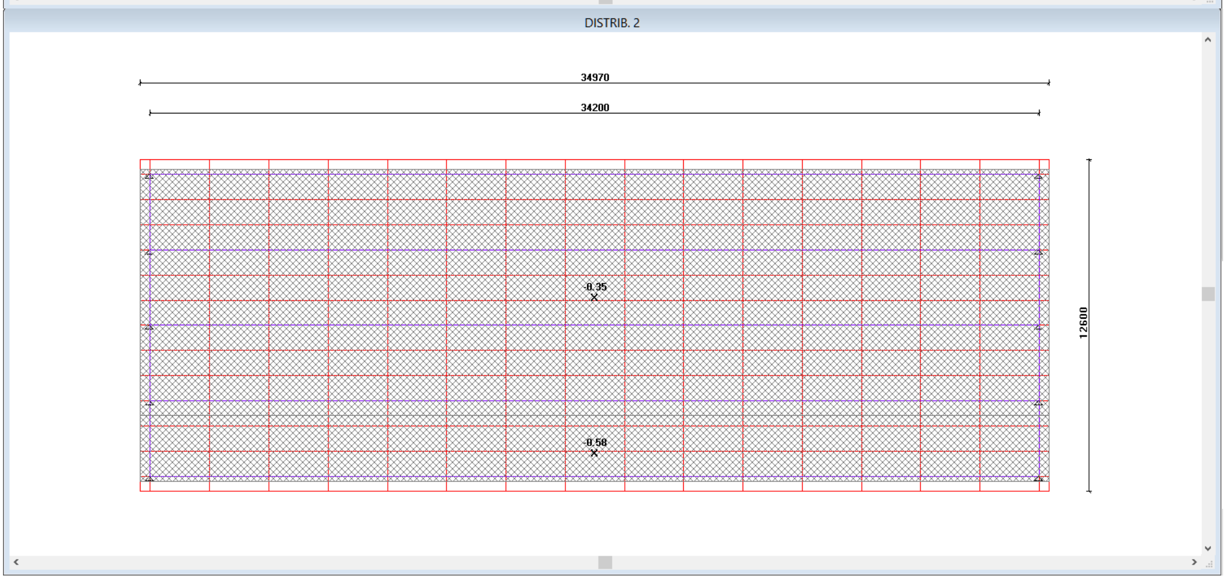
5.2
5.2
5.2
5.2
12600


DISTRIB. 2
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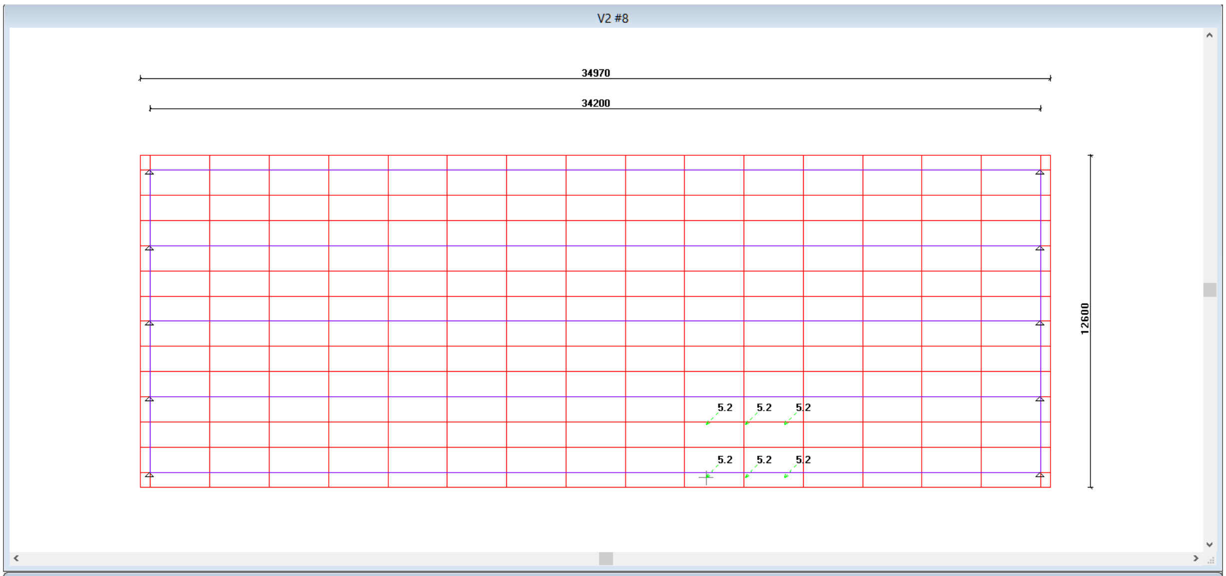
V2 #8
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34200
12600
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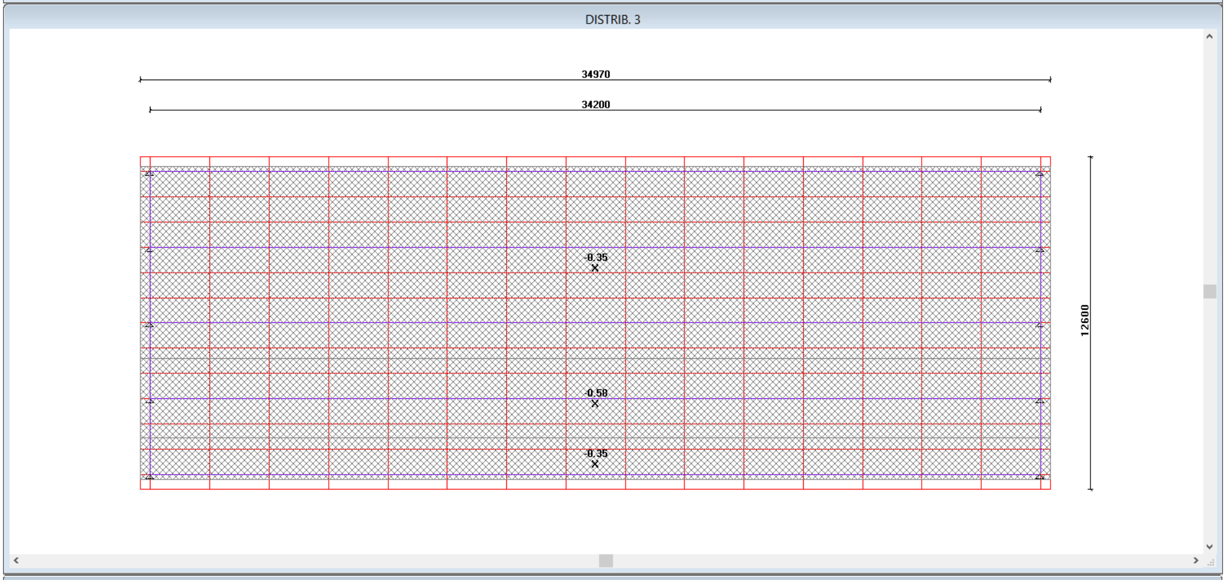
5.2
5.2
5.2
5.2
5.2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12600
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-0.58
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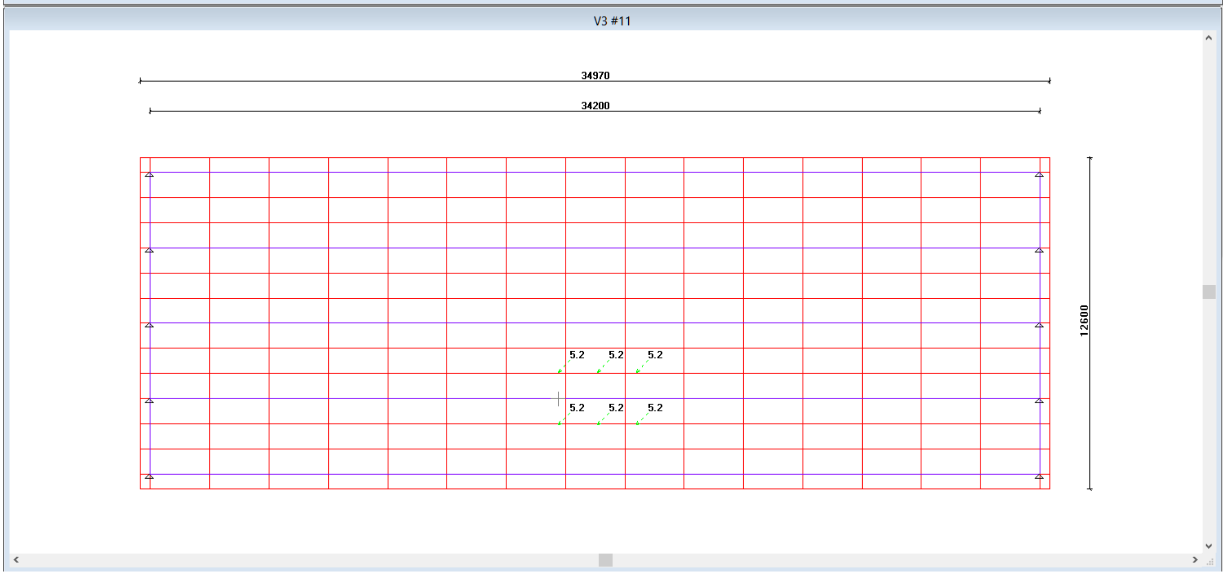
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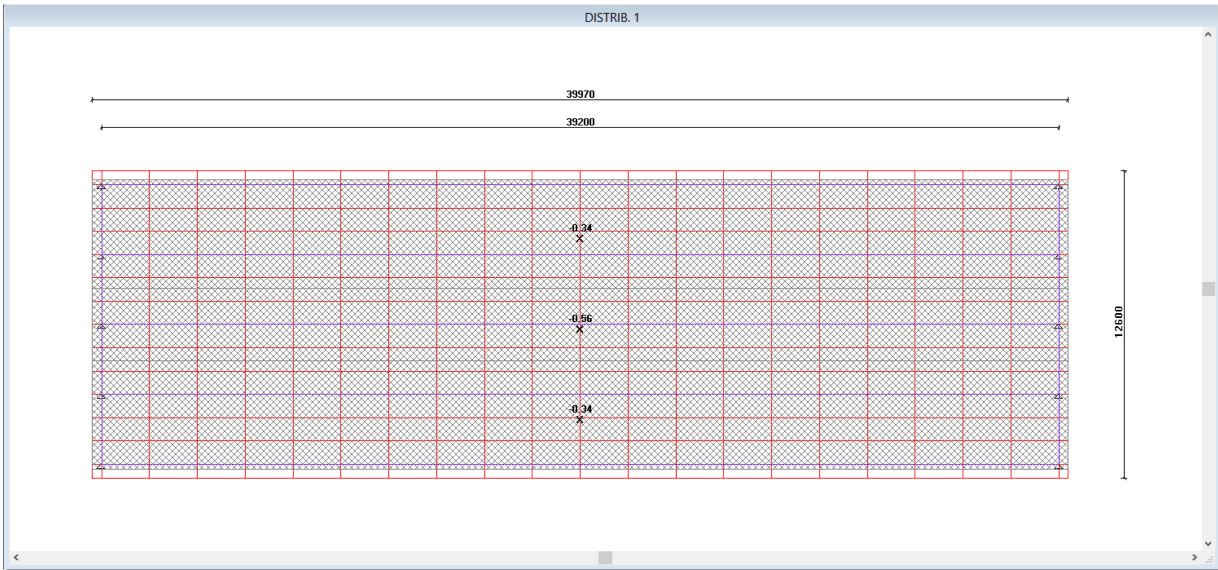
34200
12600
5.2
5.2
5.2
5.2
5.2
5.2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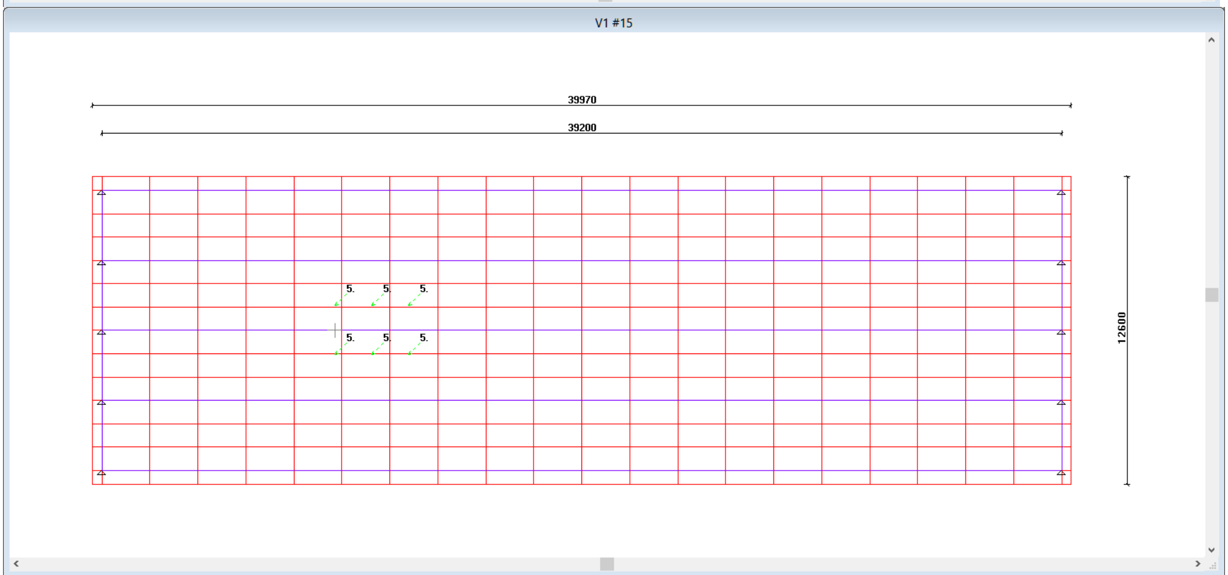
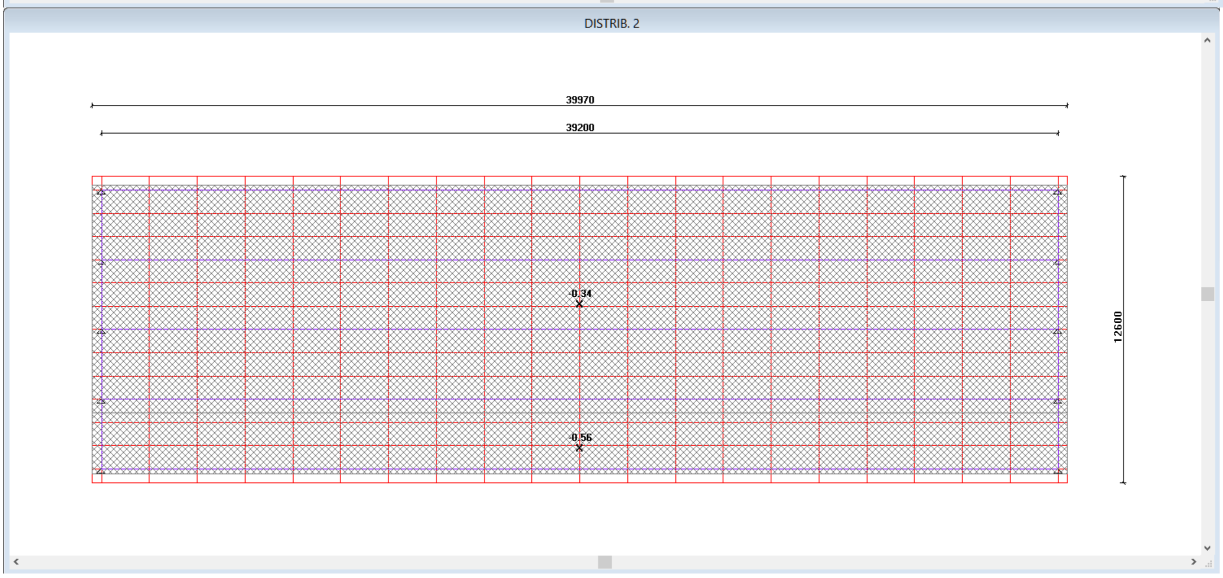
12600


V1 #15
39970
39200
5.
12600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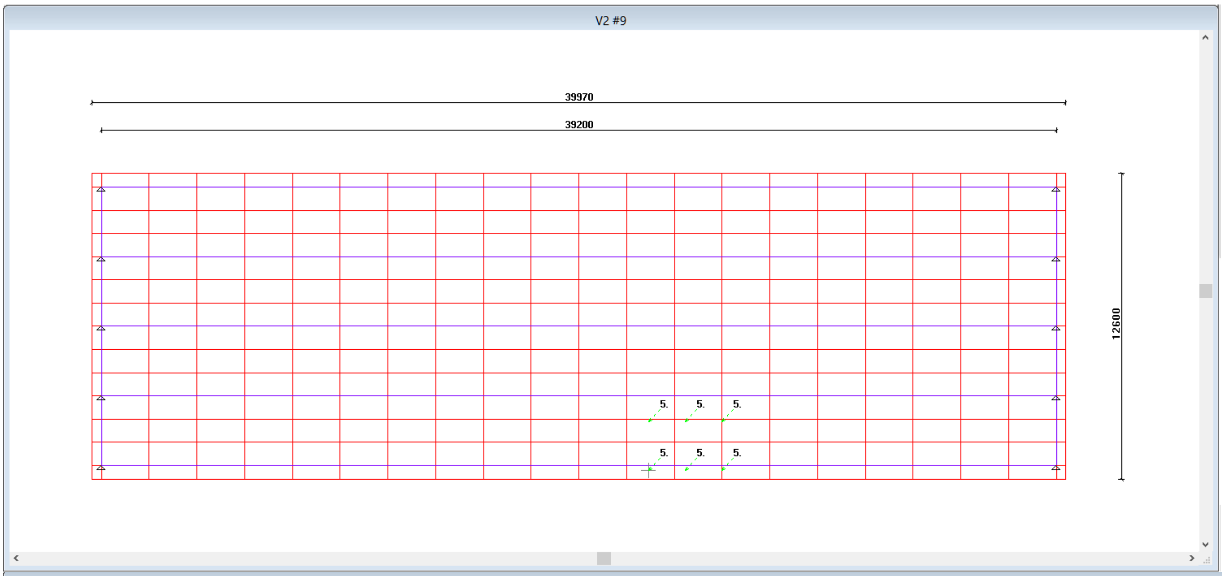
-0.56
12600


V2 #9
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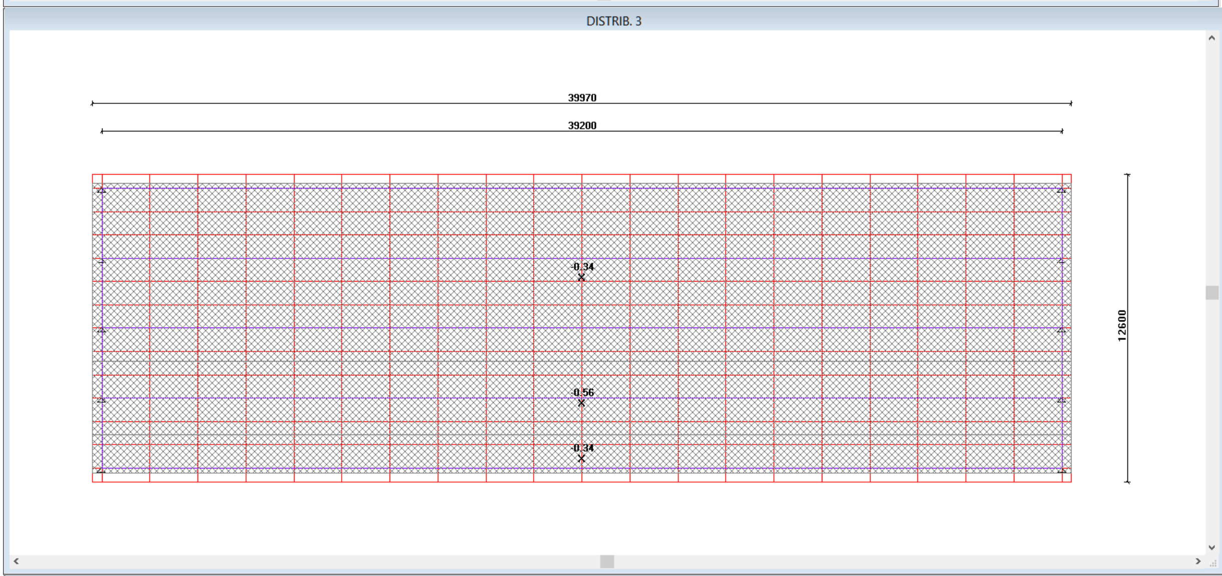
39200
12600
5.
5.
5.
5.
5.
5.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39200
12600
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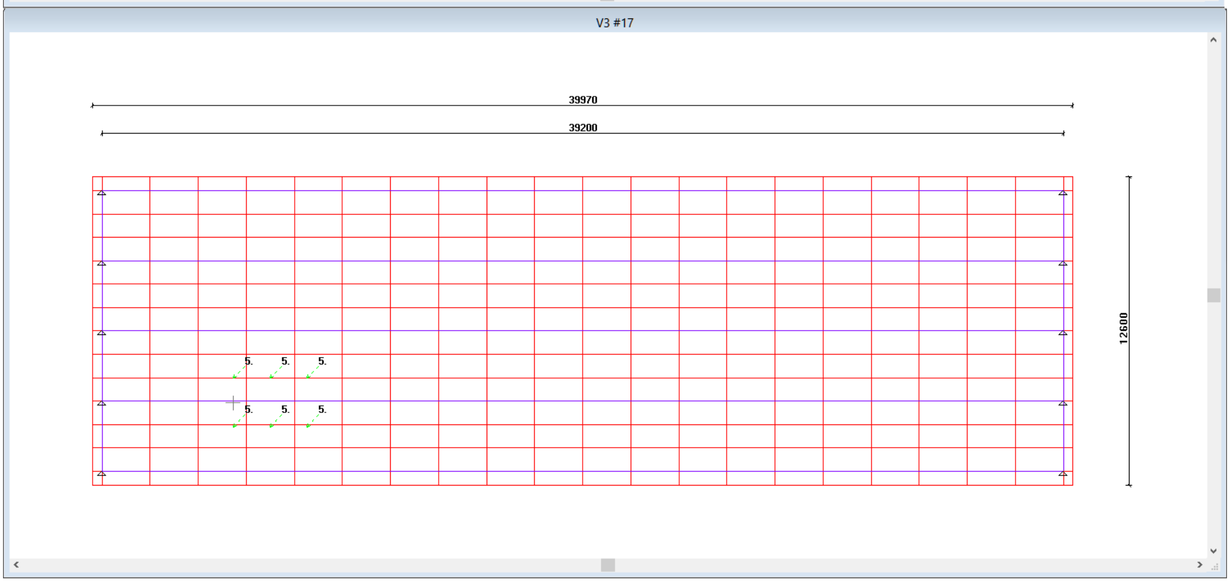
V3 #17
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39200
12600
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5.
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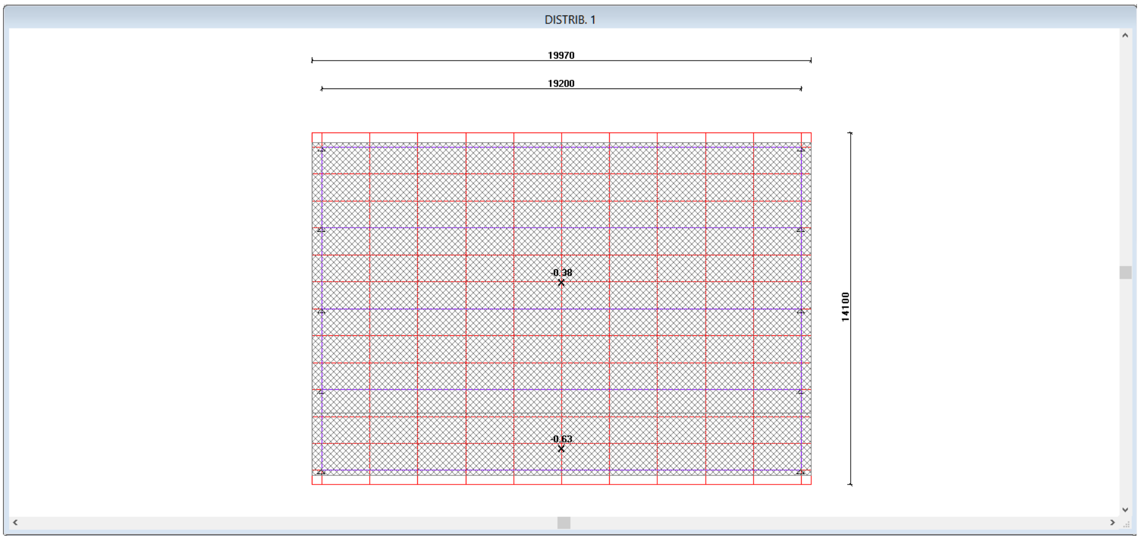
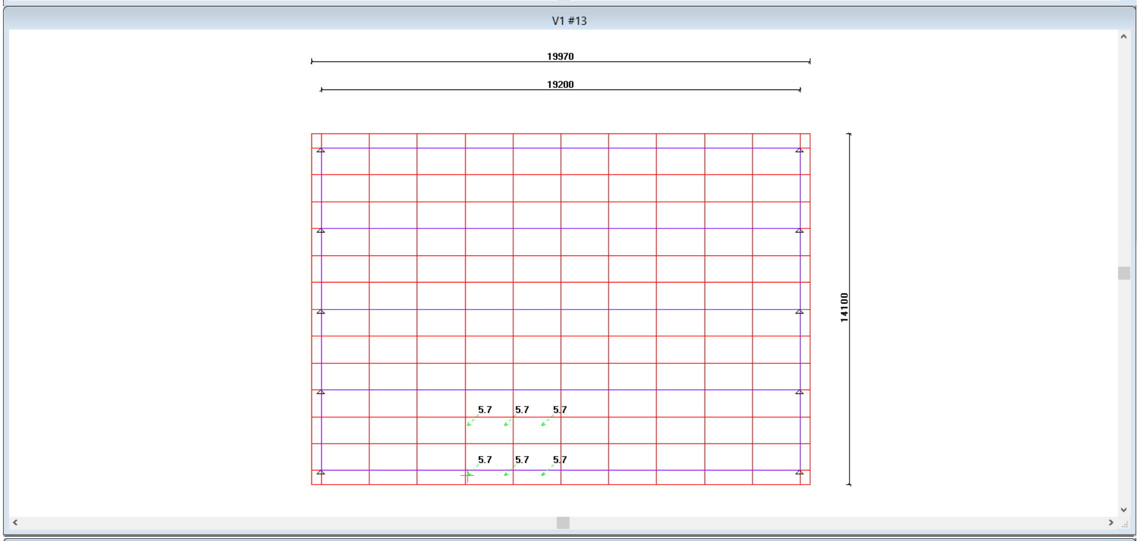
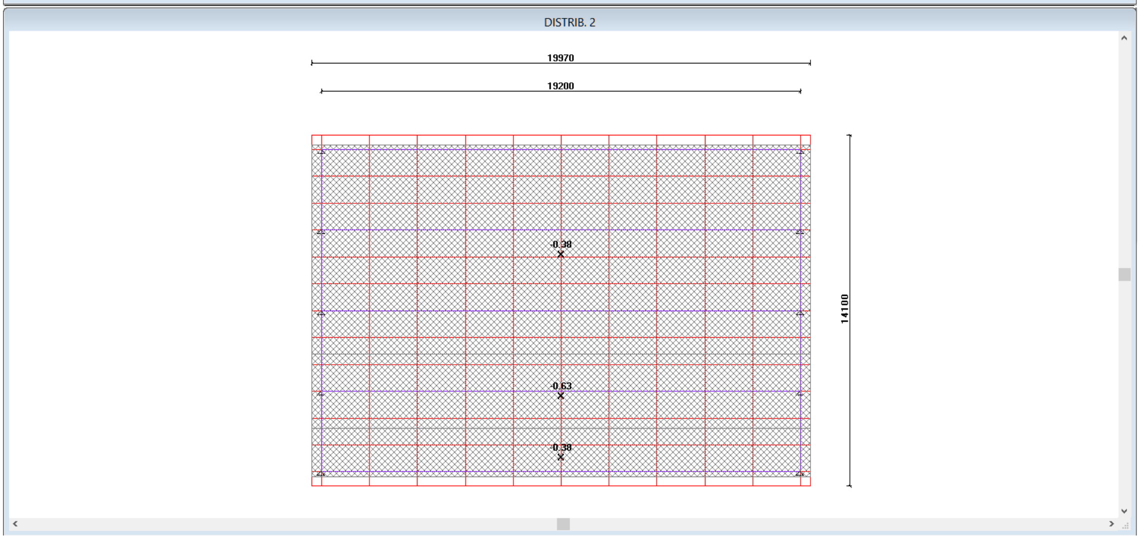
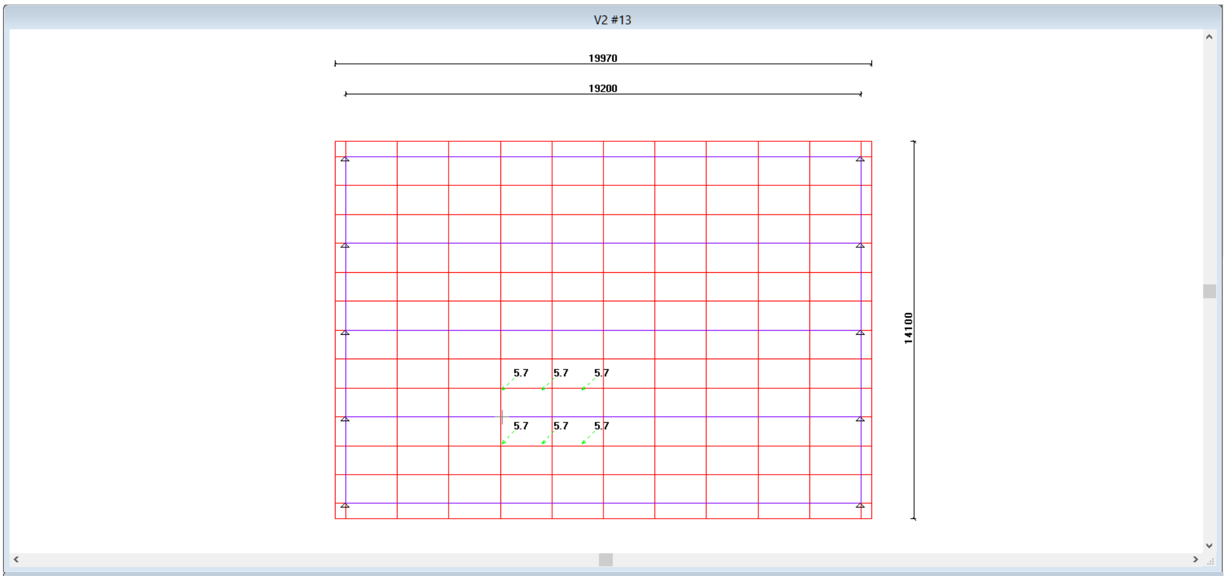
5.
5.

4.4.3. Tabuleiro 14,10 m





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14100
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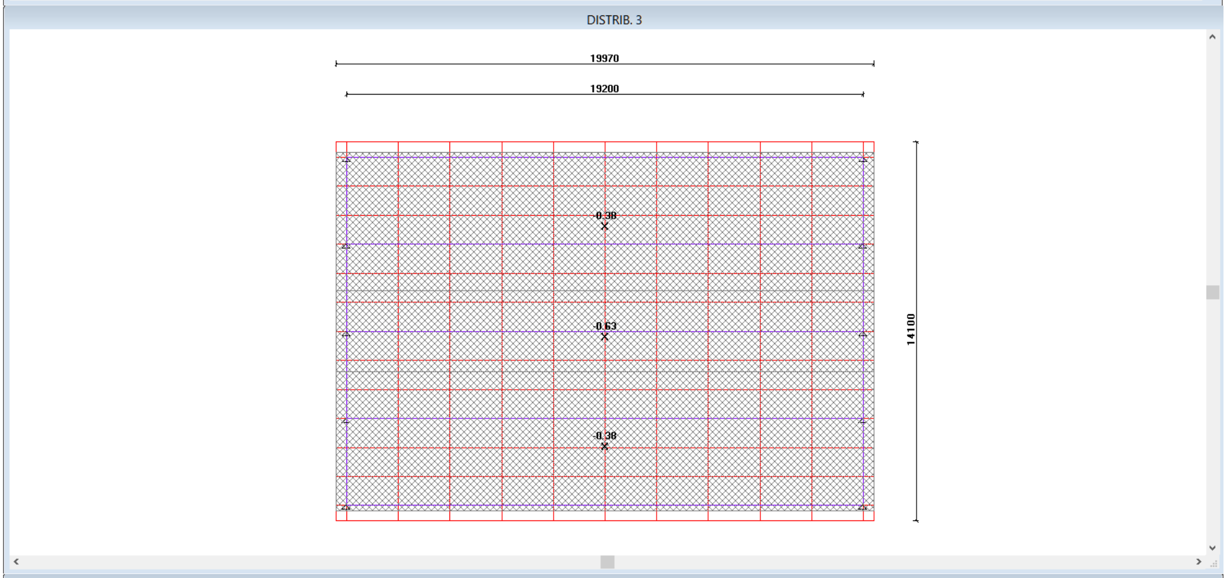
5.7
5.7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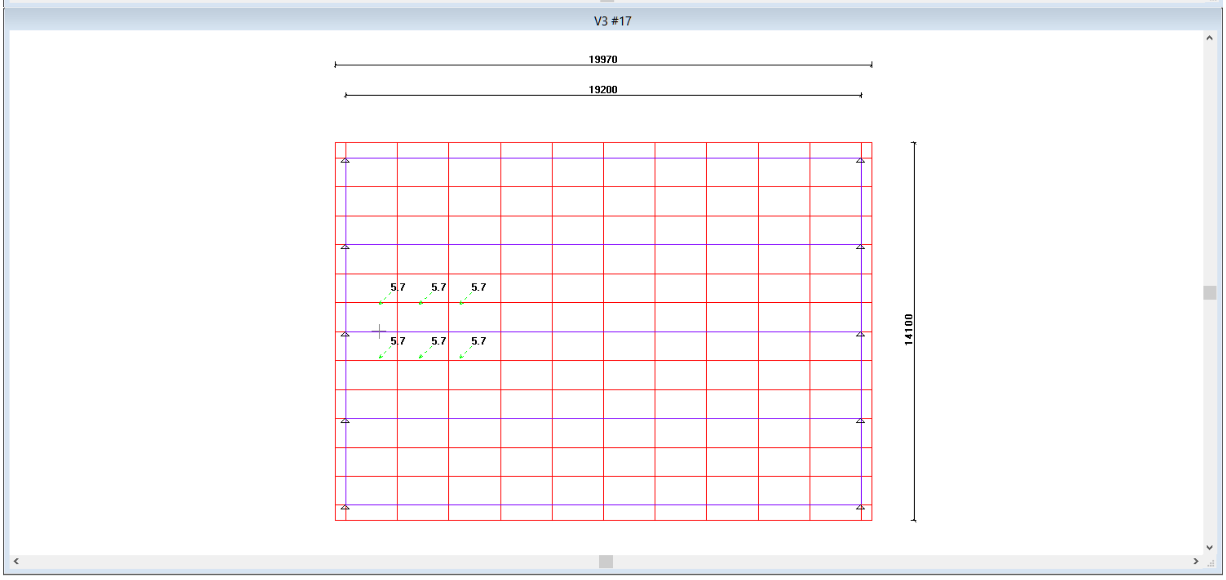
-0.38


V3 #17
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14100
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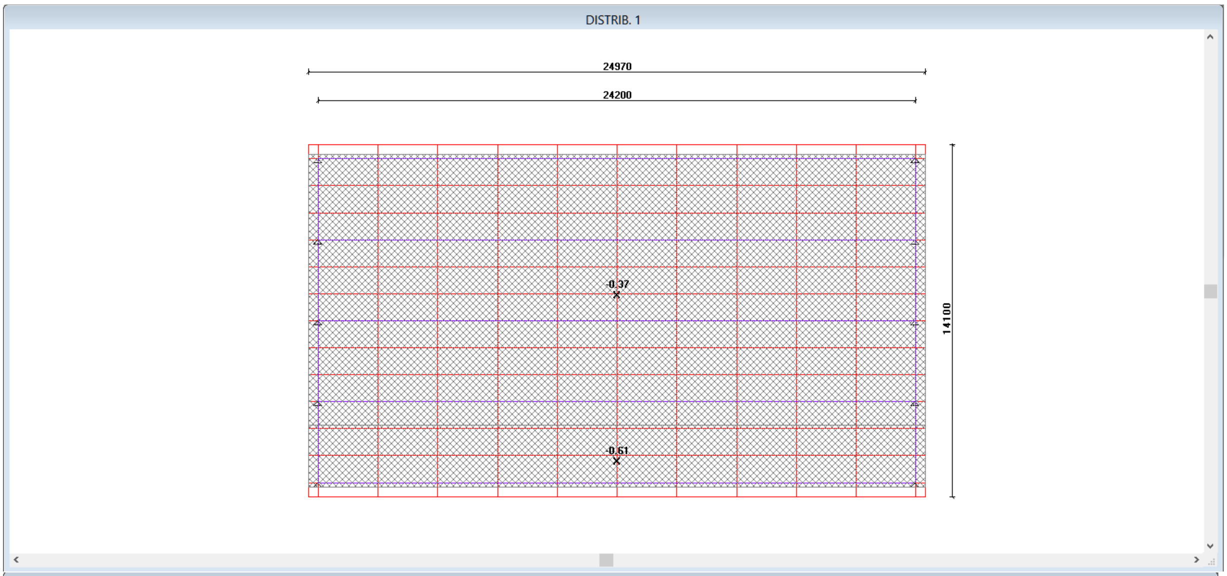
5.7
5.7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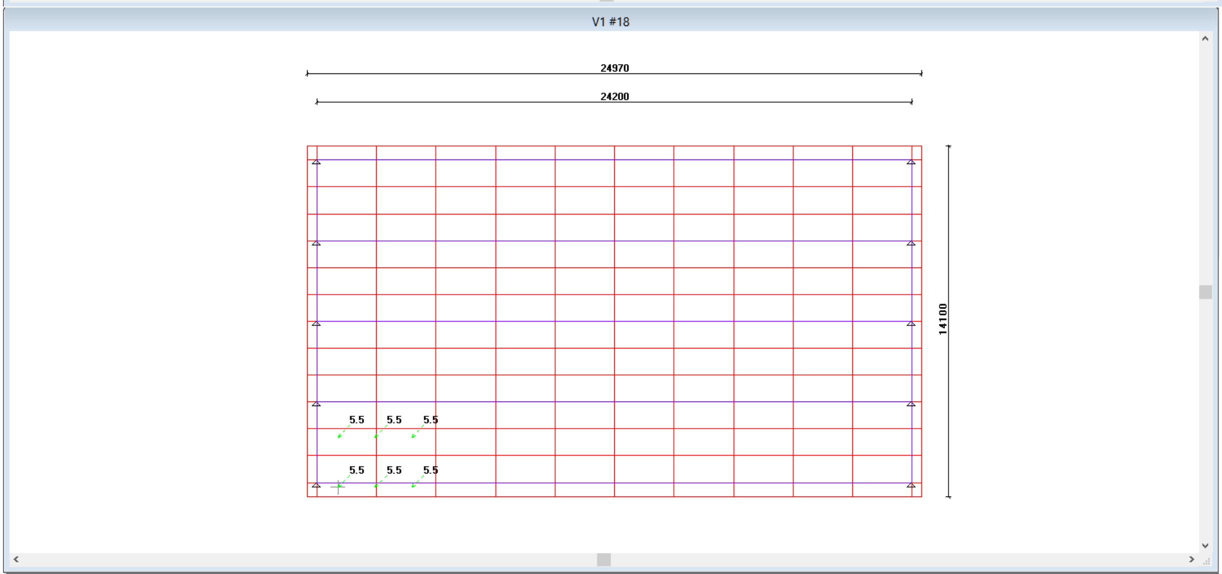
14100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5.5
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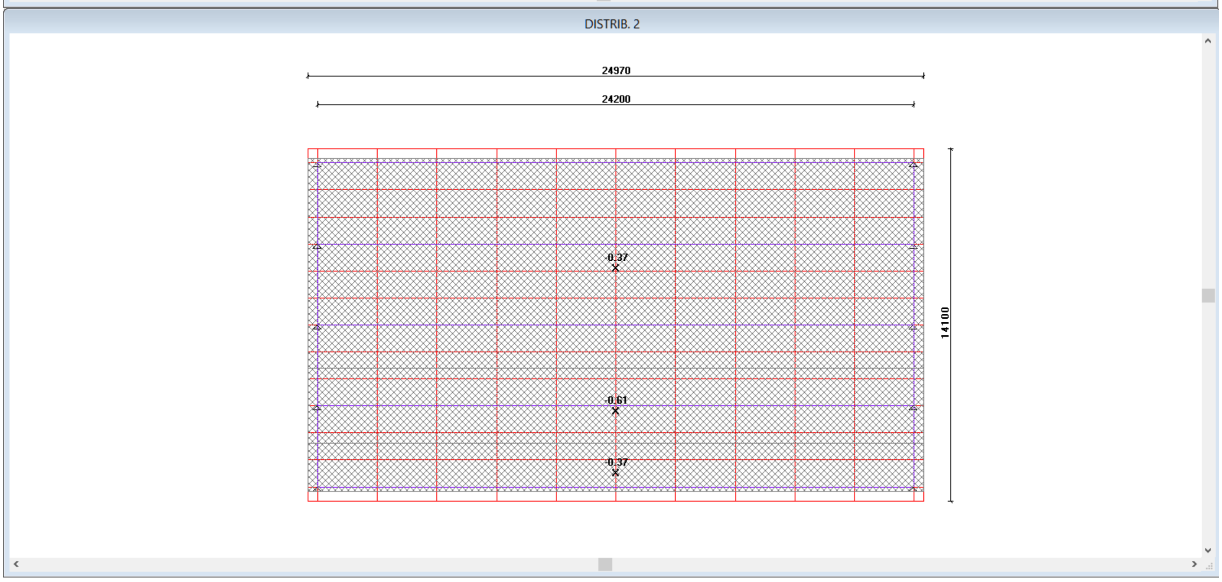
5.5
5.5
14100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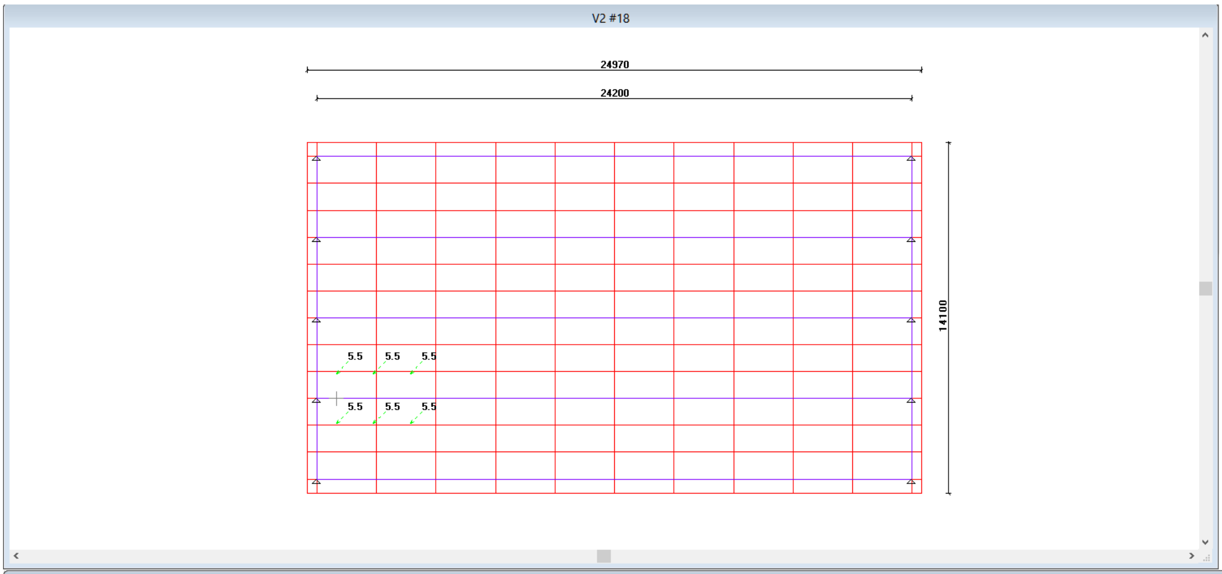
-0.37
14100


V2 #18
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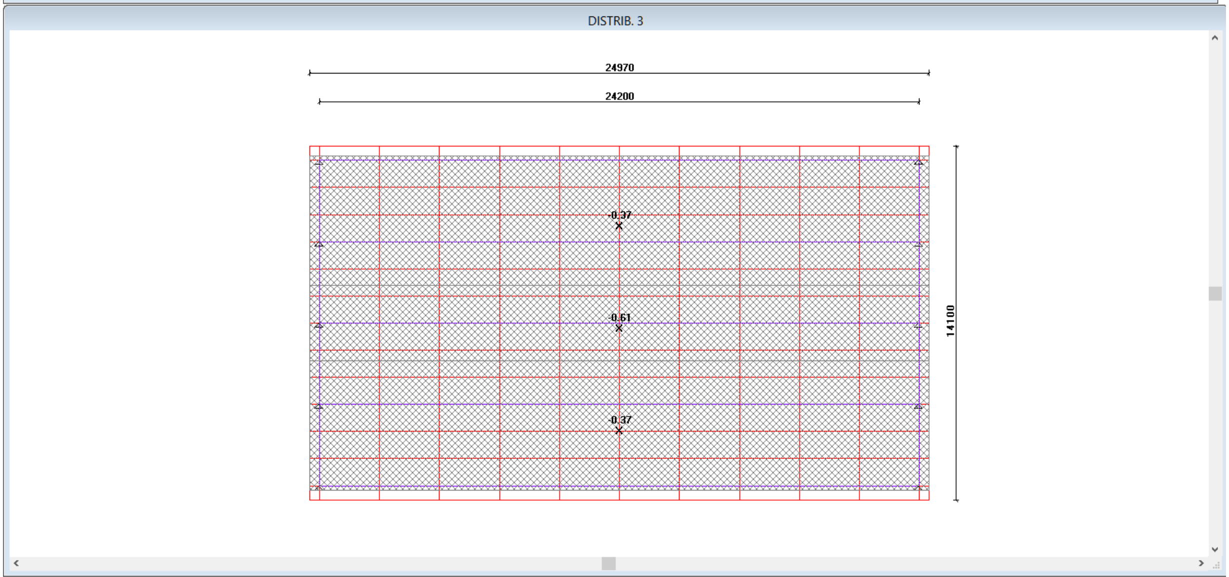
24200
14100
5.5
5.5
5.5
5.5
5.5
5.5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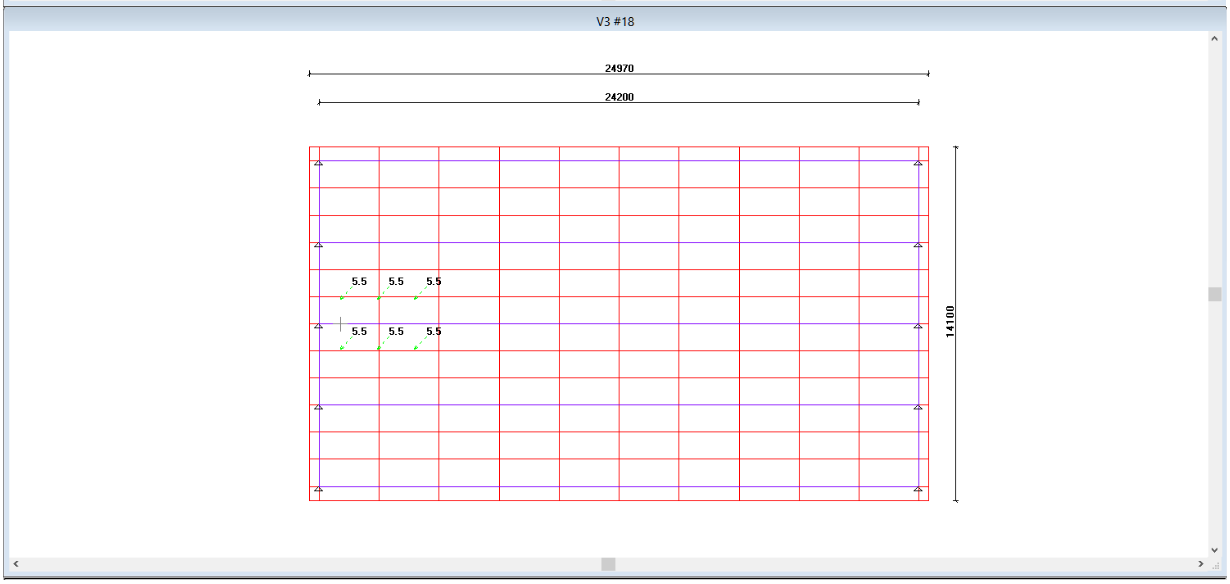
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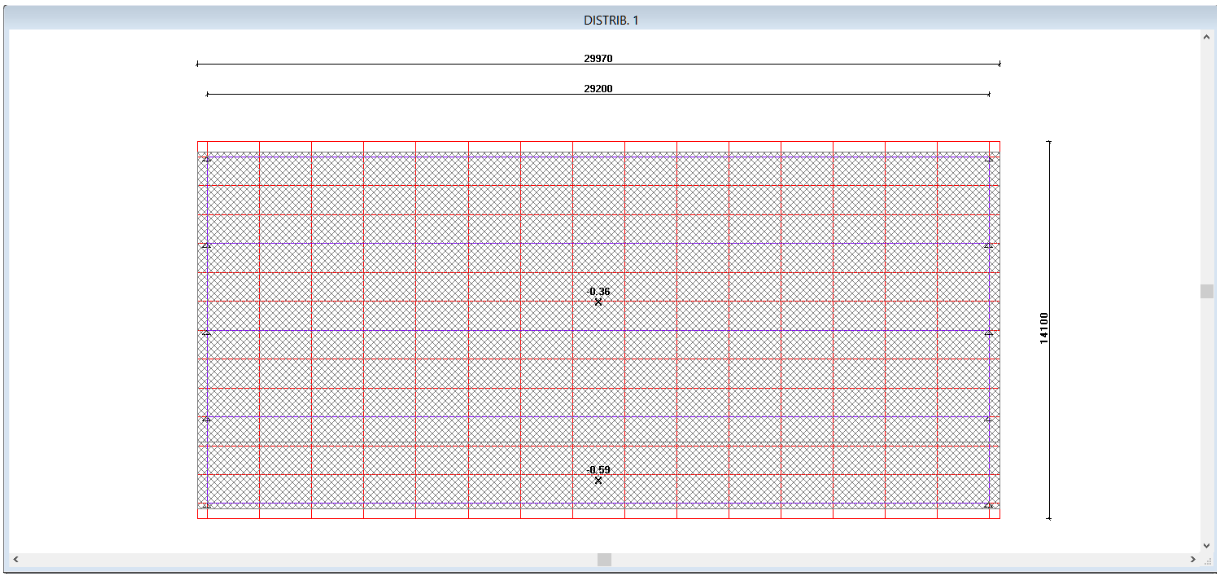
5.5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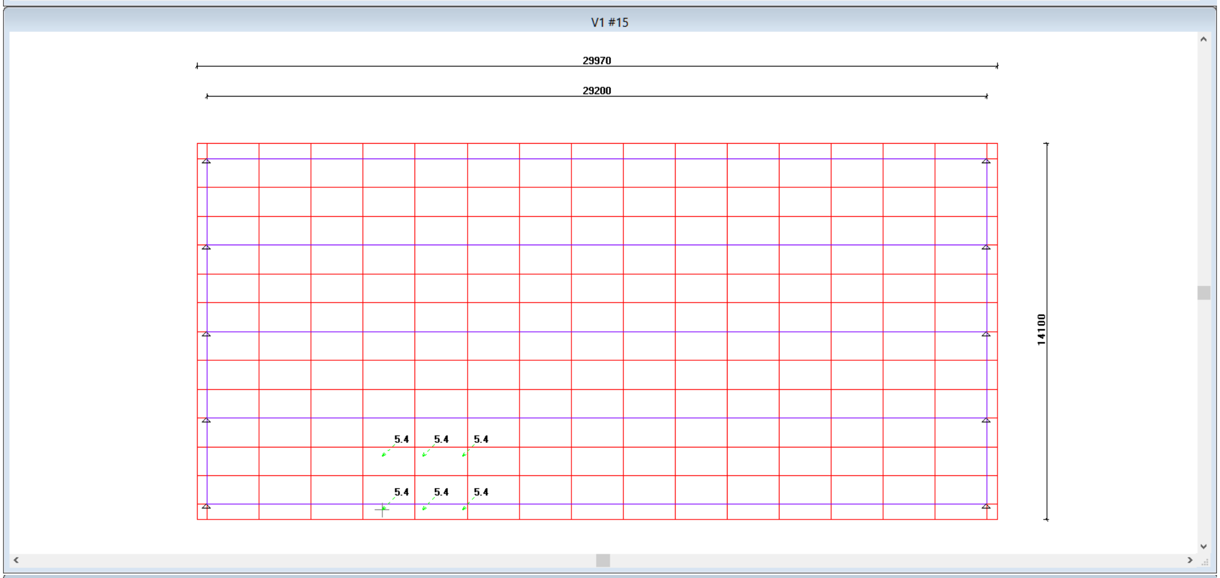
-0.59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14100
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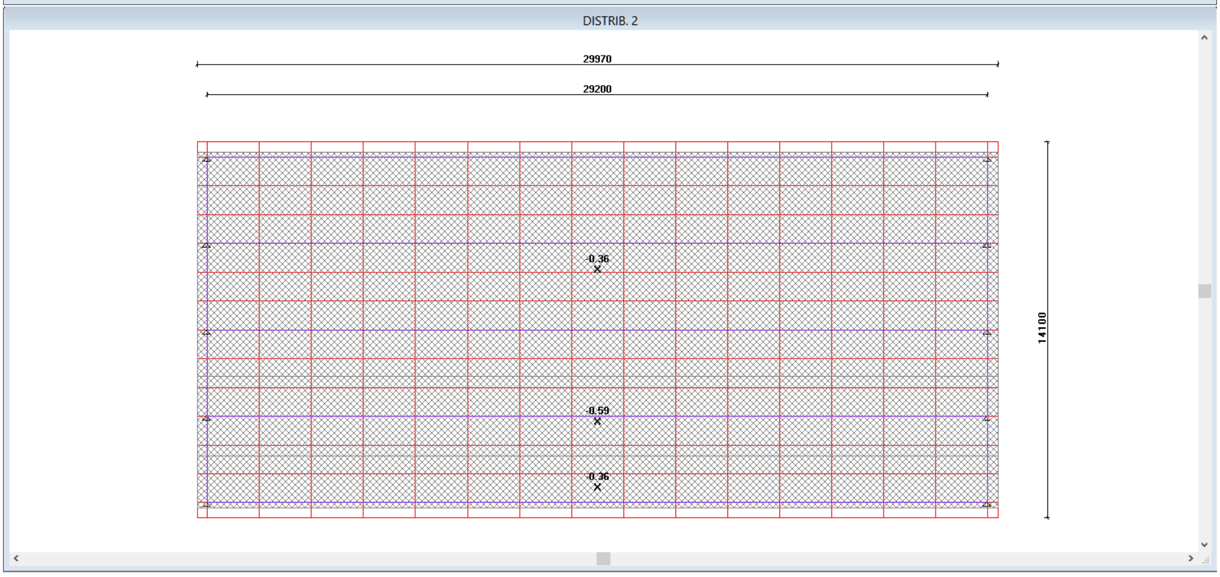
5.4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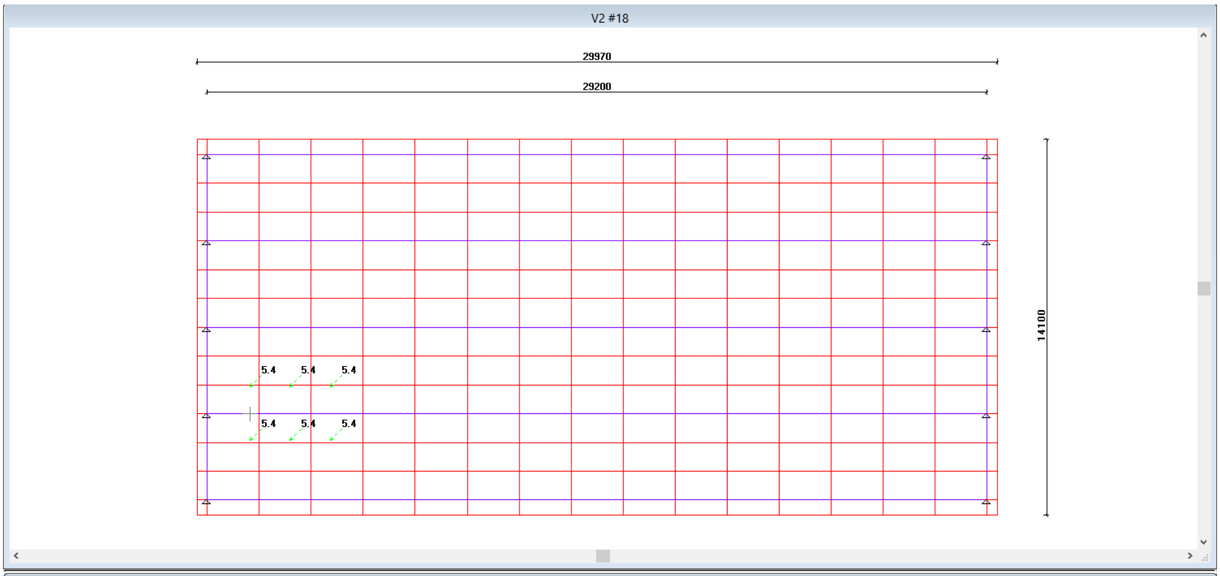
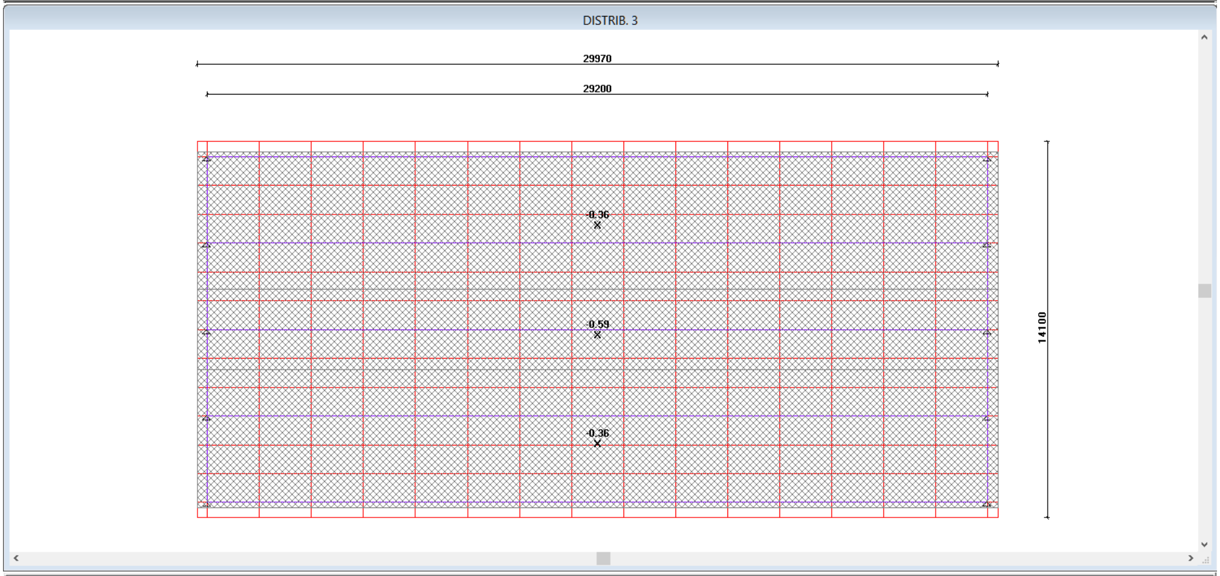
-0.36


V2 #18
29970
29200
14100
5.4
5.4
5.4
5.4
5.4
5.4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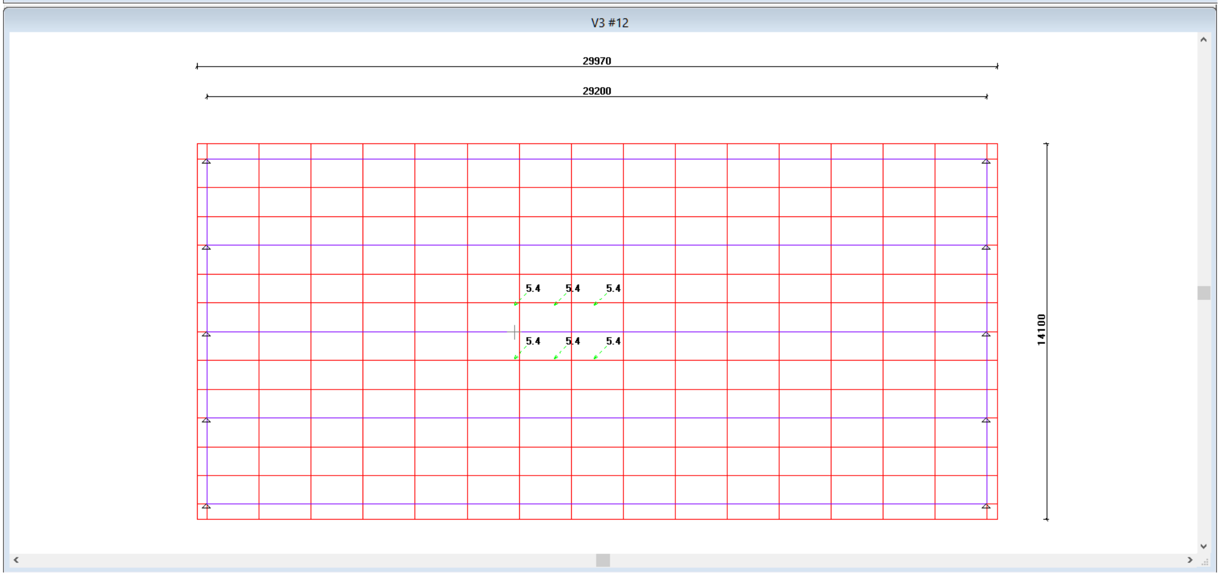
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14100
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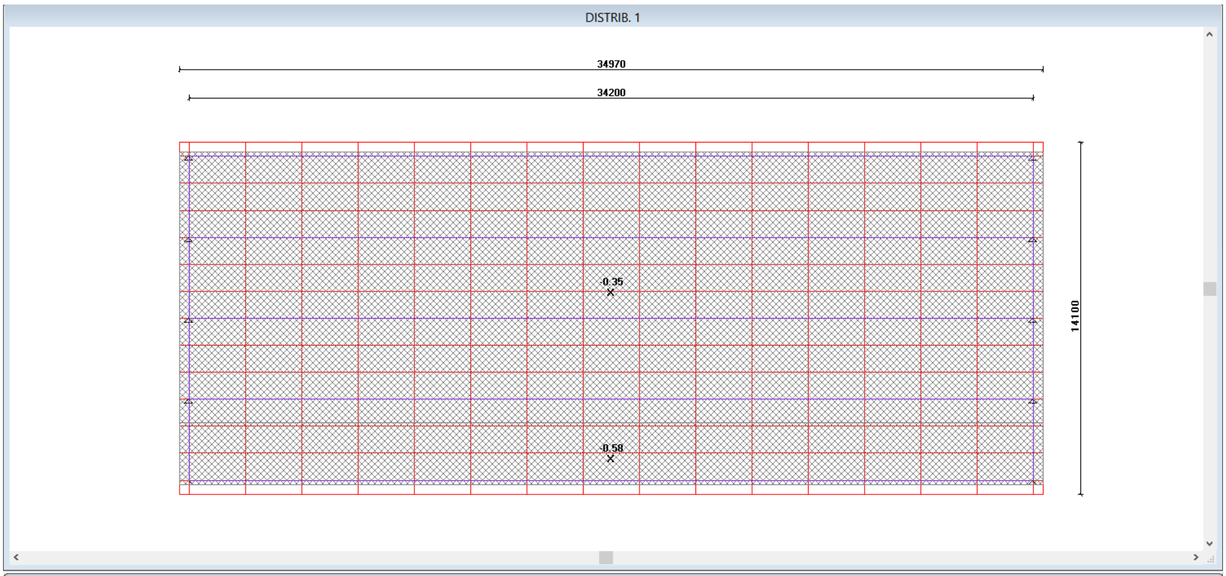
5.4
5.4
5.4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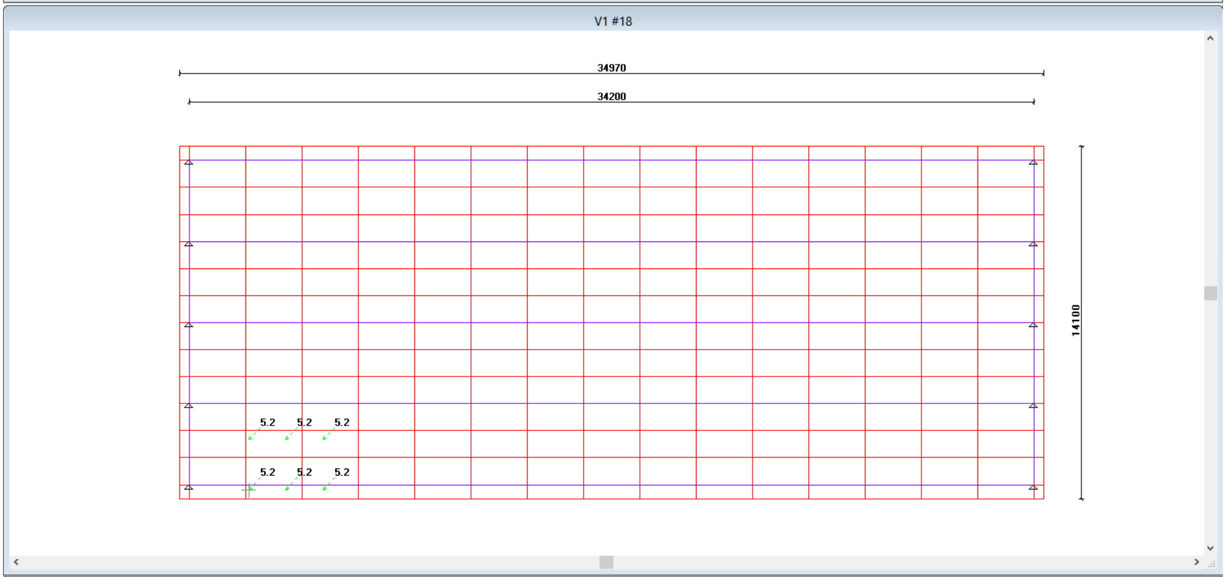
-0.58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14100
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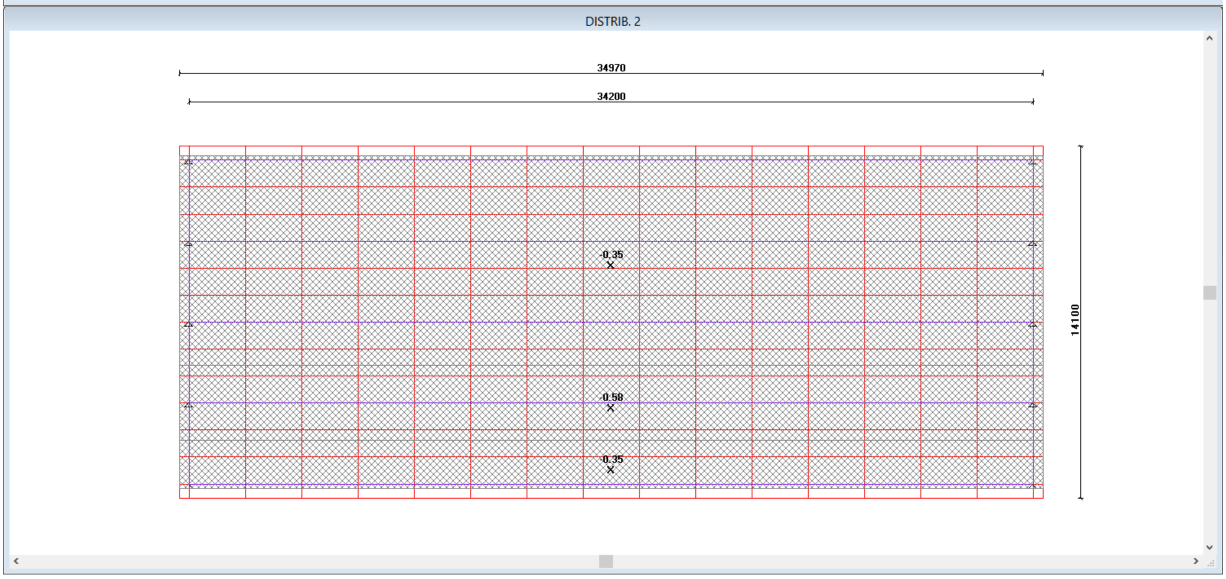
5.2
5.2
5.2
5.2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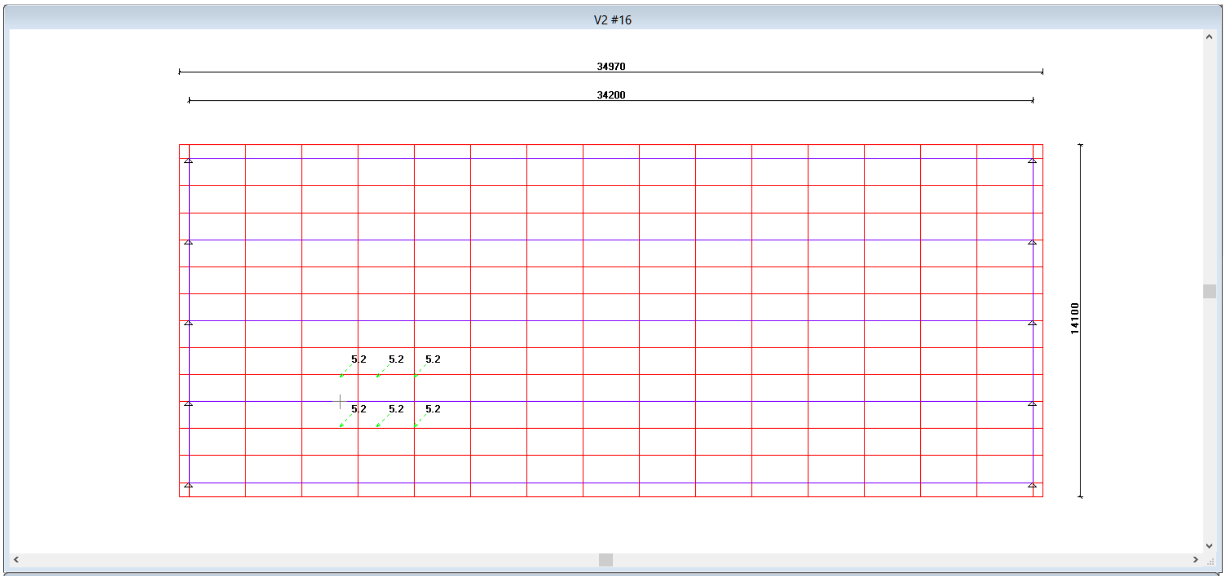
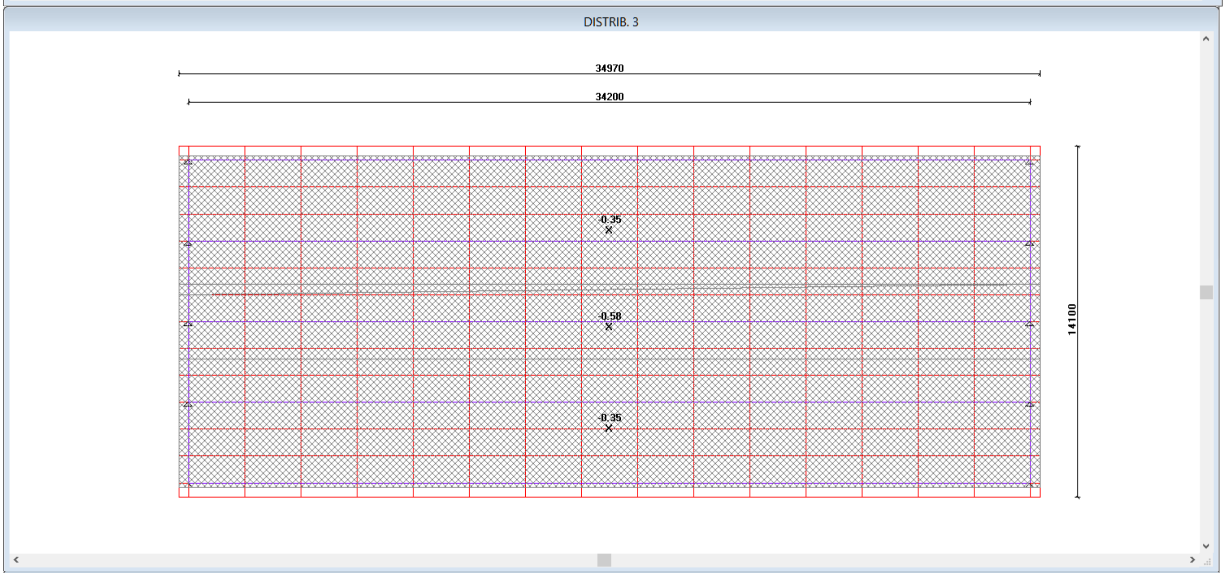
34200
14100
-0.35
-0.58
-0.35


V2 #16
34970
34200
14100
5.2
5.2
5.2
5.2
5.2
5.2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14100
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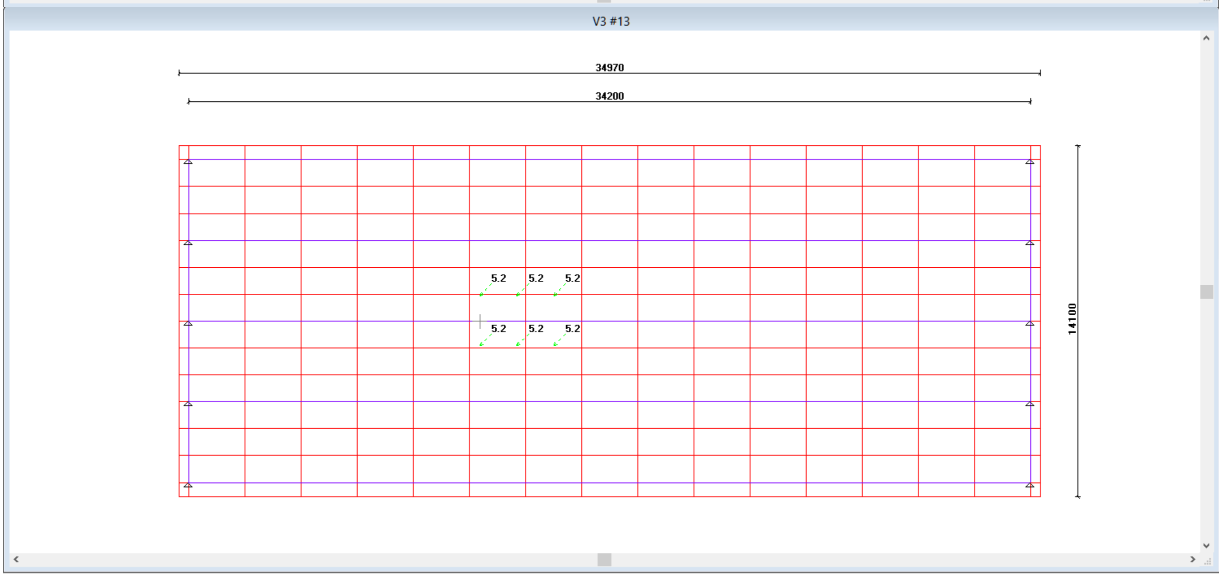
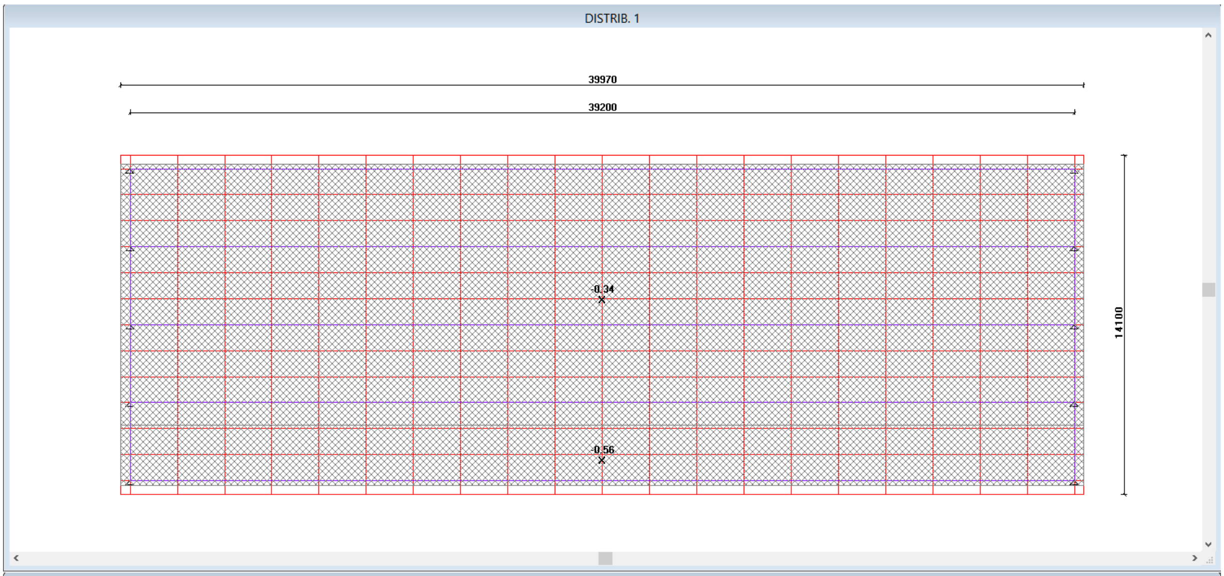
-0.35


V3 #13
34970
34200
14100
5.2
5.2
5.2
5.2
5.2
5.2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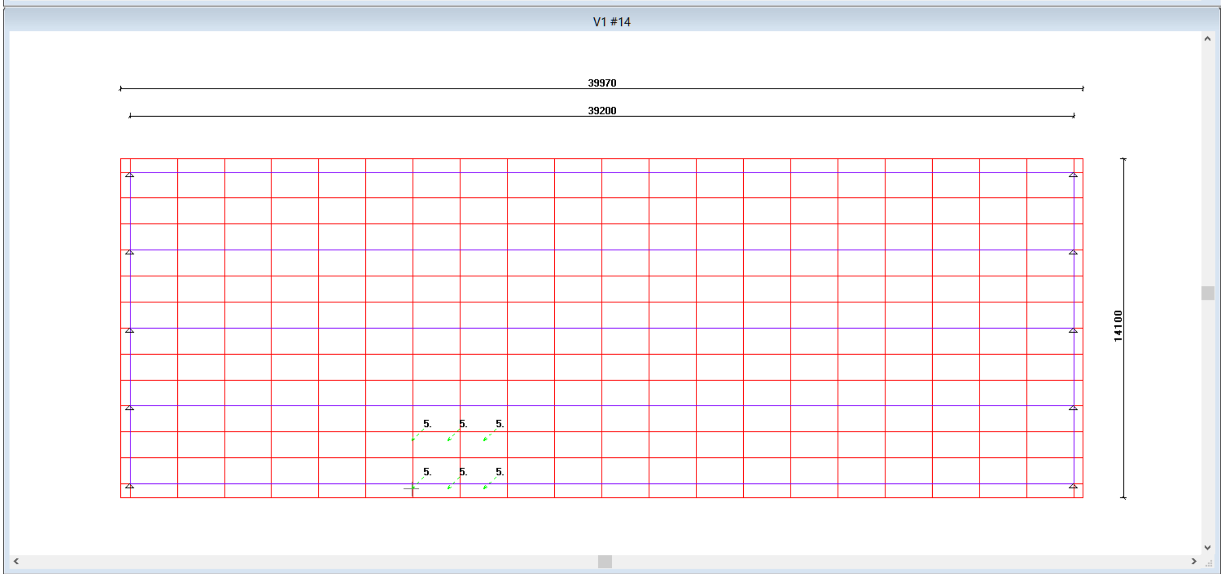
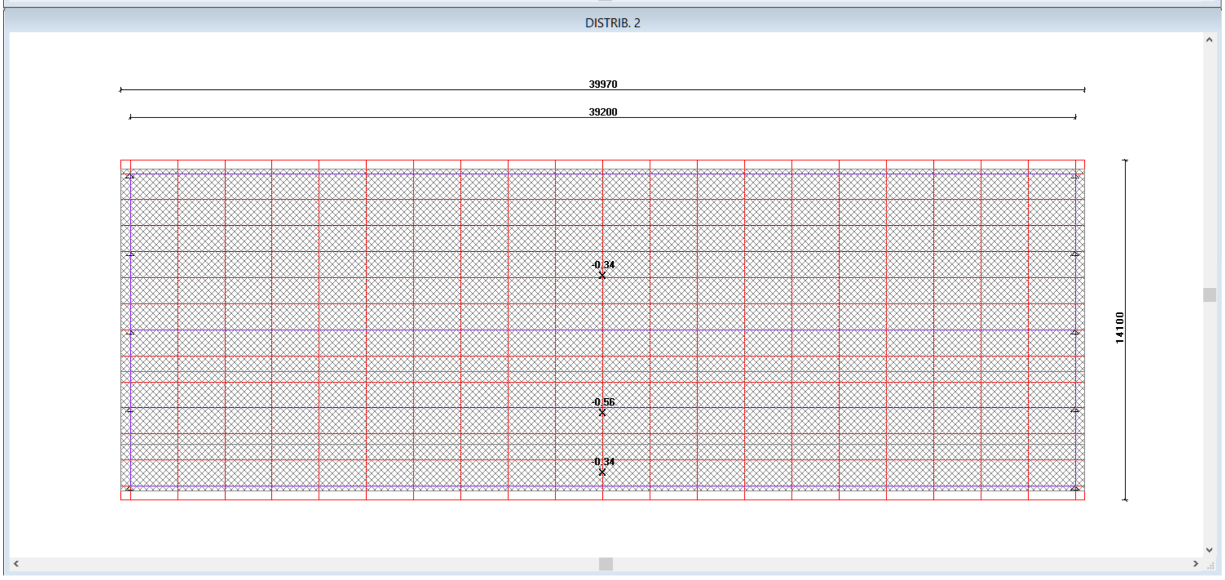

V1 #14
39970
39200
5.
5.
5.
5.
5.
5.
14100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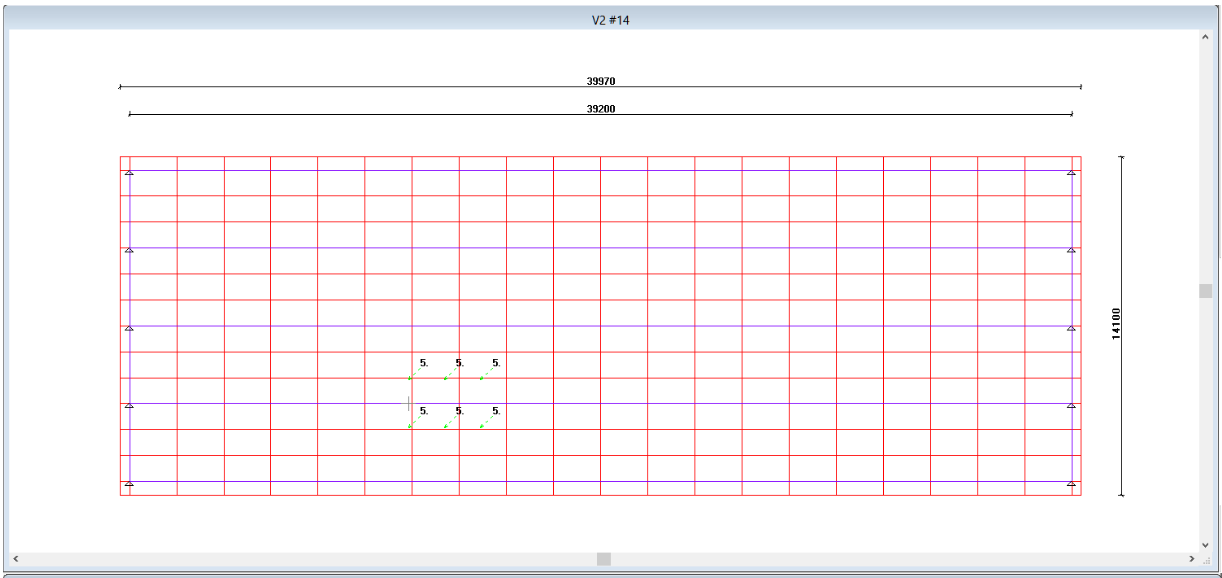
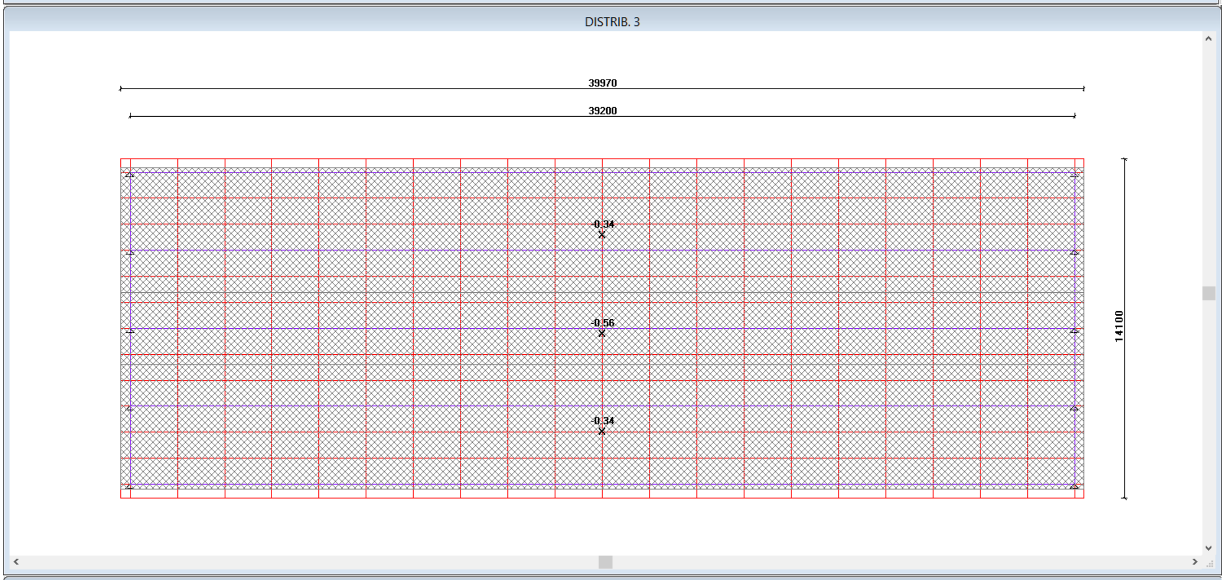
-0.56
-0.34
14100


V2 #14
39970
39200
14100
5. 5. 5.
5. 5. 5.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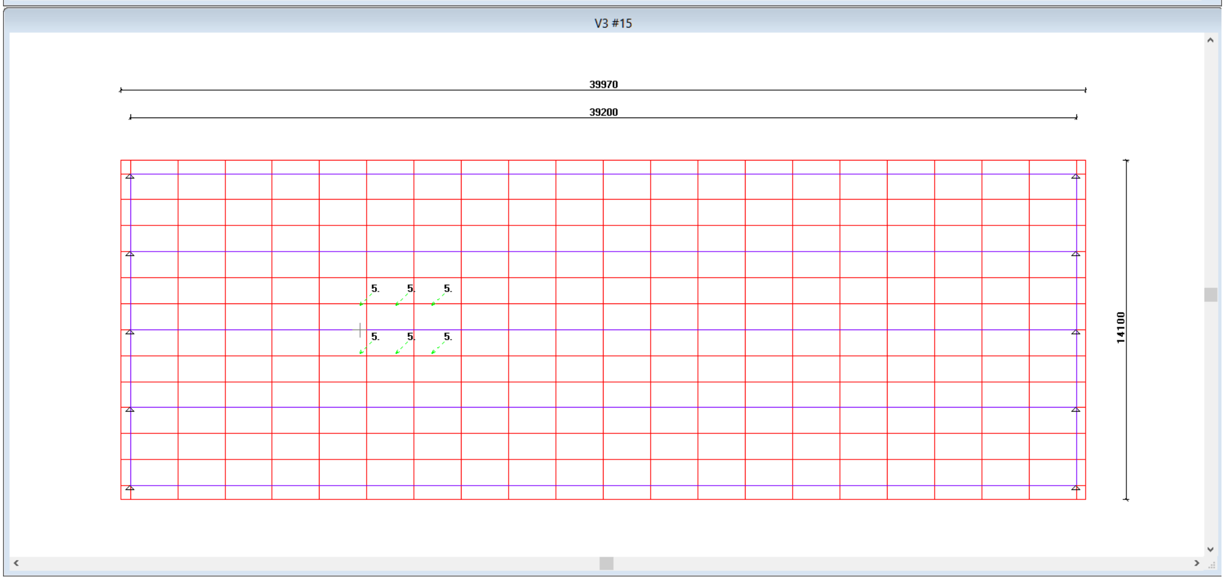
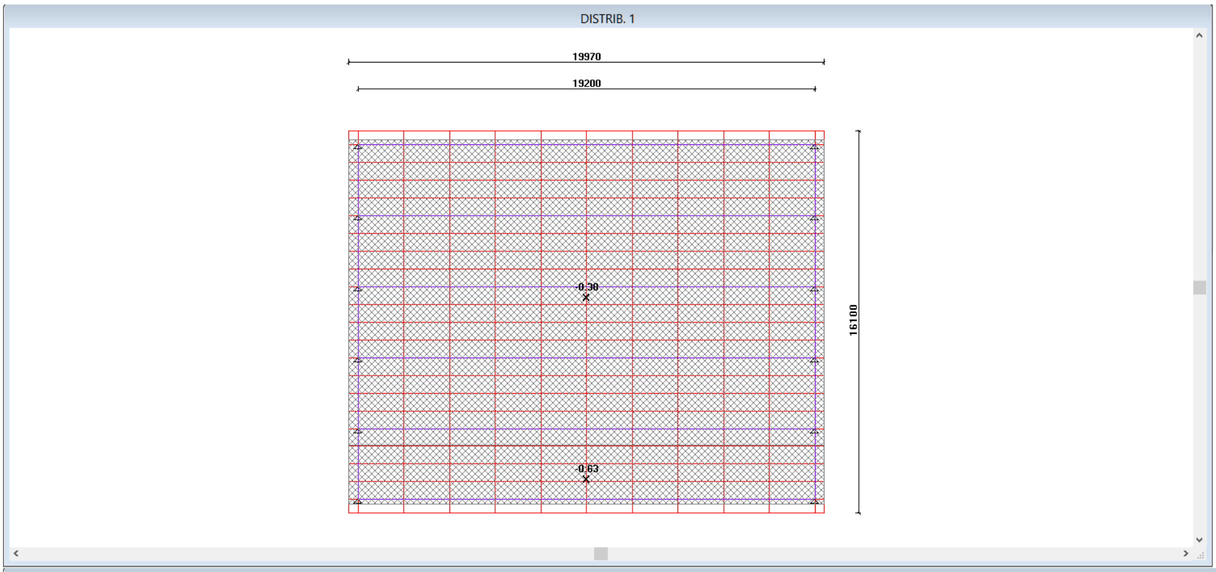
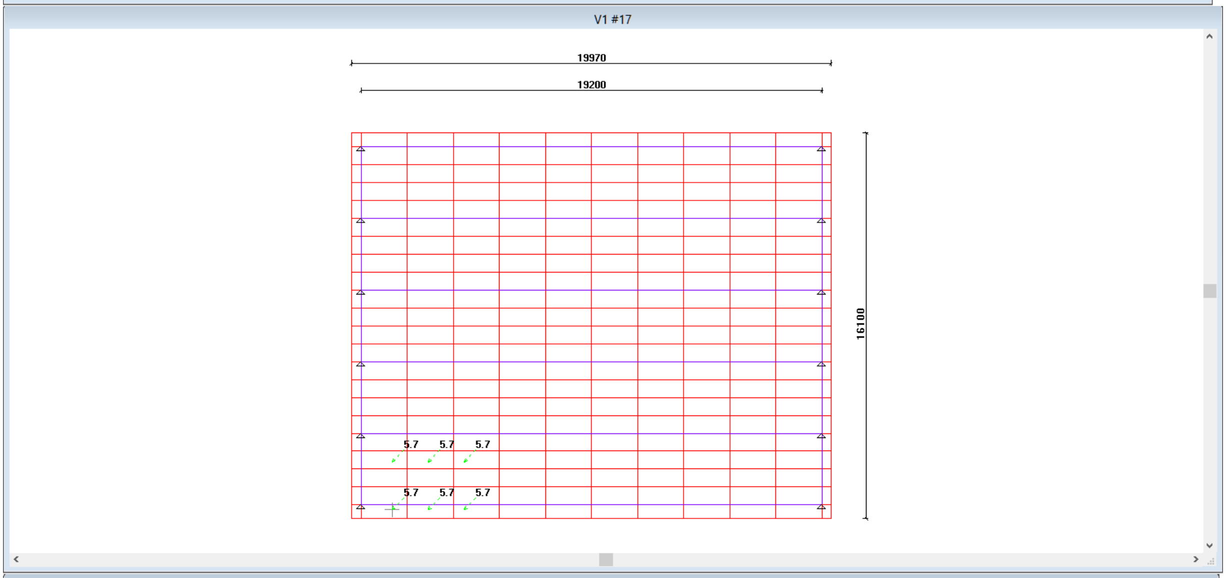
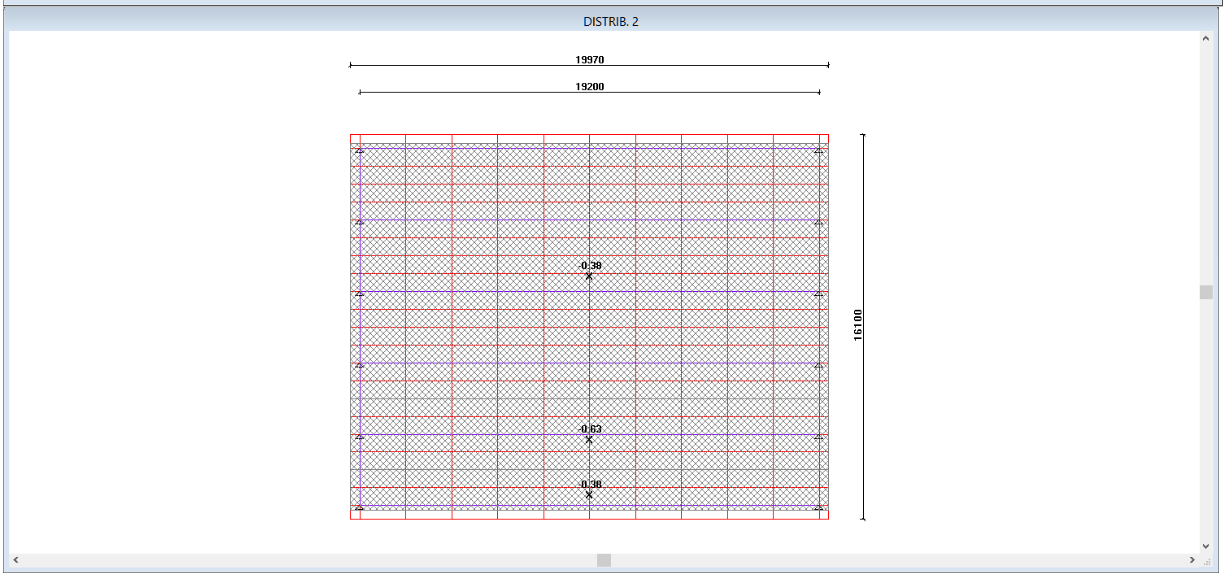
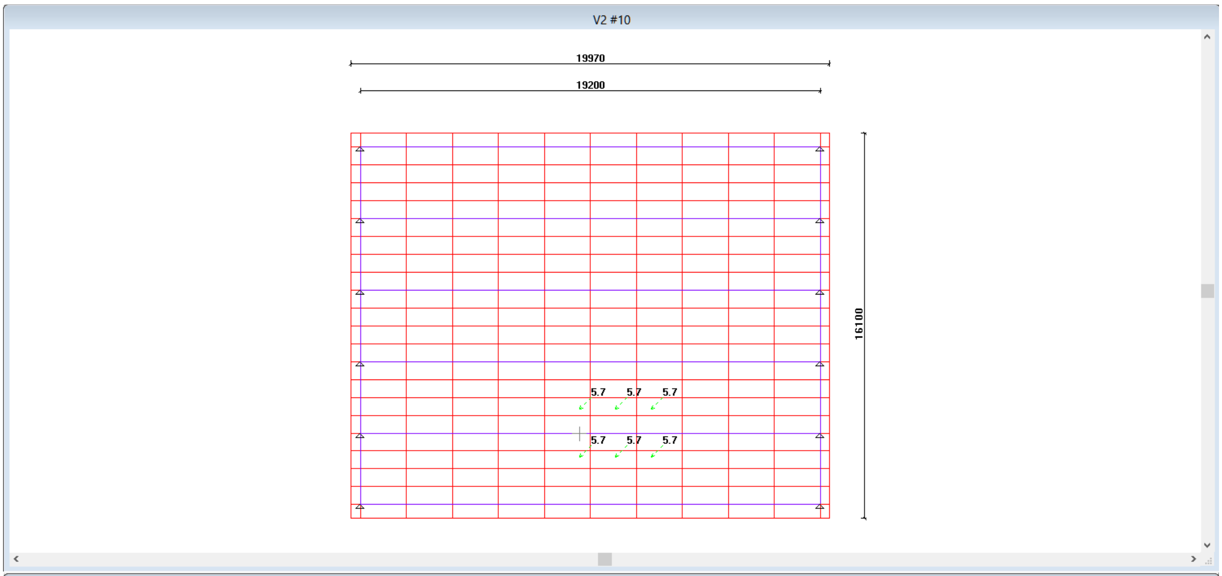

V3 #15
39970
39200
14100
5. 5. 5.
5. 5. 5.

4.4.4. Tabuleiro 16,10 m





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19970
19200
16100
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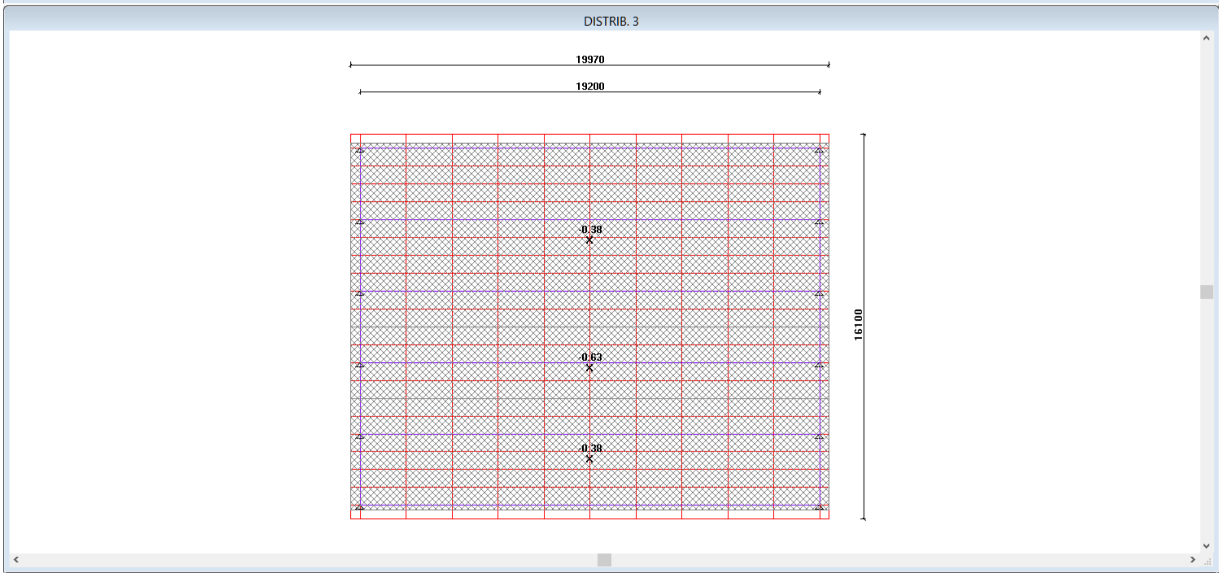
5.7
5.7
5.7
5.7
5.7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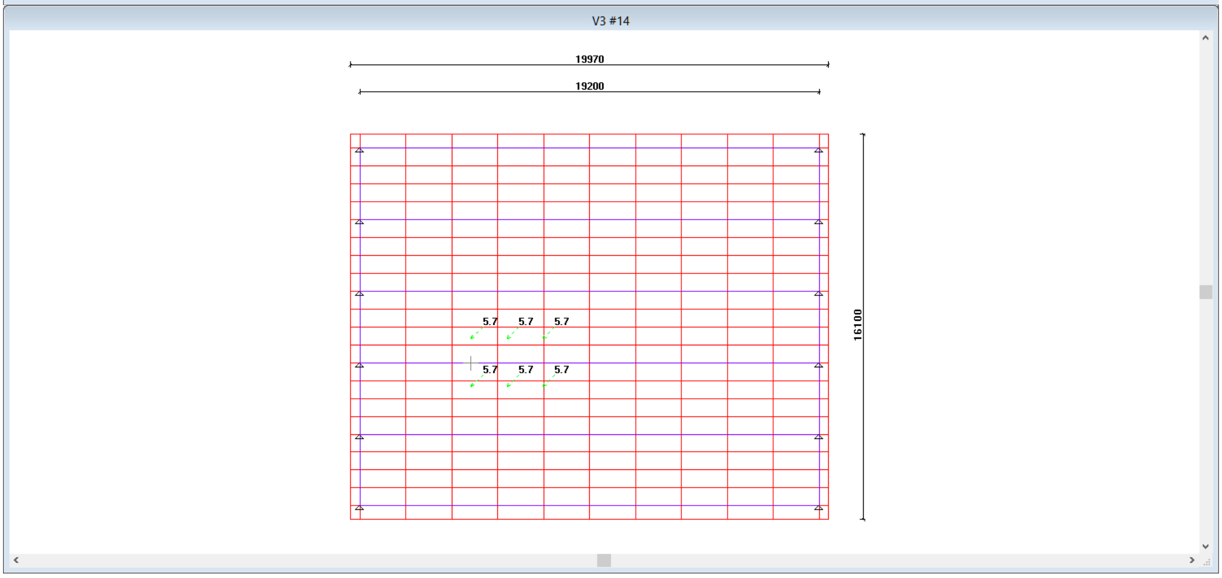
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16100
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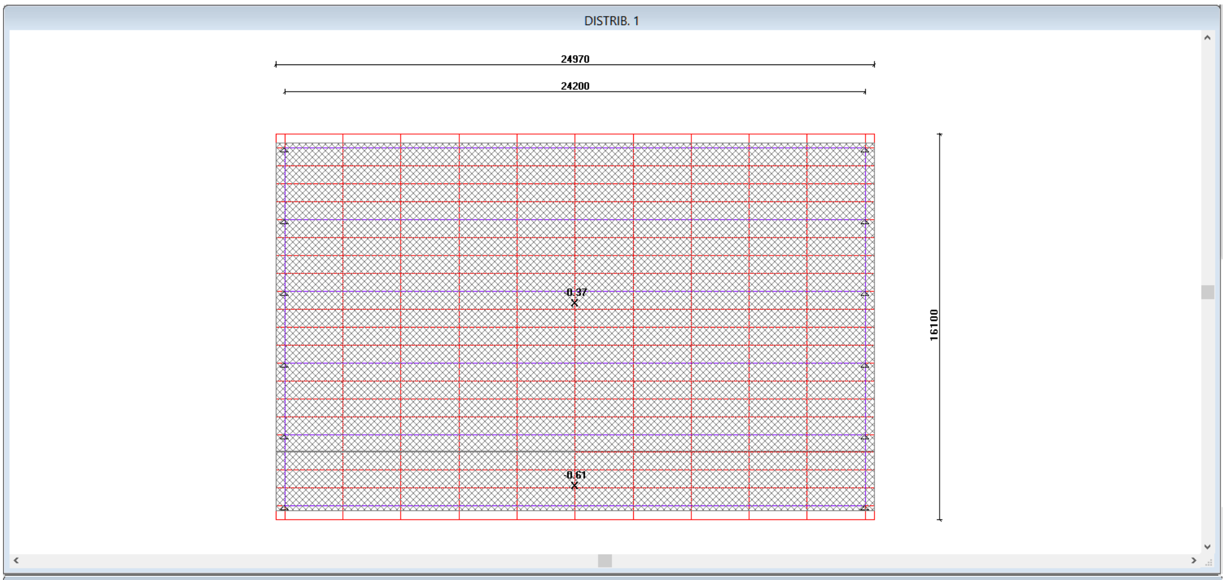
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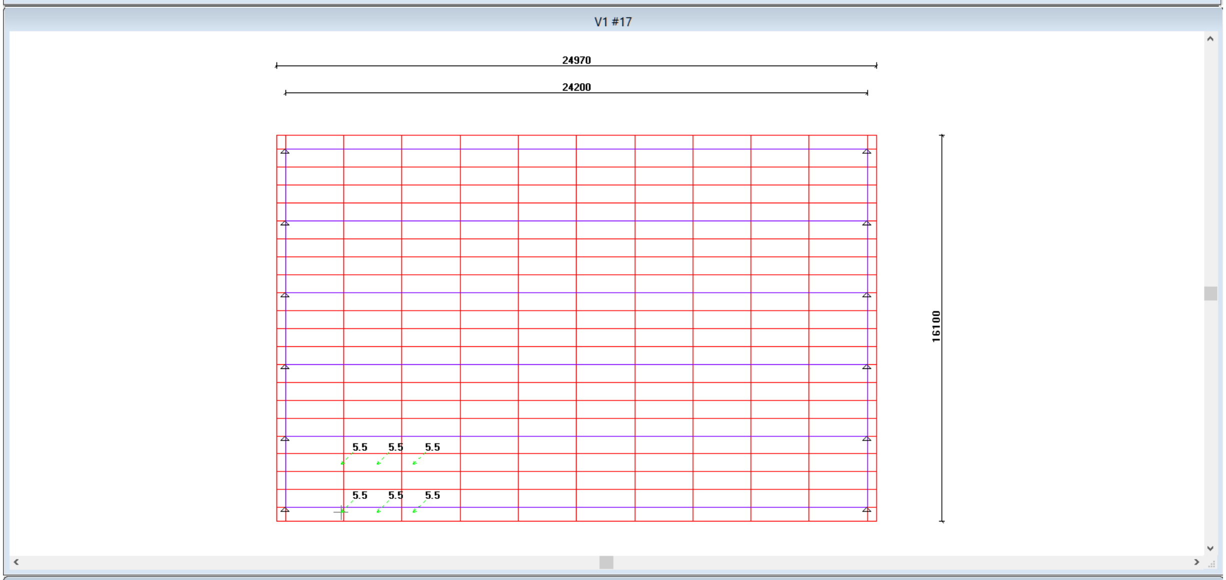
16100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5.5
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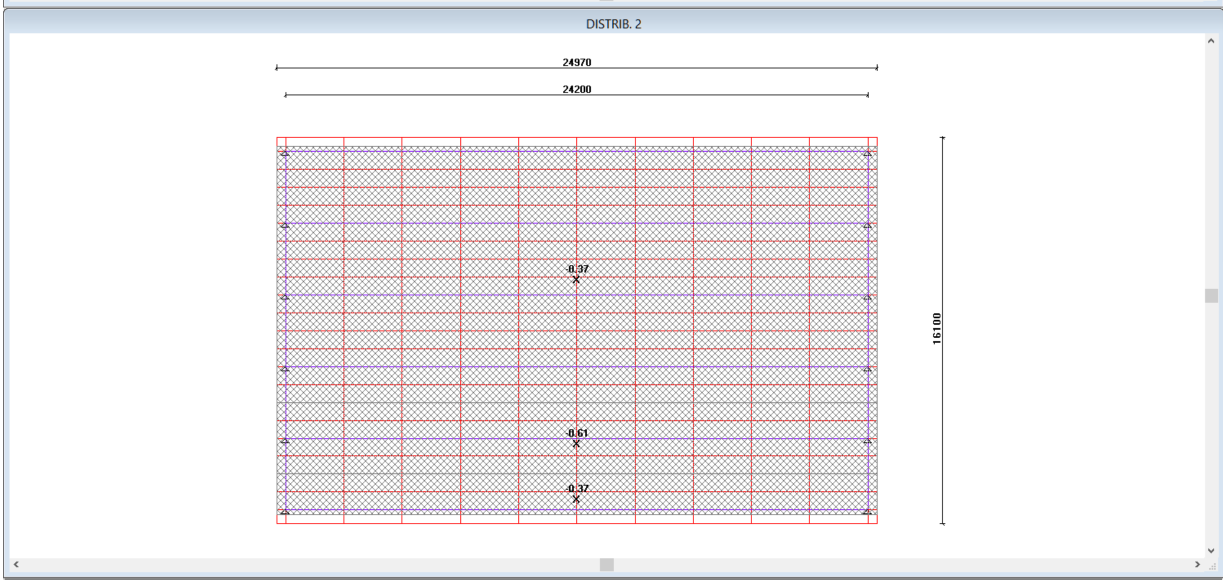
5.5
5.5
16100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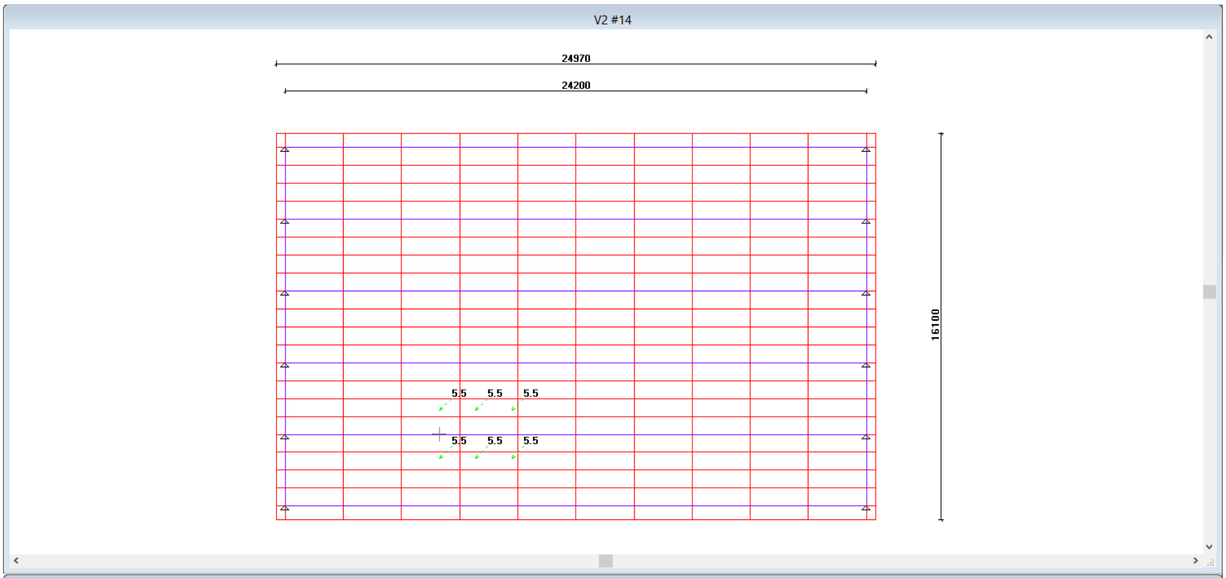
V2 #14
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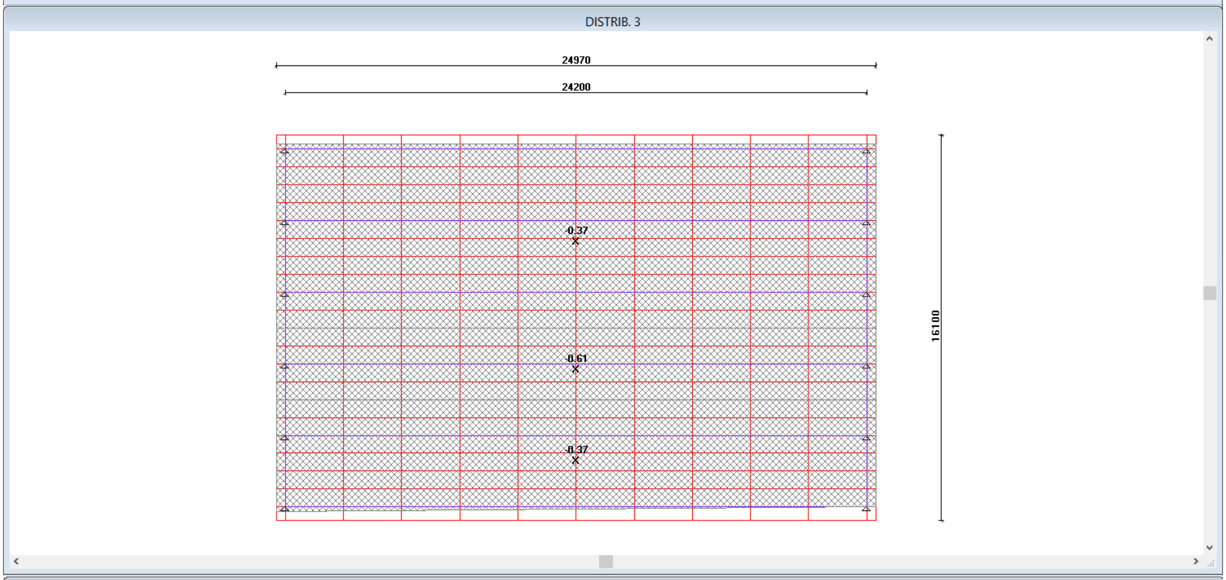
24200
16100
5.5 5.5 5.5
5.5 5.5 5.5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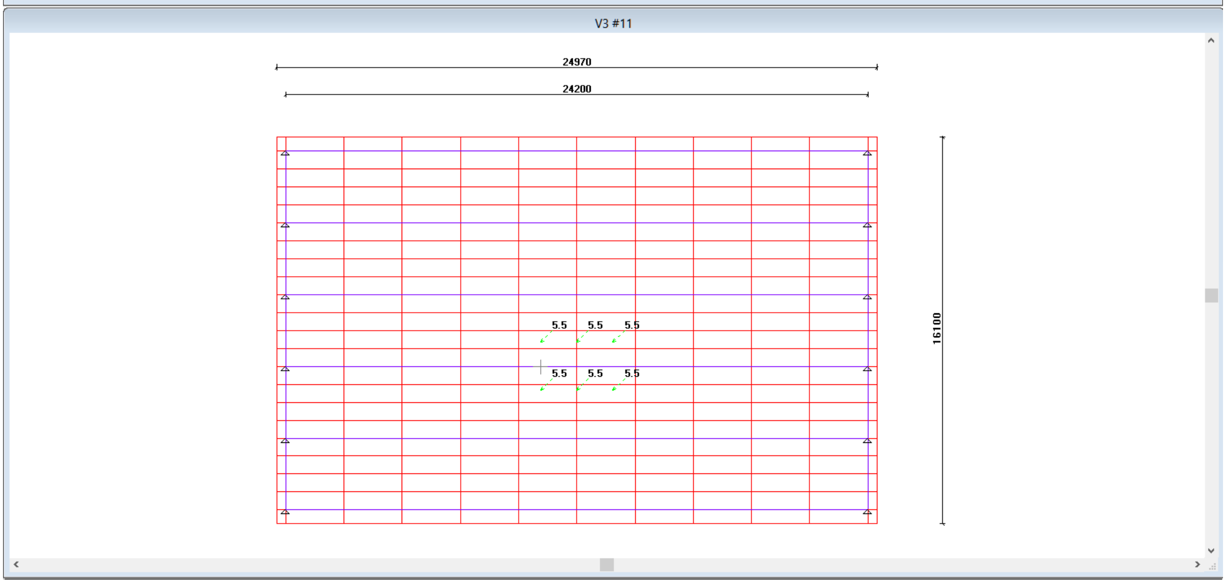
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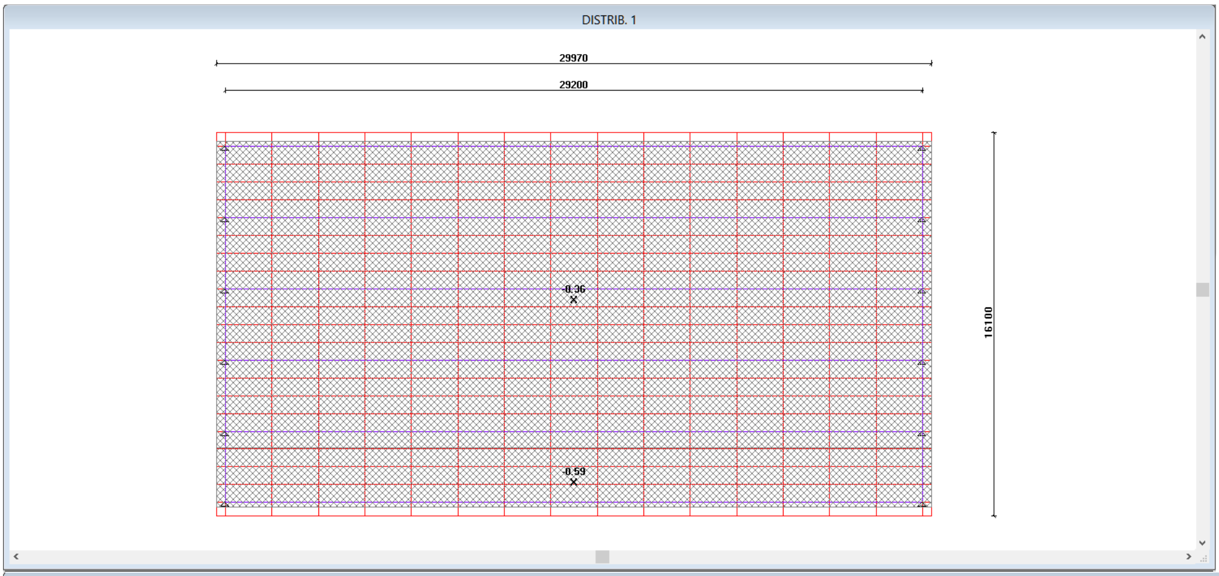
5.5 5.5 5.5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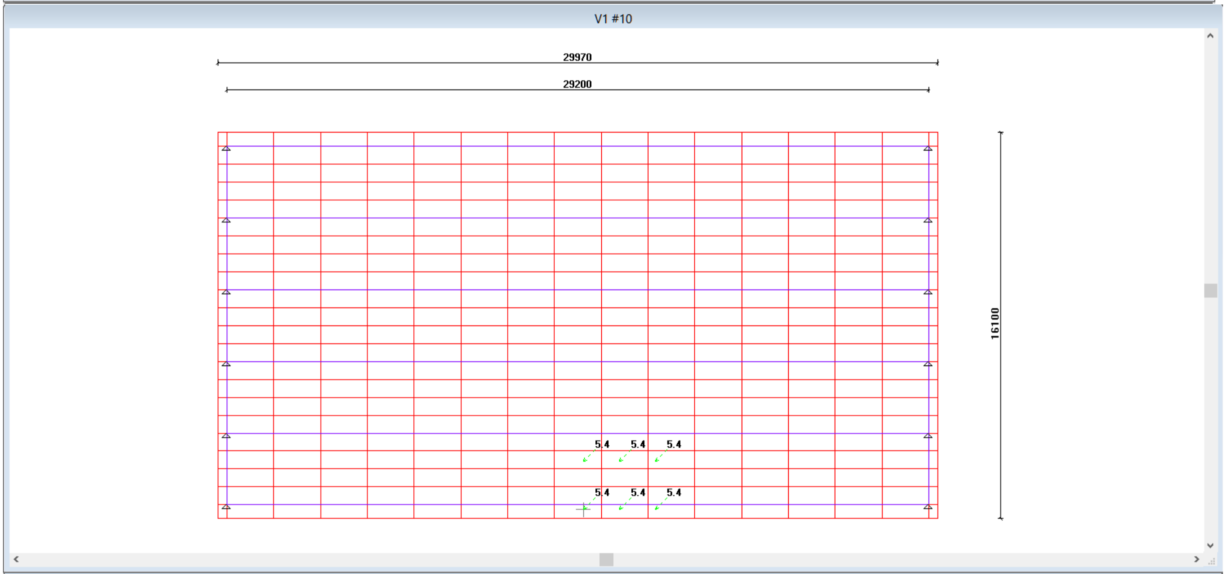
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29200
16100
5.4
5.4
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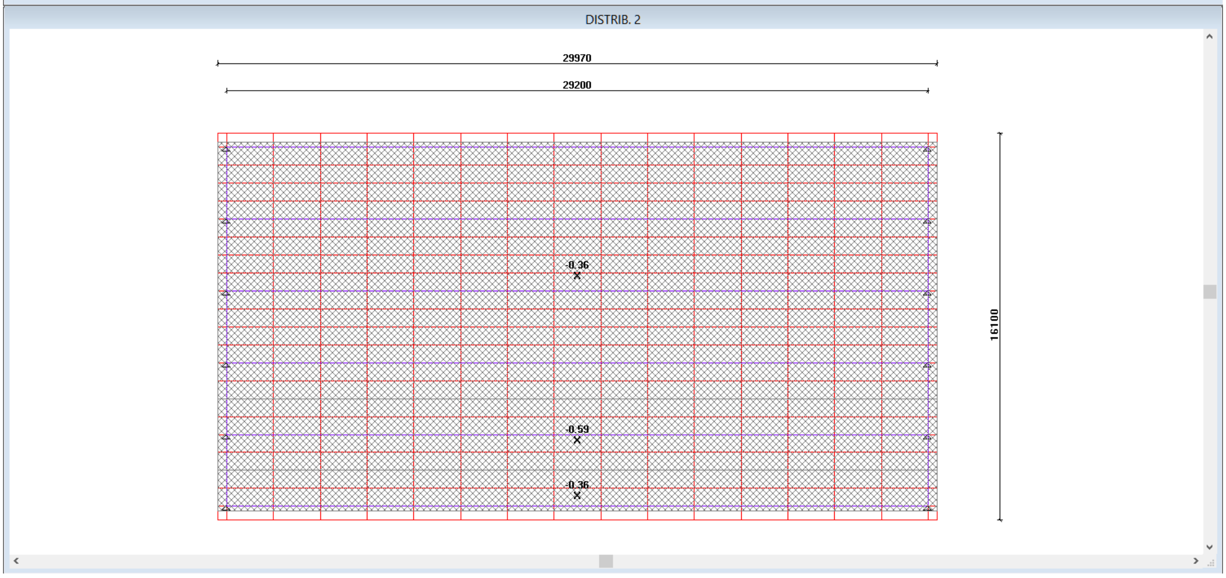
5.4
5.4
5.4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16100
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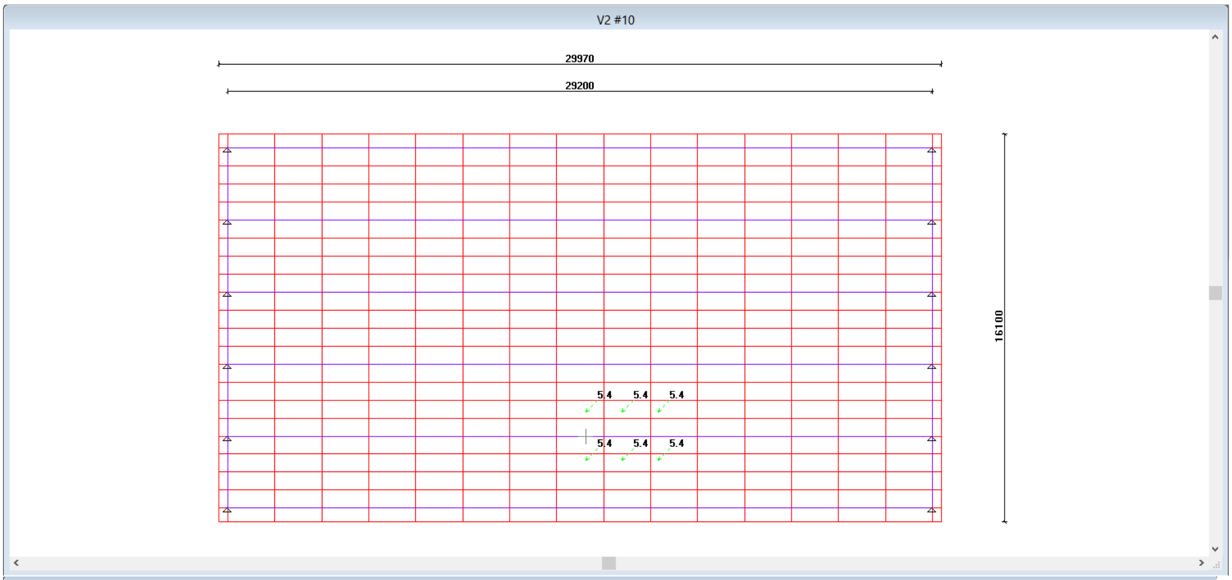
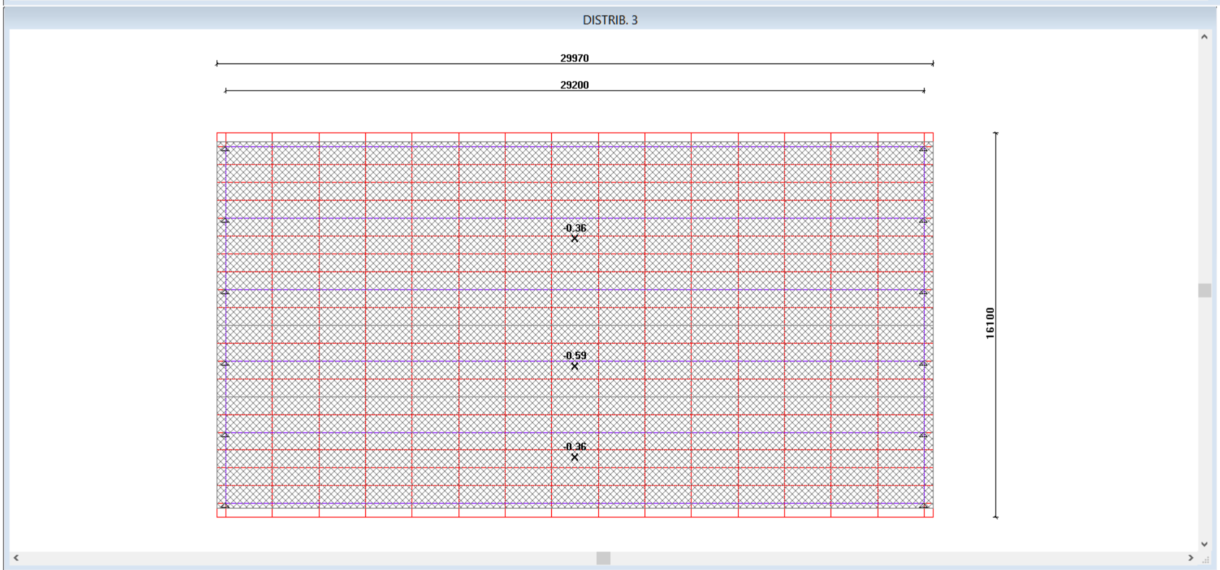

V2 #10
29970
29200
16100
5.4
5.4
5.4
5.4
5.4
5.4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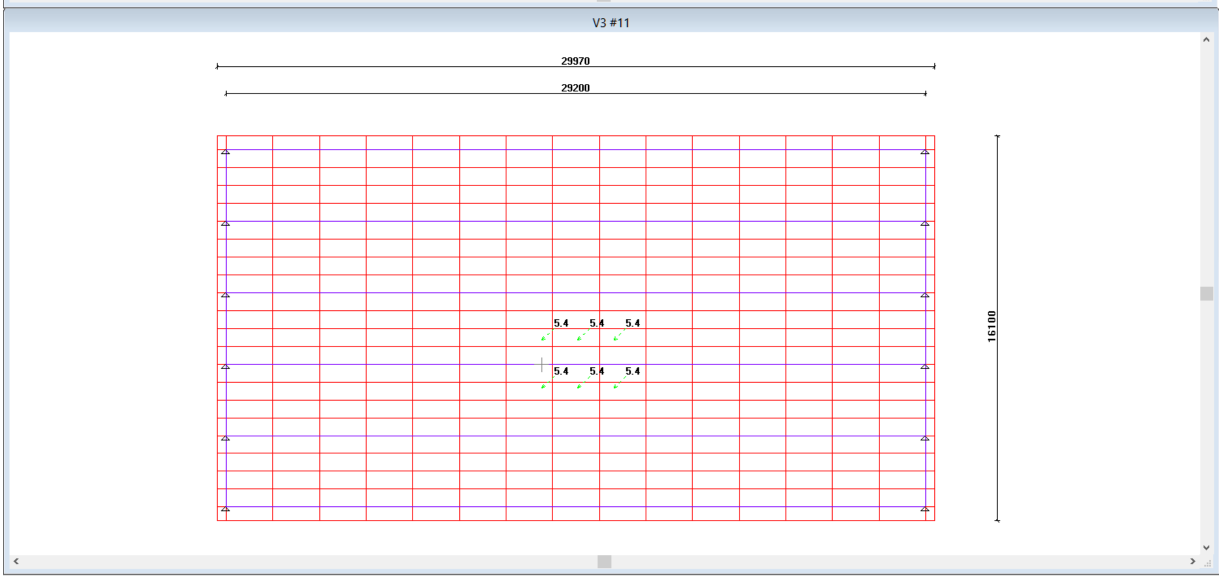
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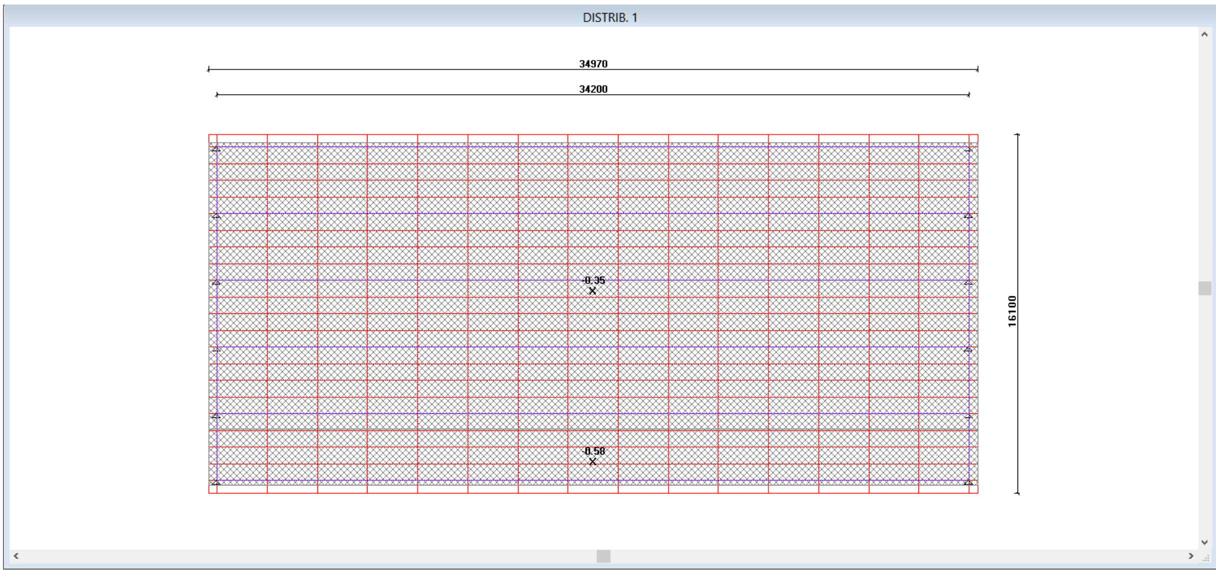
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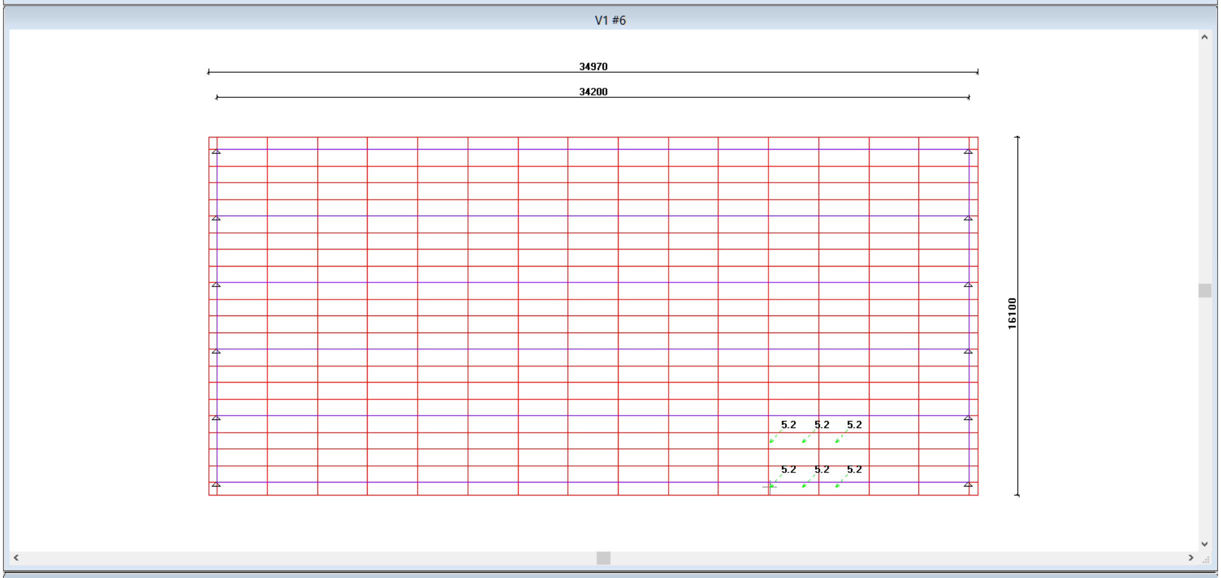
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16100
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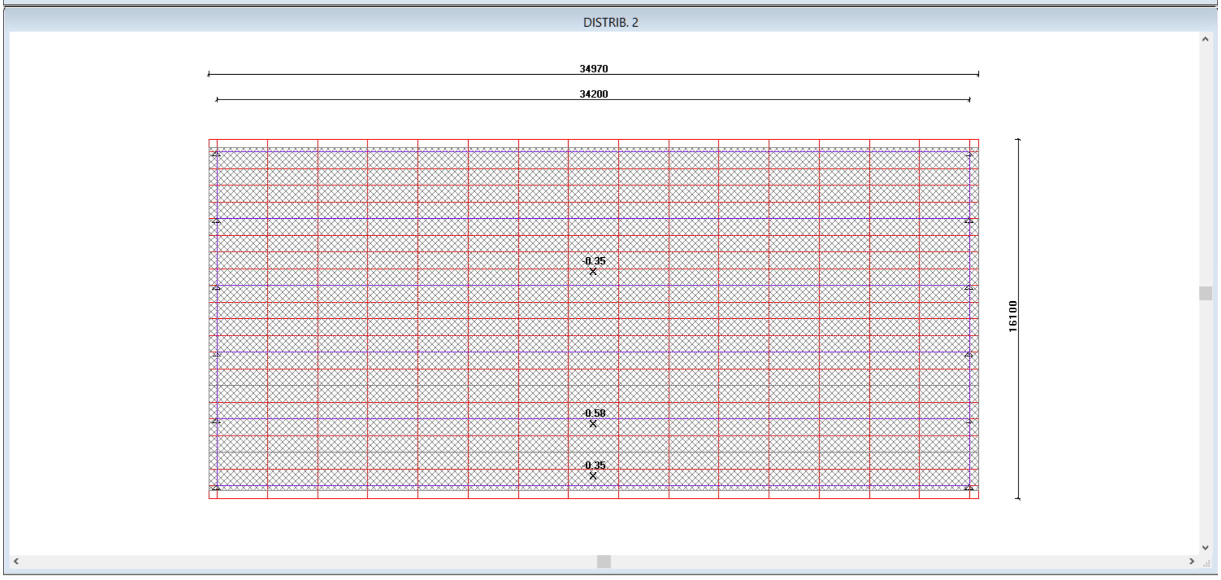
5.2 5.2 5.2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16100
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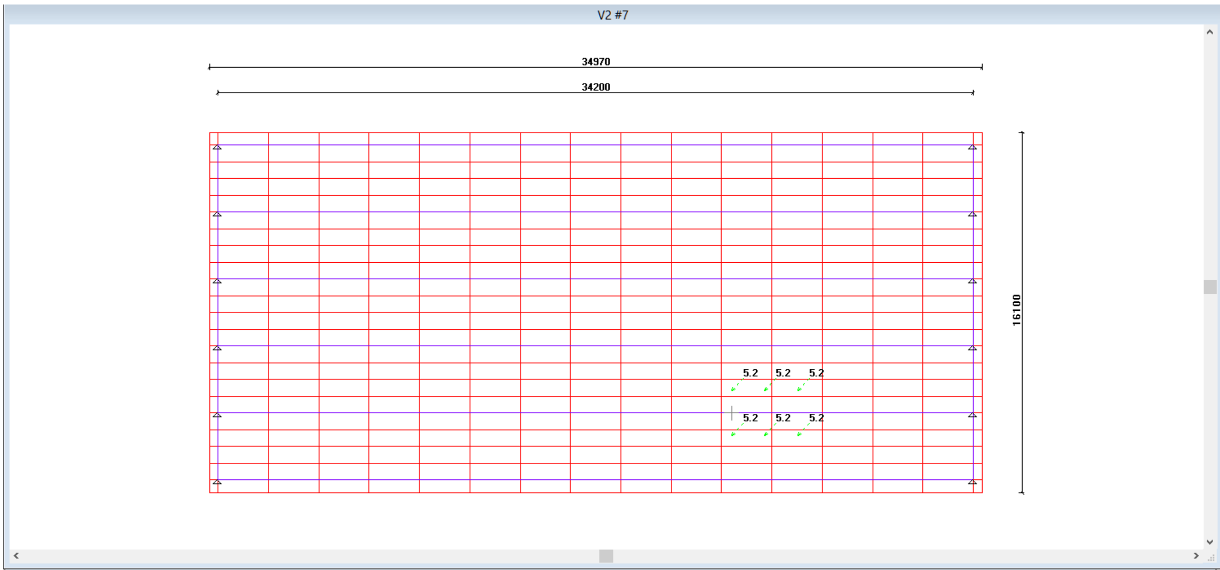
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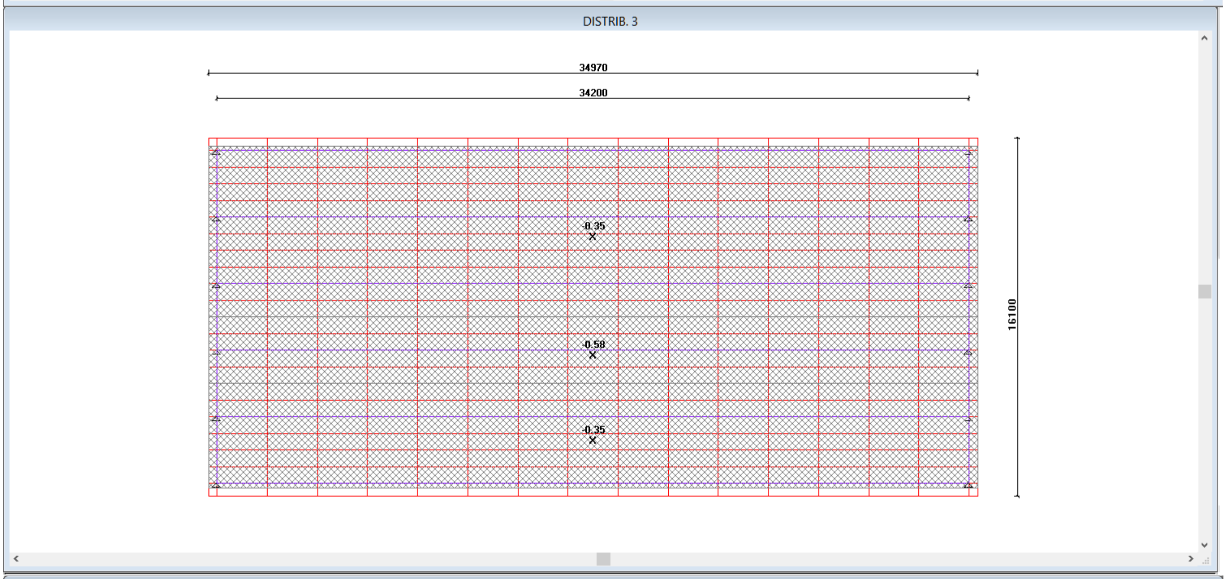
34200
16100
5.2 5.2 5.2
5.2 5.2 5.2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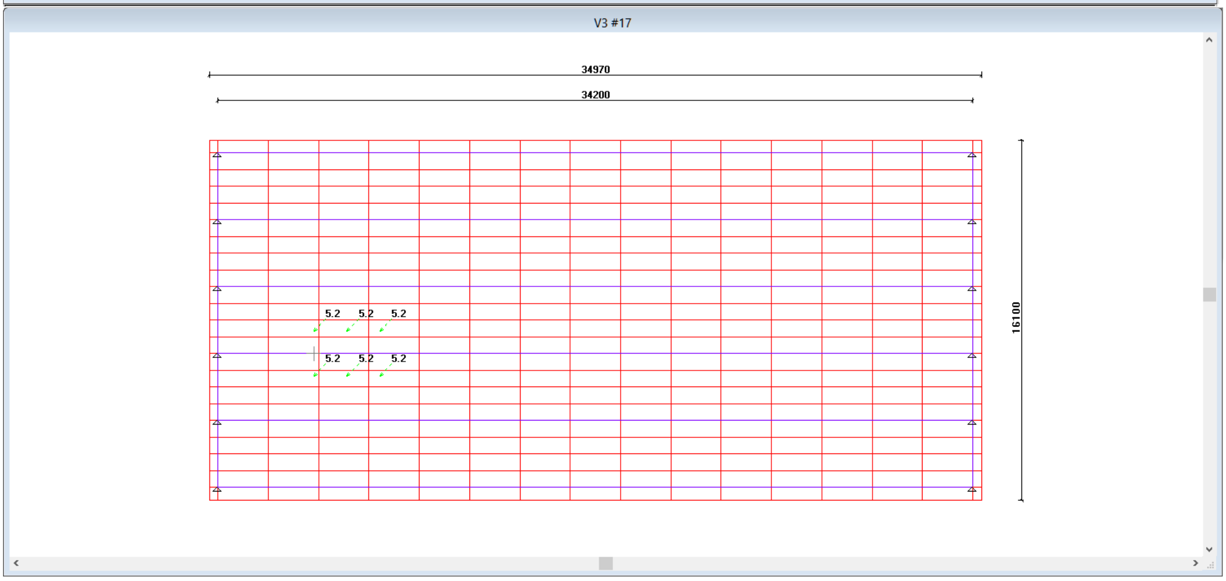
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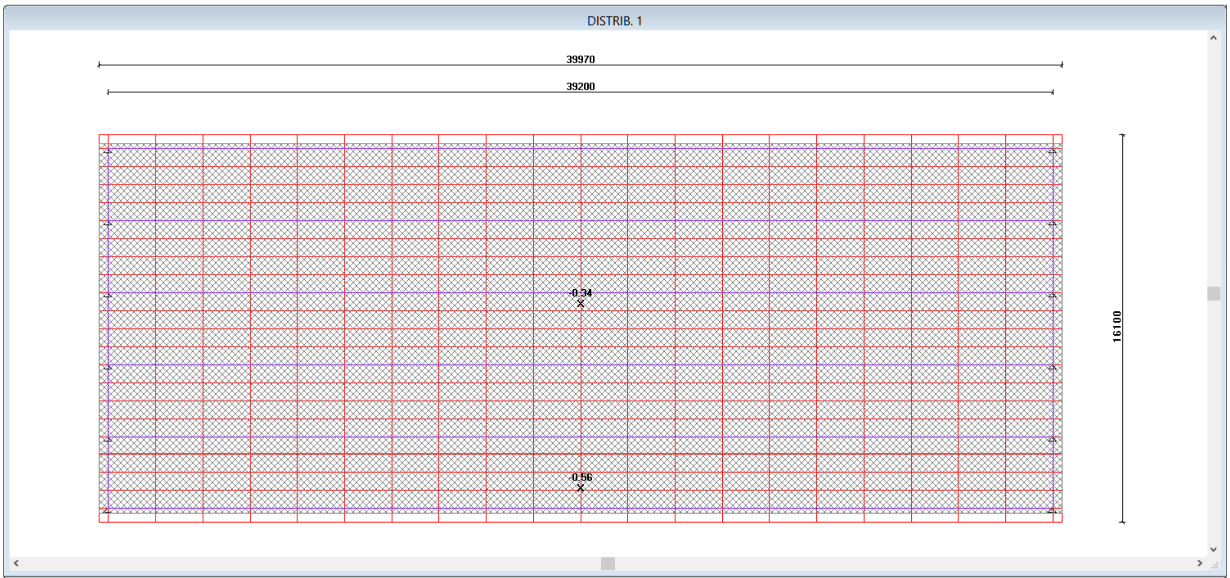
34970
34200
16100
5.2 5.2 5.2
5.2 5.2 5.2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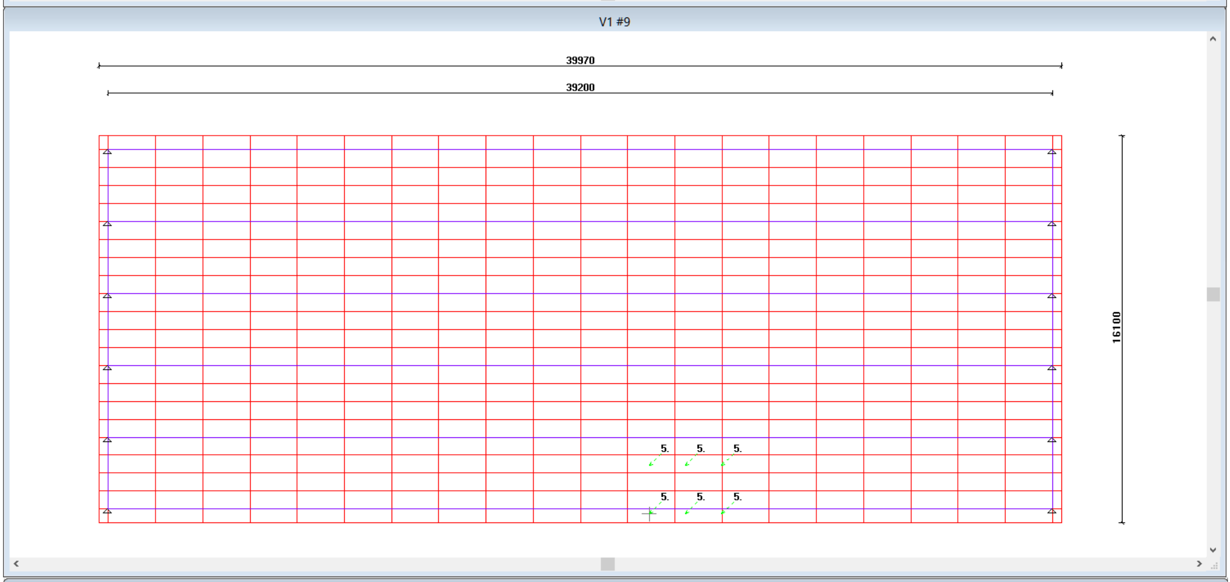
V1 #9
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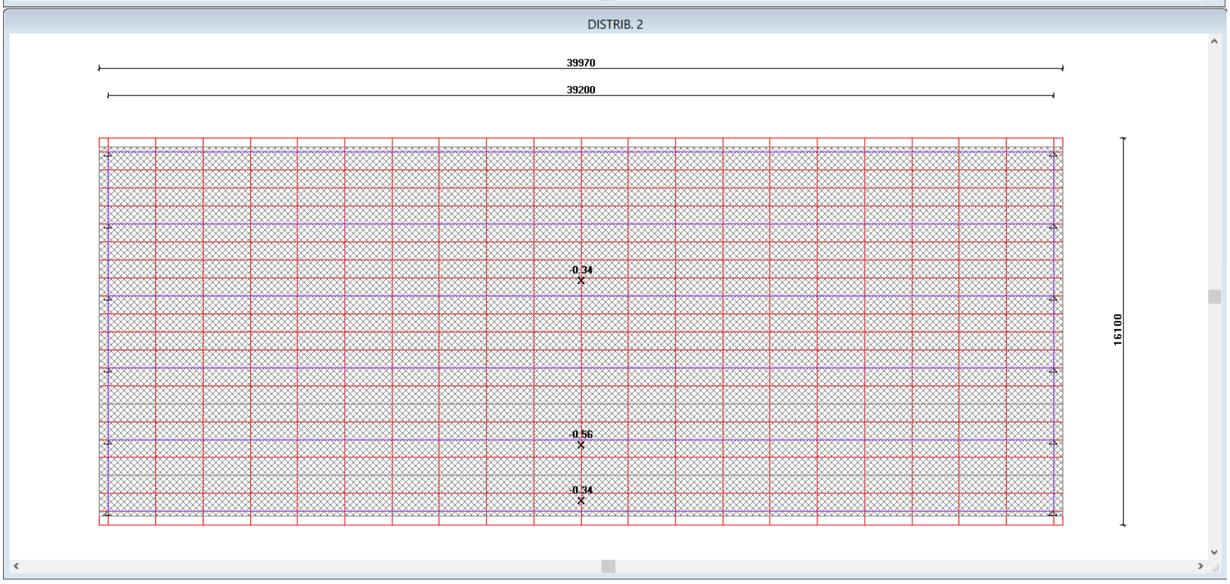
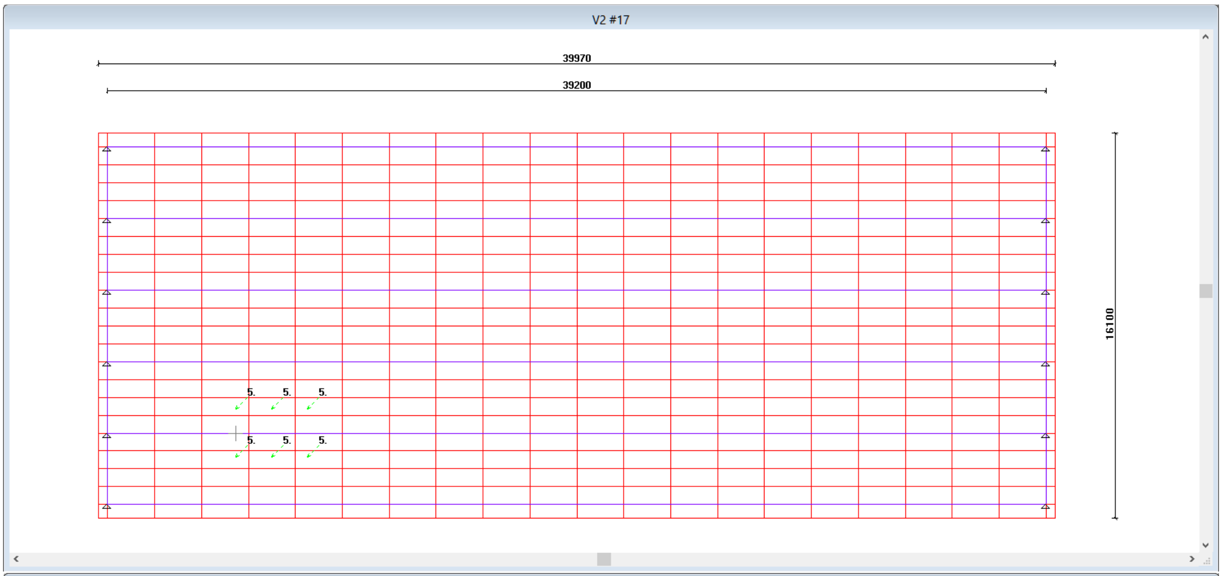
39200
5.
5.
5.
5.
5.
5.
16100


DISTRIB. 2
39970
39200
-0.34
-0.56
-0.34
16100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39200
16100
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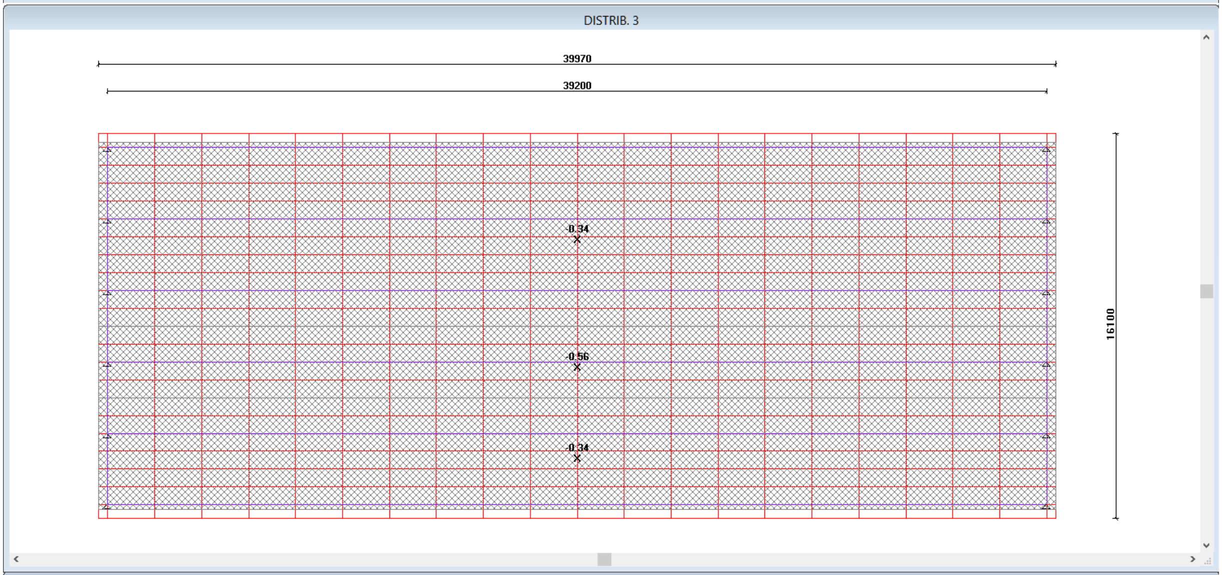
5.
5.
5.
5.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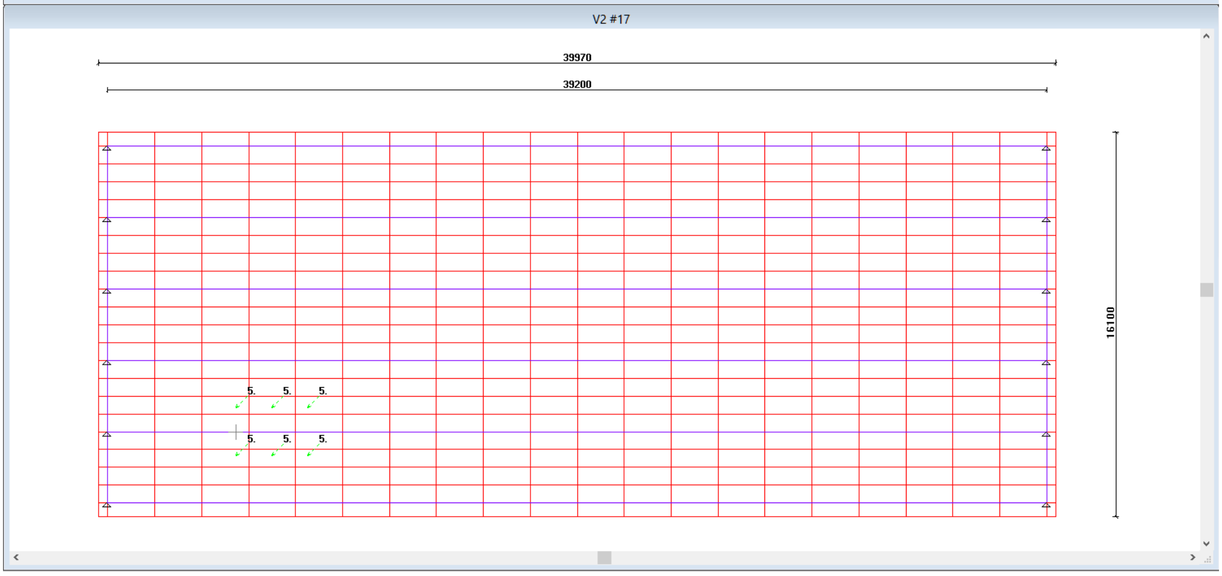
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16100
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5.
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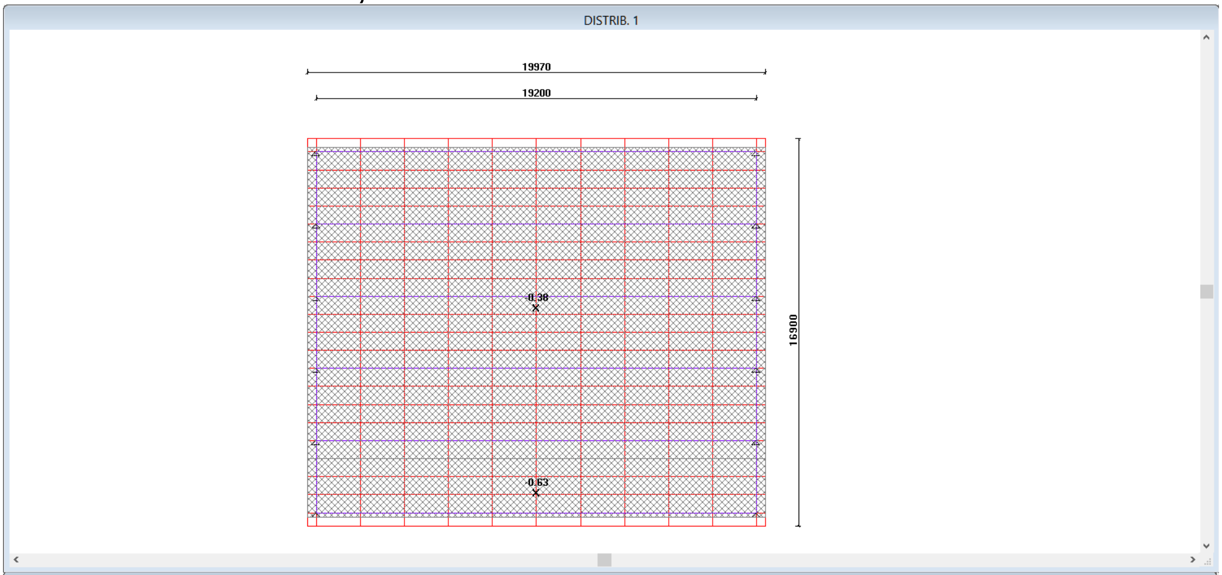
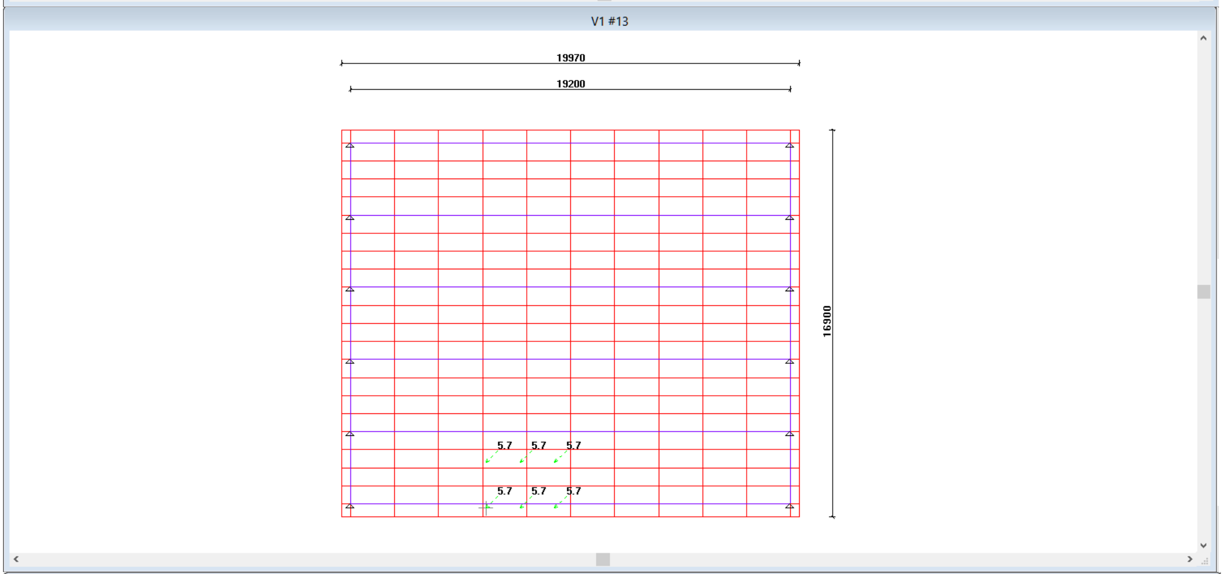
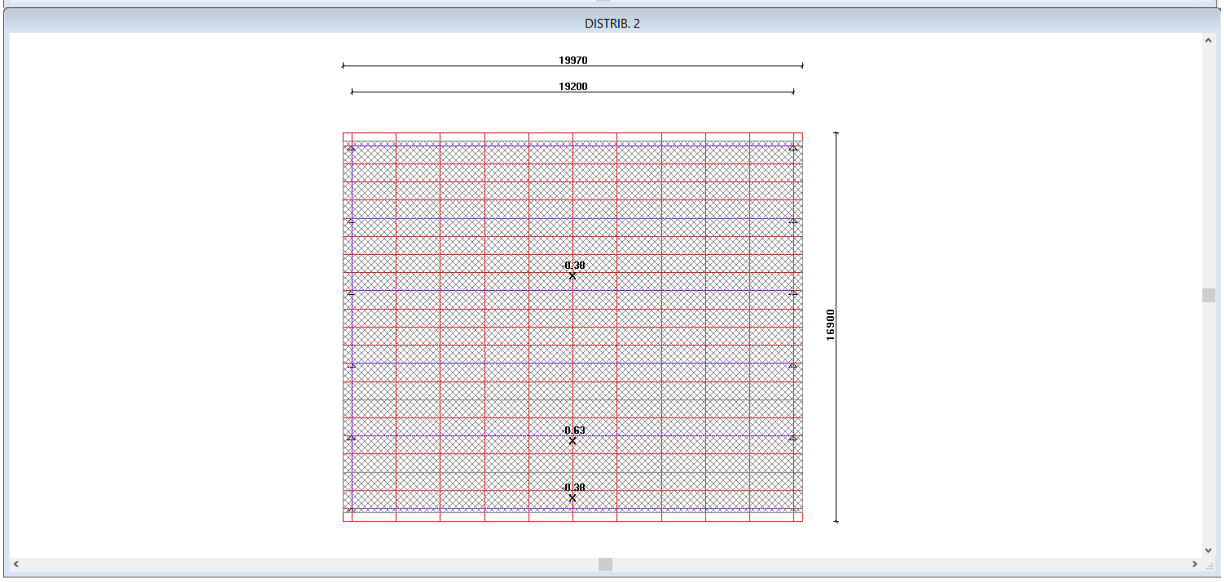
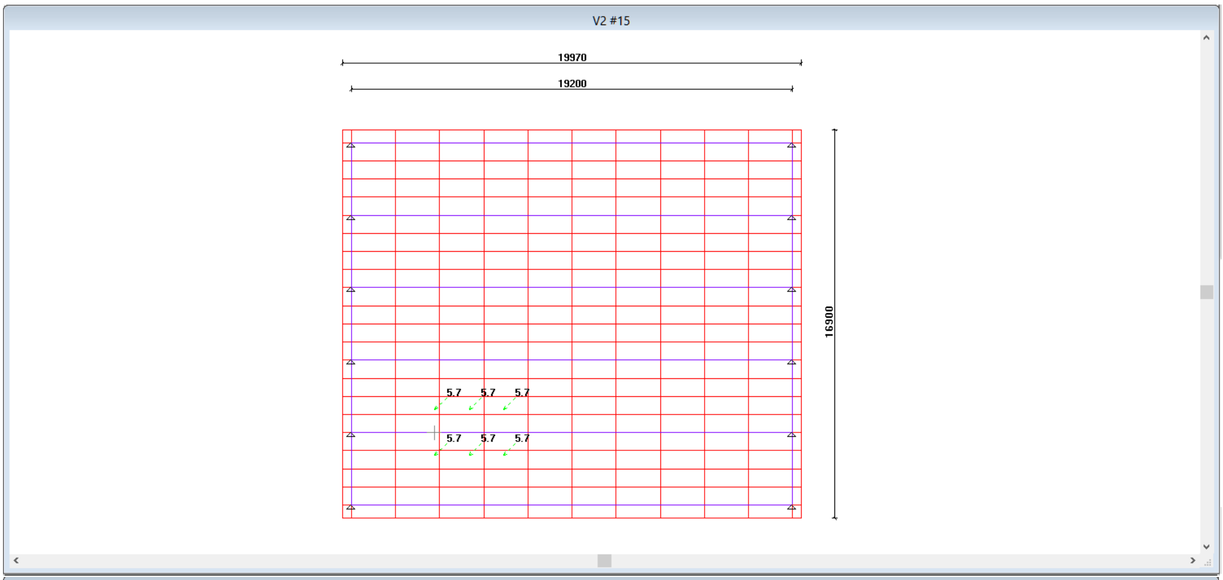
5.
5.

4.4.5. Tabuleiro 16,90 m





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16900
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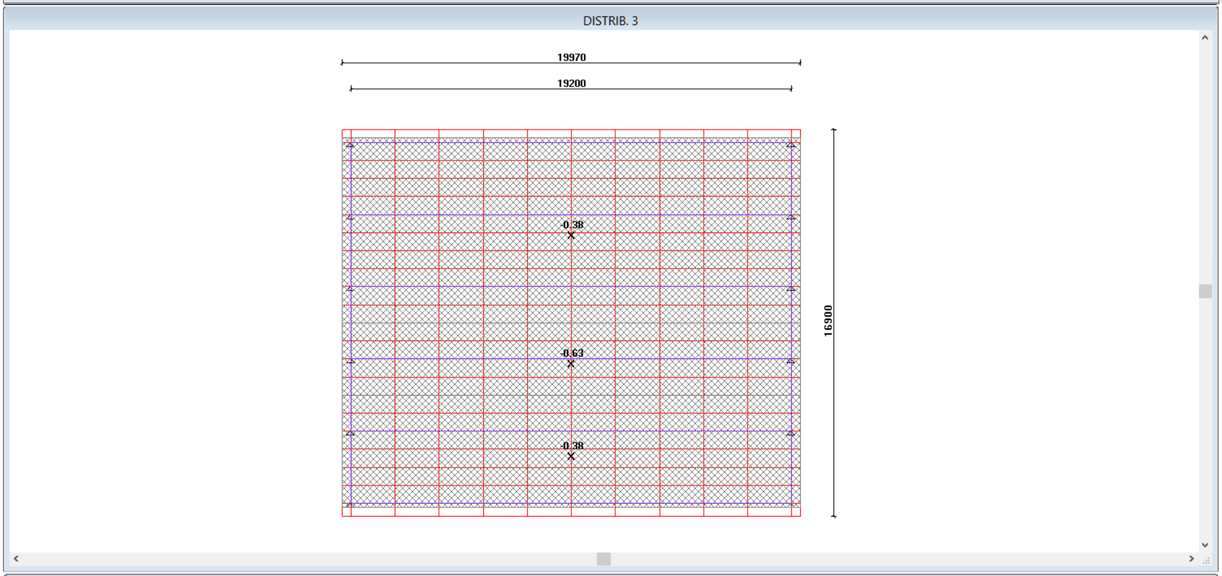
5.7
5.7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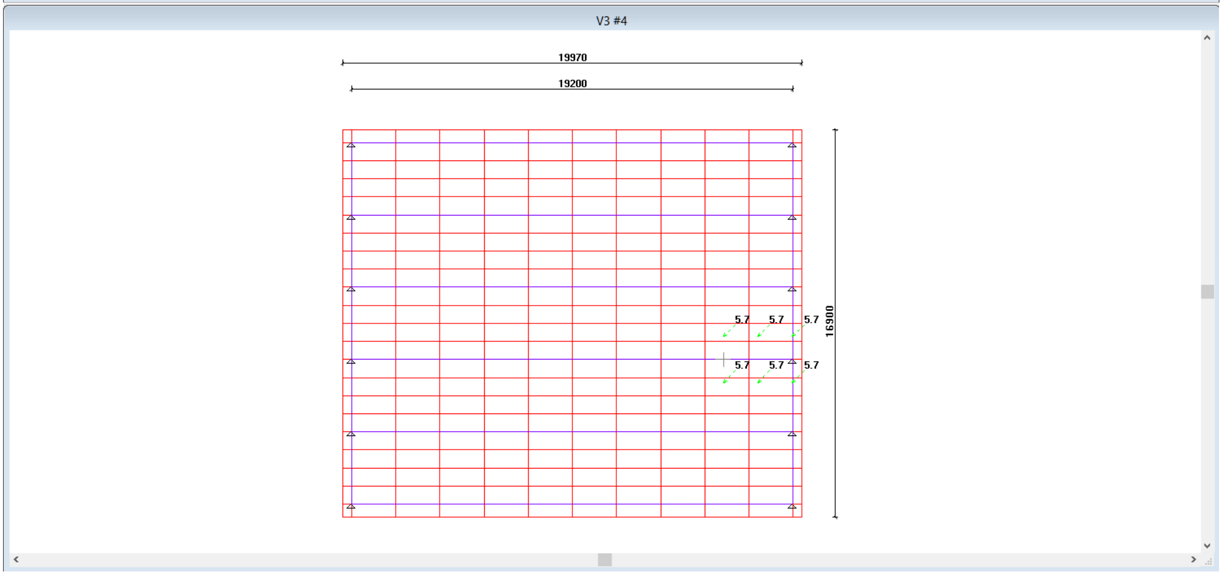
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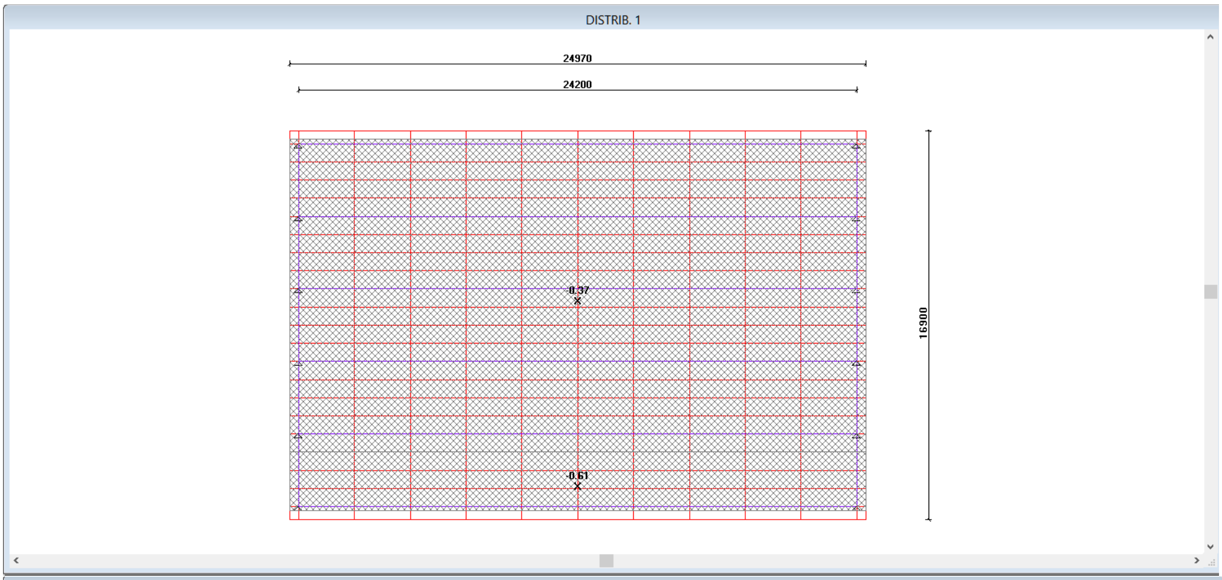
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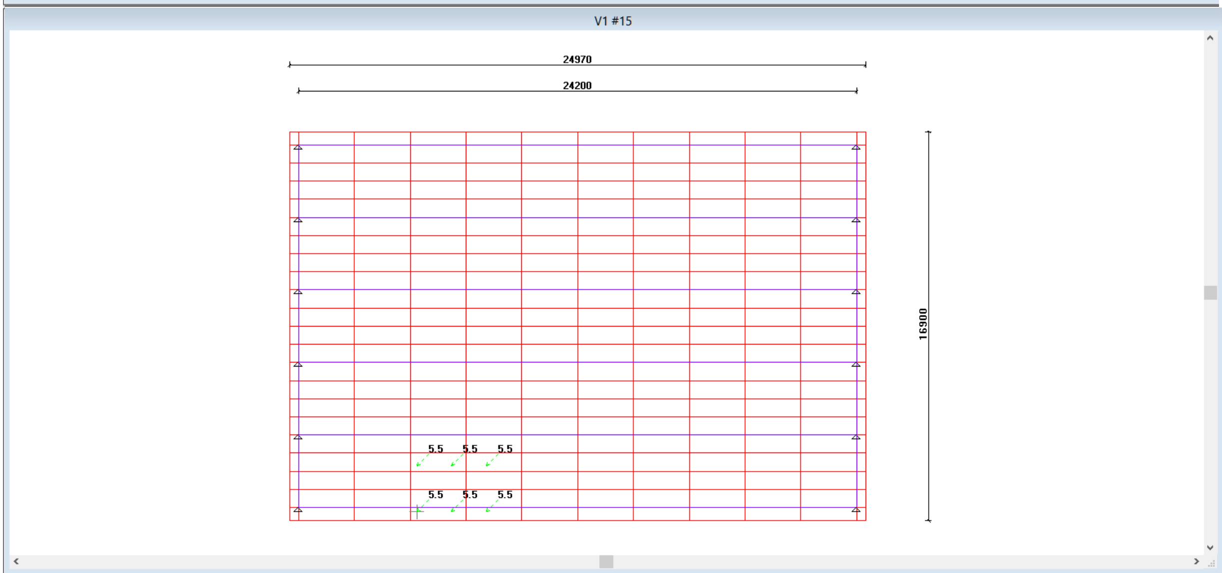
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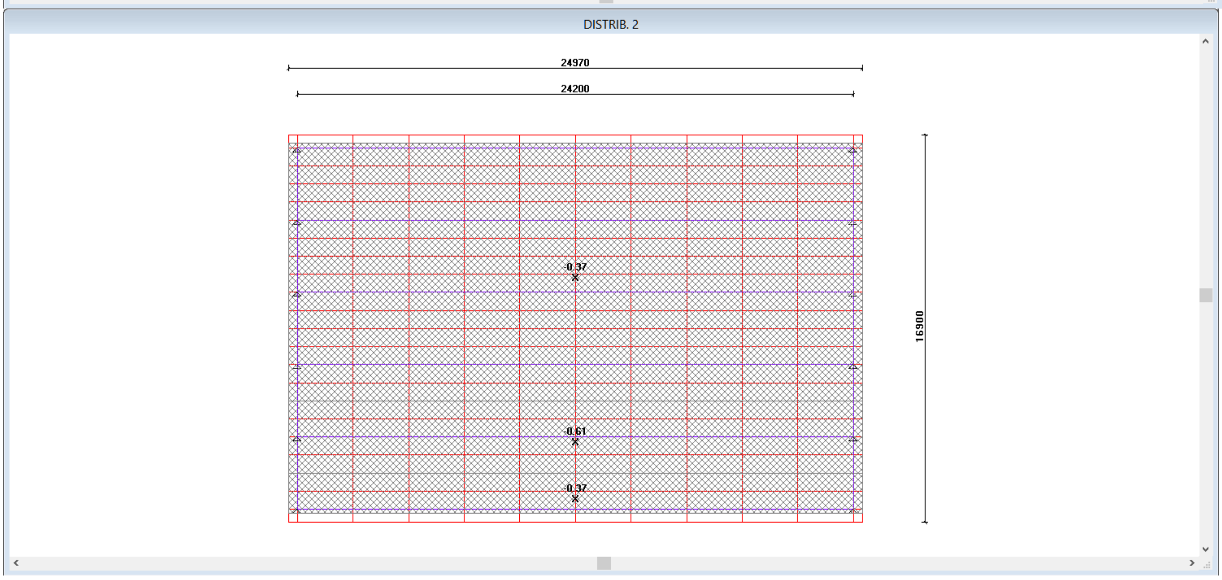
16900
5.5 5.5 5.5
5.5 5.5 5.5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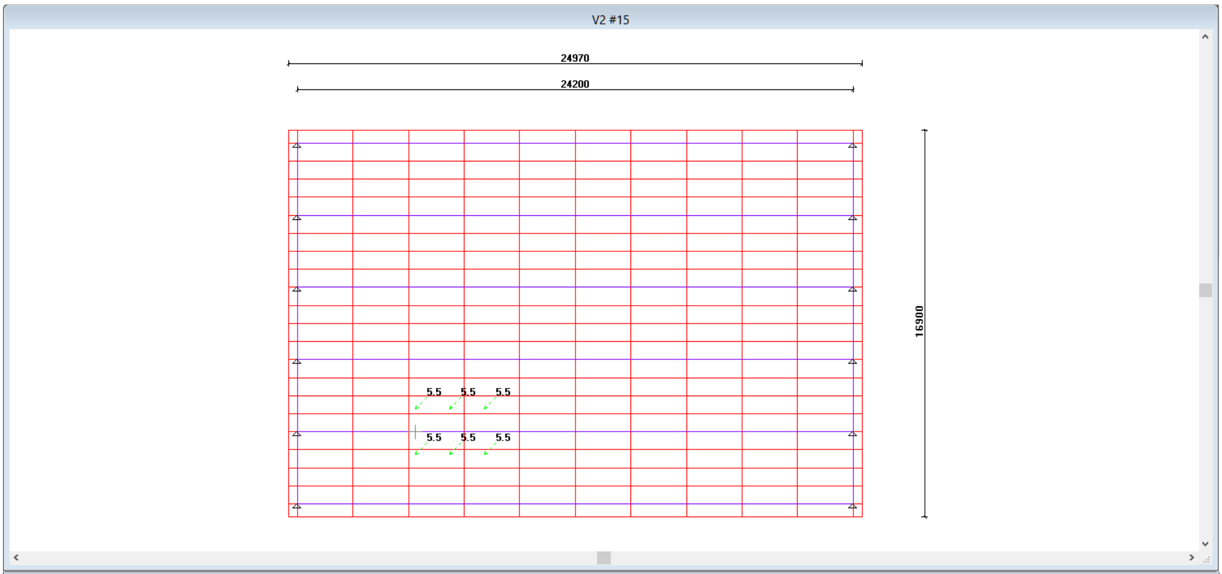
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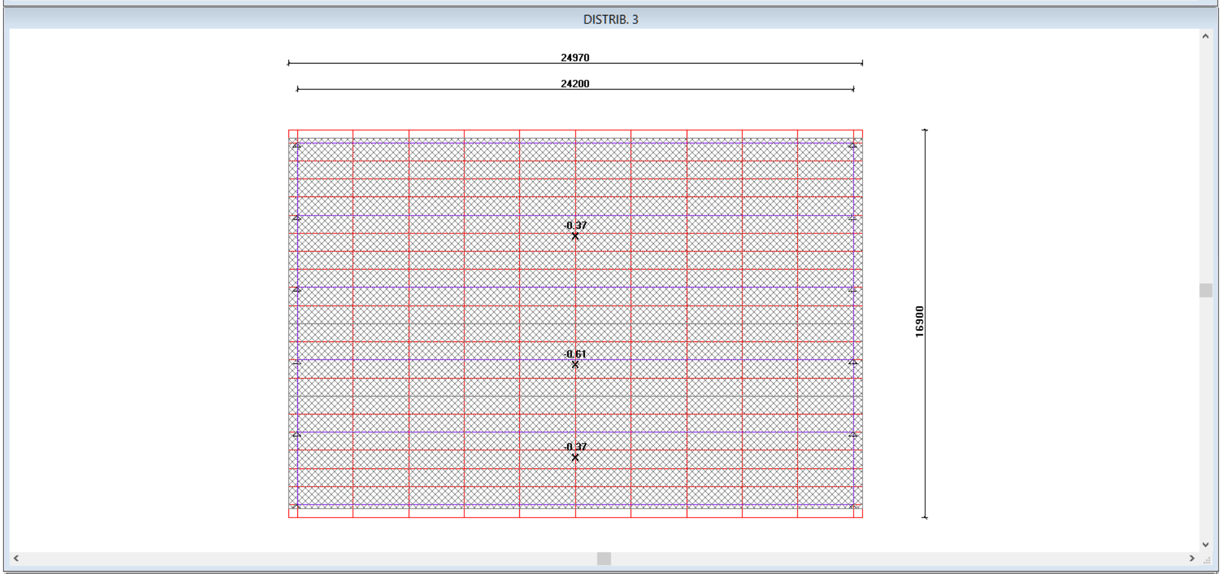
5.5 5.5 5.5
5.5 5.5 5.5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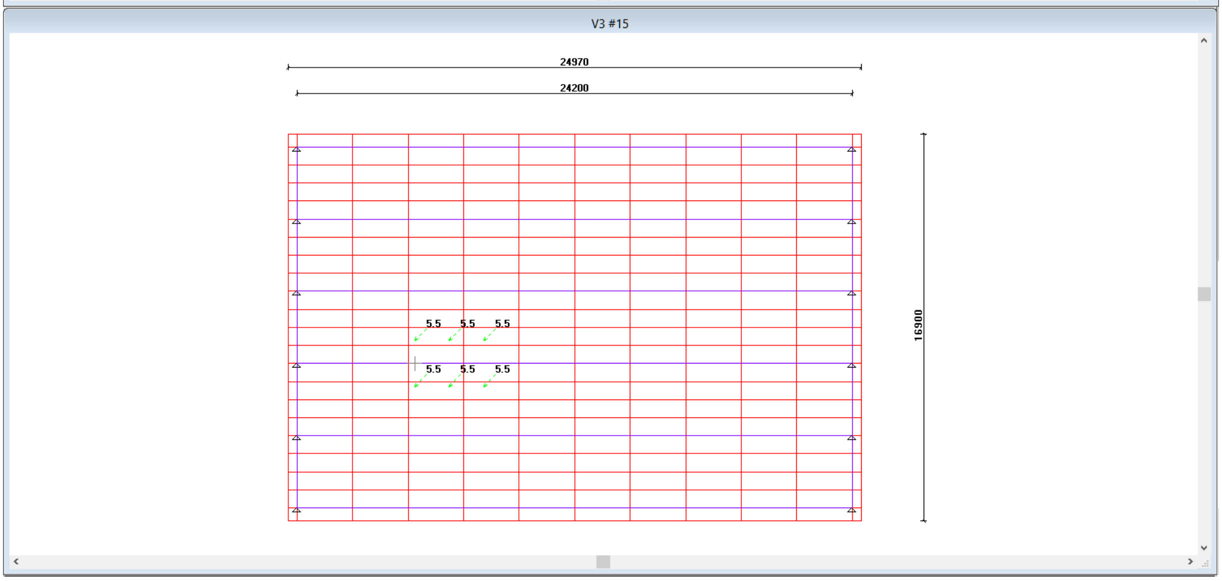
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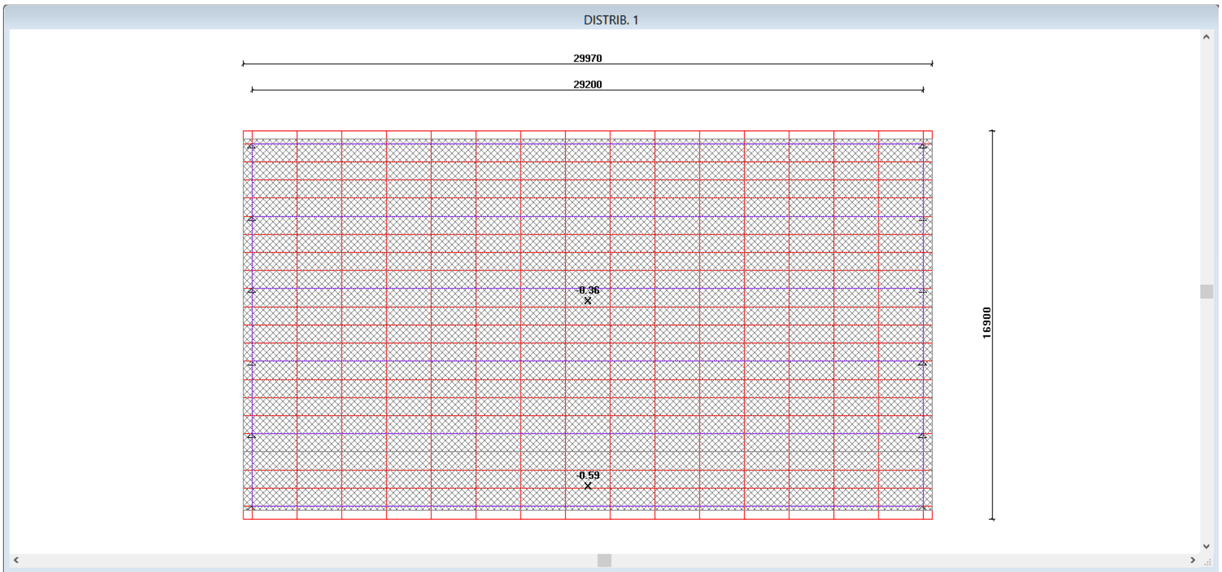
5.5 5.5 5.5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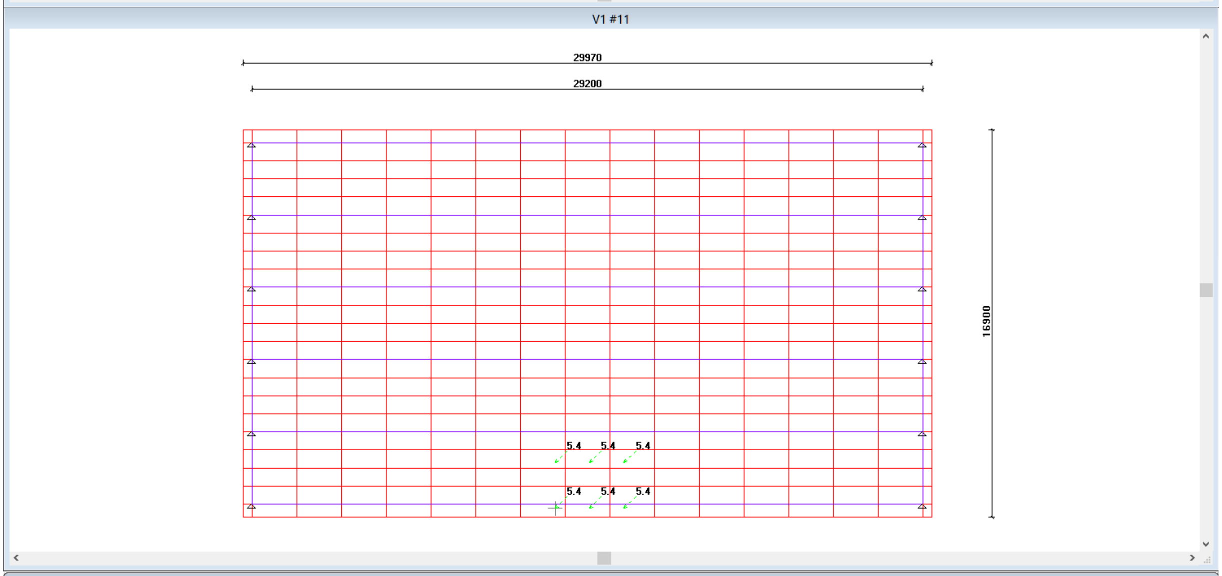
V1 #11
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16900
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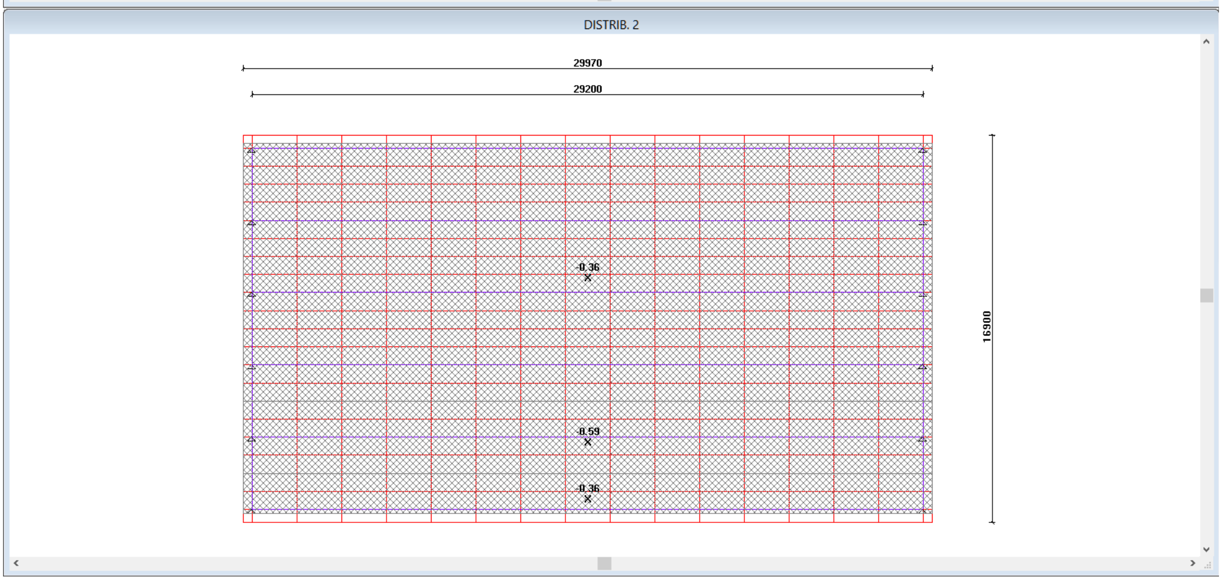
5.4
5.4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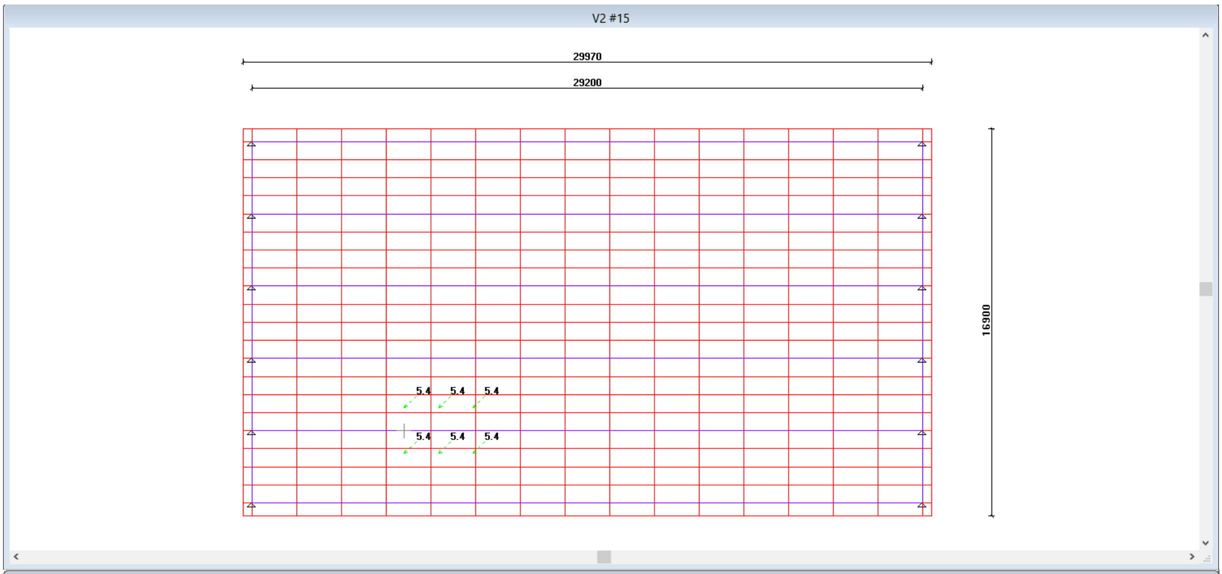
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16900
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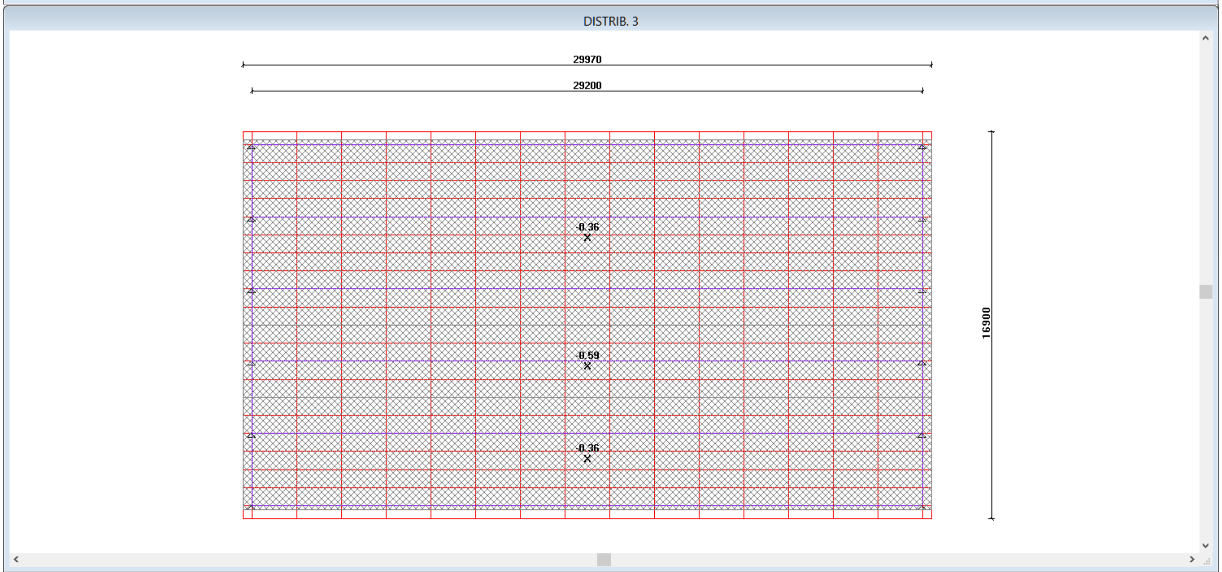
5.4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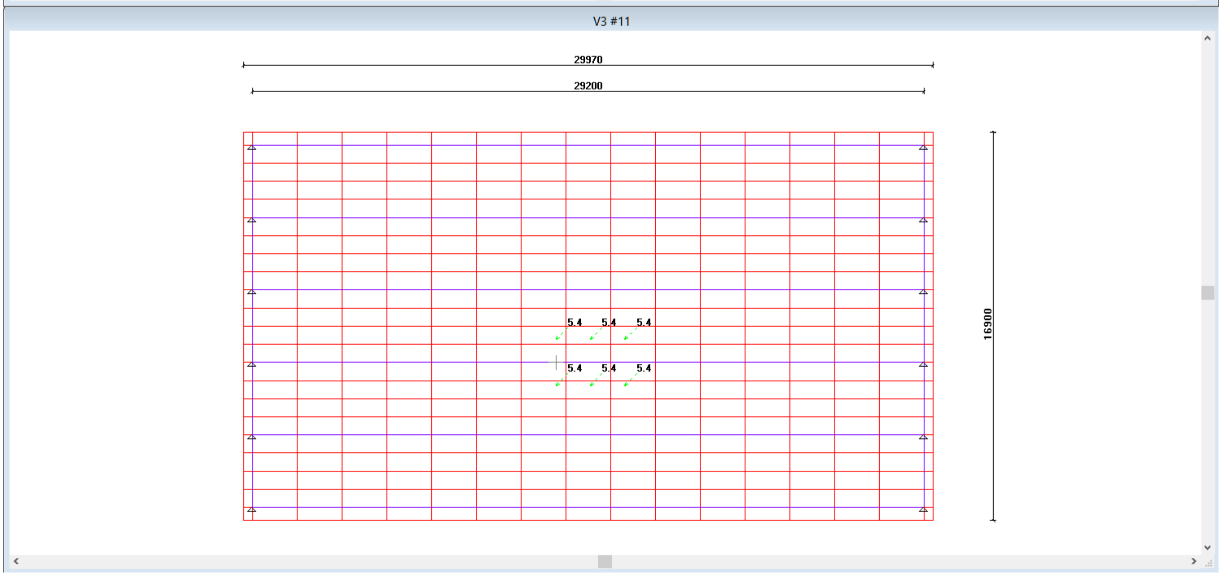
V3 #11
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16900
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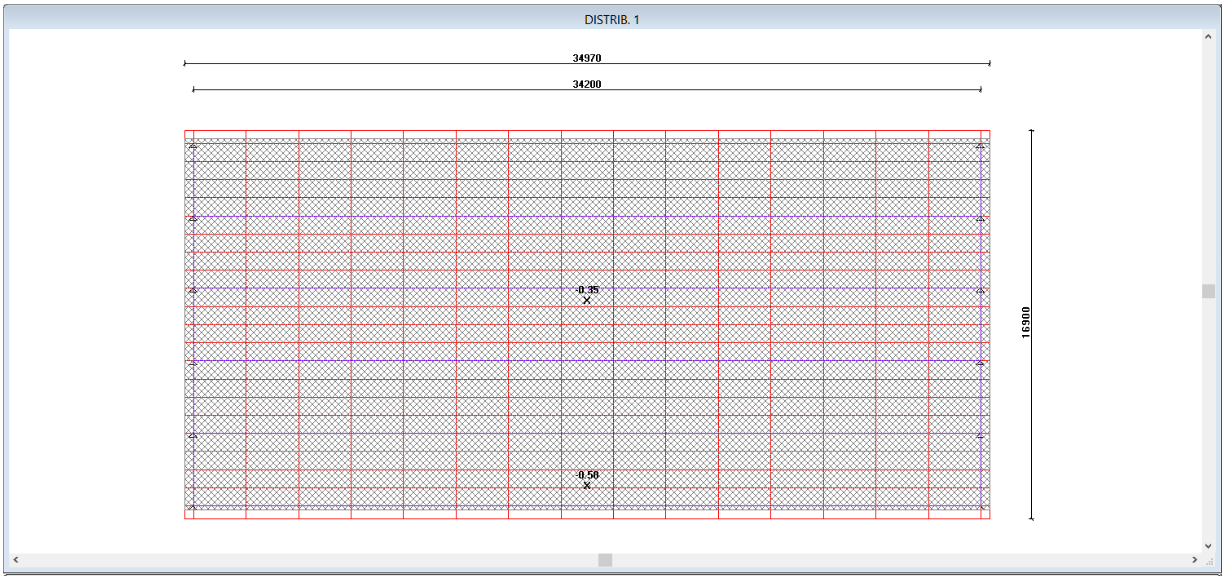
5.4
5.4
5.4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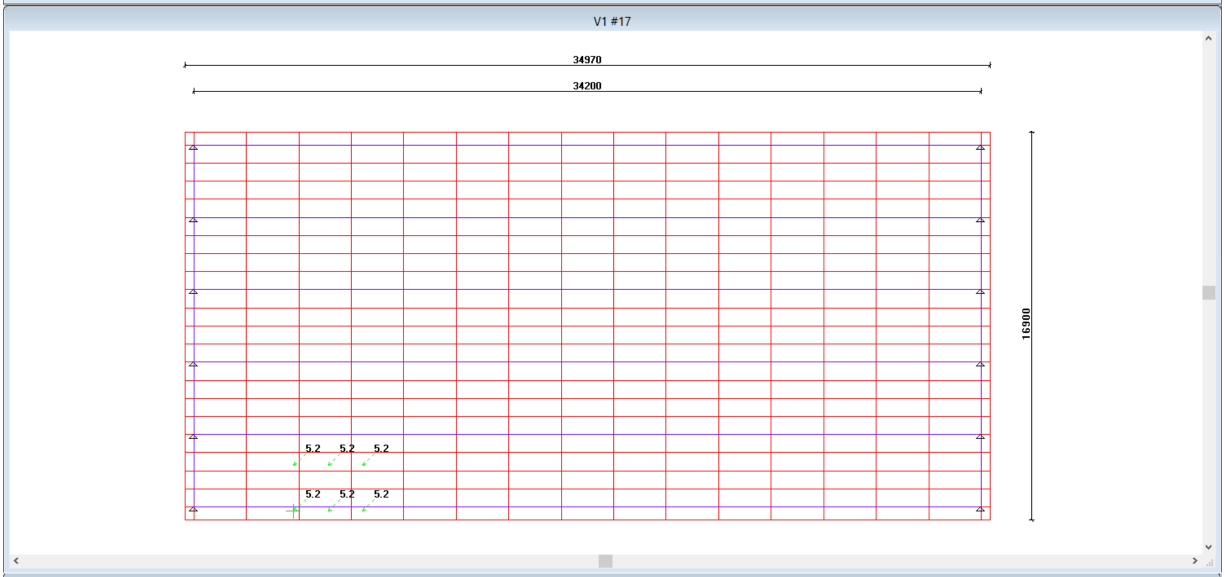
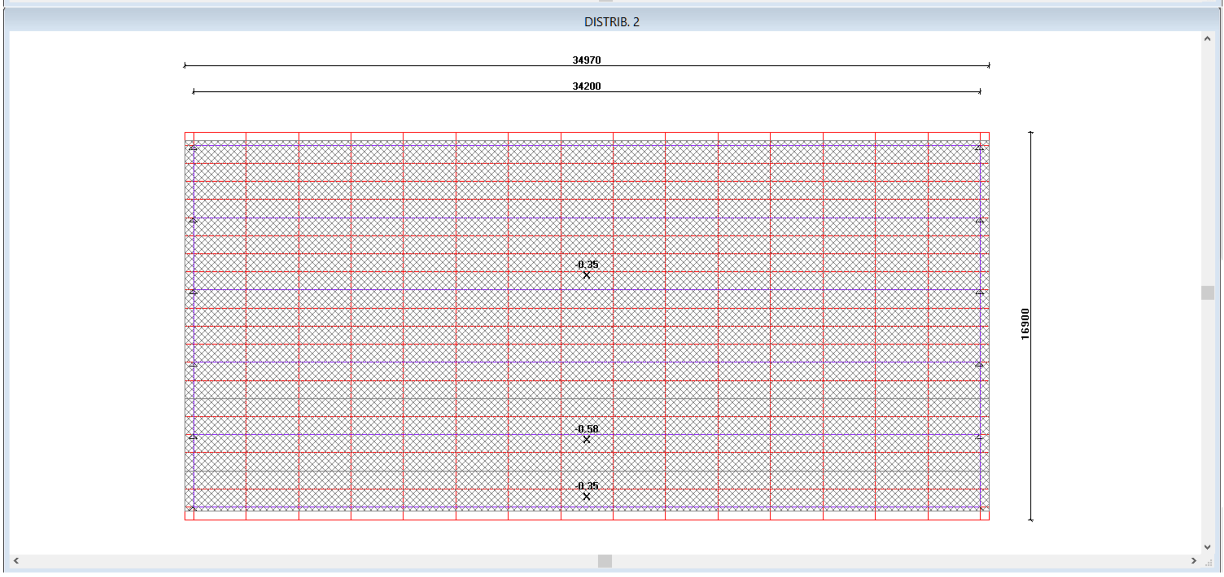
16900
-0.35
-0.58


V1 #17
34970
34200
16900
5.2 5.2 5.2
5.2 5.2 5.2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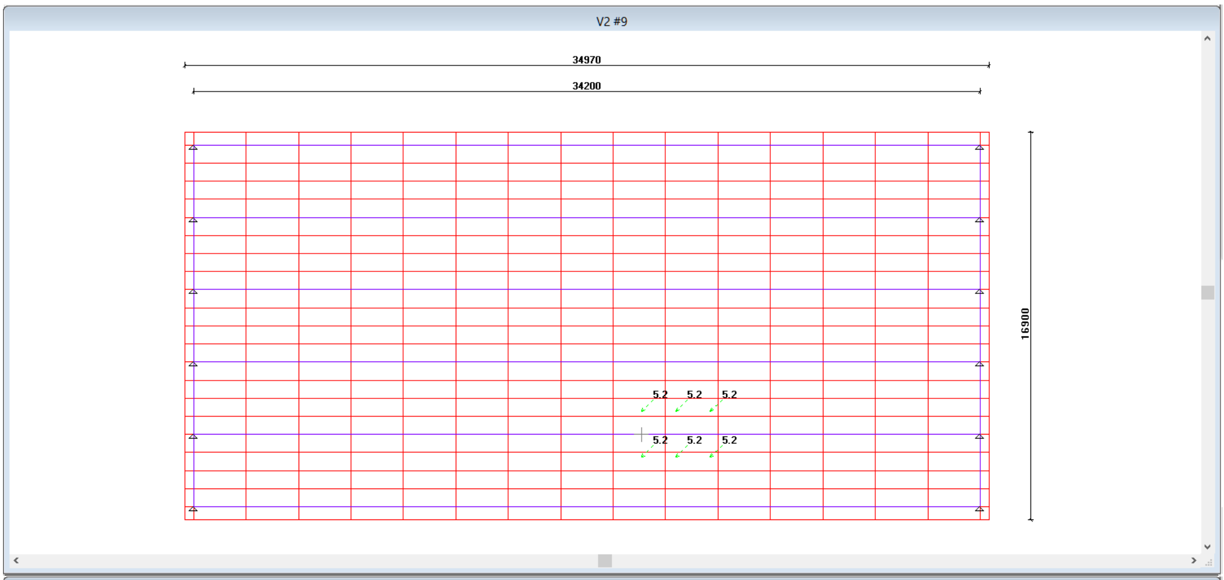
16900
-0.35
-0.58
-0.35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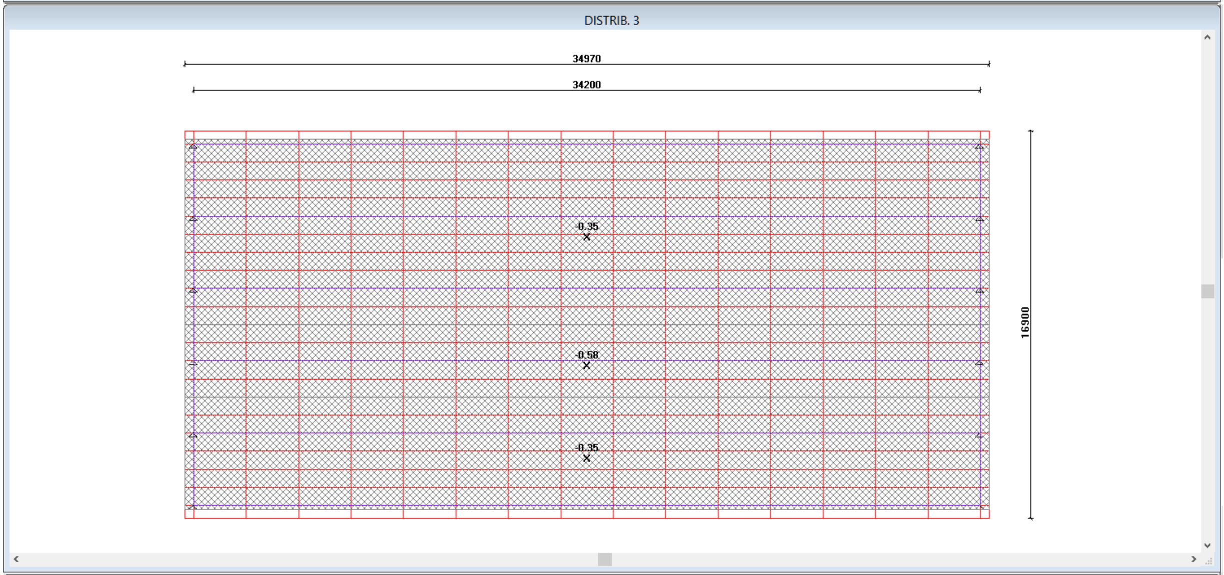
34200
16900
5.2
5.2
5.2
5.2
5.2
5.2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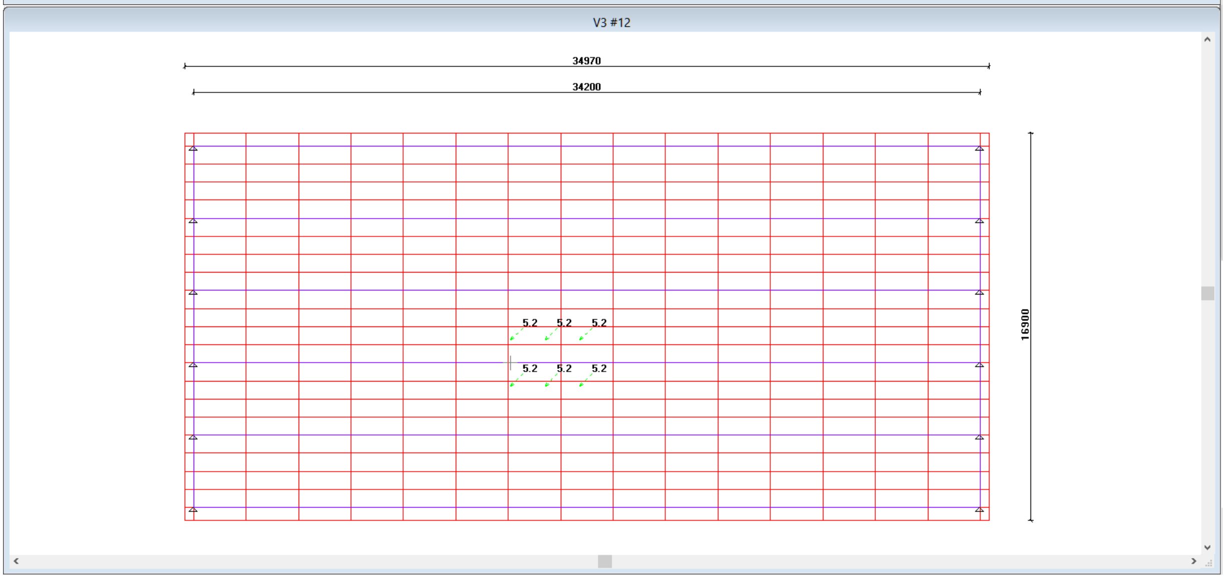
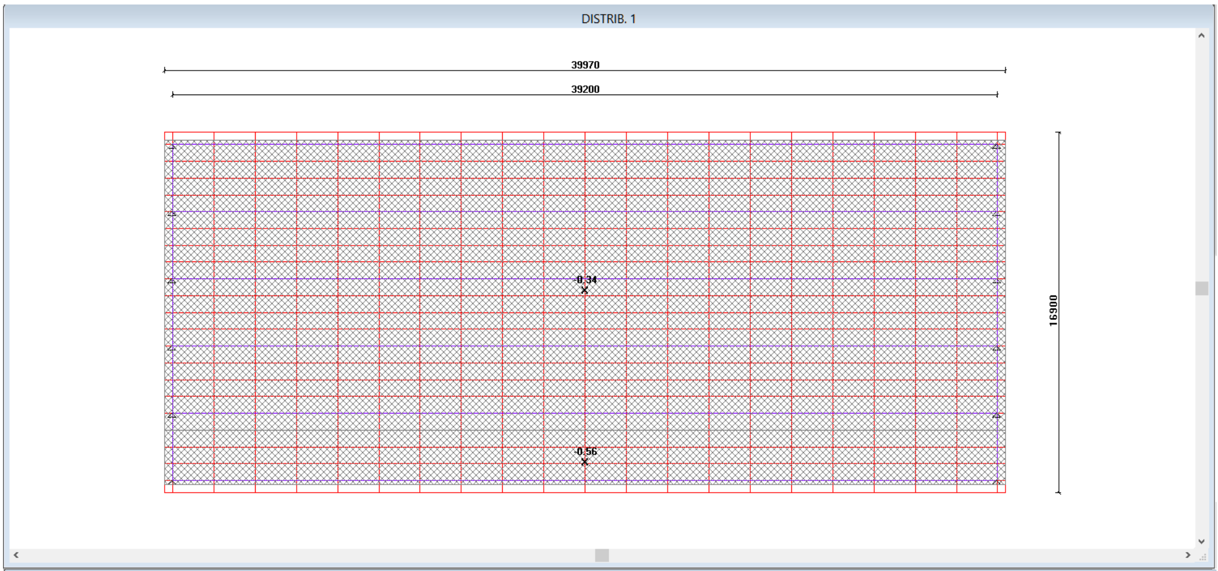
-0.35
-0.58
-0.35


V3 #12
34970
34200
16900
5.2
5.2
5.2
5.2
5.2
5.2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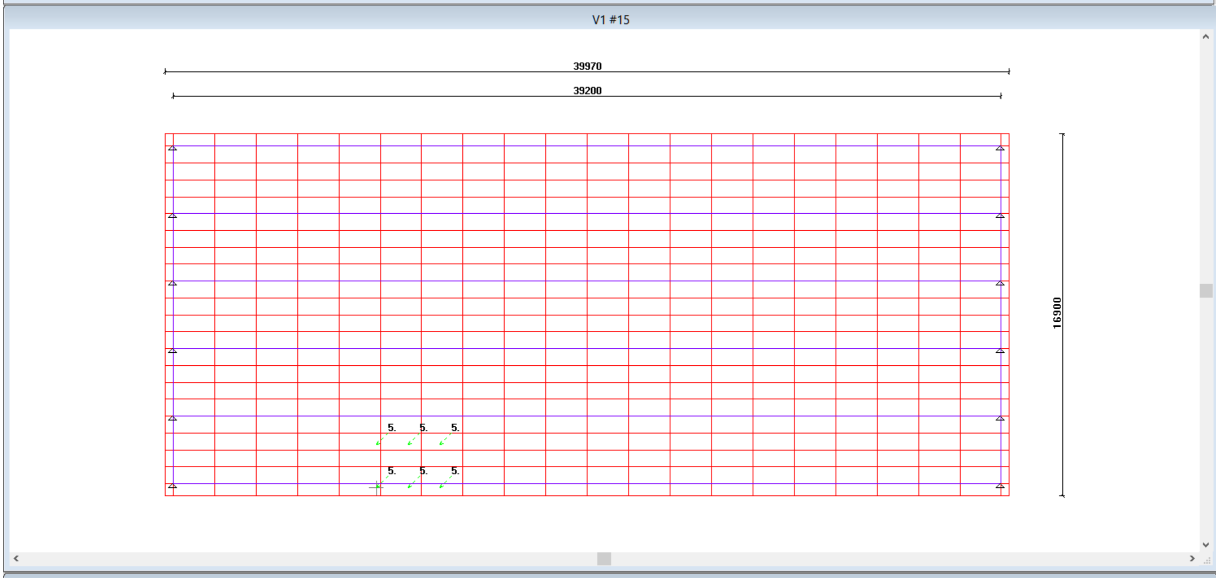
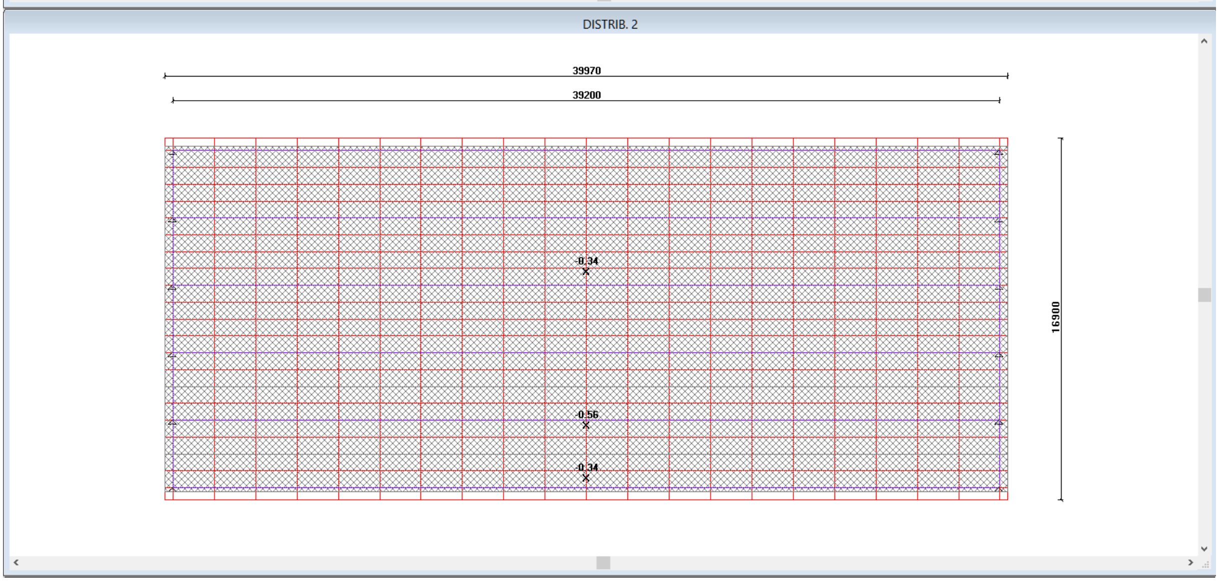

V1 #15
39970
39200
16900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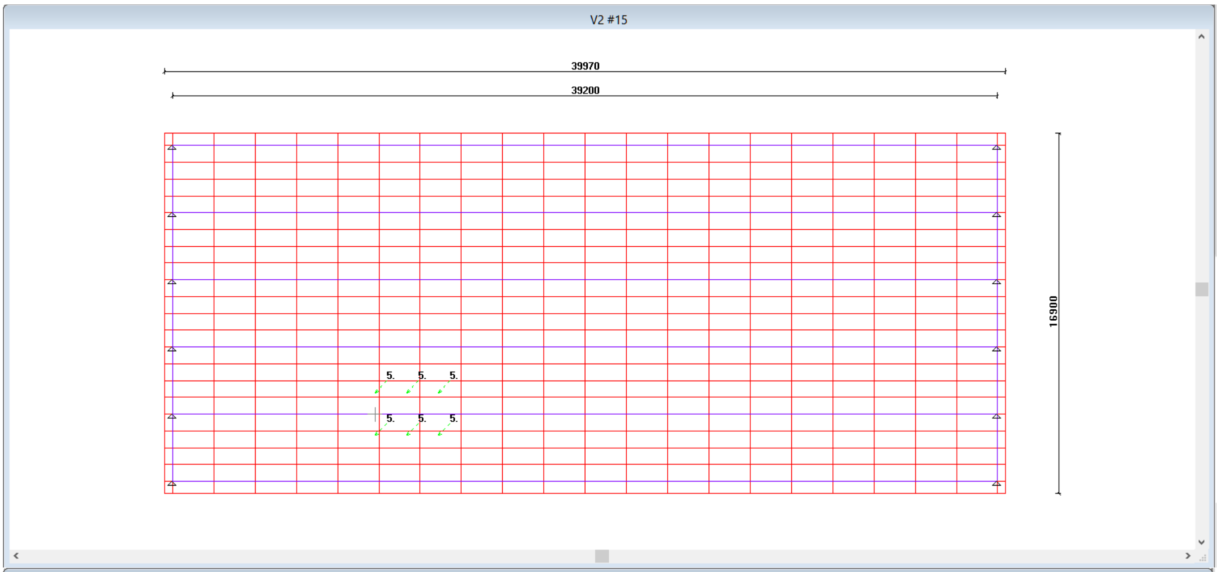
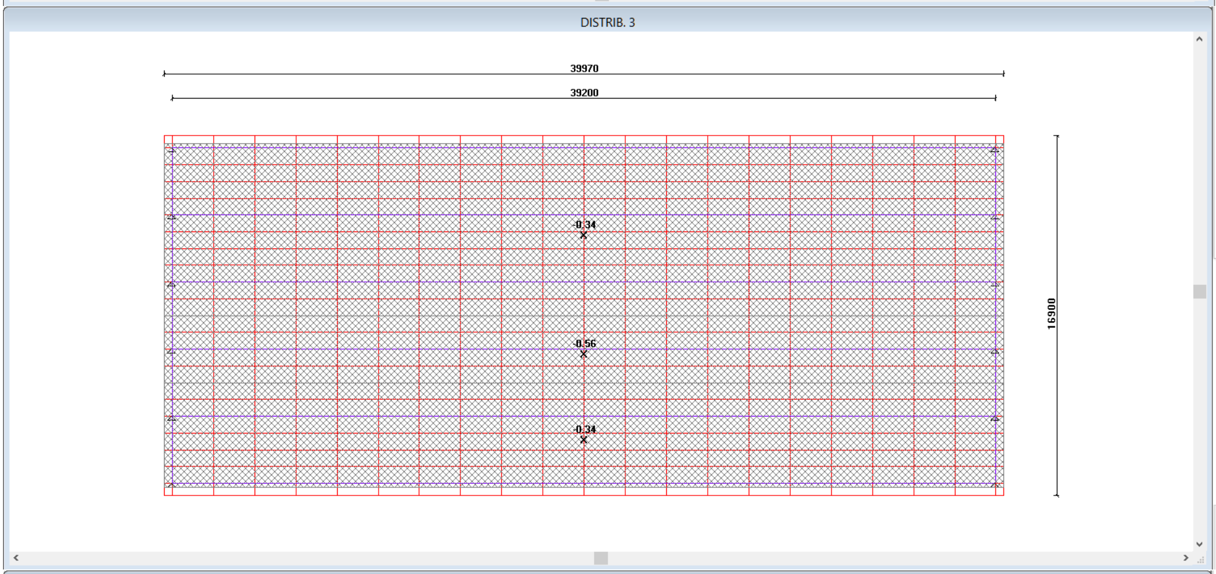
39200
16900
-0.34
-0.56
-0.34


V2 #15
39970
39200
16900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39200
16900
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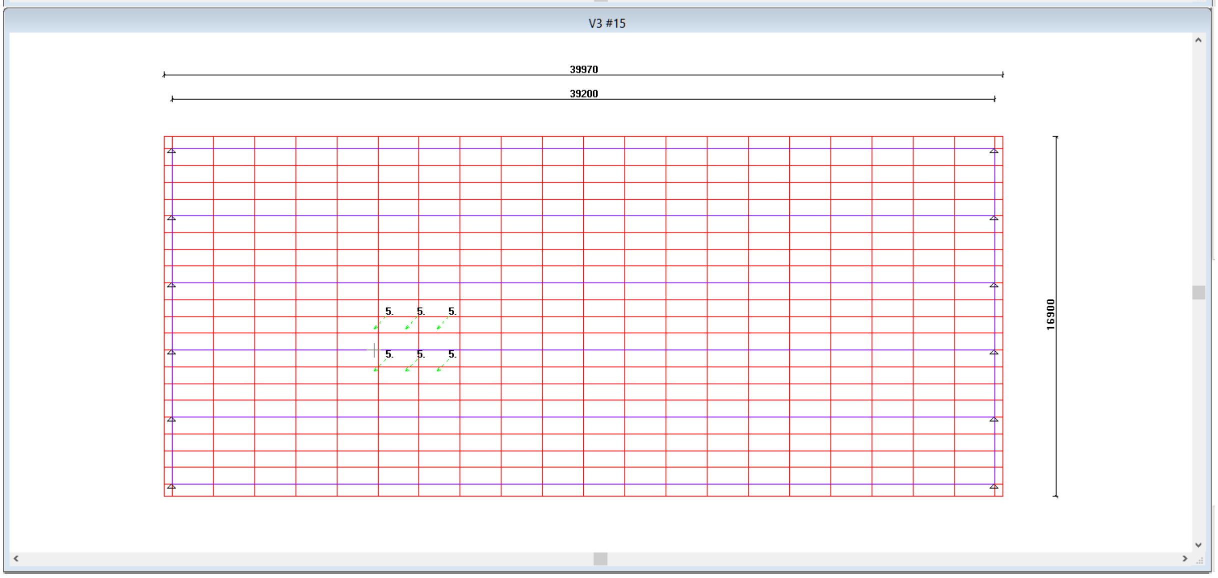
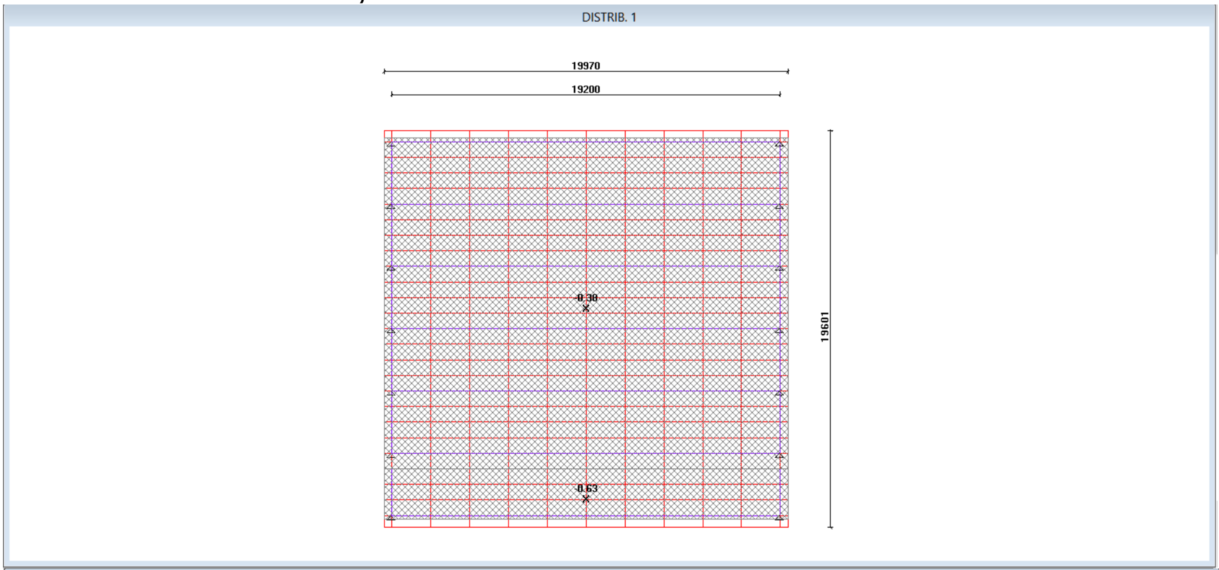
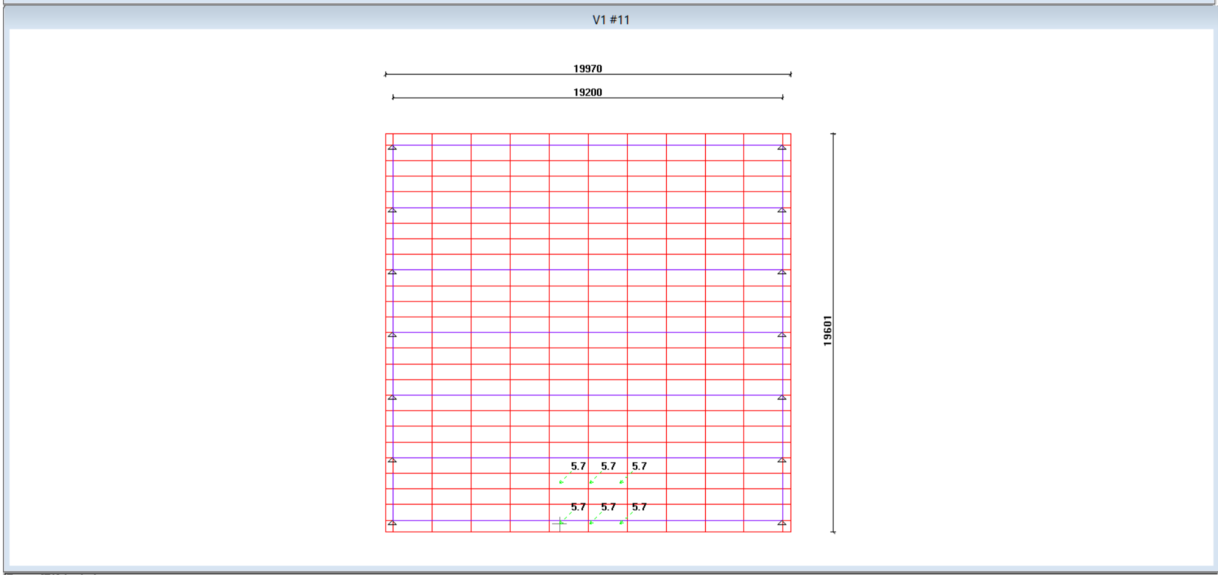
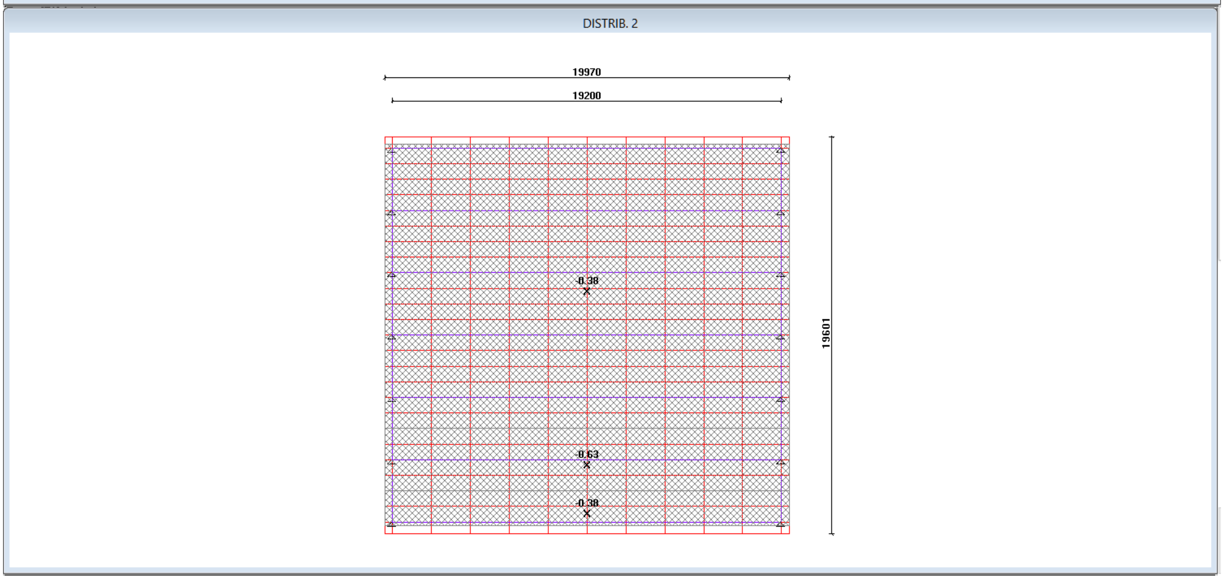
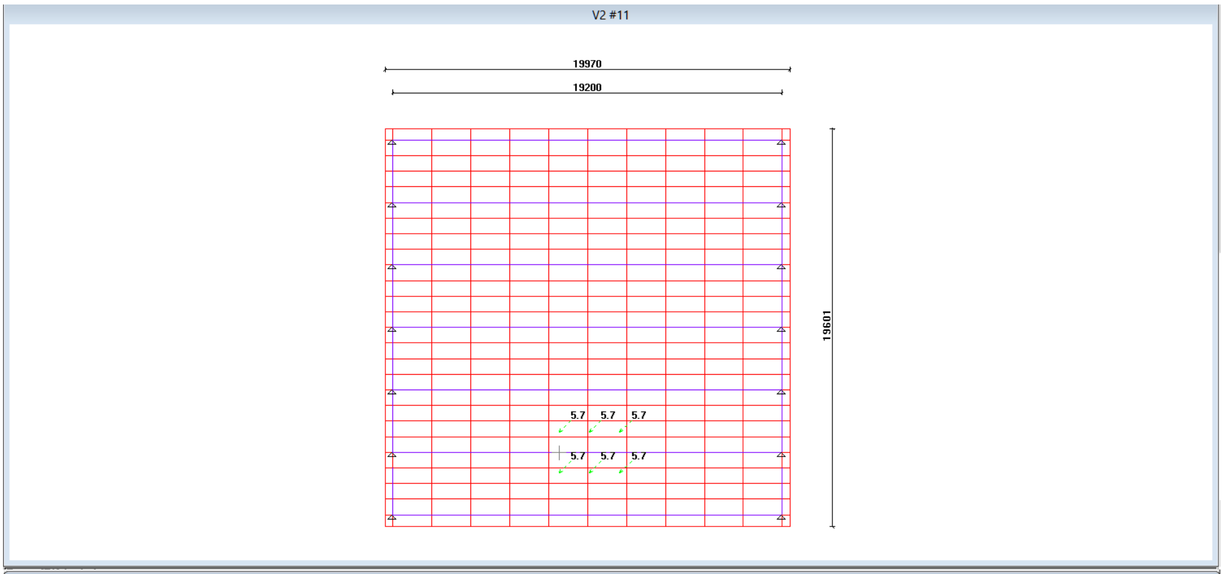

V3 #15
39970
39200
16900

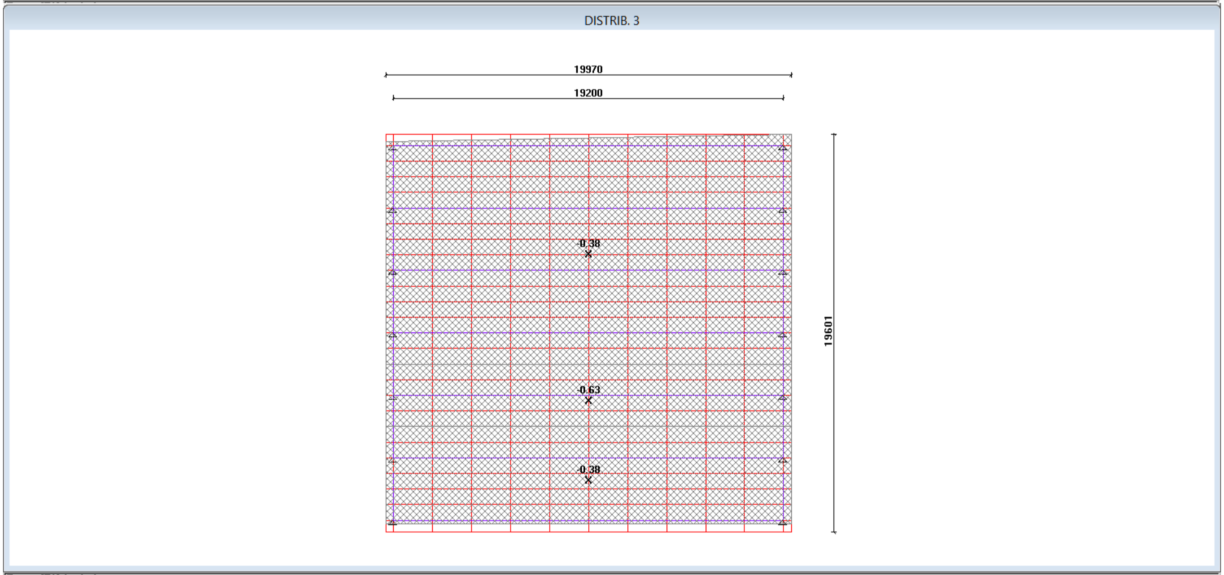
4.4.6. Tabuleiro 19,60 m








V2 #11
19970
19200
19601
5.7 5.7 5.7
5.7 5.7 5.7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19200
19601
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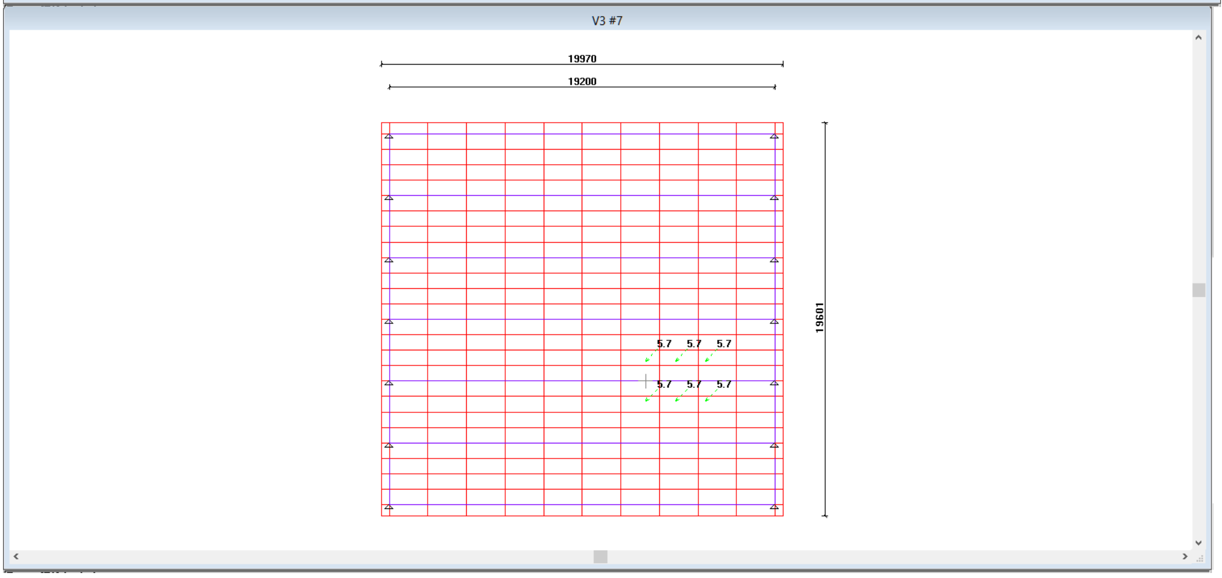
-0.63
-0.38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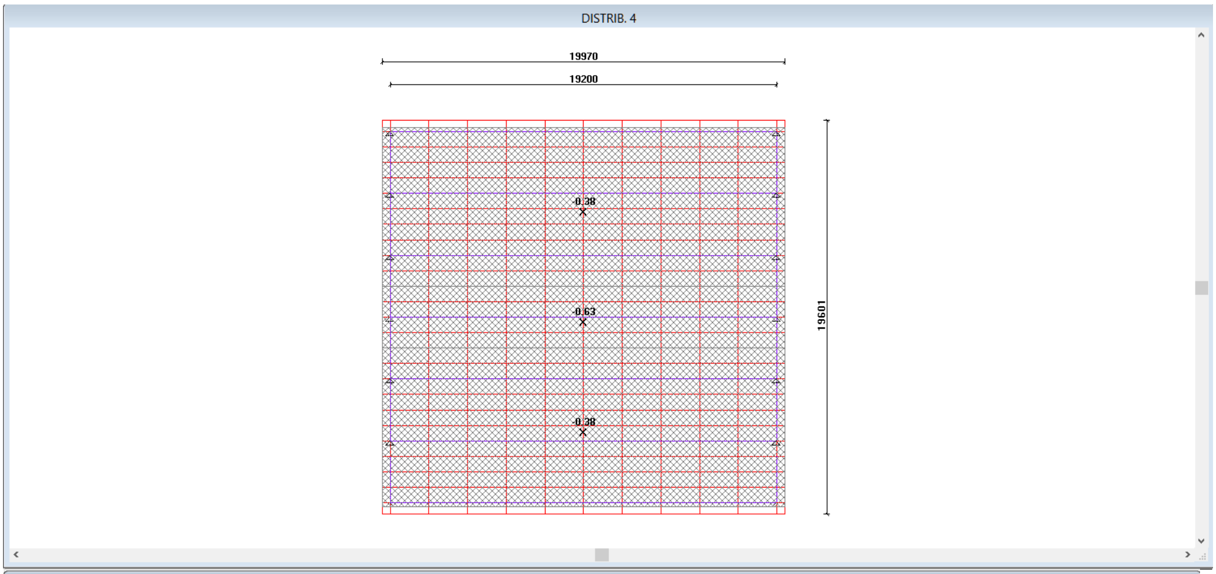
19970
19200
19601
5.7 5.7 5.7
5.7 5.7 5.7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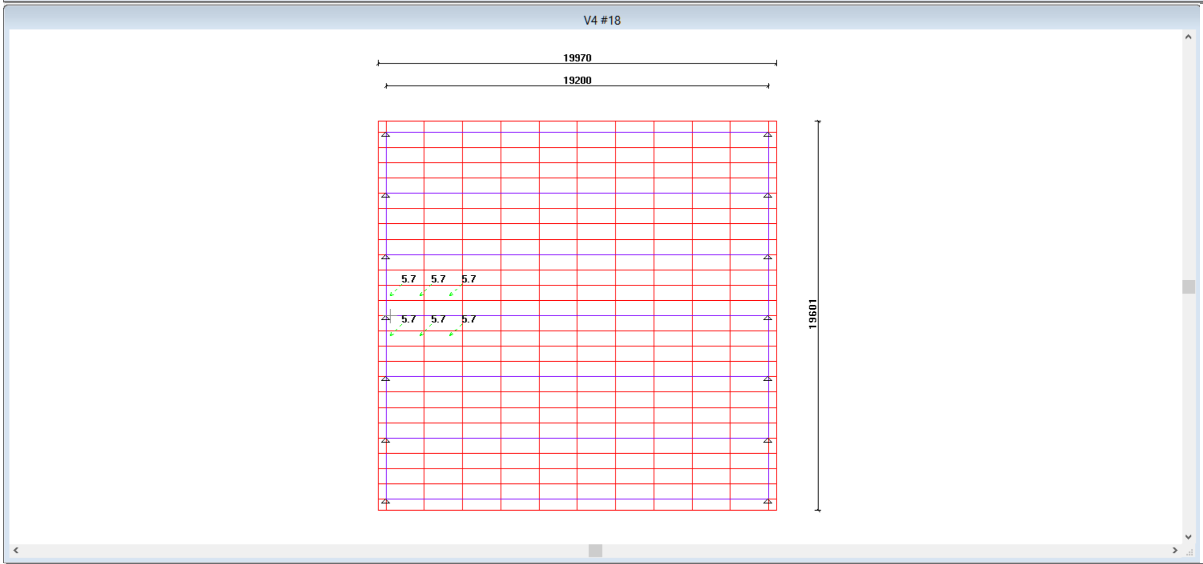
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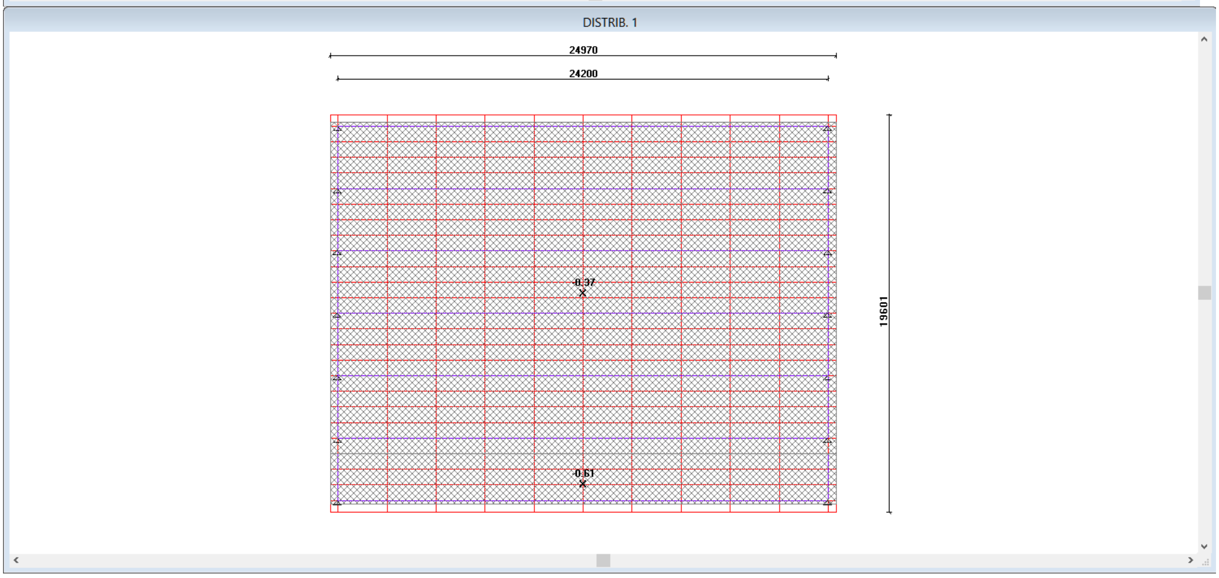
19200
5.7
5.7
5.7
5.7
5.7
5.7
19601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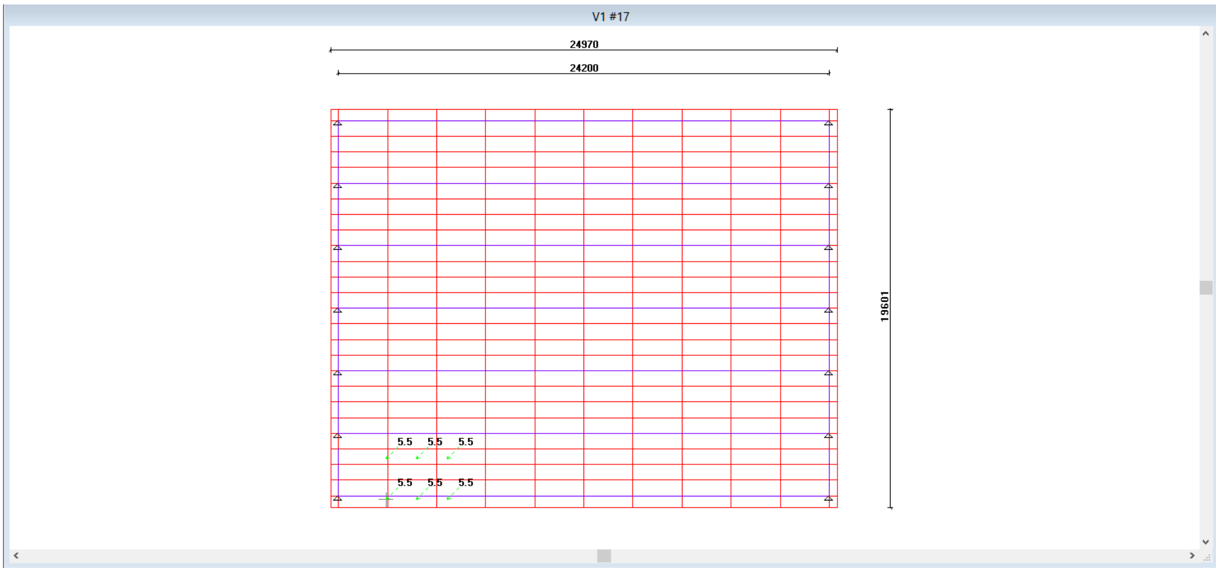
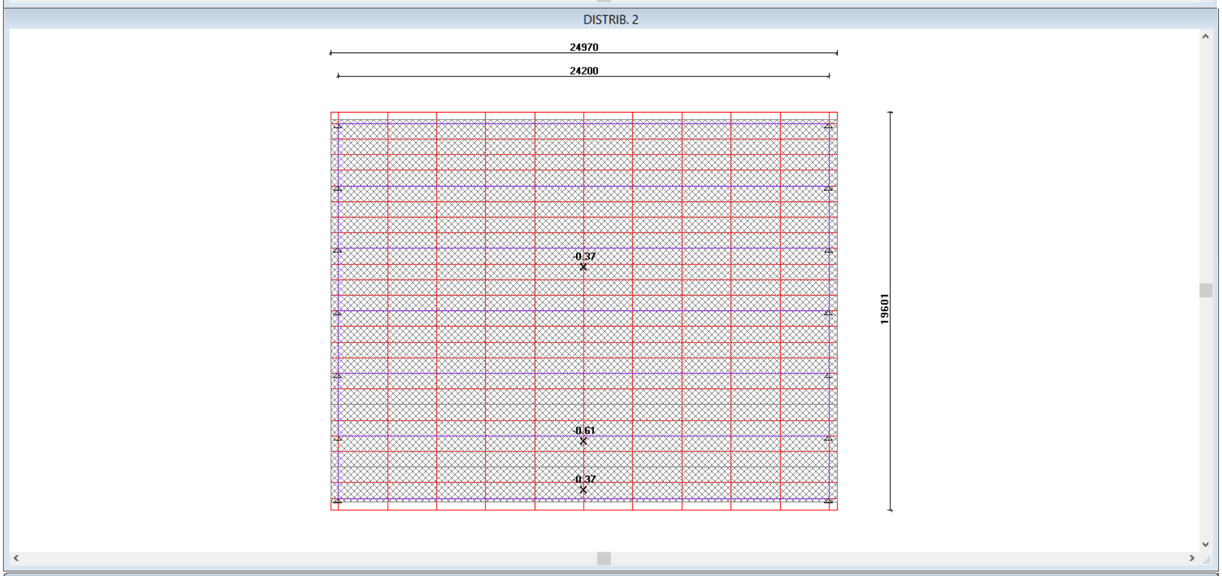

V1 #17
24970
24200
19601
5.5 5.5 5.5
5.5 5.5 5.5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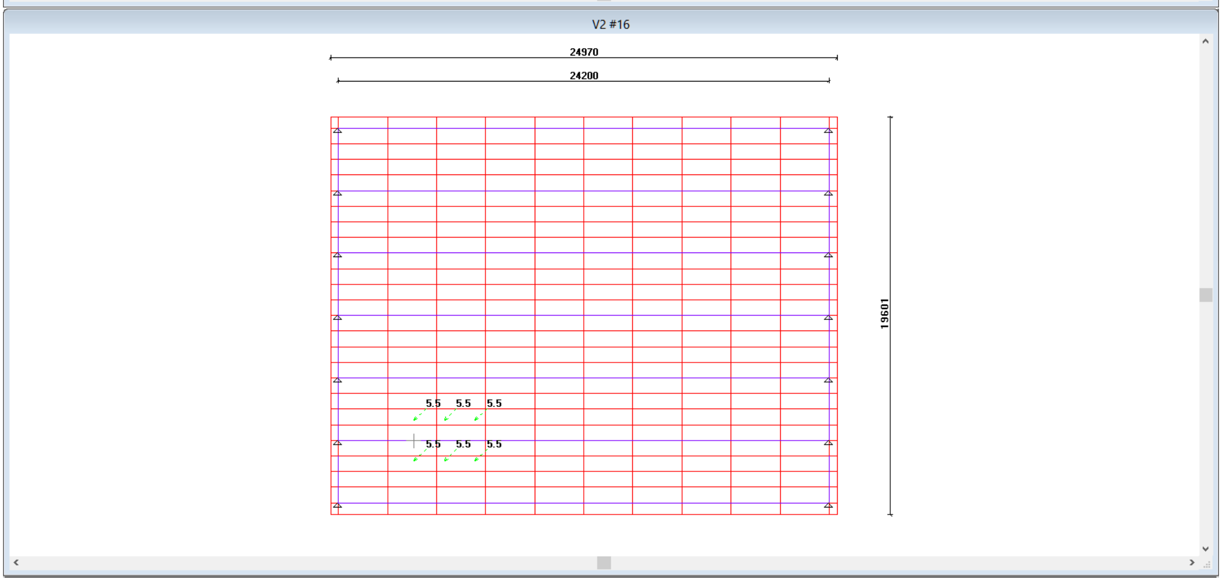
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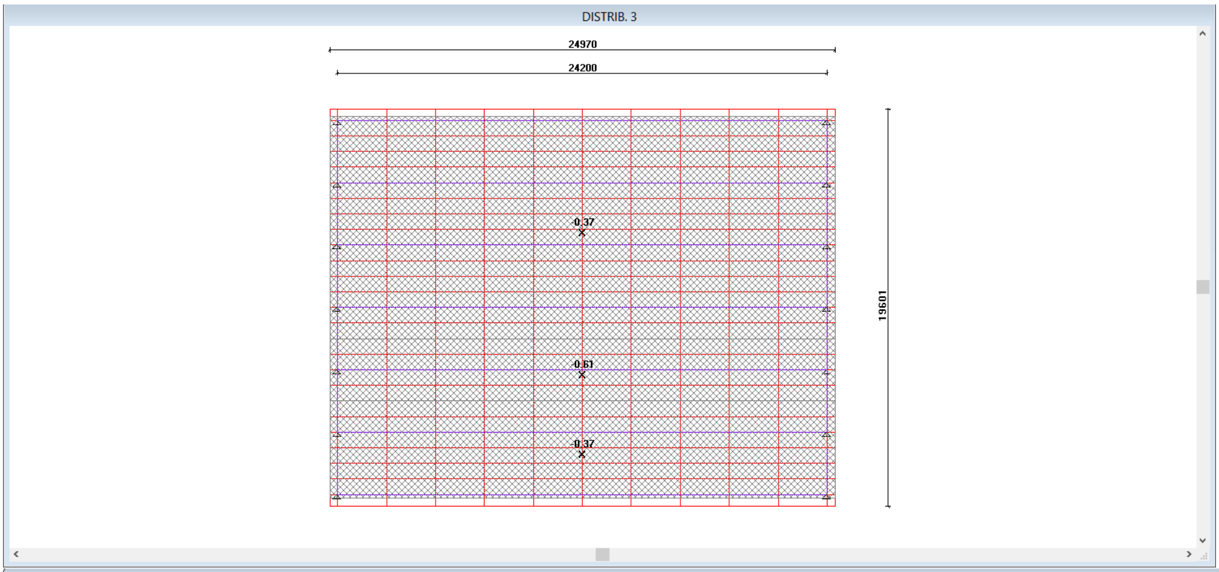
24200
19601
5.5 5.5 5.5
5.5 5.5 5.5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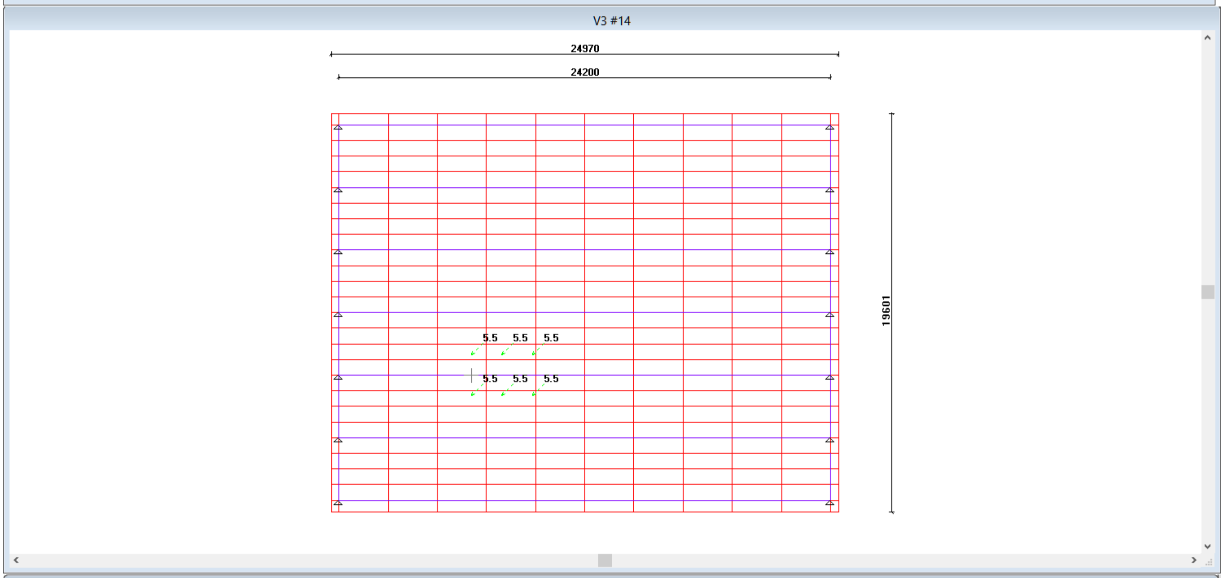
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24200
19601
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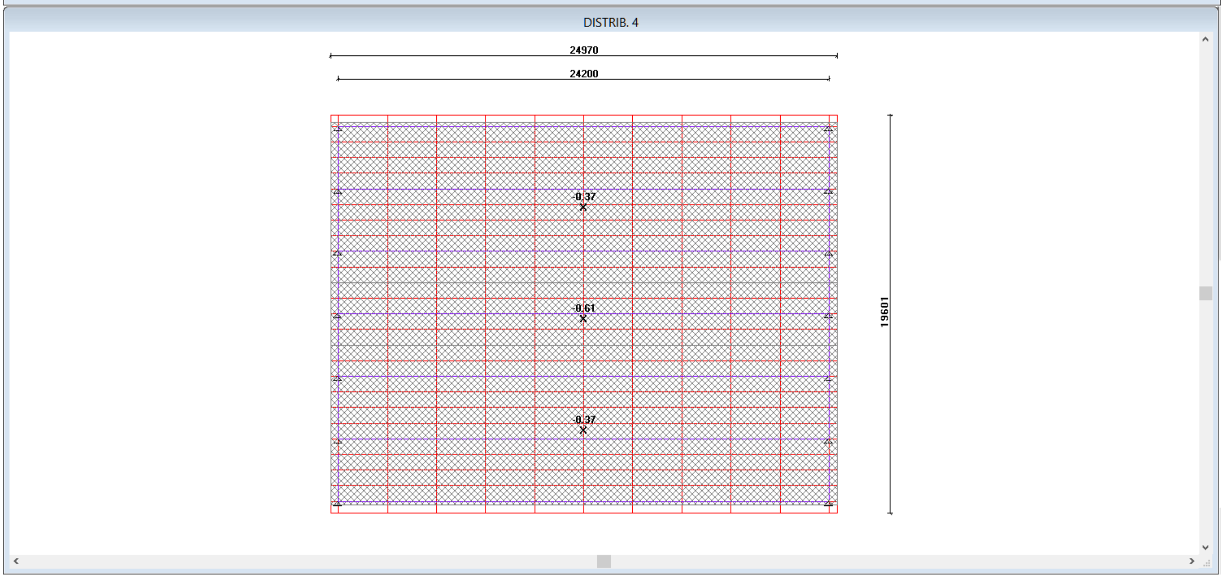
5.5 5.5 5.5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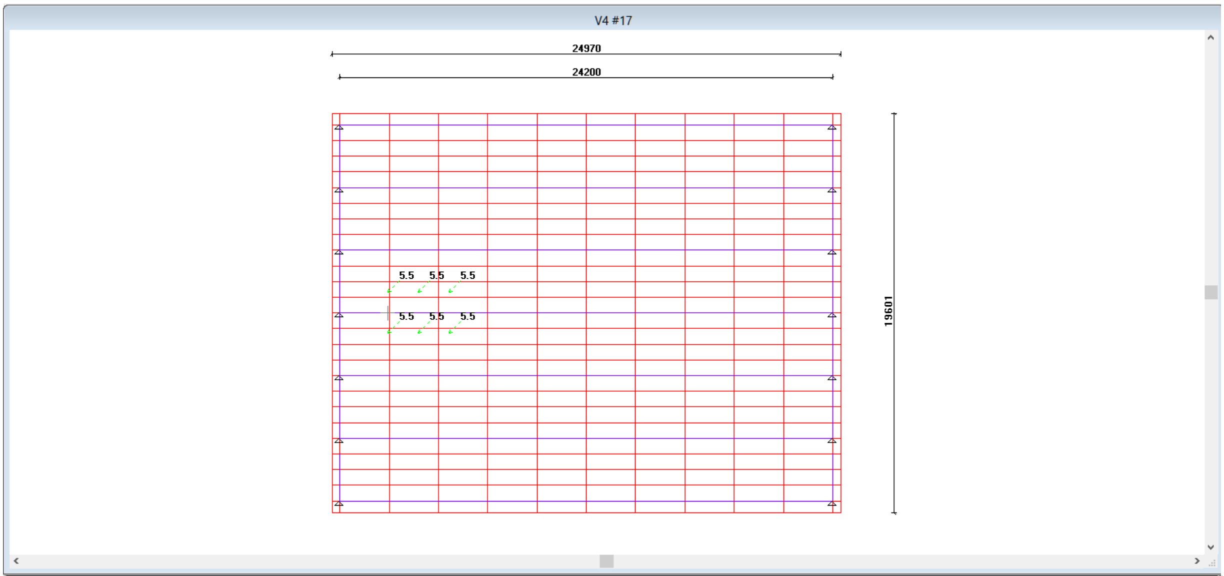
-0.37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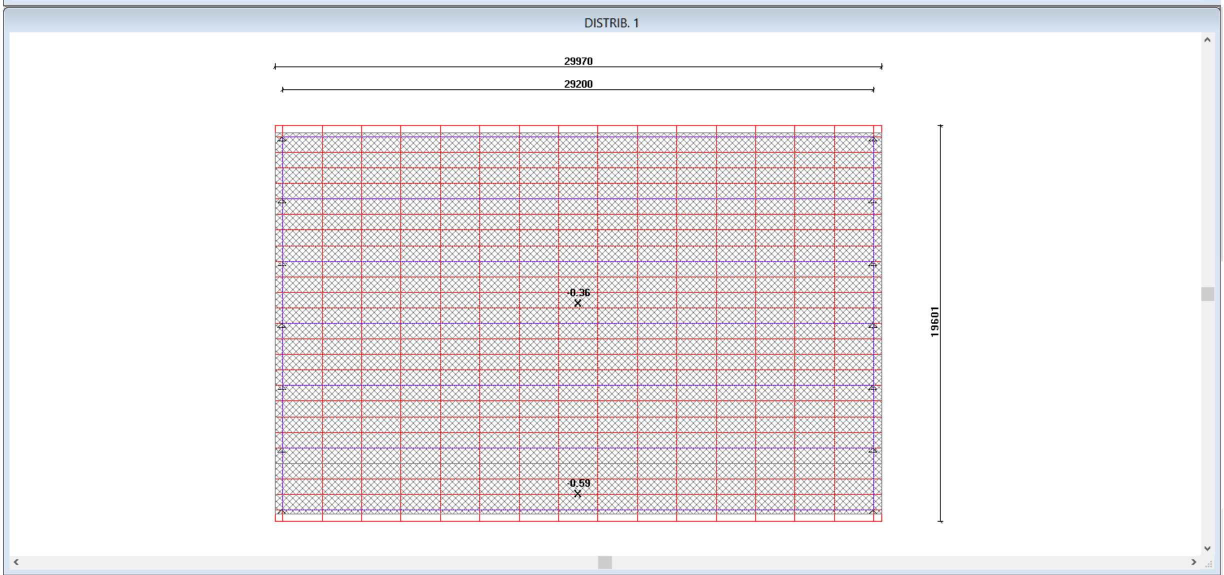
24970
24200
5.5 5.5 5.5
5.5 5.5 5.5
19601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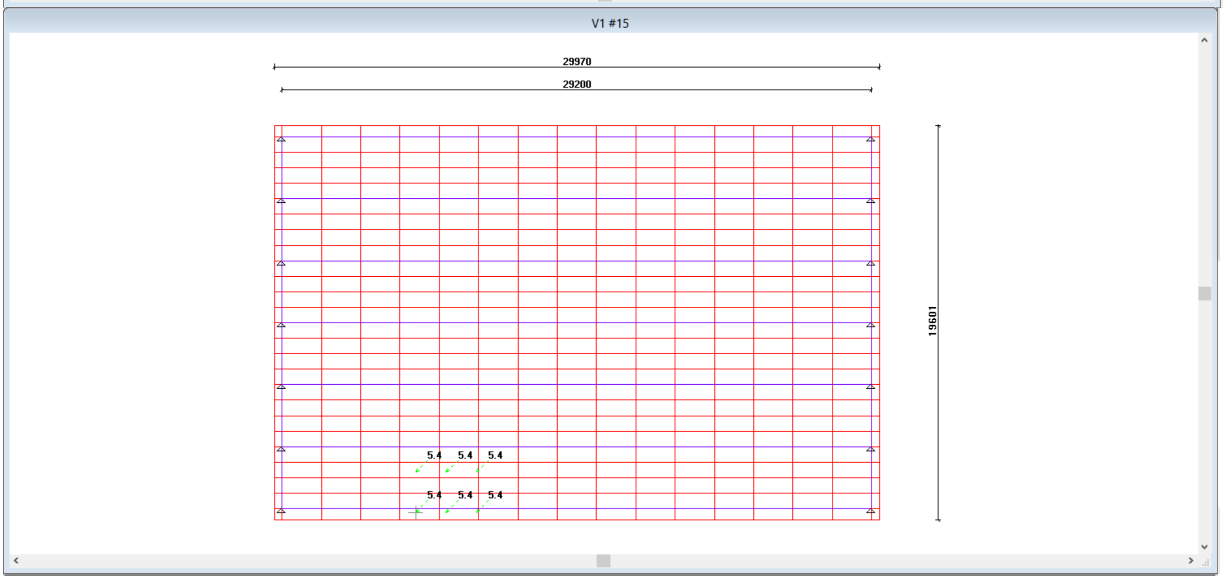
19601


V1 #15
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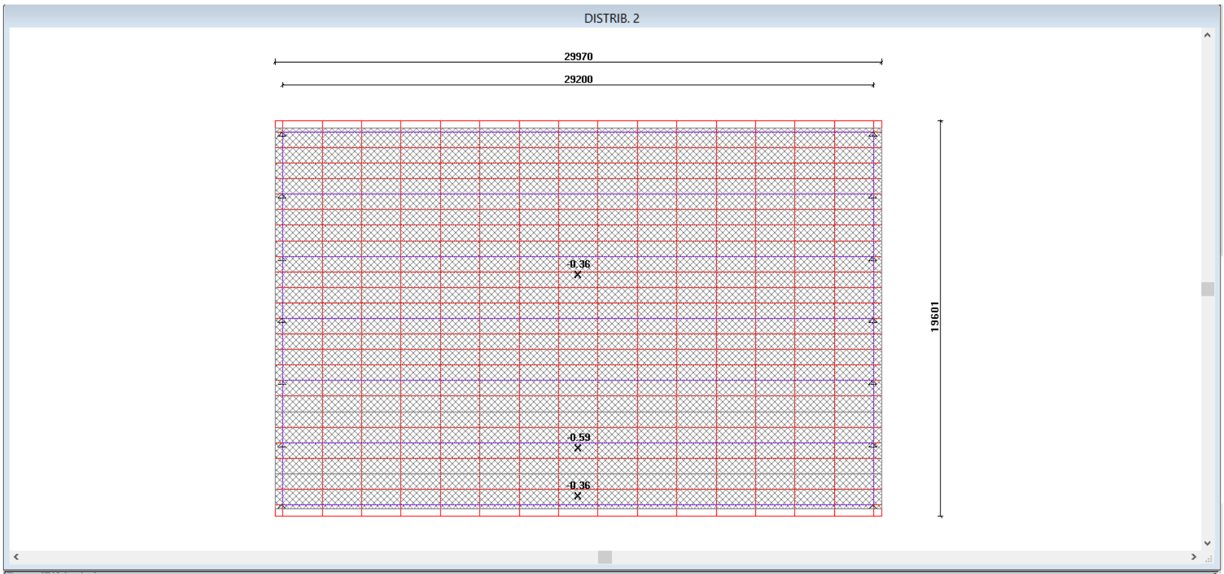
29200
5.4 5.4 5.4
5.4 5.4 5.4
19601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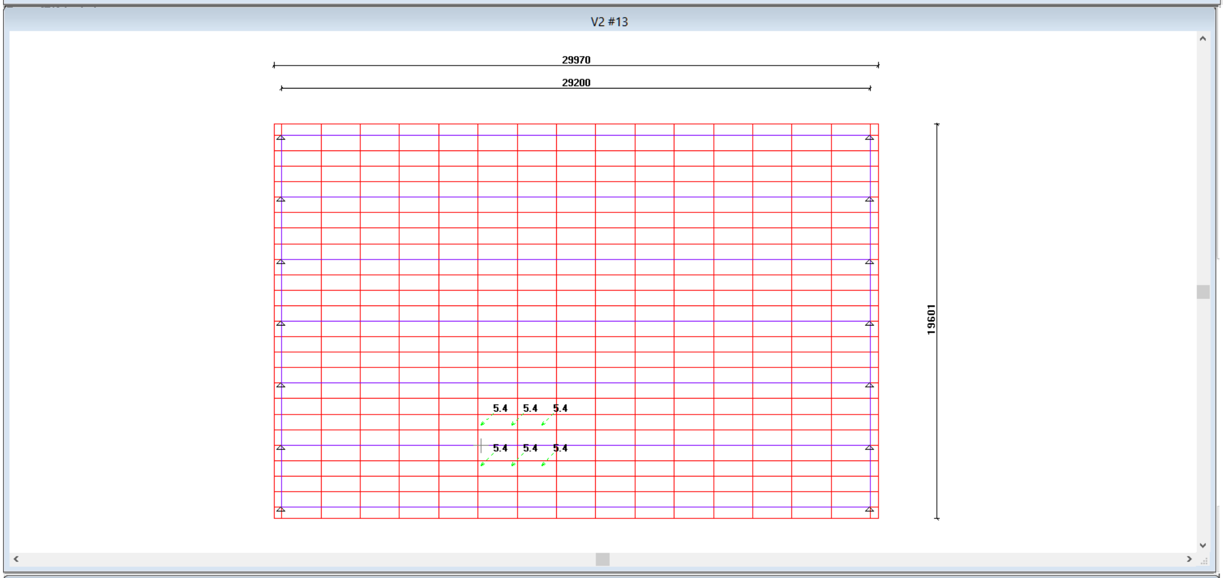
-0.36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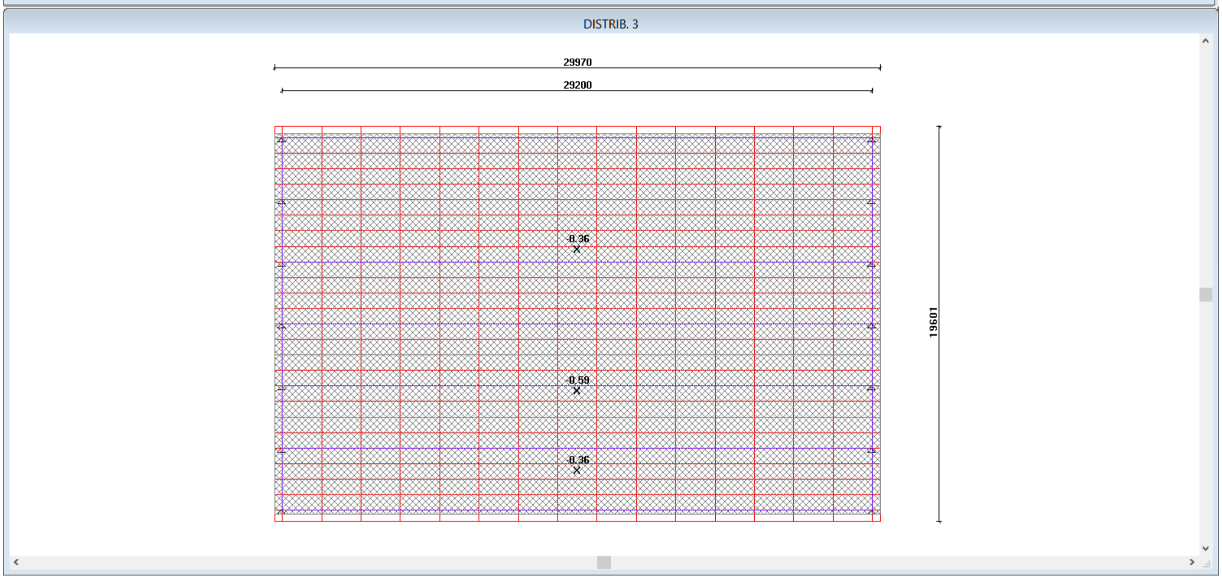
29200
19601
5.4 5.4 5.4
5.4 5.4 5.4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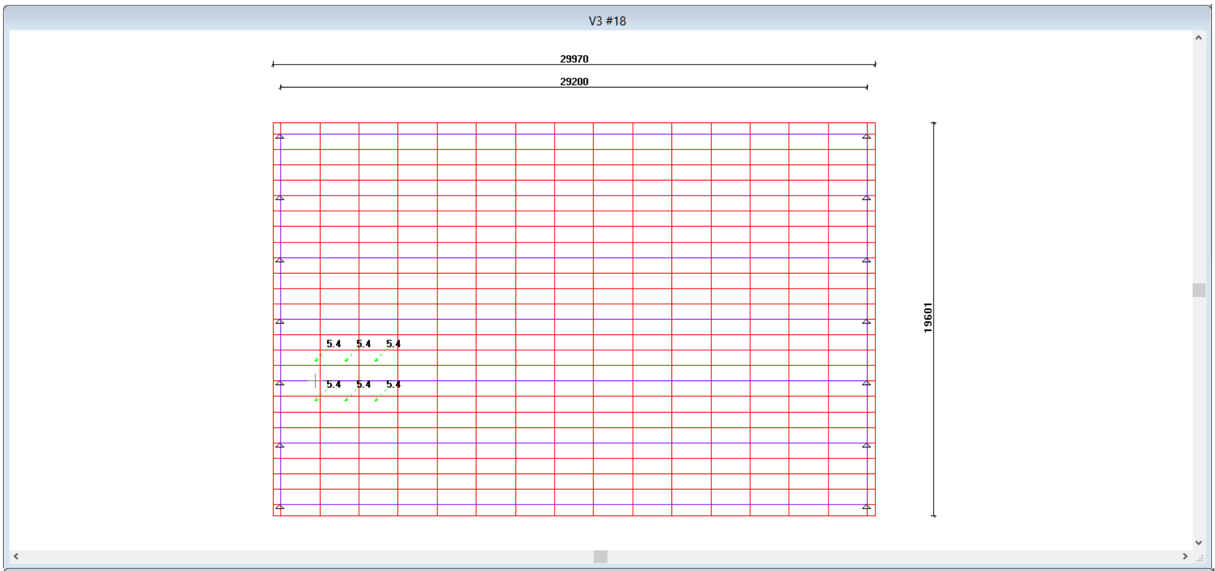
-0.36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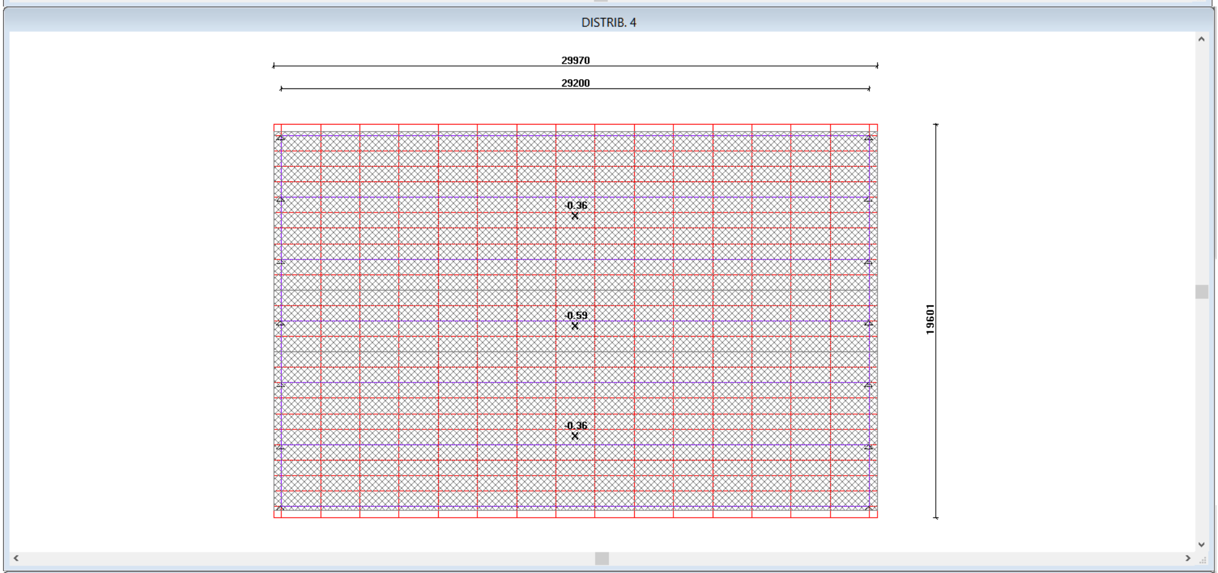
29200
19601
5.4 5.4 5.4
5.4 5.4 5.4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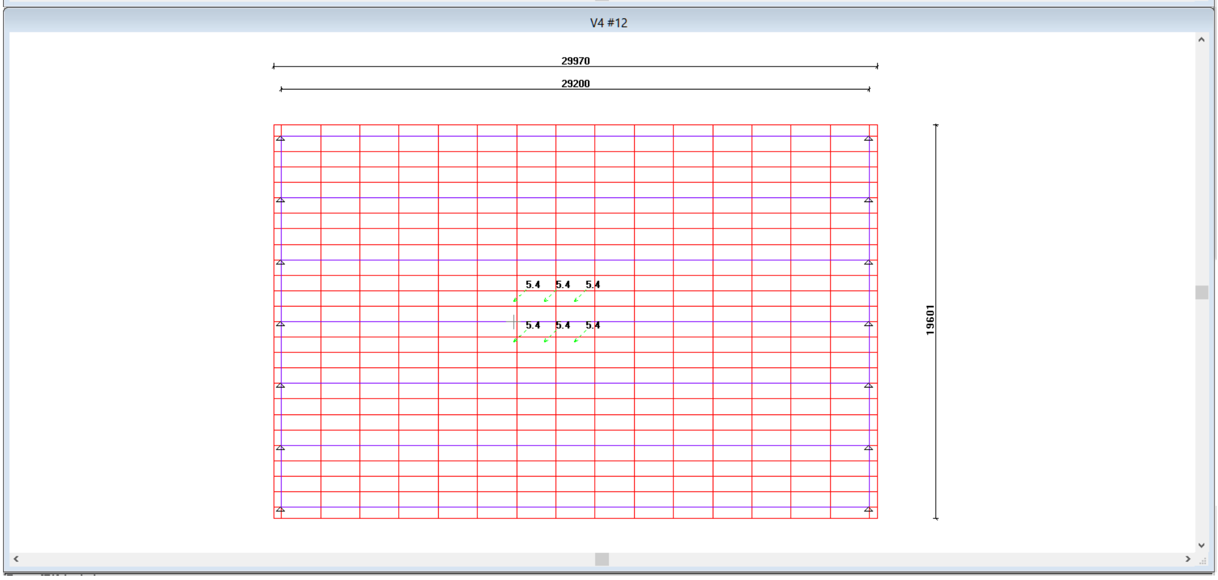
V4 #12
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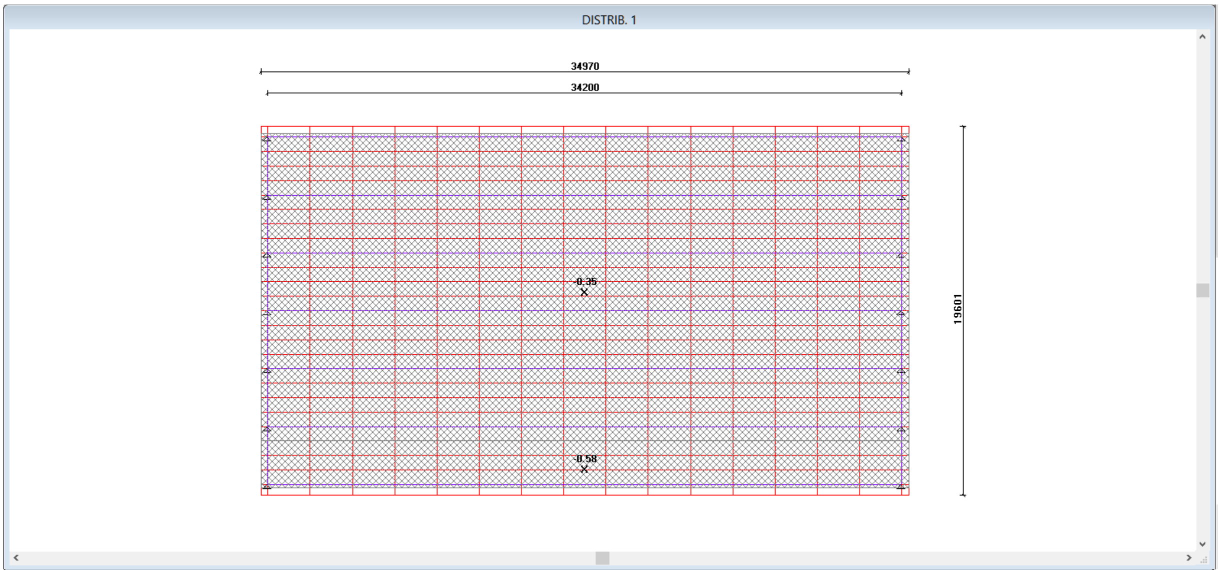
29200
19601
5.4 5.4 5.4
5.4 5.4 5.4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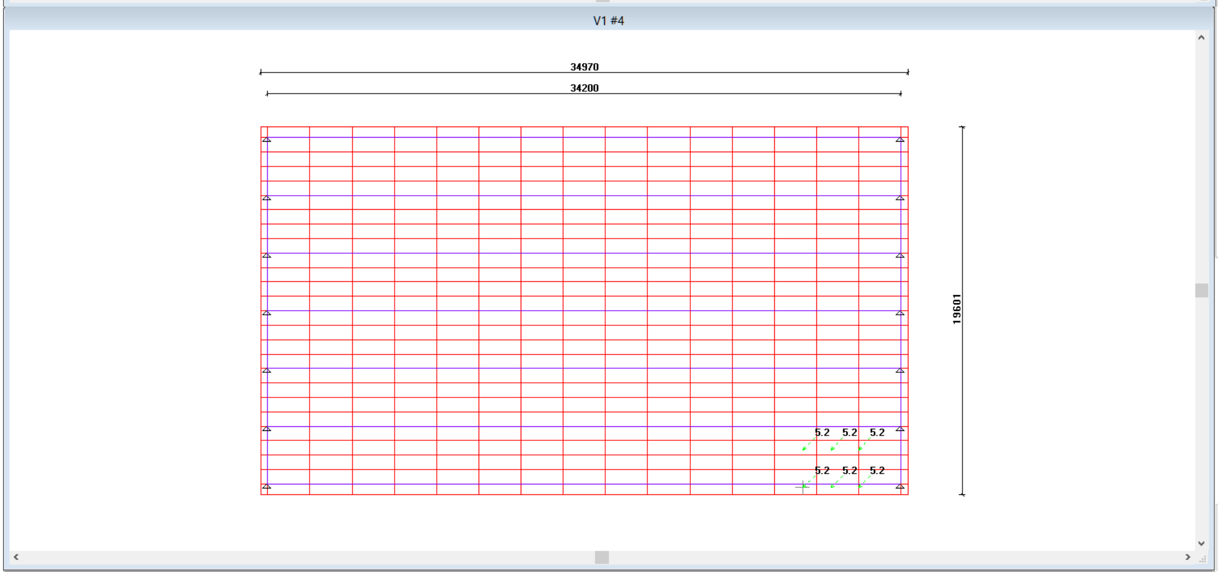
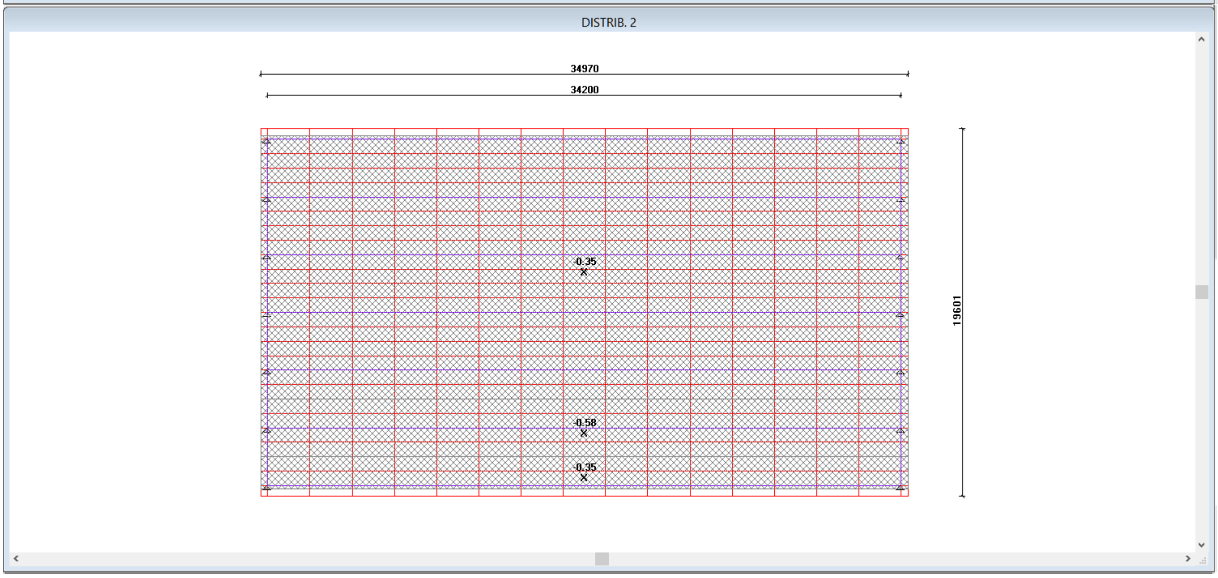

V1 #4
34970
34200
19601
5.2
5.2
5.2
5.2
5.2
5.2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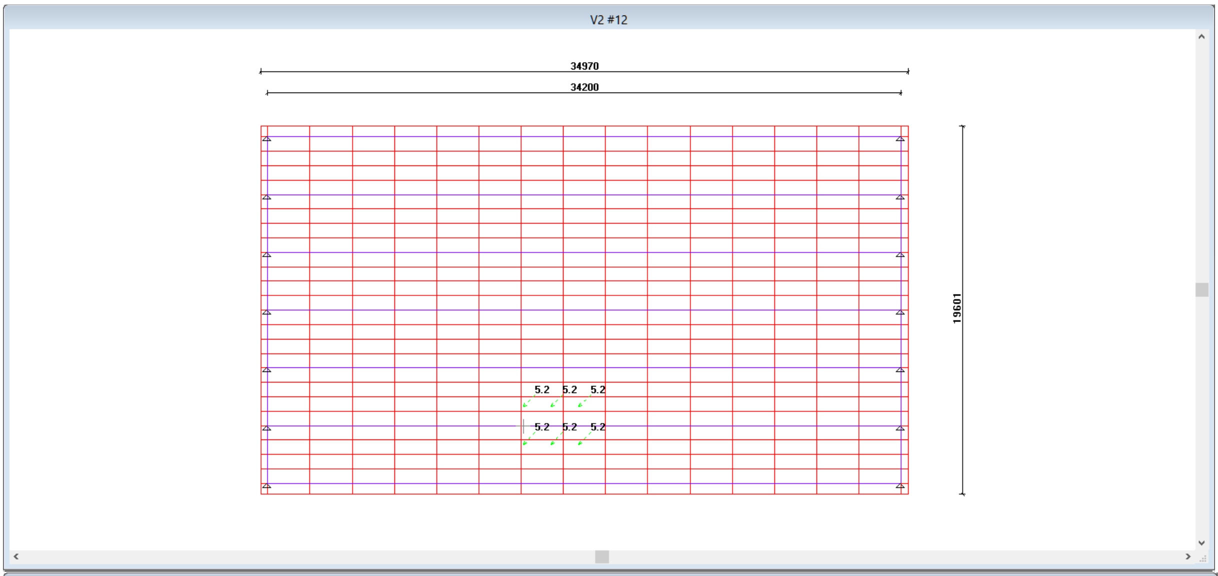
-0.58
-0.35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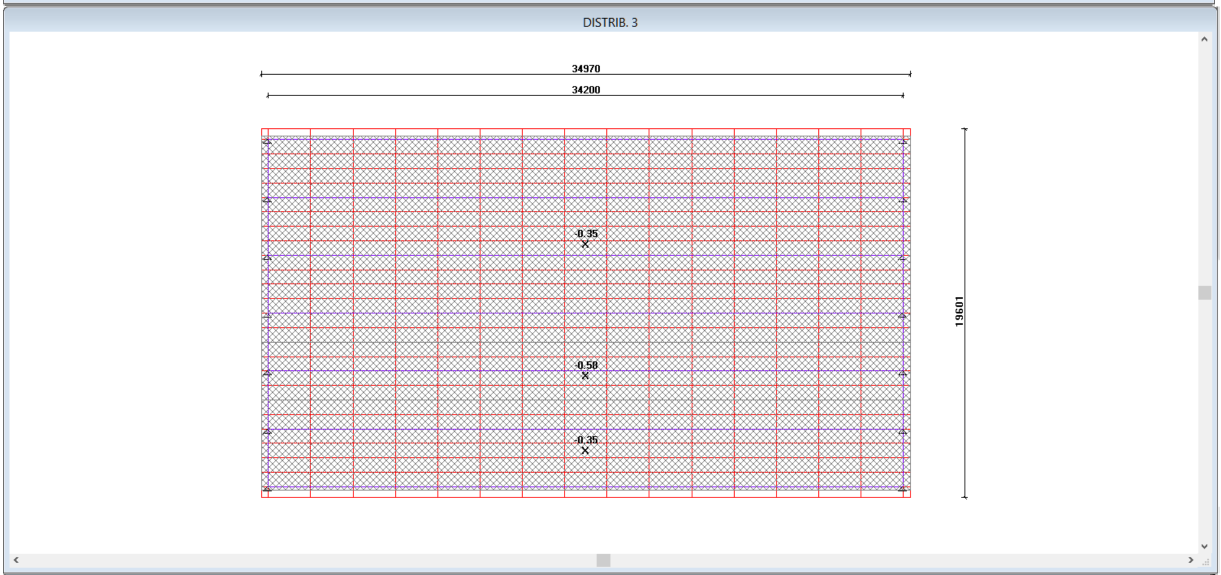
5.2 5.2 5.2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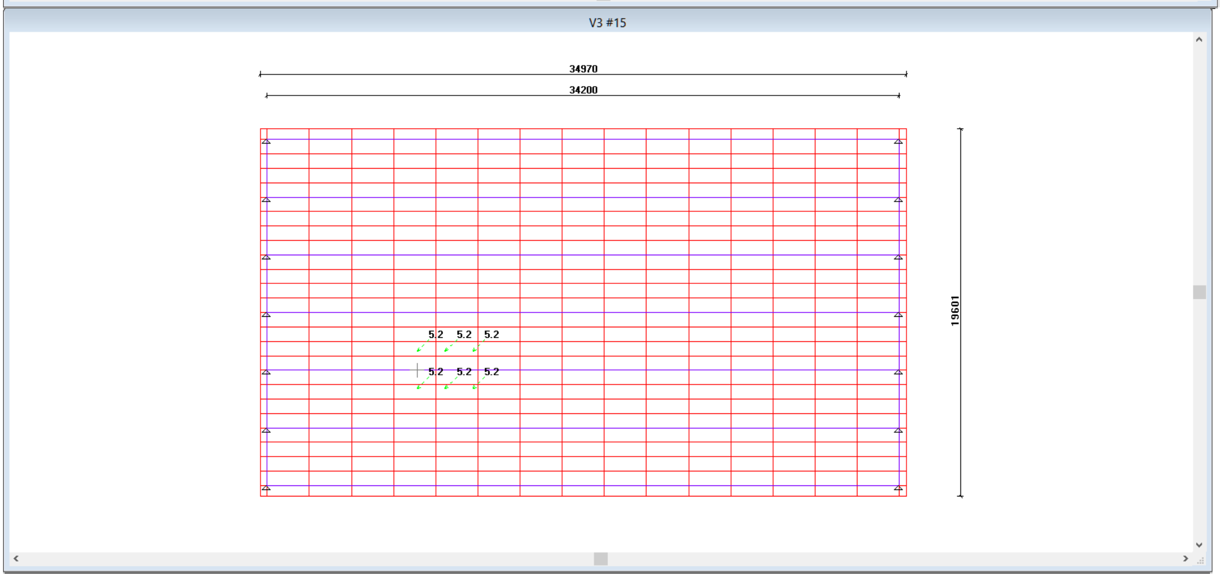
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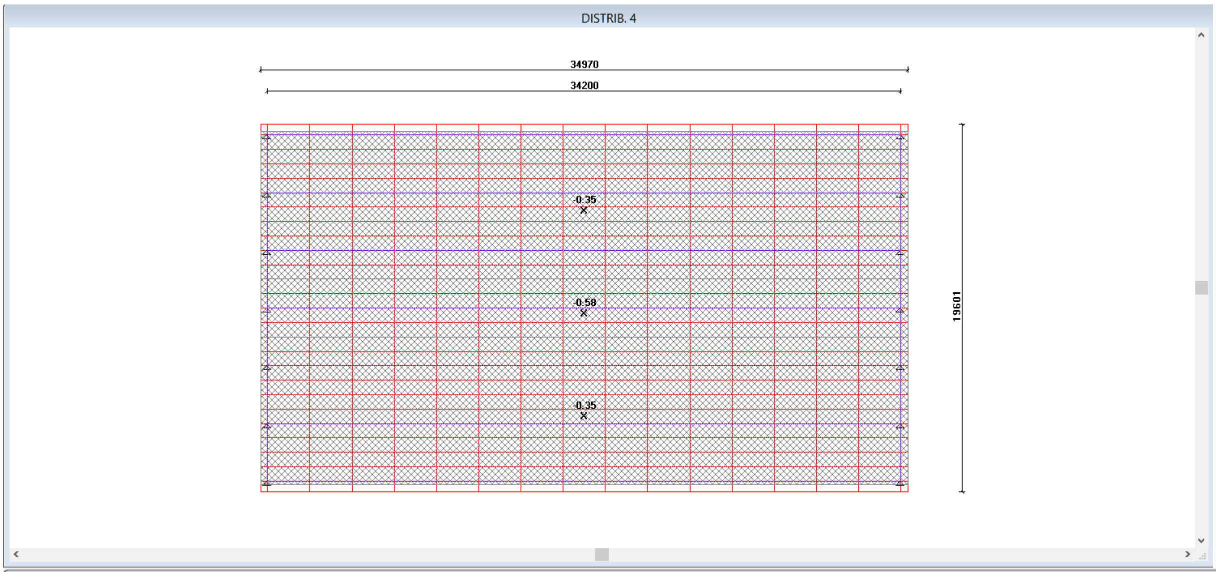
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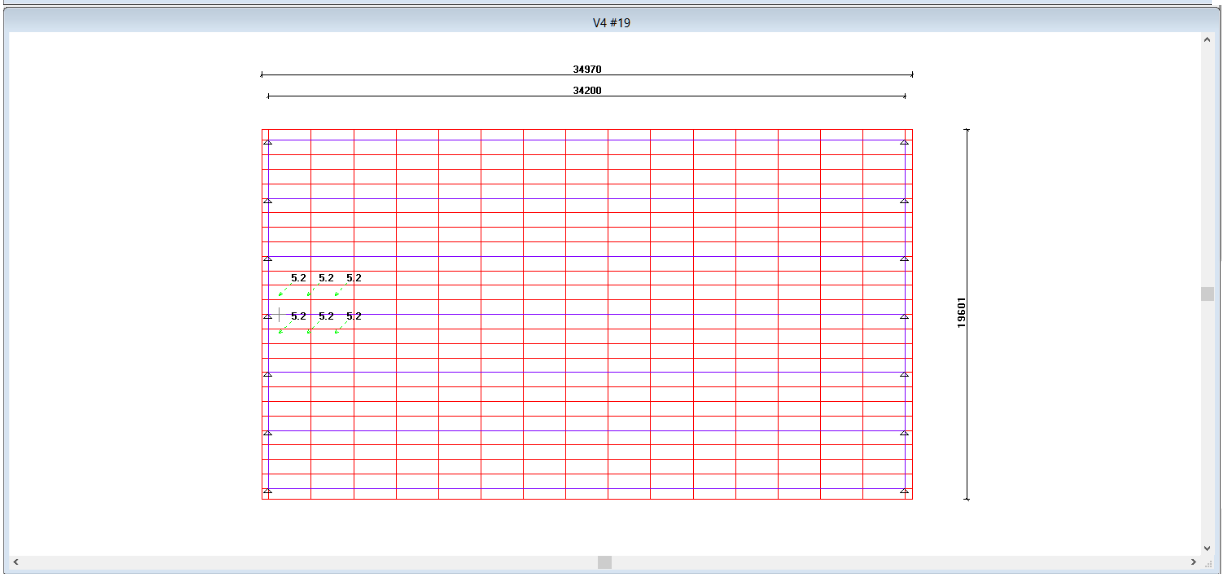
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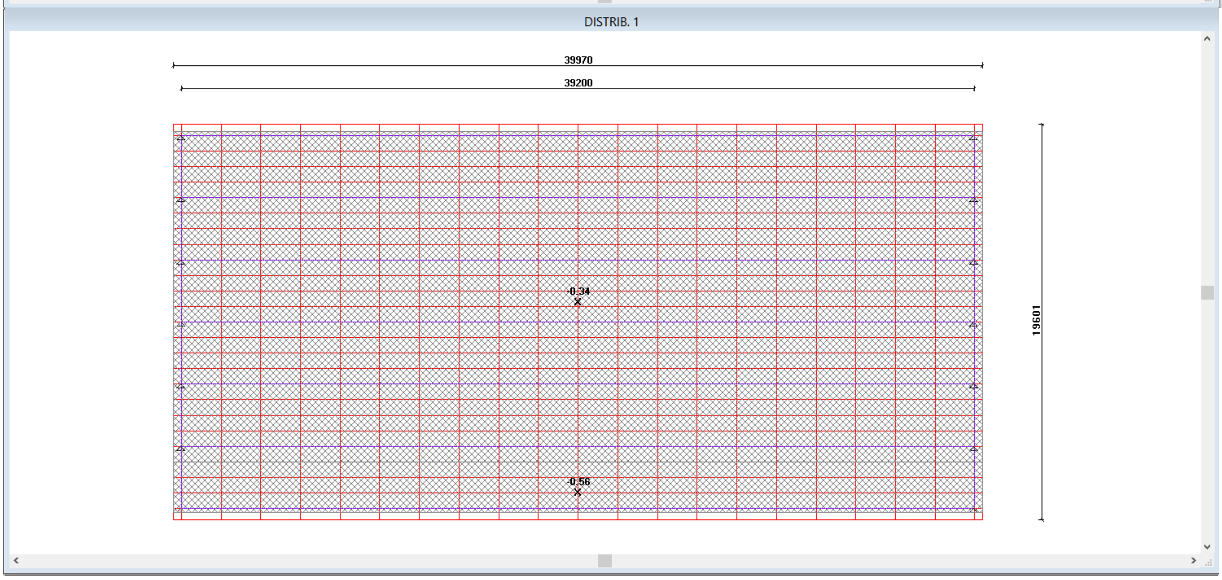
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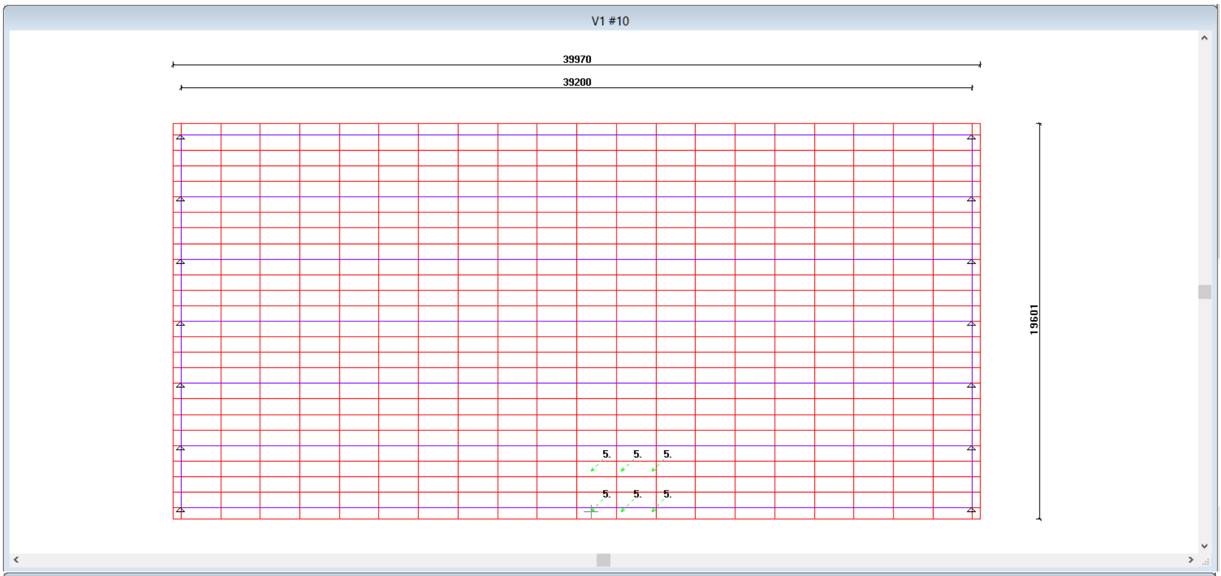
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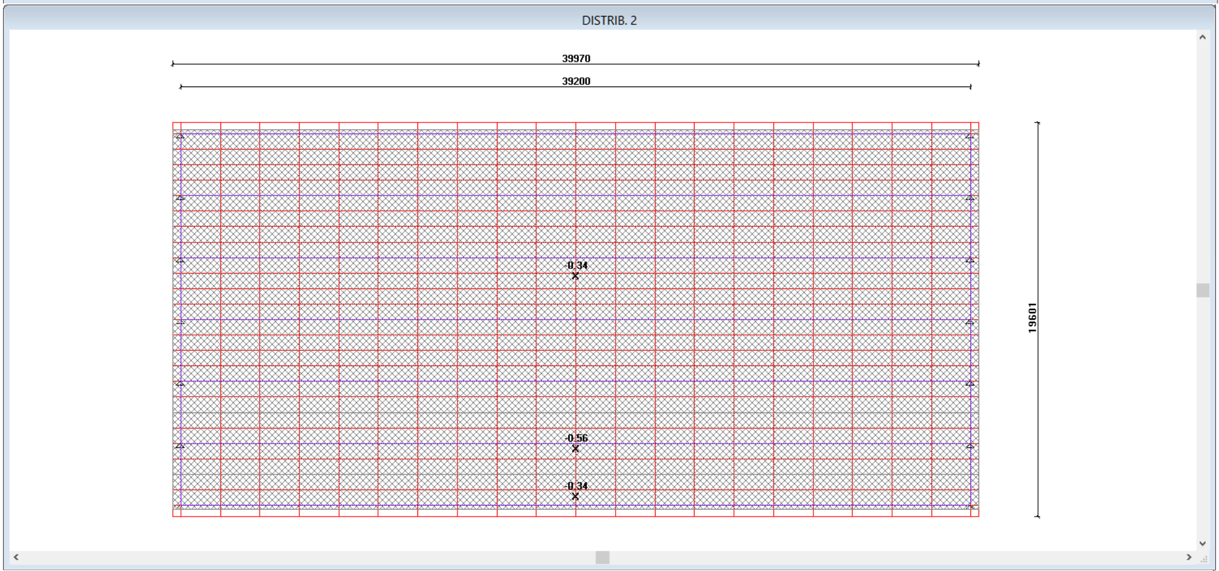
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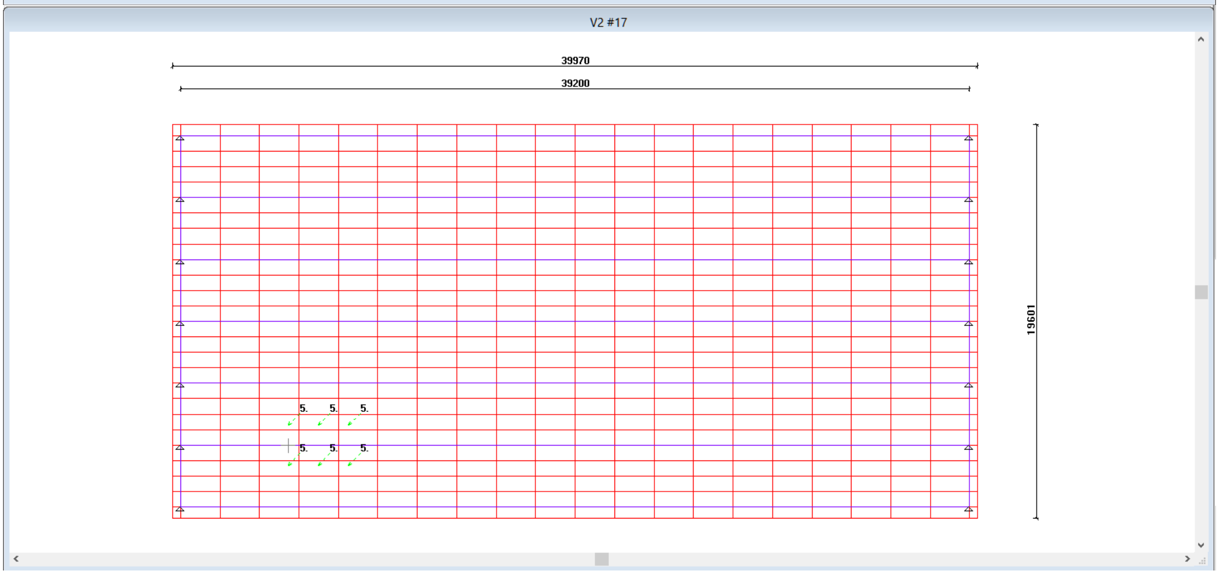
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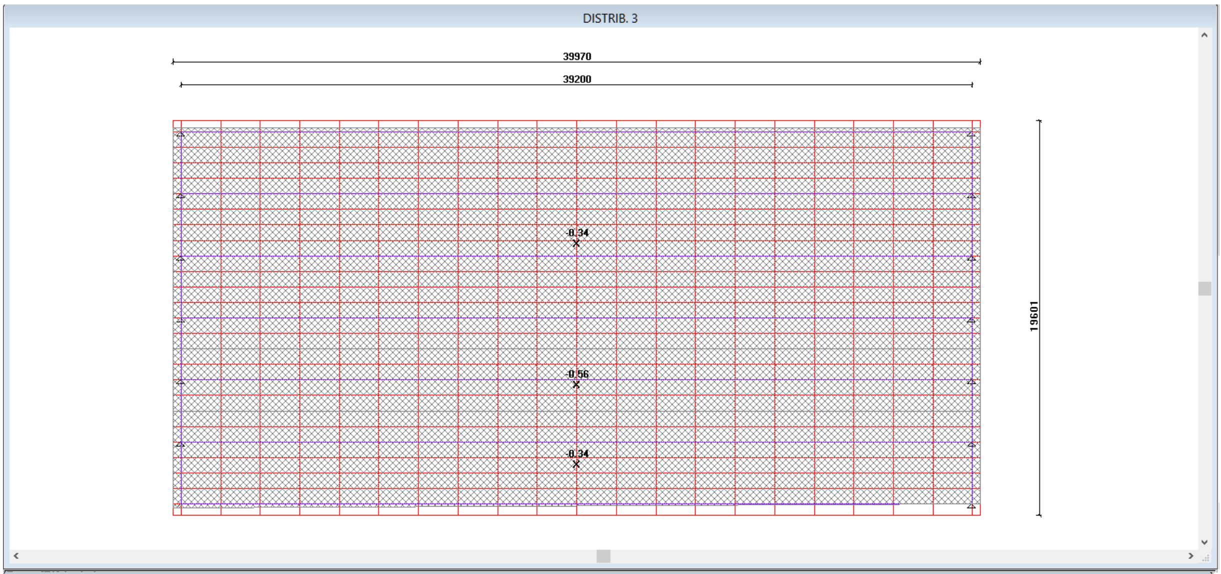
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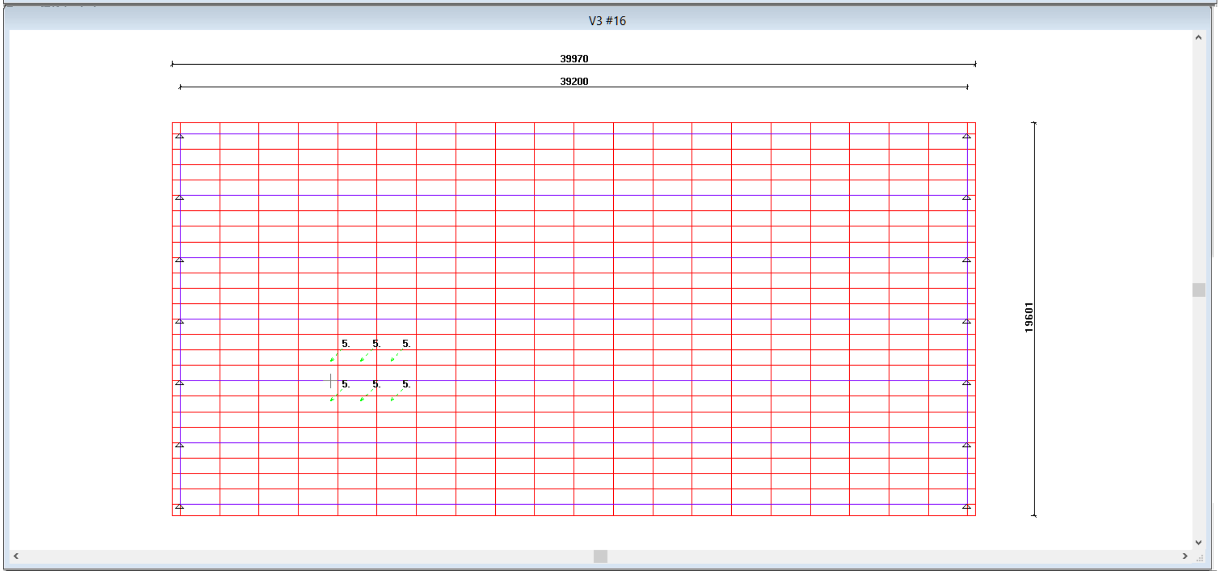
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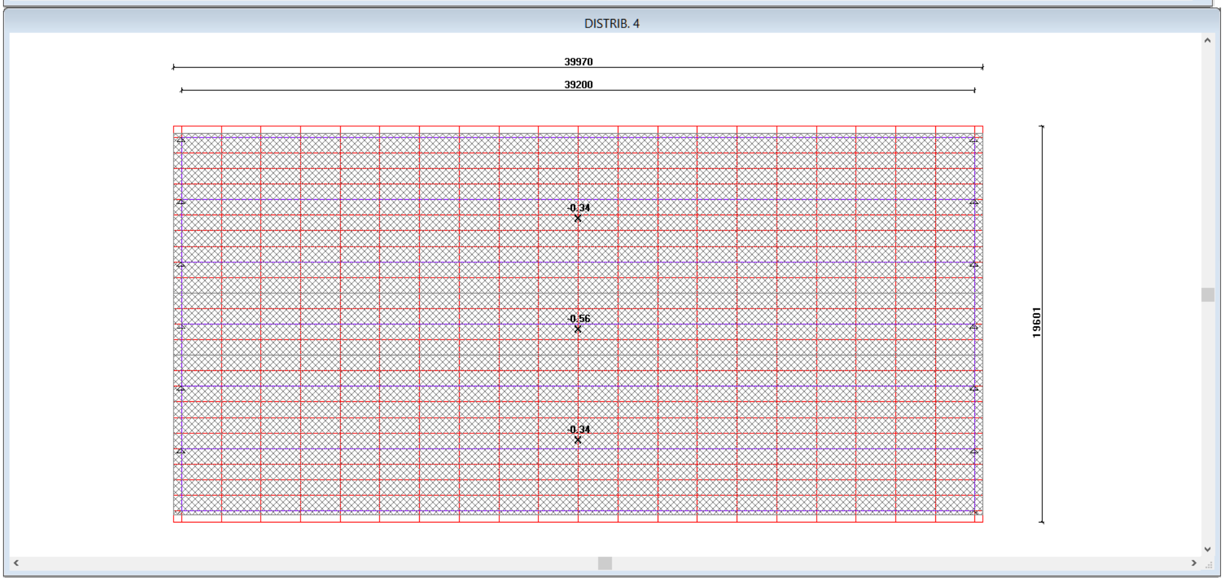
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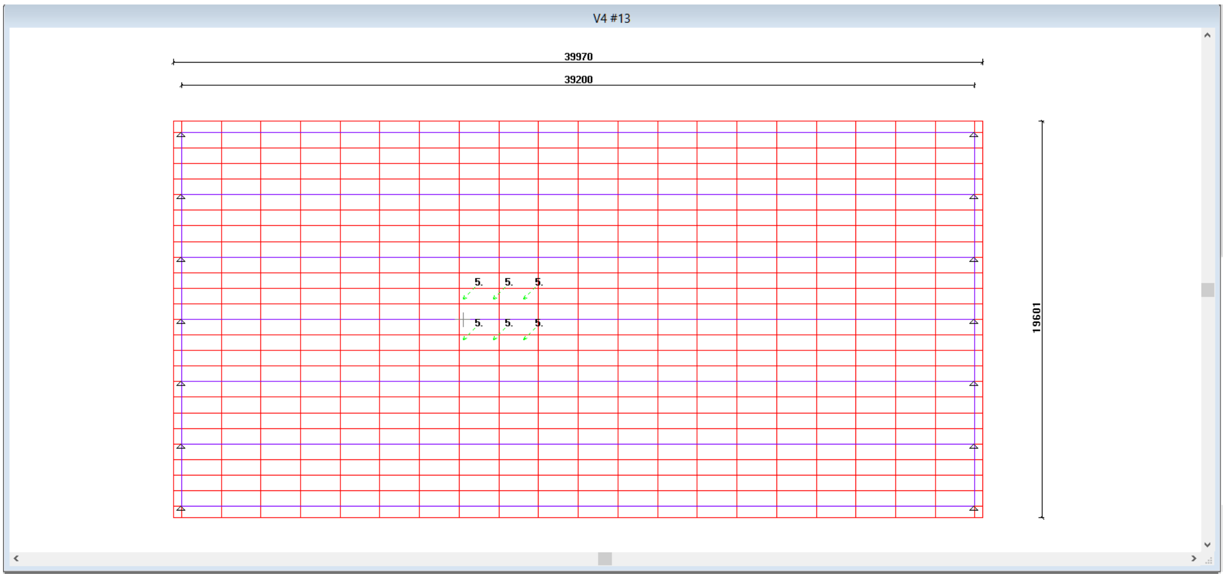
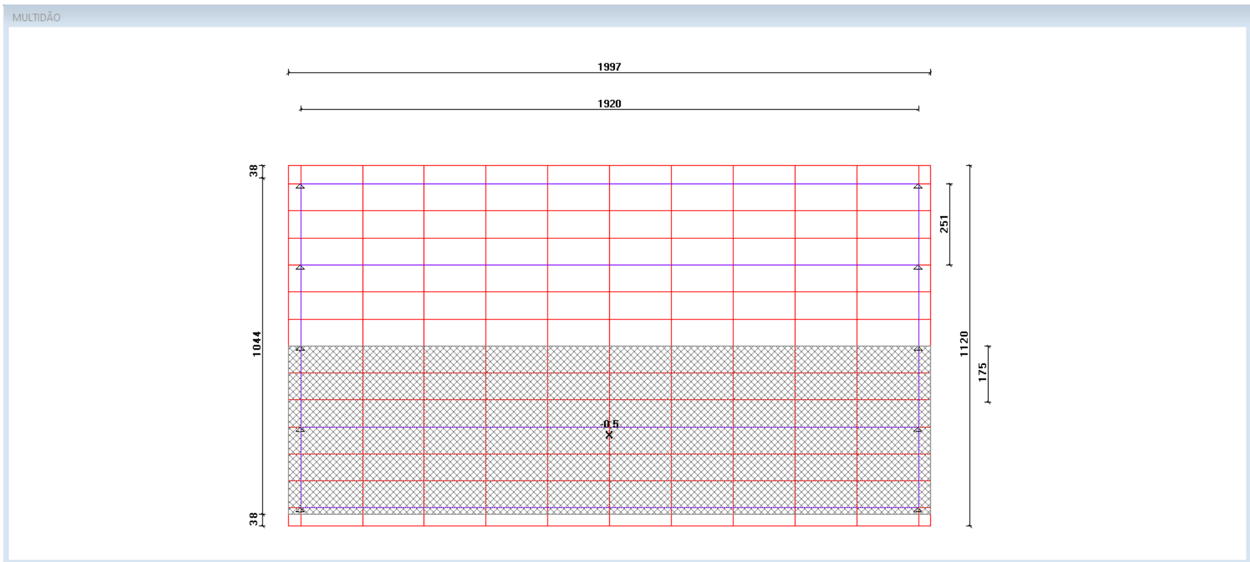


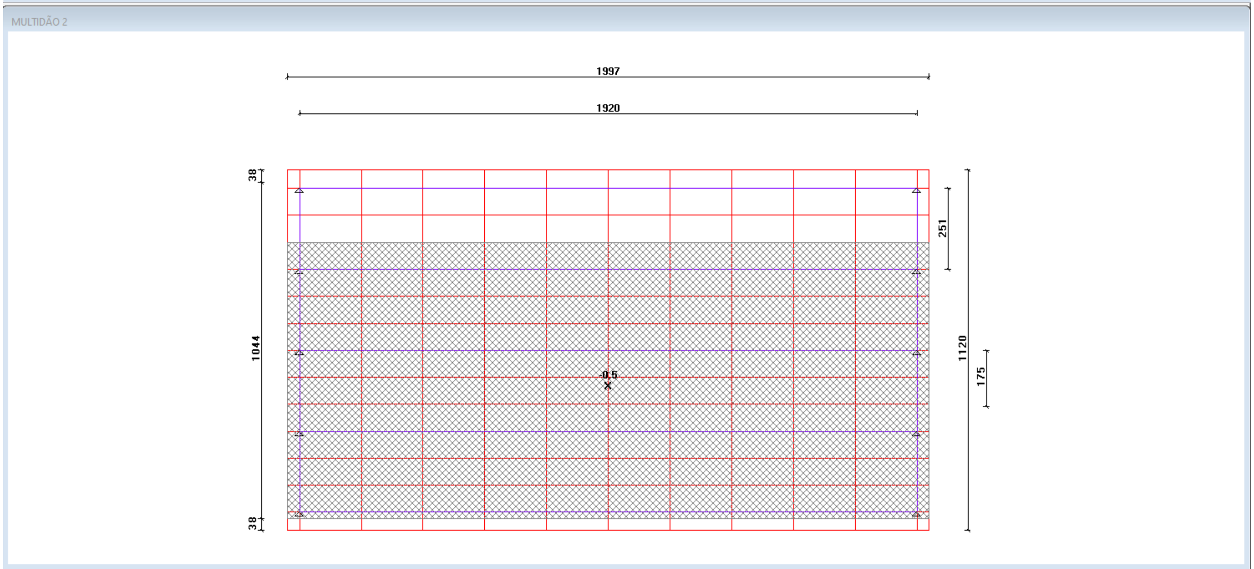
4.5. Cargas acidentais – Guindaste de 8 eixos e 96 toneladas

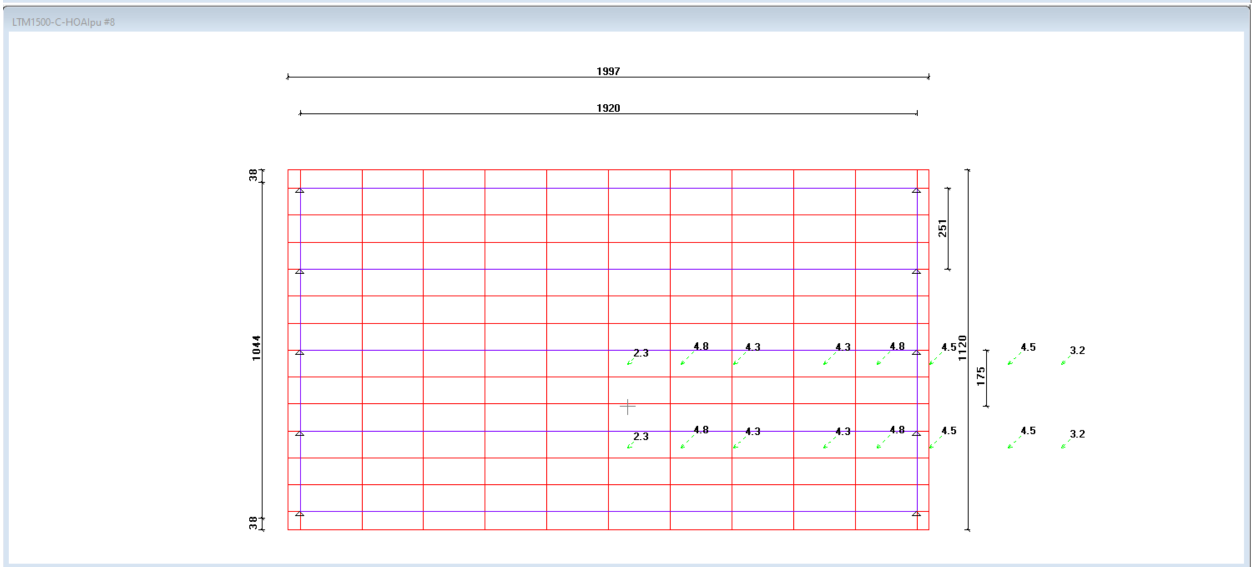
Para o Guindaste de 96 toneladas, o CIV foi aplicado após a obtenção dos momentos e cortantes. Por isso a multidão está com o valor de 0,50 tf/m.

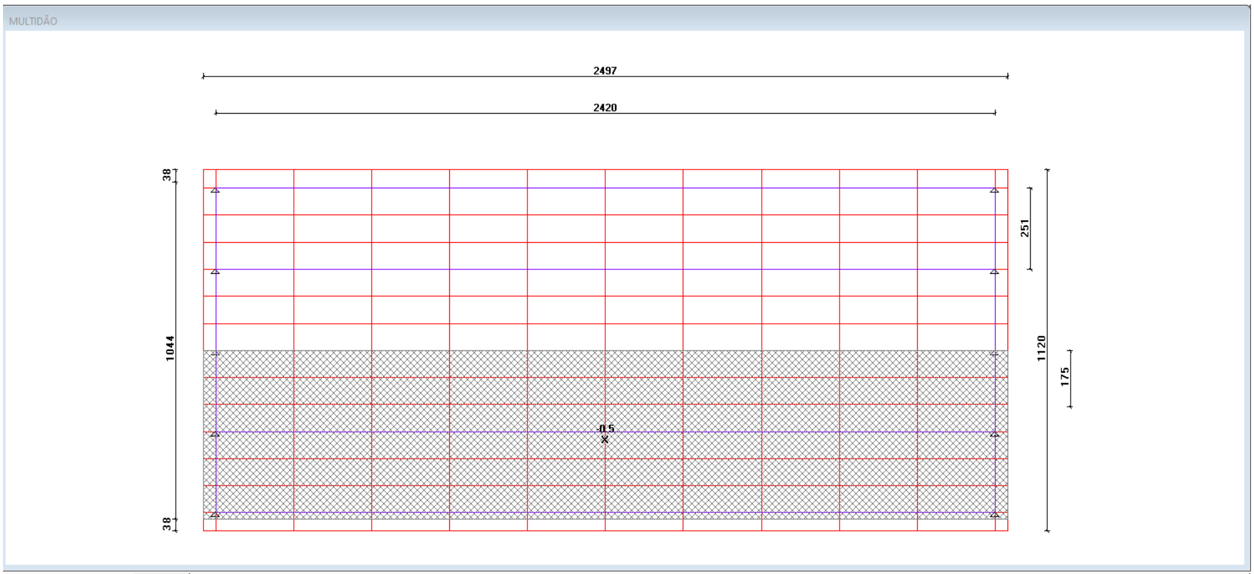
O Liebherr está trafegando homogeneizado conforme foi apresentado no item 2.

4.5.1. Tabuleiro 11,20 m





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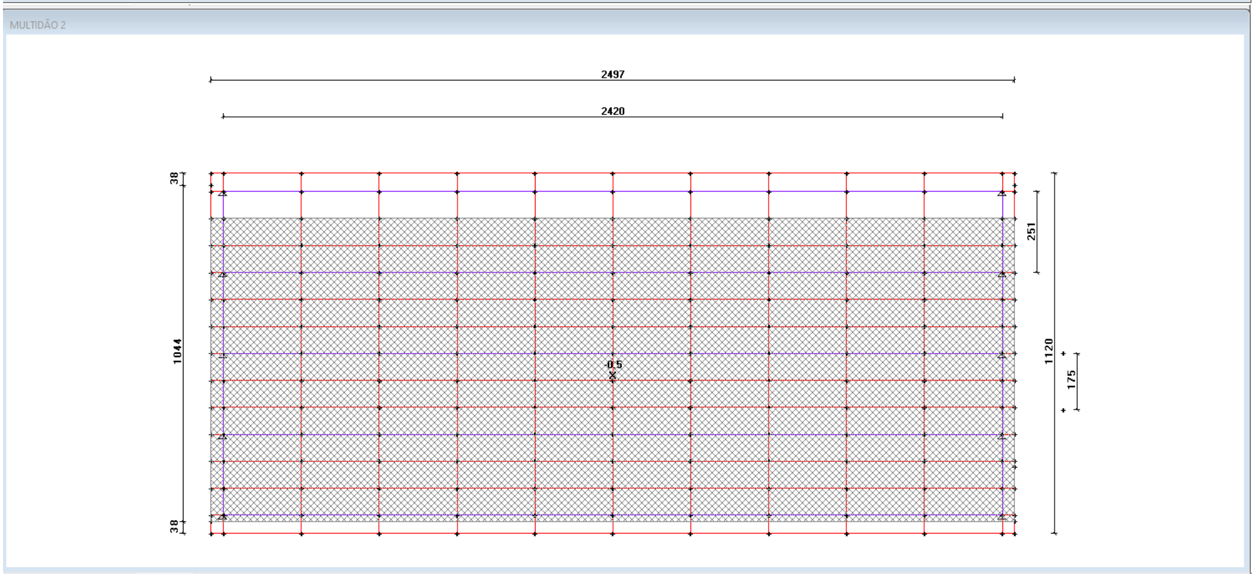
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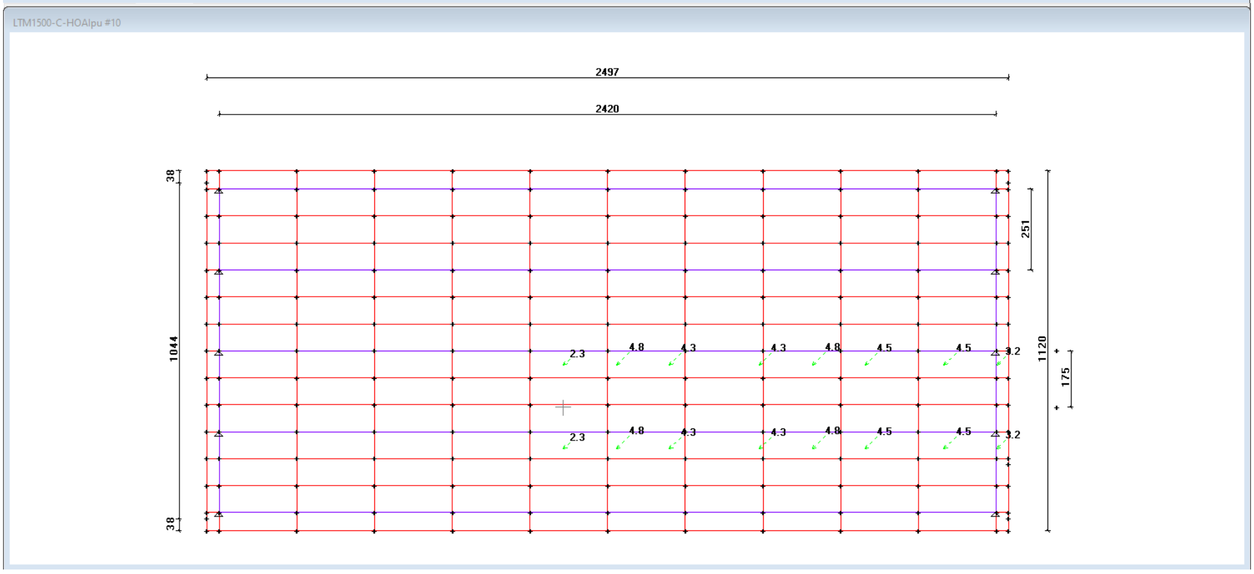
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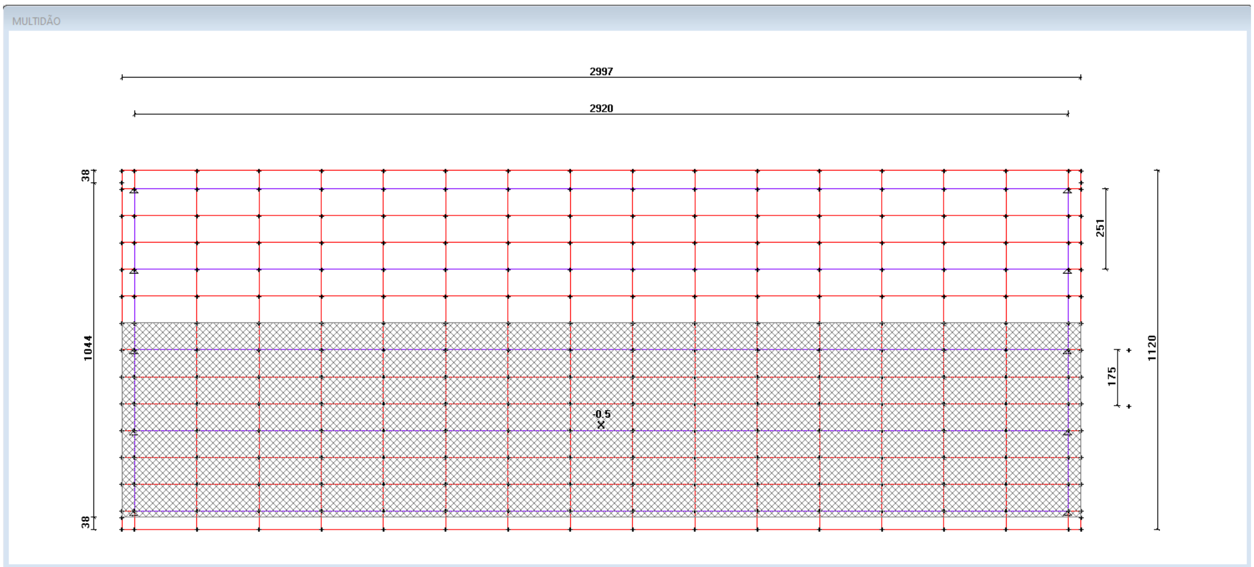
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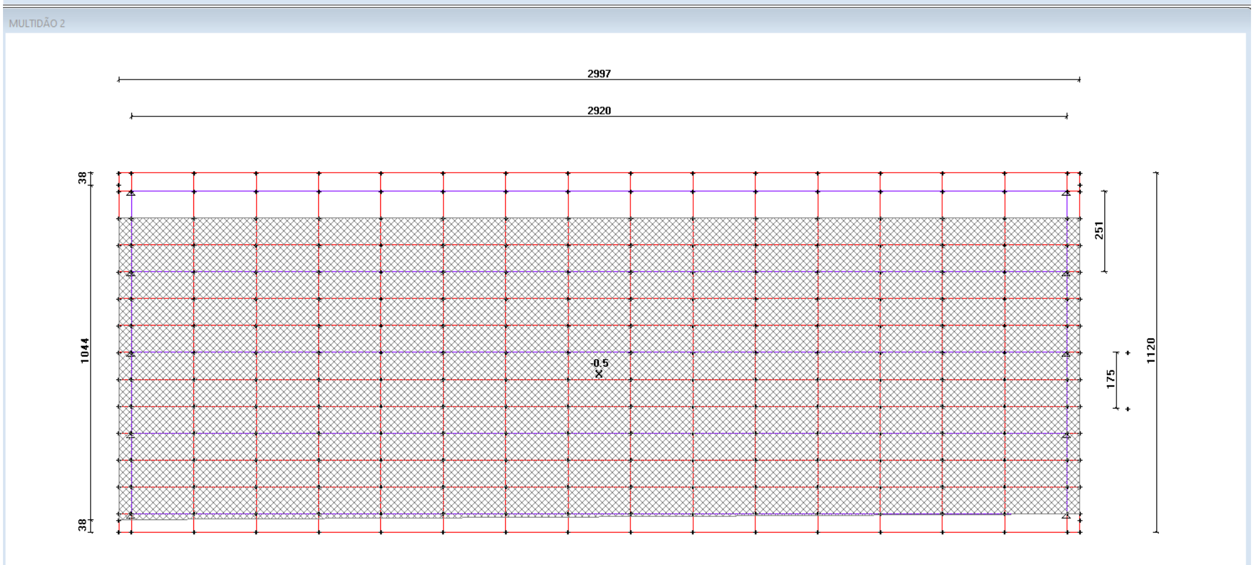
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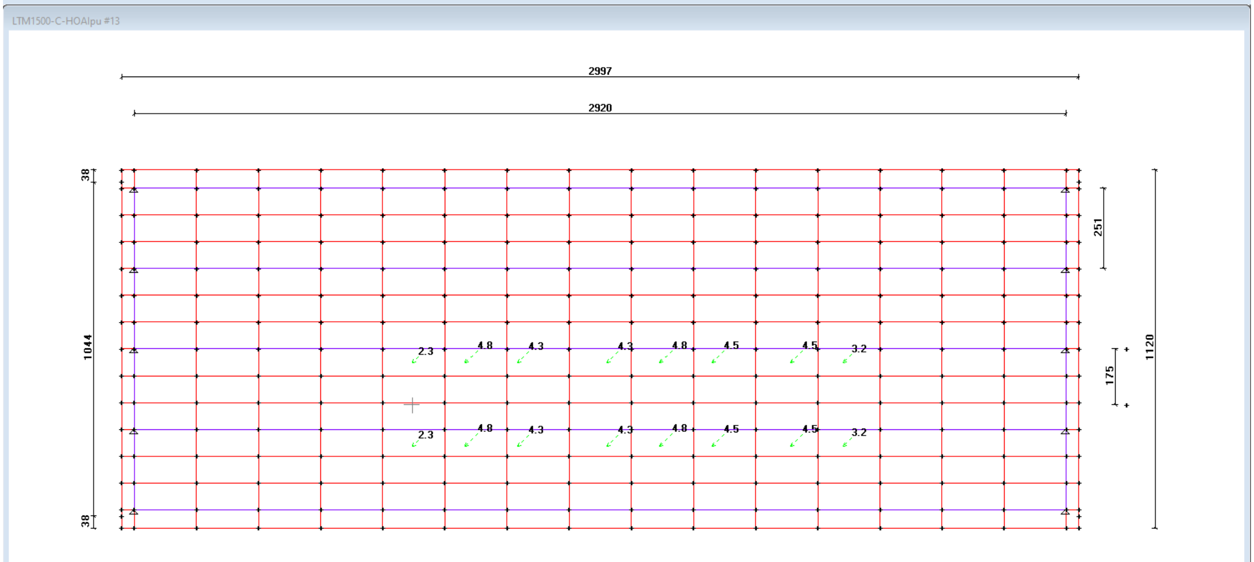
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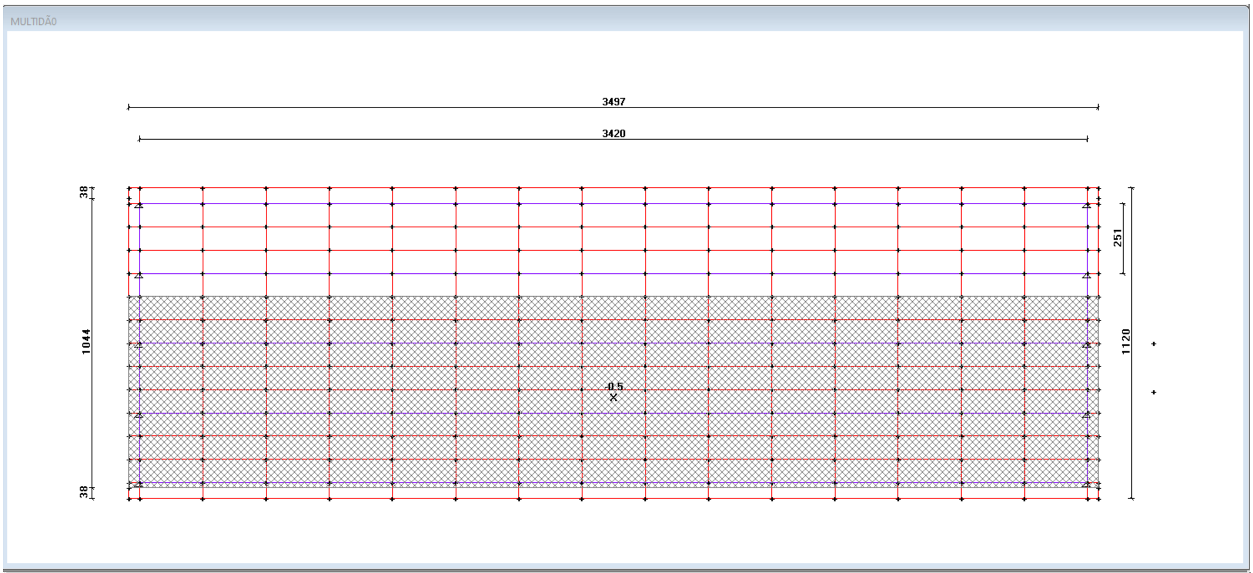
3.2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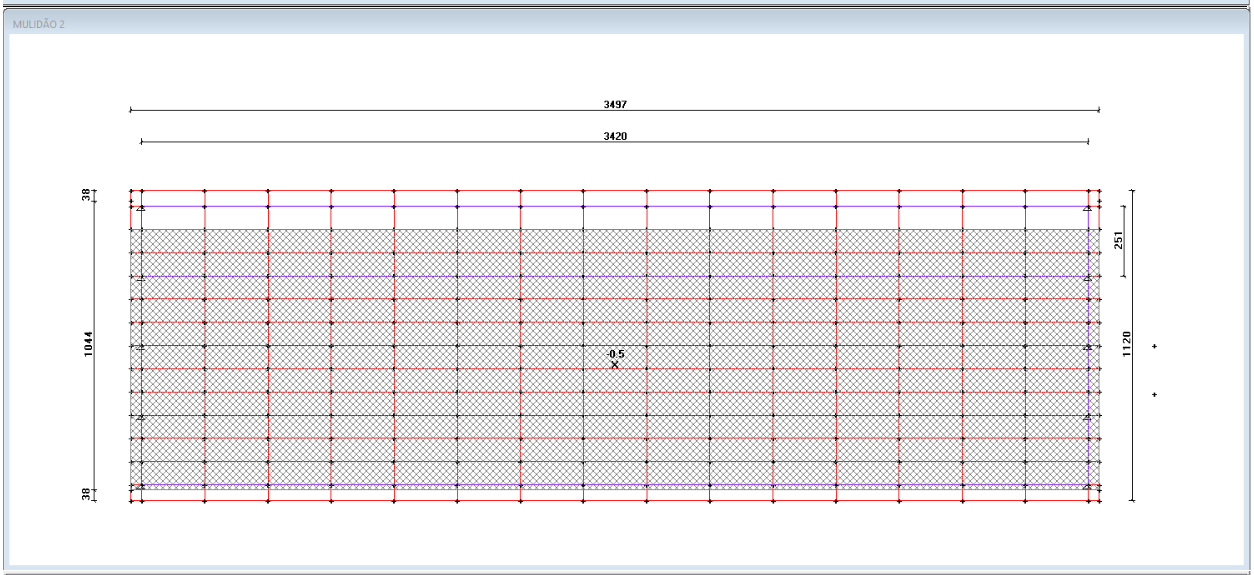
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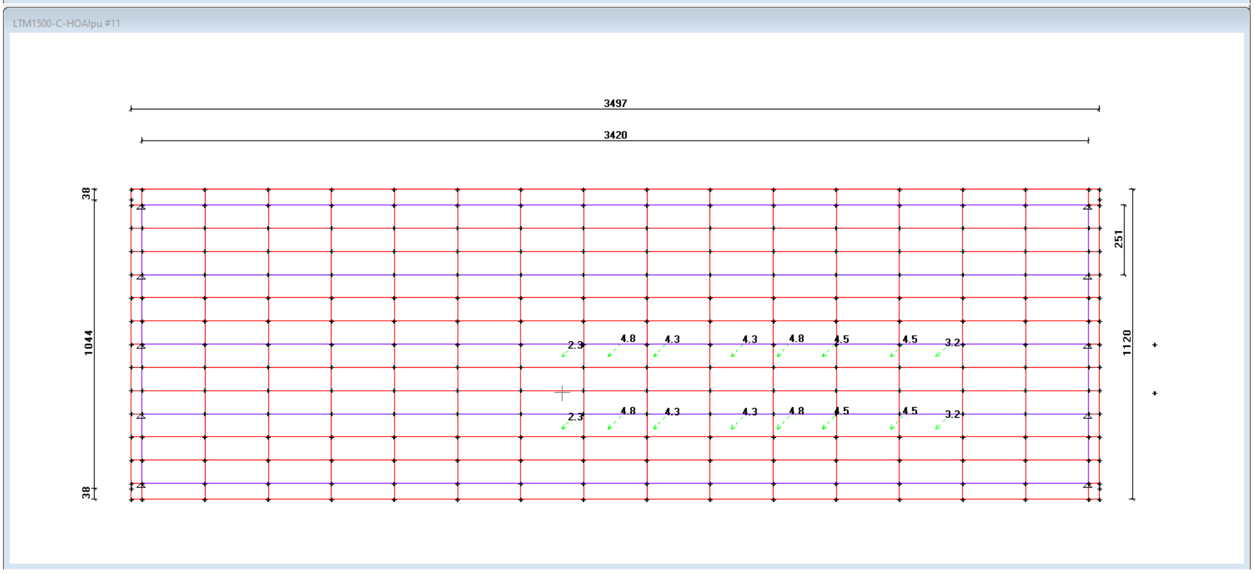
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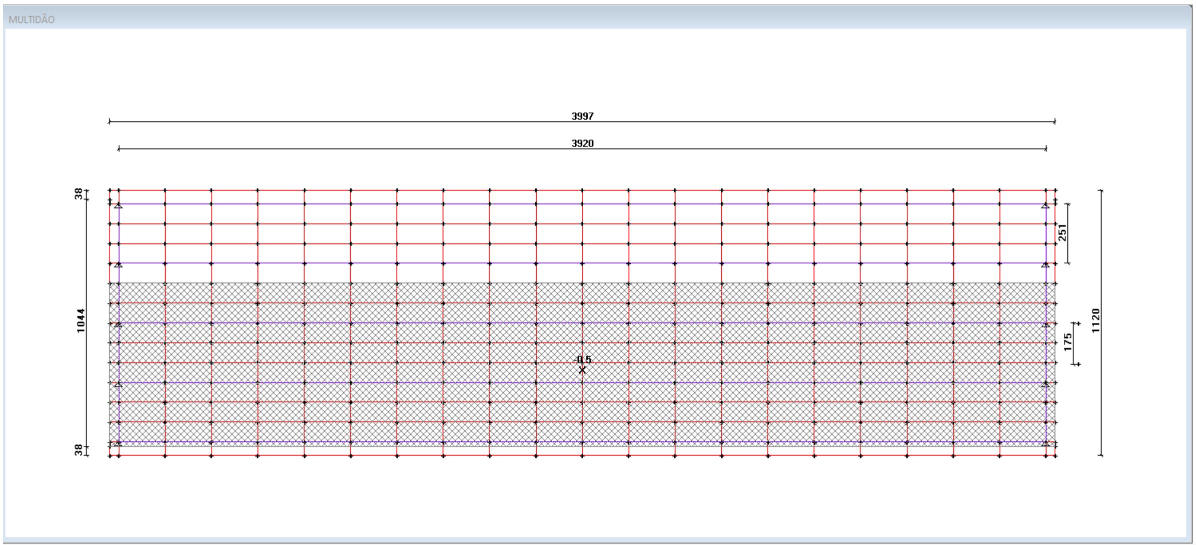
3.2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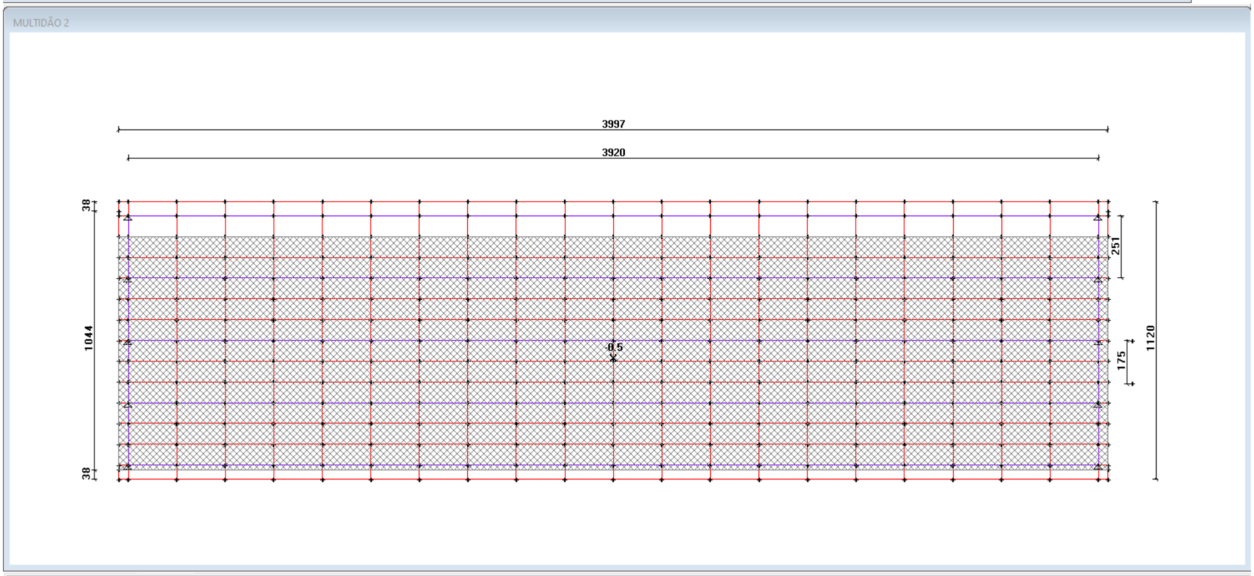
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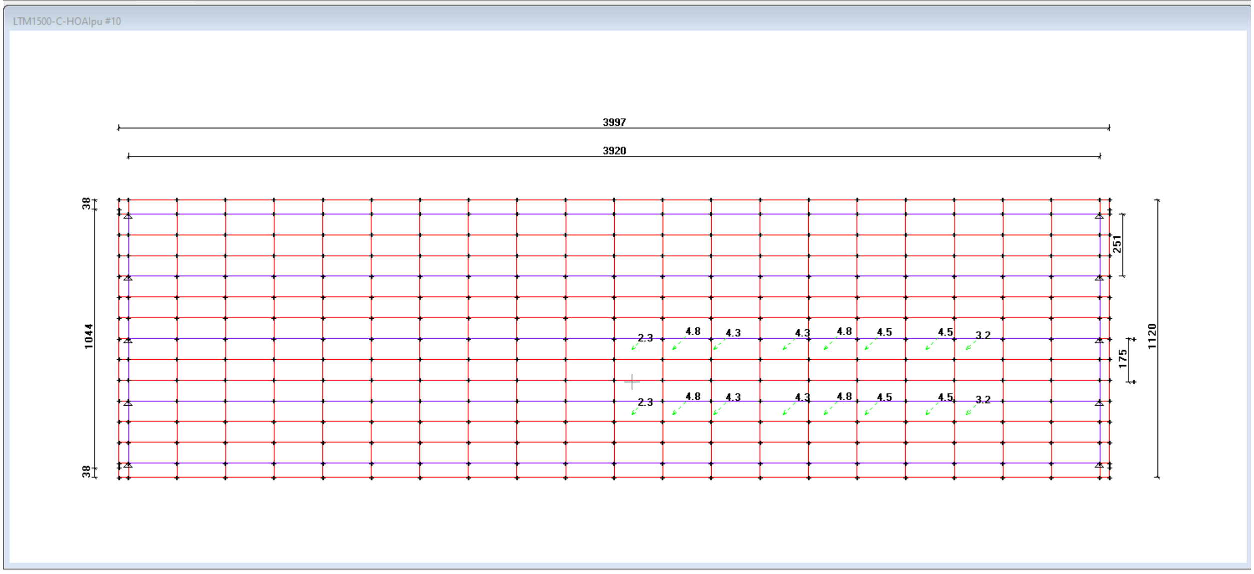
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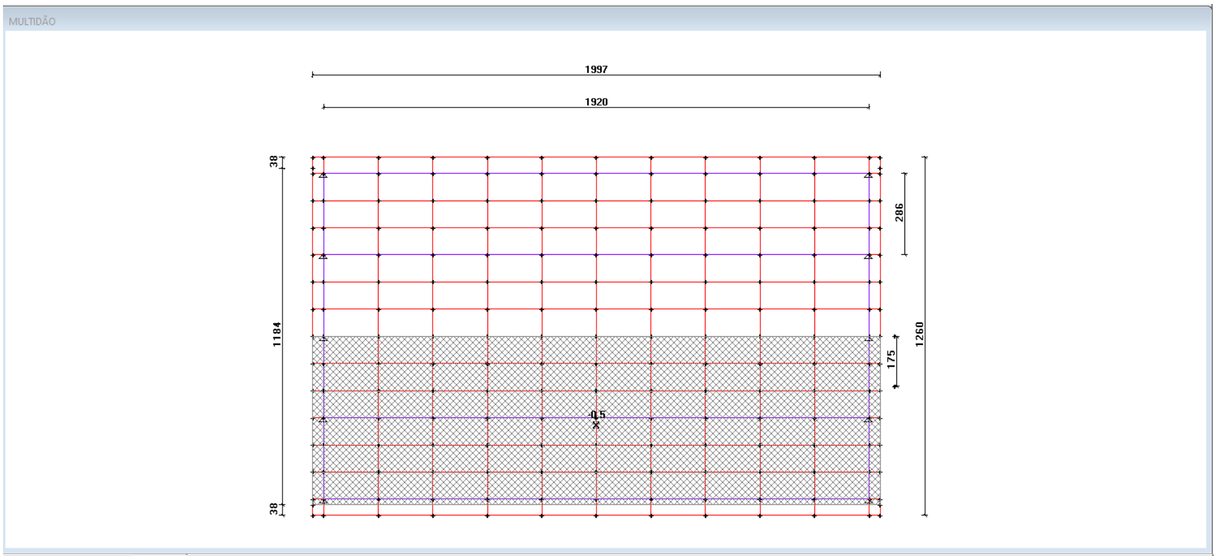
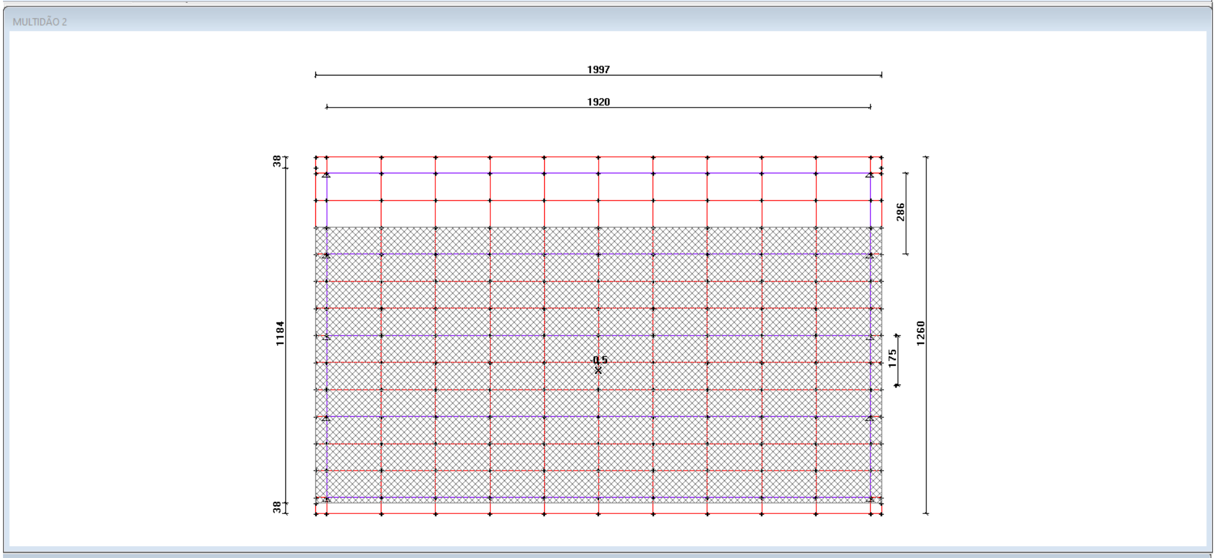
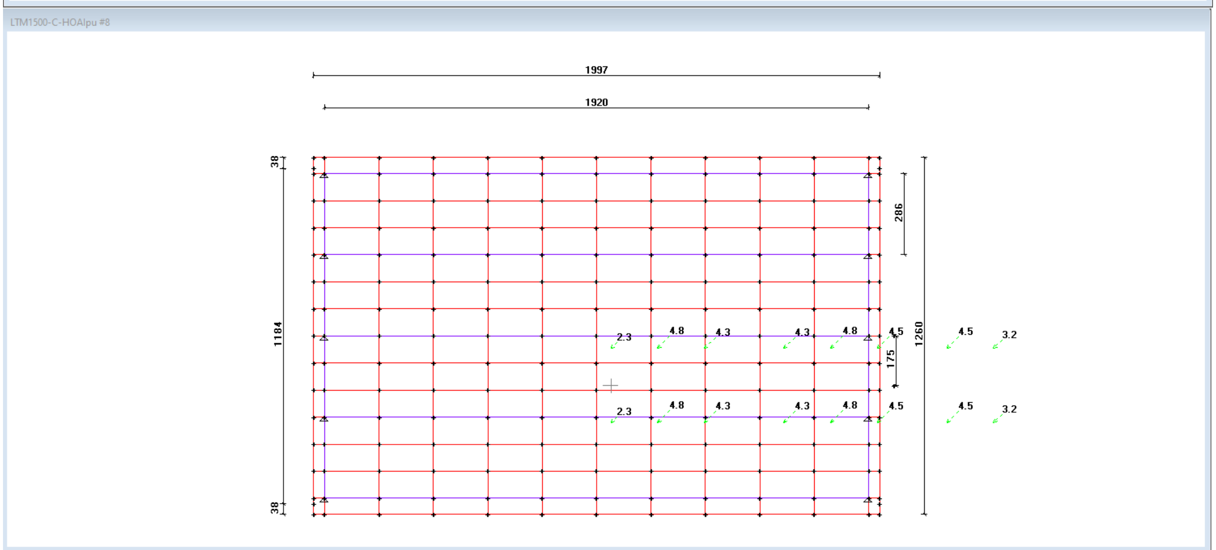
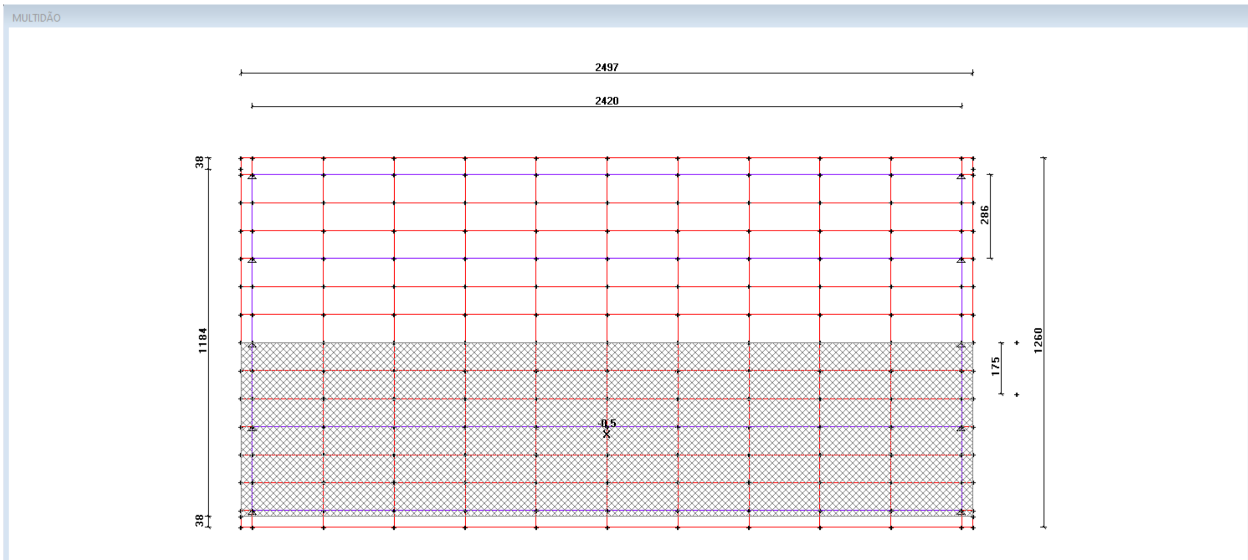
4.5
3.2

4.5.2. Tabuleiro 12,60 m





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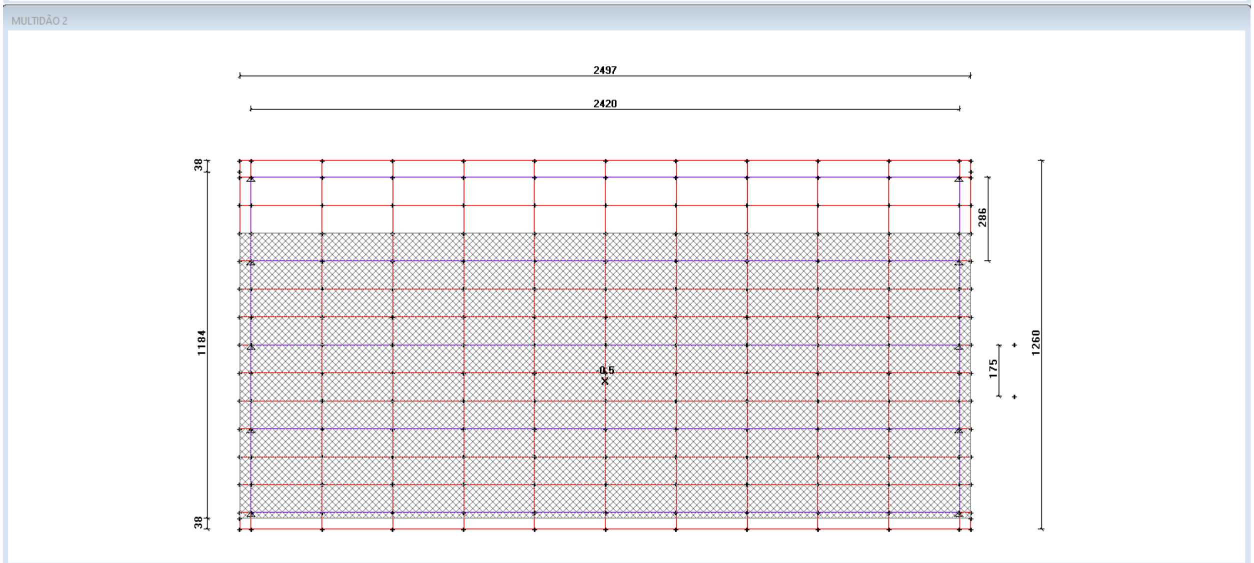
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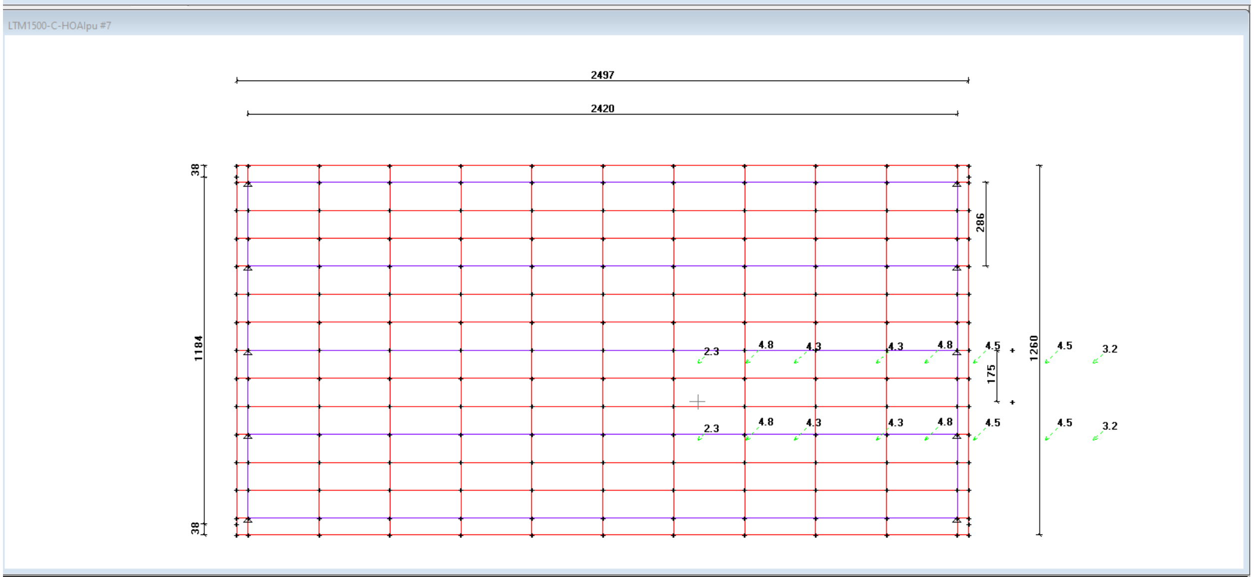
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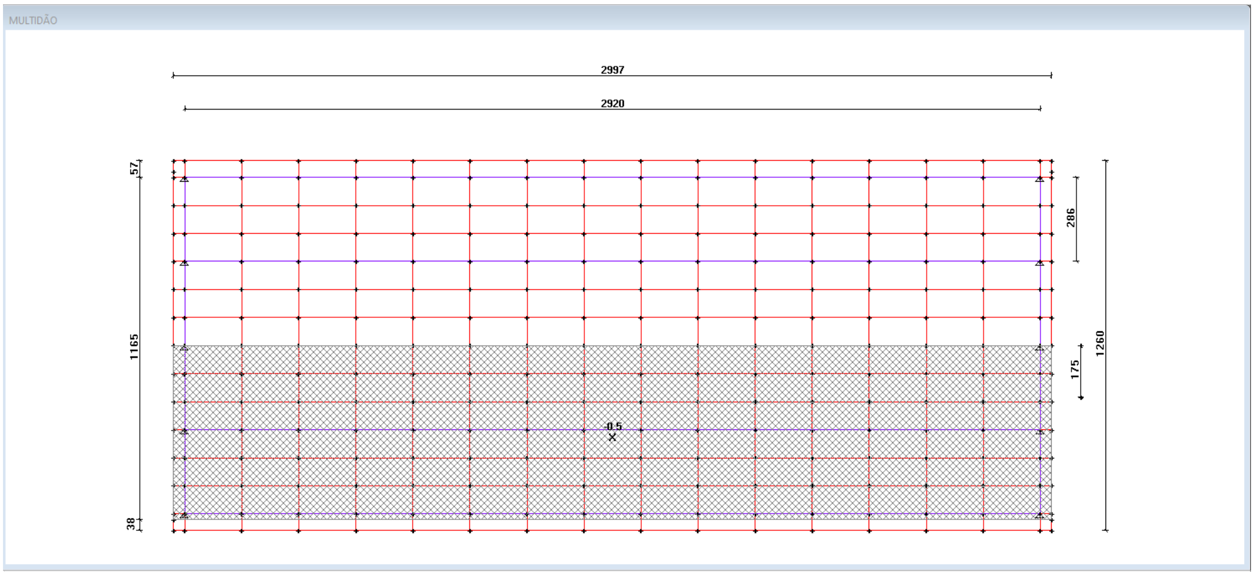
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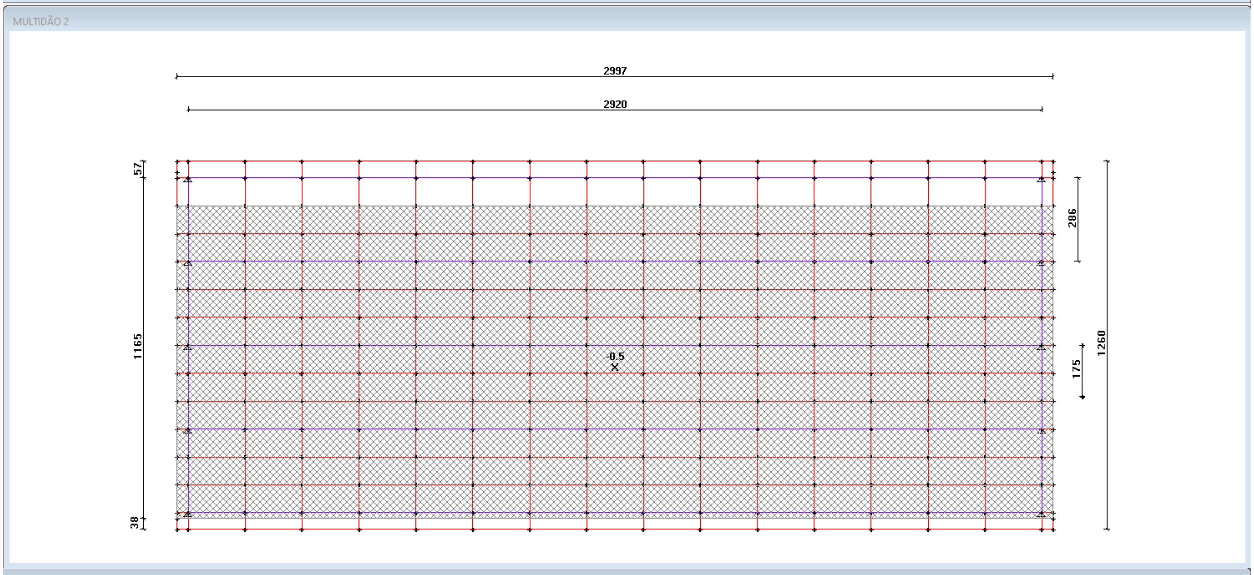
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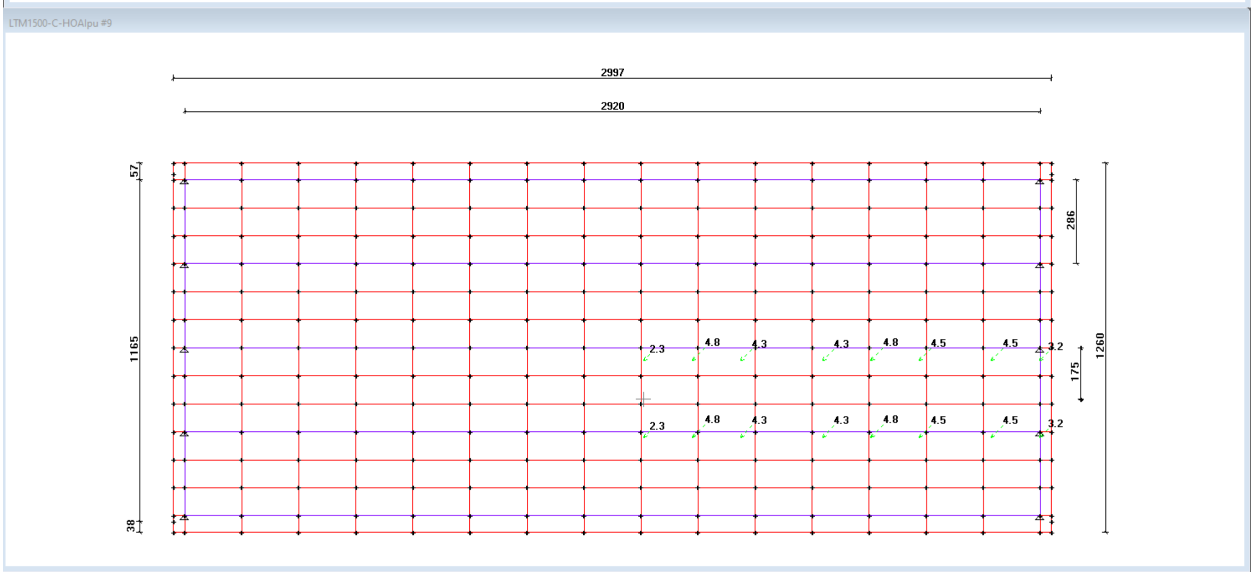
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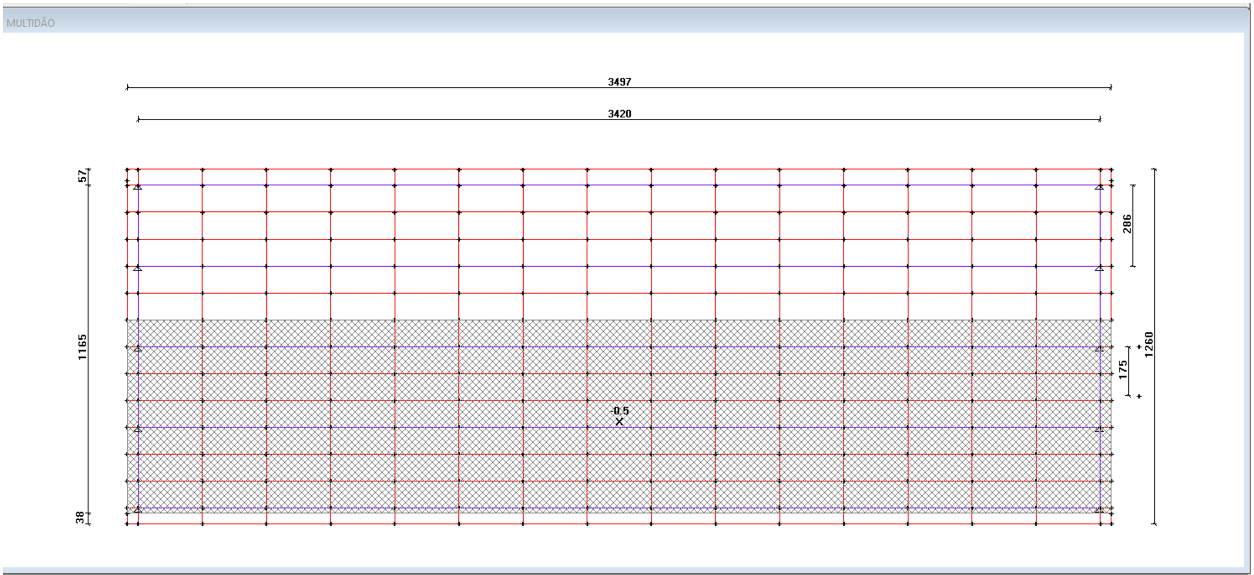
3.2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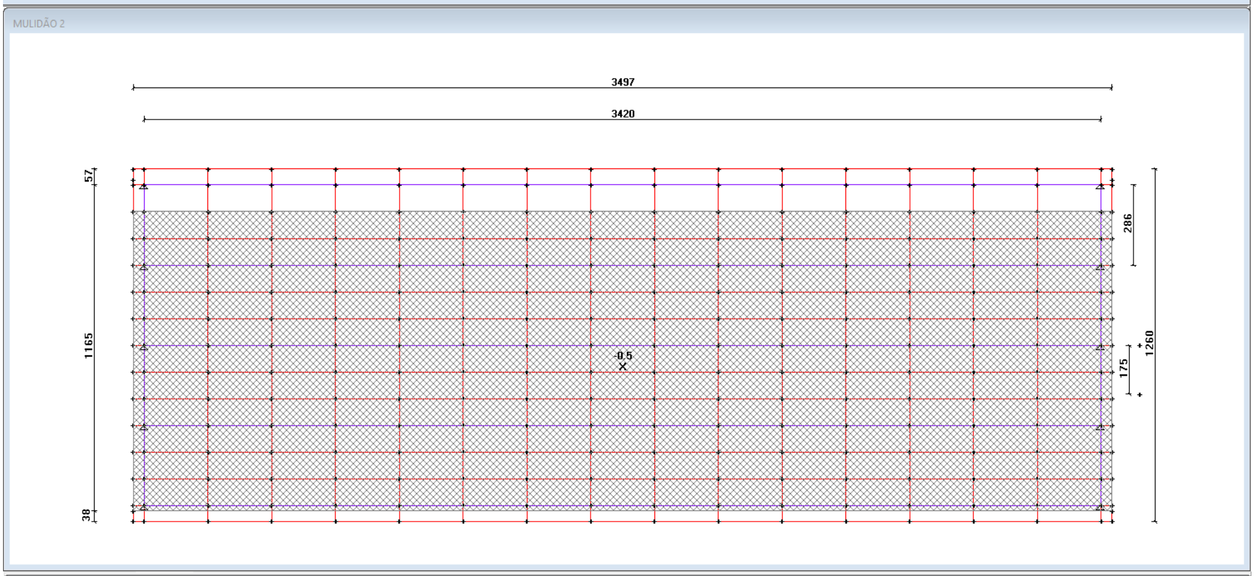
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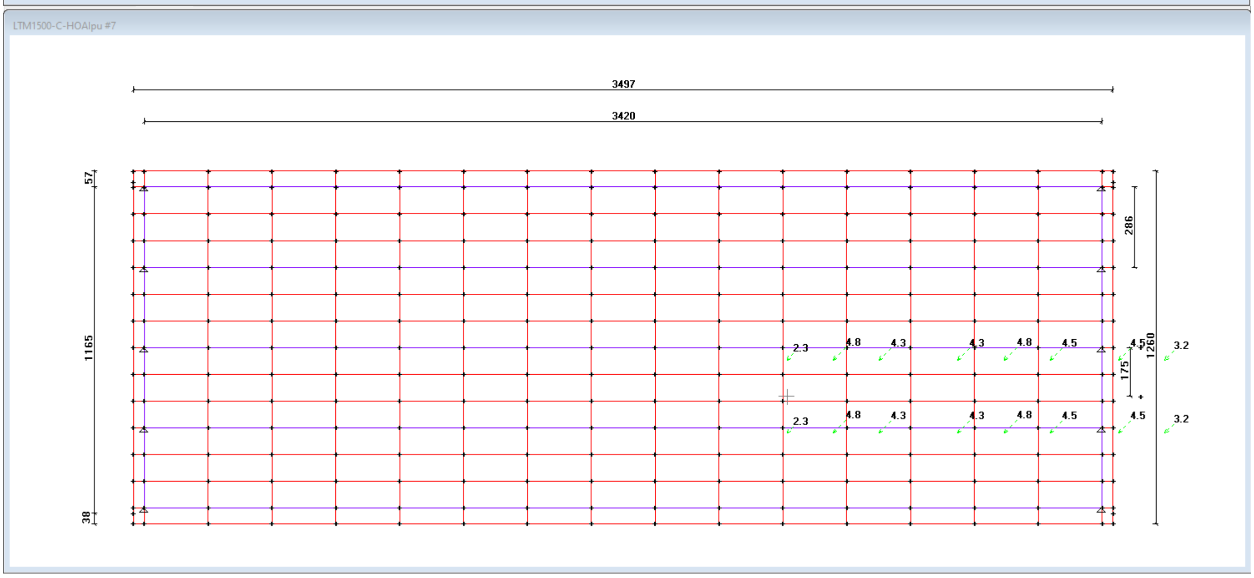
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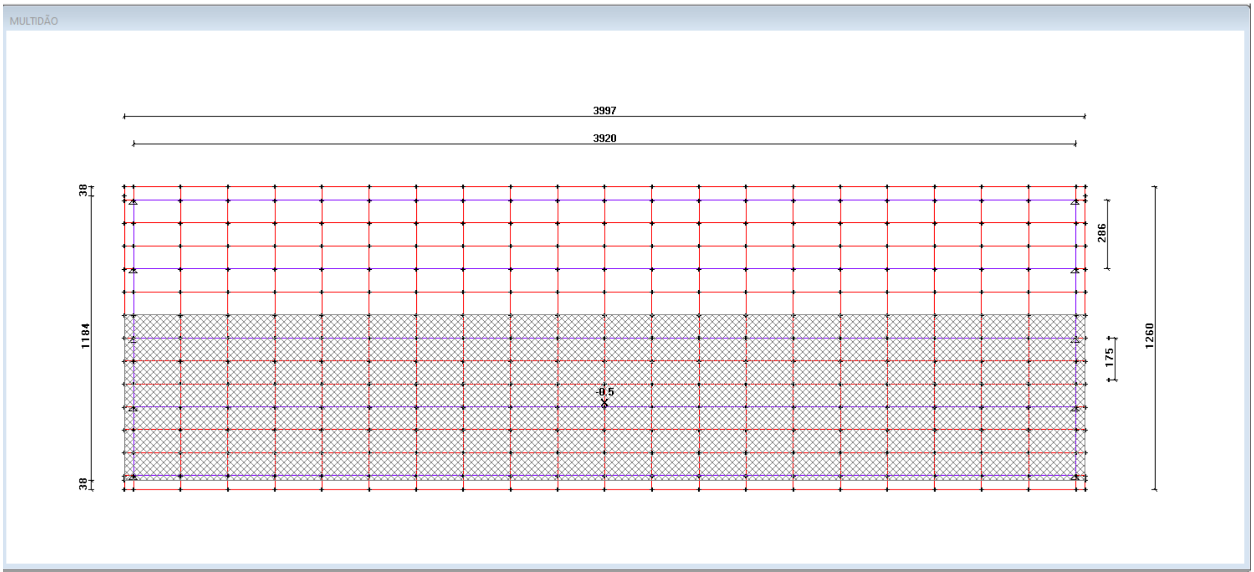
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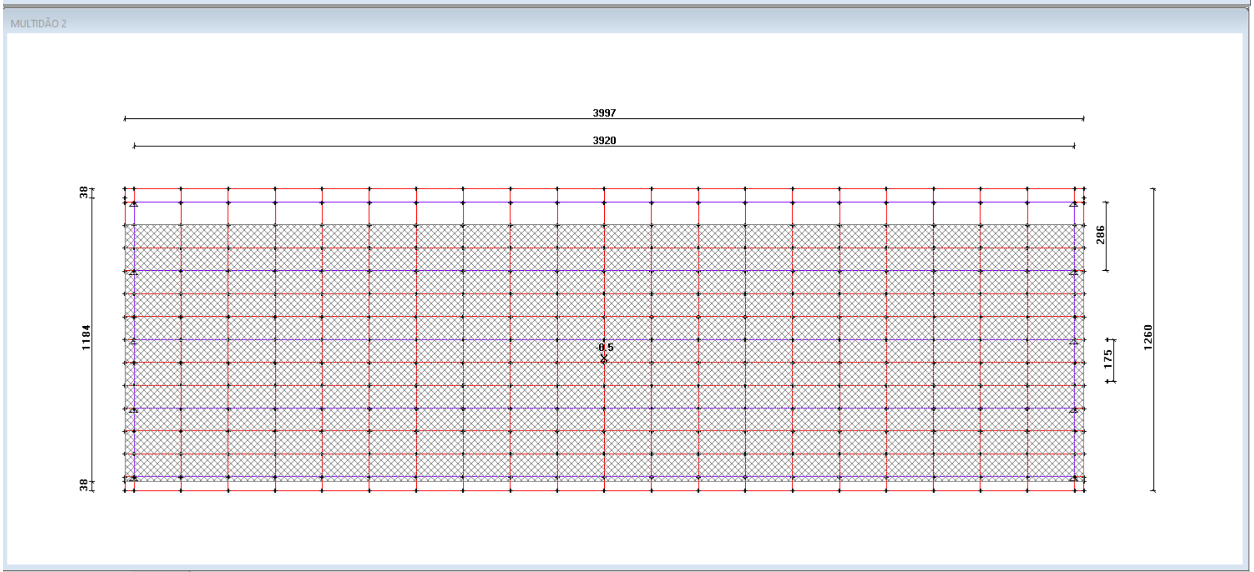
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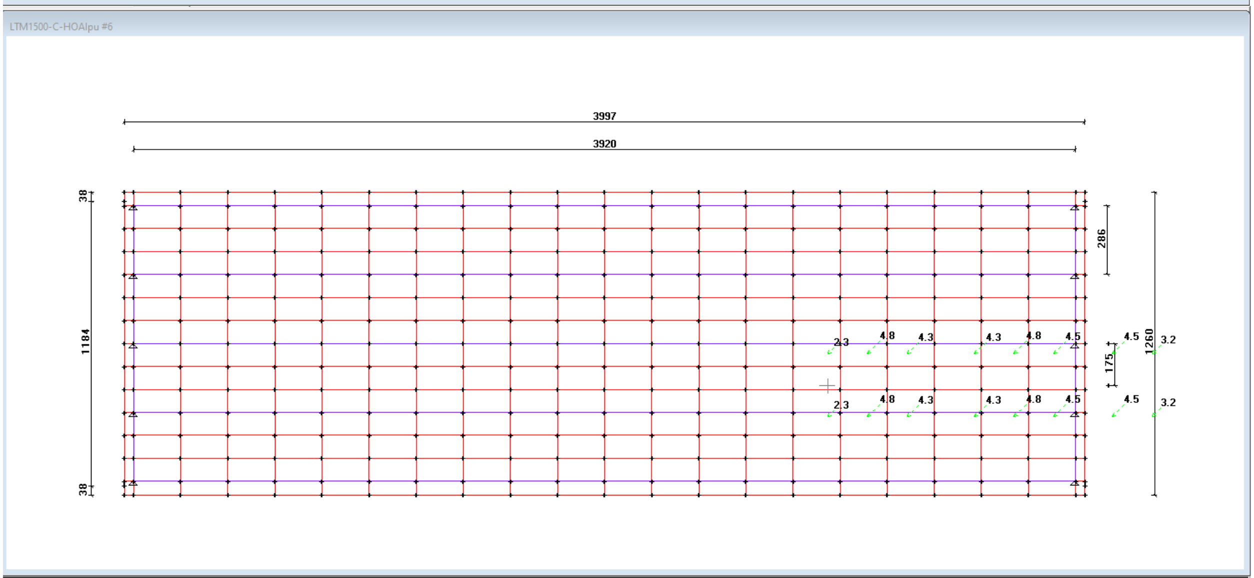
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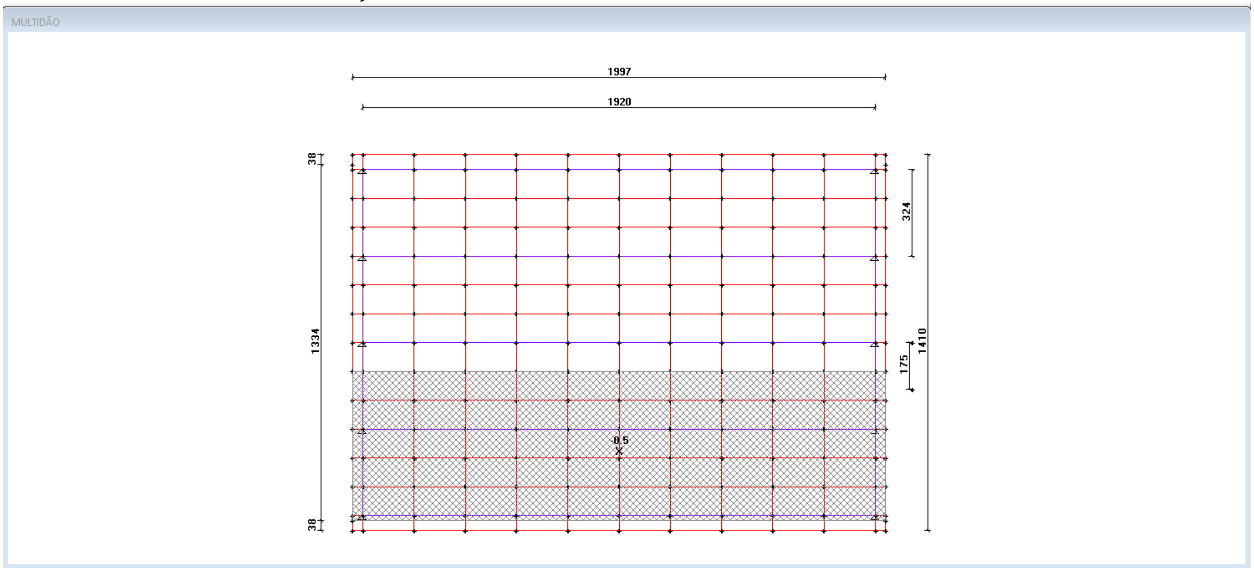
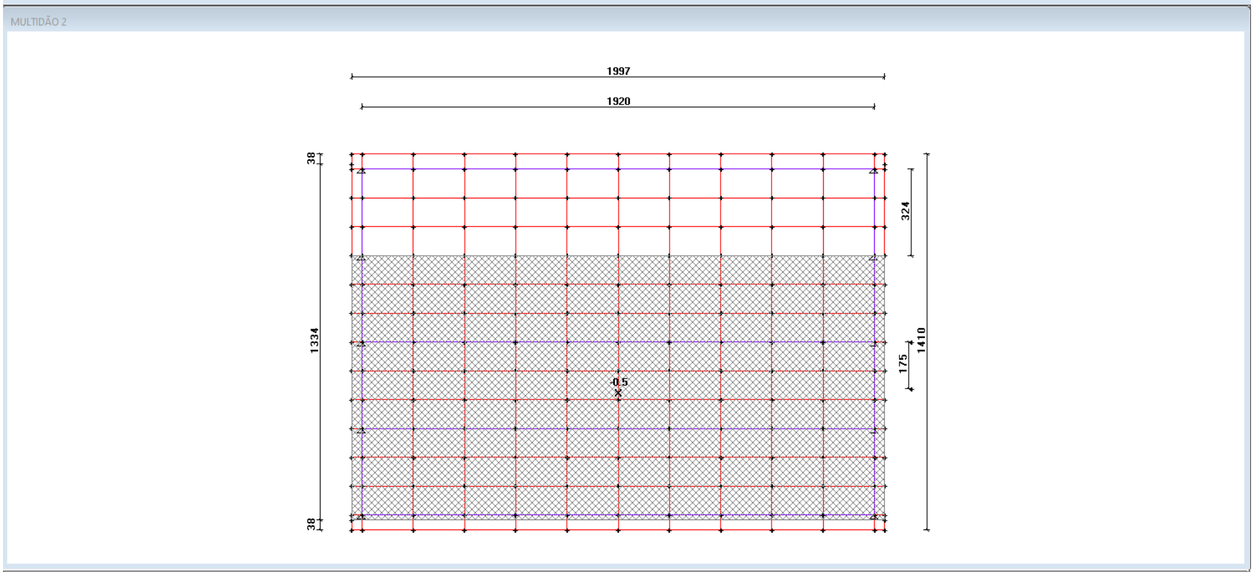
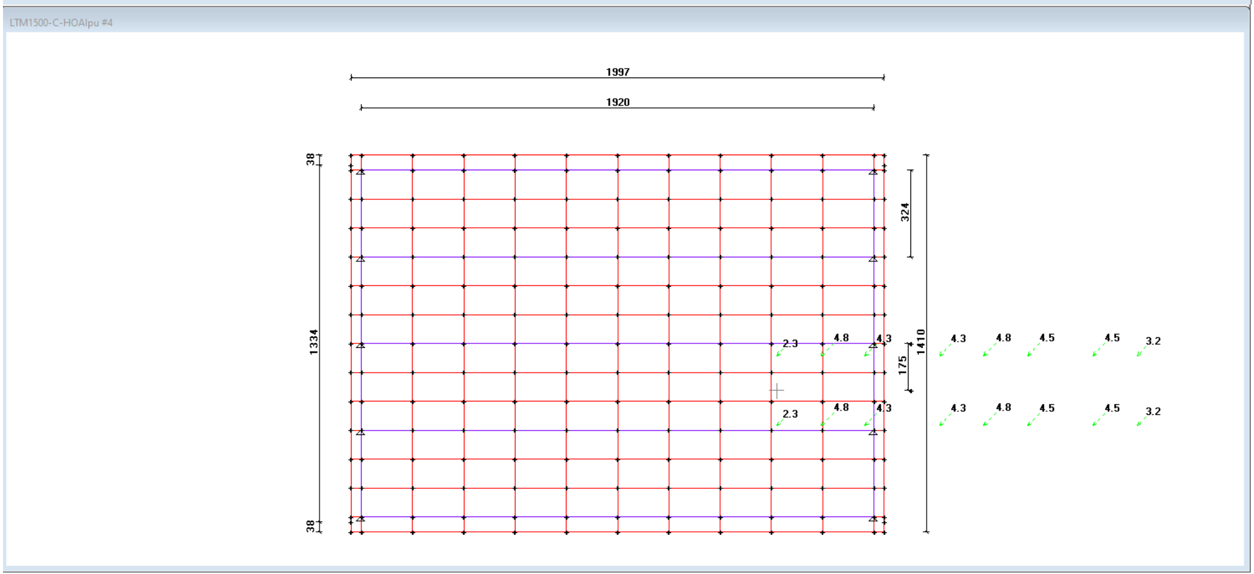
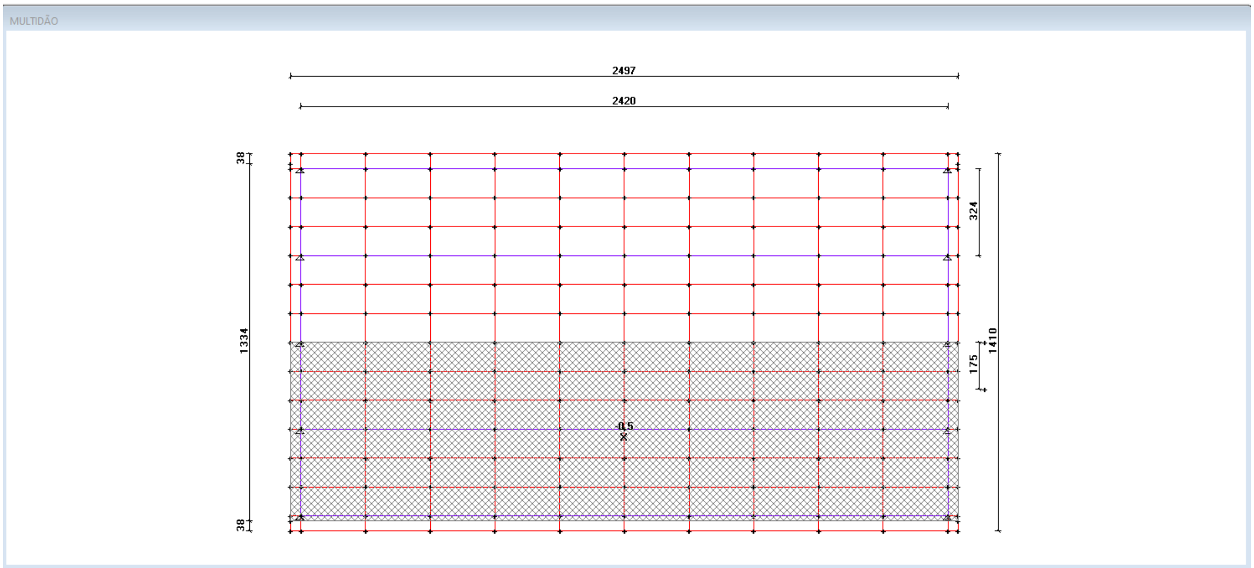
4.8
4.5
4.5
3.2

4.5.3. Tabuleiro 14,10 m





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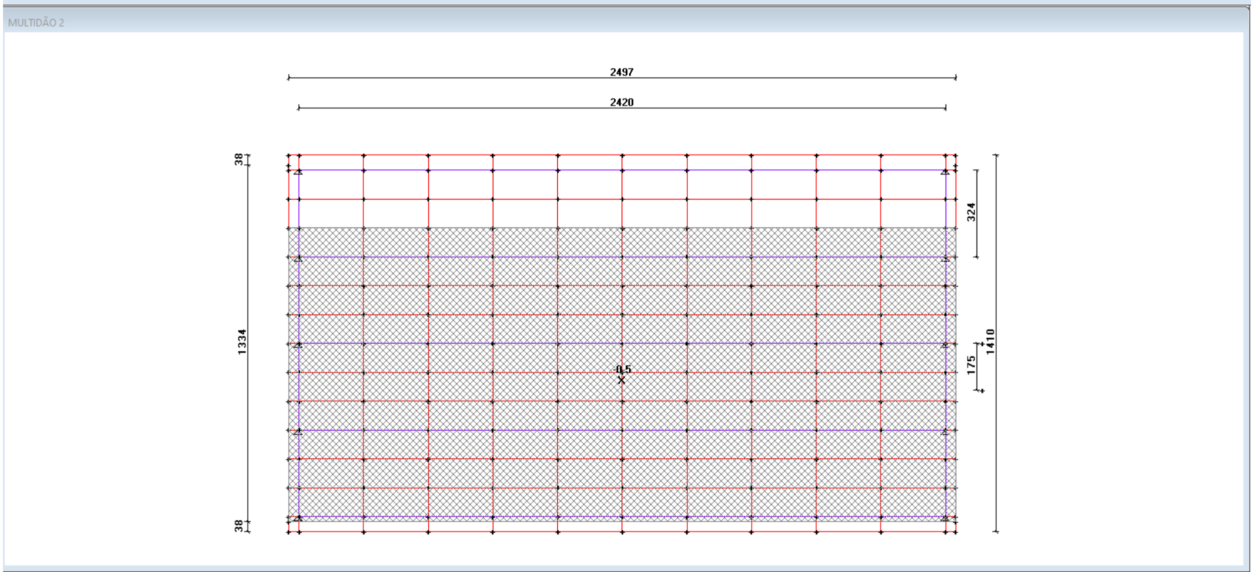
1410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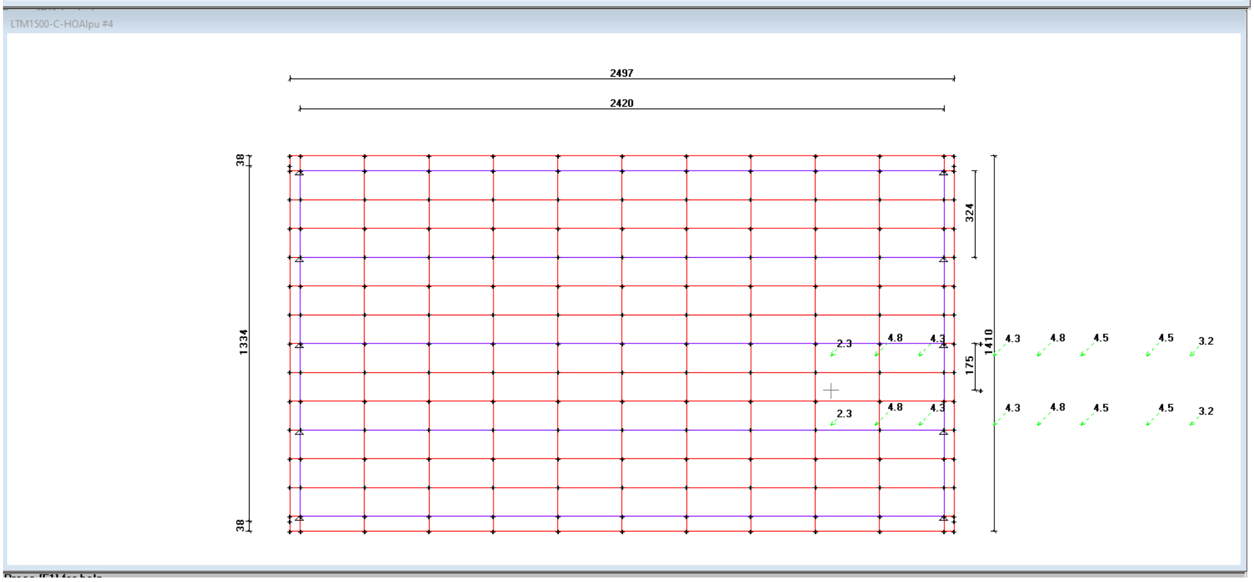
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4.3
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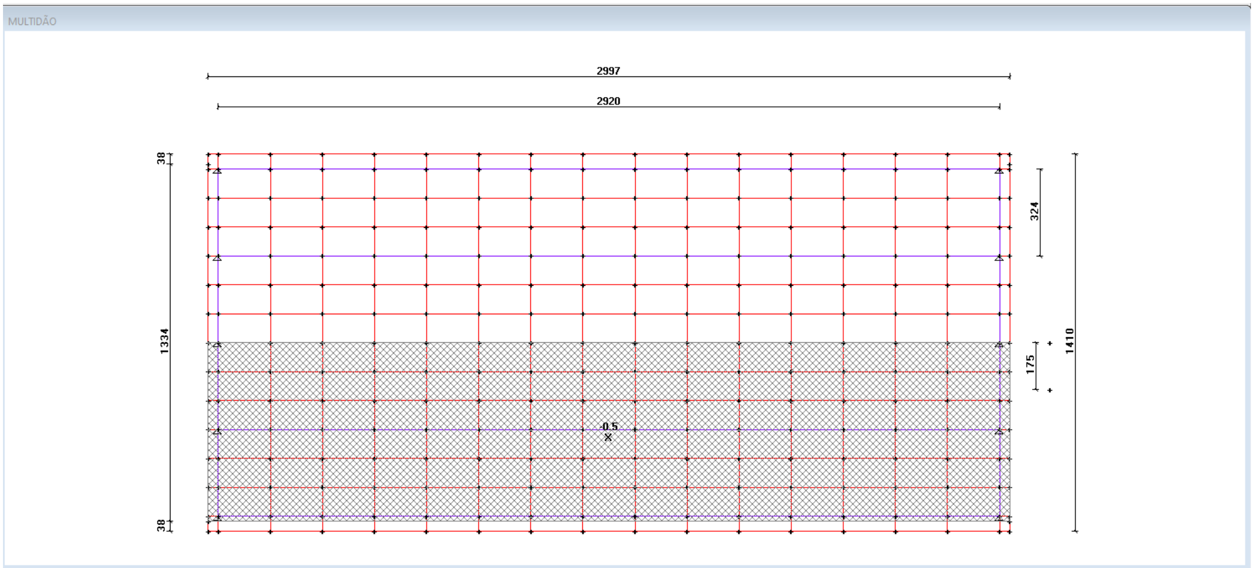
3.2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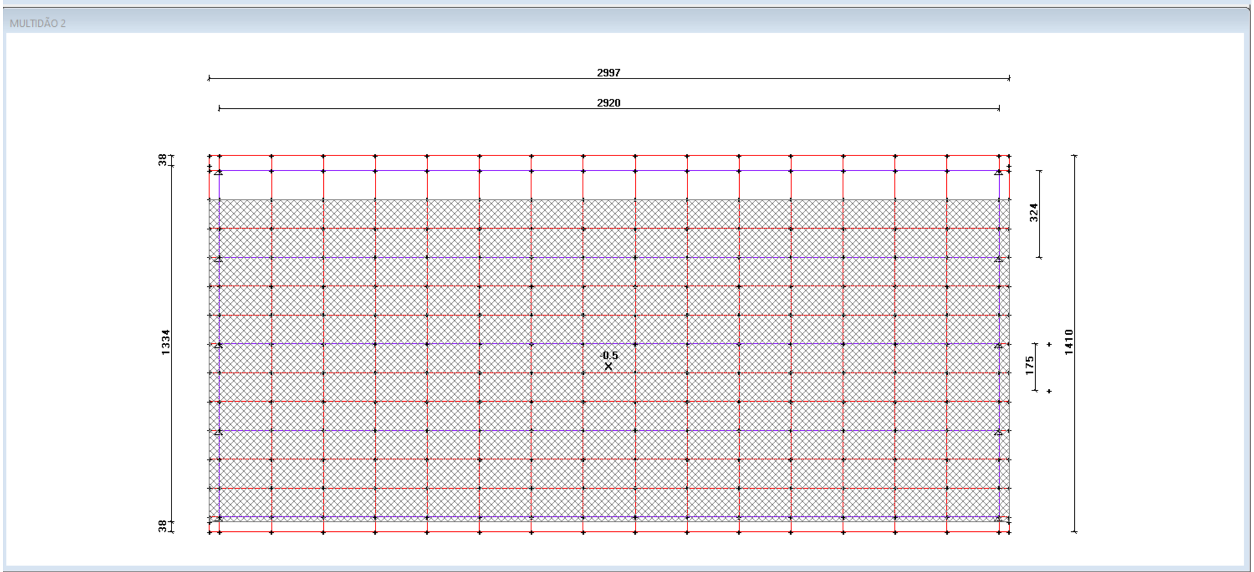
1410
-0.5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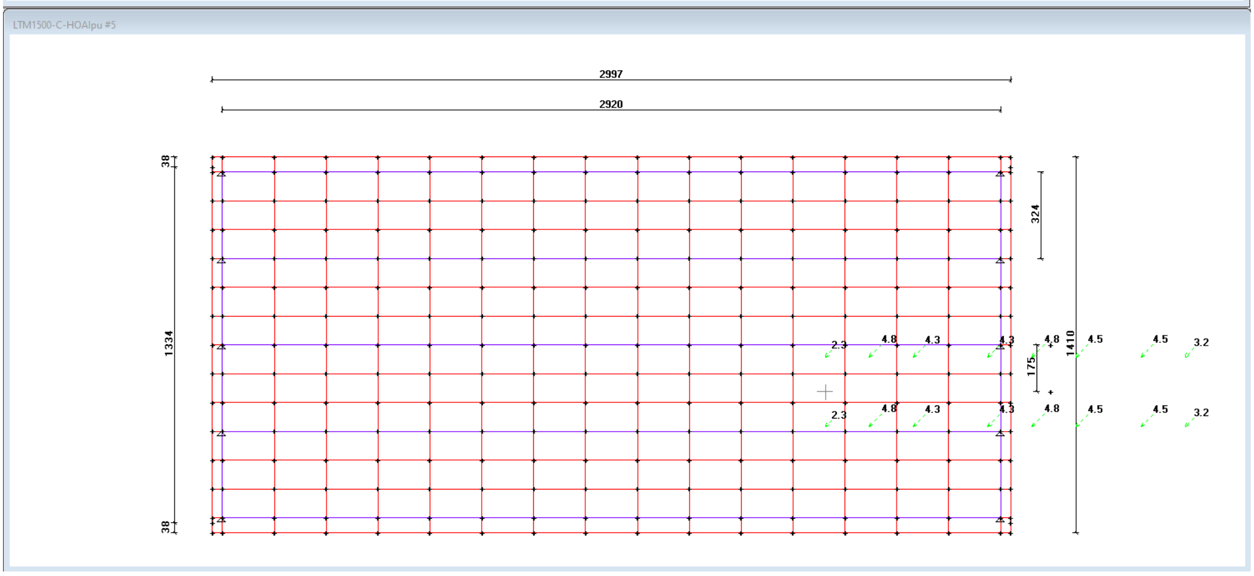
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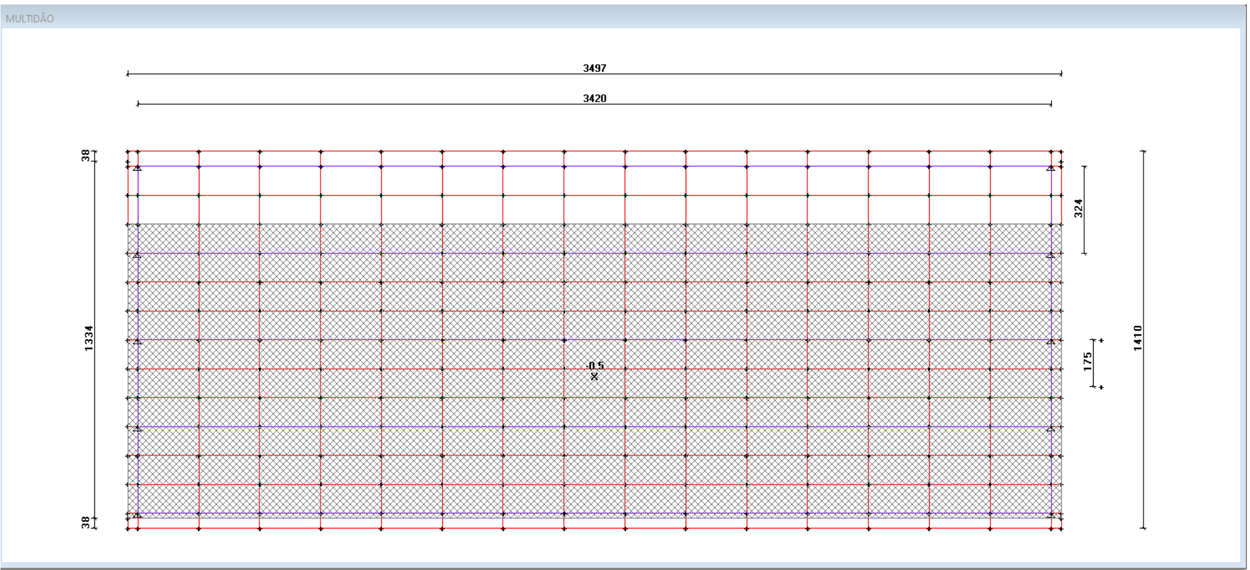
3.2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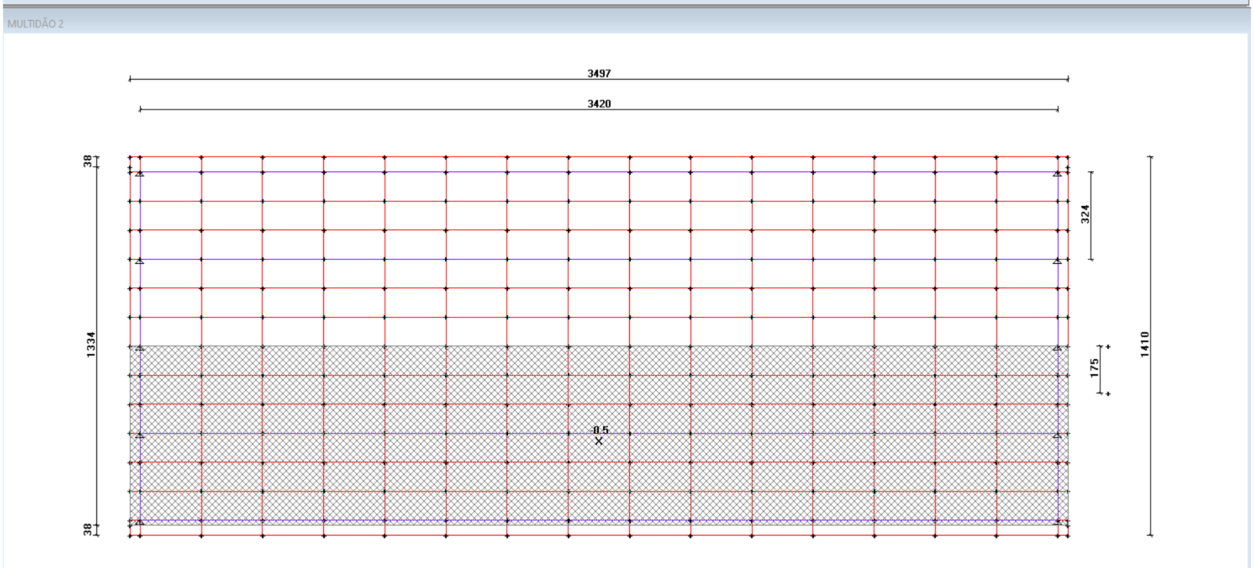
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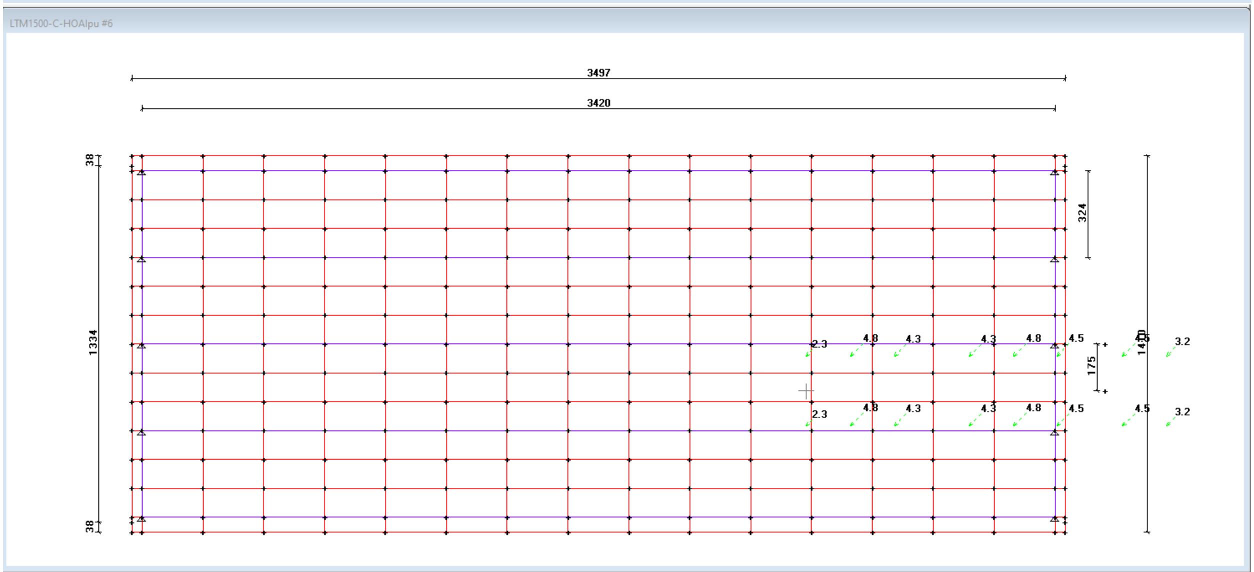
LTM1500-C-HOAlpu #6
3497
3420
38
1334
38
324
175
1410
2.3
4.8
4.3
4.3
4.8
4.5
4.5
3.2
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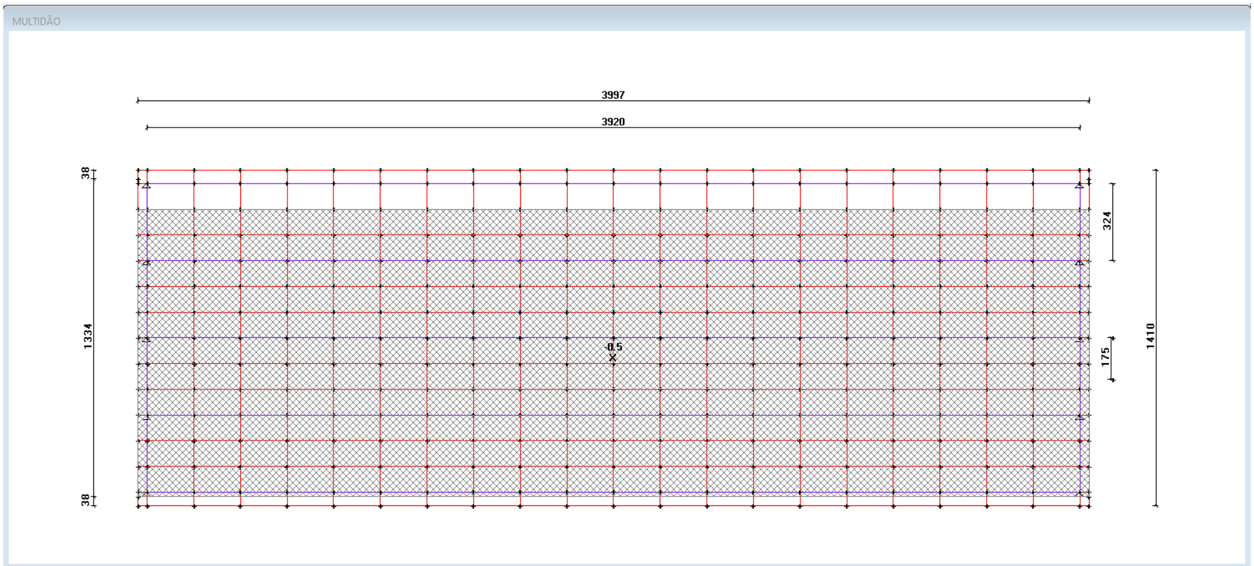
4.8
4.3
4.3
4.8
4.5
4.5
3.2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3997
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1334
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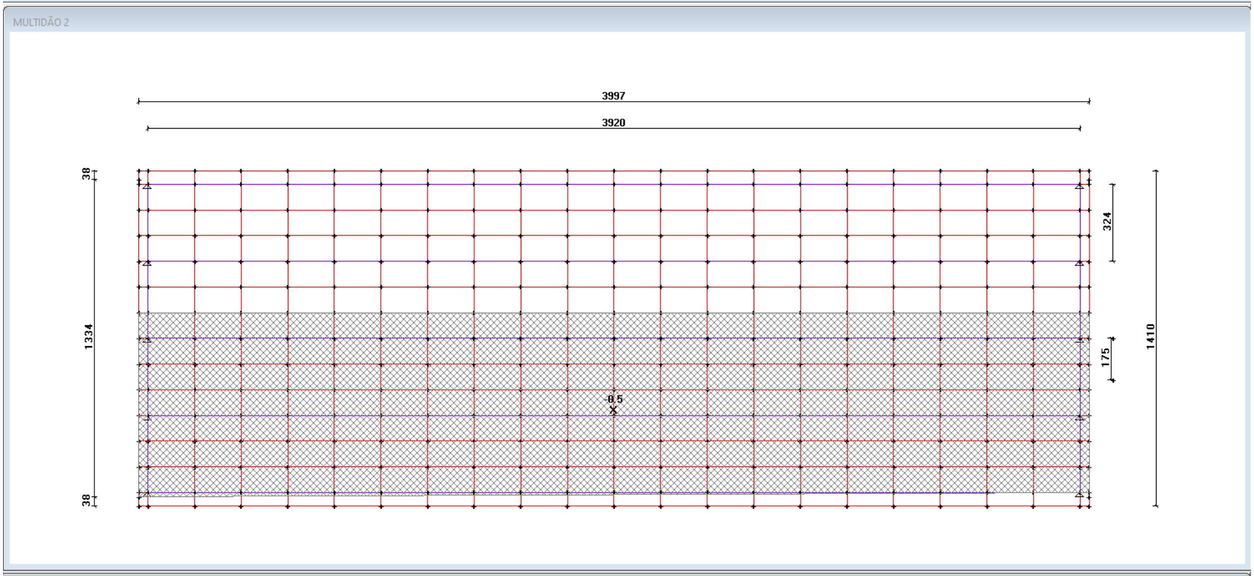
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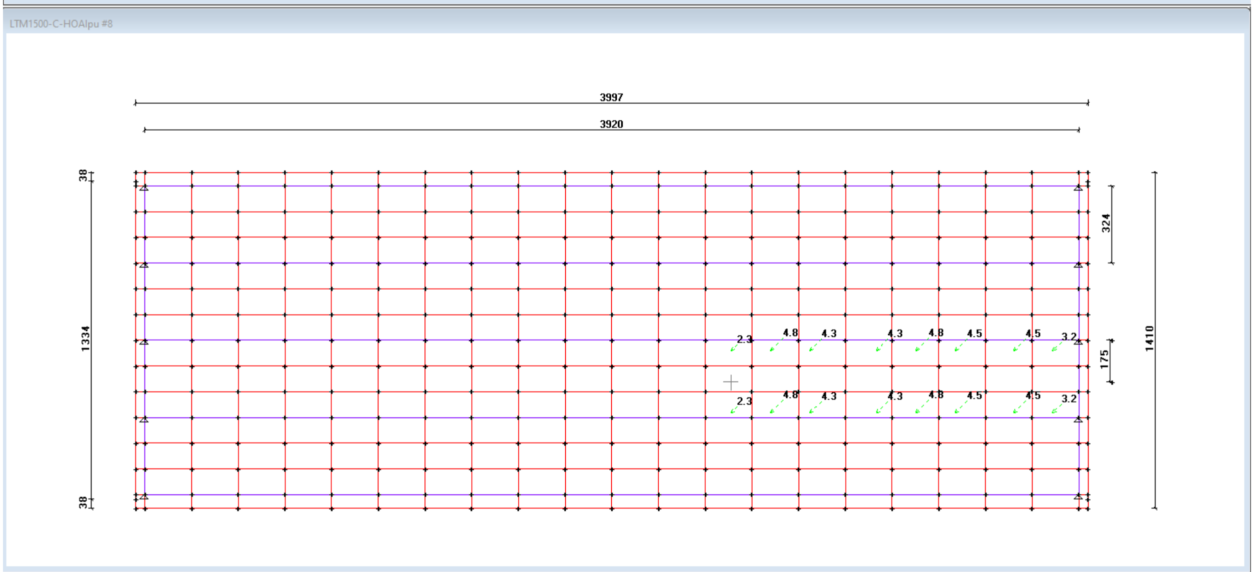
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38
324
175
1410
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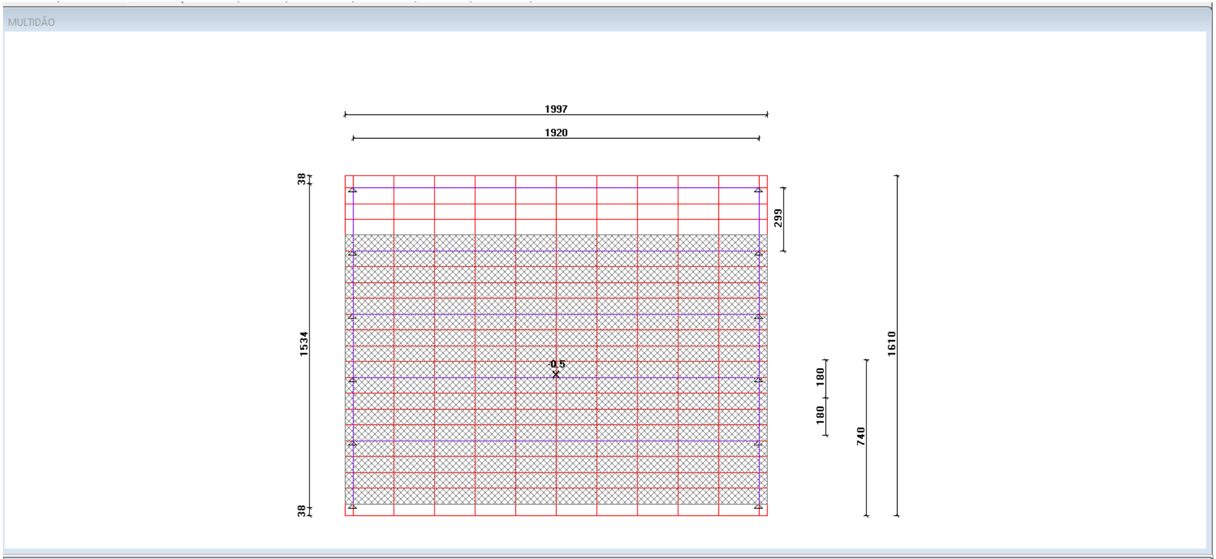
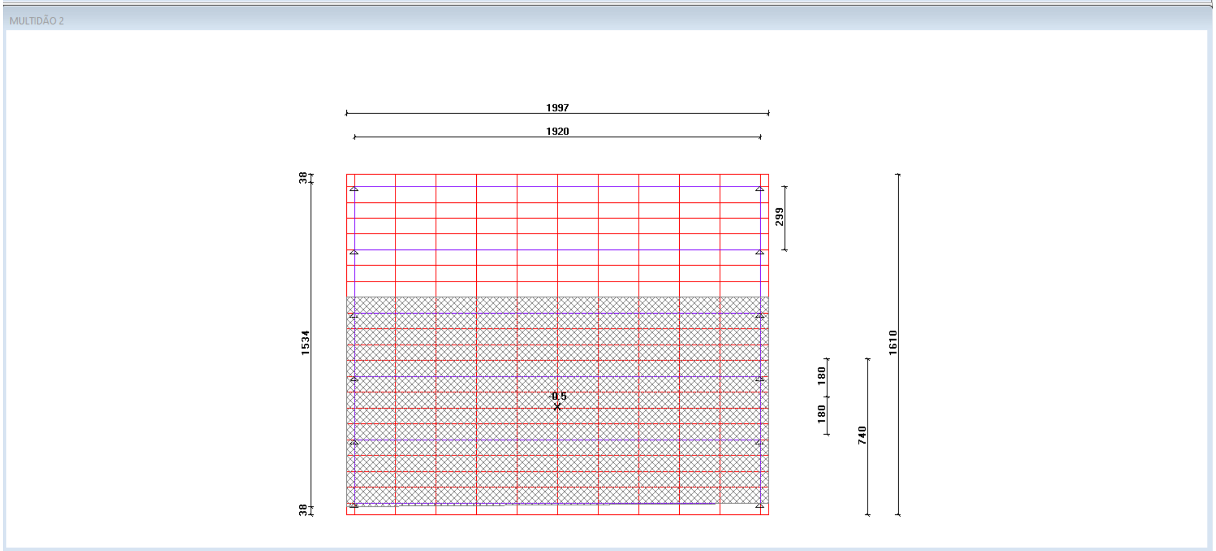
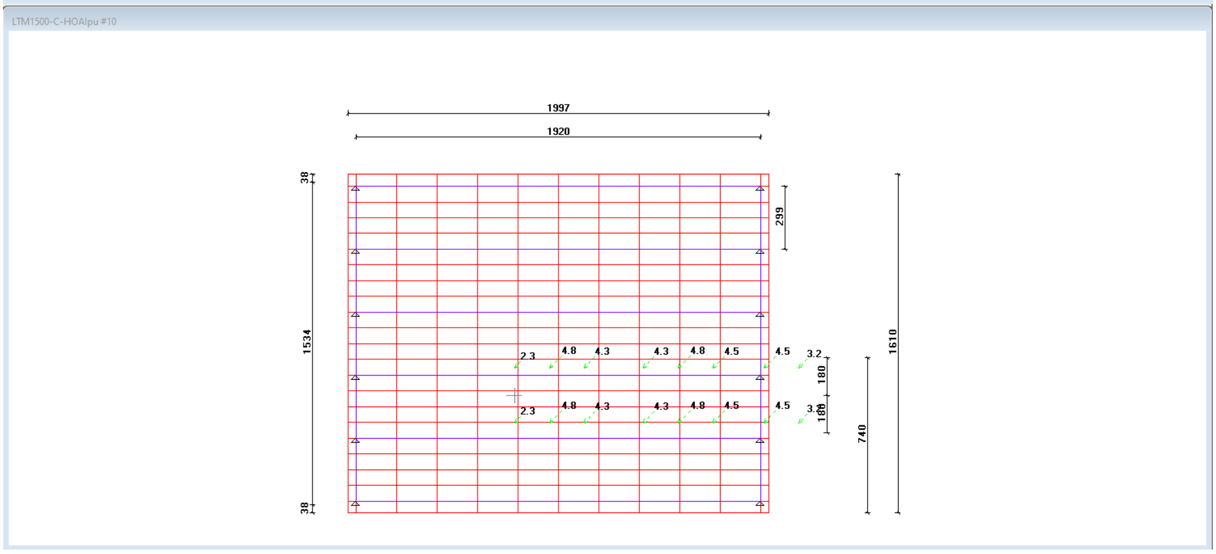
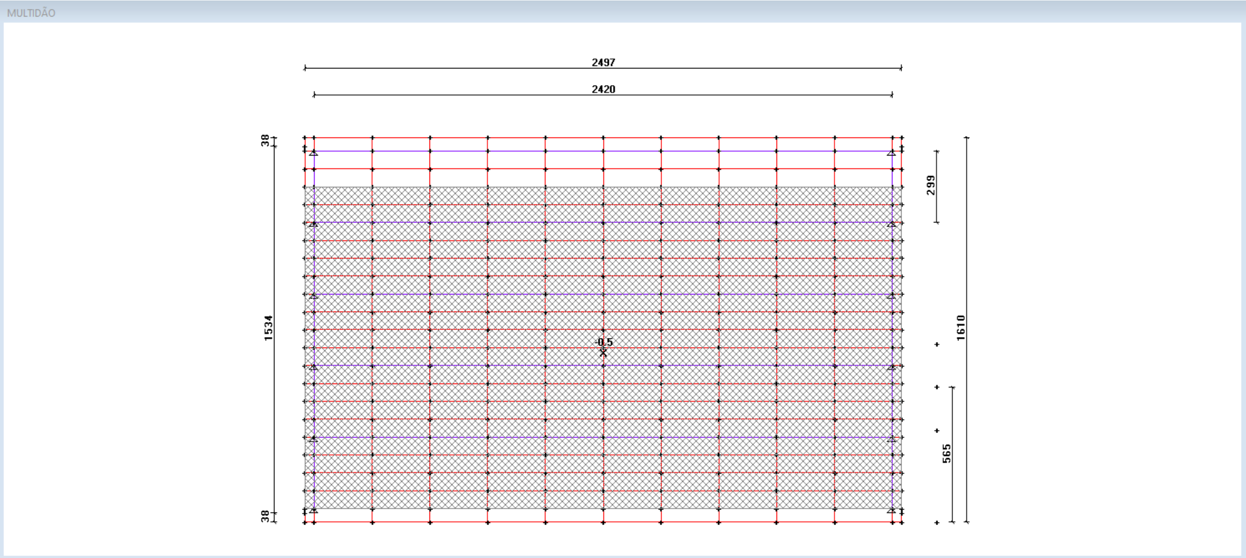
4.5.4. Tabuleiro 16,10 m





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1534
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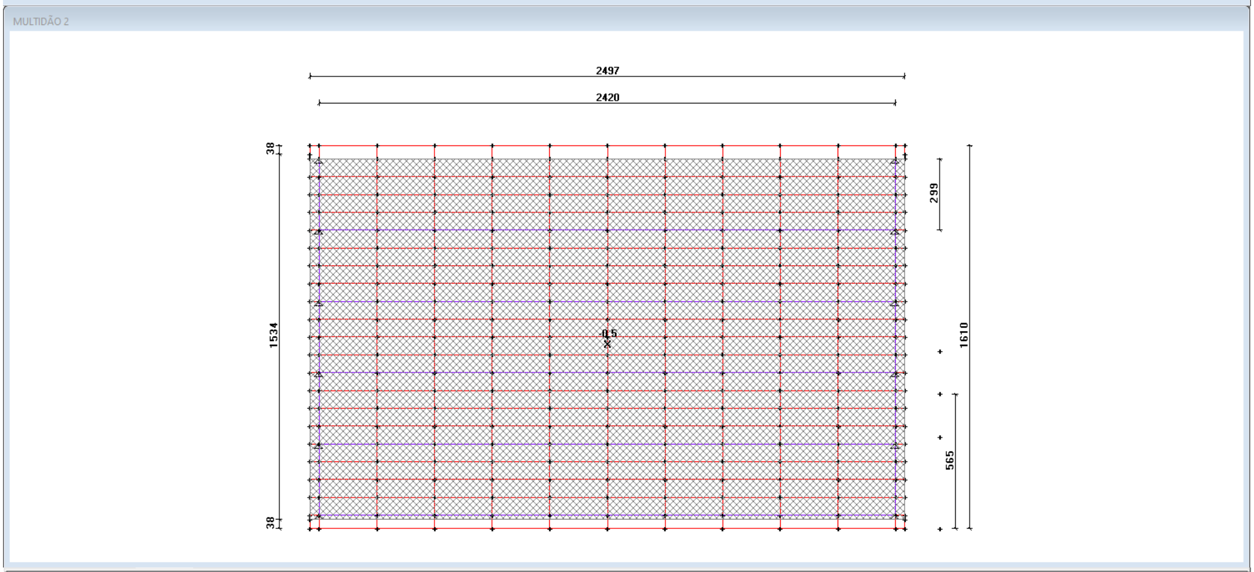
1610
565
-0.5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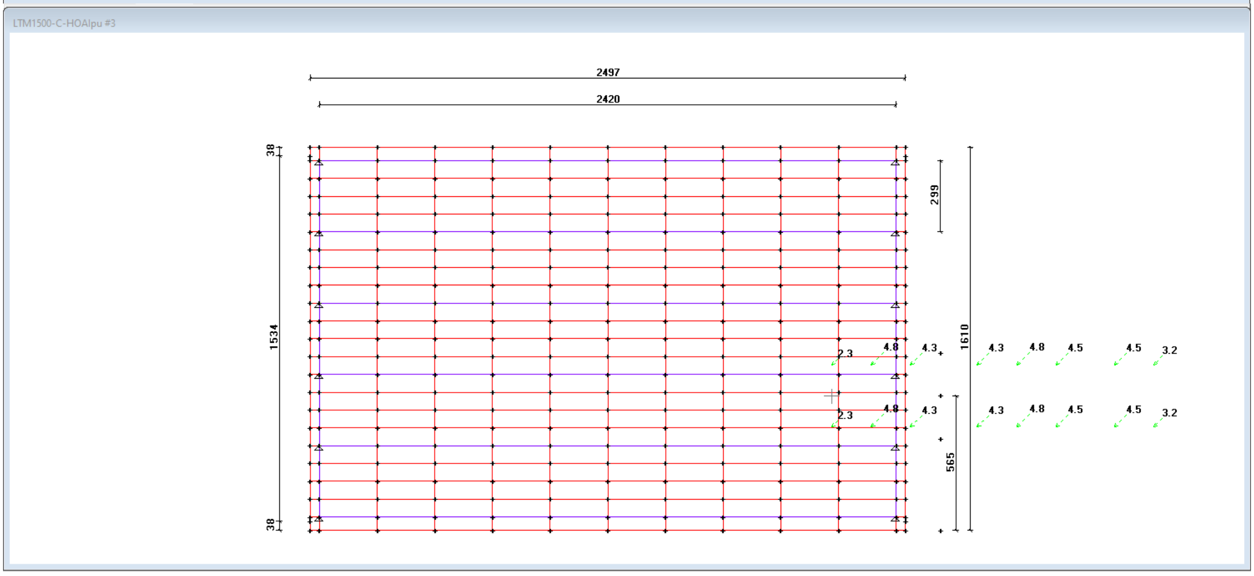
-0.5


LTM1500-C-HOAlpu #3
2497
2420
38
1534
38
299
1610
565
2.3
4.8
4.3
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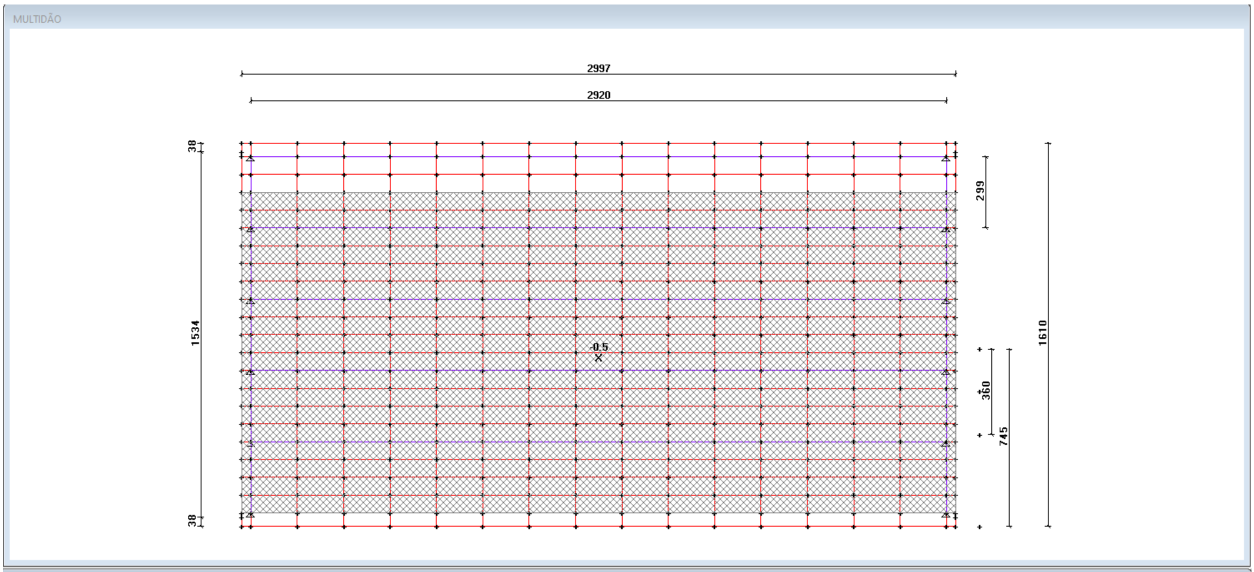
4.5
4.5
3.2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299
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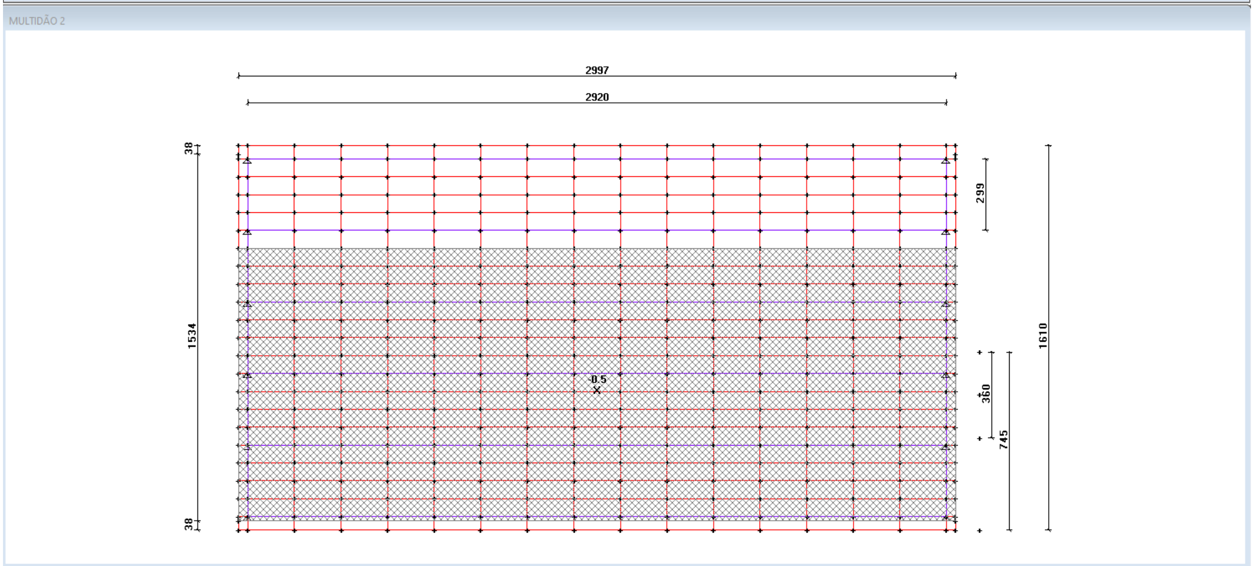
745
1610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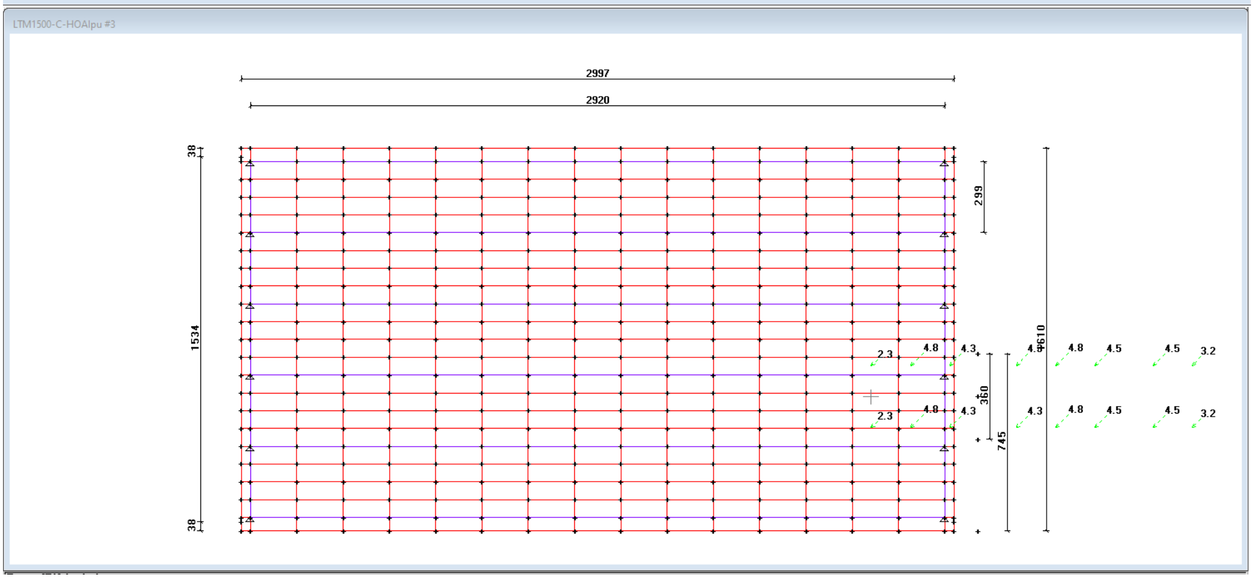
1610


LTM1500-C-HOAlpu #3
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1534
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299
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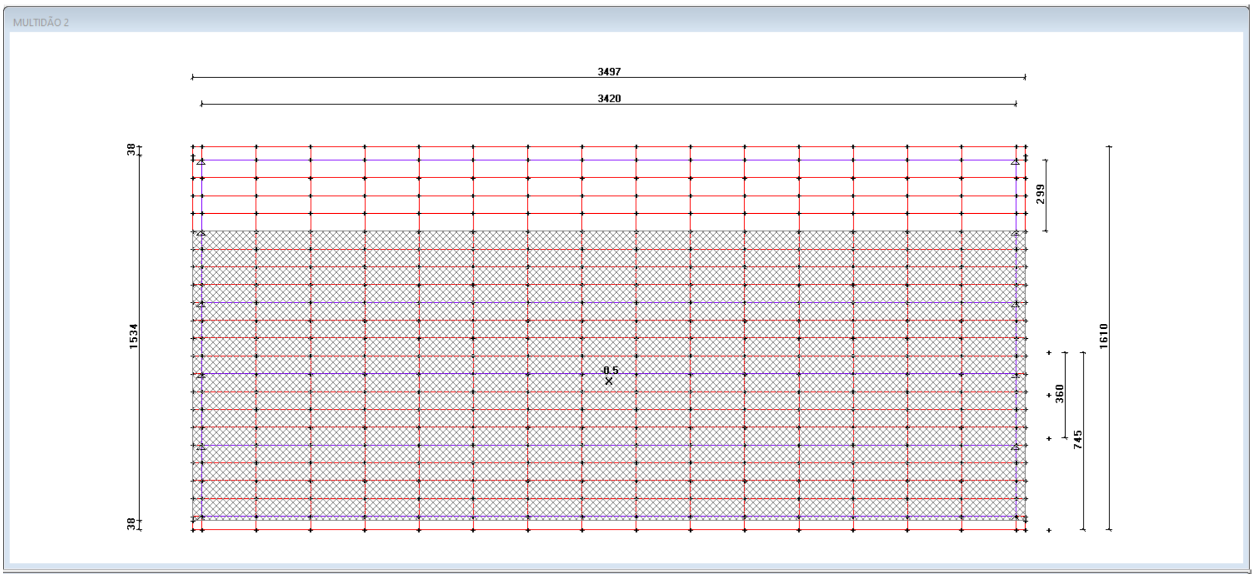
745
1610


MULTIDÃO 2
3497
3420
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1534
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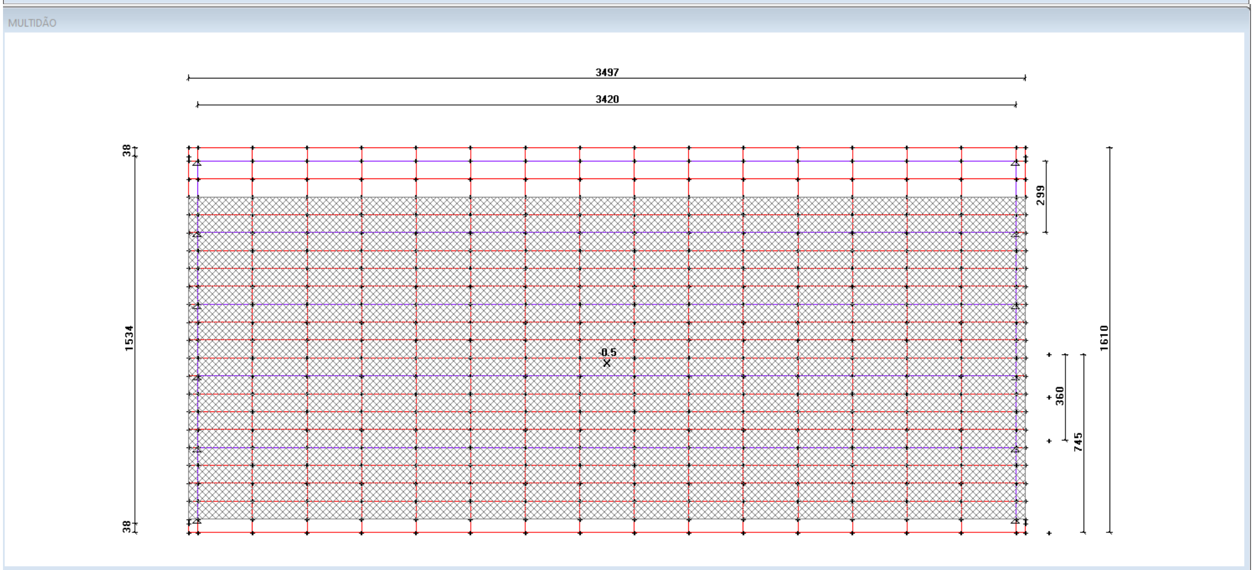
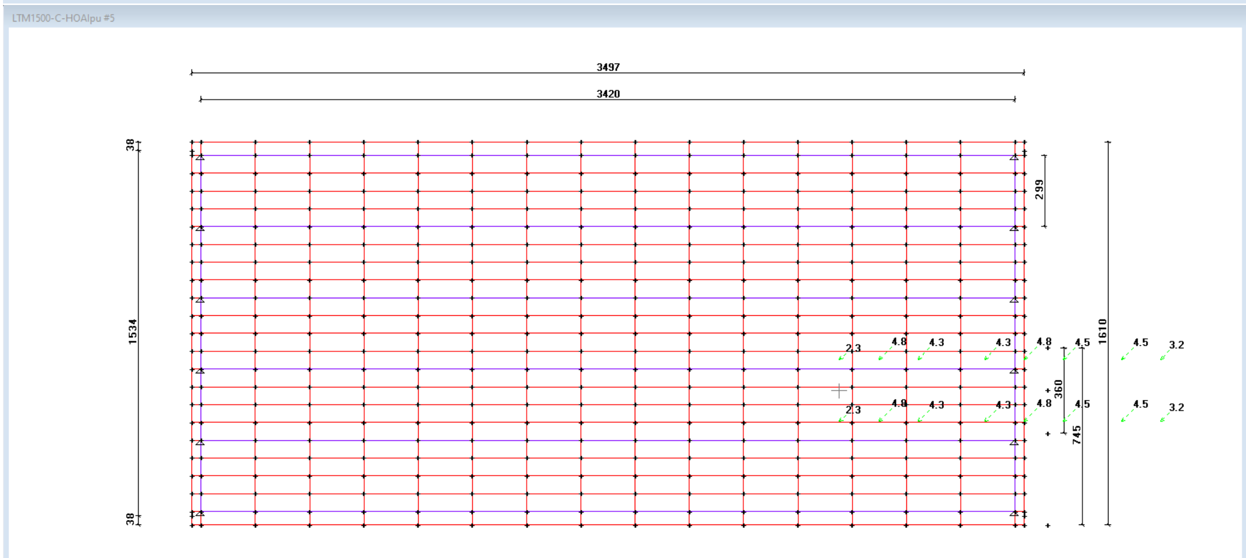
0.5
360
745
1610


MULTIDÃO
3497
3420
38
1534
38
299
0.5
360
745
1610


LTM1500-C-HOAlpu #5
3497
3420
38
1534
38
299
2.3
4.8
4.3
4.3
4.8
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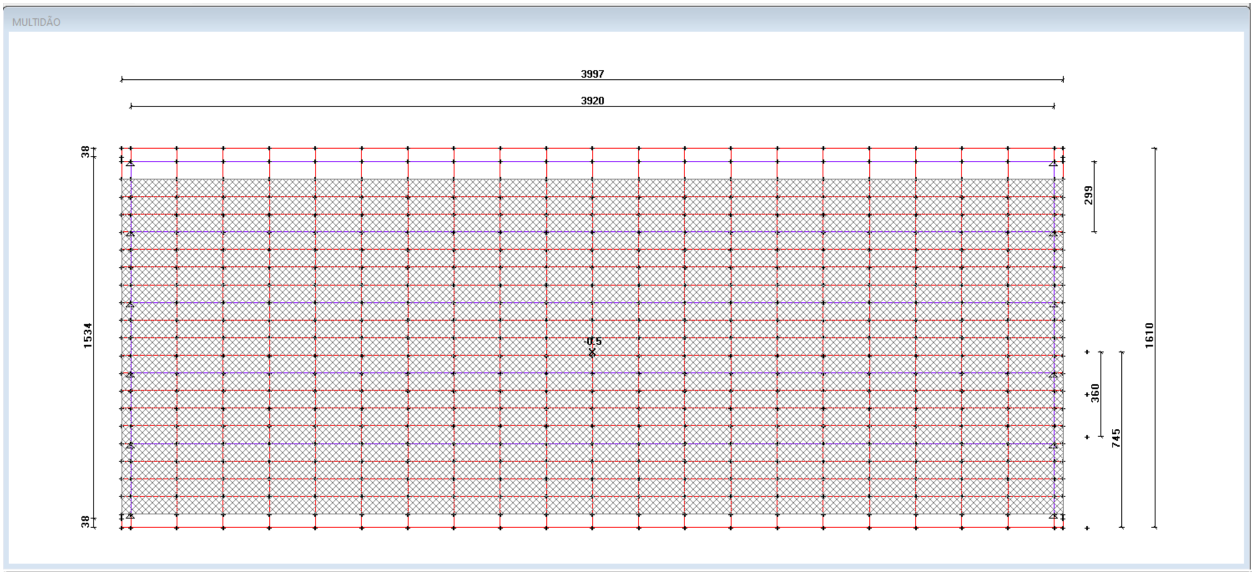
3.2
360
745
1610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1534
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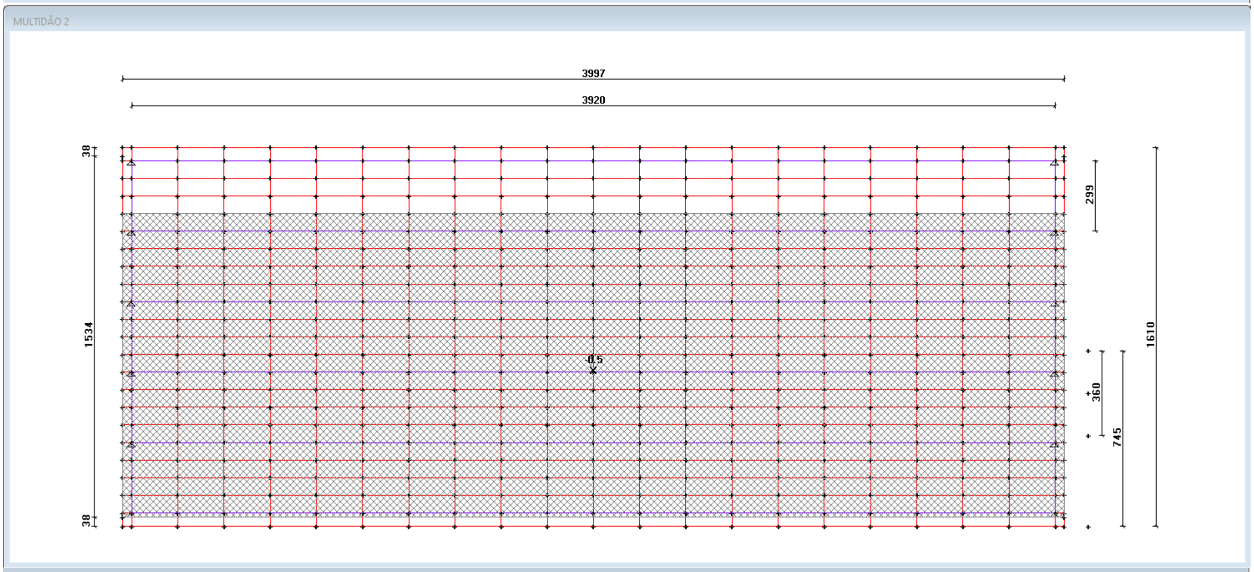
0.5
299
360
745
1610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1534
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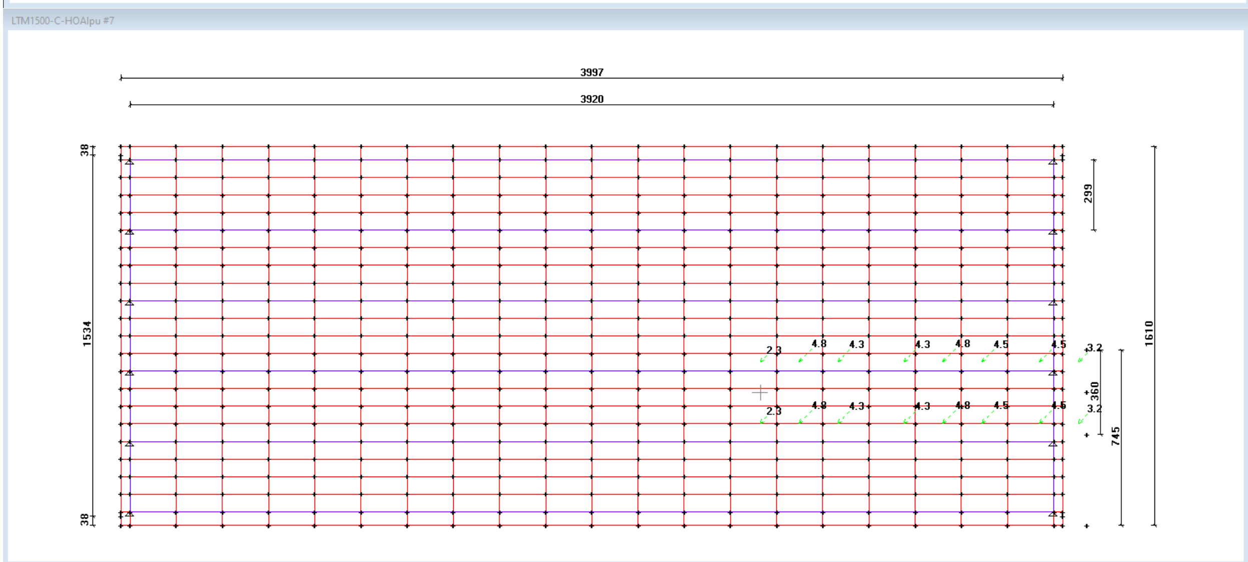
0.5
299
360
745
1610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1534
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2.3
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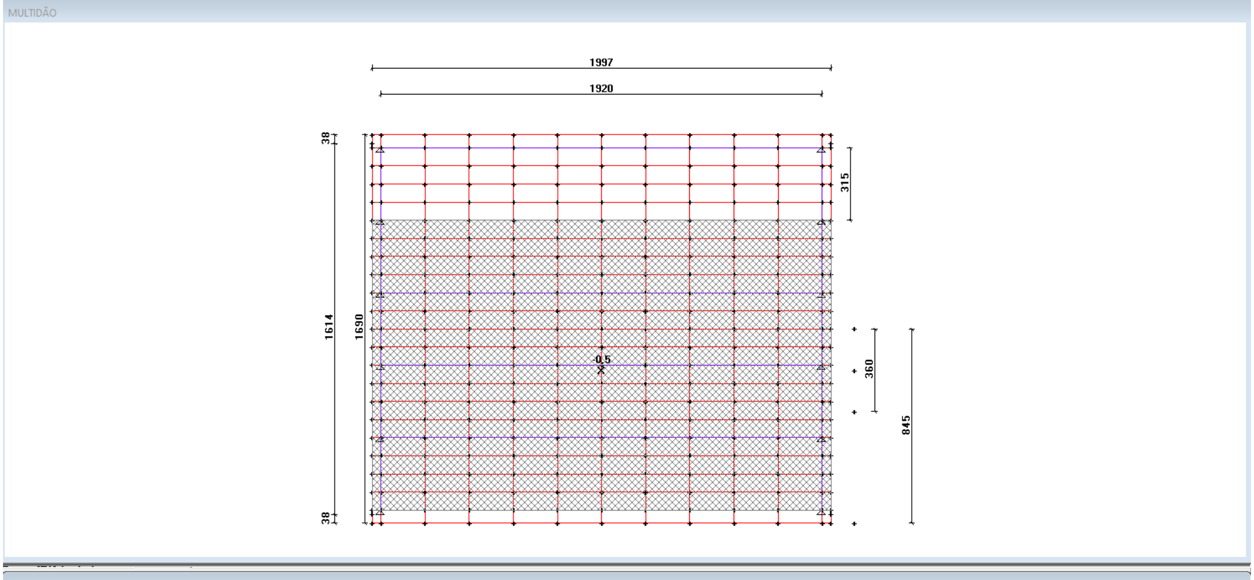
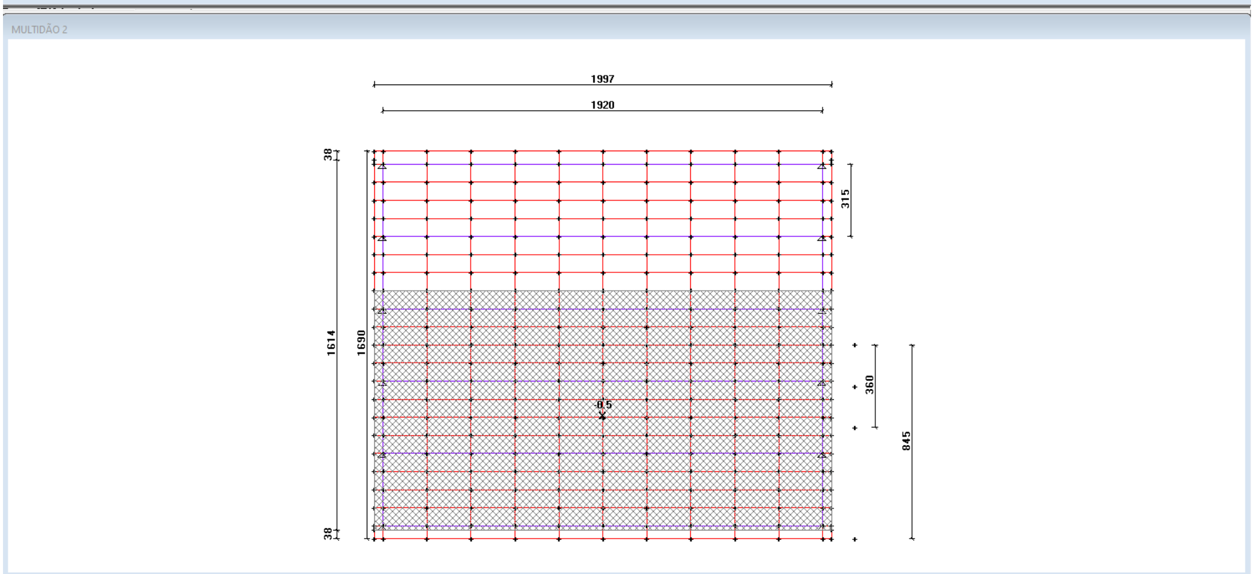
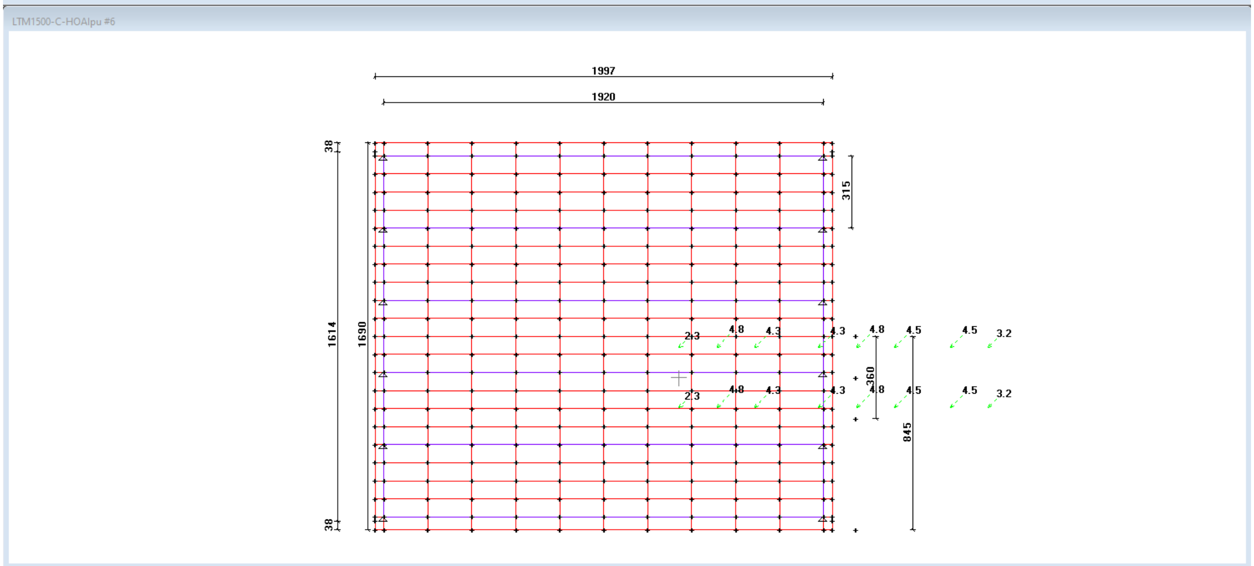
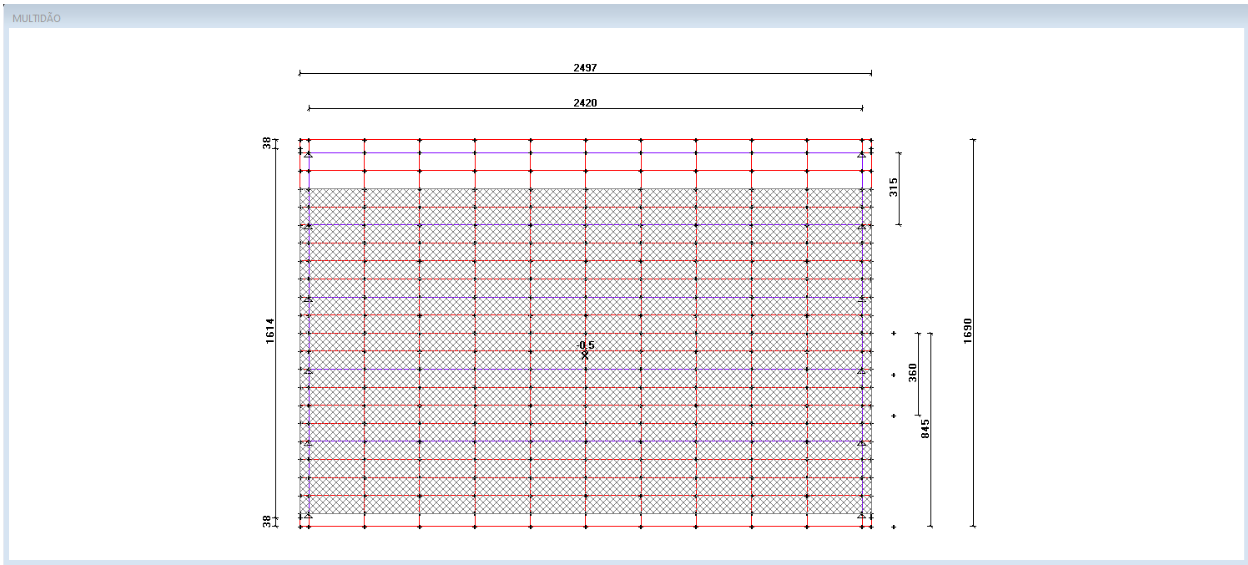
4.8
4.5
4.5
3.2
299
360
745
1610

4.5.5. Tabuleiro 16,90 m








MULTIDÃO
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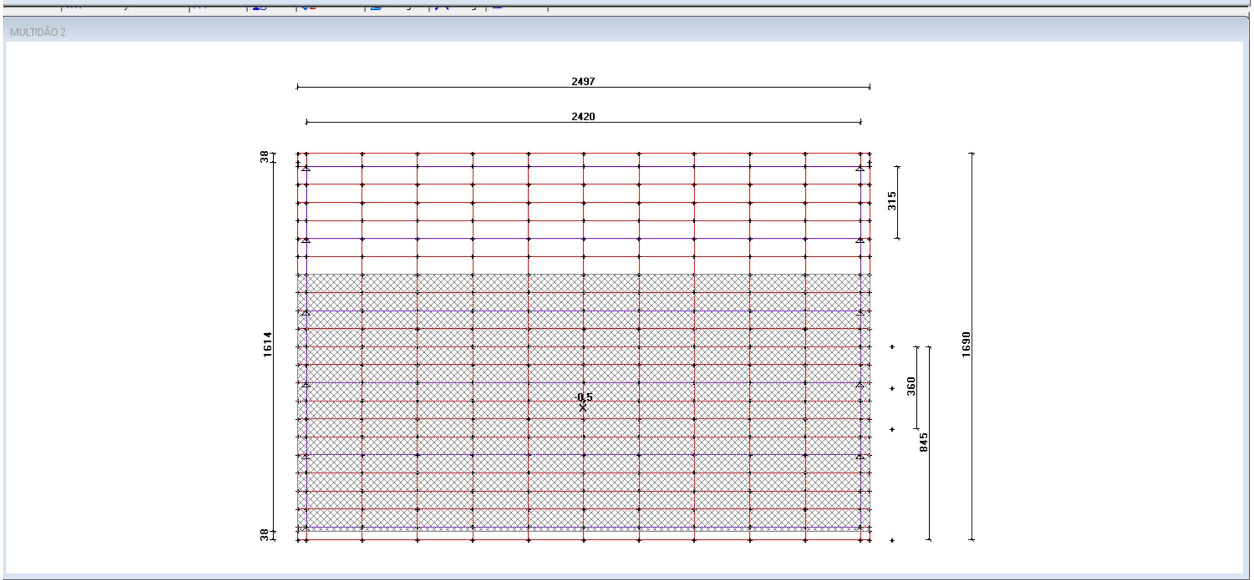
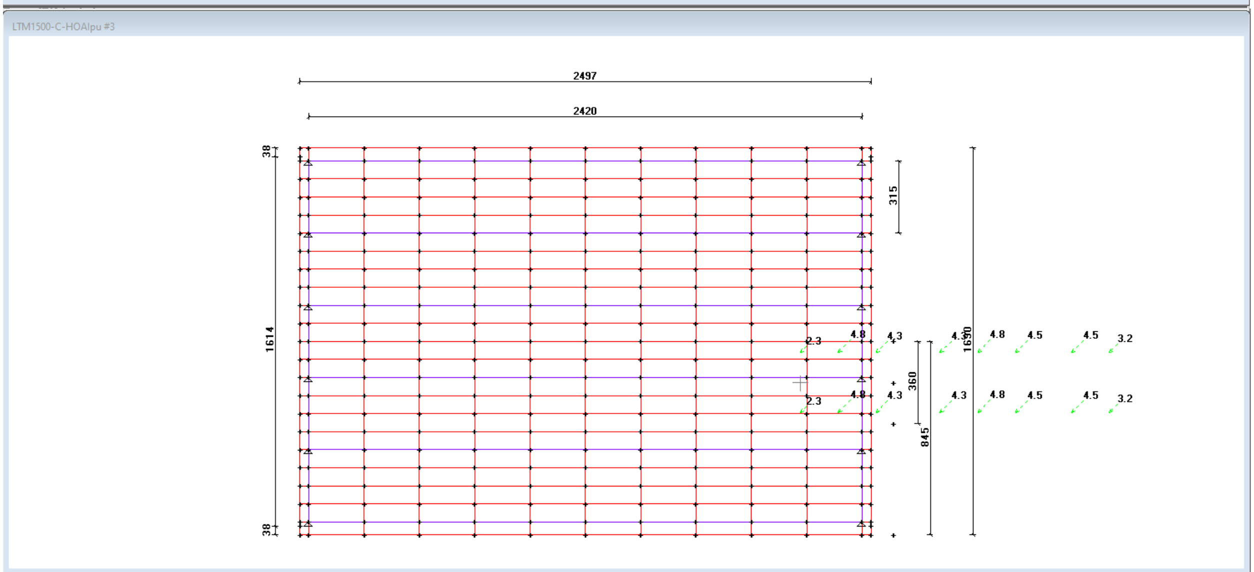
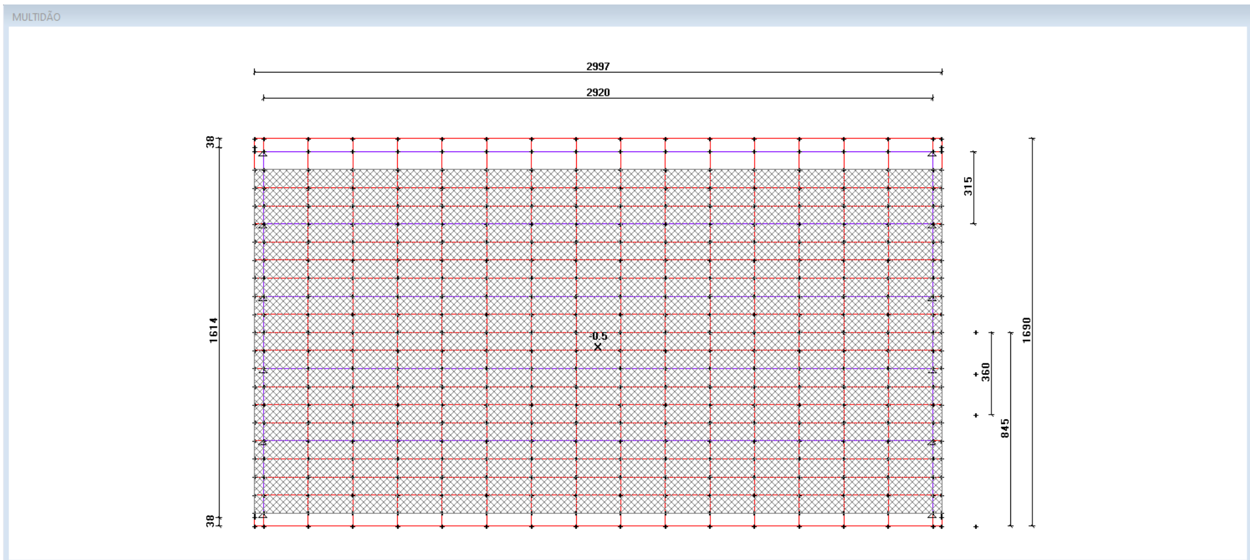
2420
38
1614
38
315
0.5
360
845
1690


MULTIDÃO 2
2497
2420
38
1614
38
315
0.5
360
845
1690


LTM1500-C-HOAIpu #3
2497
2420
38
1614
38
315
360
845
1690
2.3
4.8
4.3
4.8
4.5
4.5
3.2


MULTIDÃO
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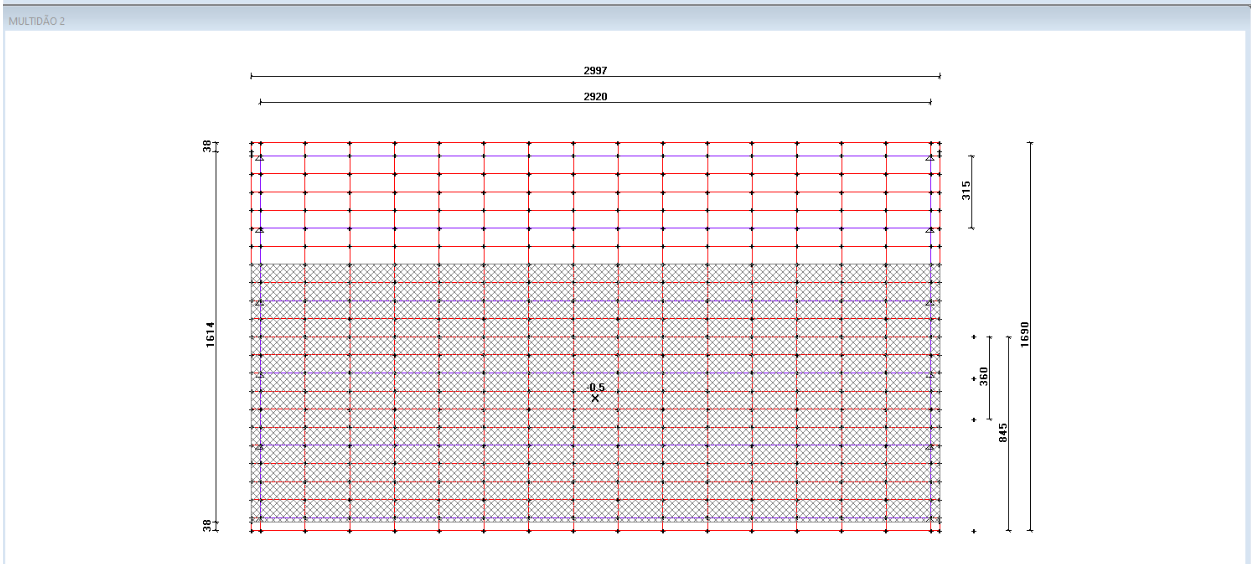
2920
38
1614
38
315
-0.5
360
845
1690


MULTIDÃO 2
2997
2920
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1614
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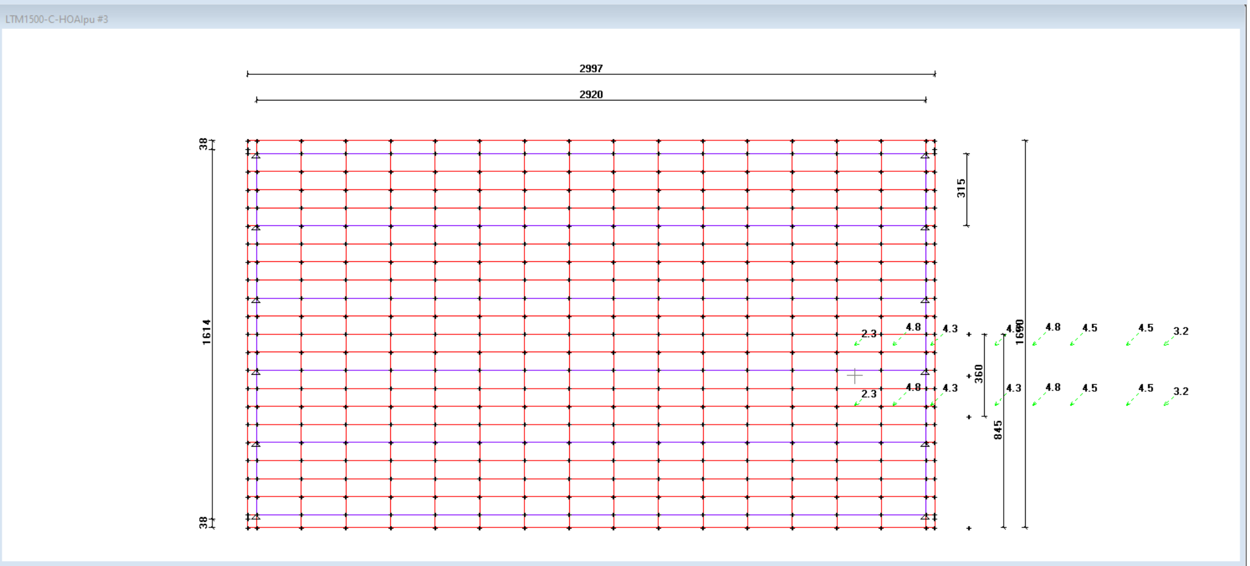
-0.5
360
845
1690


LTM1500-C-HOAlpu #3
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1614
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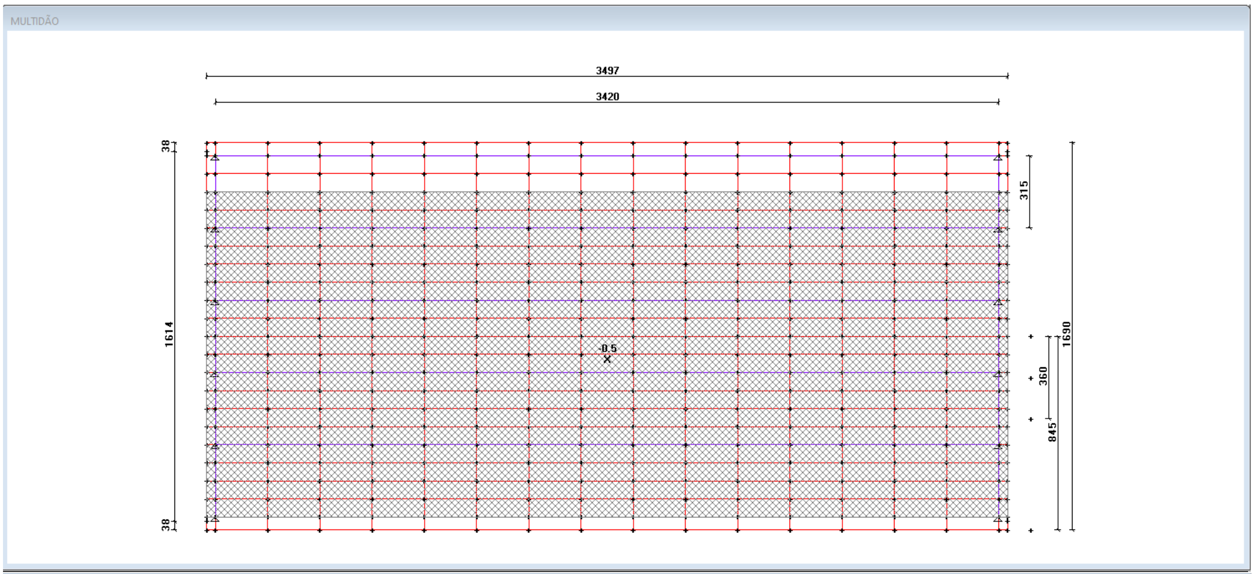
315
360
845
1690


MULTIDÃO
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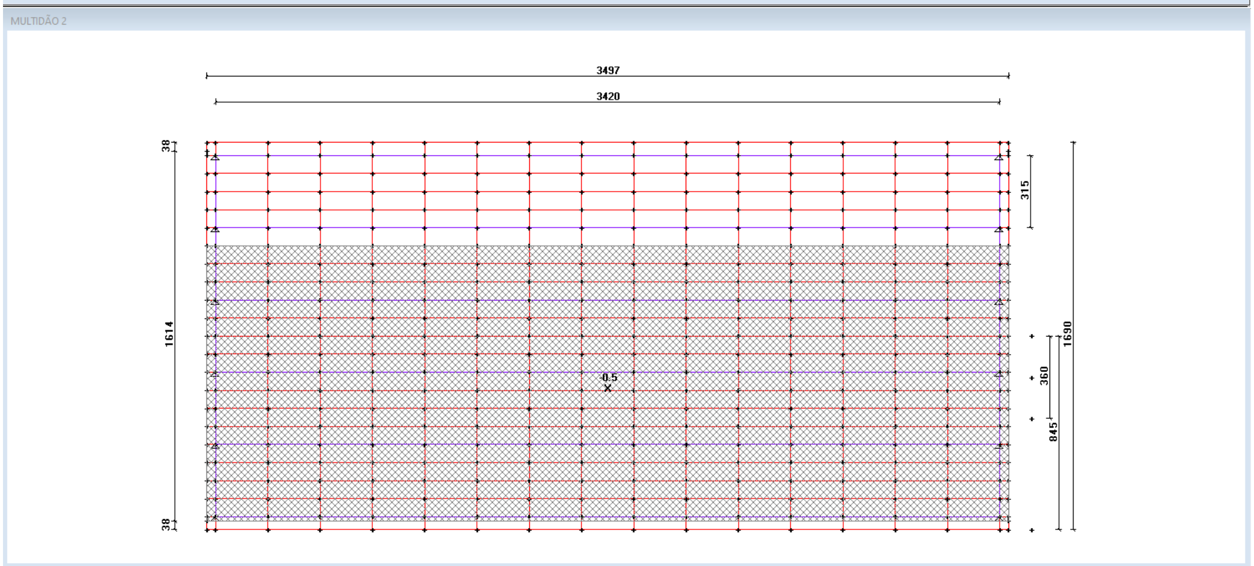
3420
38
1614
38
315
1690
360
845
-0.5


MULTIDÃO 2
3497
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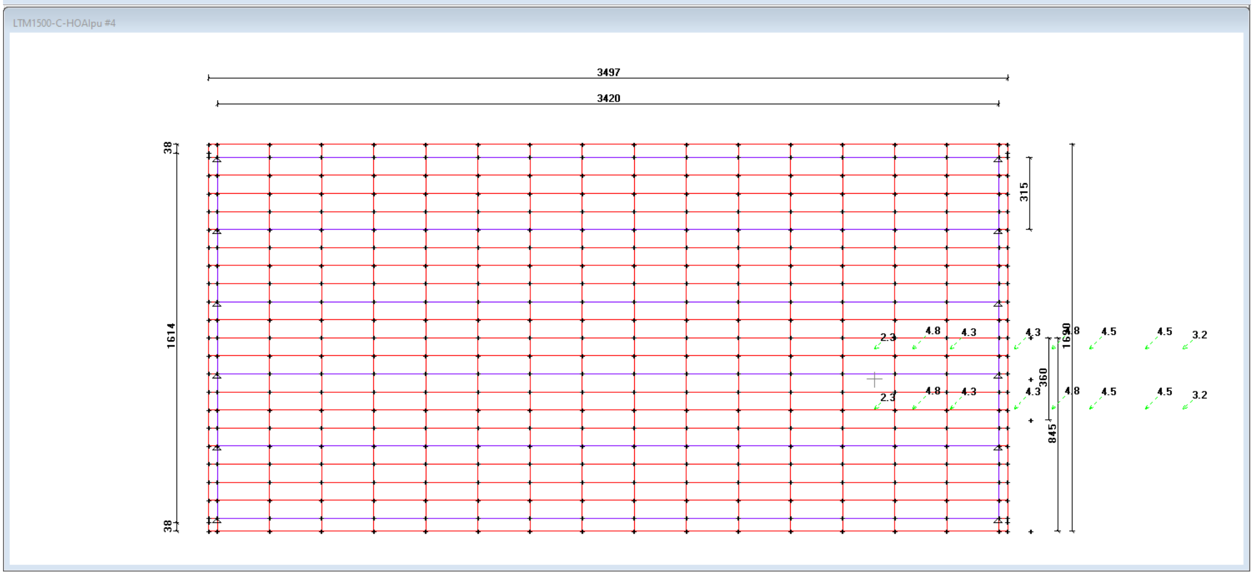
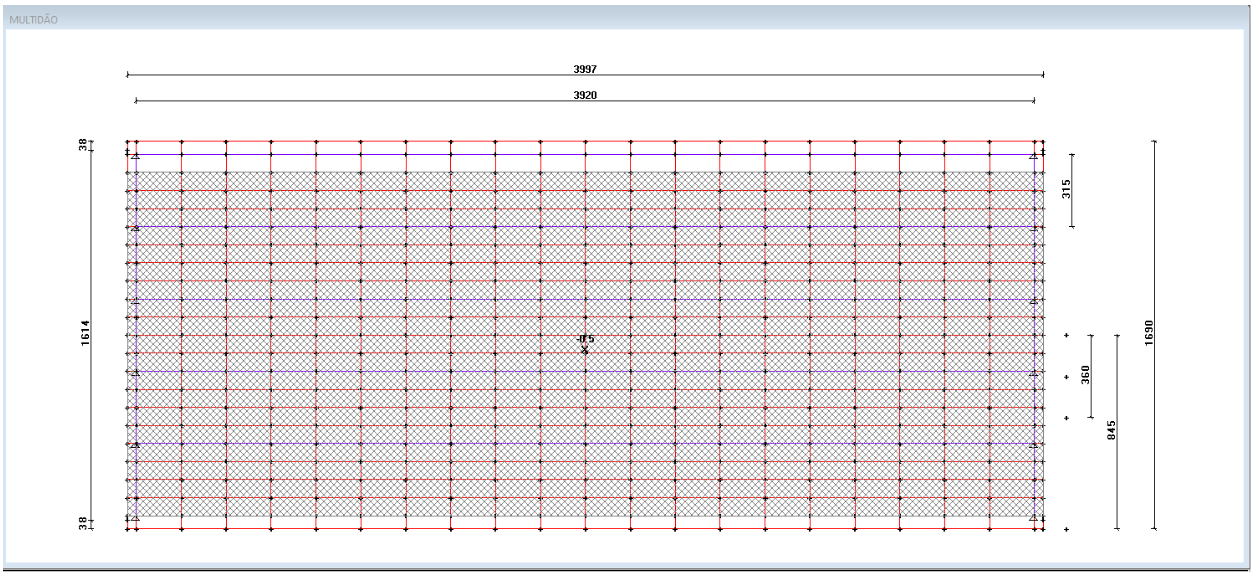
1614
38
315
1690
360
845
-0.5


LTM1500-C-HOAlpu #4
3497
3420
38
1614
38
315
1690
360
845
2.3
4.8
4.3
4.3
4.8
4.5
4.5
3.2
2.3
4.8
4.3
4.3
4.8
4.5
4.5
3.2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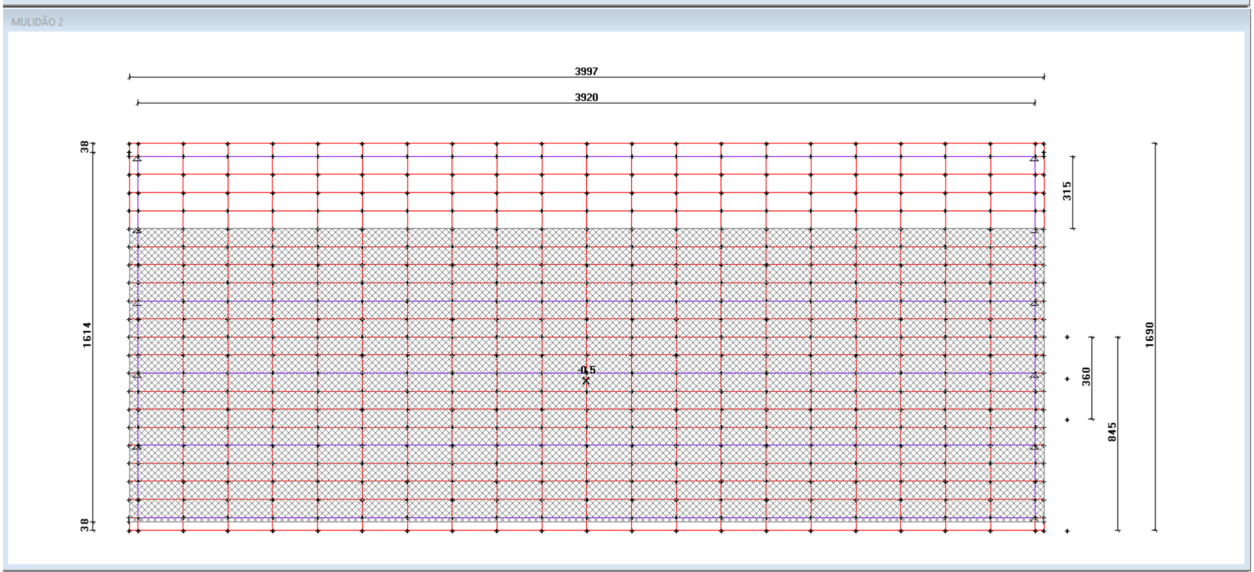
1614
38
0.5
315
360
845
1690


MULIDÃO 2
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1614
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0.5
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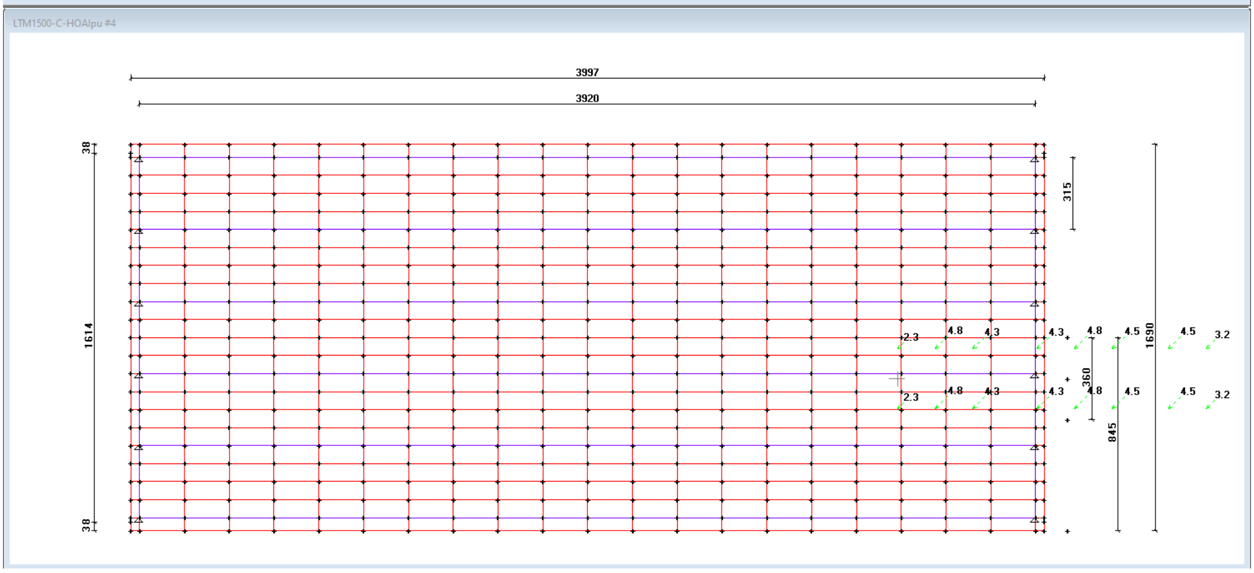
360
845
1690


3997
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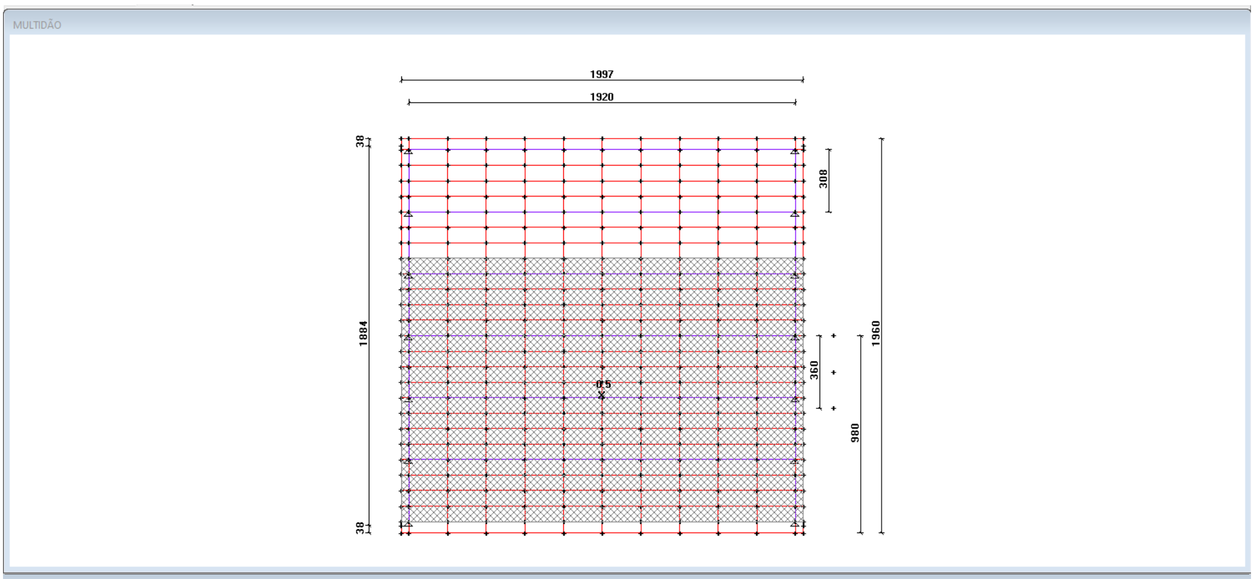
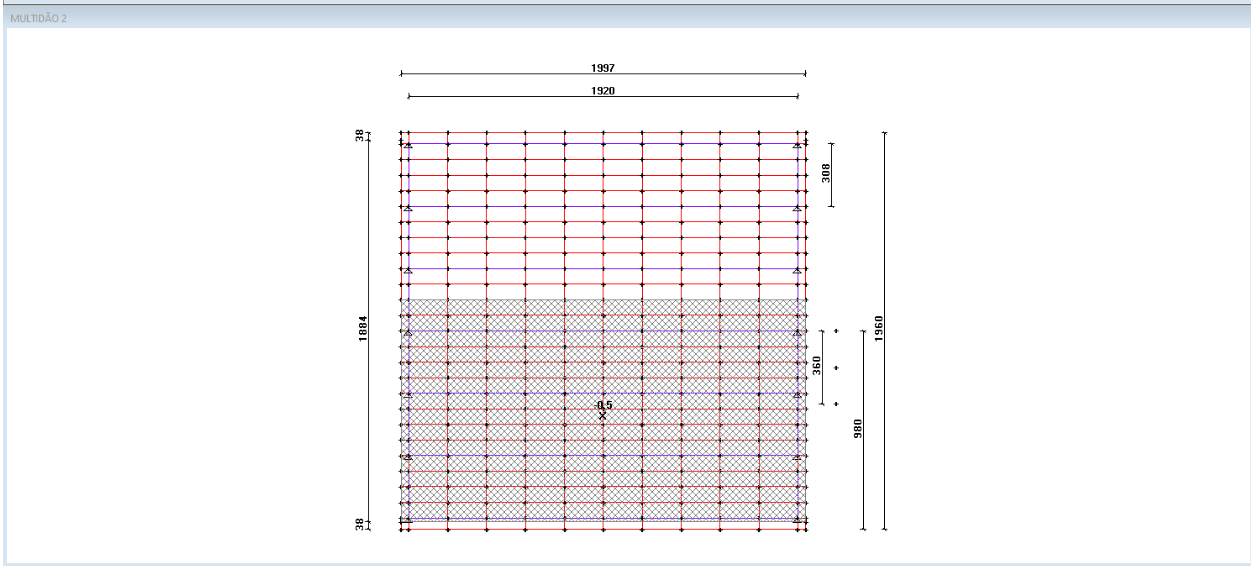
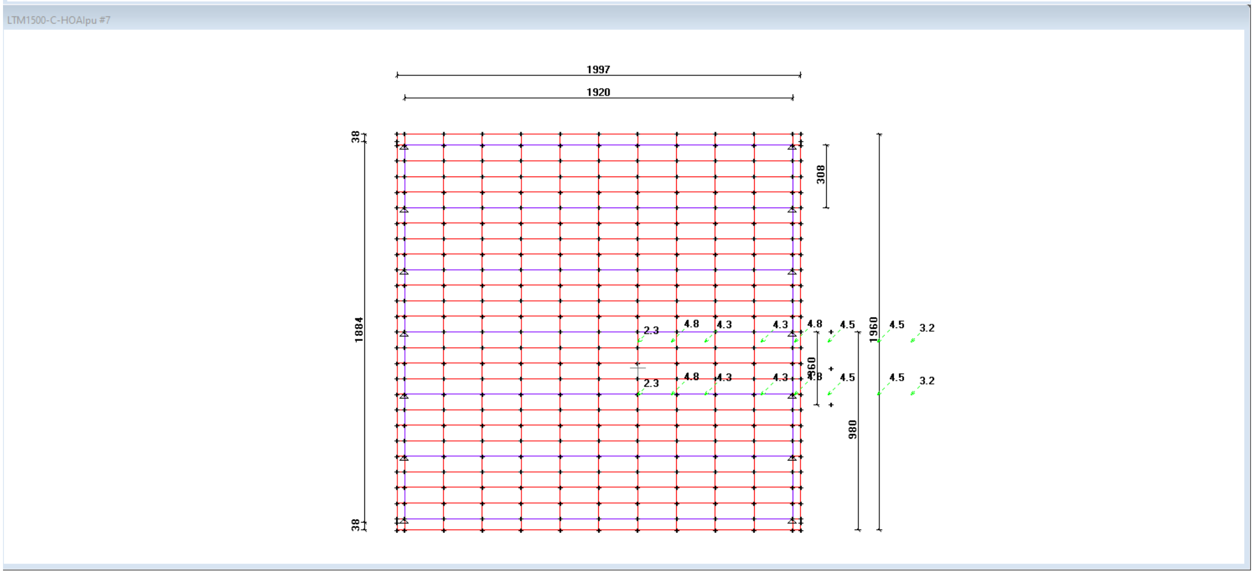
38
1614
38
315
360
845
1690
2.3
4.8
4.3
4.3
4.8
4.5
4.5
3.2

4.5.6. Tabuleiro 19,60 m







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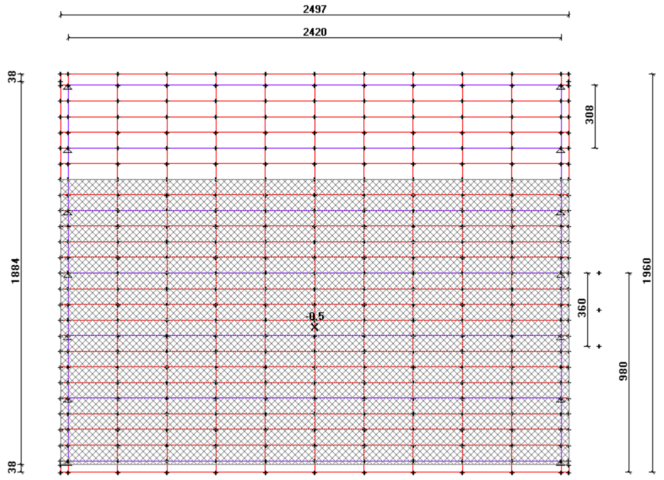
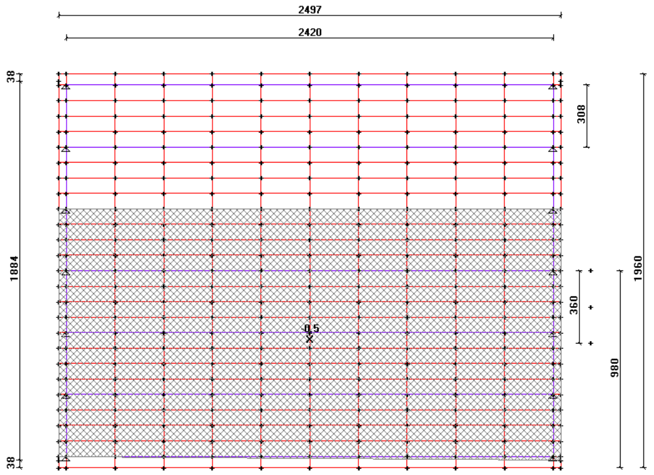
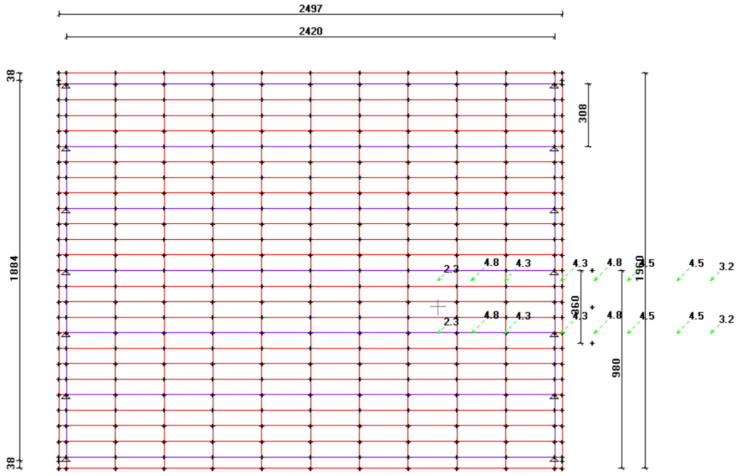
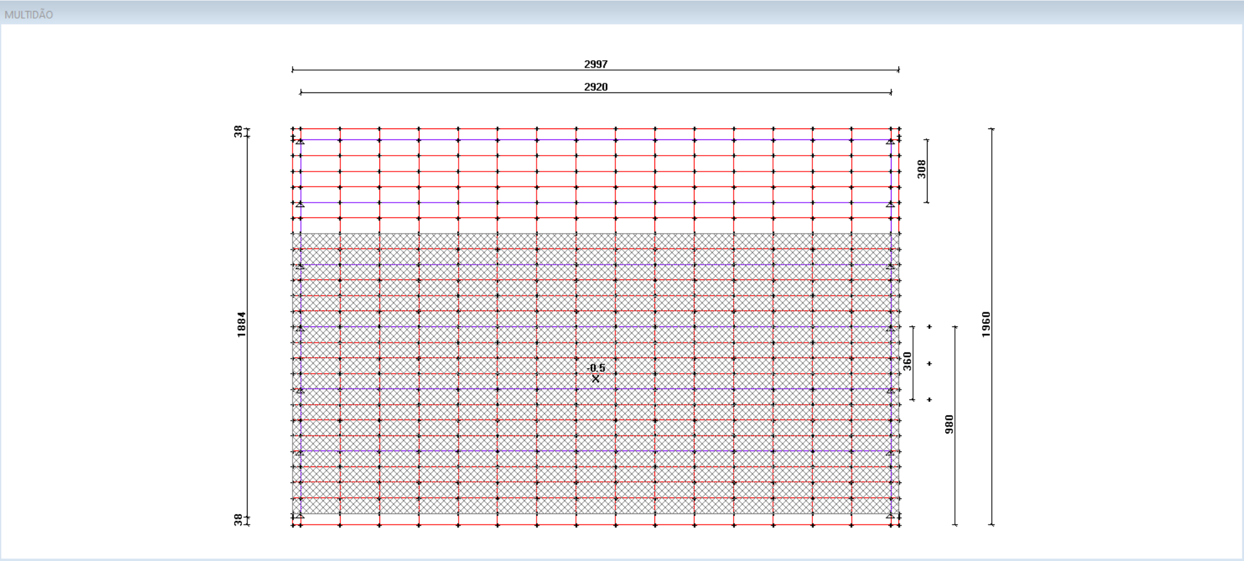


MULTIDÃO 2



LTM1500-C-HOAIpu #5

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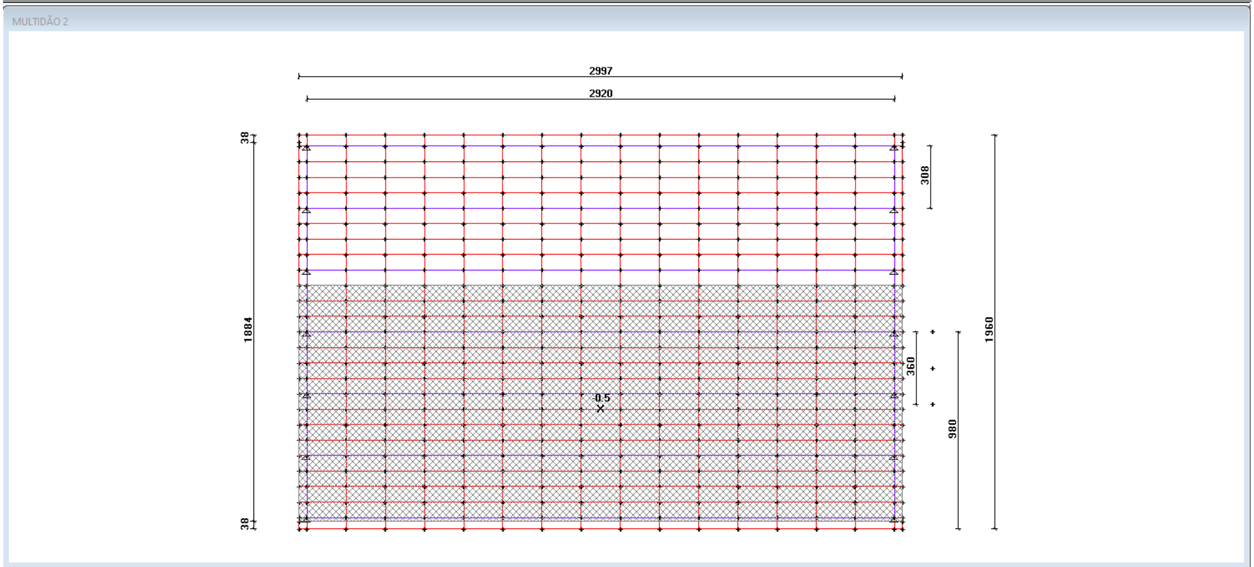
1884
38
308
360
980
1960
-0.5


MULTIDÃO 2
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1884
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980
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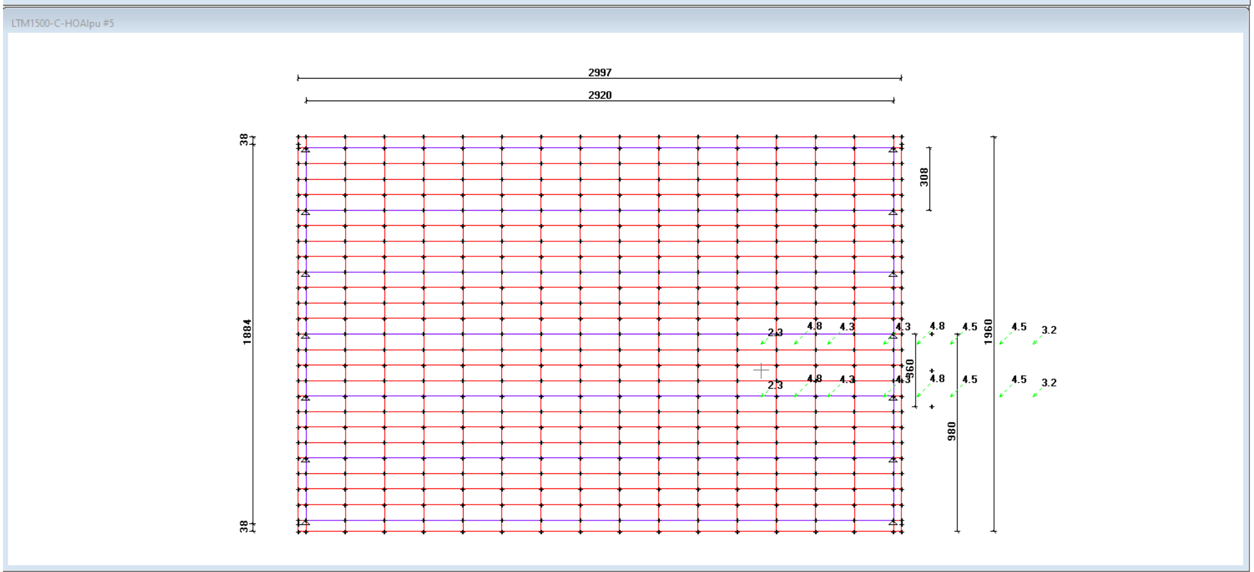
-0.5


LTM1500-C-HOAlpu #5
2997
2920
38
1884
38
308
360
980
1960
2.3
4.8
4.3
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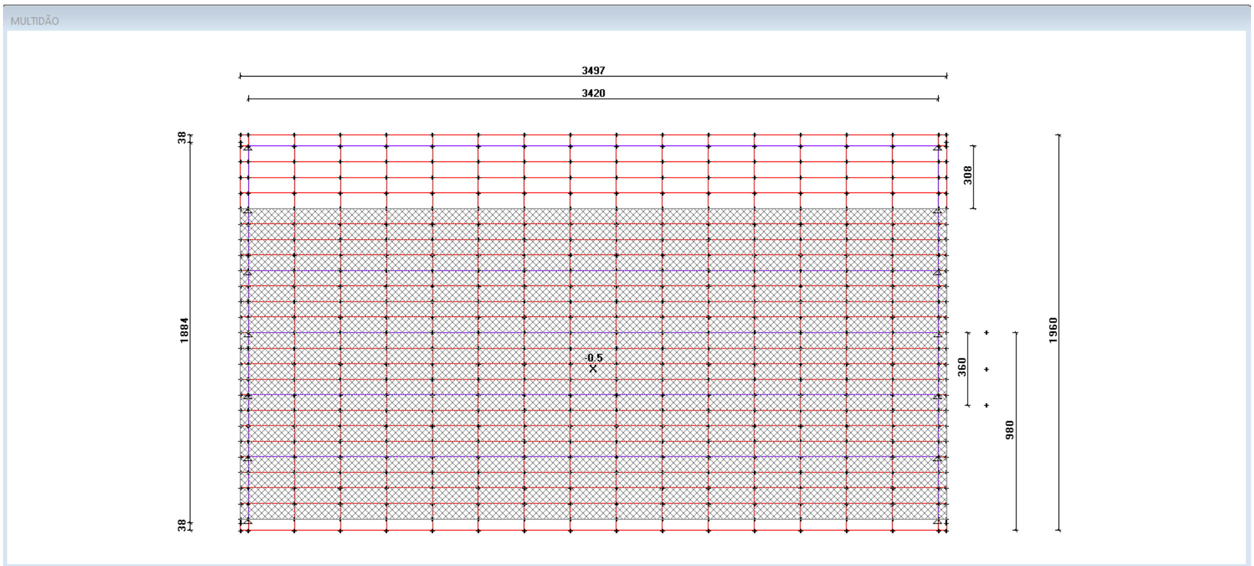
3.2


MULTIDÃO
3497
3420
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1884
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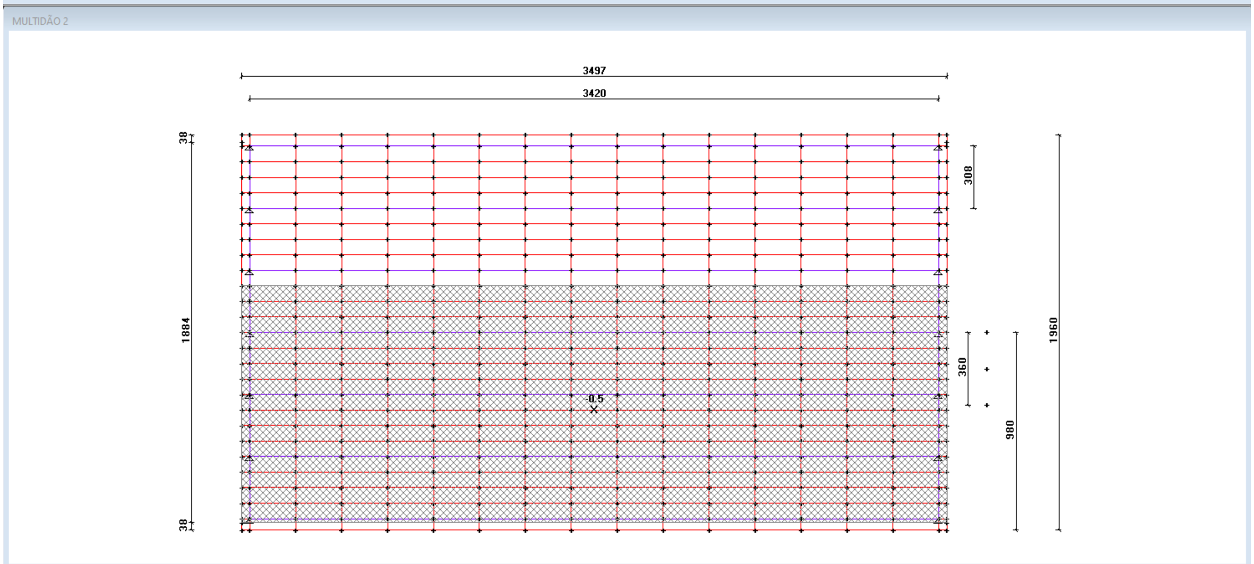
0.5


MULTIDÃO 2
3497
3420
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1884
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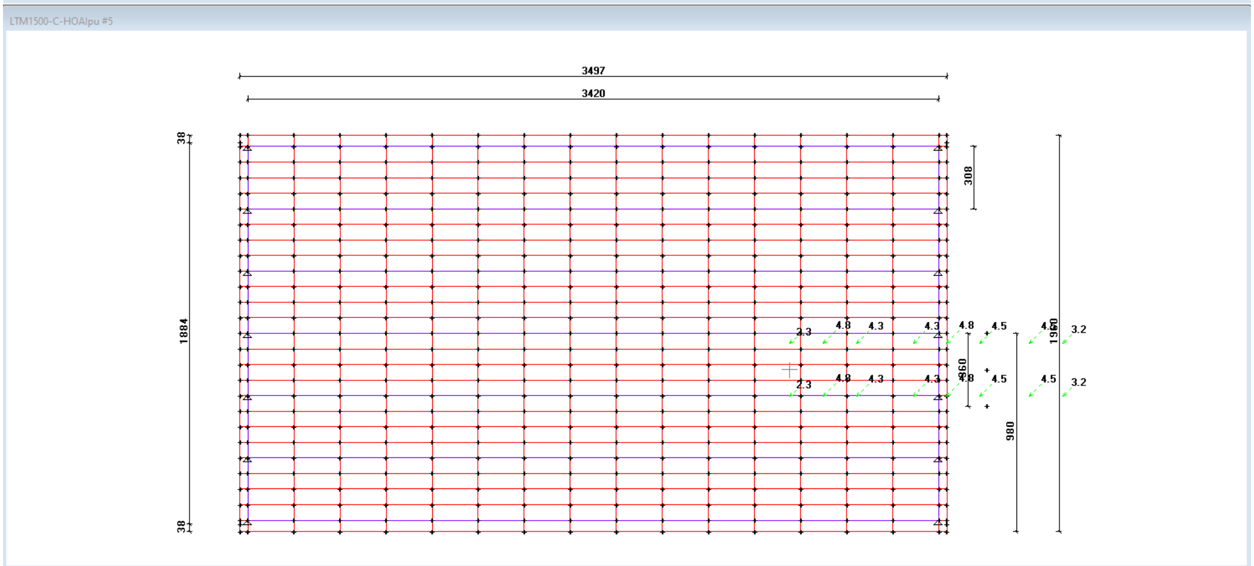
0.5


LTM1500-C-HOAlpu #5
3497
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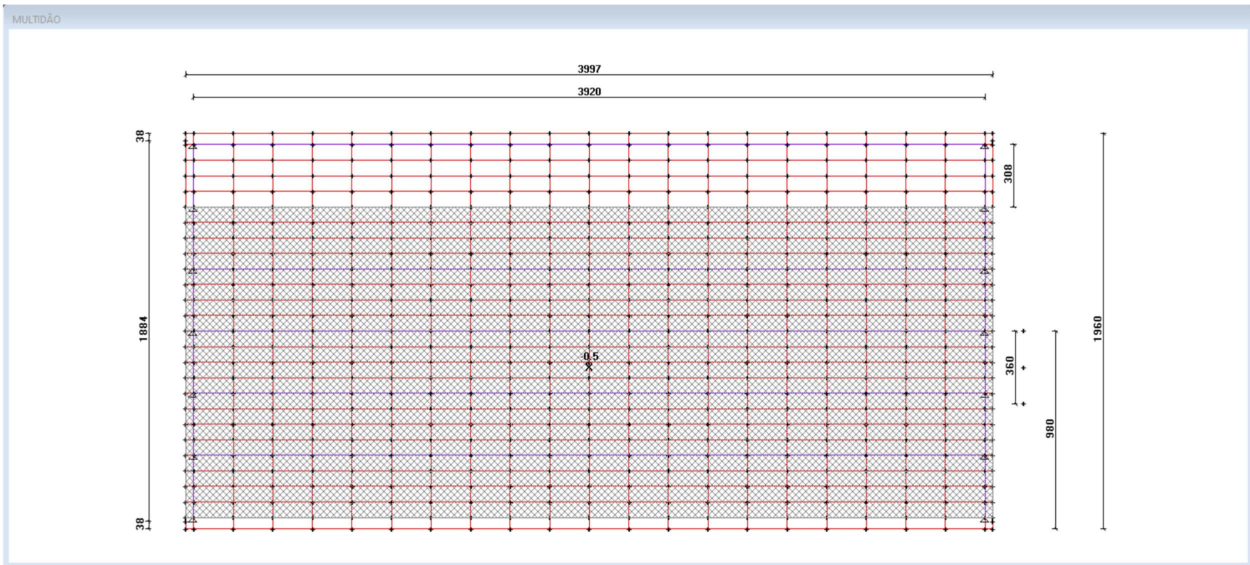
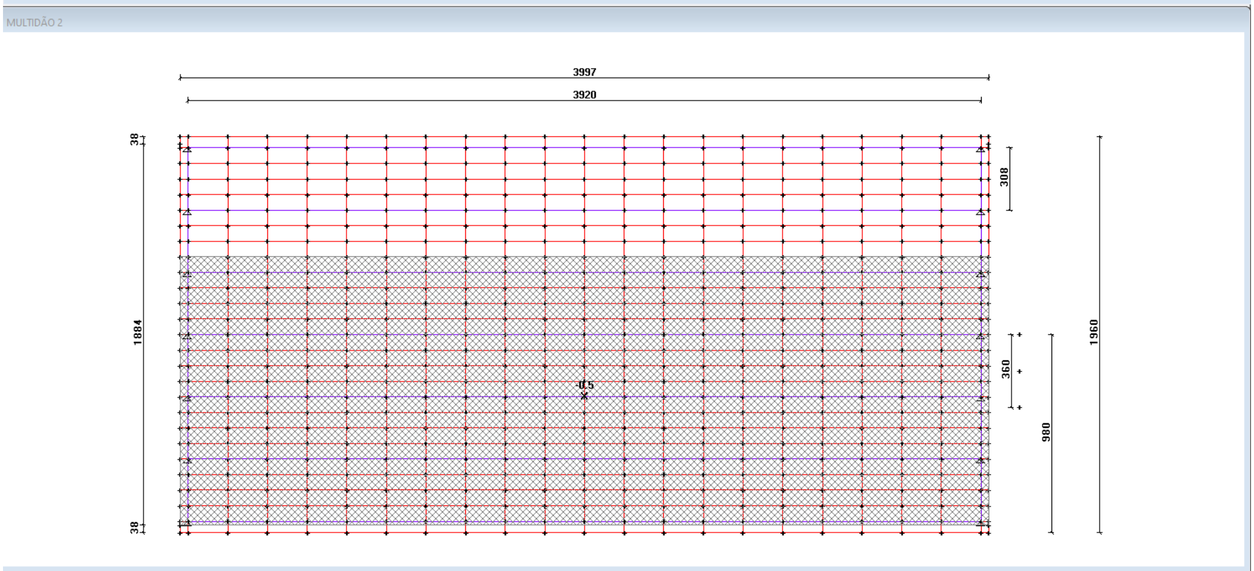
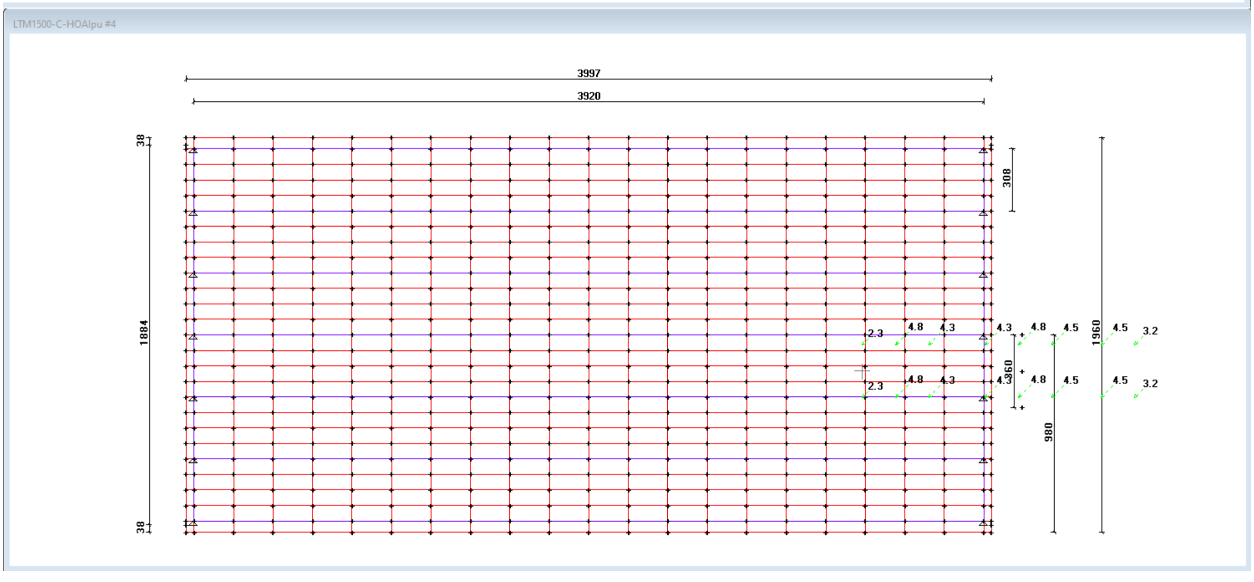
980
1960
2.3
4.8
4.3
4.5
3.2

NOTA TÉCNICA

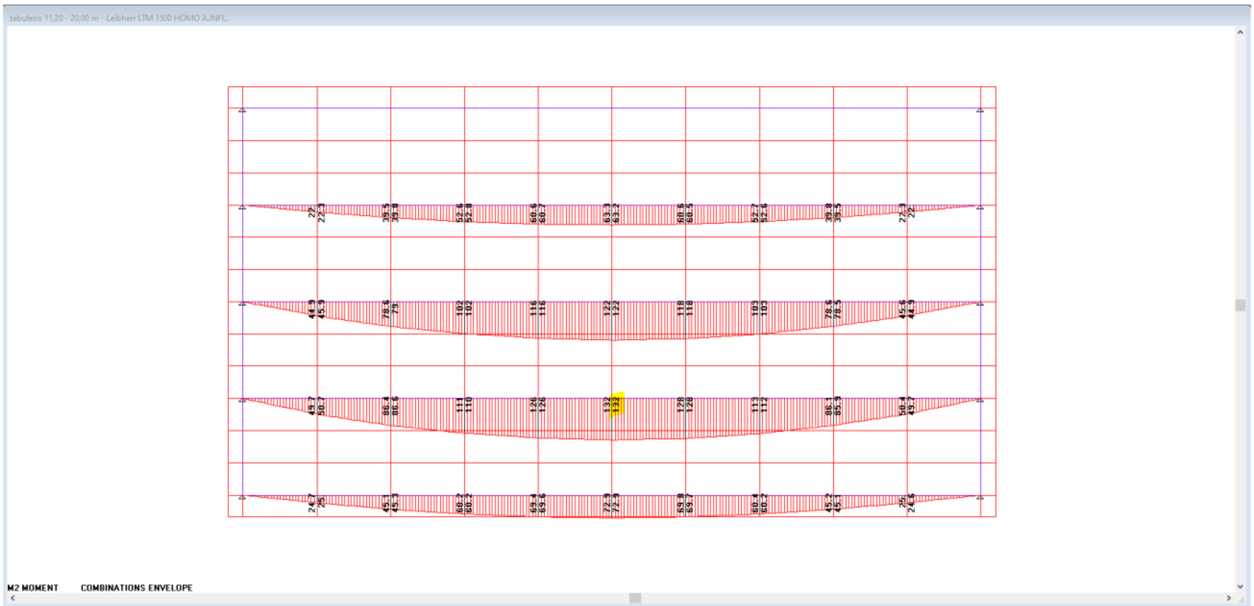


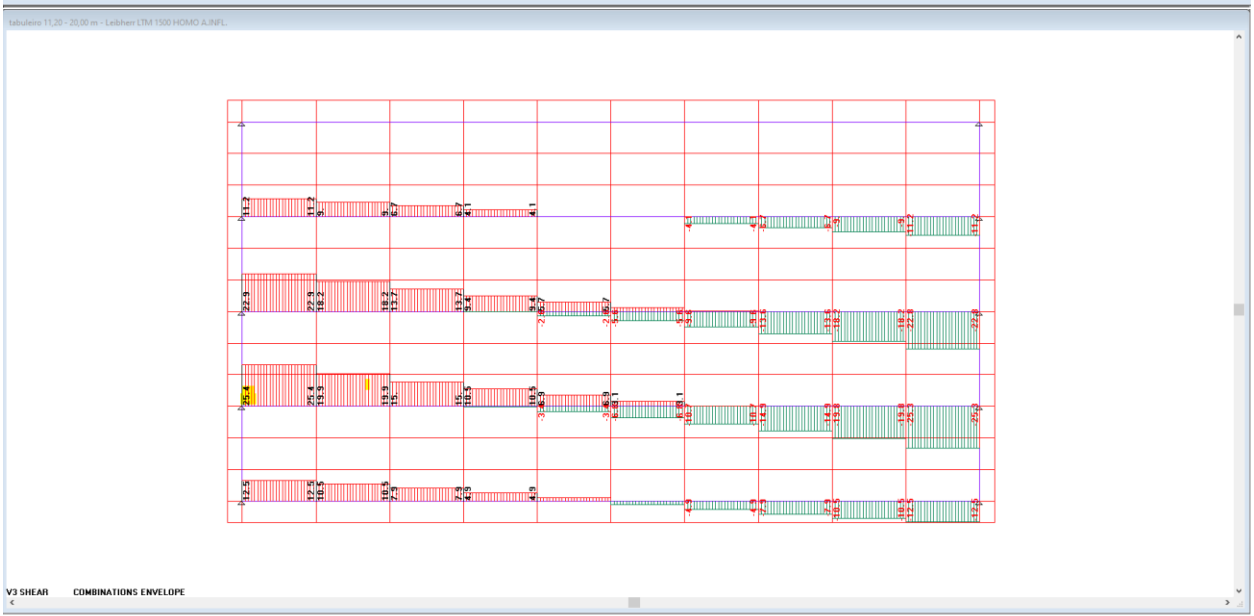


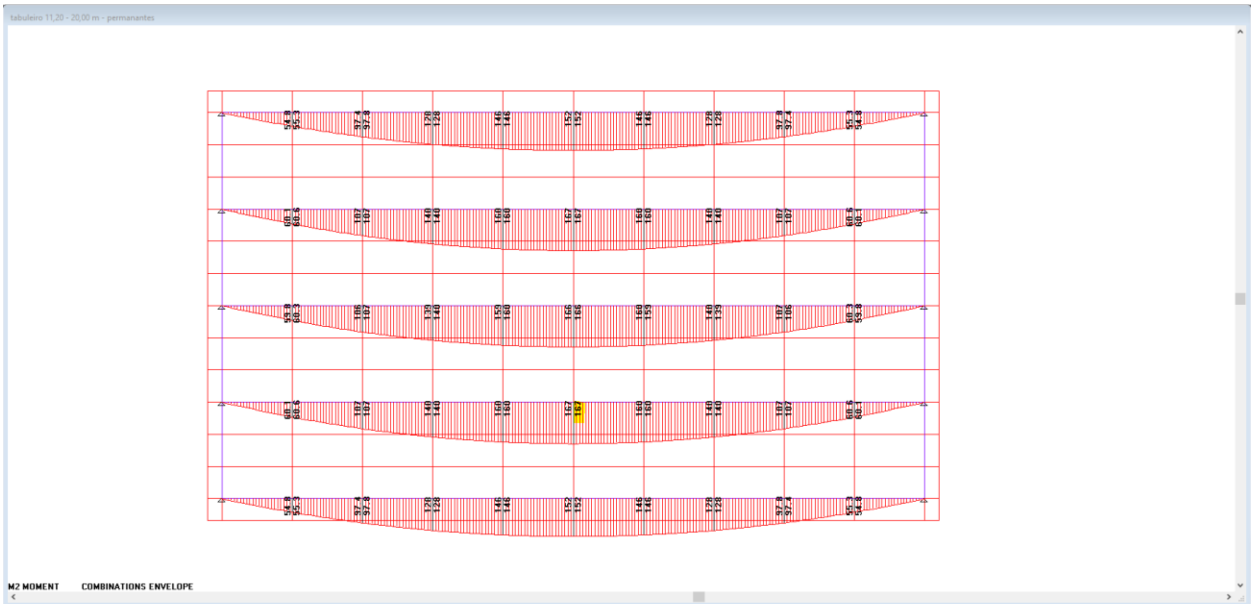


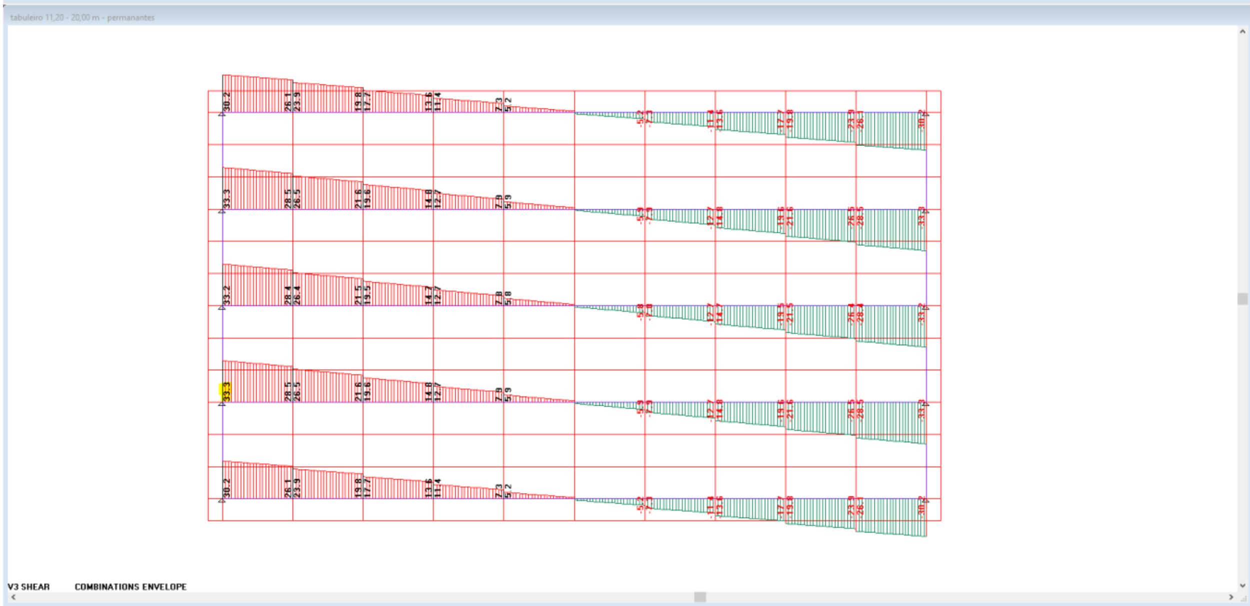
4.6. Momentos e cortantes (cargas permanentes, TB-36 e Liebherr)

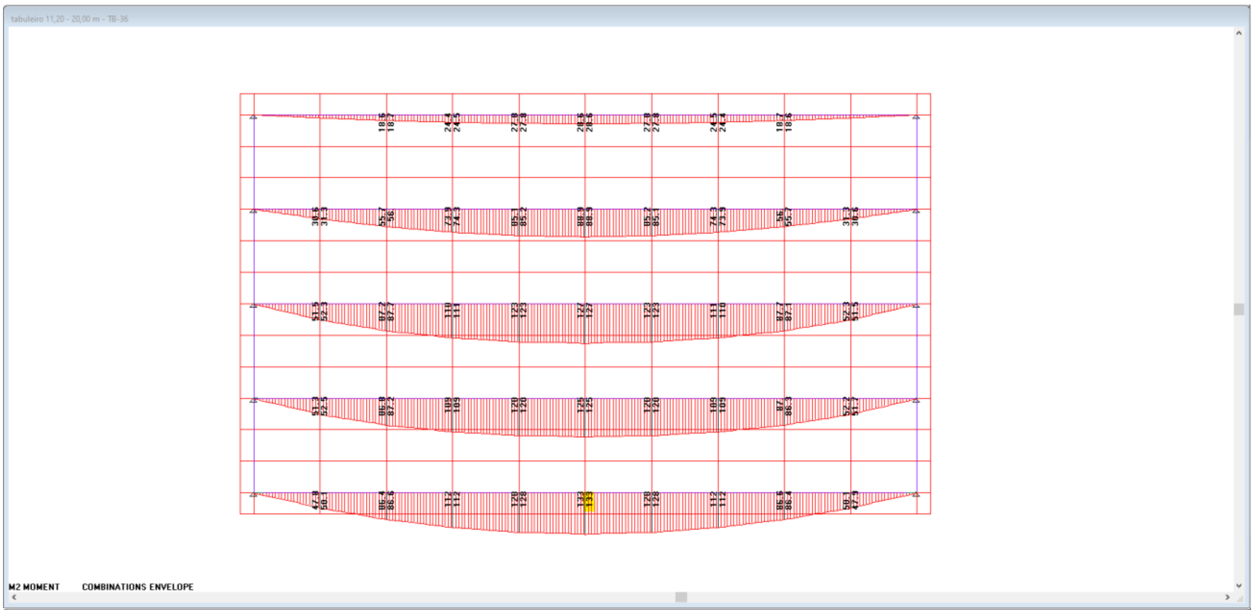
4.6.1. Tabuleiro 11,20 m

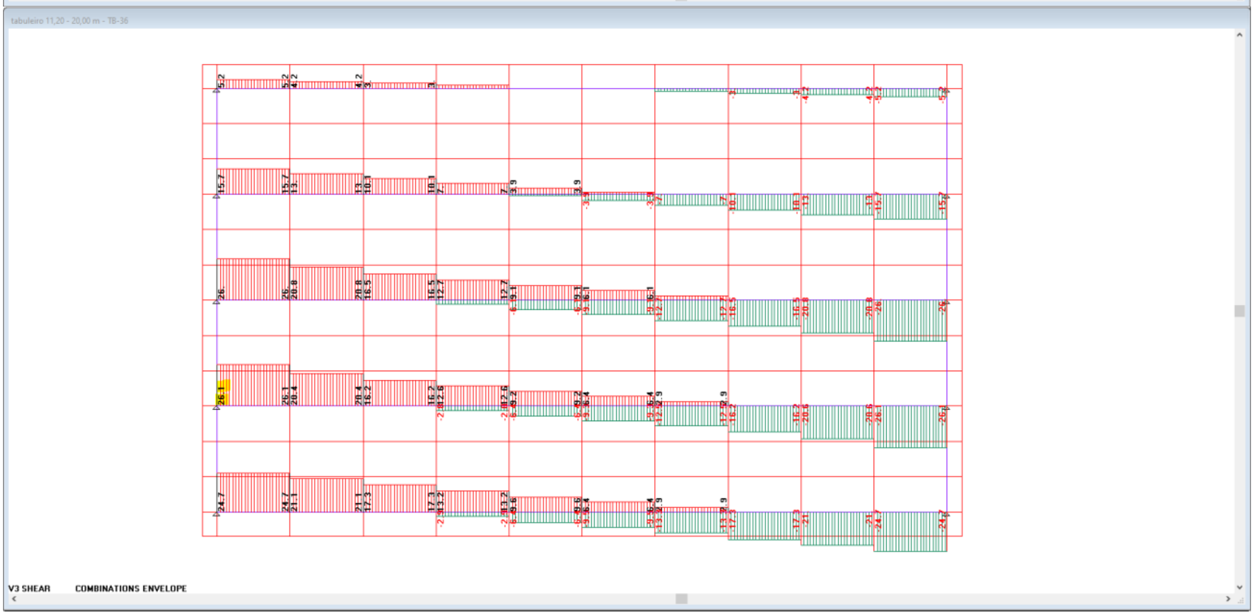


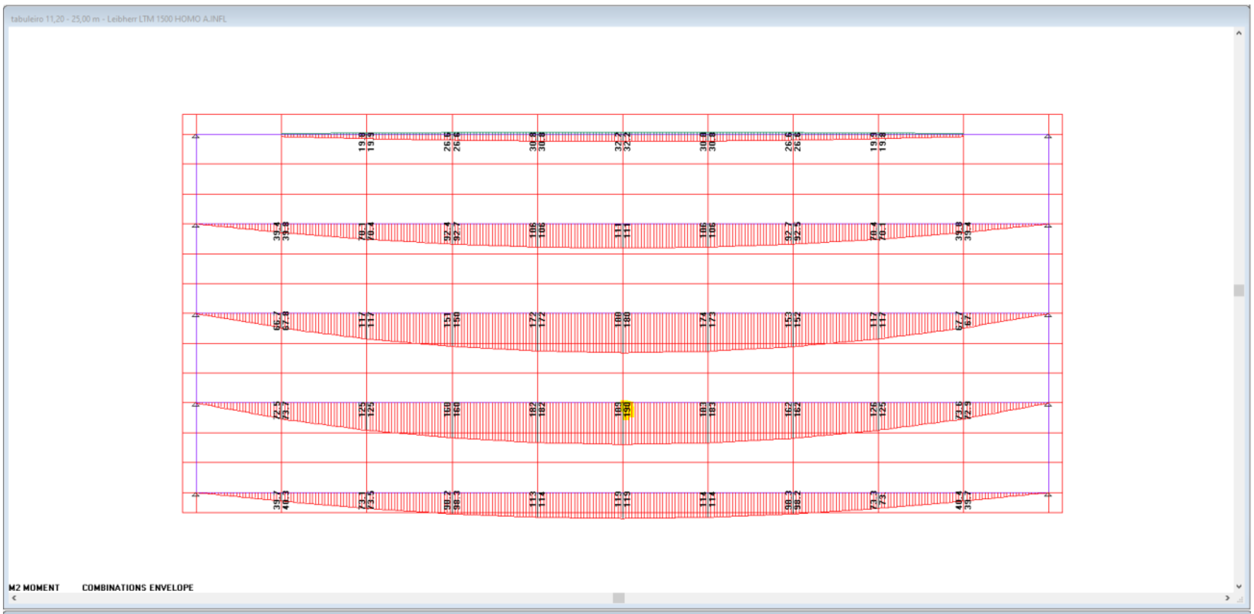


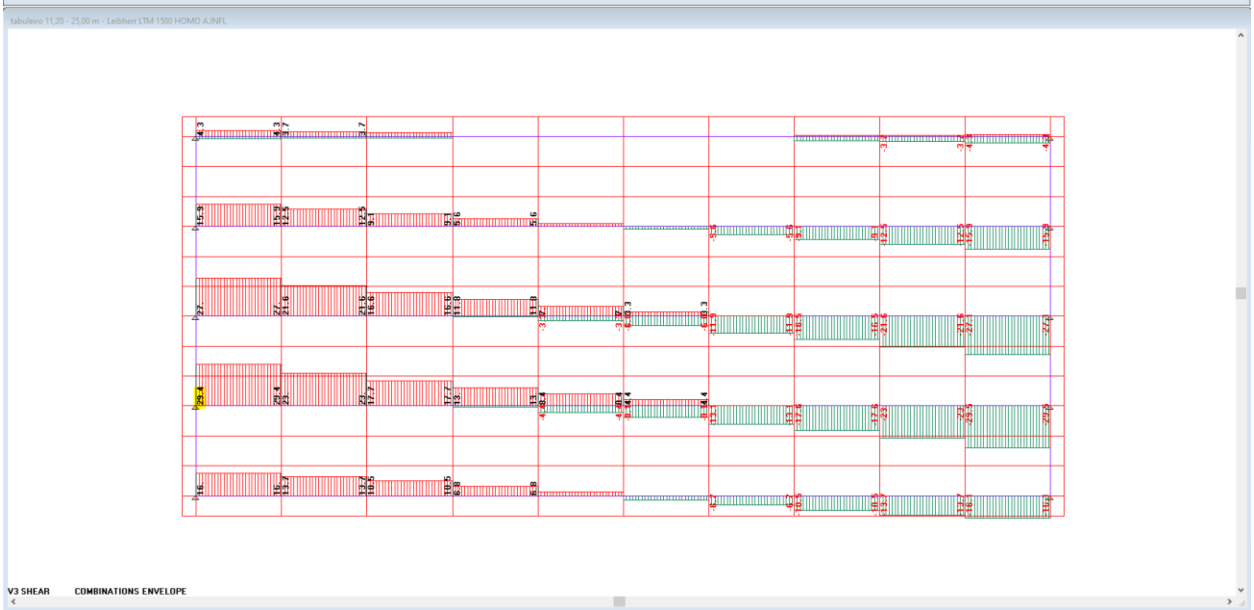

tabuleiro 11,20 - 20,00 m - permanentes
M2 MOMENT COMBINATIONS ENVELOPE

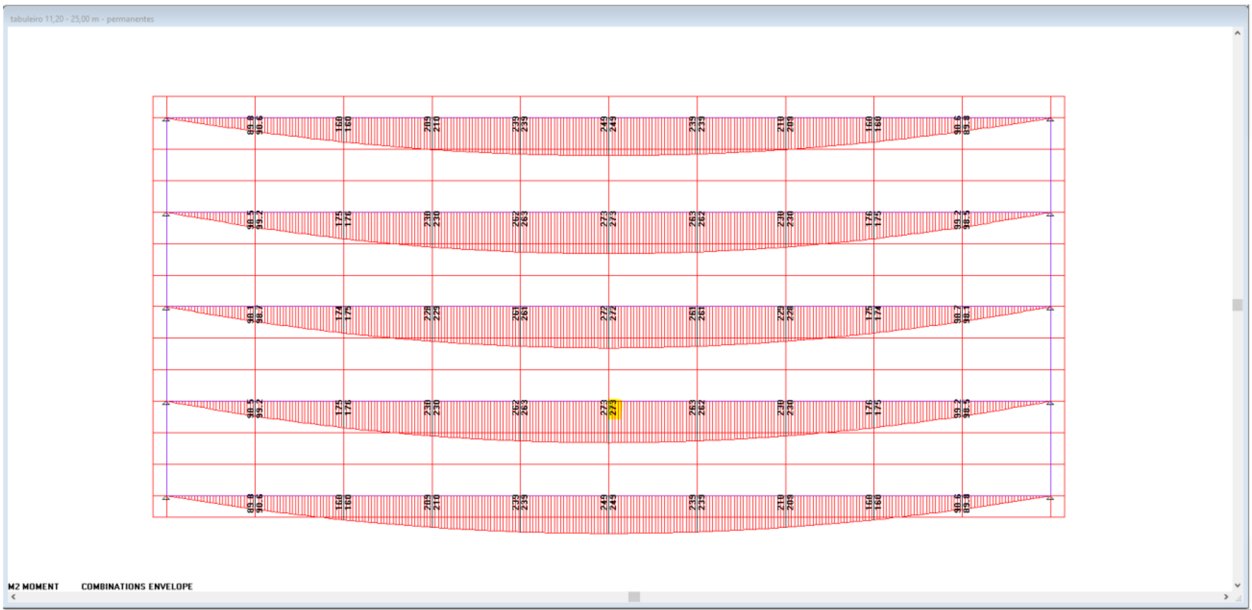

tabuleiro 11,20 - 20,00 m - permanentes
V3 SHEAR COMBINATIONS ENVELOPE

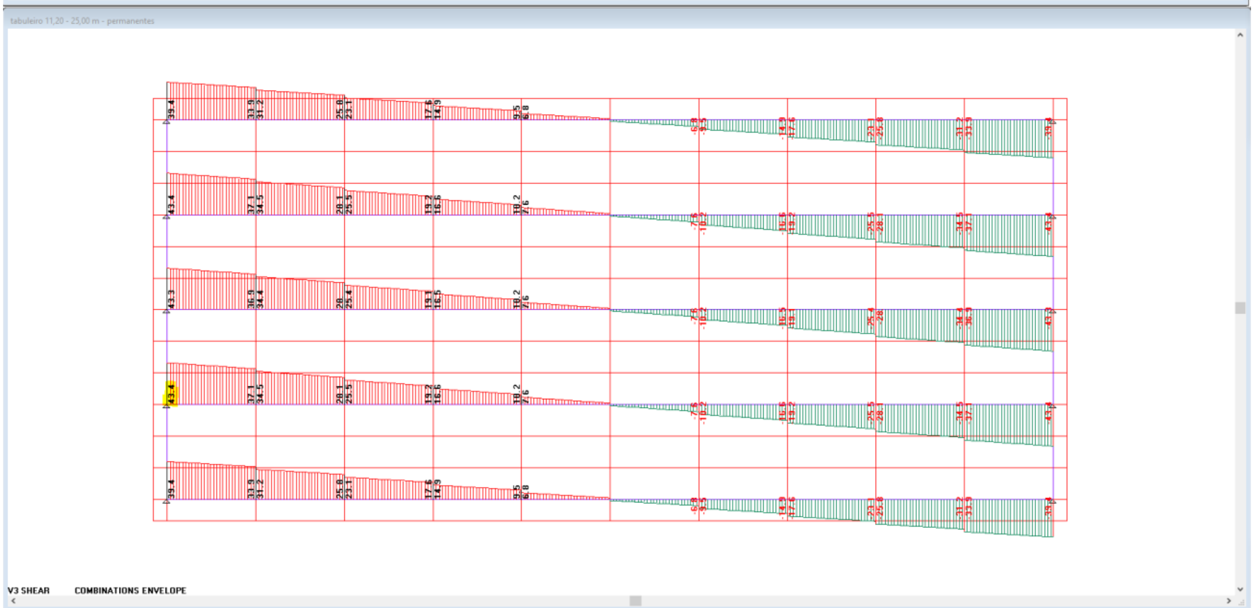

M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 11,20 - 25,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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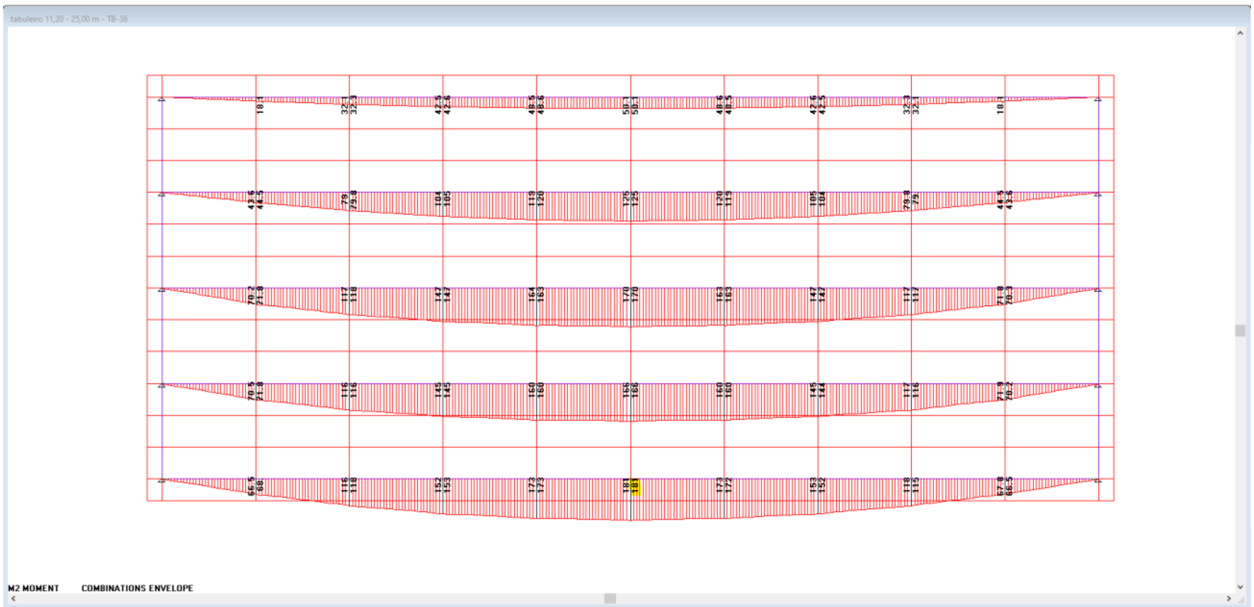
COMBINATIONS ENVELOPE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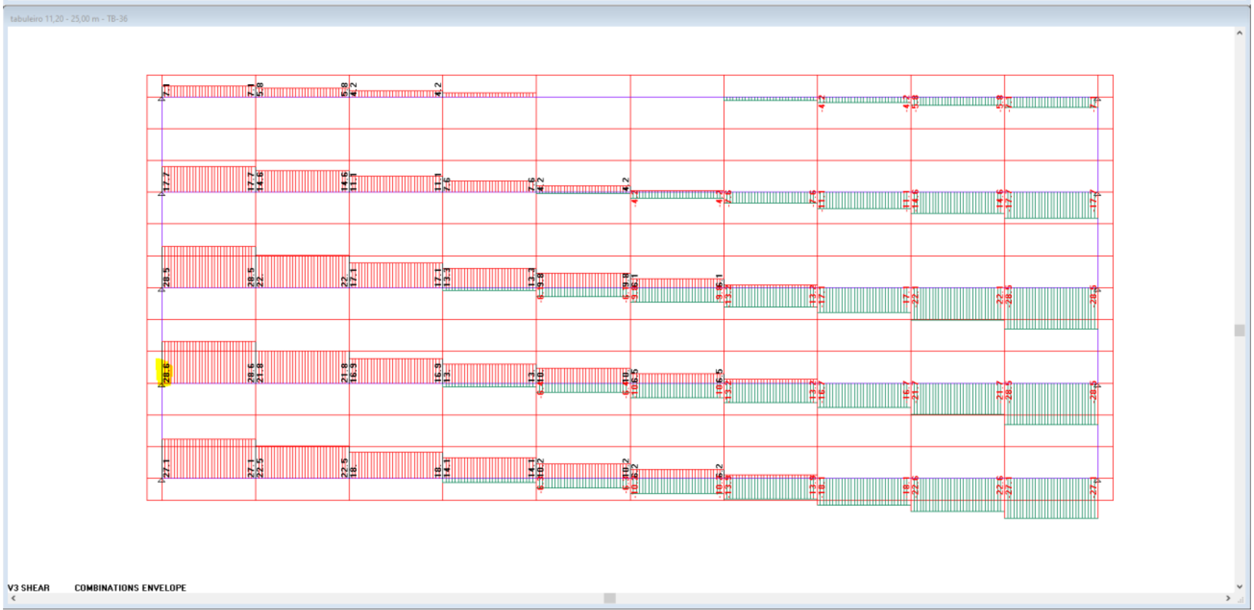
M2 MOMENT
COMBINATIONS ENVELOPE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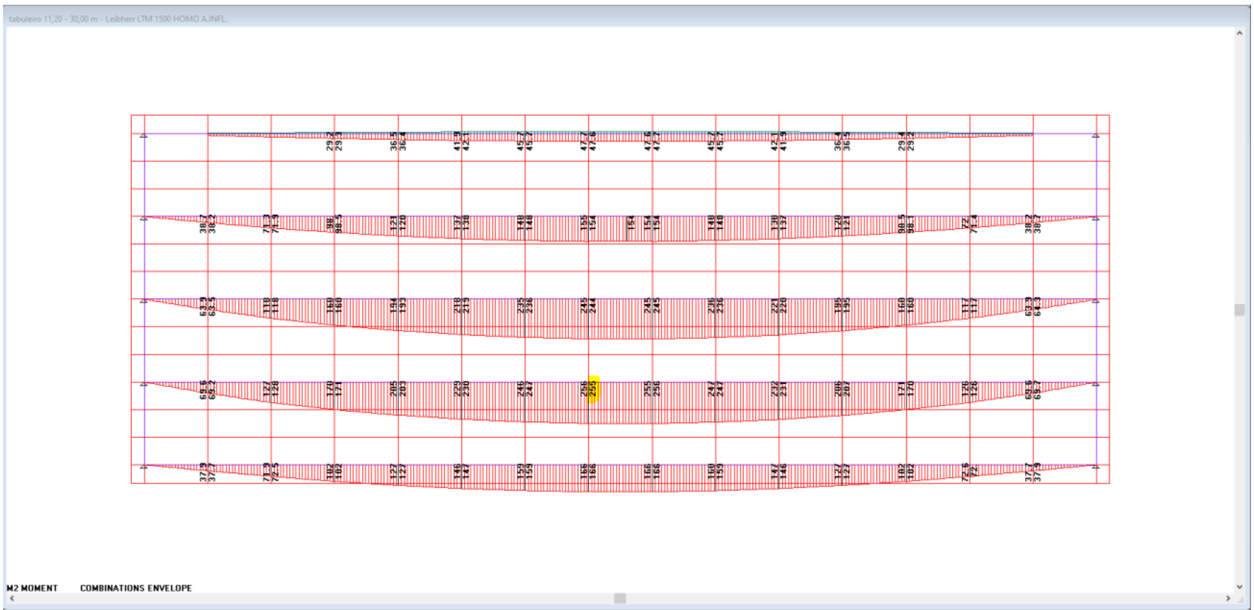
COMBINATIONS ENVELOPE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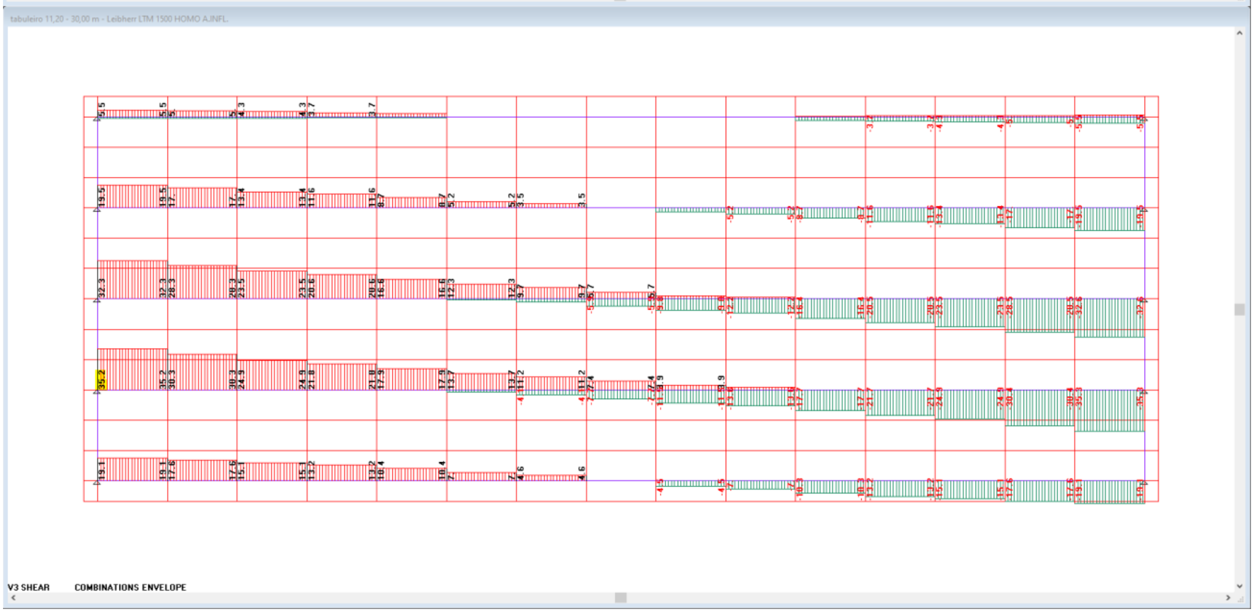
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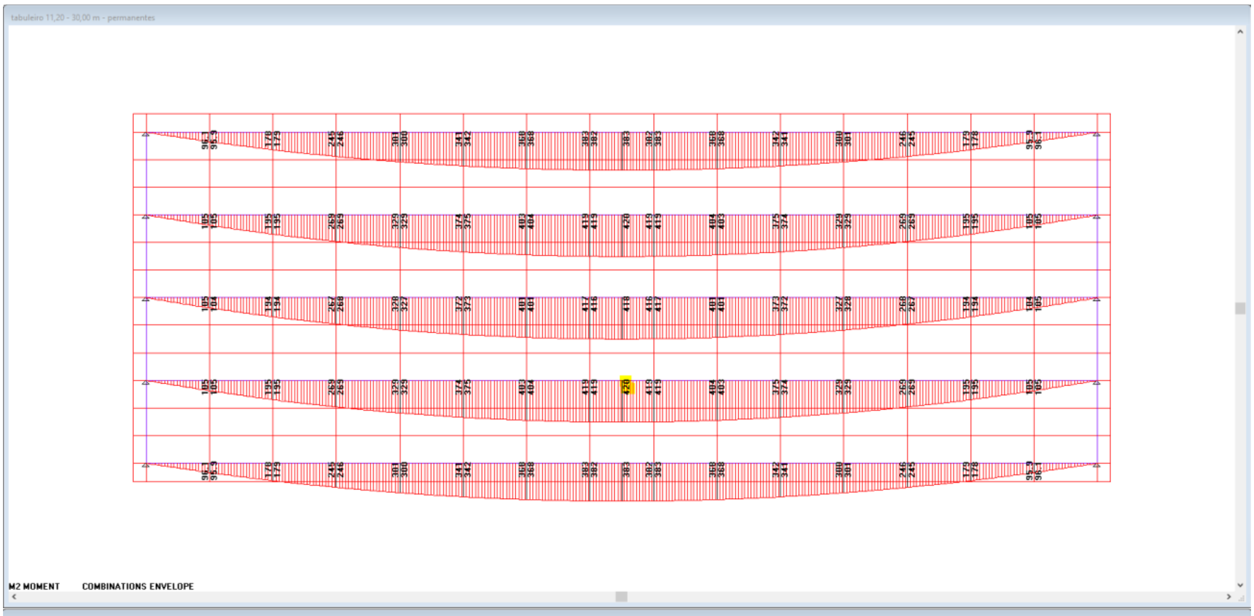
COMBINATIONS ENVELOPE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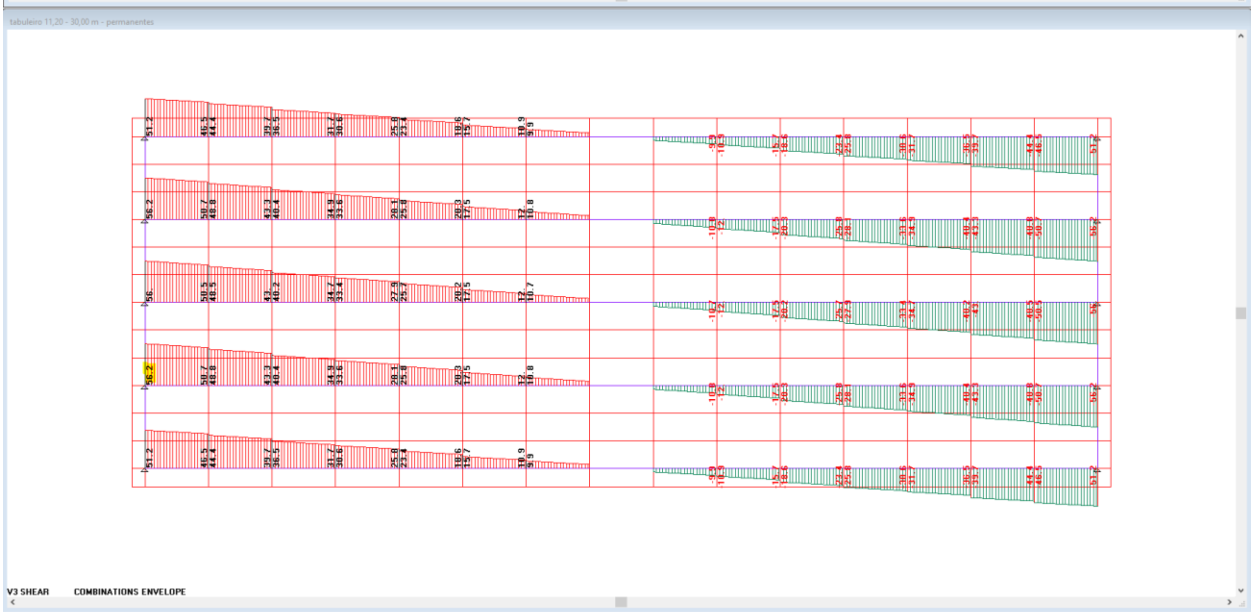
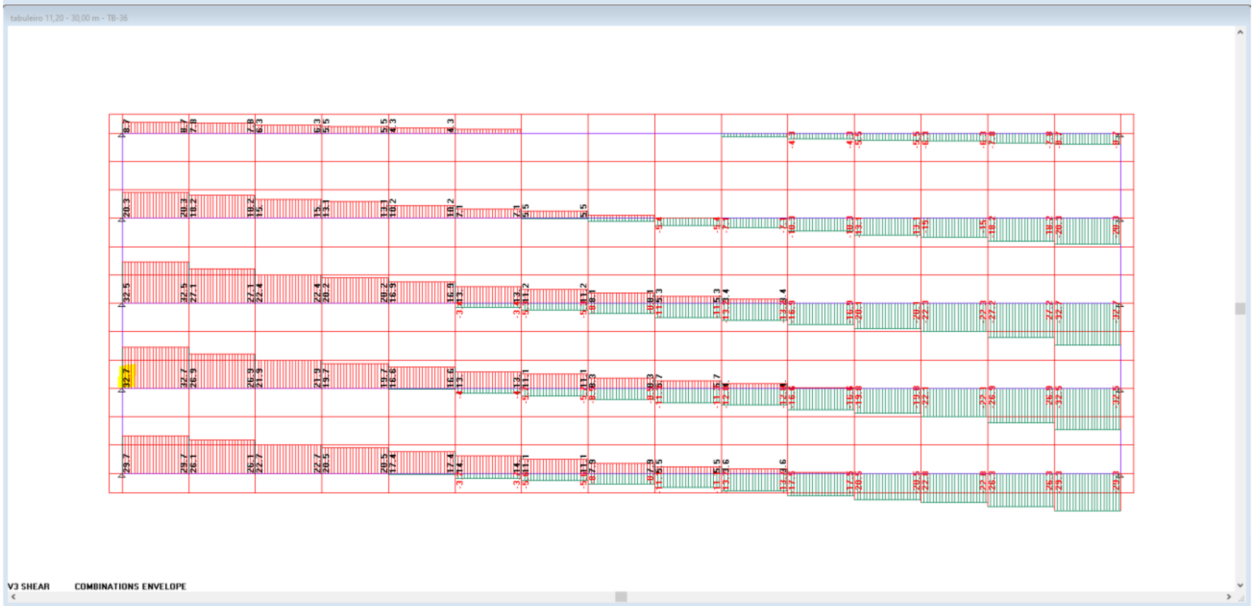

V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 11,20 - 30,00 m - TB-36
M2 MOMENT COMBINATIONS ENVELOPE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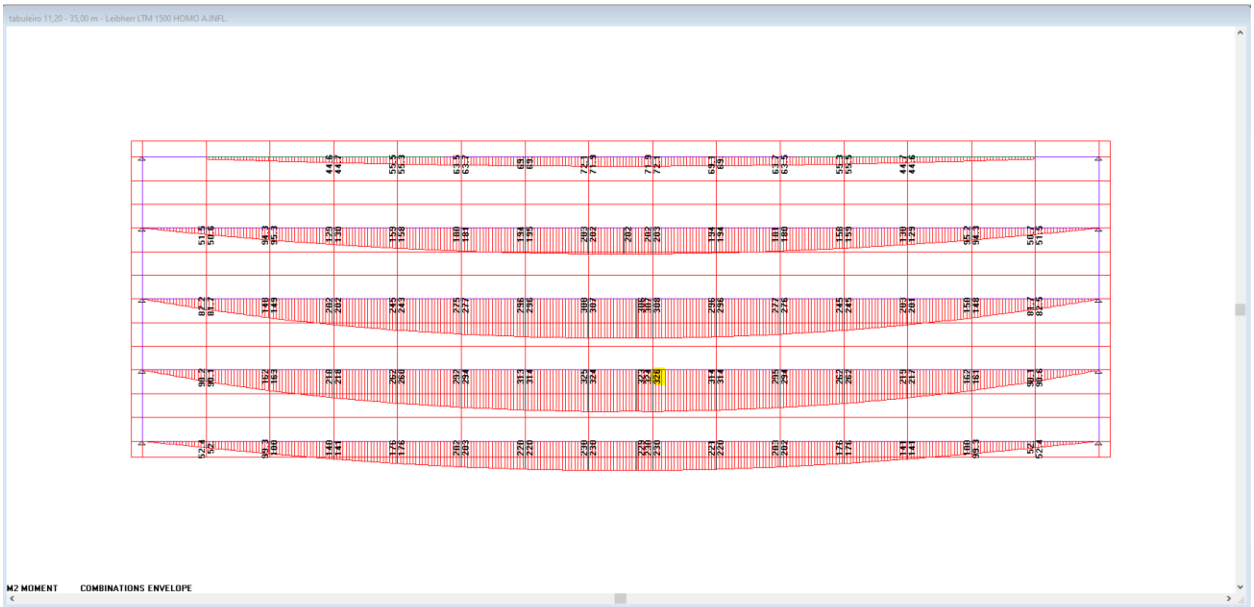
V3 SHEAR COMBINATIONS ENVELOPE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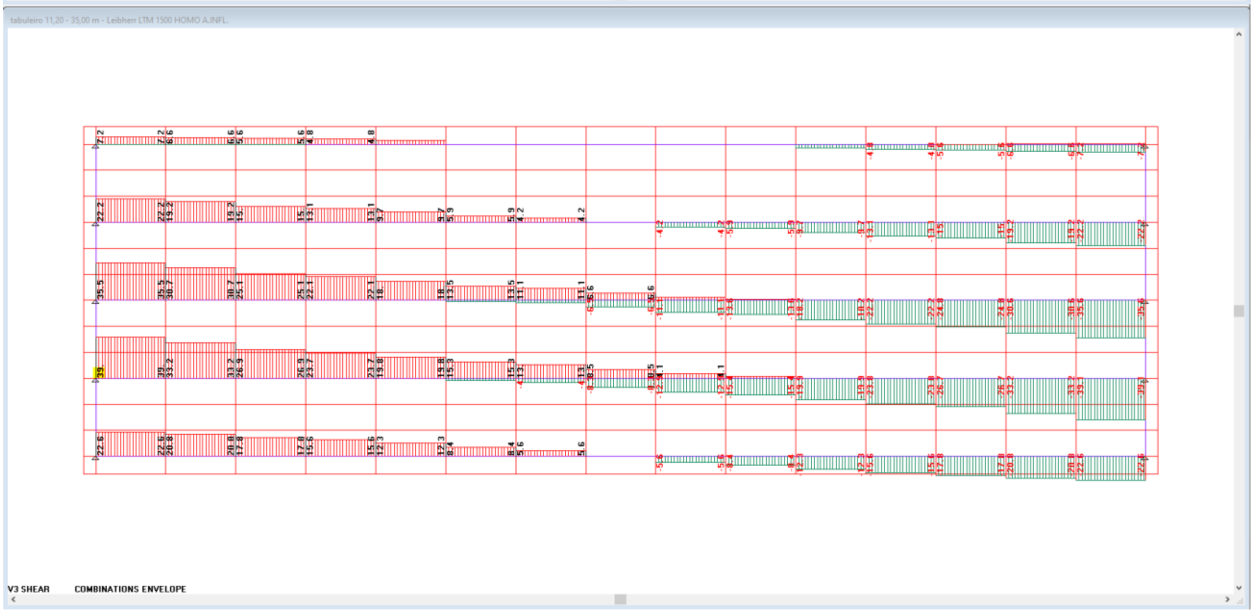
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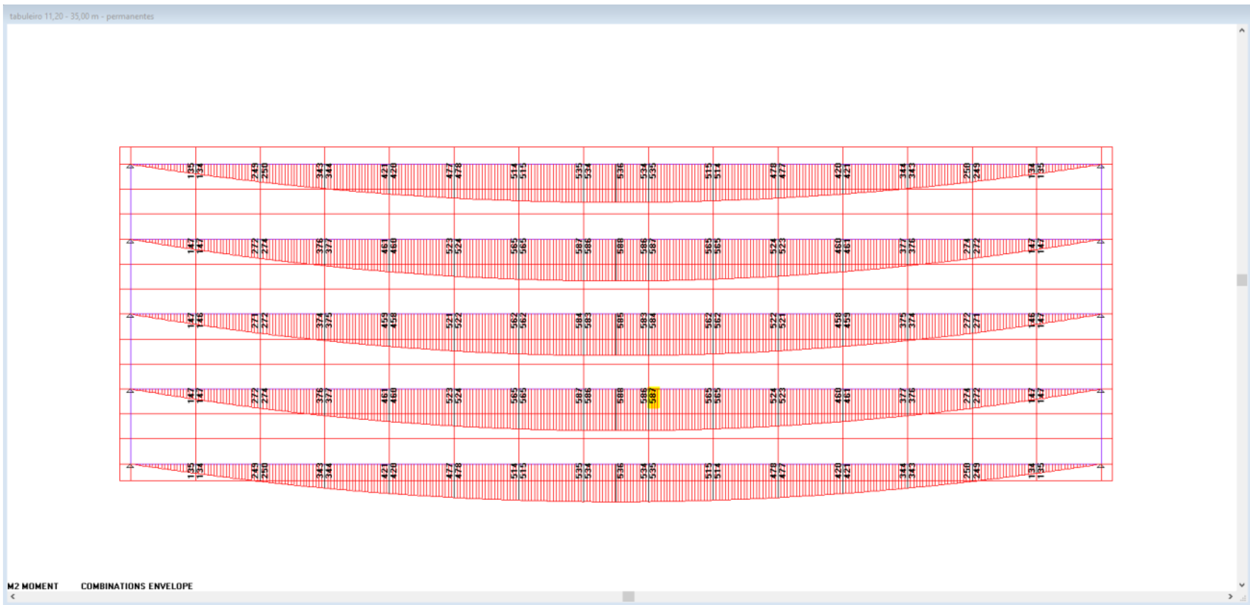
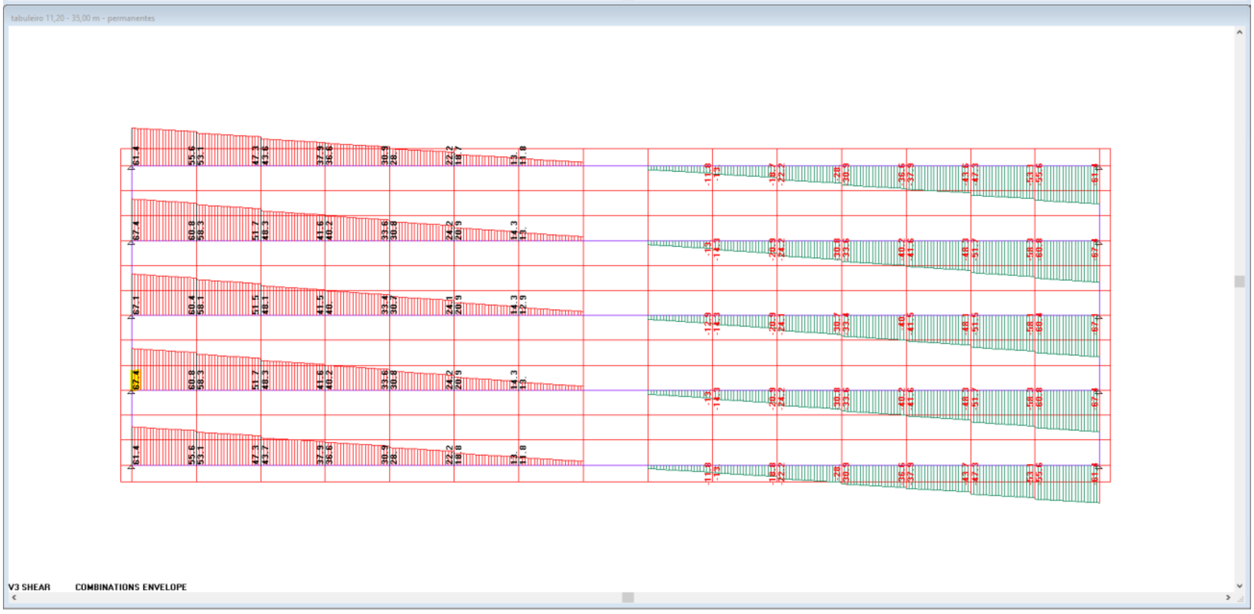

tabuleiro 11,20 - 35,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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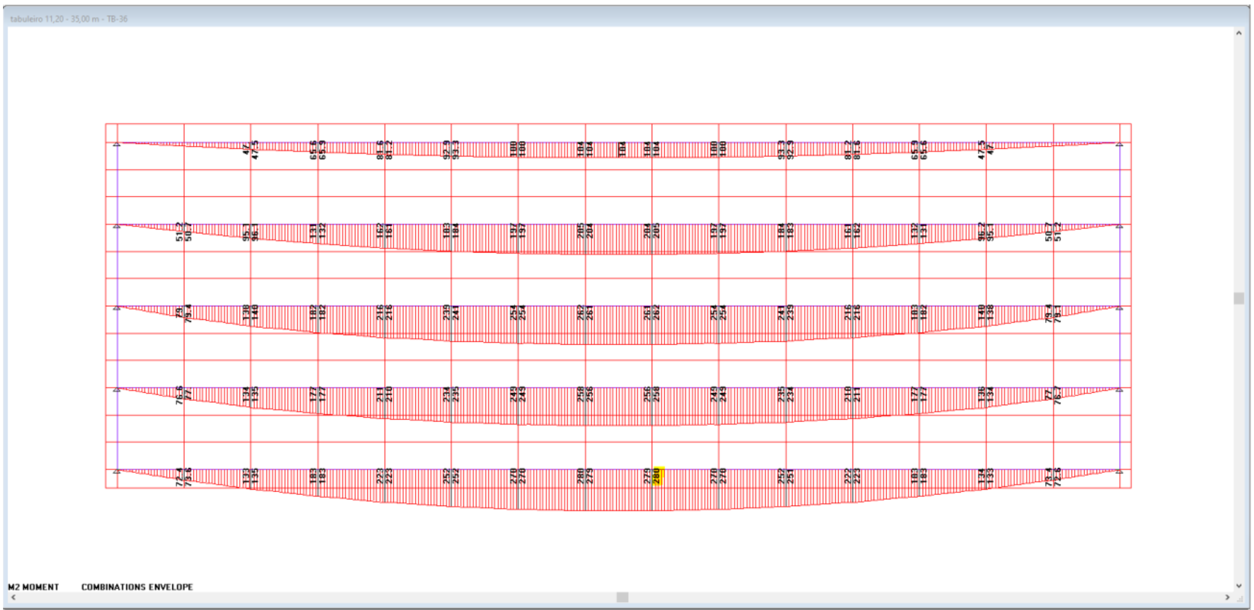
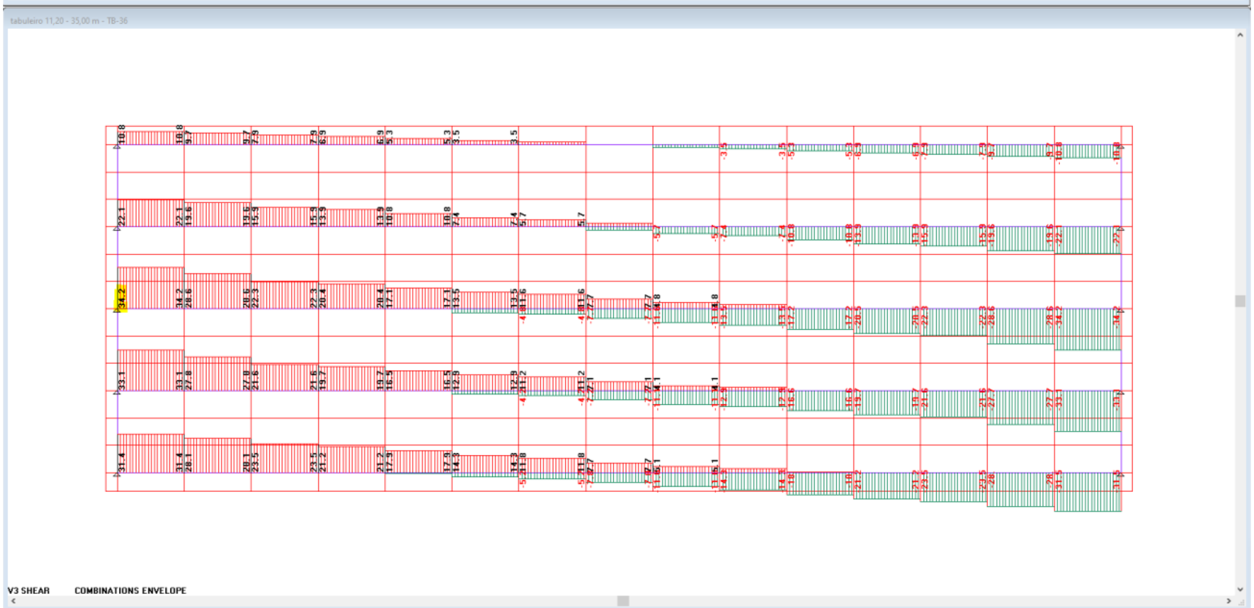
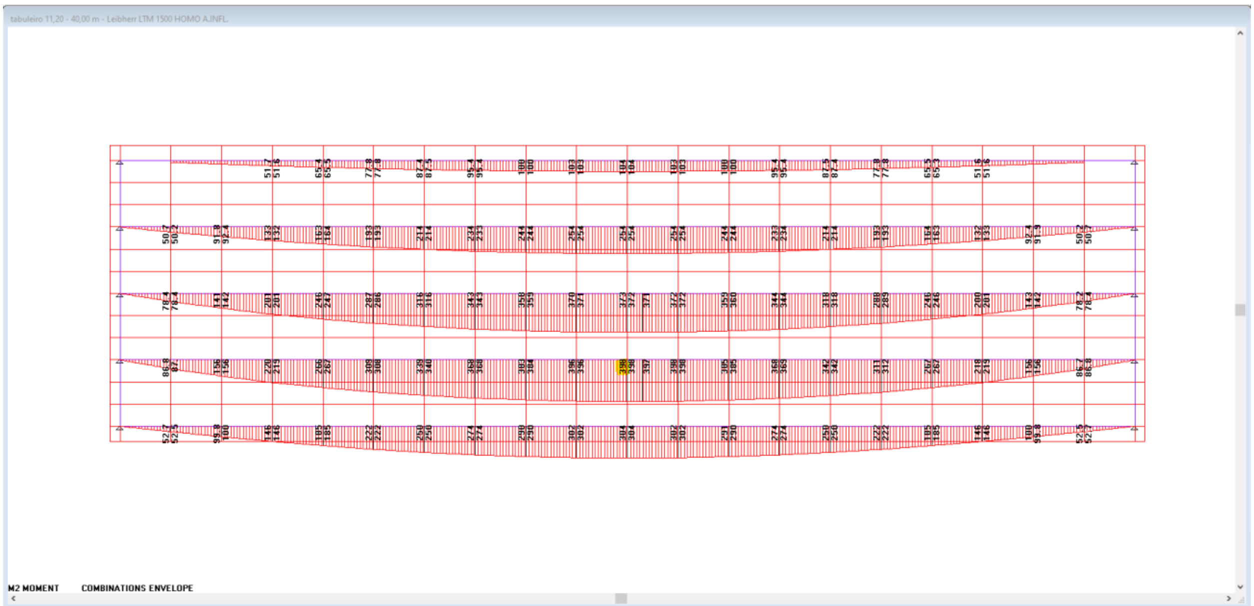

tabuleiro 11,20 - 35,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 11,20 - 35,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE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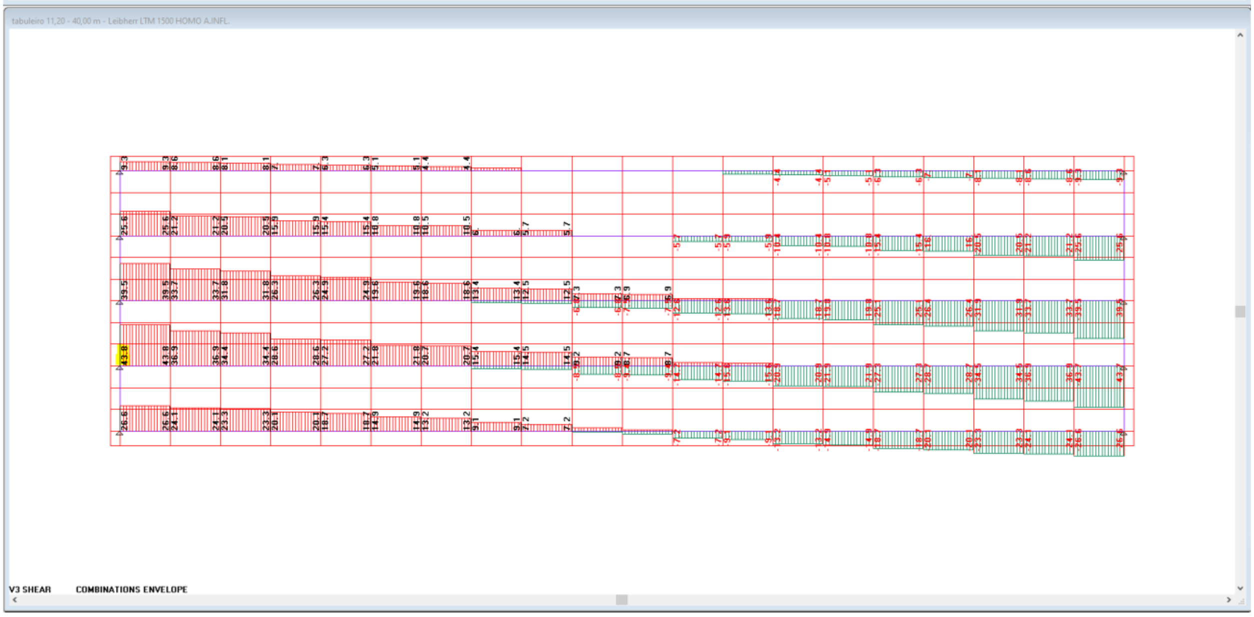
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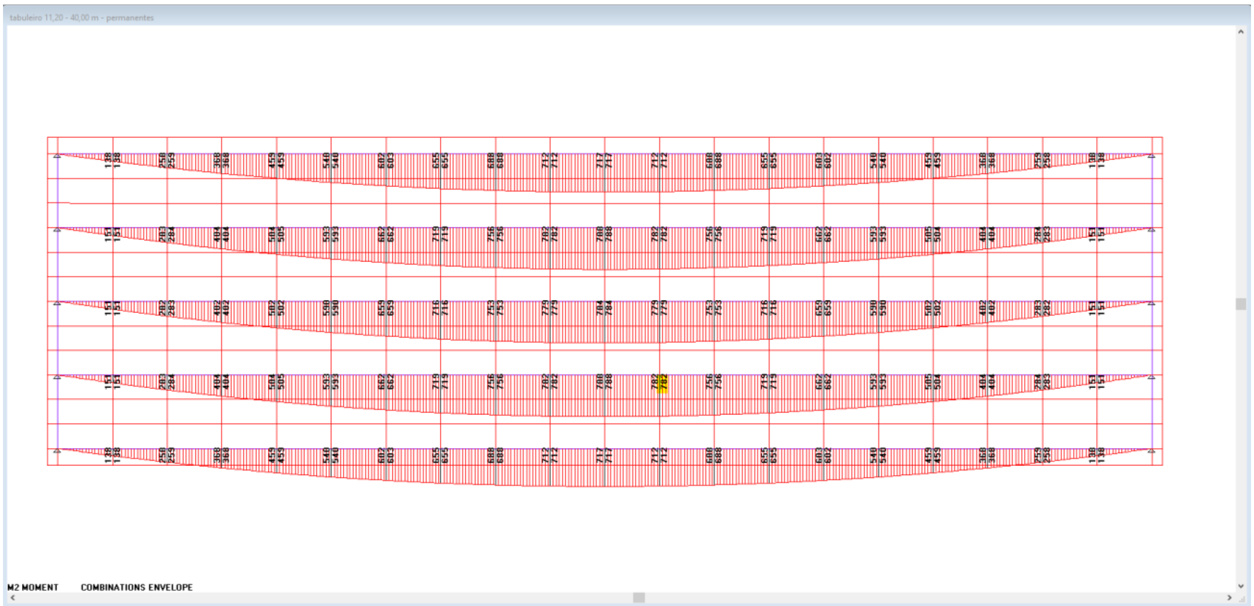
COMBINATIONS ENVELOPE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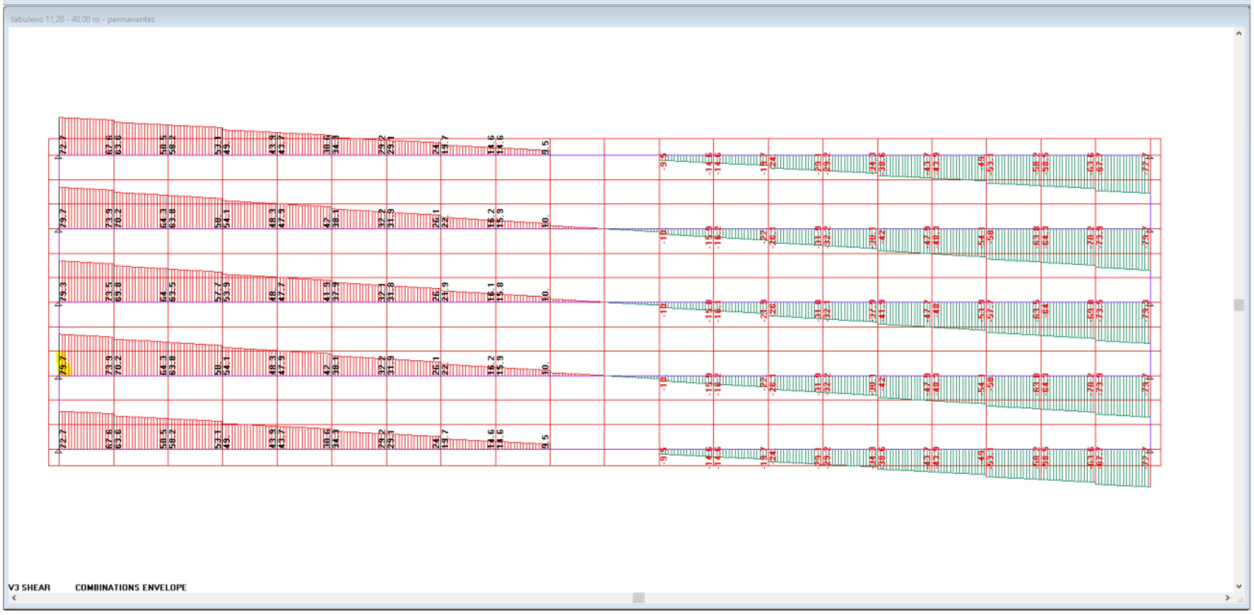
M2 MOMENT
COMBINATIONS ENVELOPE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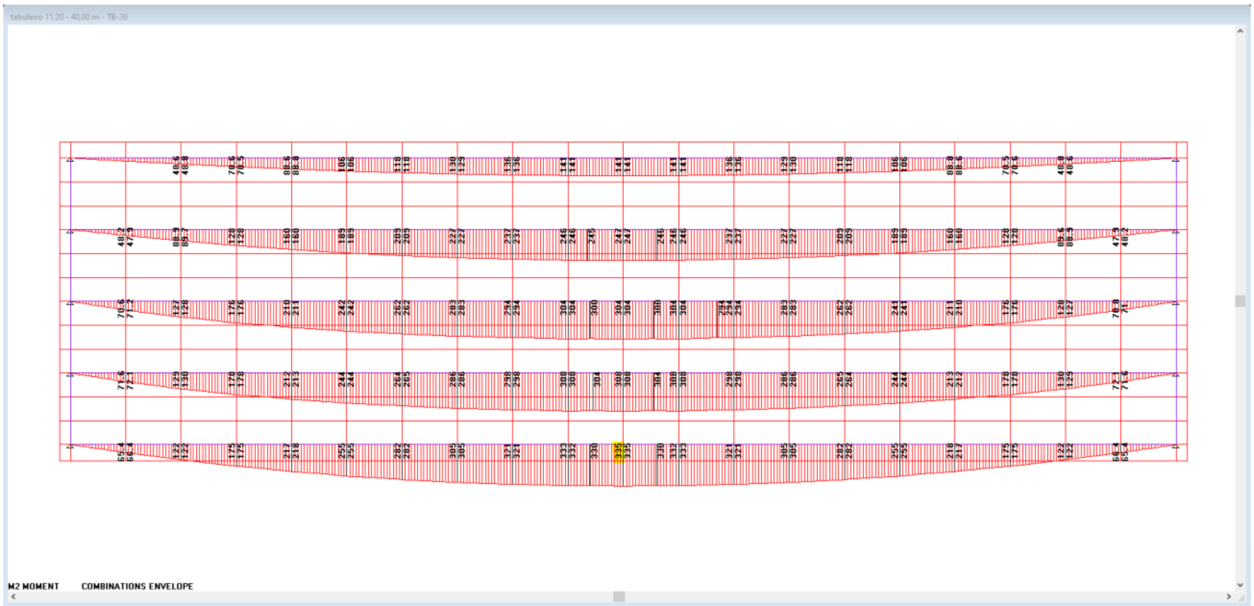
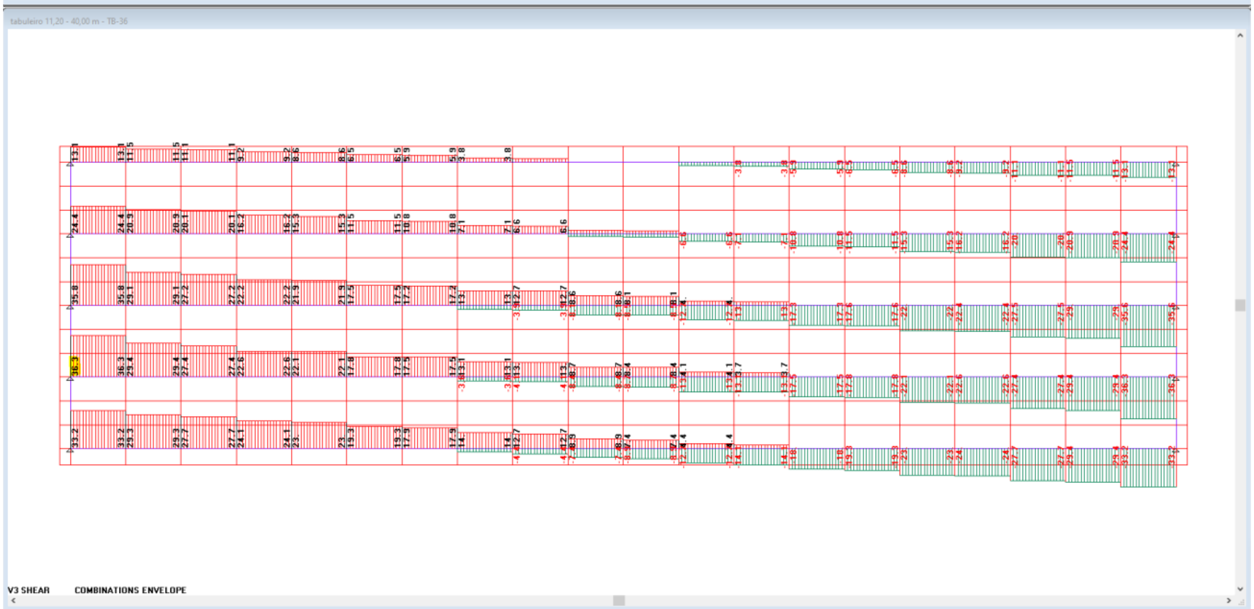
COMBINATIONS ENVELOPE


tabuleiro 11,20 - 40,00 m - TB-36
M2 MOMENT COMBINATIONS ENVELOPE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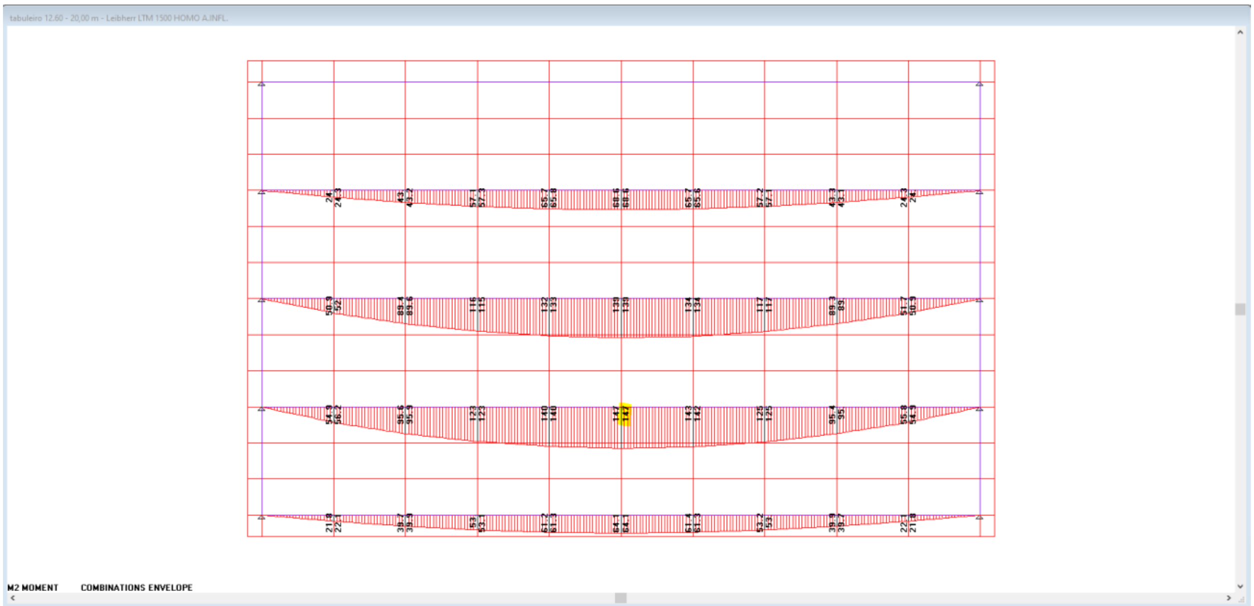
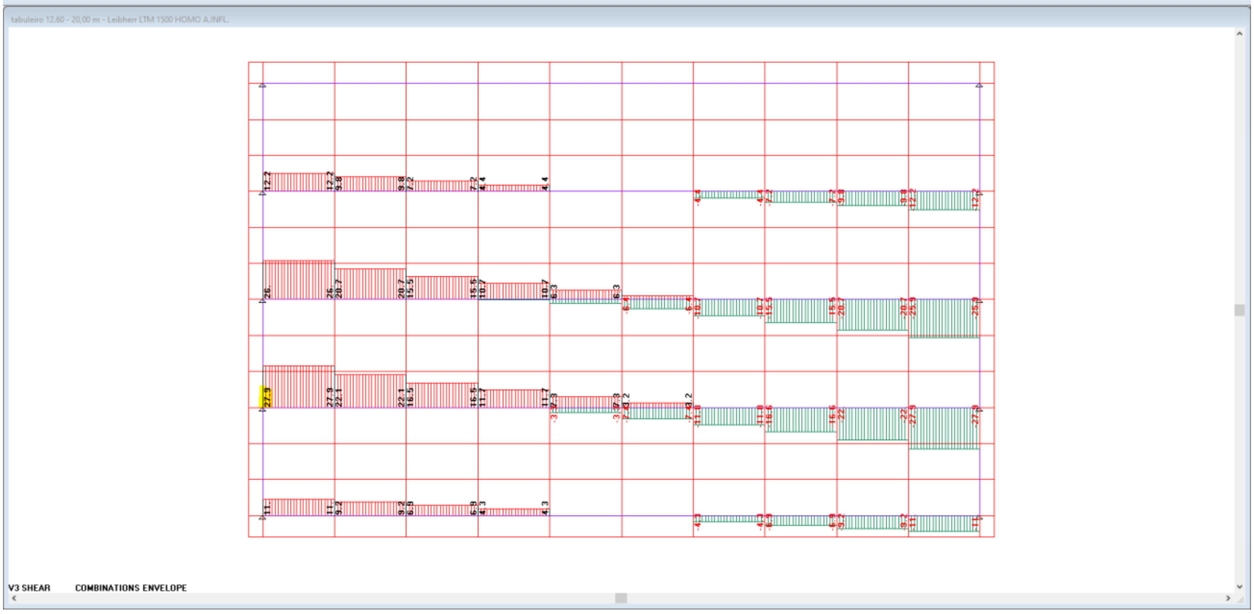
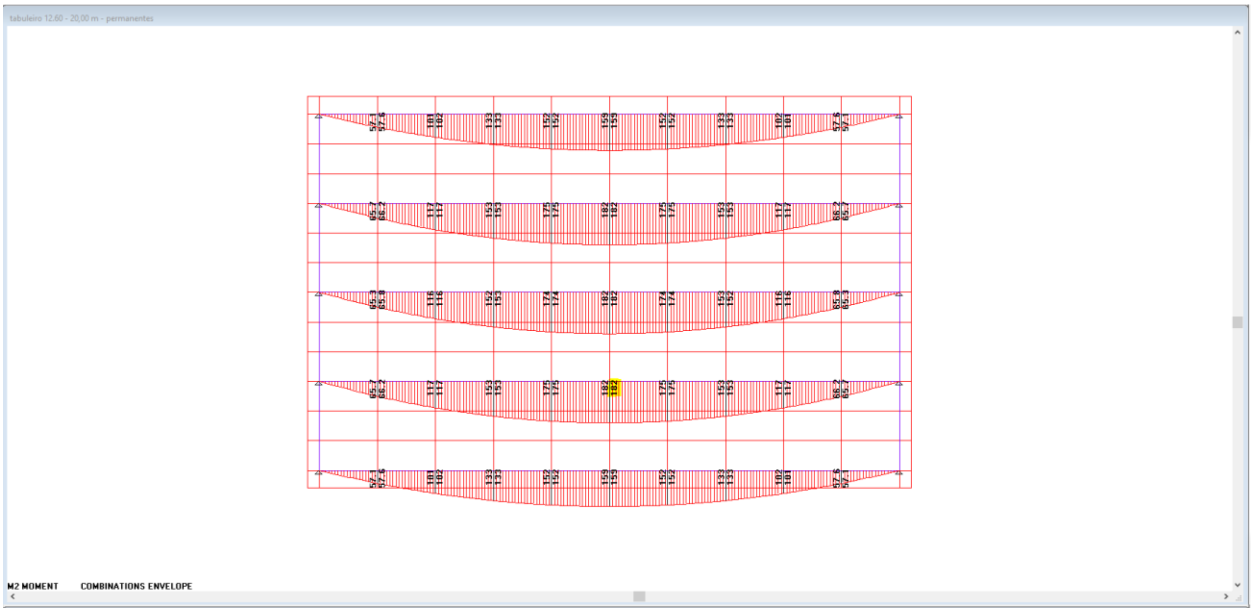
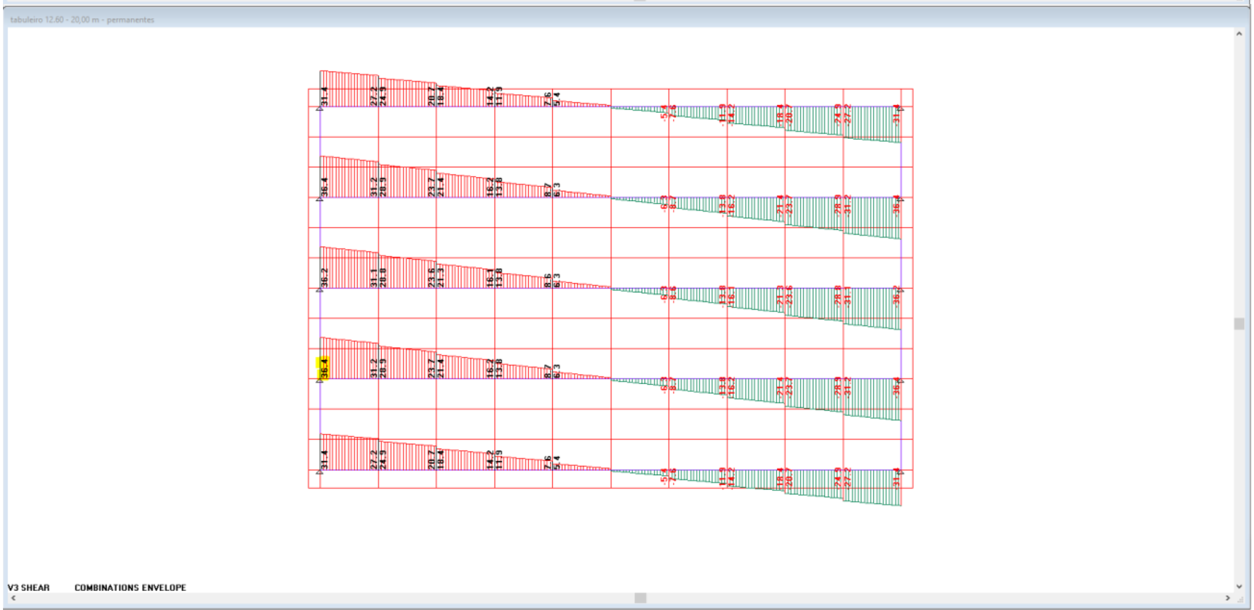
V3 SHEAR COMBINATIONS ENVELOPE

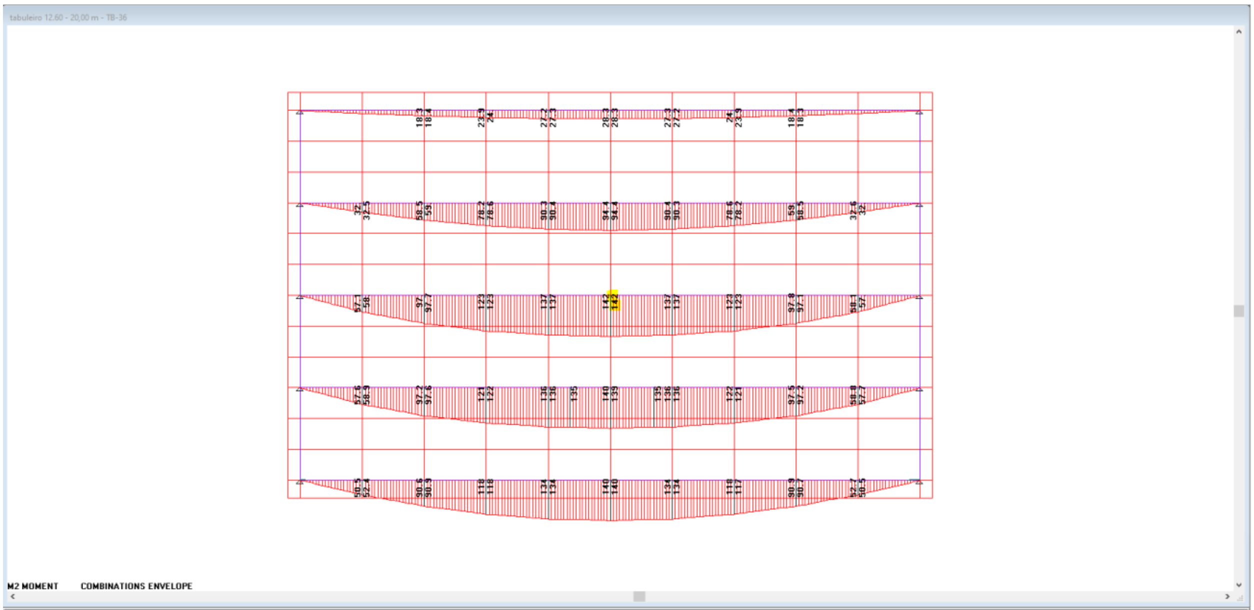
4.6.2. Tabuleiro 12,60 m

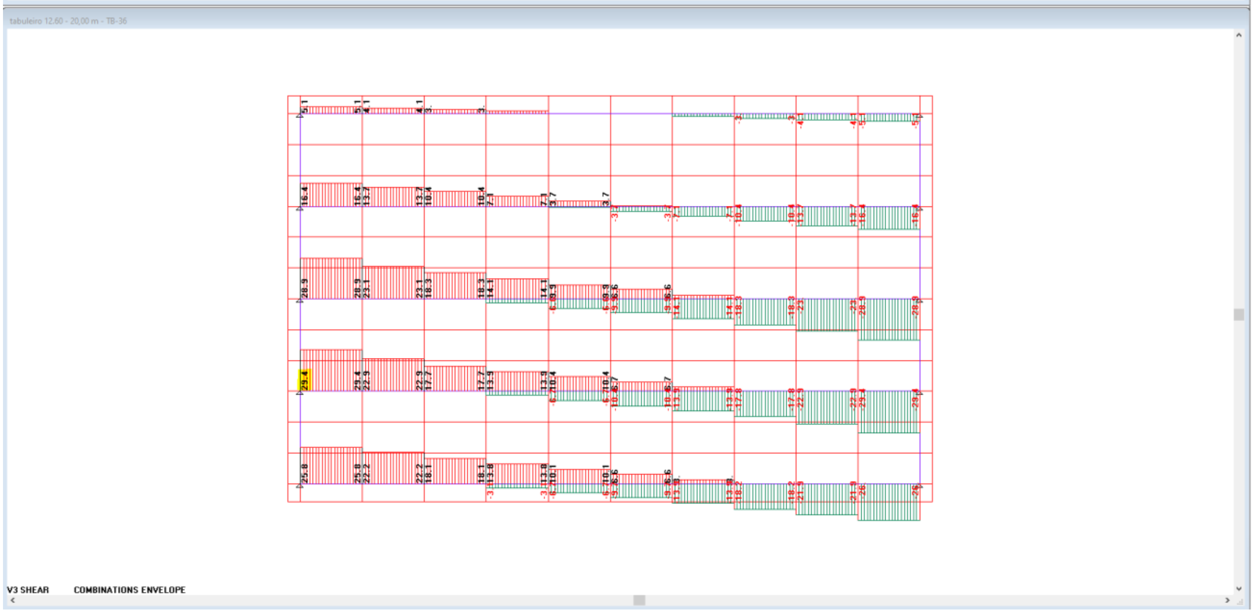





M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 12,60 - 20,00 m - TB-36
M2 MOMENT COMBINATIONS ENVELOPE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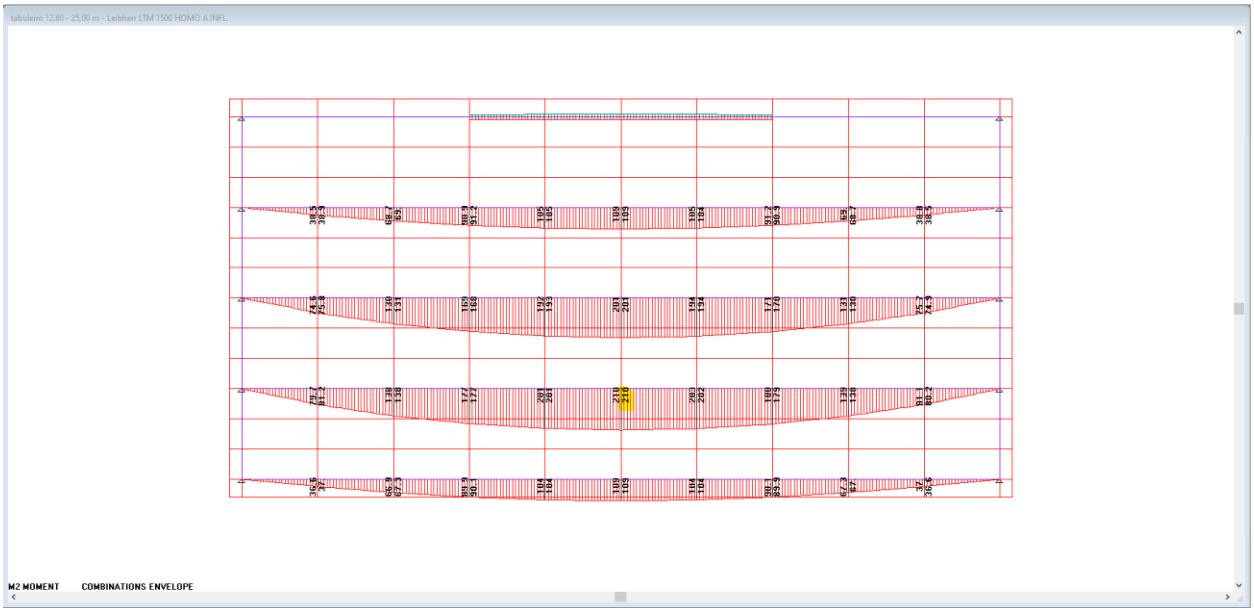
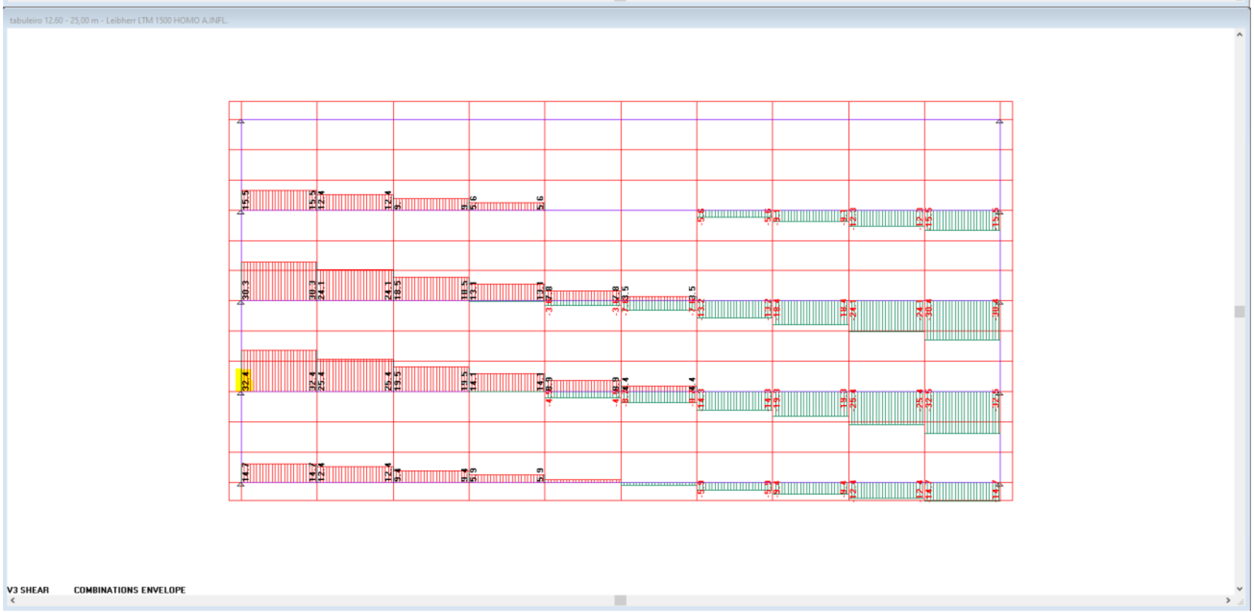
V3 SHEAR COMBINATIONS ENVELOPE


tabuleiro 12.60 - 25,00 m - Leibherr LTM 1500 HOMO A.INFL.
M2 MOMENT
COMBINATIONS ENVELOPE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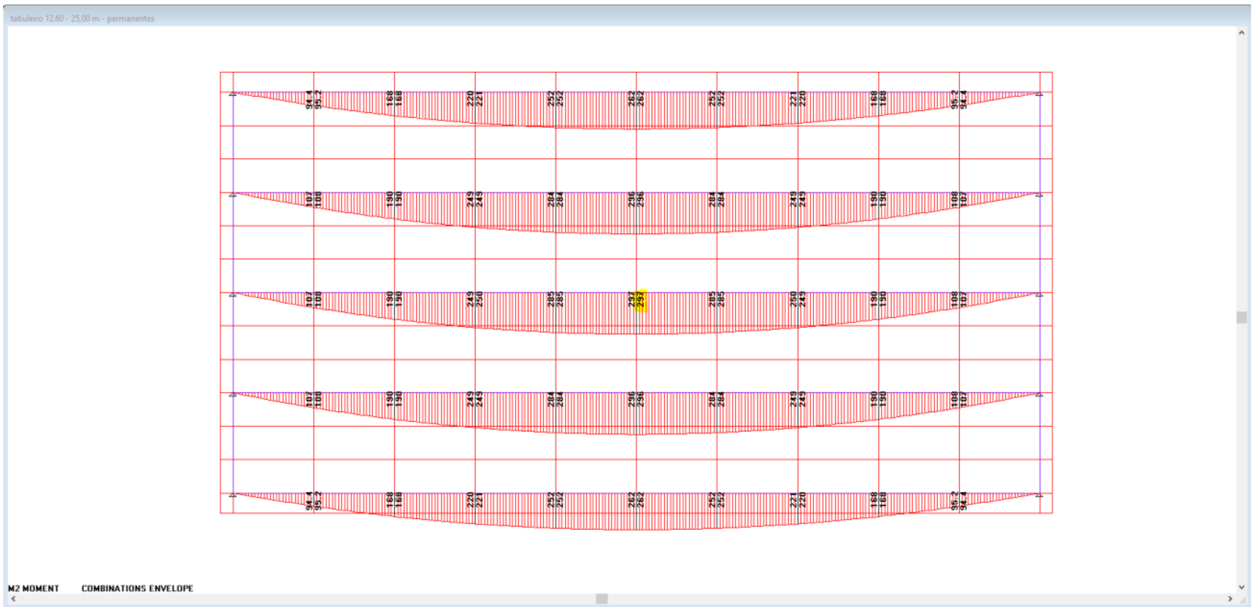
V3 SHEAR
COMBINATIONS ENVELOPE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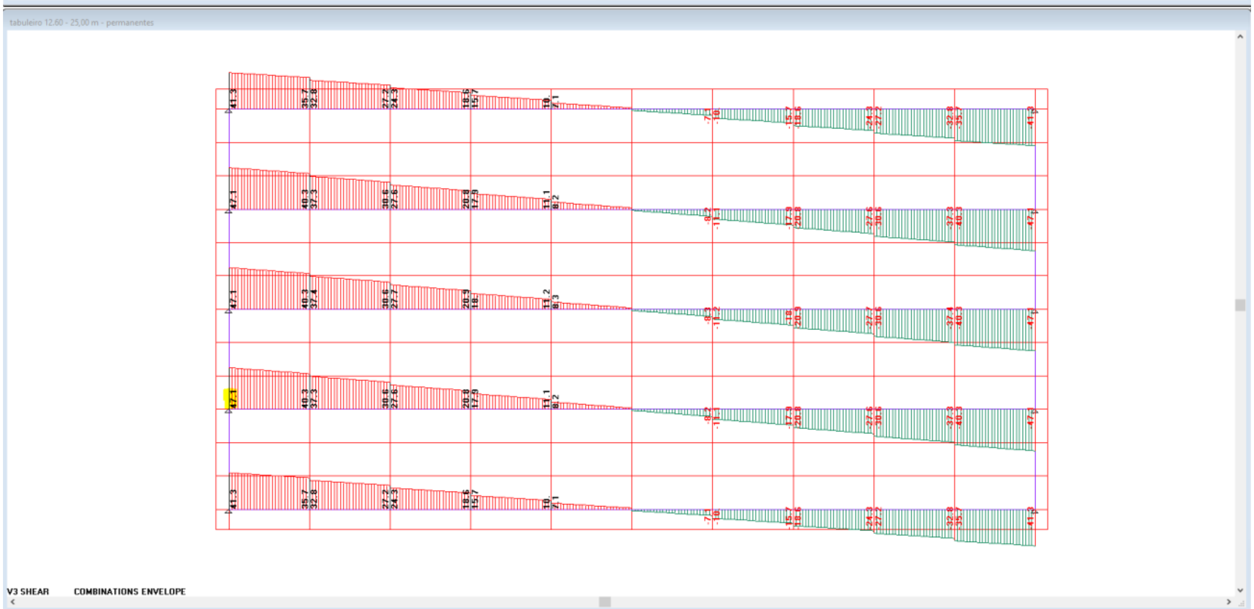
M2 MOMENT
COMBINATIONS ENVELOPE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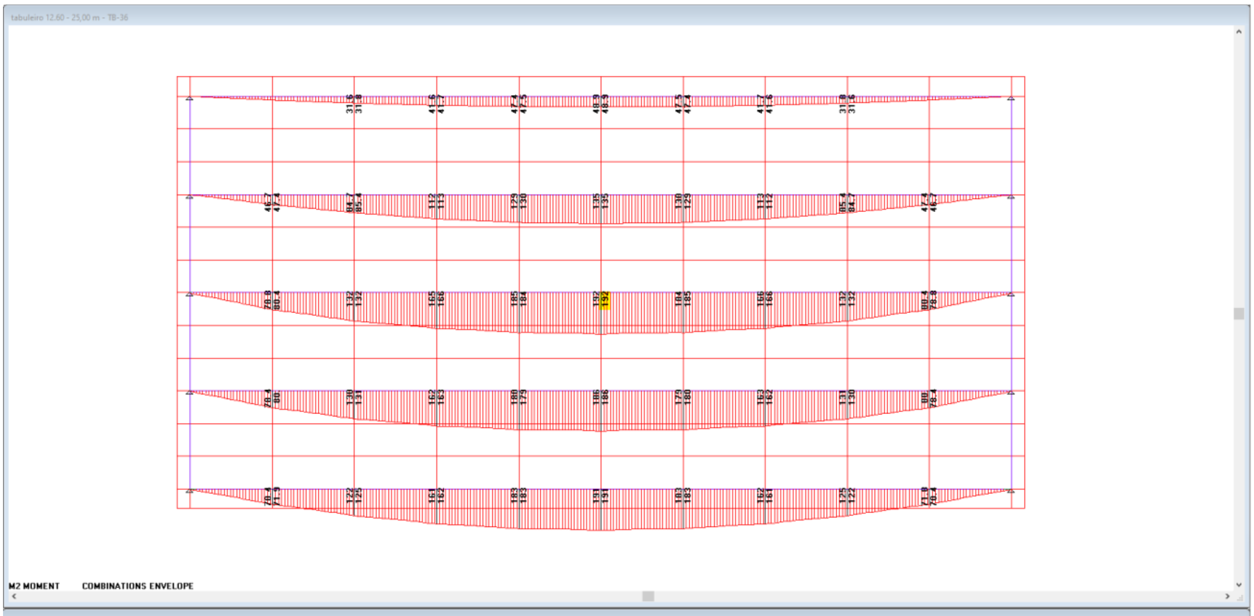
COMBINATIONS ENVELOPE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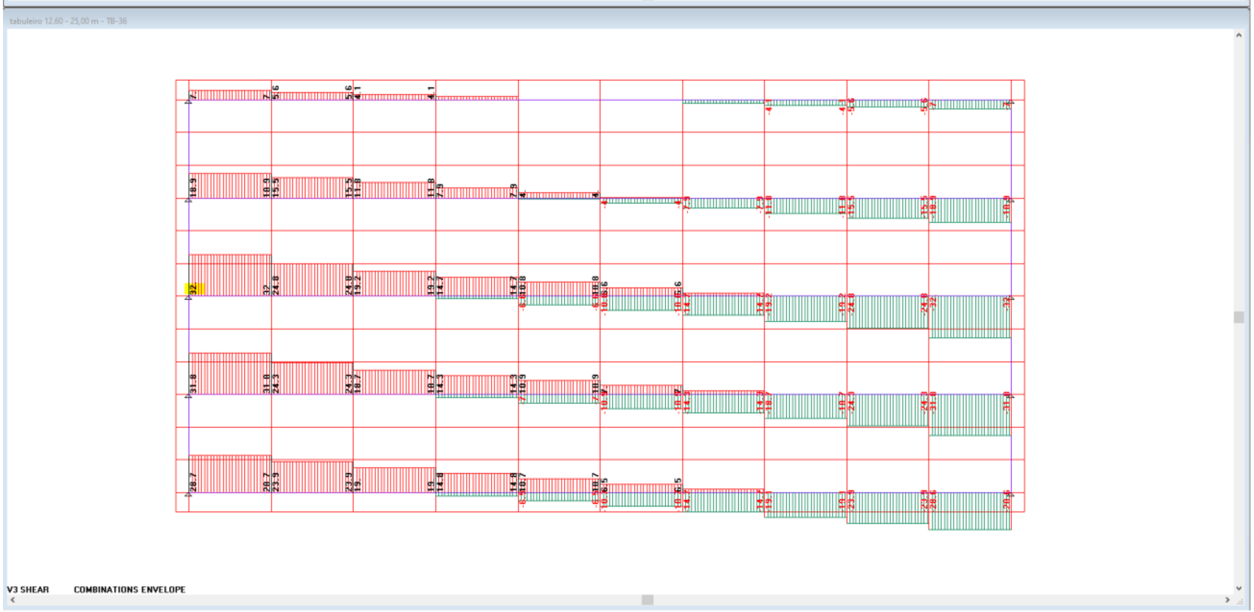
COMBINATIONS ENVELOPE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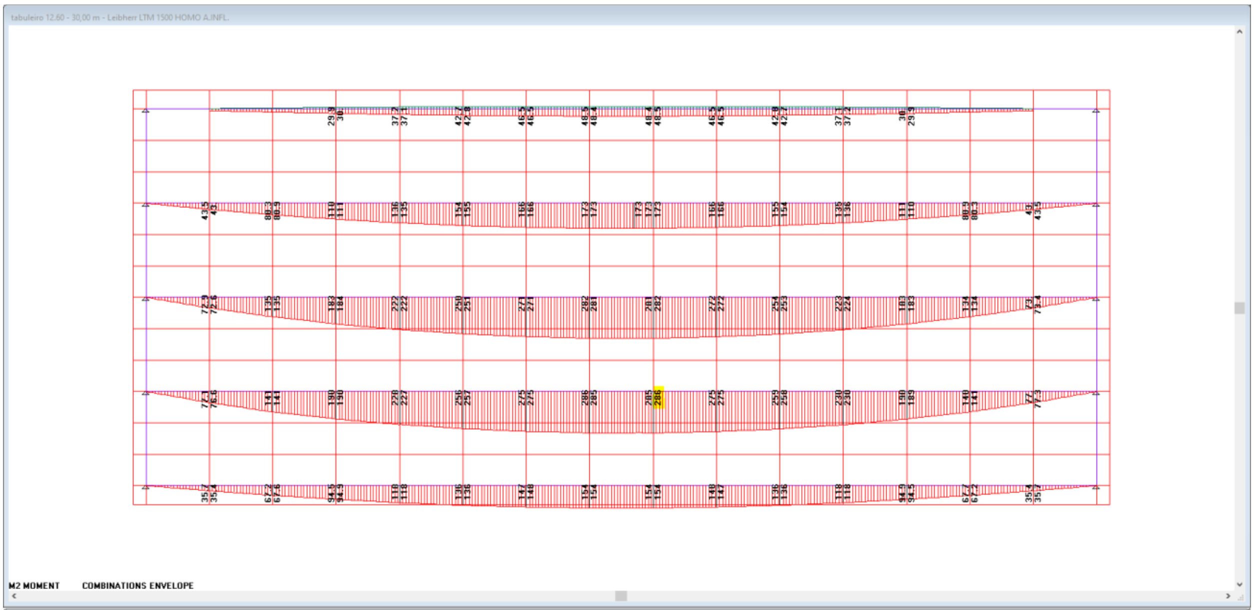
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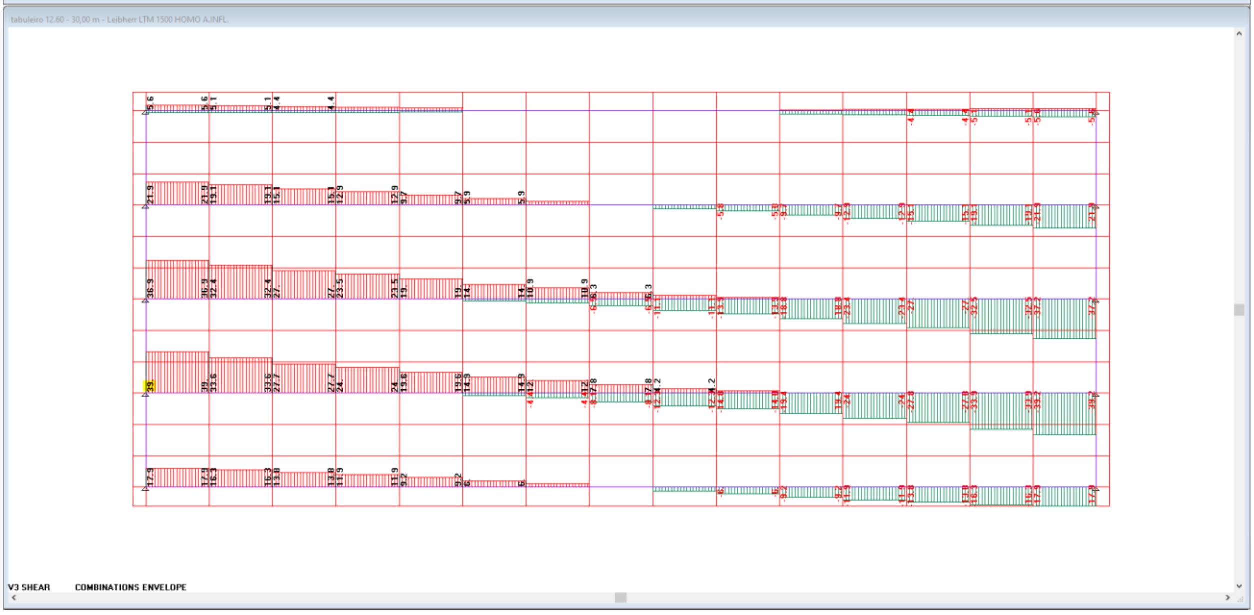
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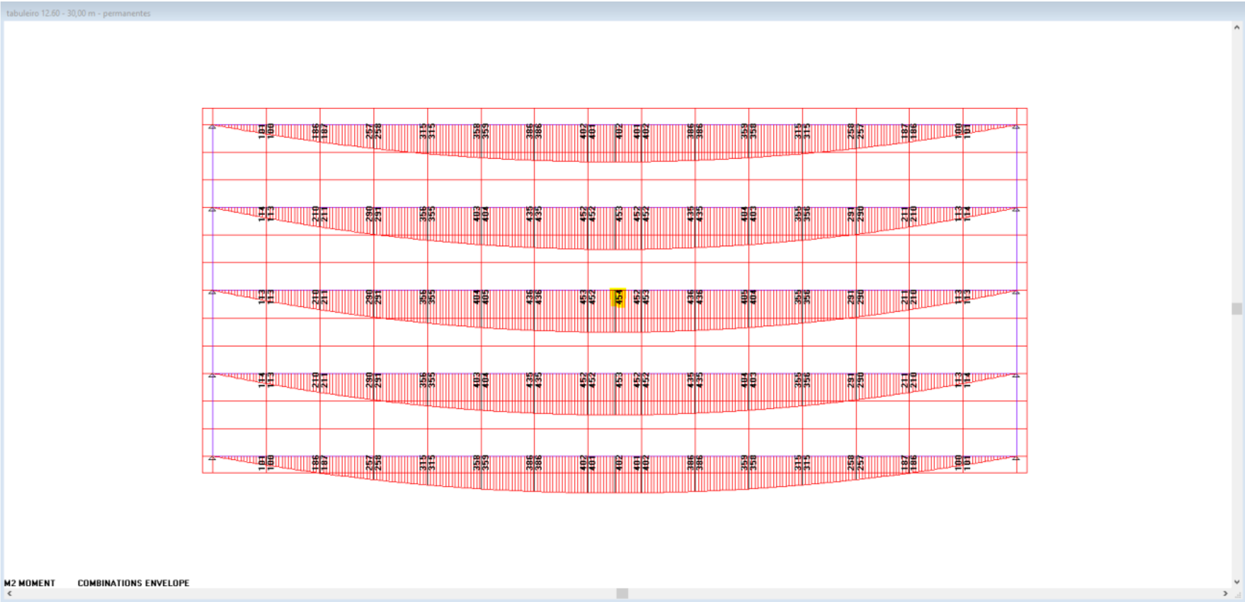
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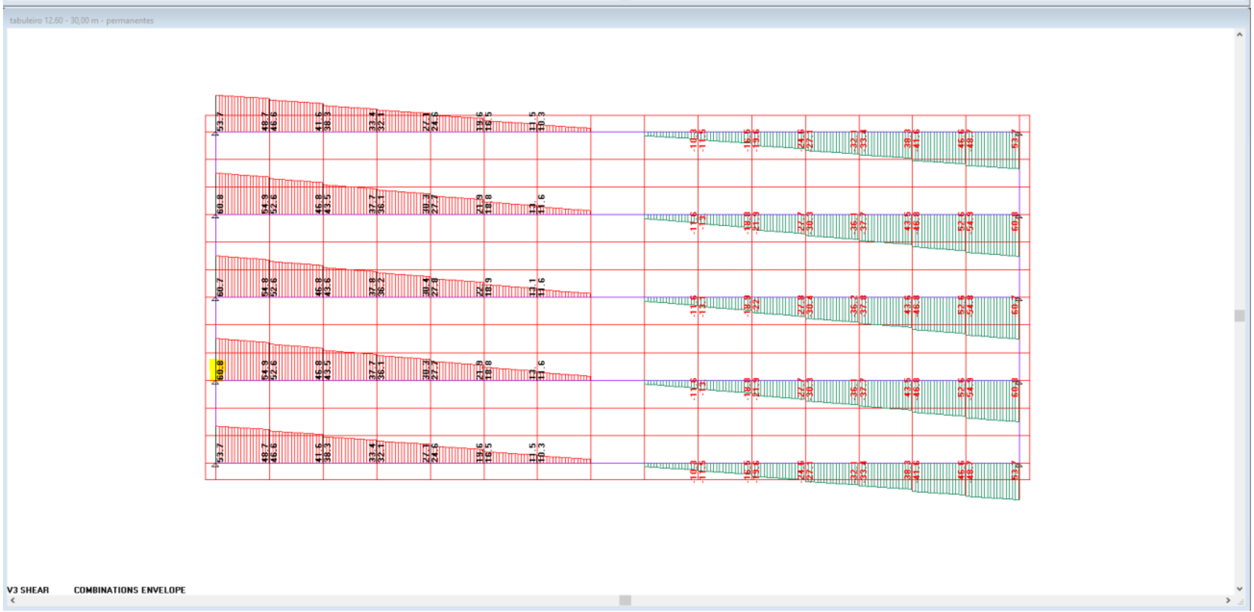
M2 MOMENT
COMBINATIONS ENVELOPE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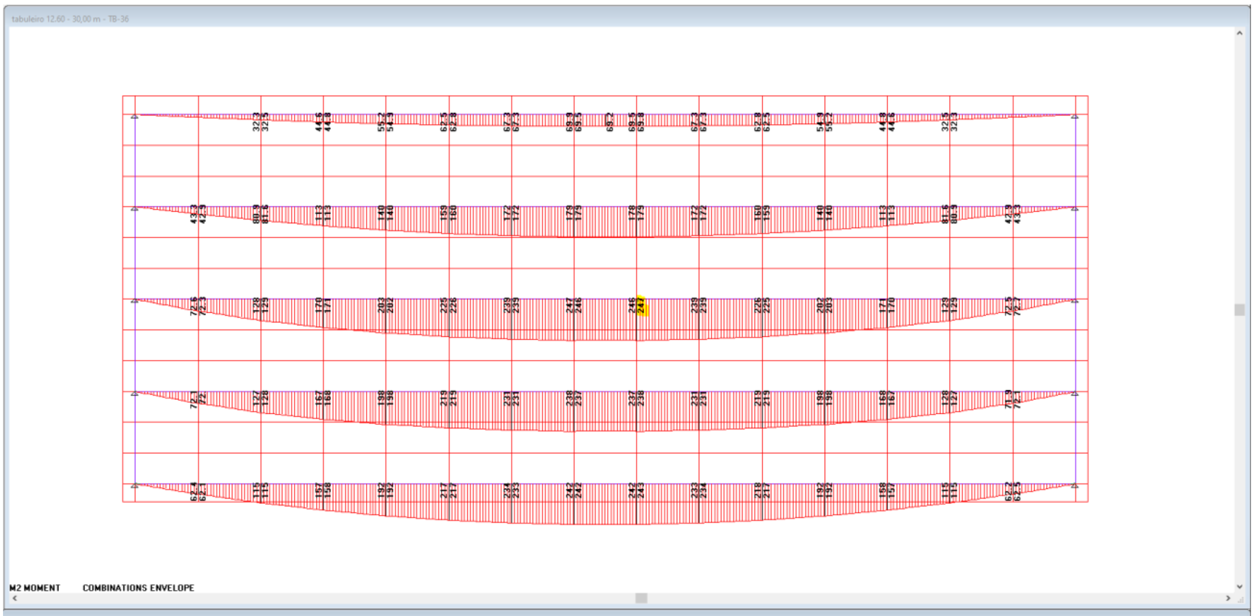
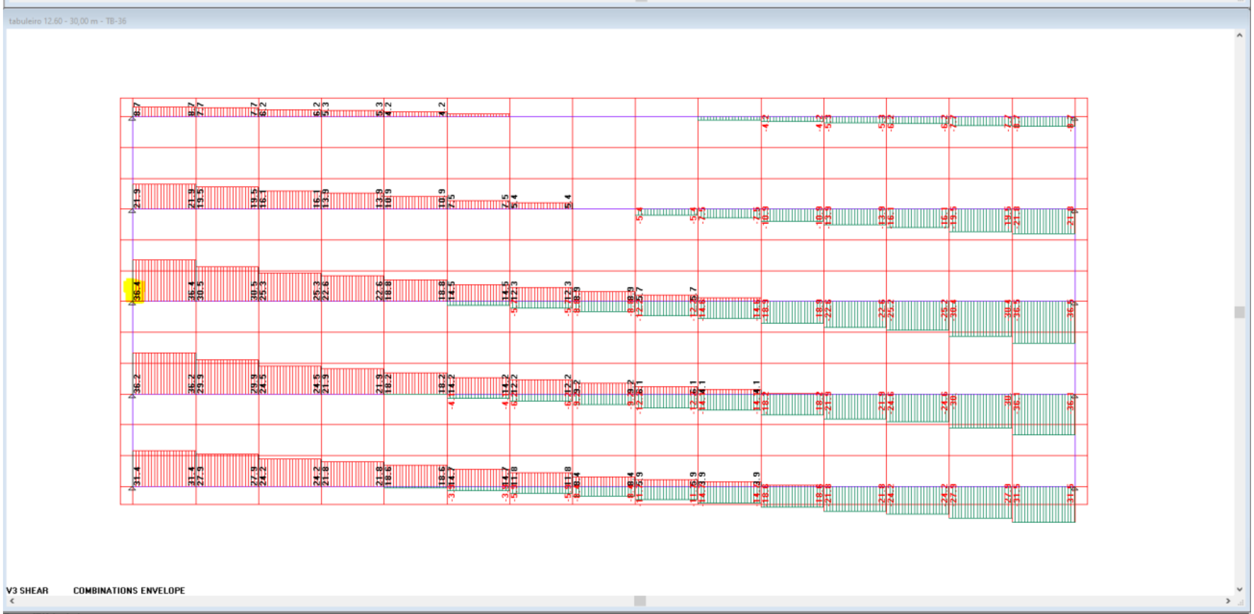
V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 12,60 - 30,00 m - TB-36
M2 MOMENT COMBINATIONS ENVELOPE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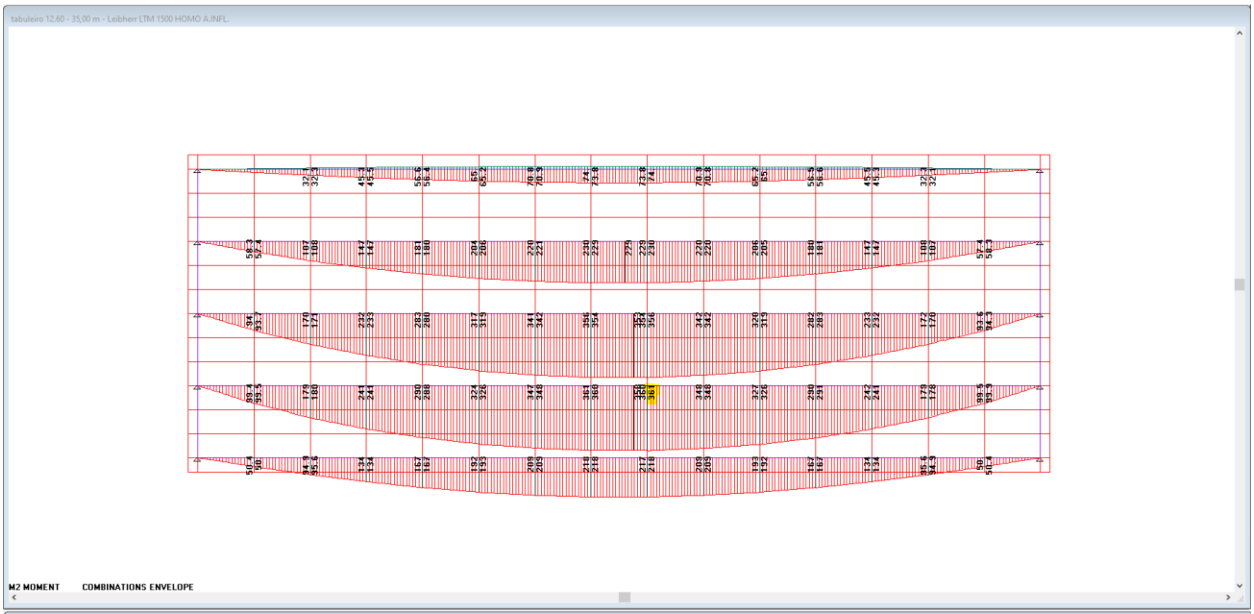
V3 SHEAR COMBINATIONS ENVELOPE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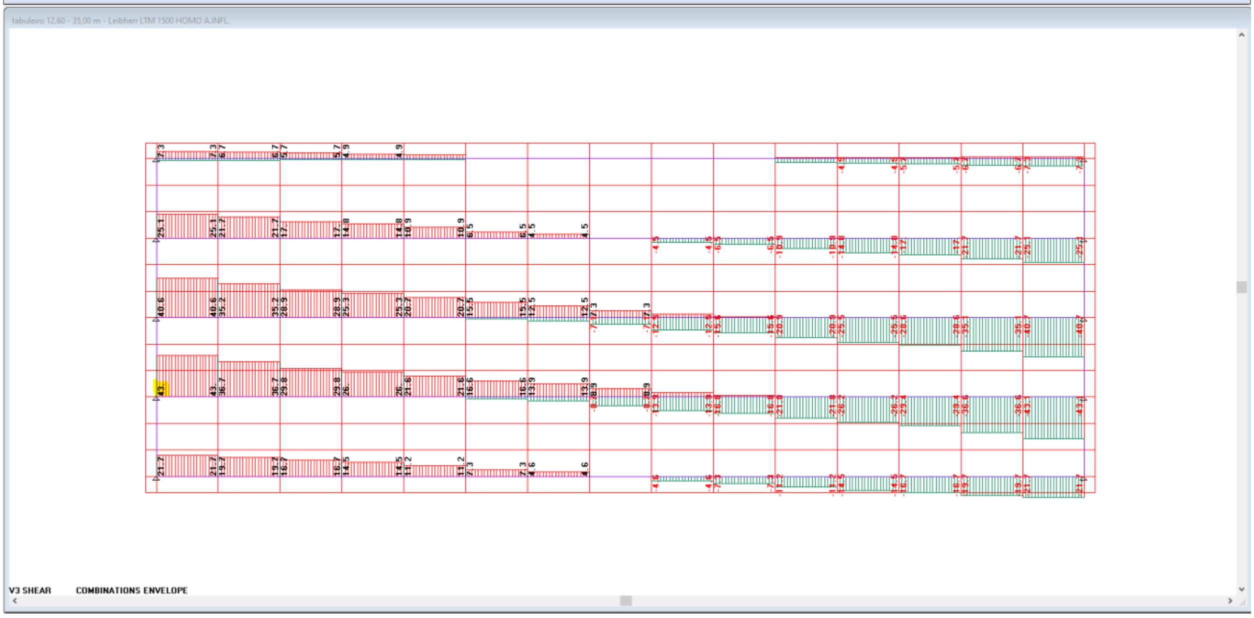
M2 MOMENT
COMBINATIONS ENVELOPE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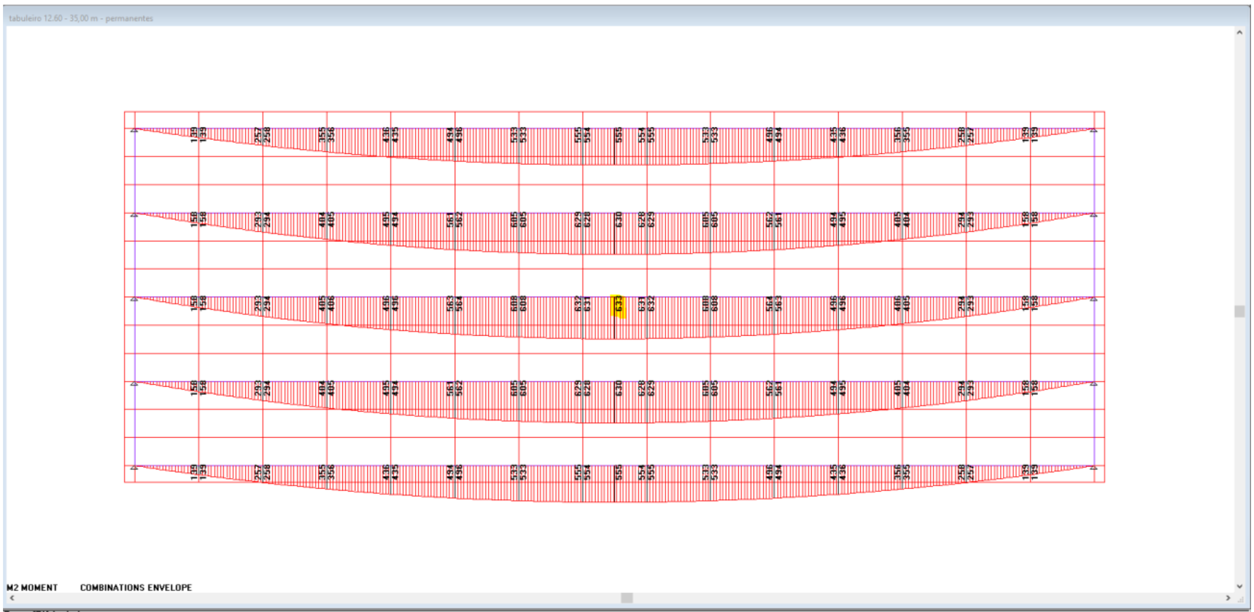
V3 SHEAR
COMBINATIONS ENVELOPE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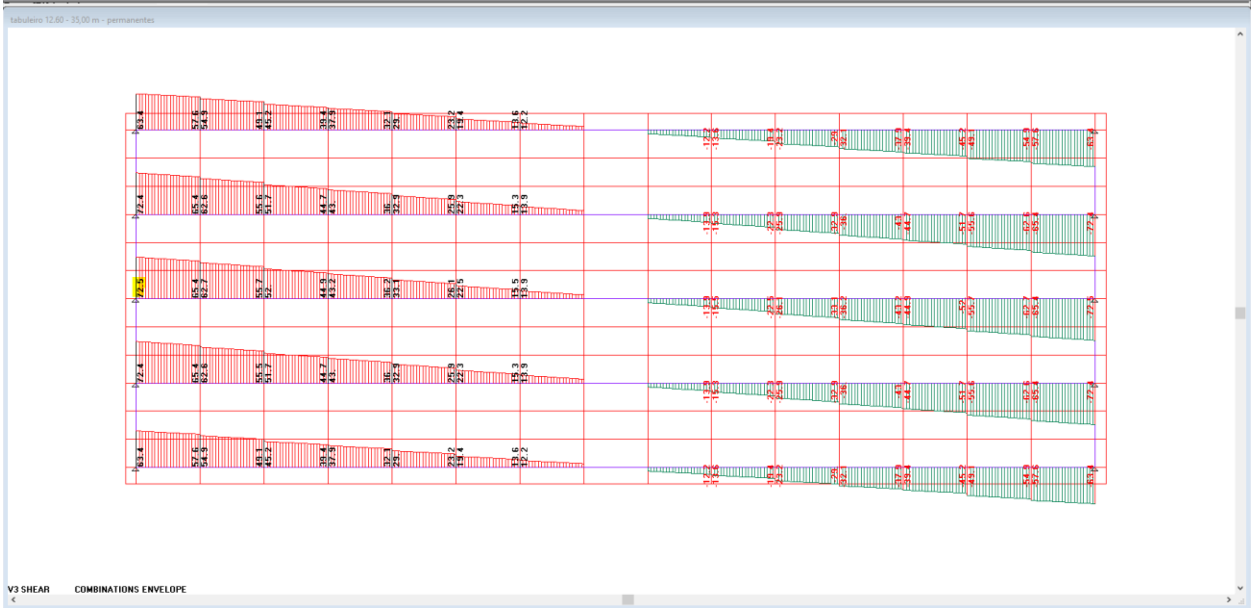
M2 MOMENT
COMBINATIONS ENVELOPE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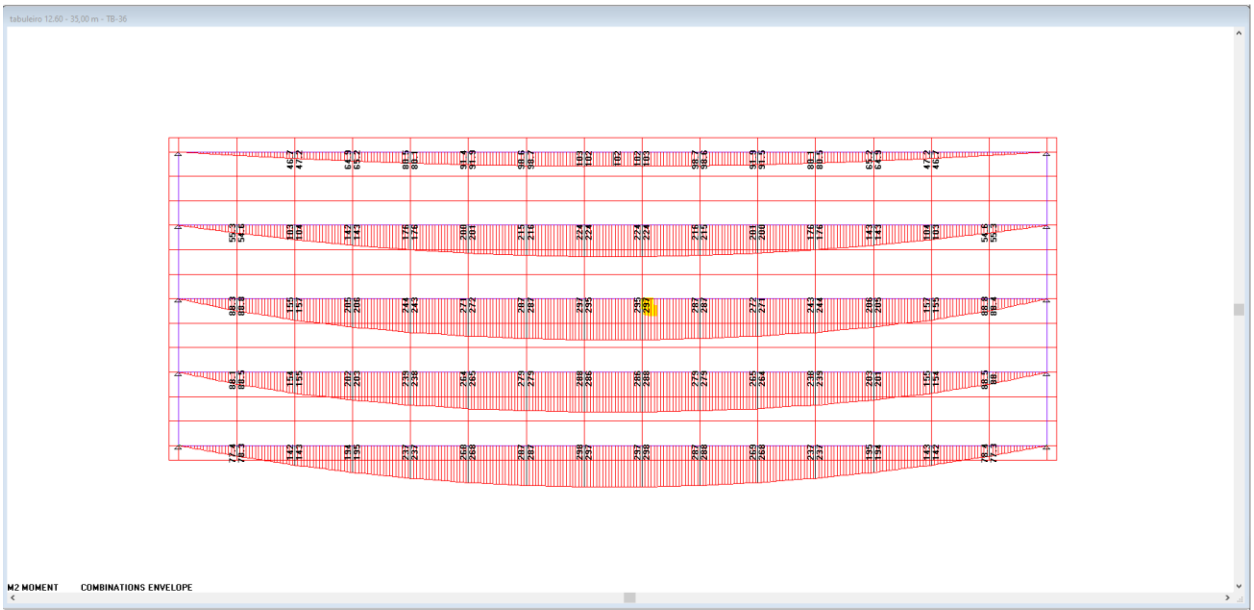
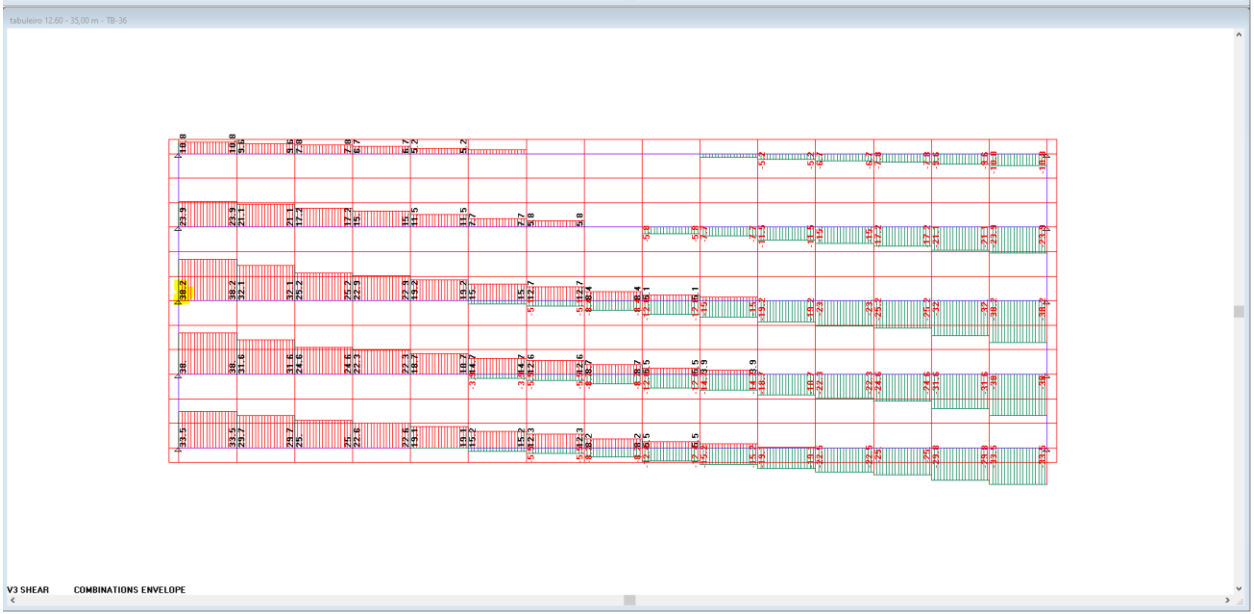
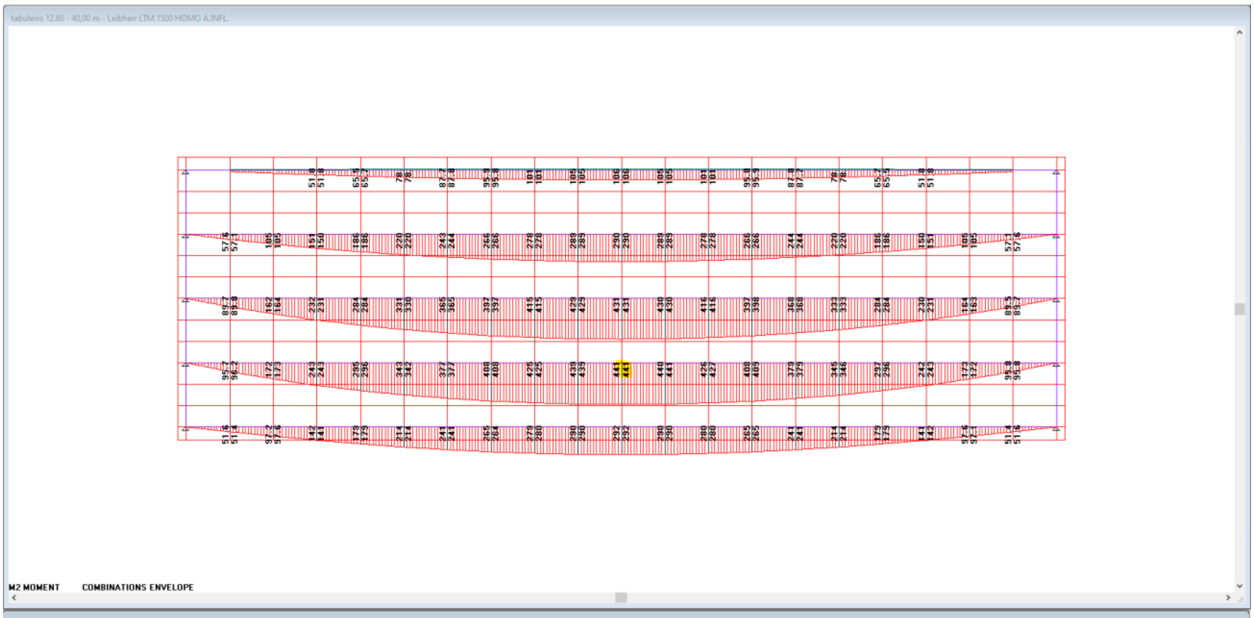
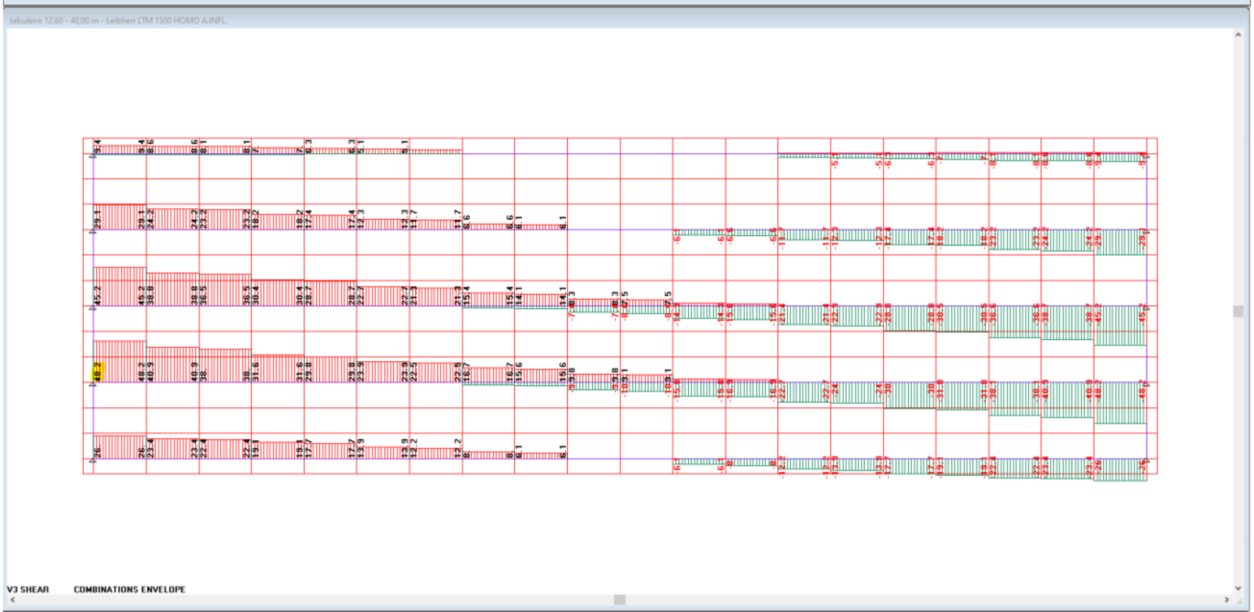
V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE


V3 SHEAR COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE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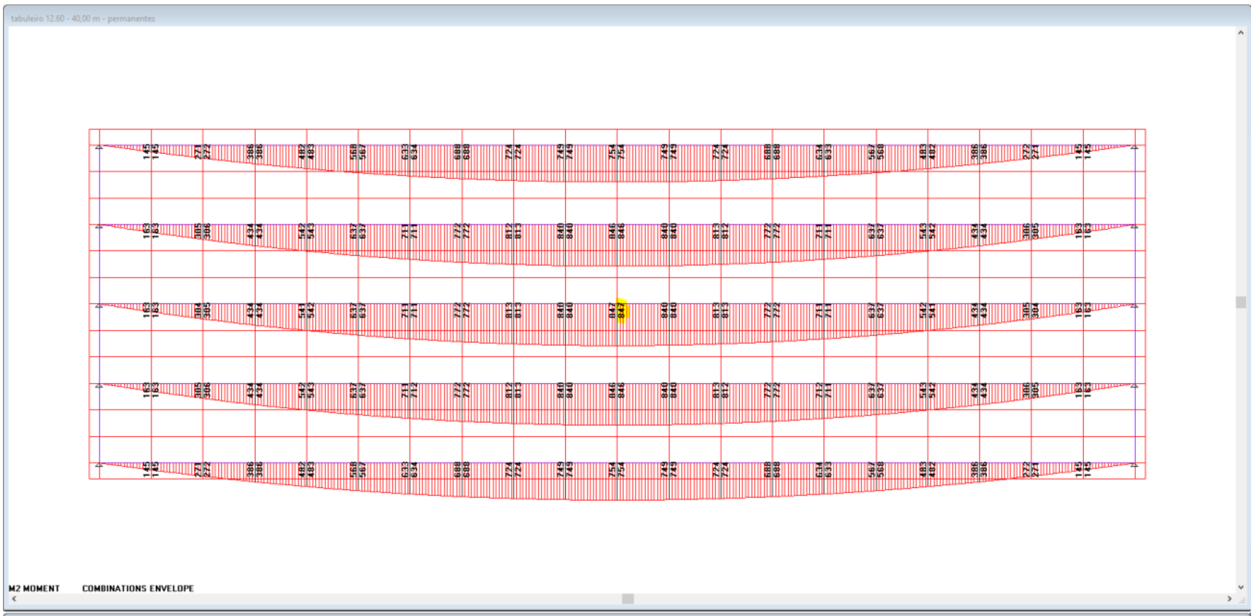
COMBINATIONS ENVELOPE


tabuleiro 12,60 - 40,00 m - permanentes
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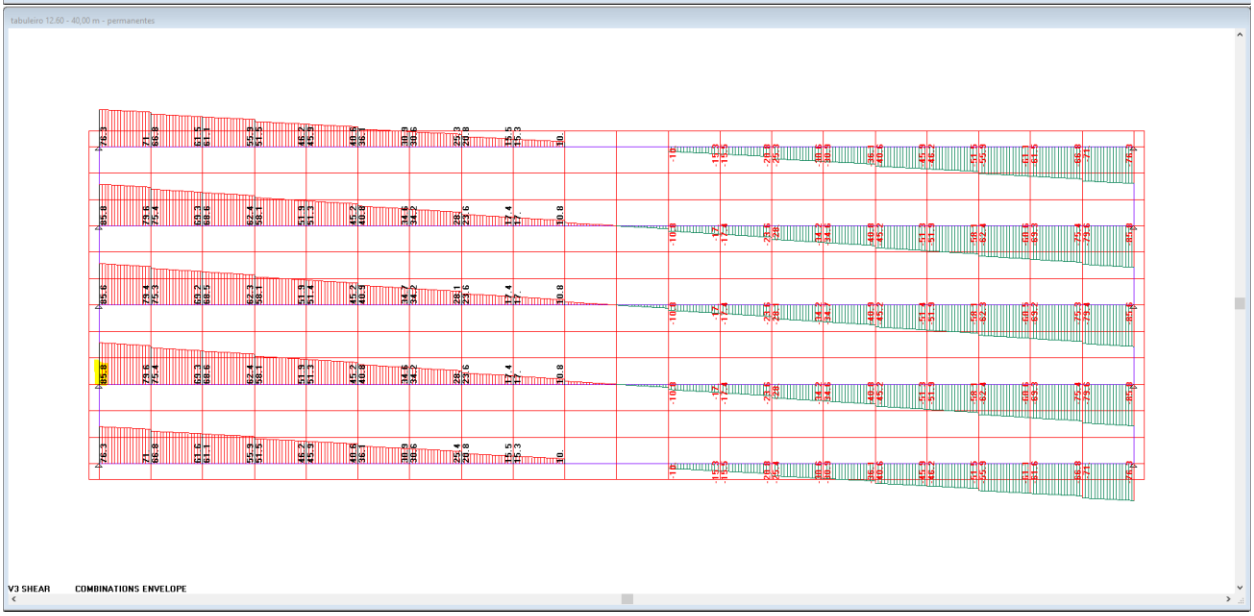
COMBINATIONS ENVELOPE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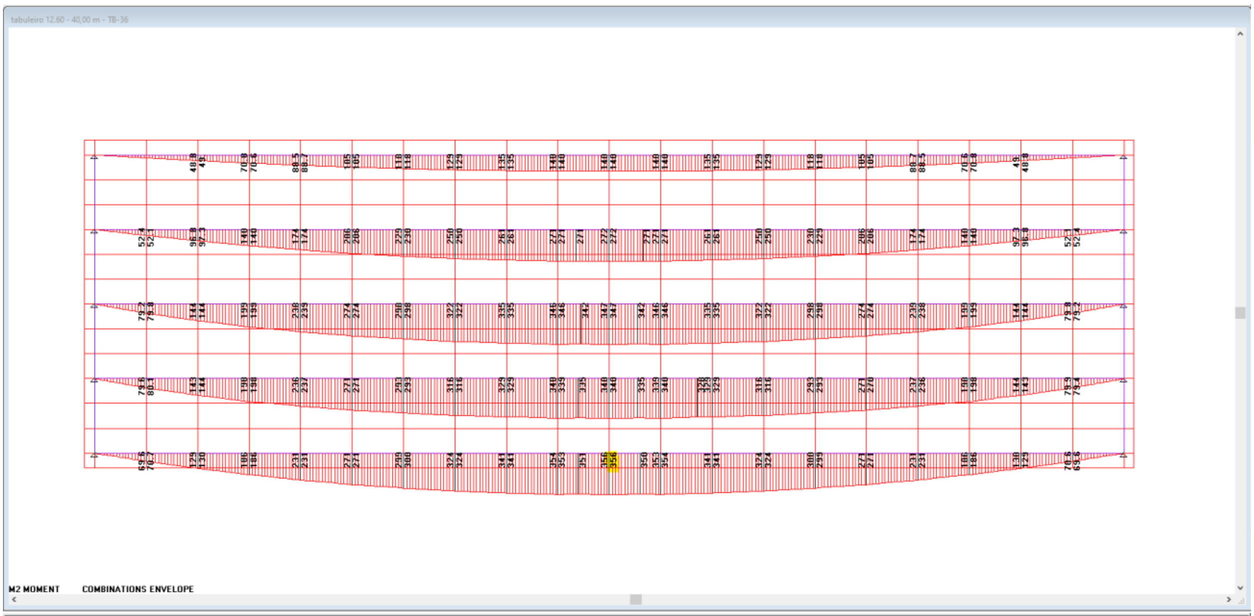
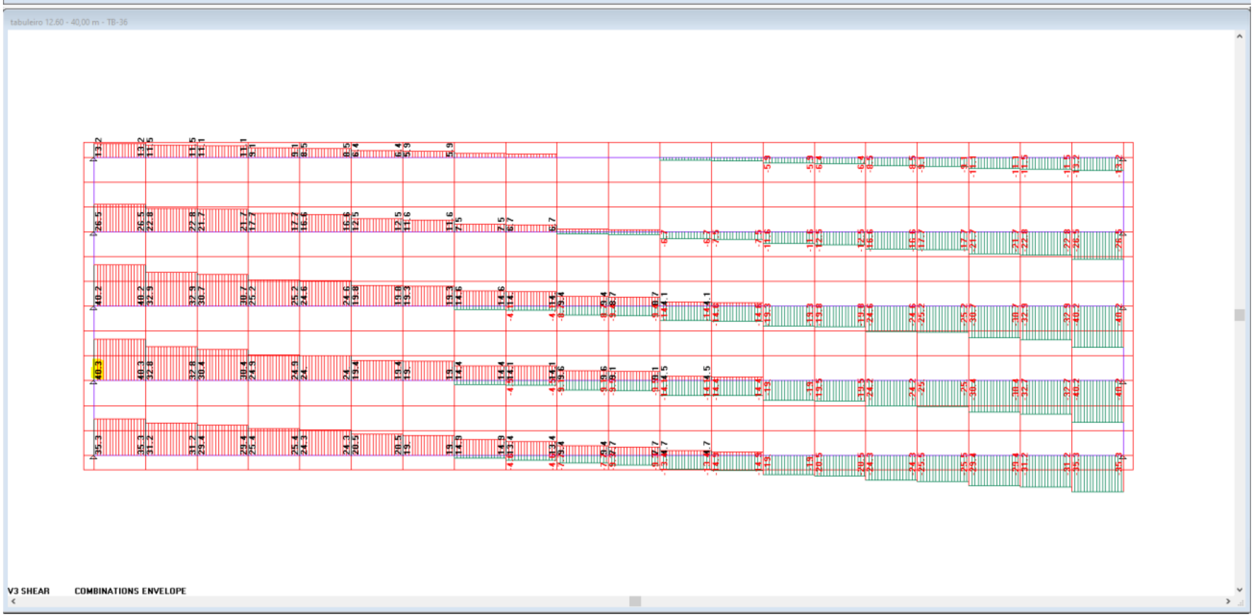
V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 12,60 - 40,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE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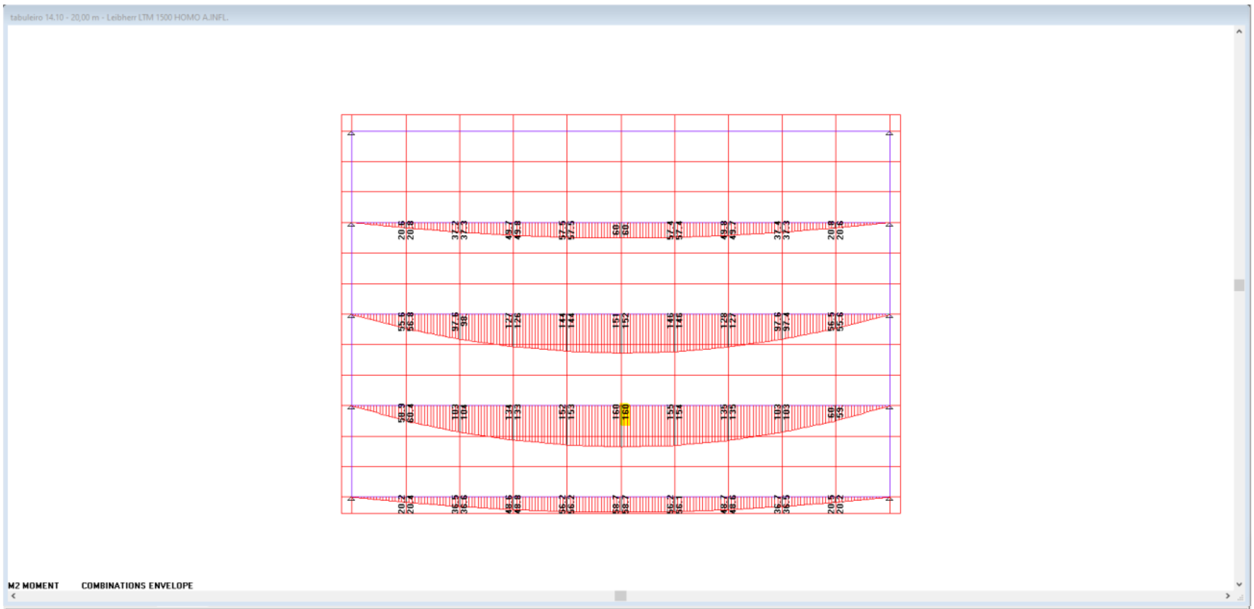
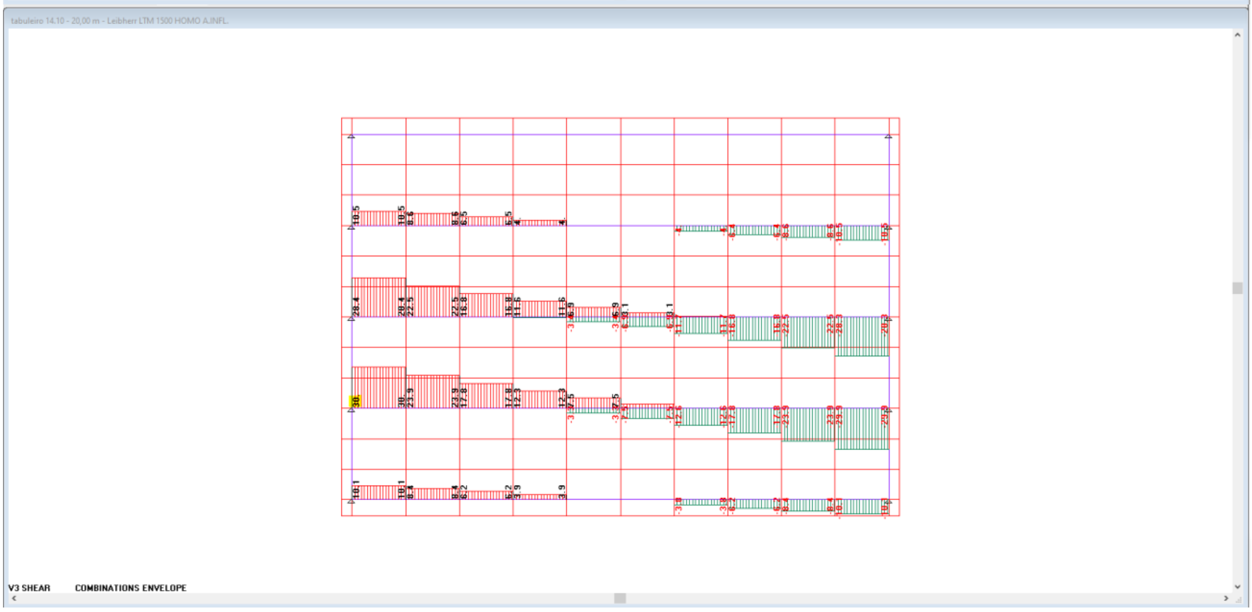
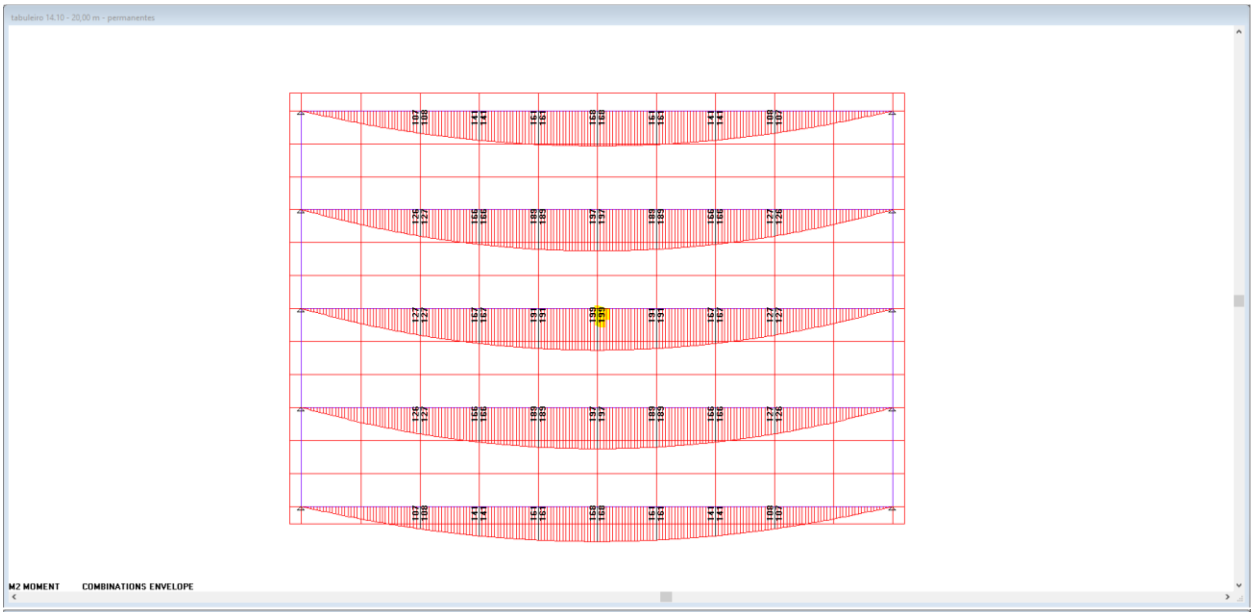
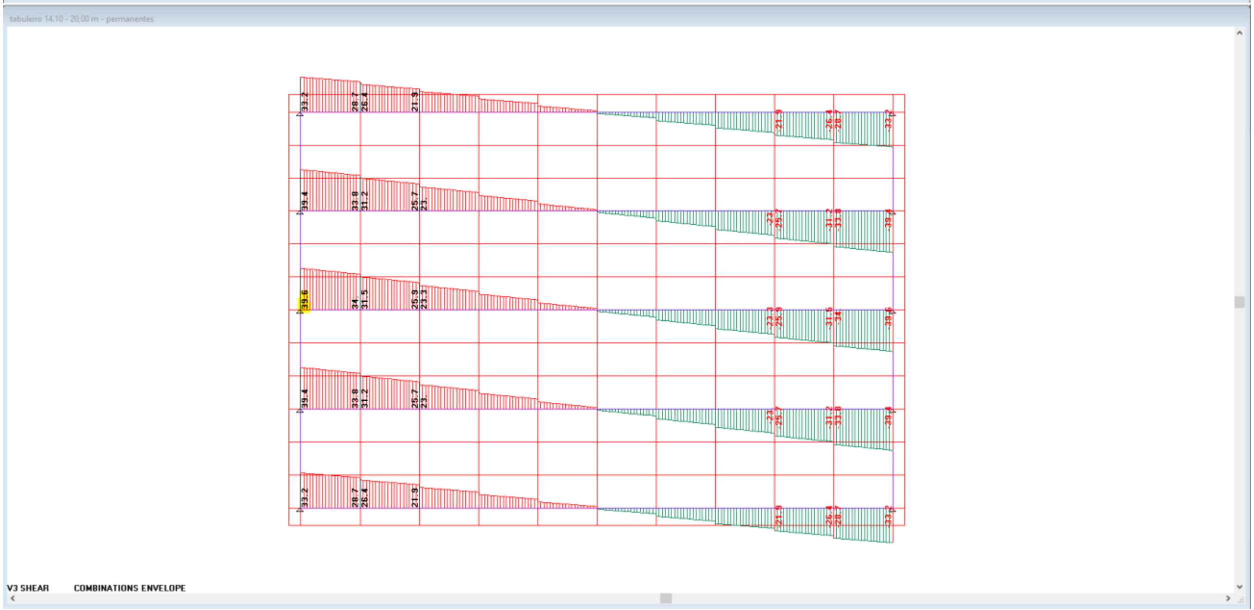
V3 SHEAR
COMBINATIONS ENVELOPE

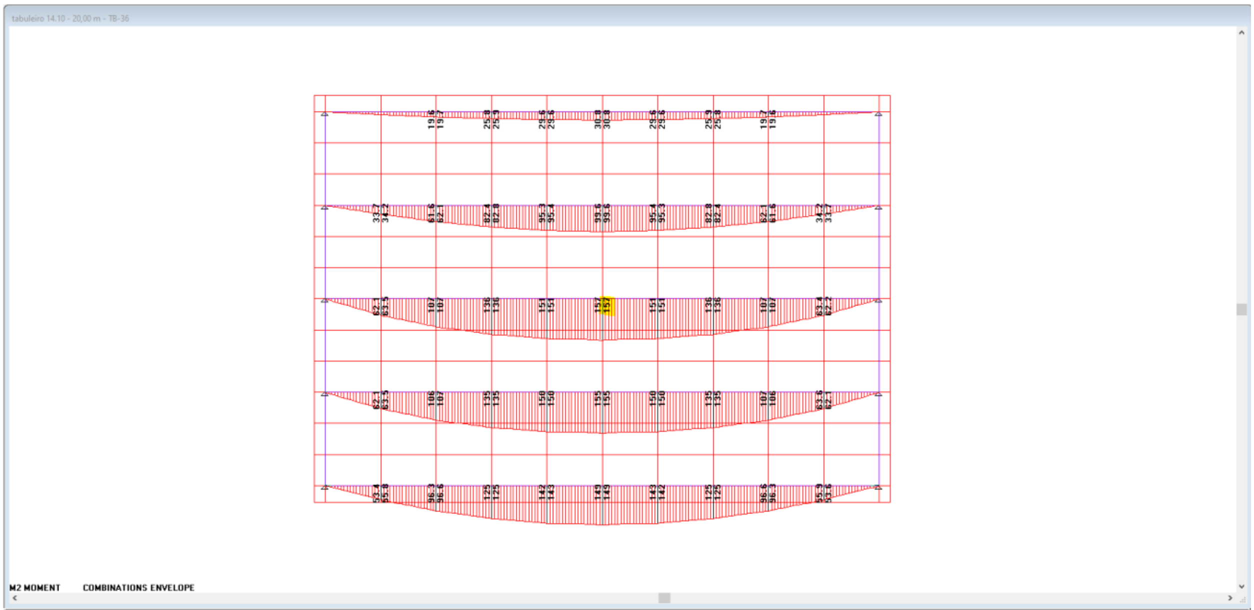
4.6.3. Tabuleiro 14,10 m

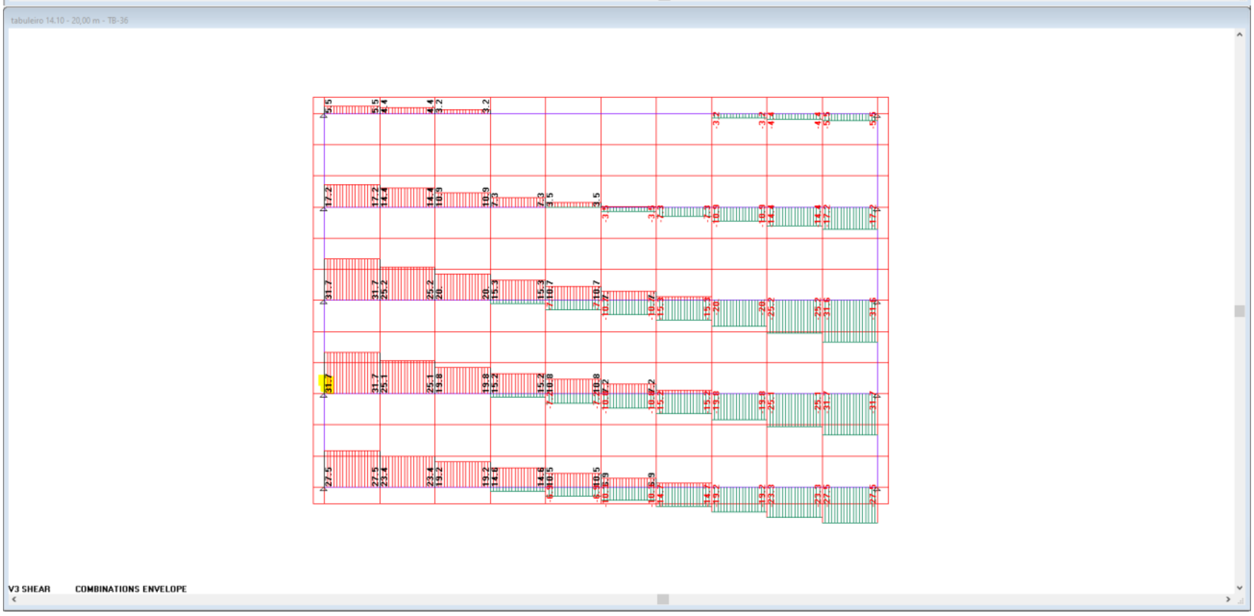


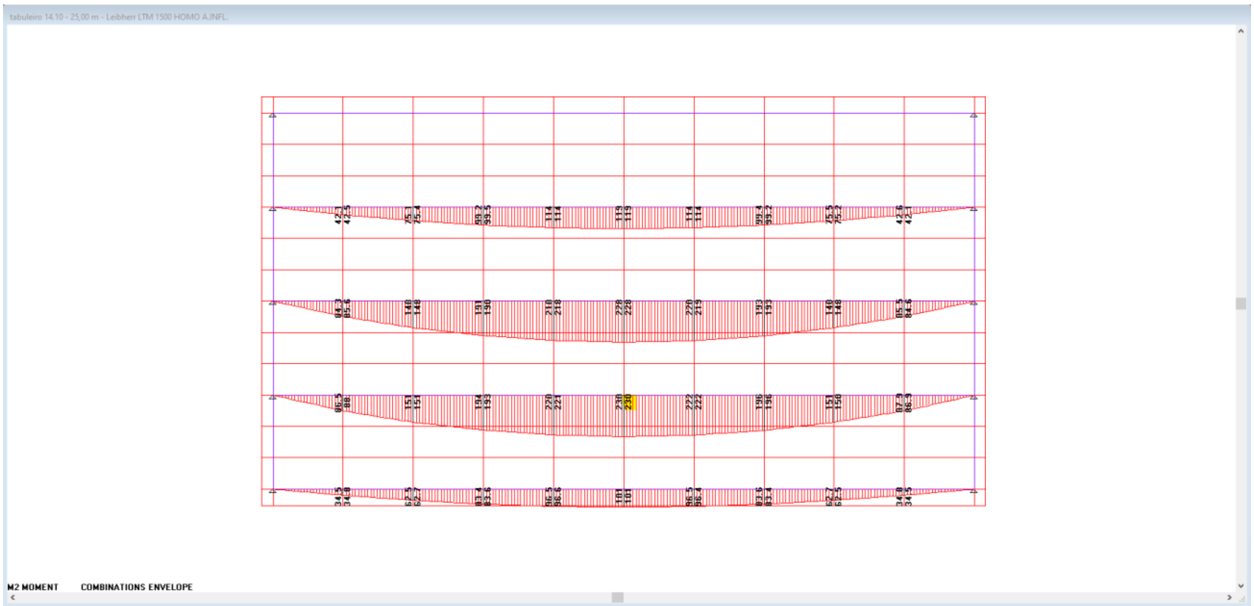


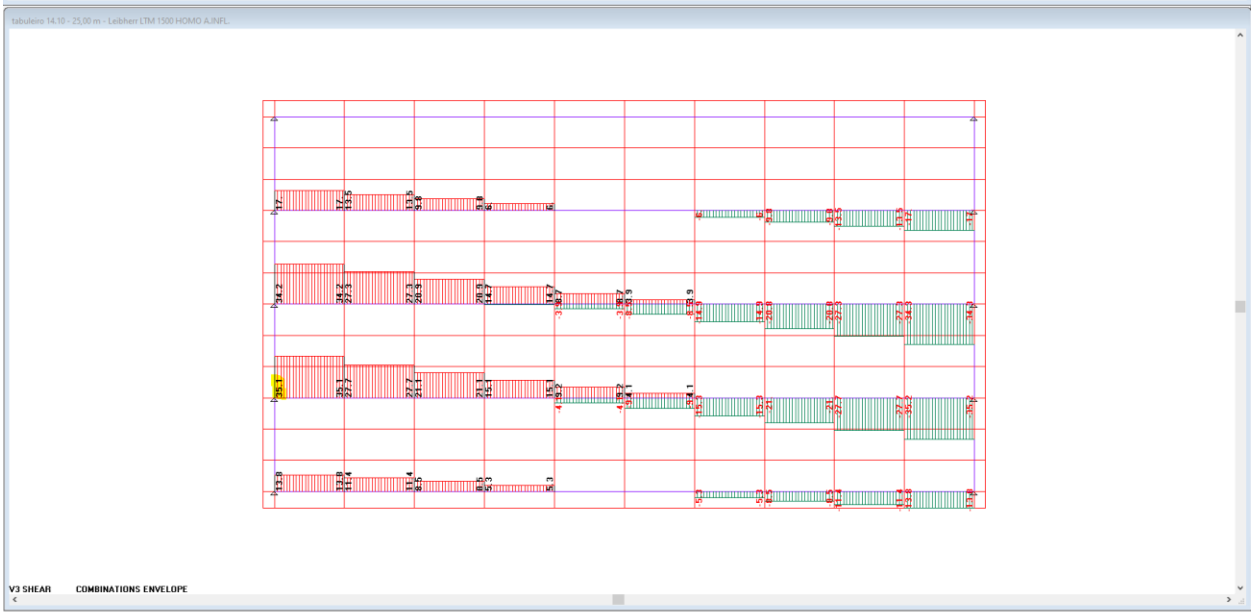

M2 MOMENT
COMBINATIONS ENVELOPE

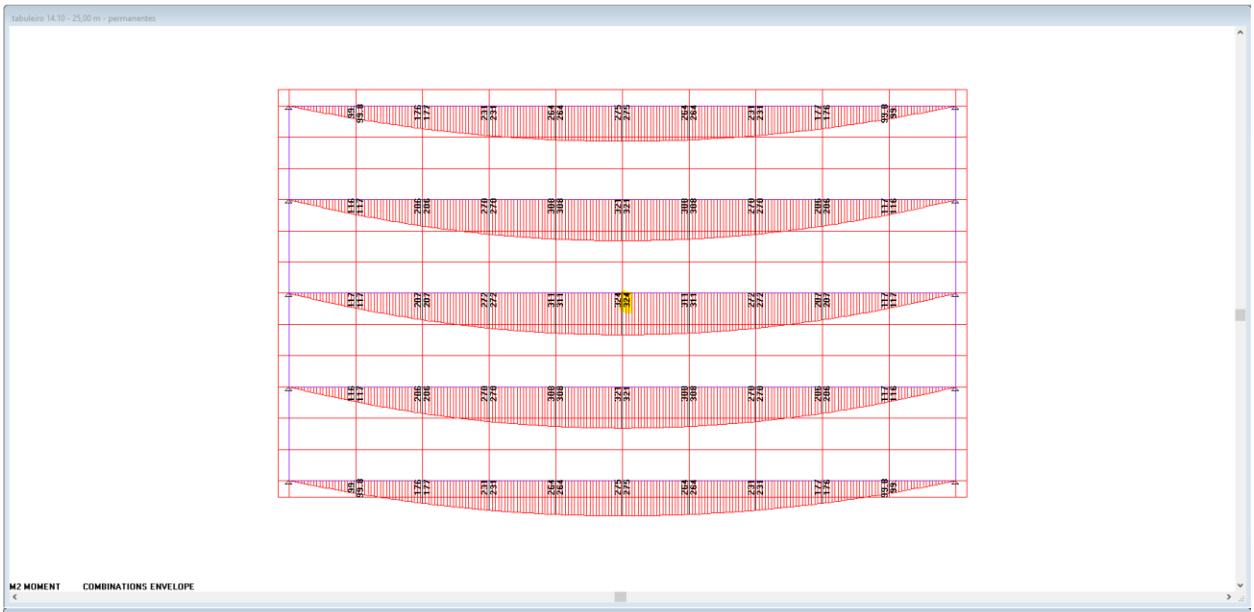

V3 SHEAR
COMBINATIONS ENVELOPE

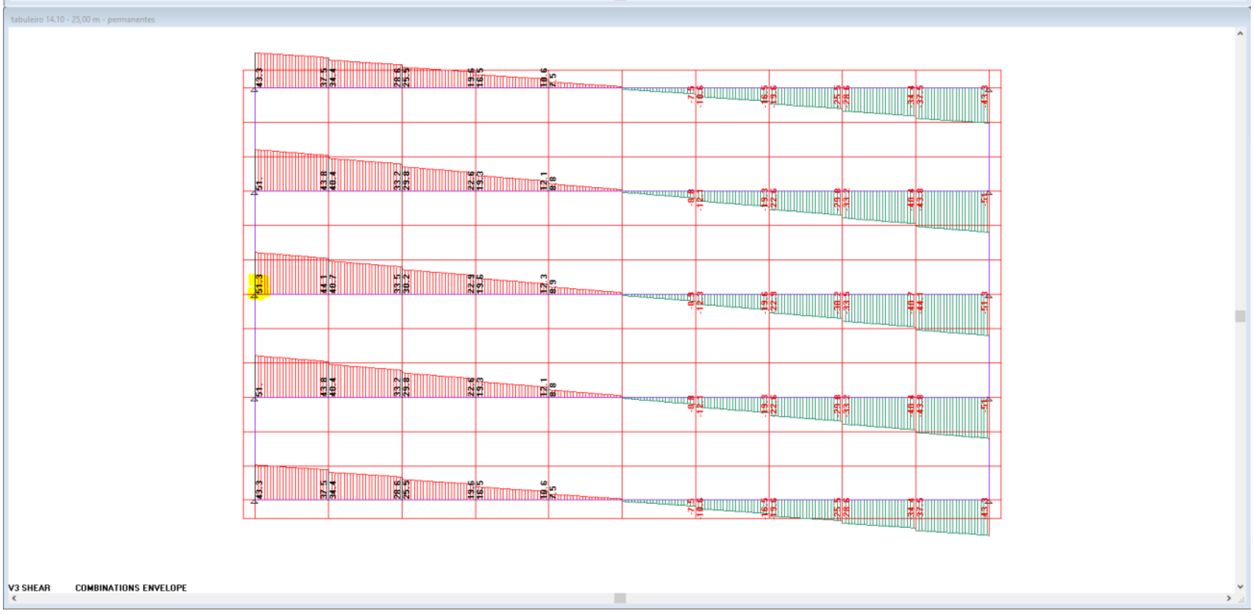

tabuleiro 14.10 - 20,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE

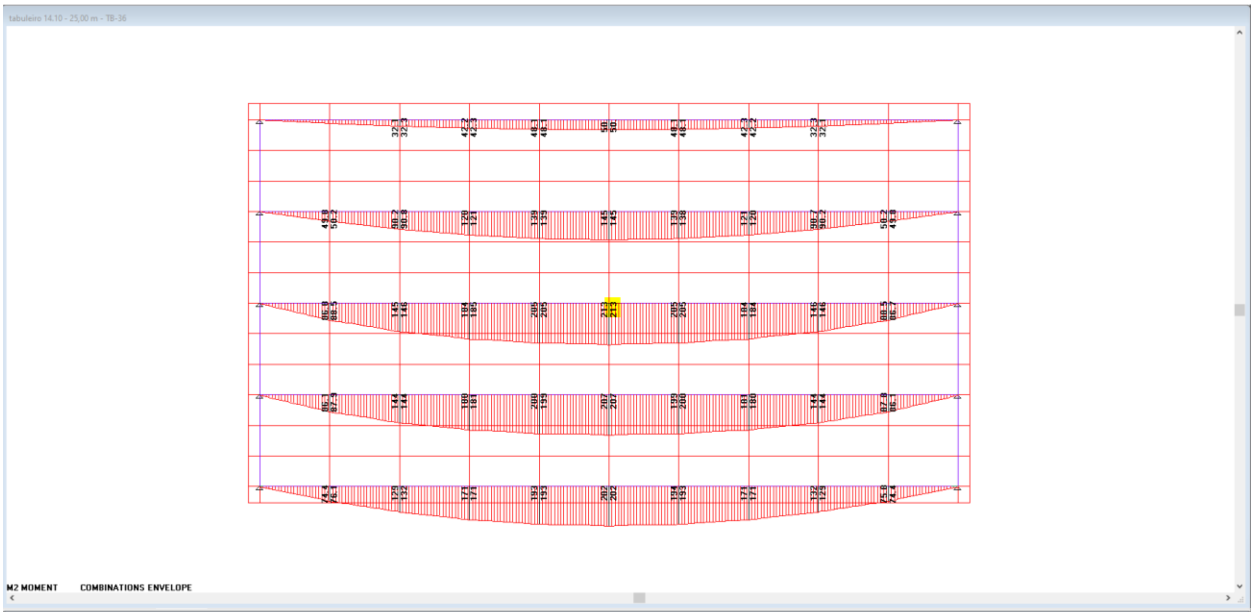

tabuleiro 14.10 - 20,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE

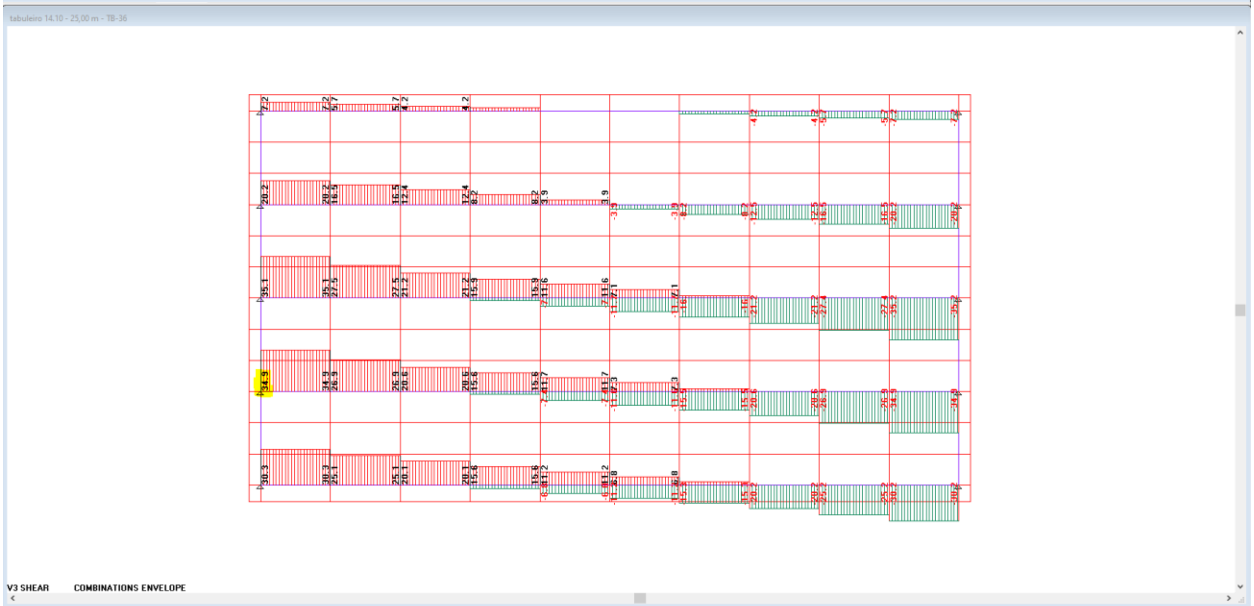

M2 MOMENT
COMBINATIONS ENVELOPE

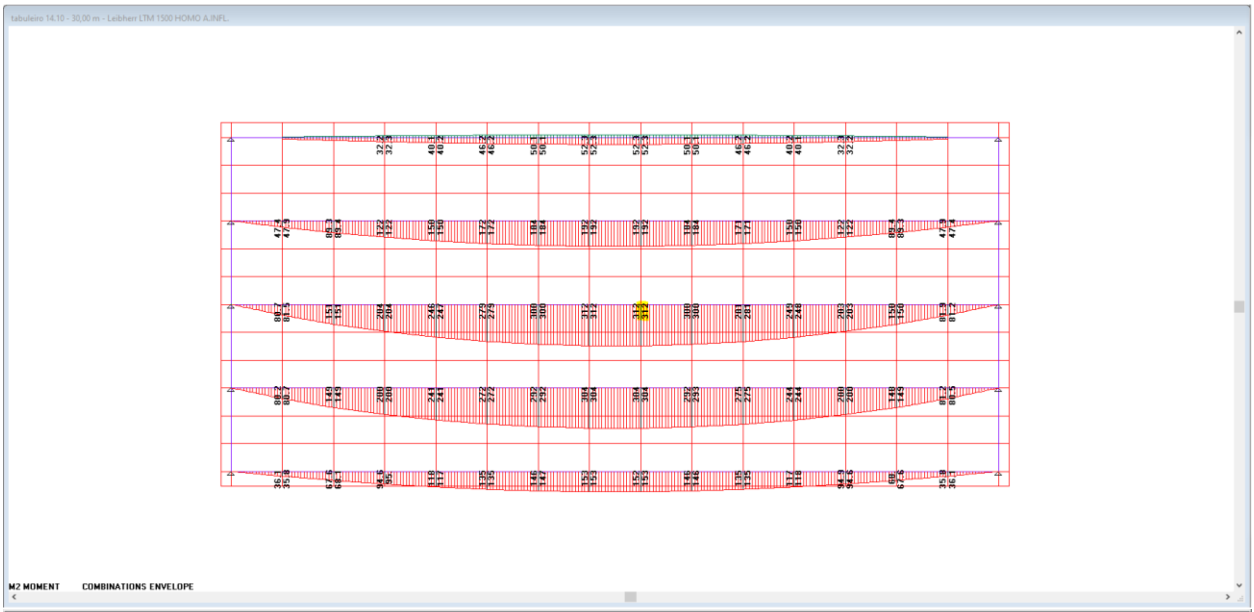

V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 14.10 - 25,00 m - permanentes
M2 MOMENT COMBINATIONS ENVELOPE


tabuleiro 14.10 - 25,00 m - permanentes
V3 SHEAR COMBINATIONS ENVELOPE


tabuleiro 14.10 - 25,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 14.10 - 25,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE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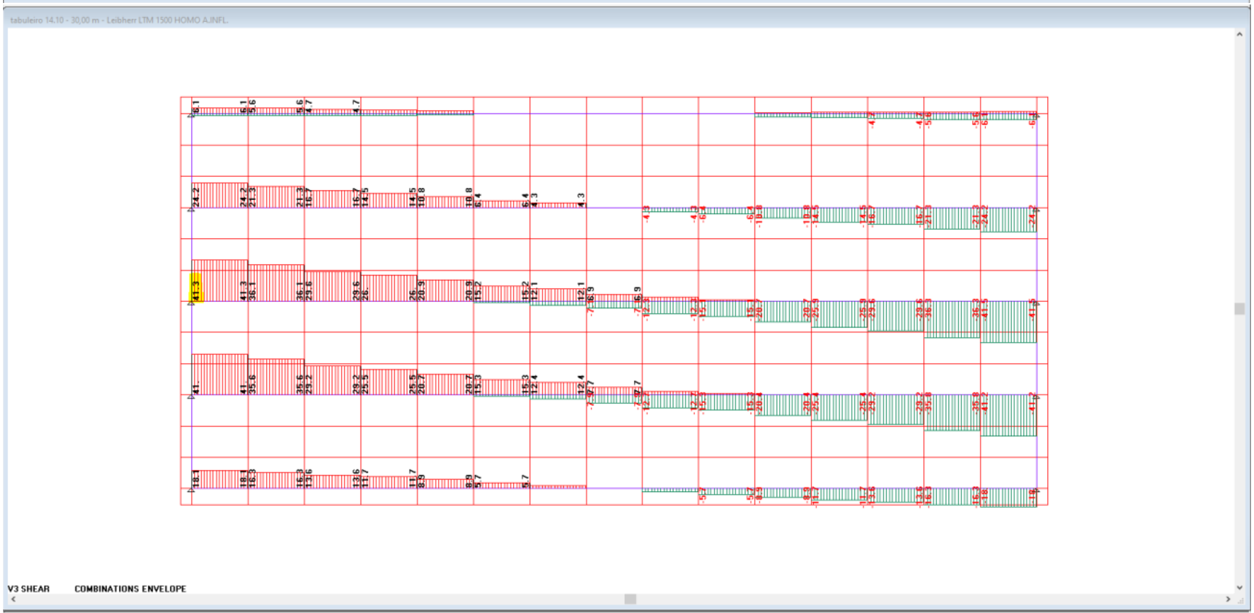
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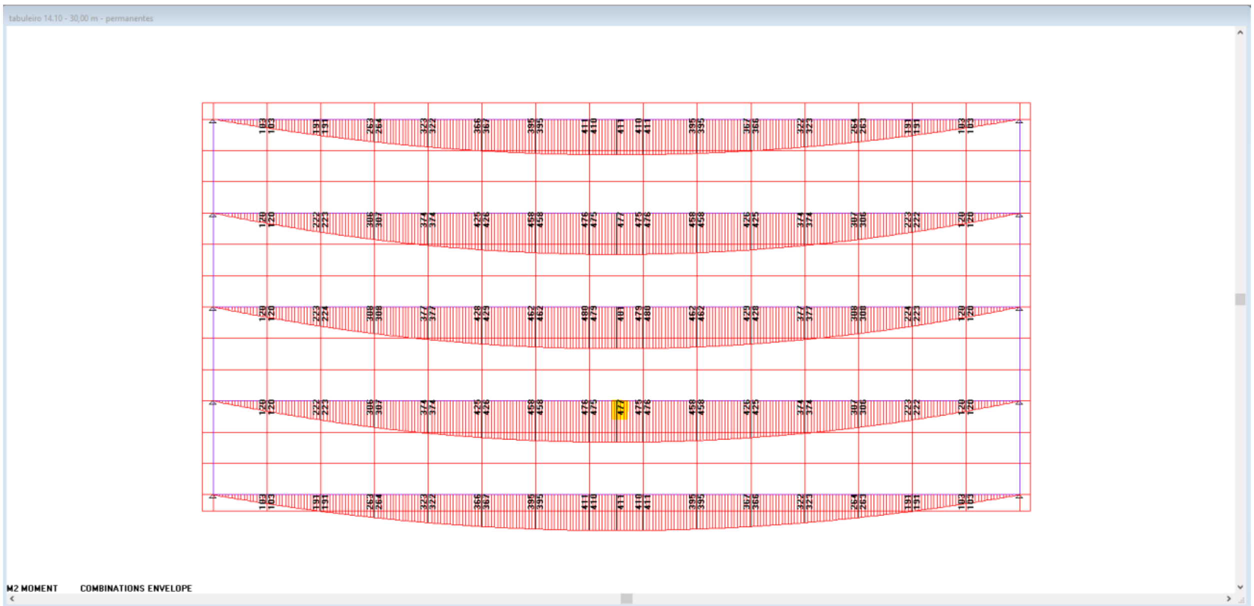
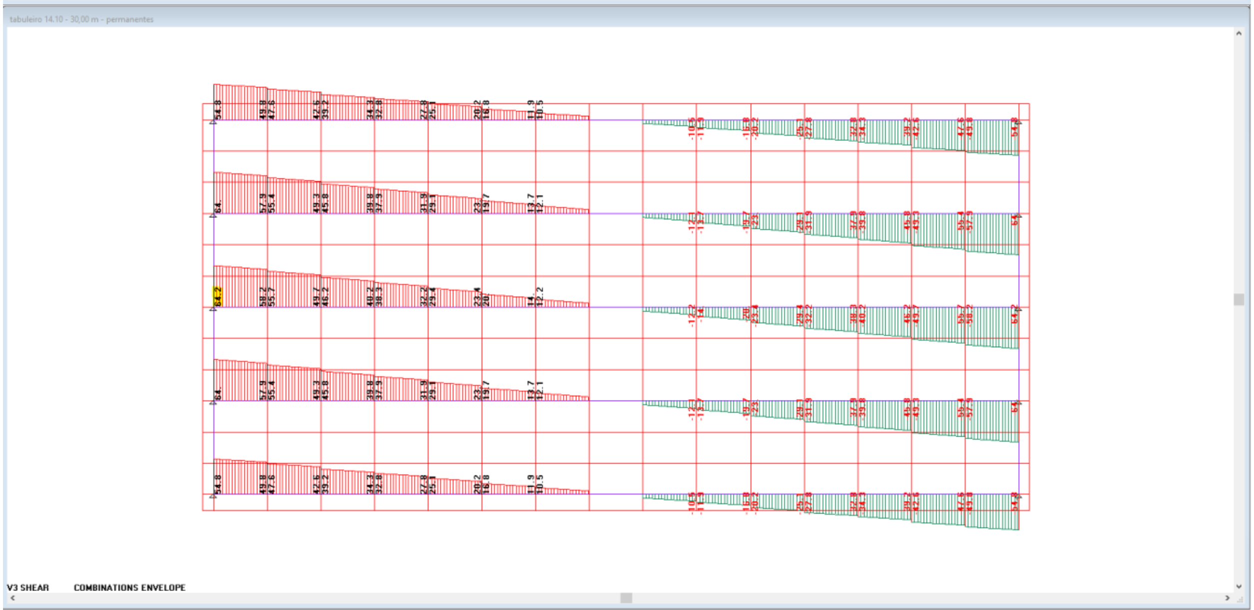

tabuleiro 14.10 - 30,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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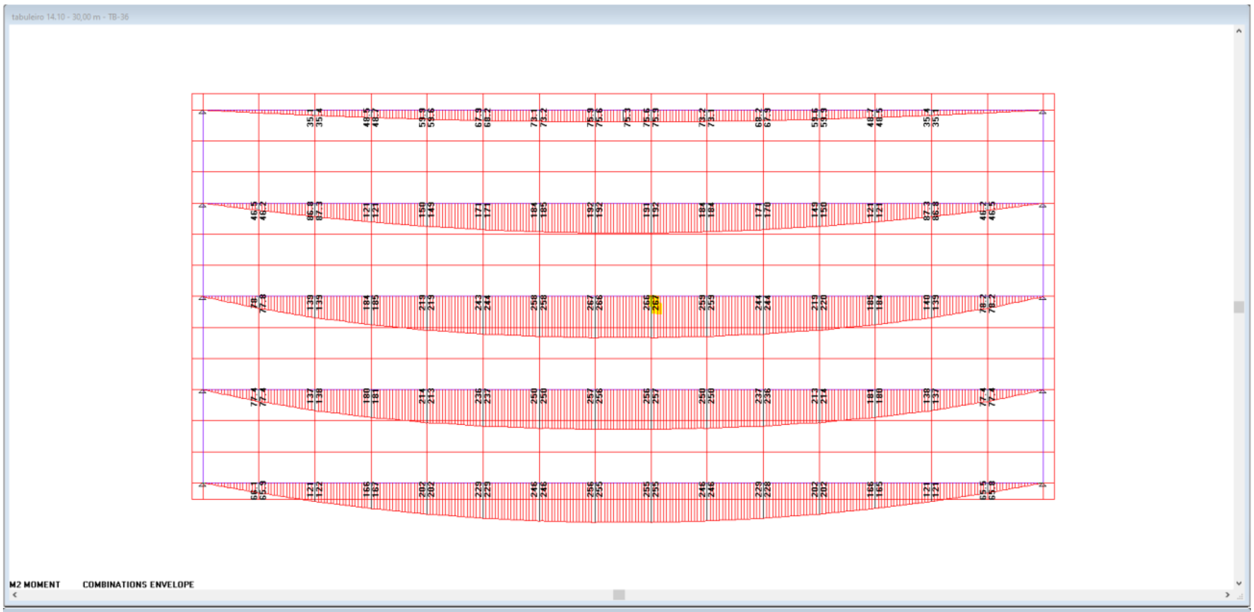
V3 SHEAR
COMBINATIONS ENVELOPE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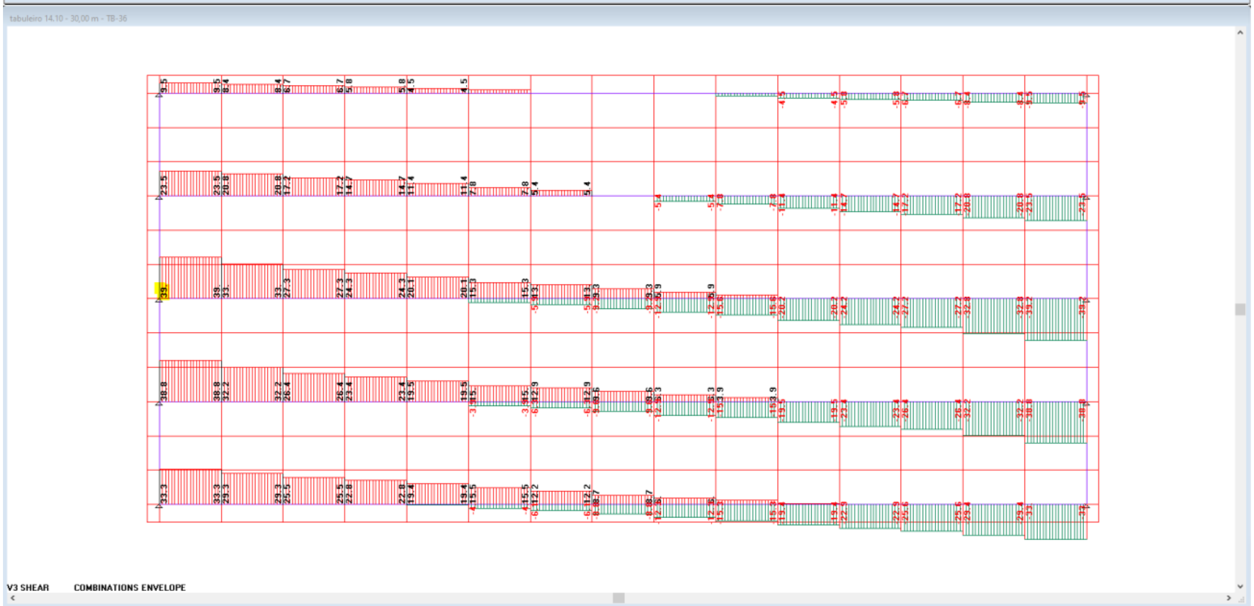
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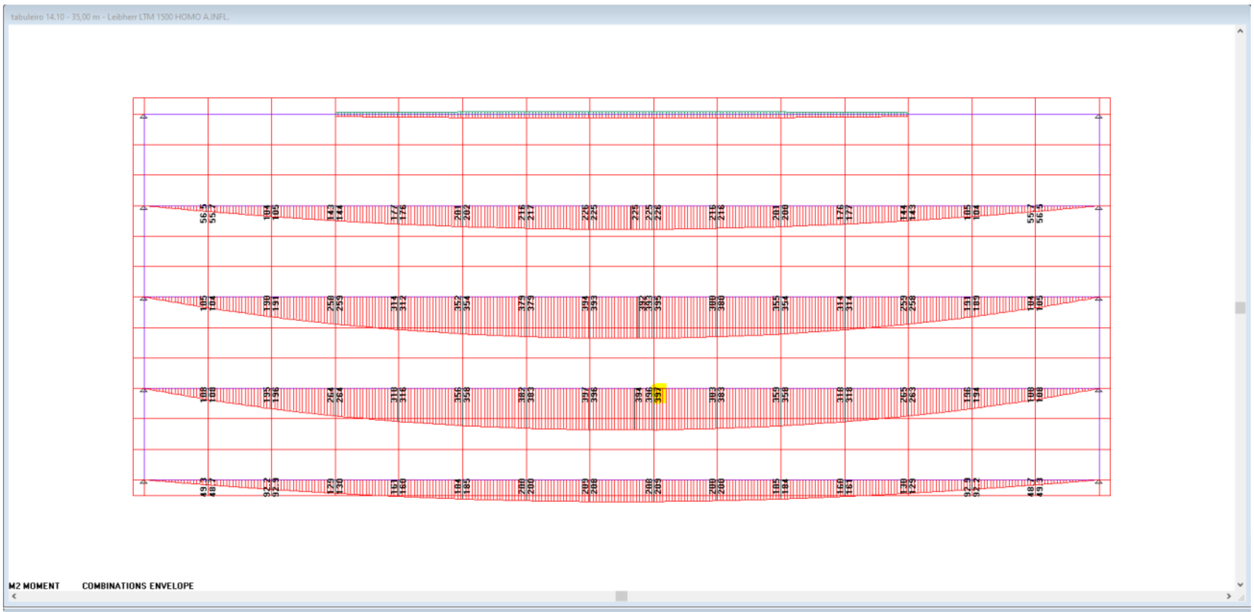
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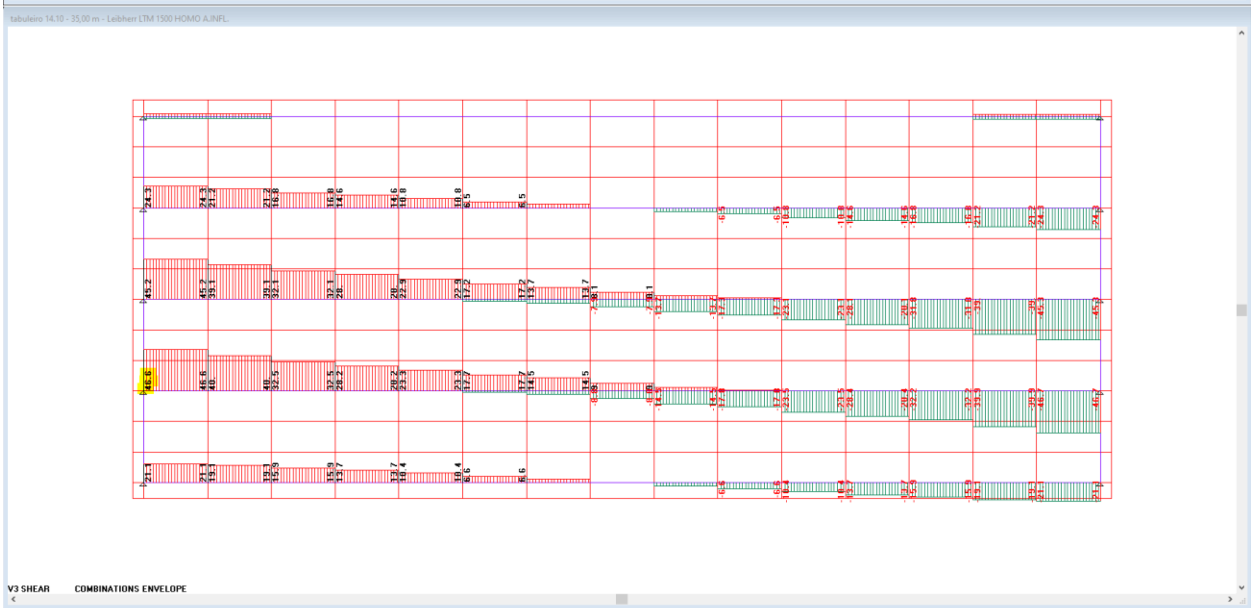
COMBINATIONS ENVELOPE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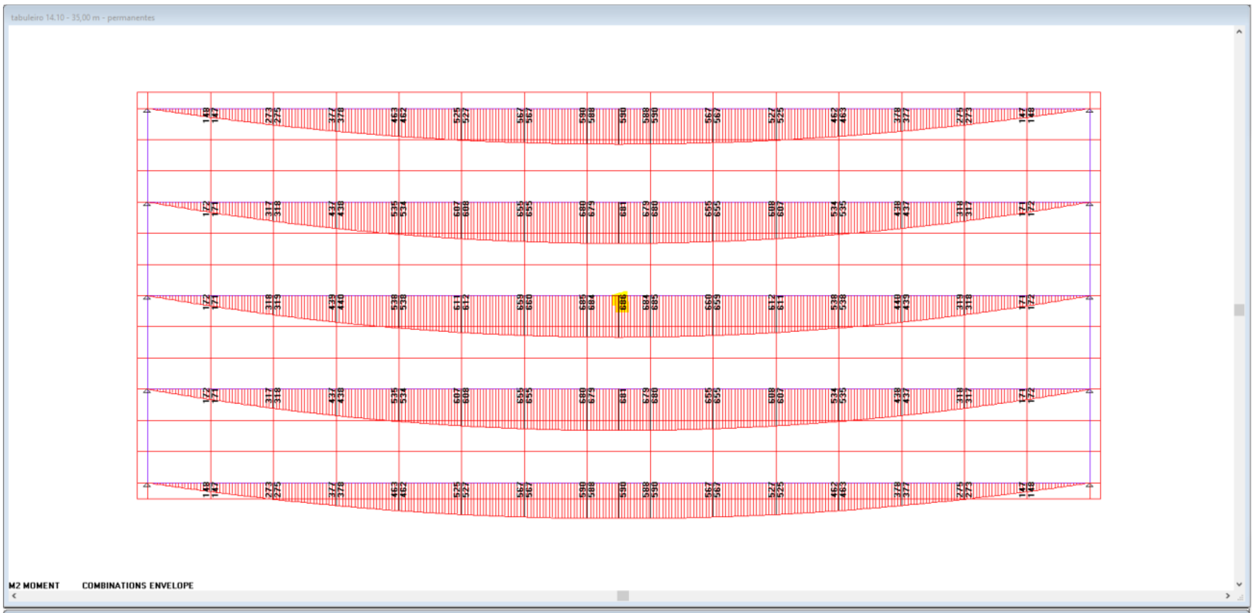
COMBINATIONS ENVELOPE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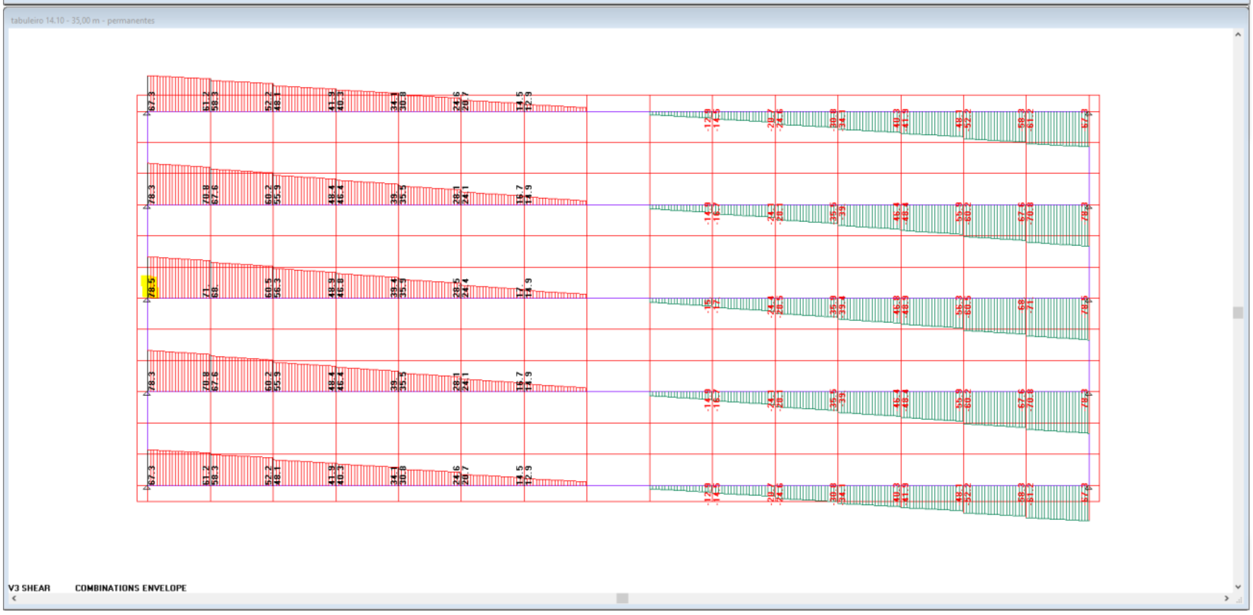
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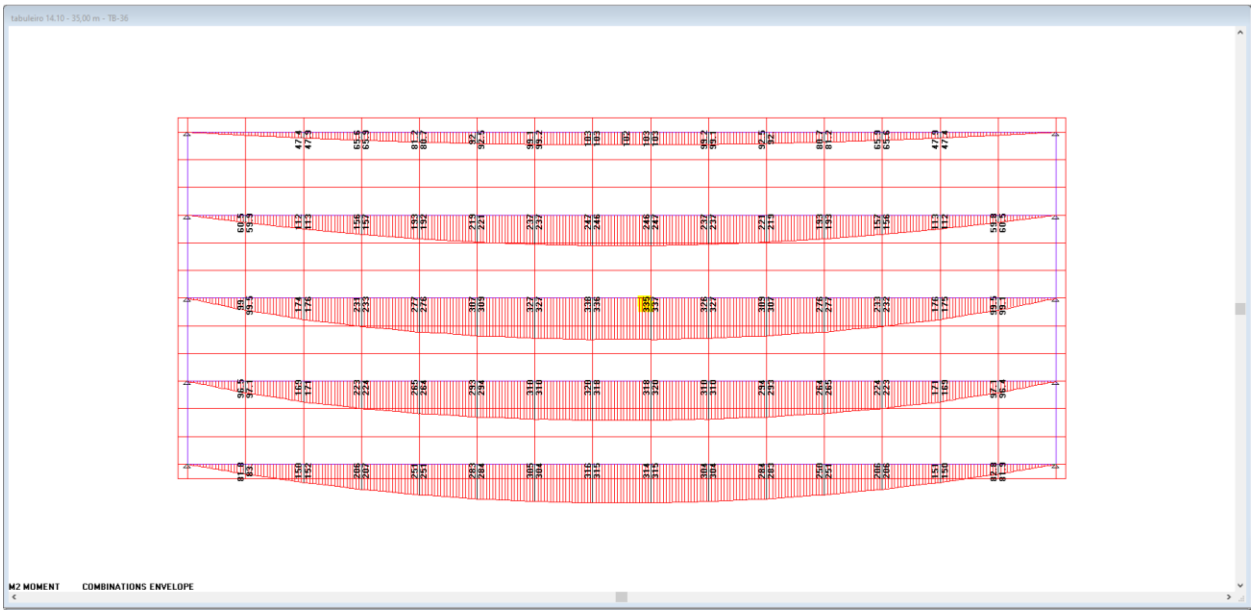
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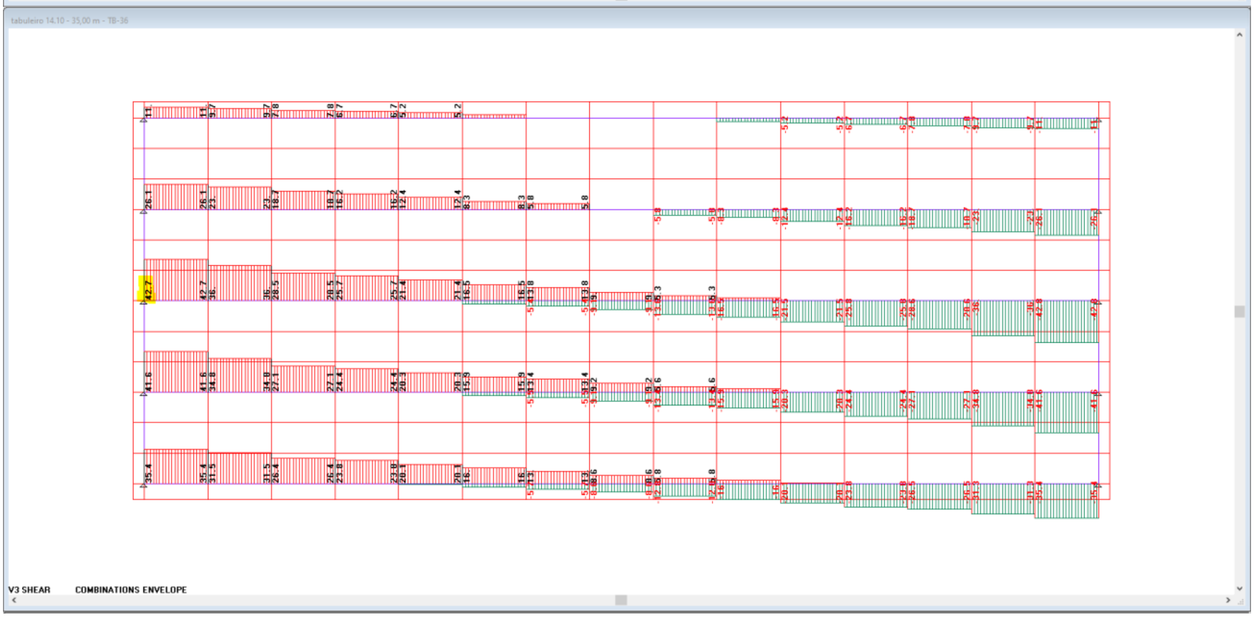
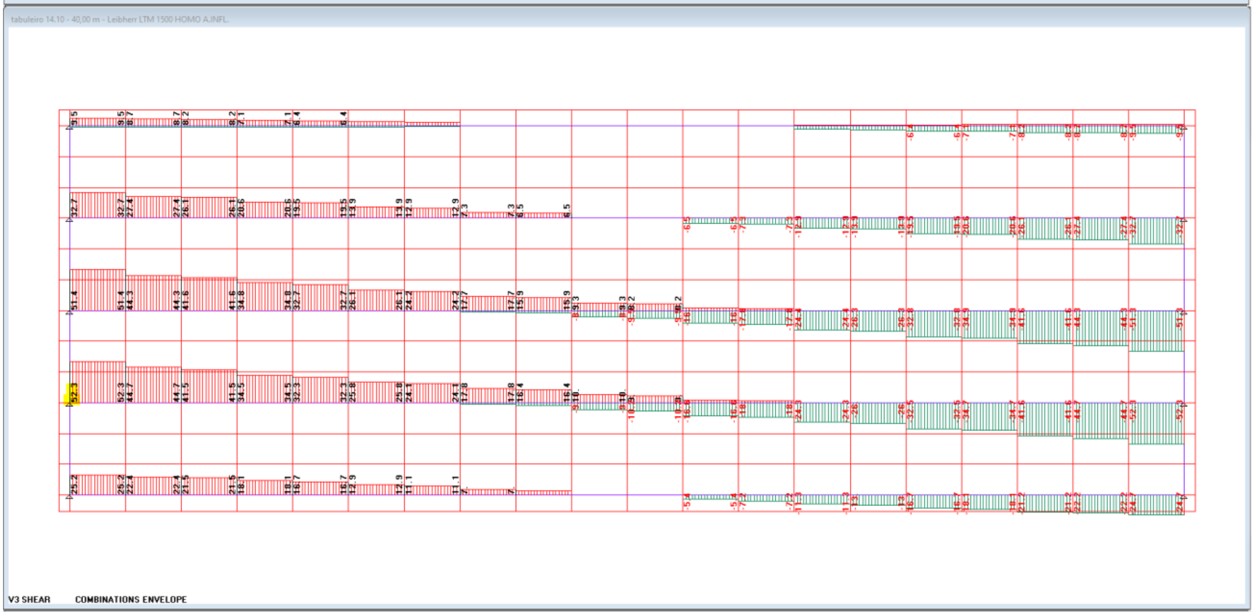
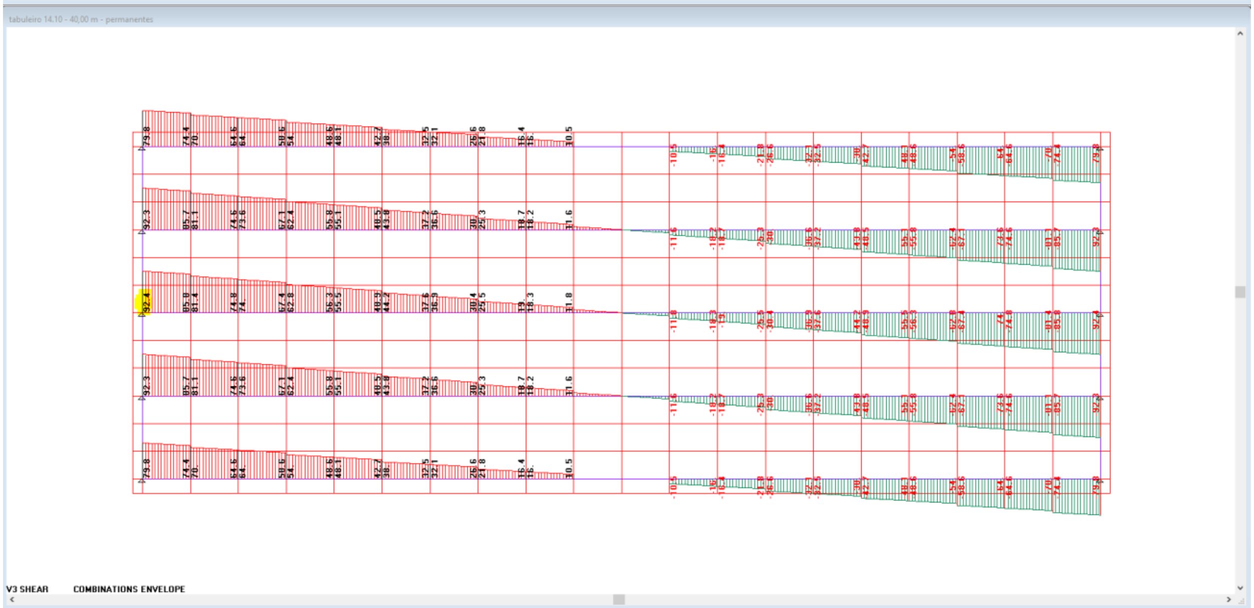

V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE


V3 SHEAR COMBINATIONS ENVELOPE


tabuleiro 14.10 - 40,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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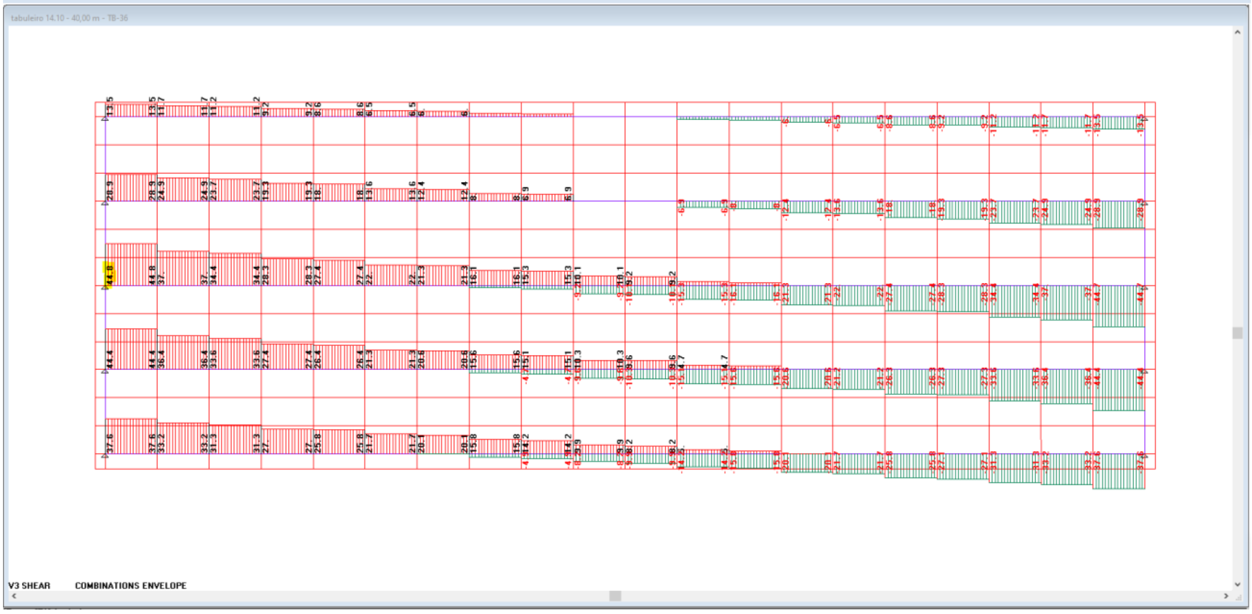
V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE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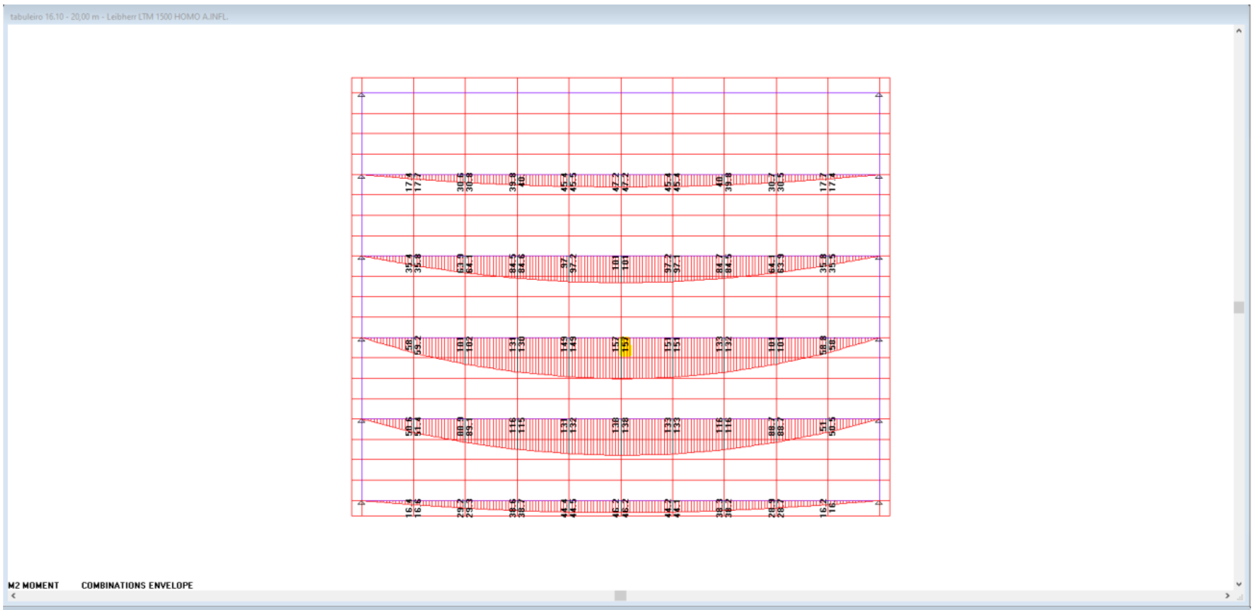
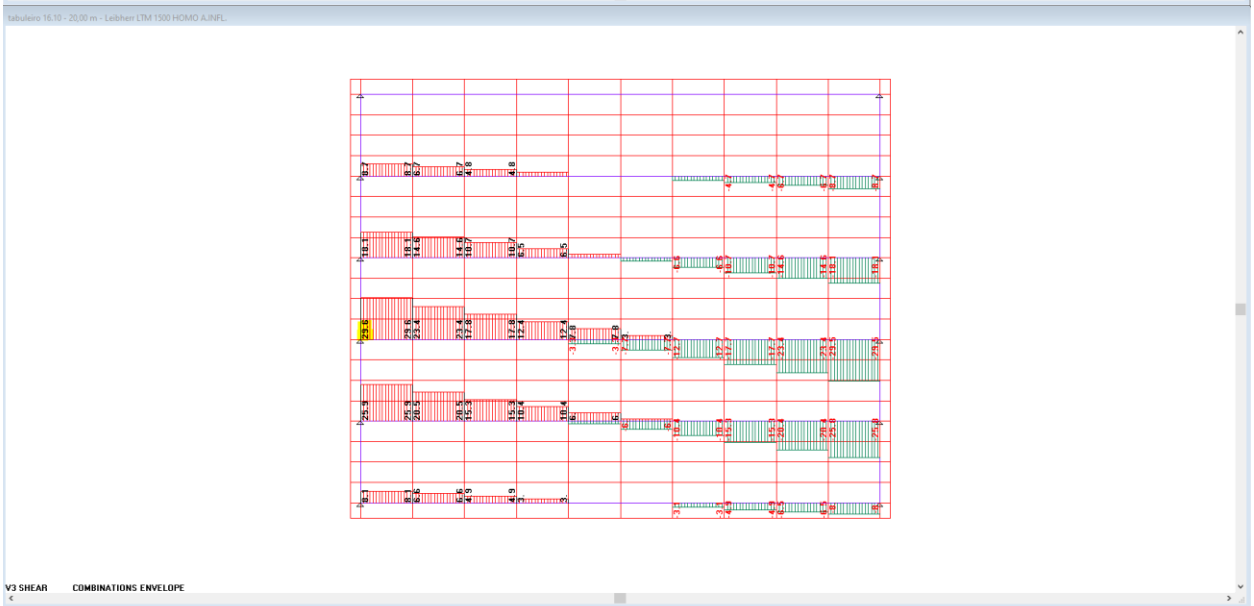
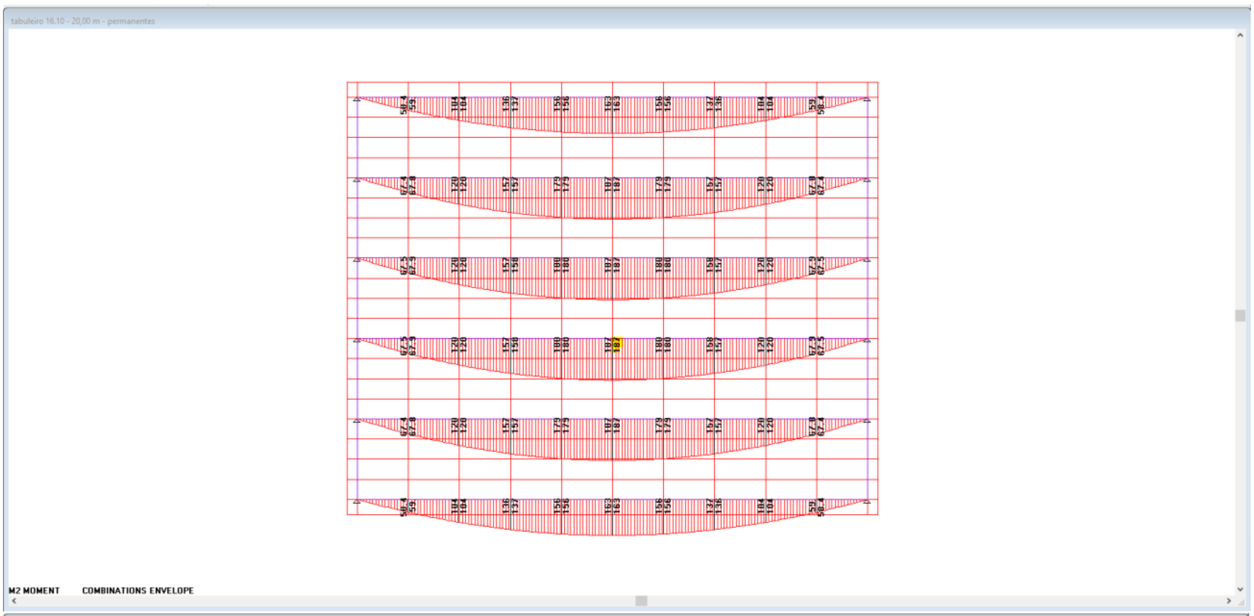
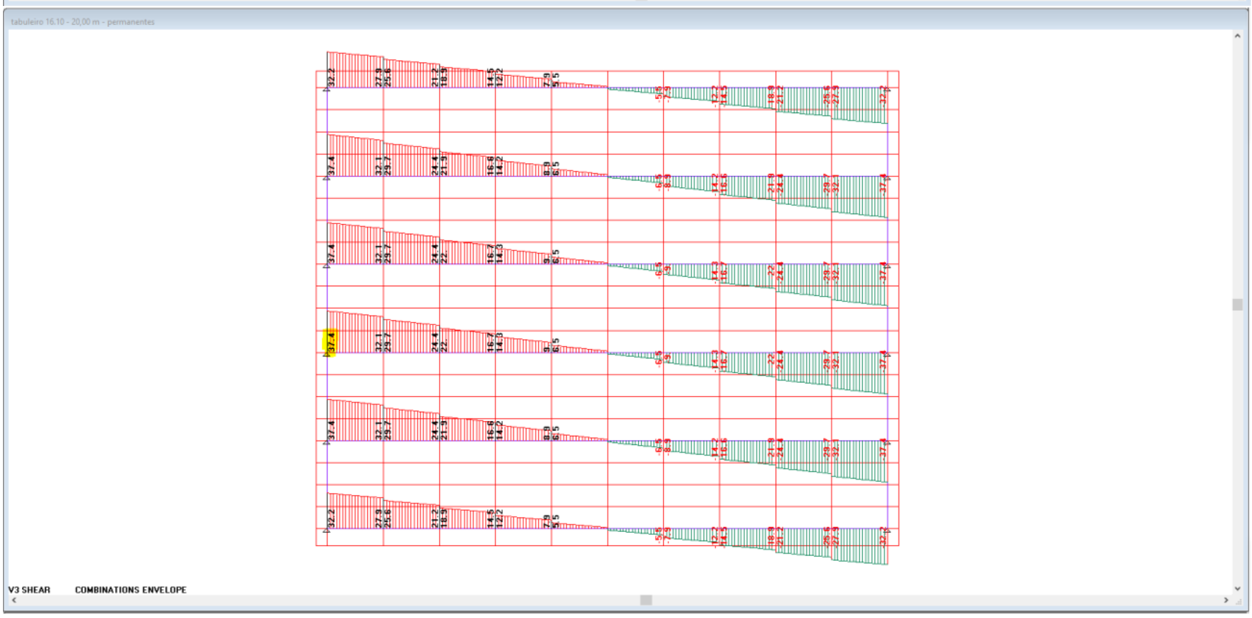
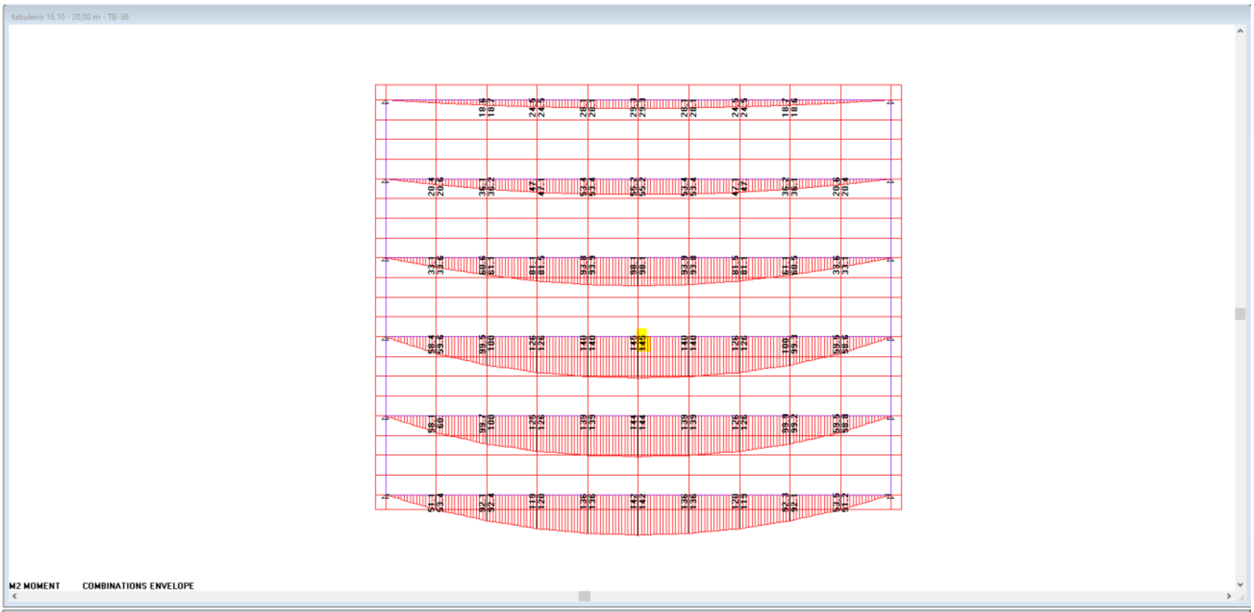
4.6.4. Tabuleiro 16,10 m

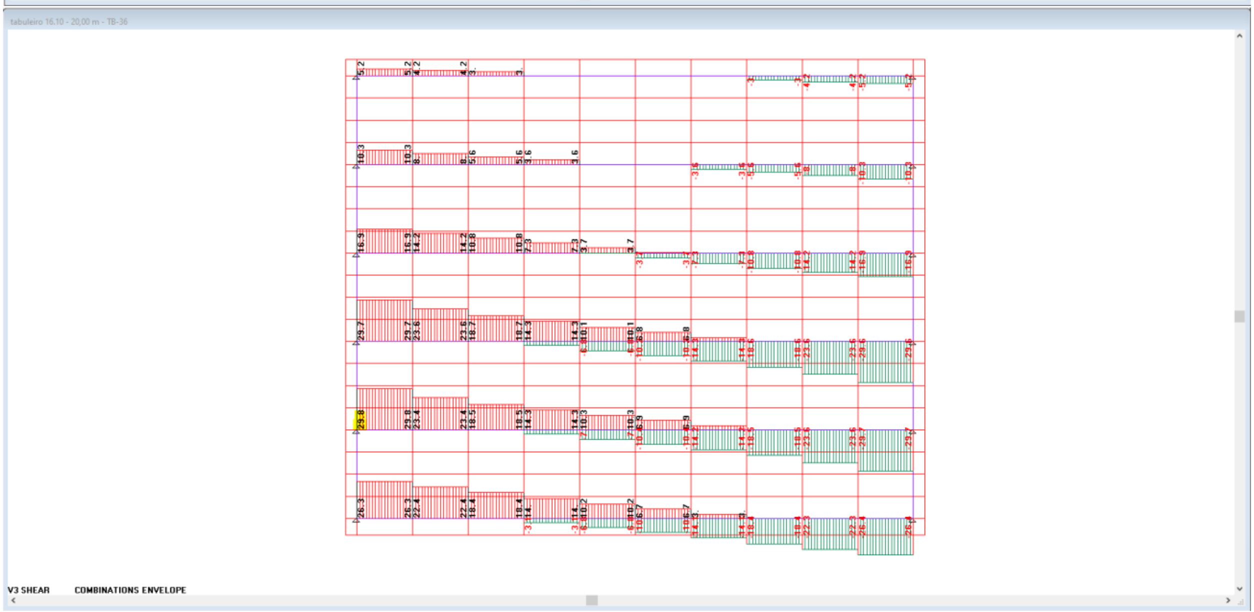


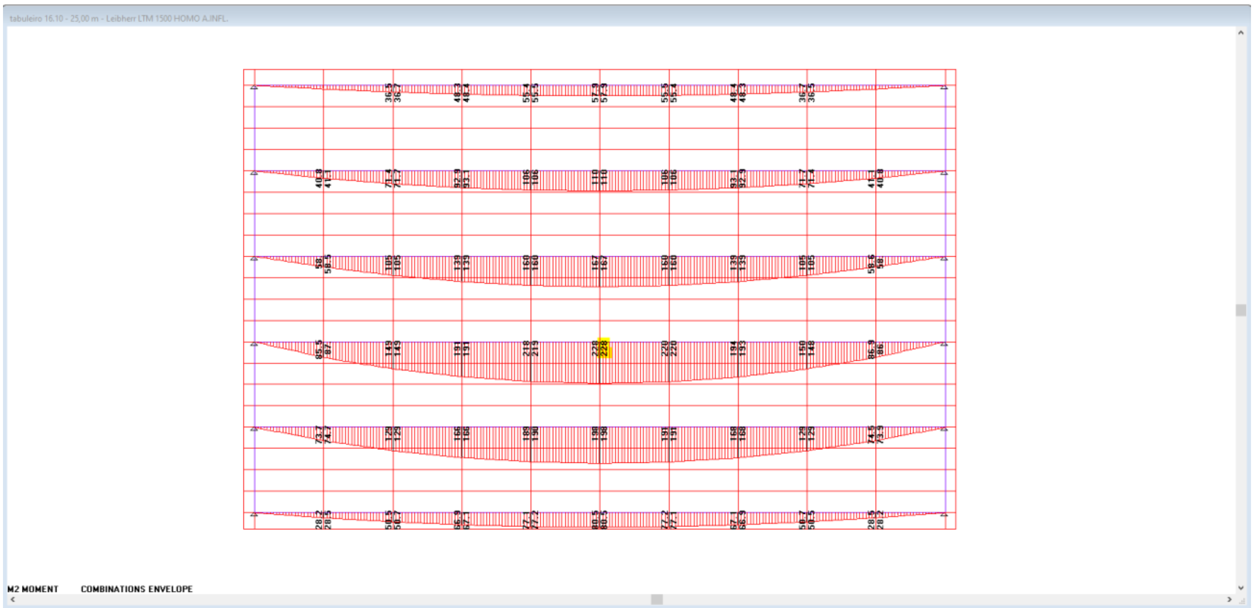


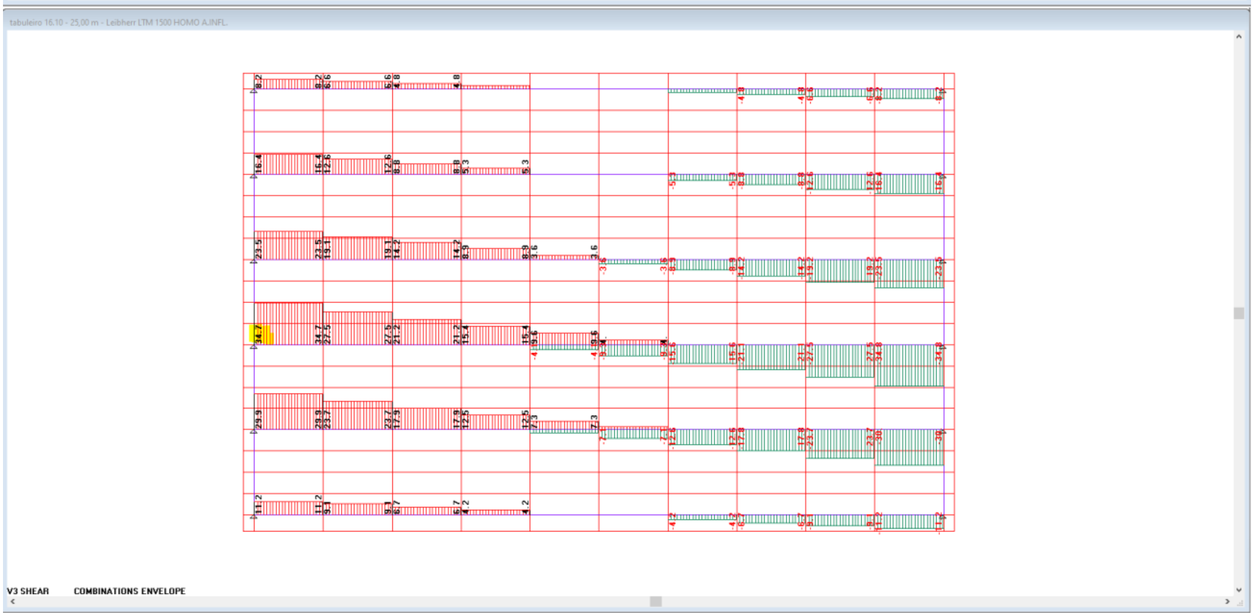

tabuleiro 16.10 - 20,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 20,00 m - permanentes
V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE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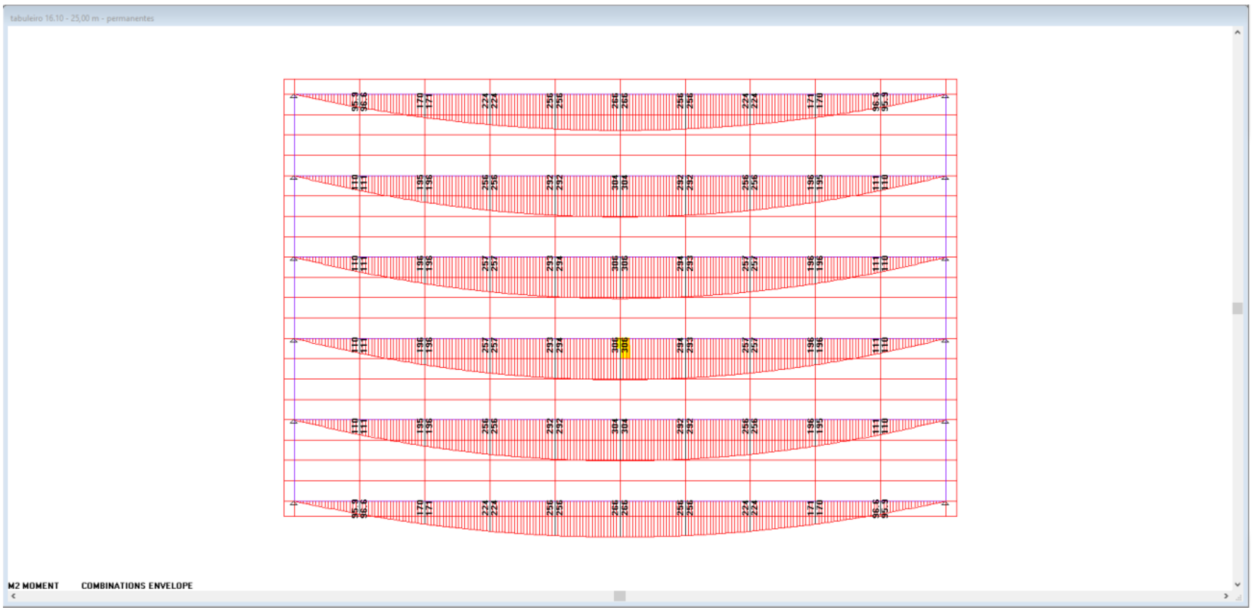
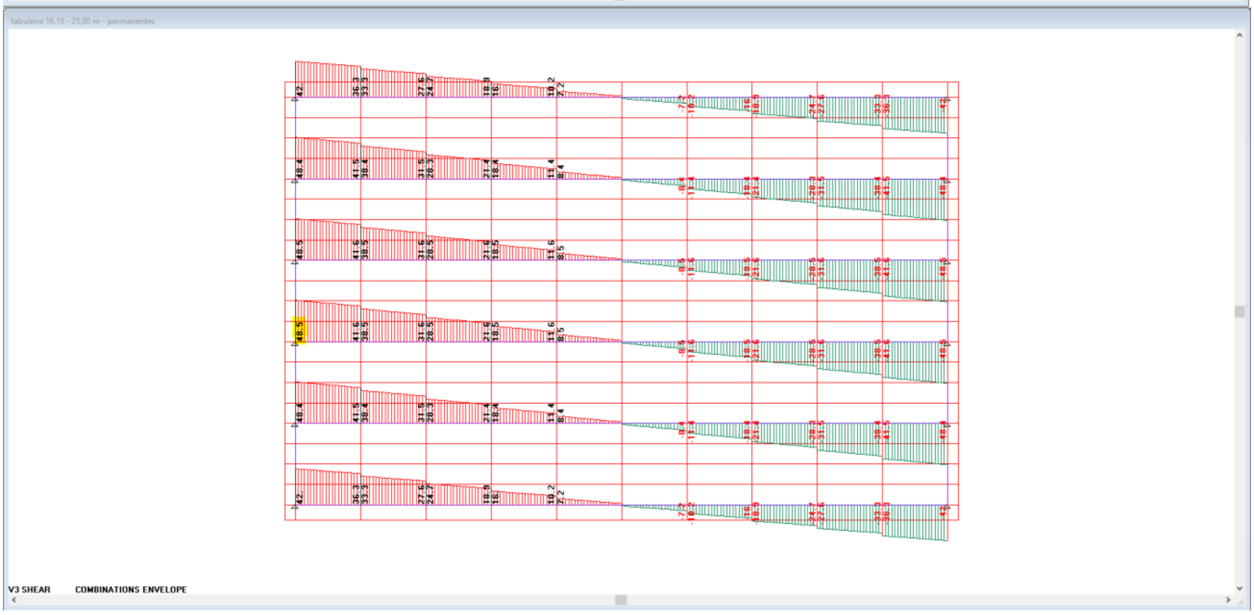
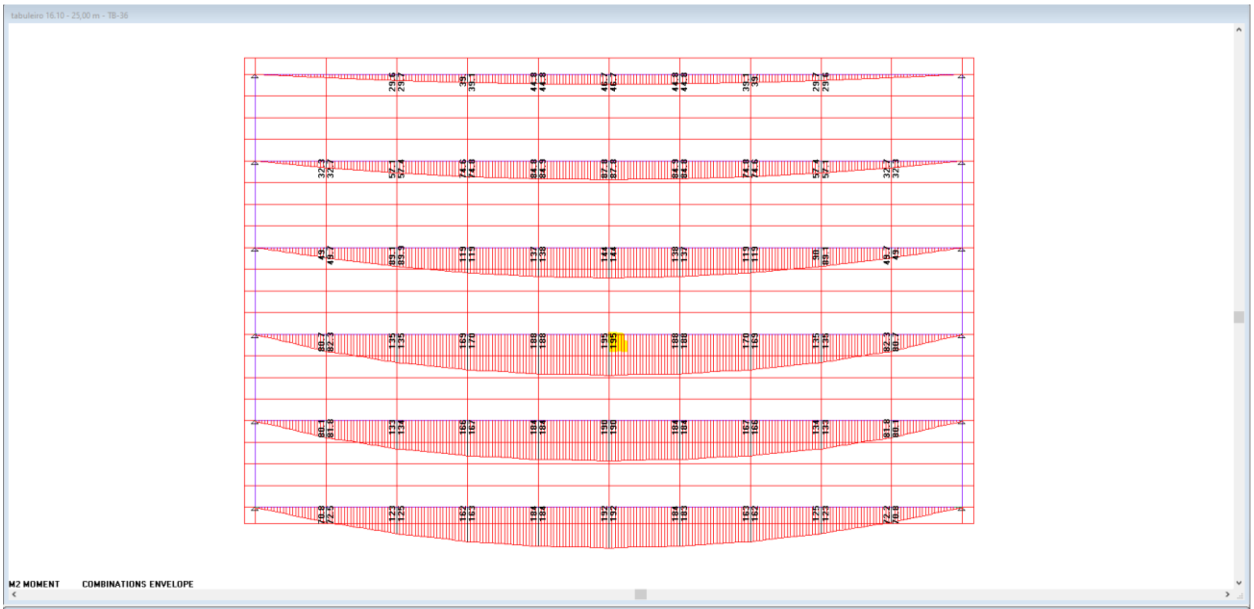
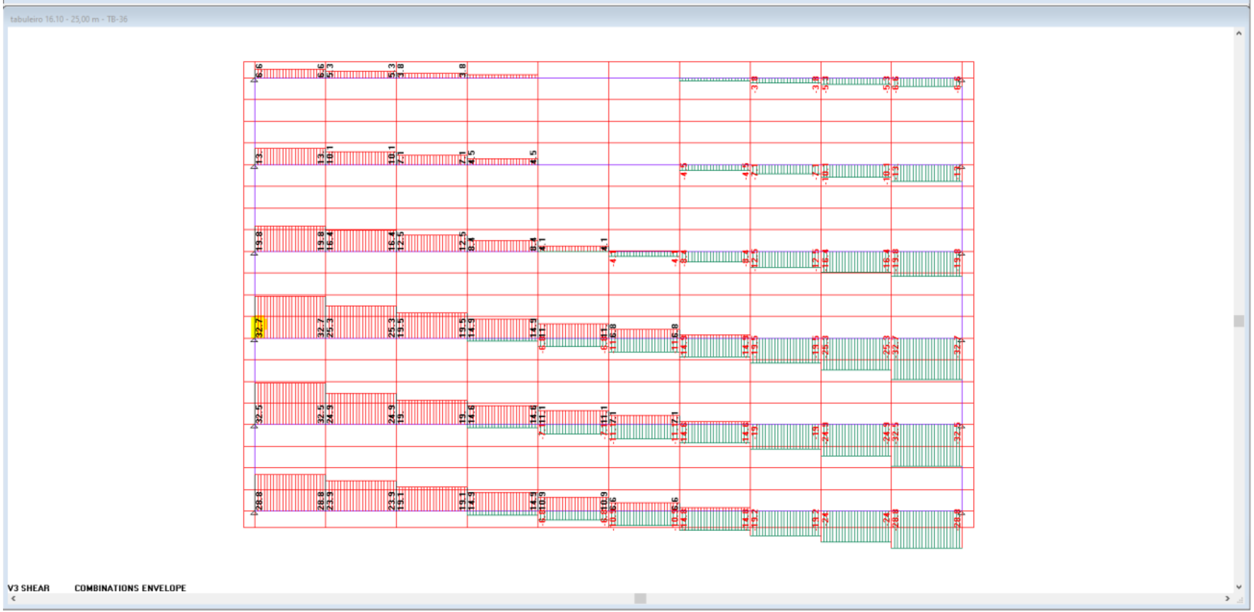
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 25,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 25,00 m - permanentes
V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE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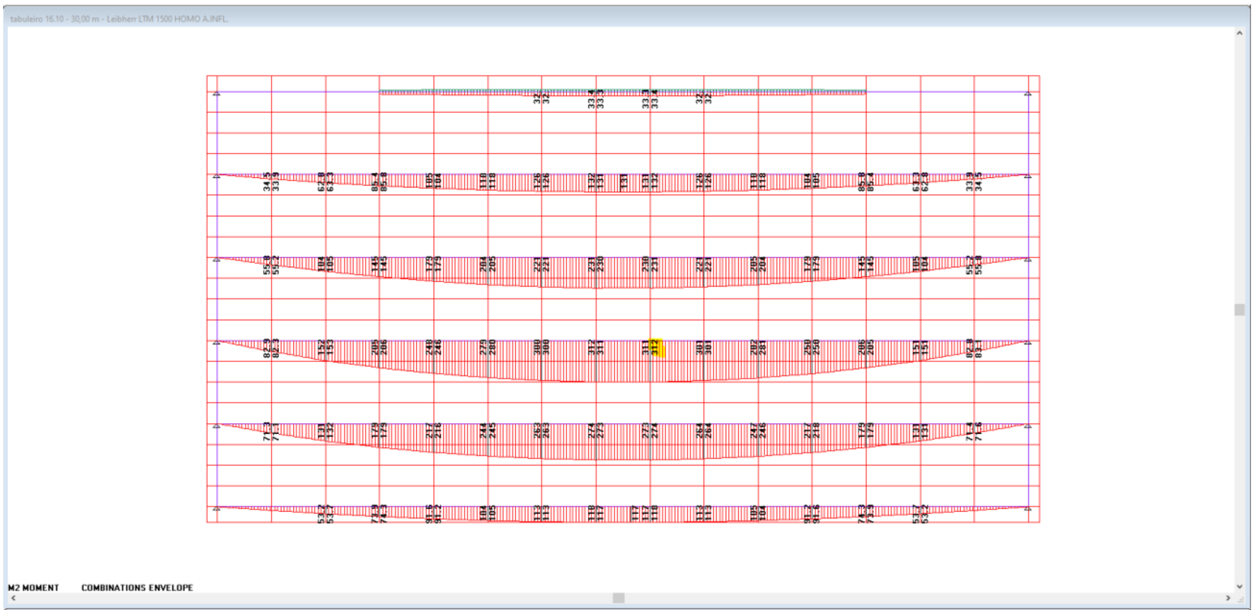
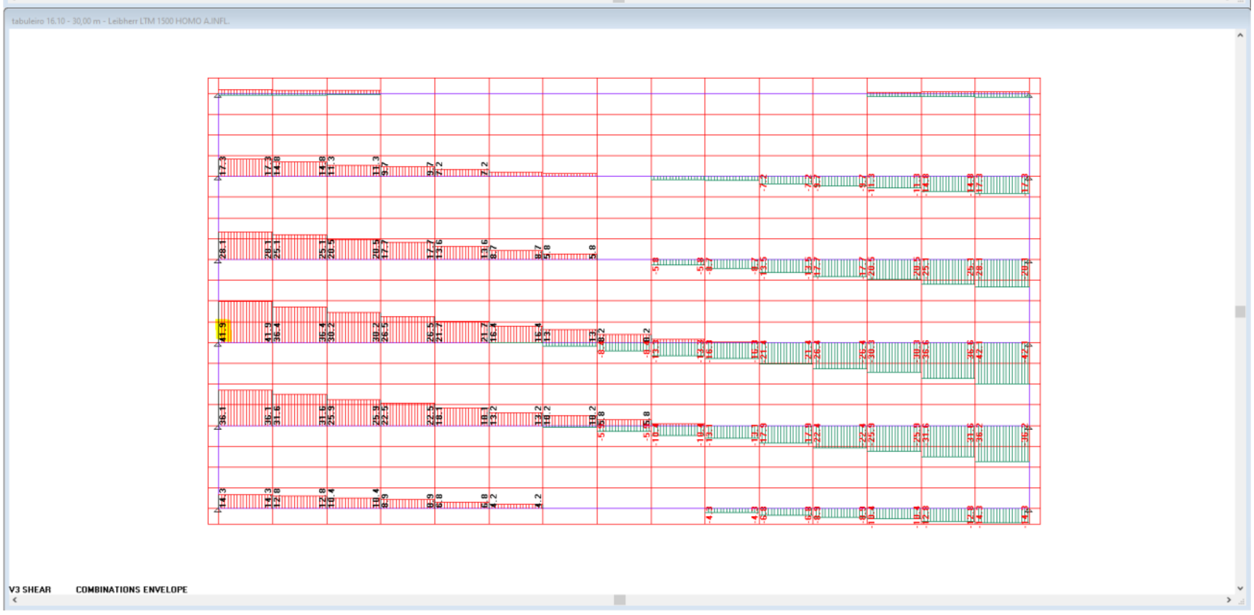
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 30,00 m - Leibherr LTM 1500 HOMO A.INFL.
M2 MOMENT
COMBINATIONS ENVELOPE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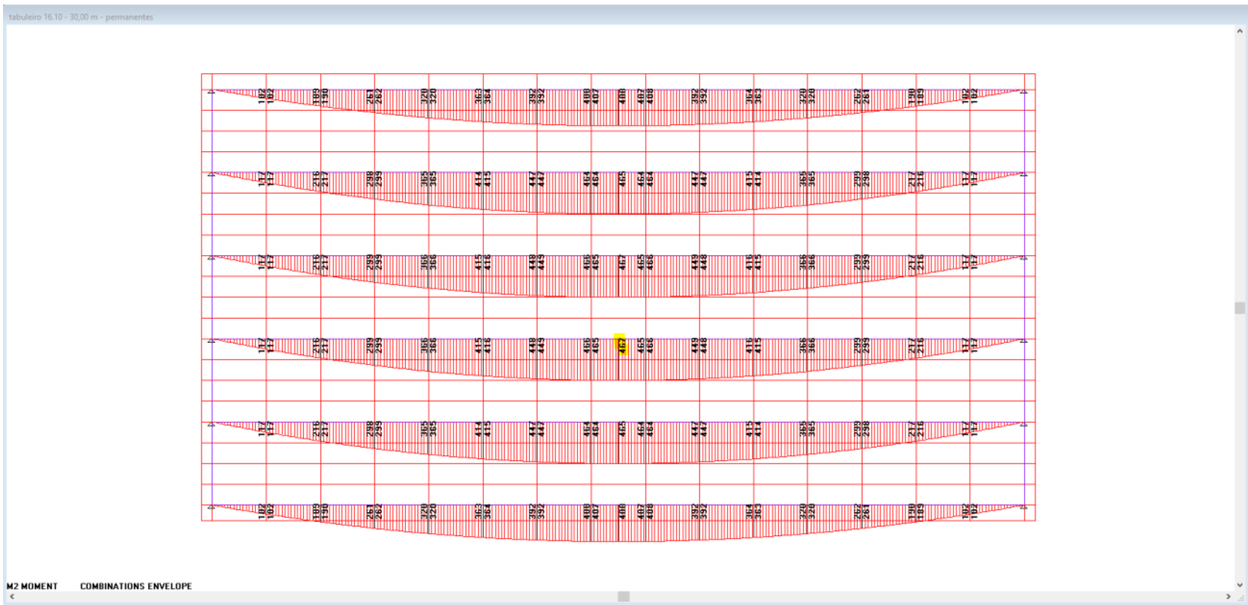
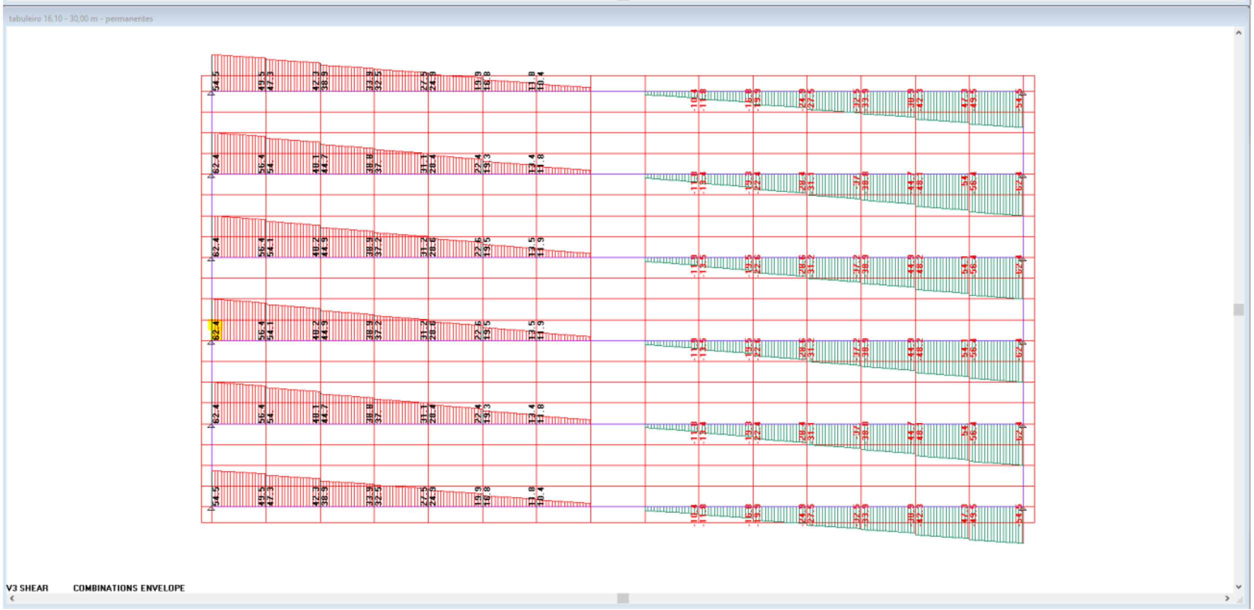
V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 30,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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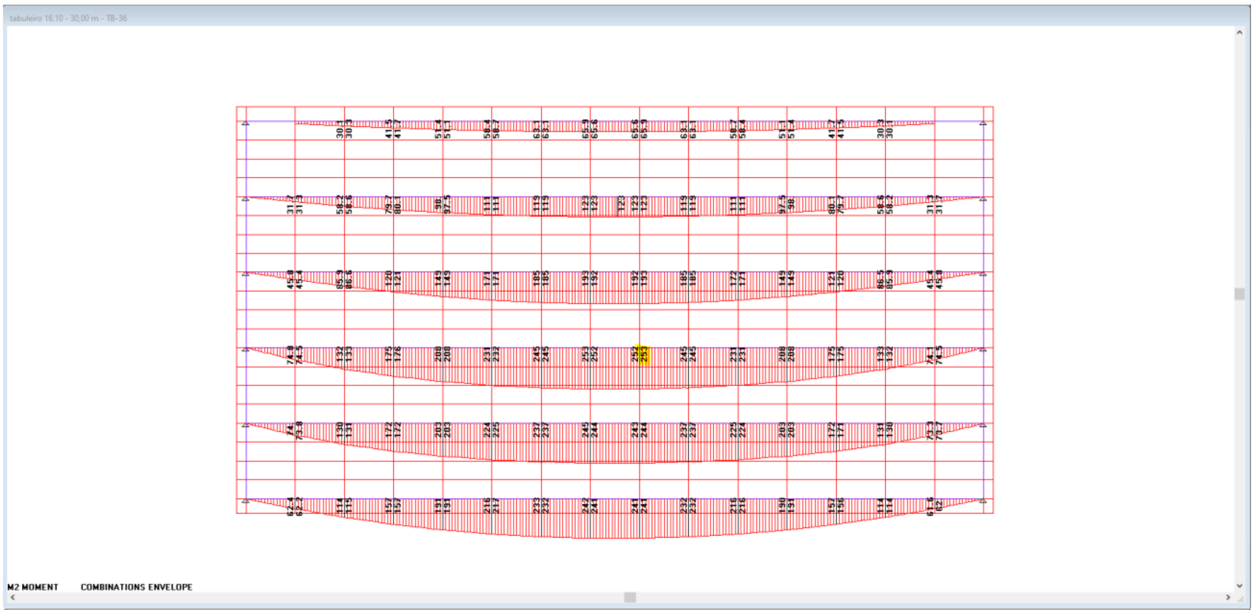
V3 SHEAR
COMBINATIONS ENVELOPE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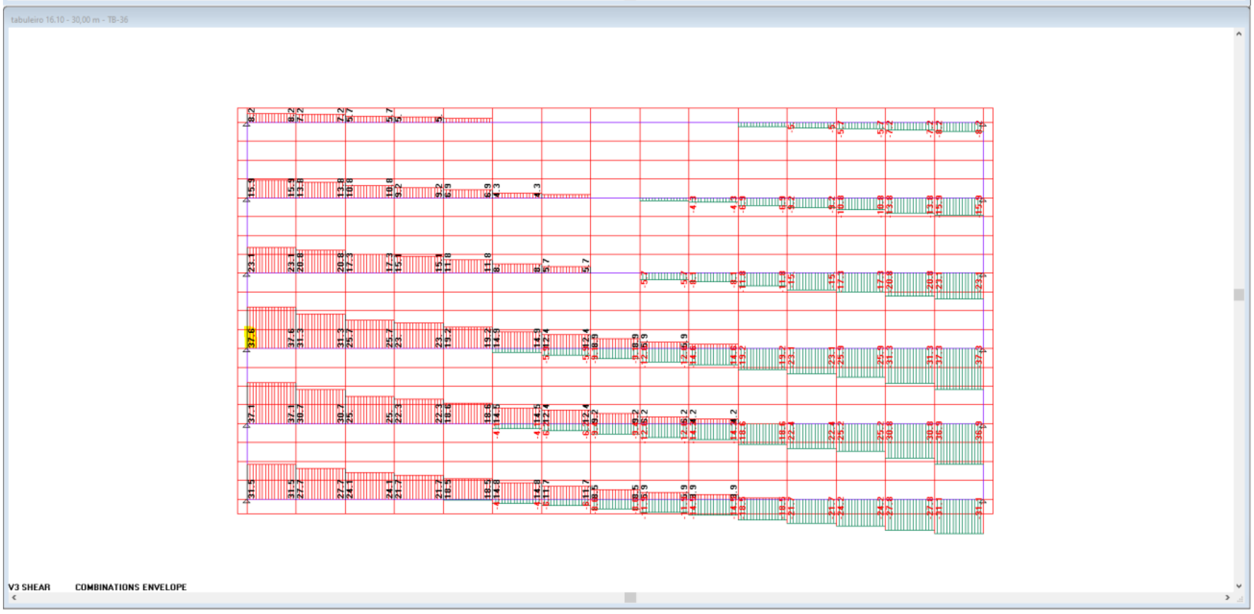
COMBINATIONS ENVELOPE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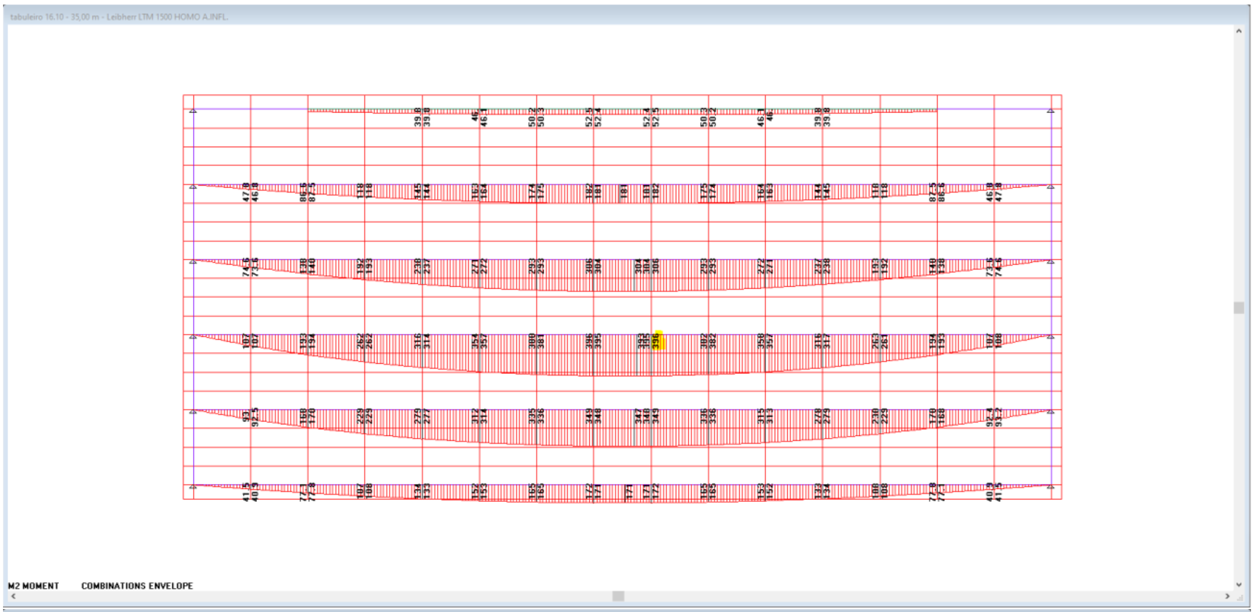
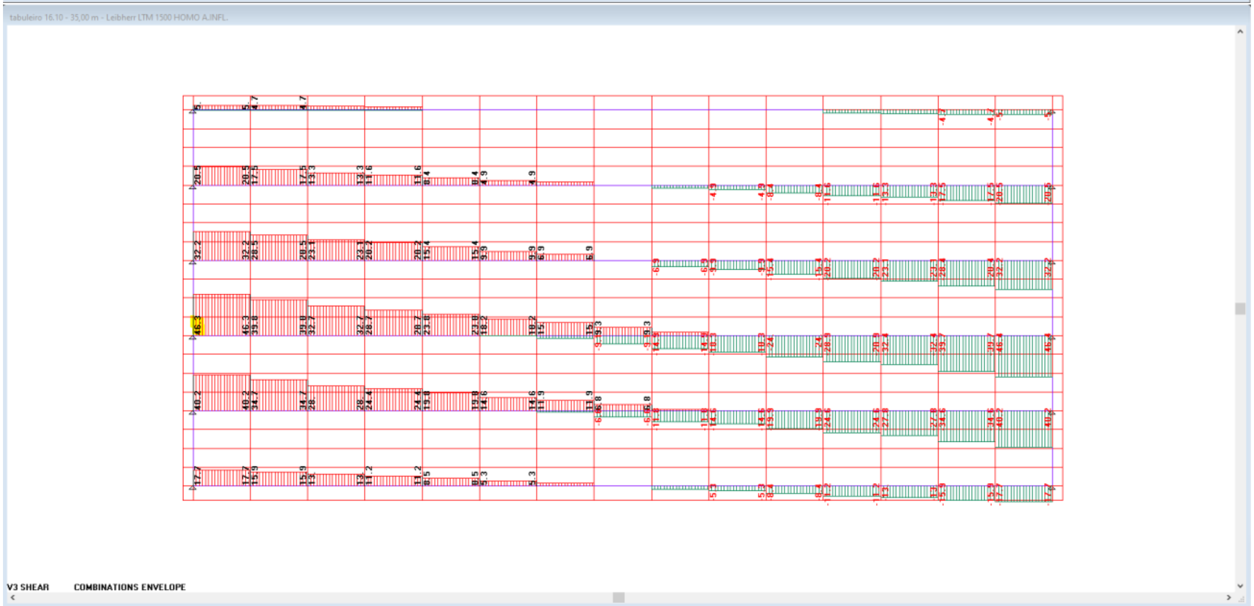
COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE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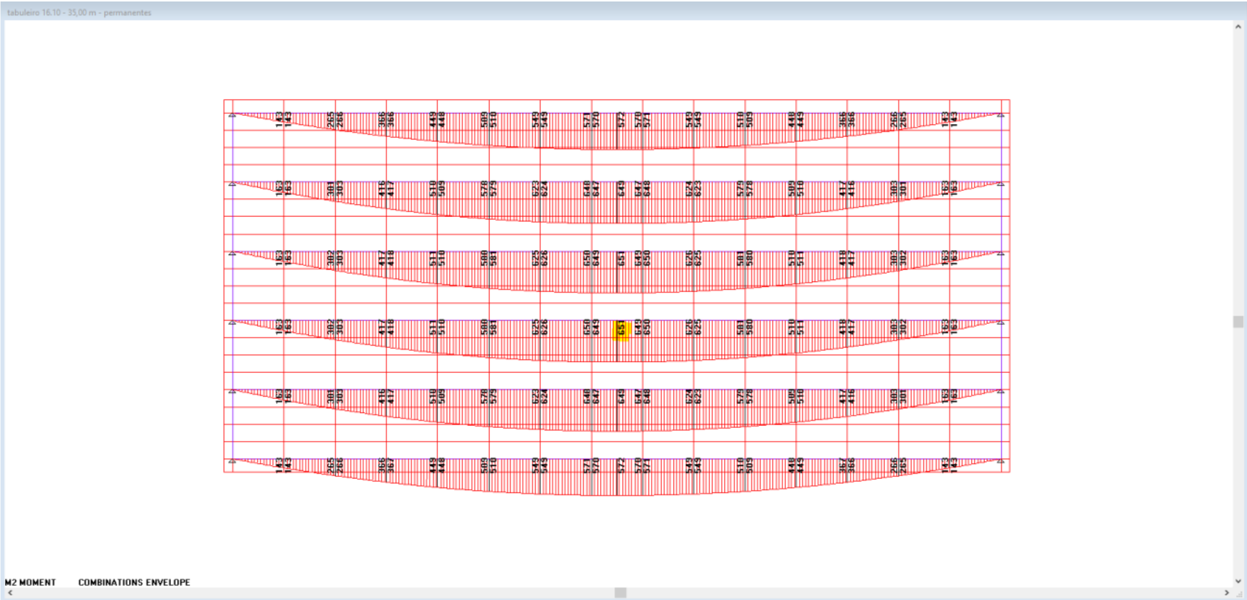
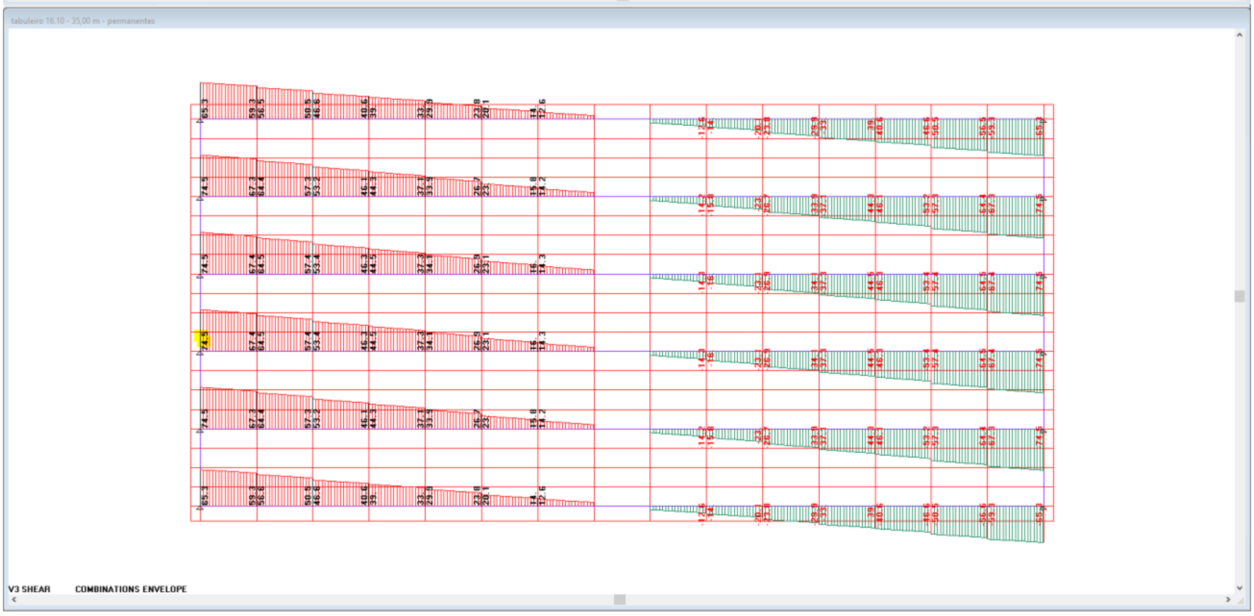

tabuleiro 16.10 - 35,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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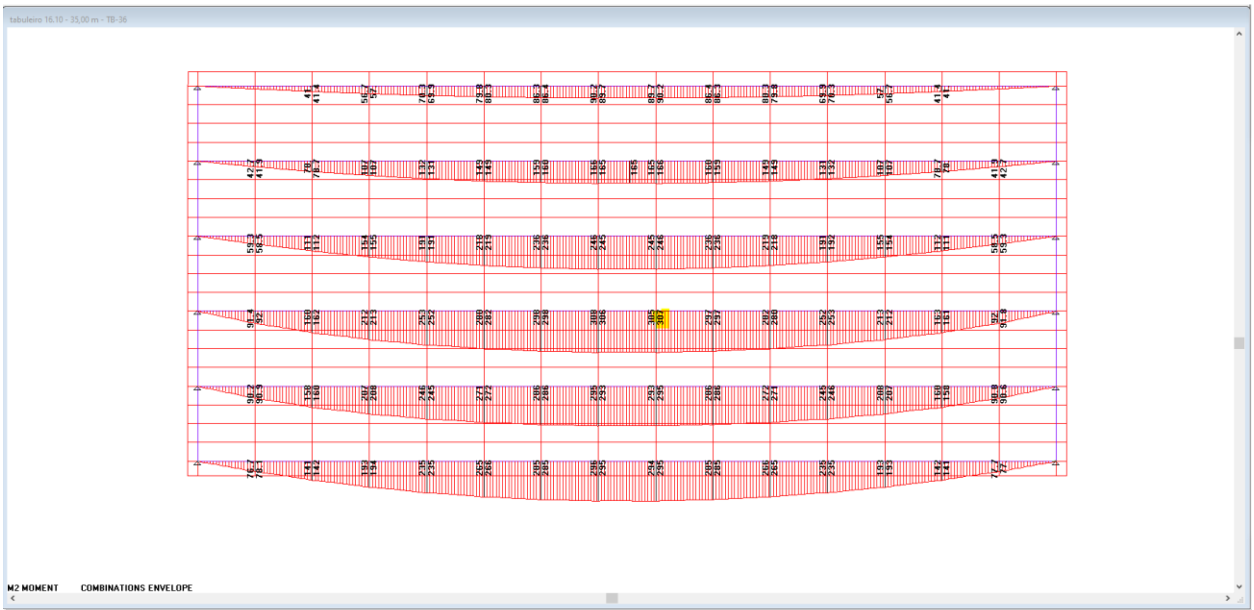
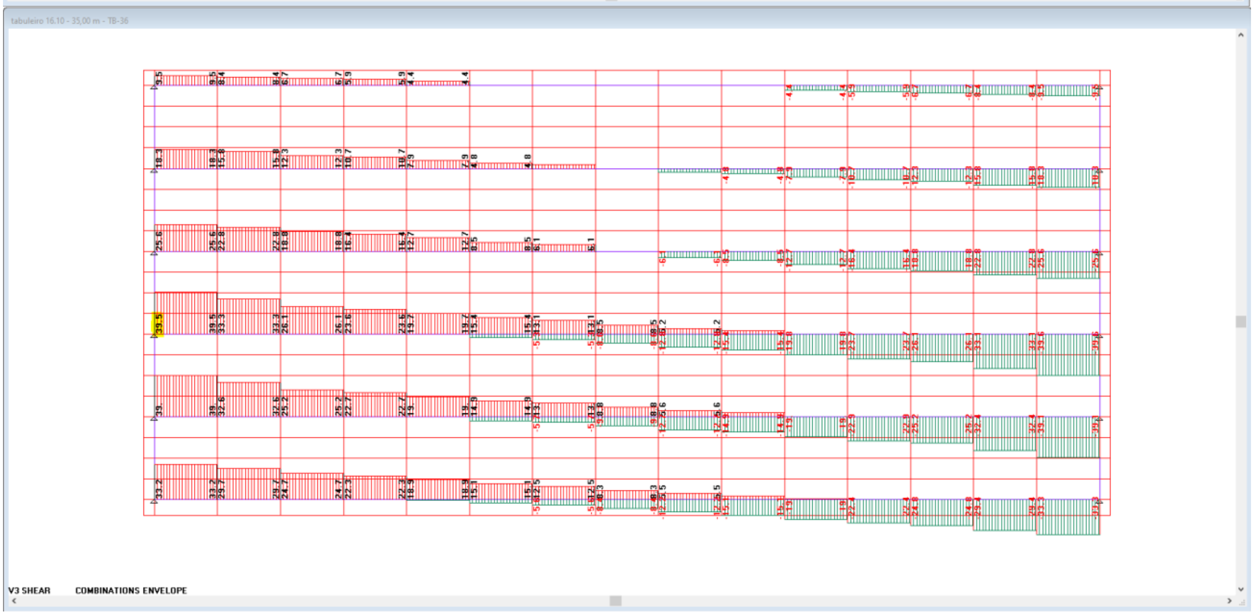
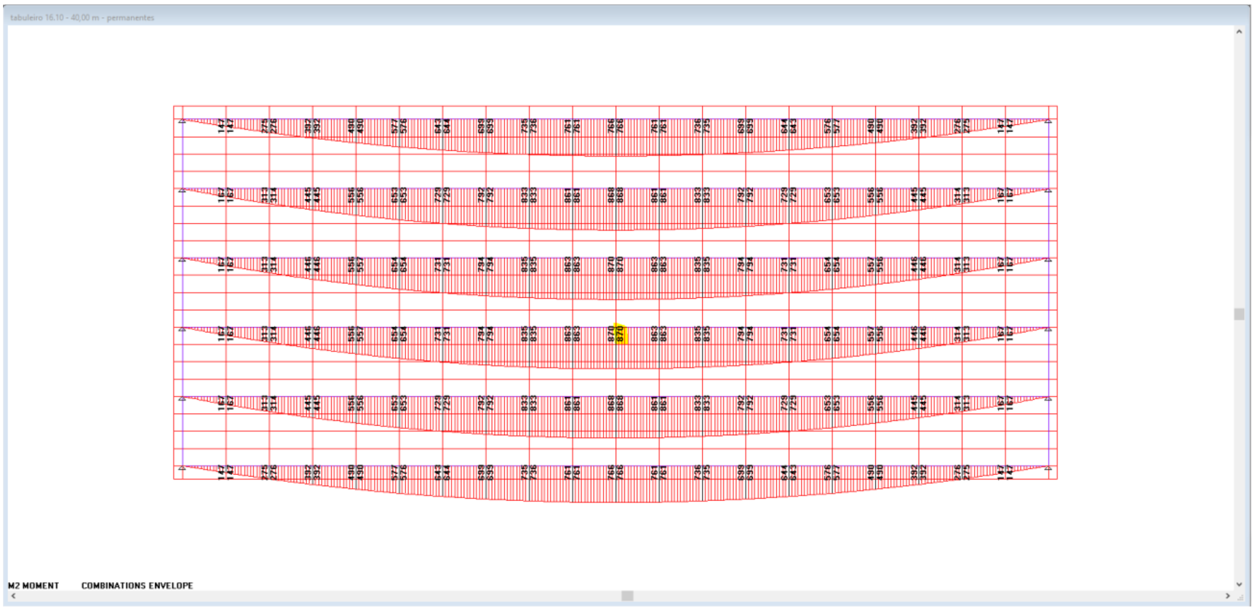
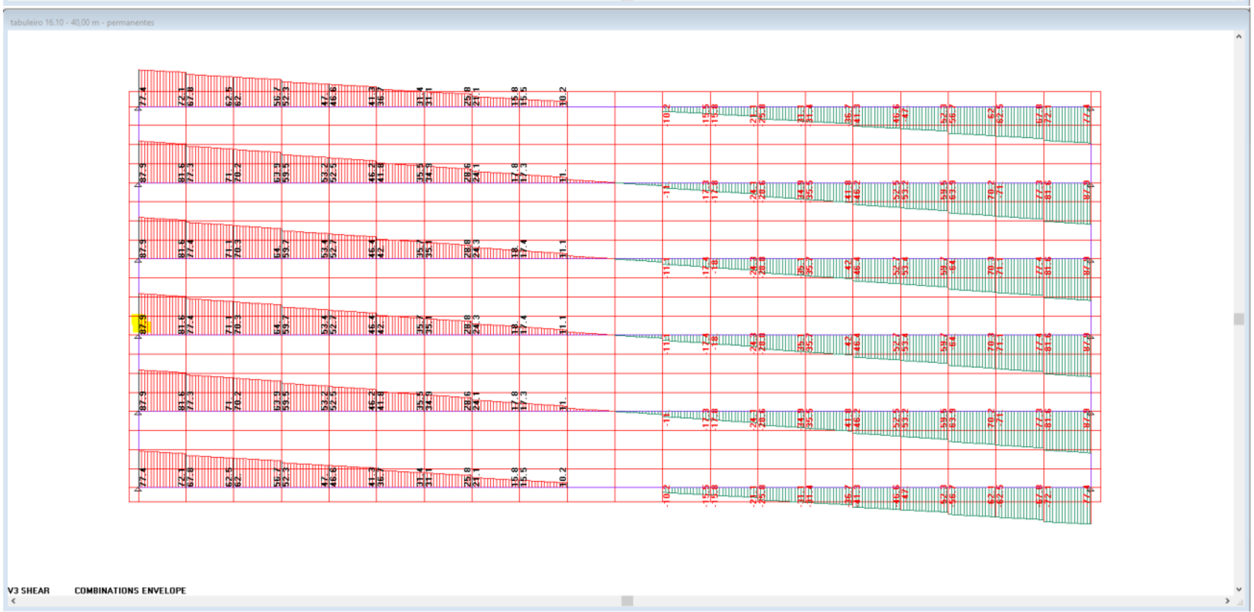
V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 35,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 35,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 16.10 - 40,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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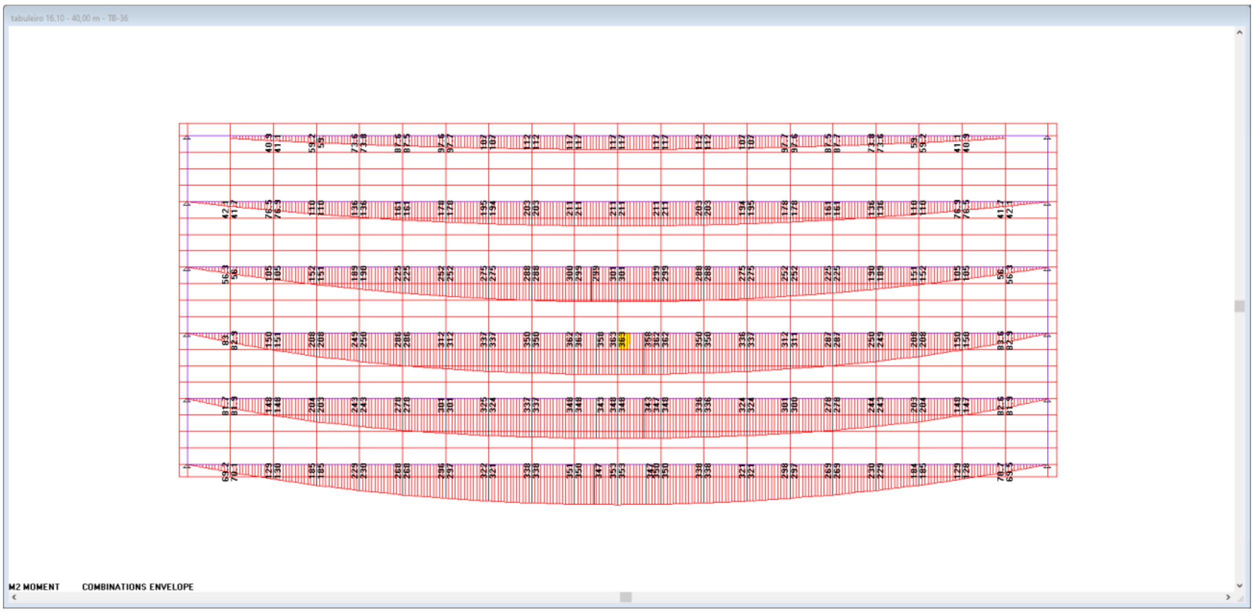
V3 SHEAR
COMBINATIONS ENVELOPE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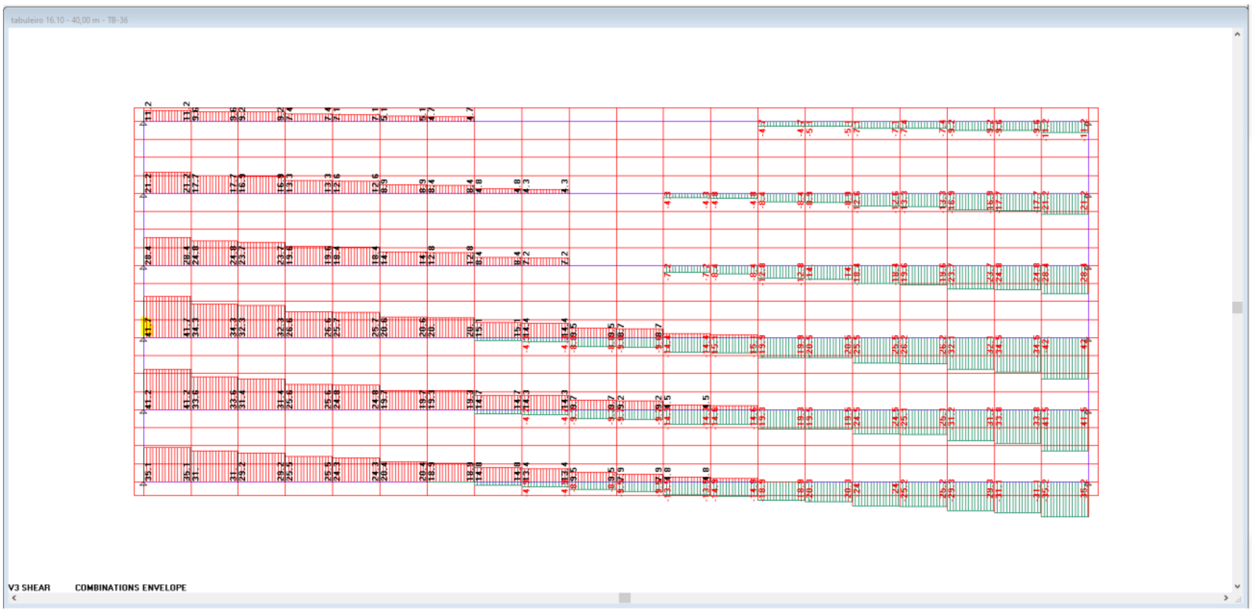
M2 MOMENT
COMBINATIONS ENVELOPE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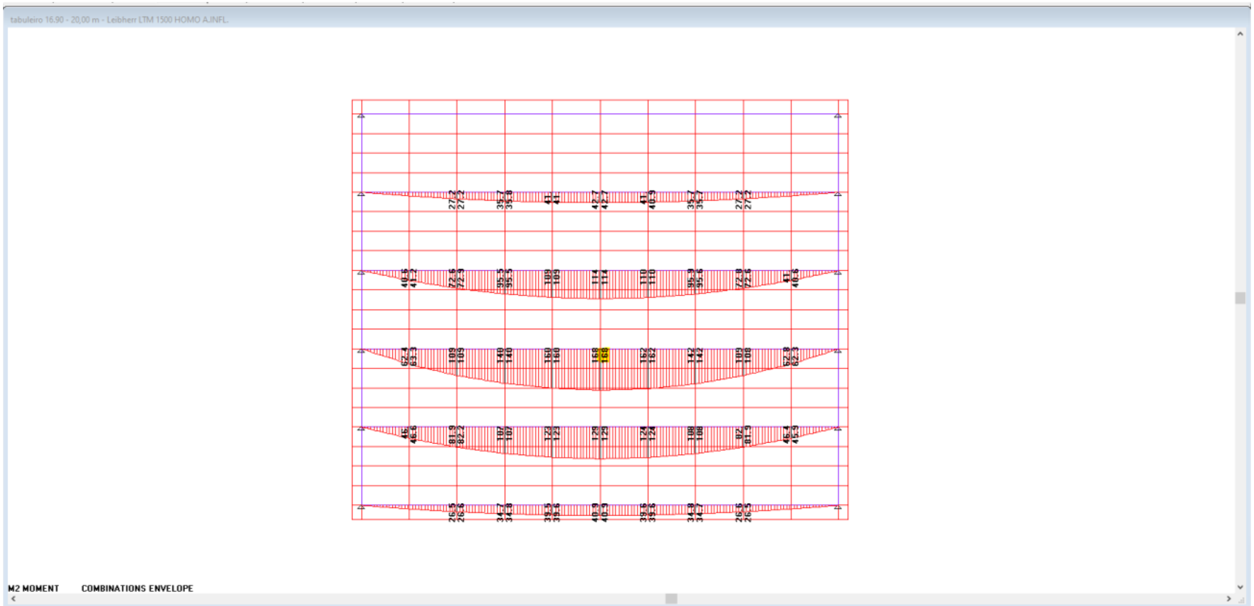
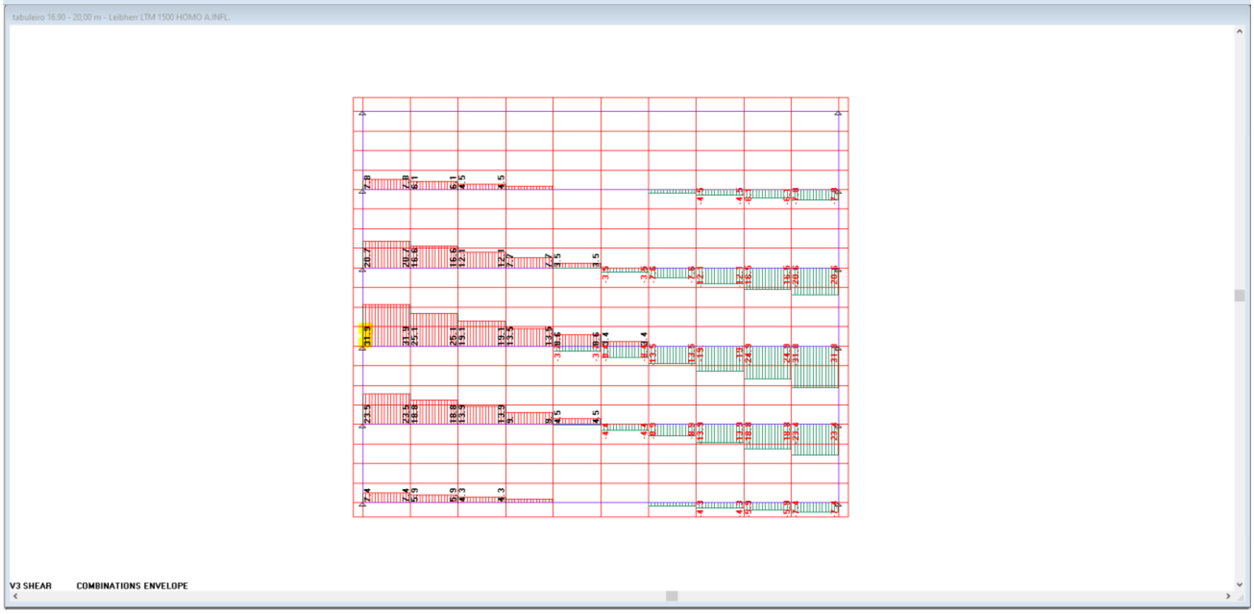
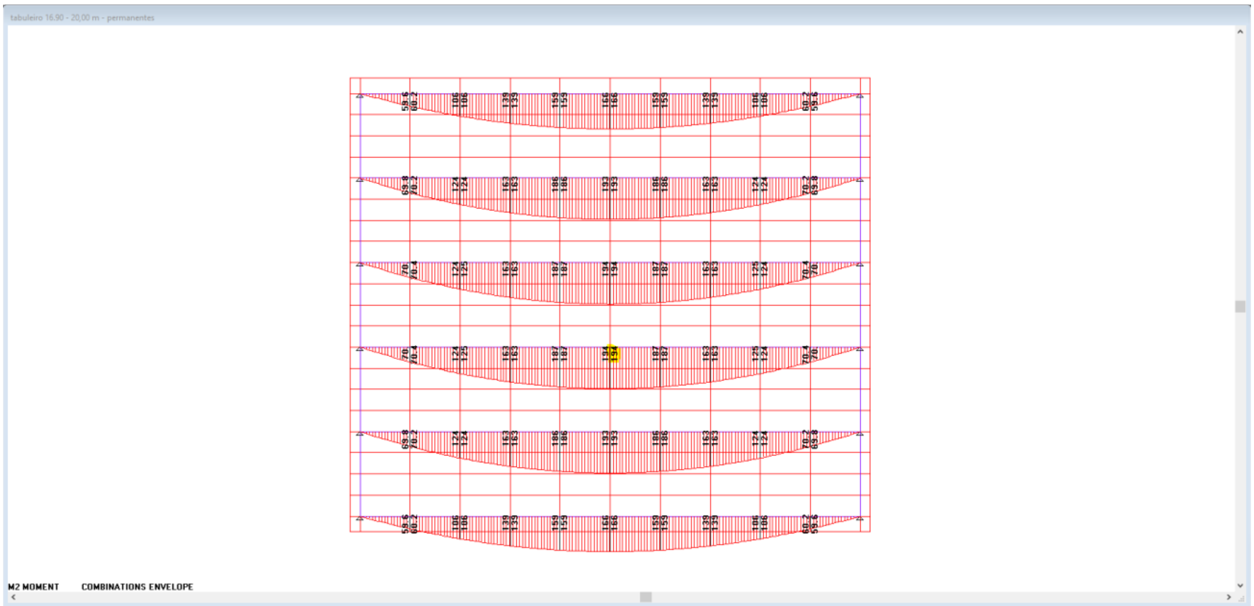
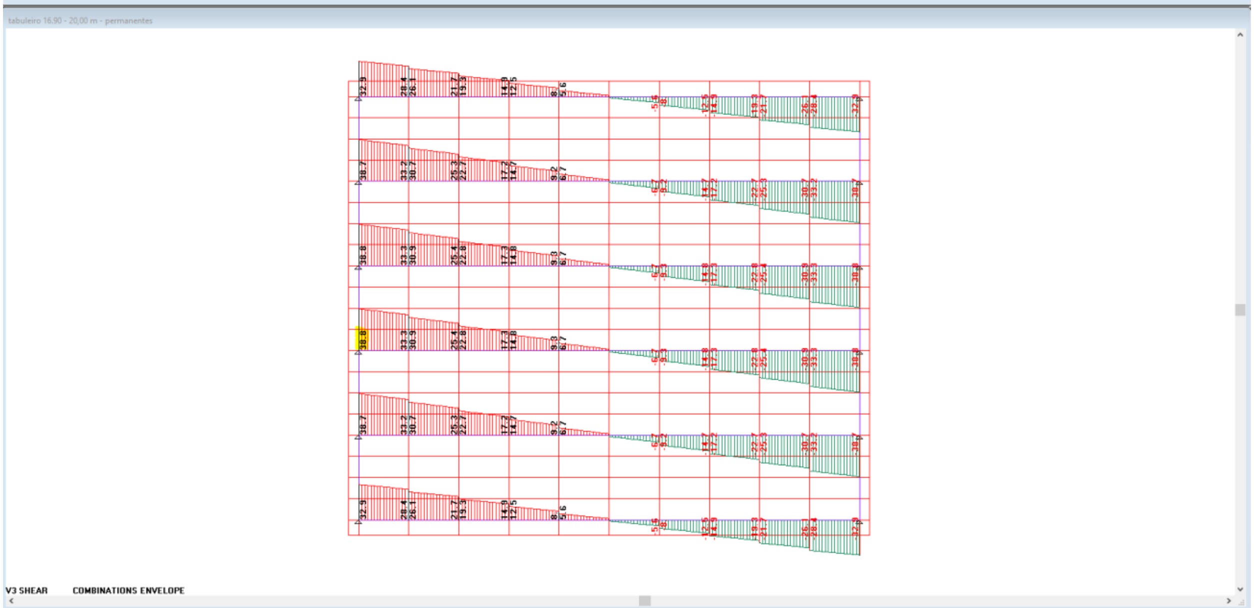
V3 SHEAR
COMBINATIONS ENVELOPE

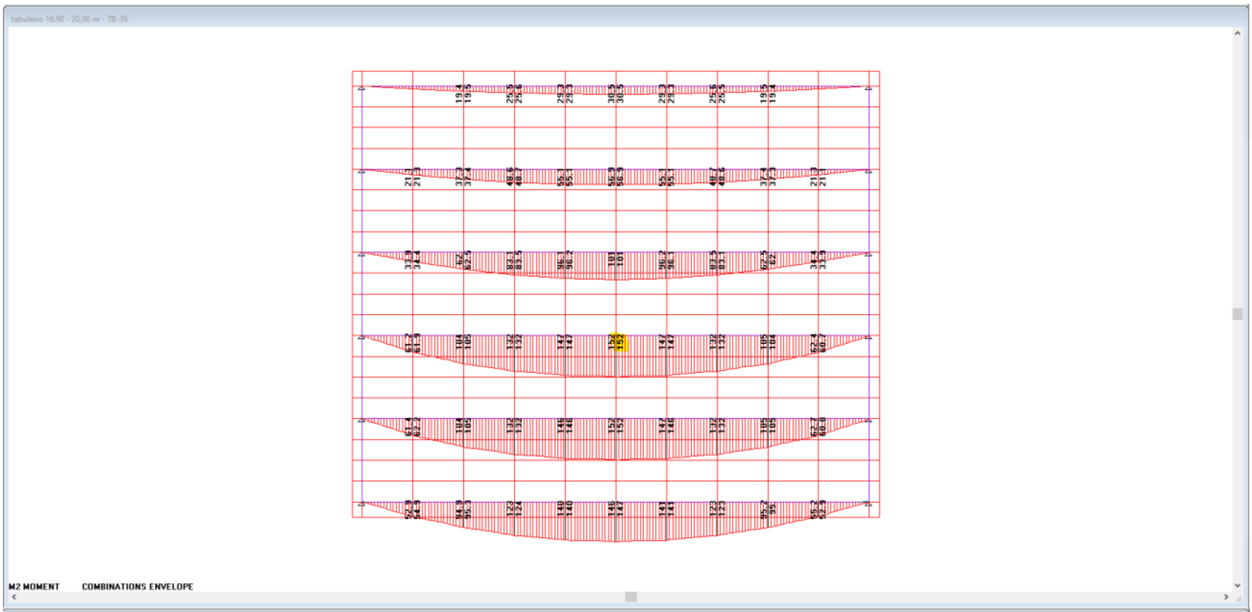
4.6.5. Tabuleiro 16,90 m

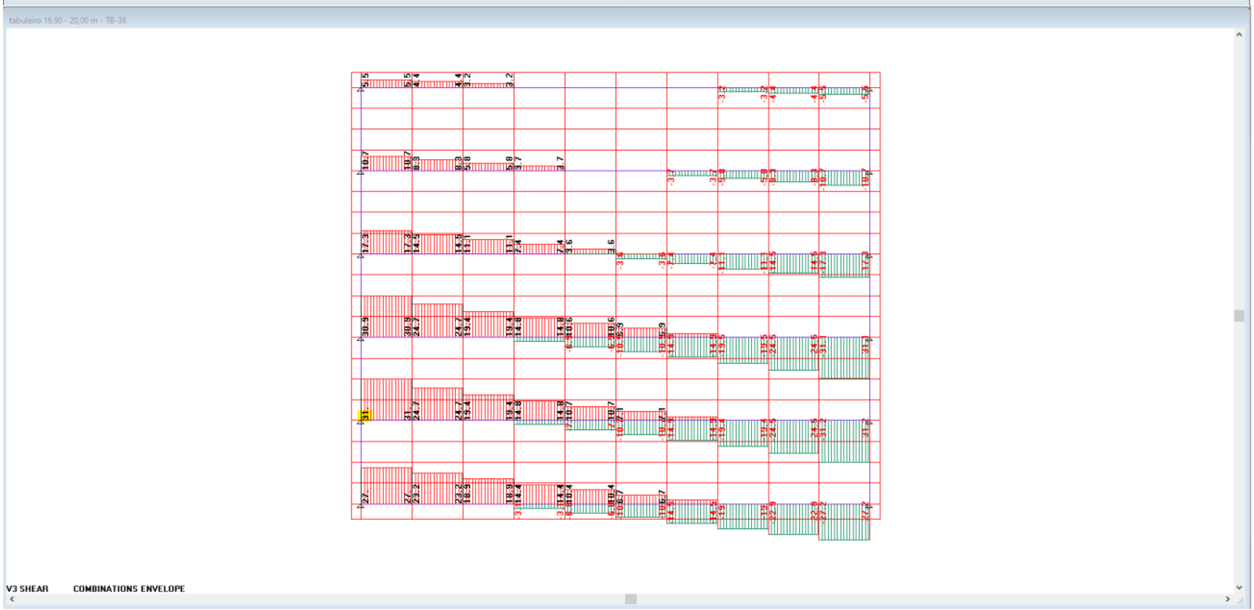





M2 MOMENT COMBINATIONS ENVELOPE


V3 SHEAR COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE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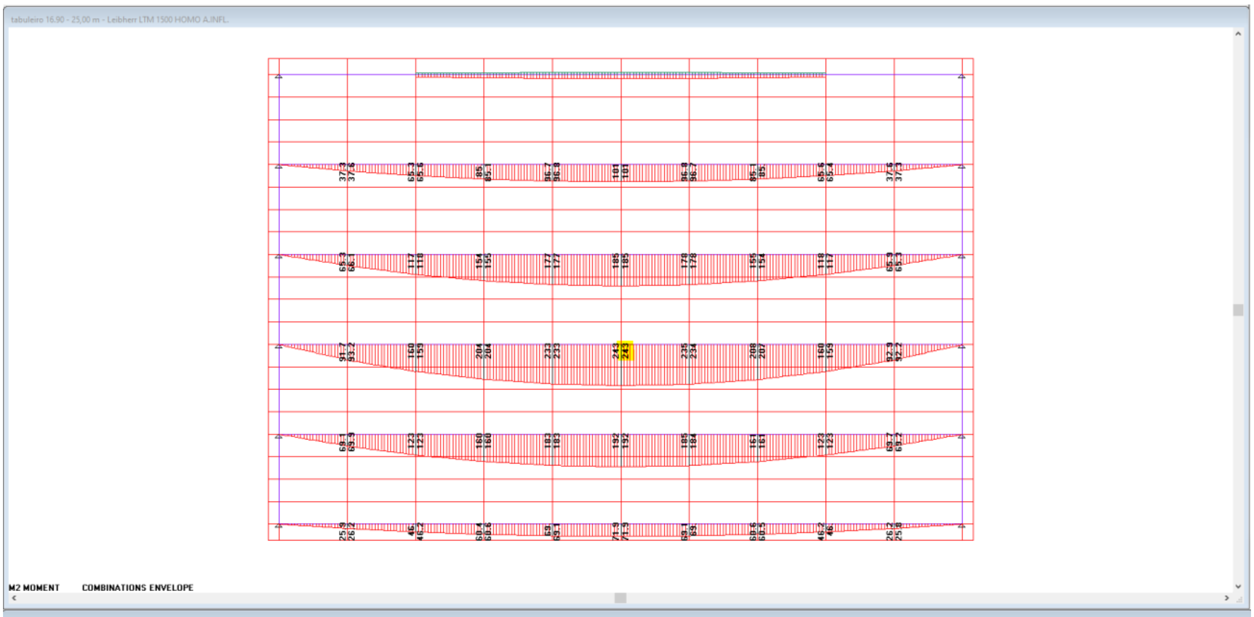
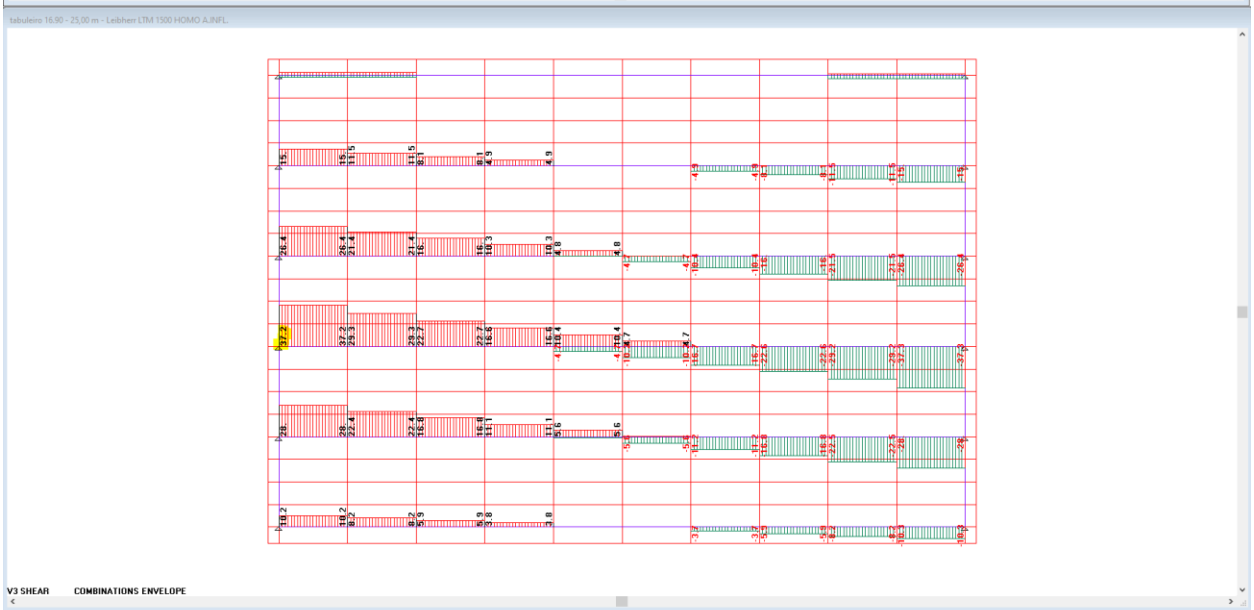
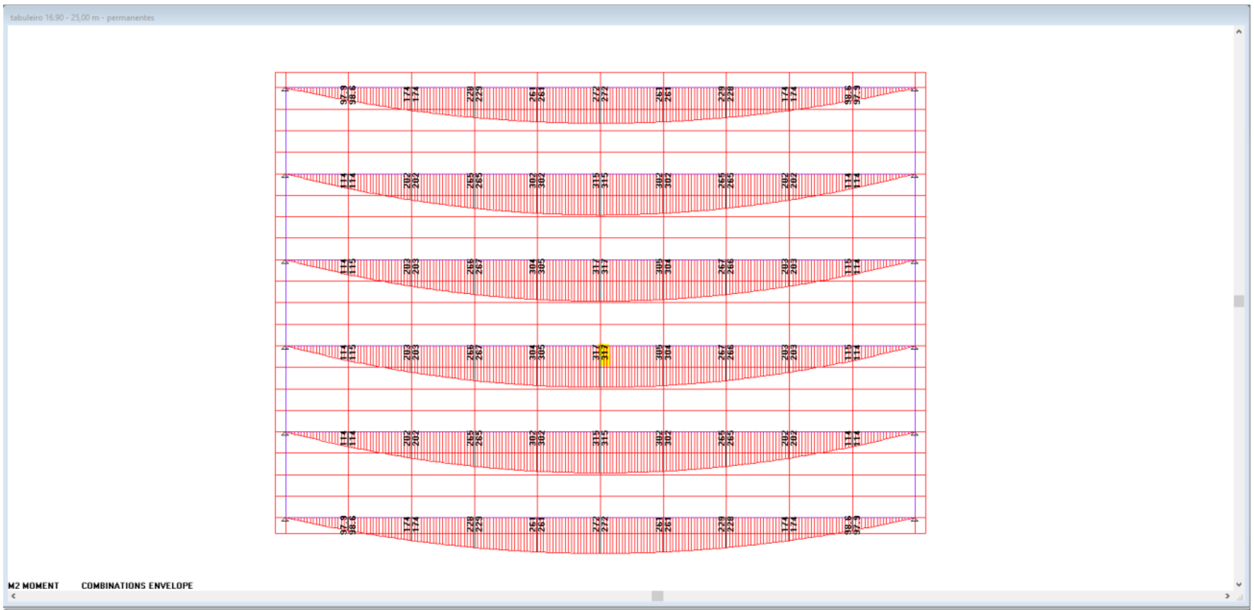
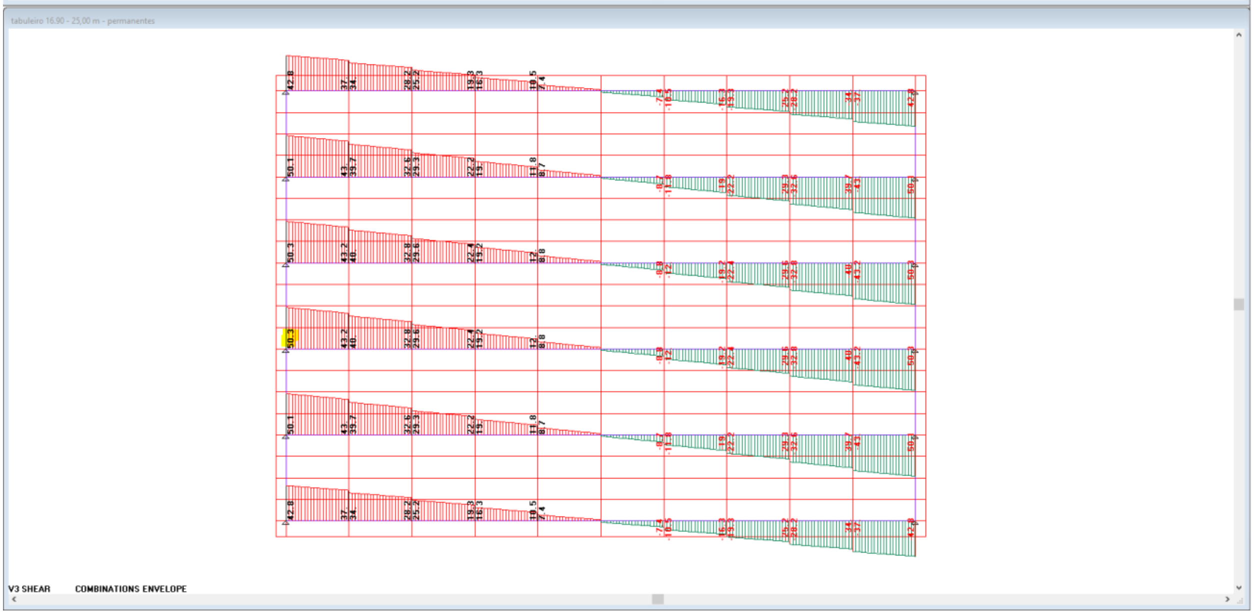

M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 16.90 - 25,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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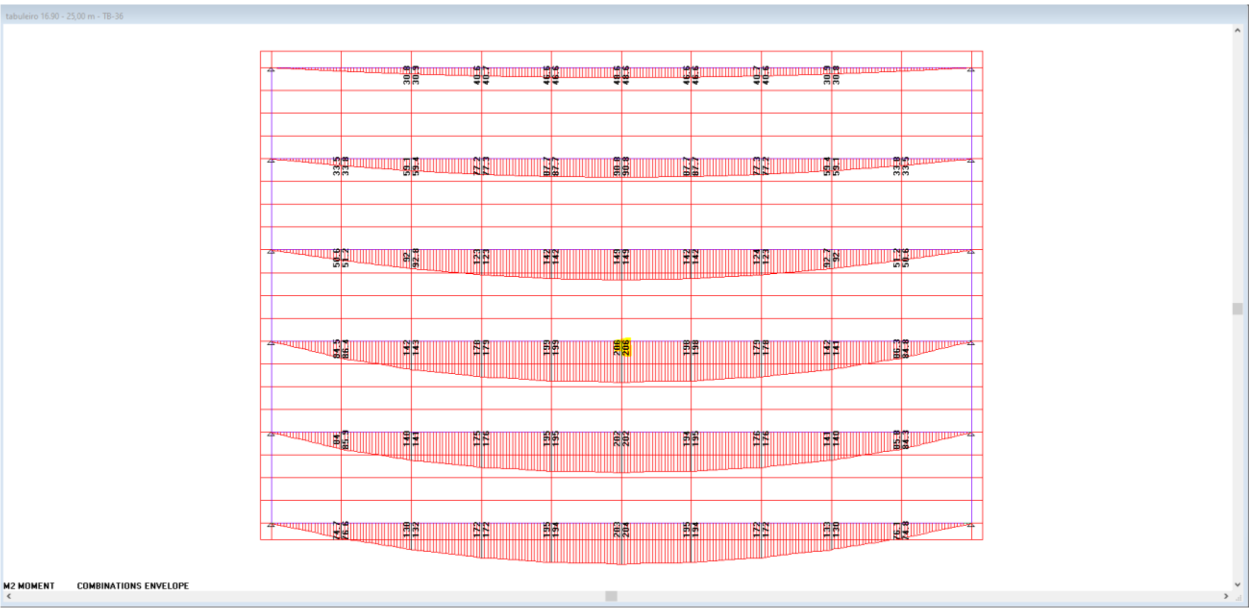
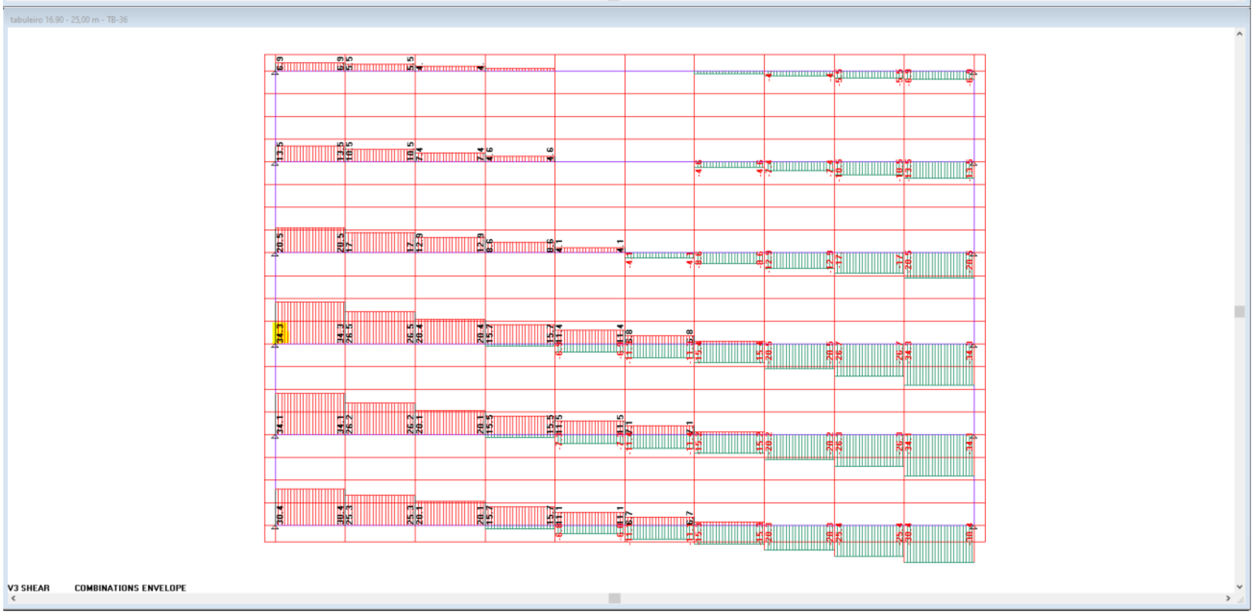
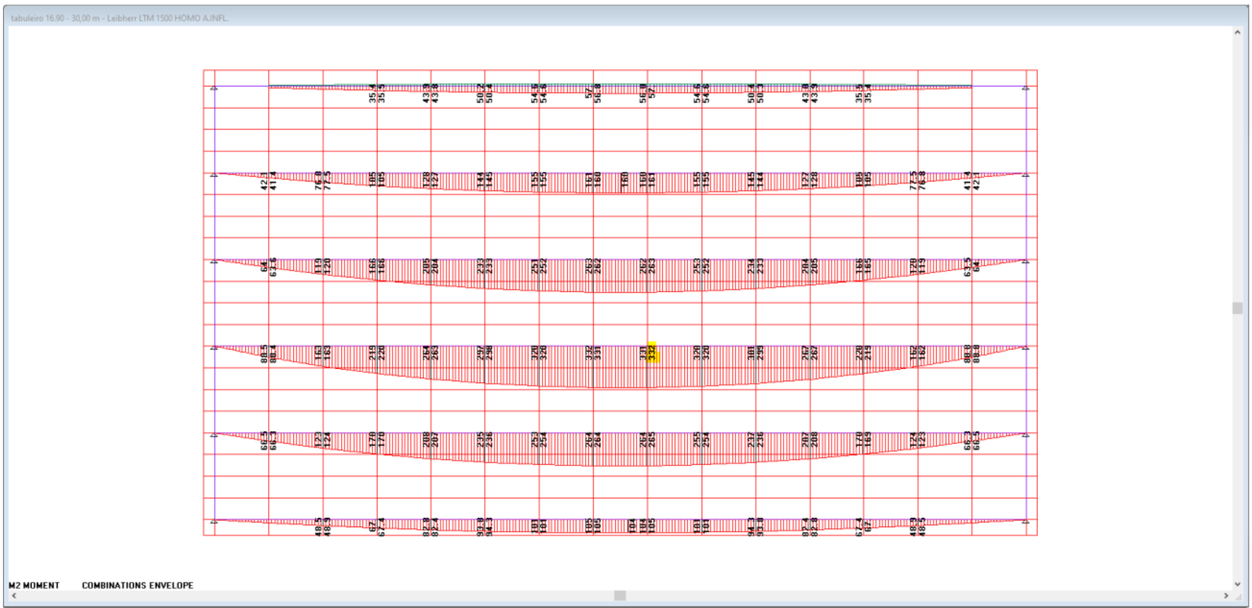
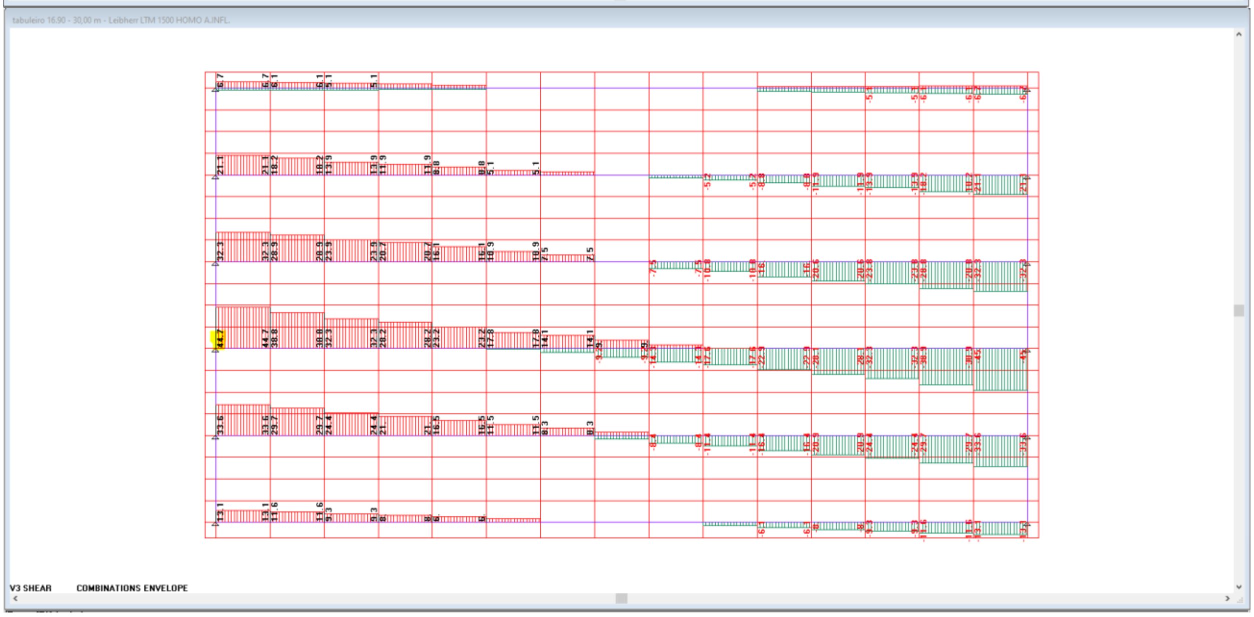
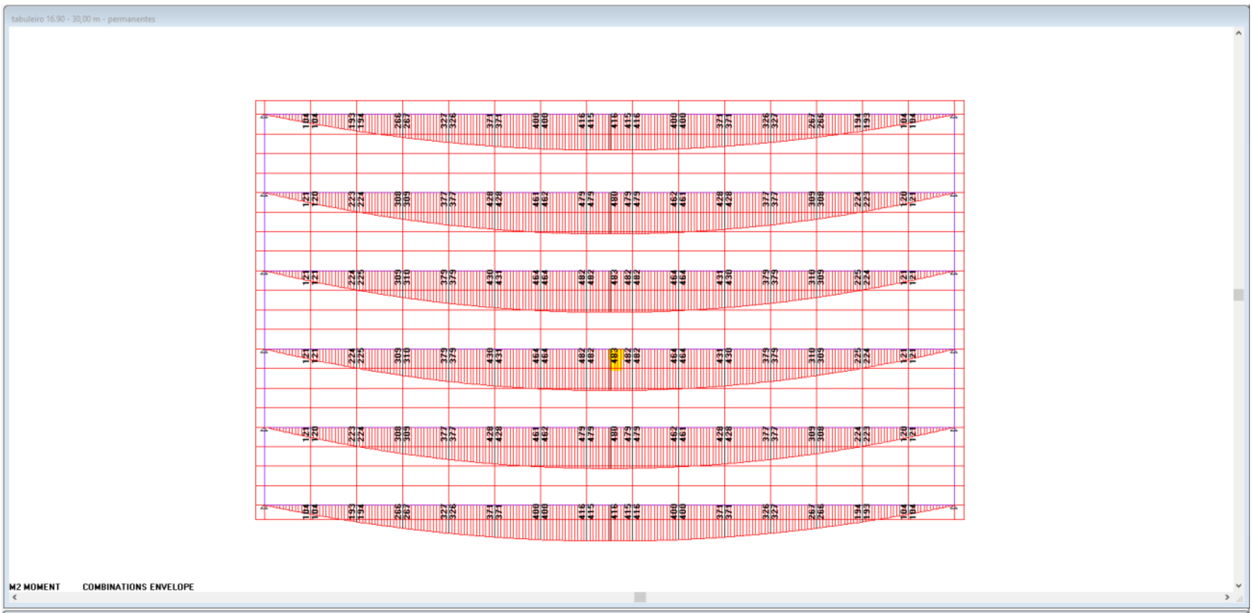
V3 SHEAR
COMBINATIONS ENVELOPE

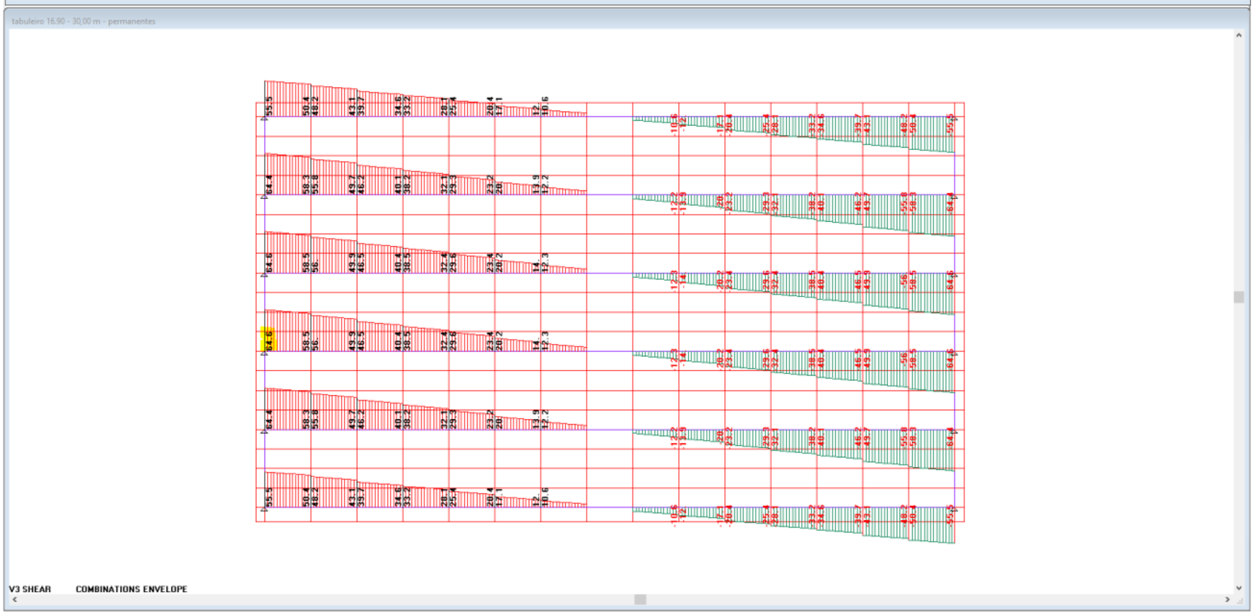

tabuleiro 16,90 - 25,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE

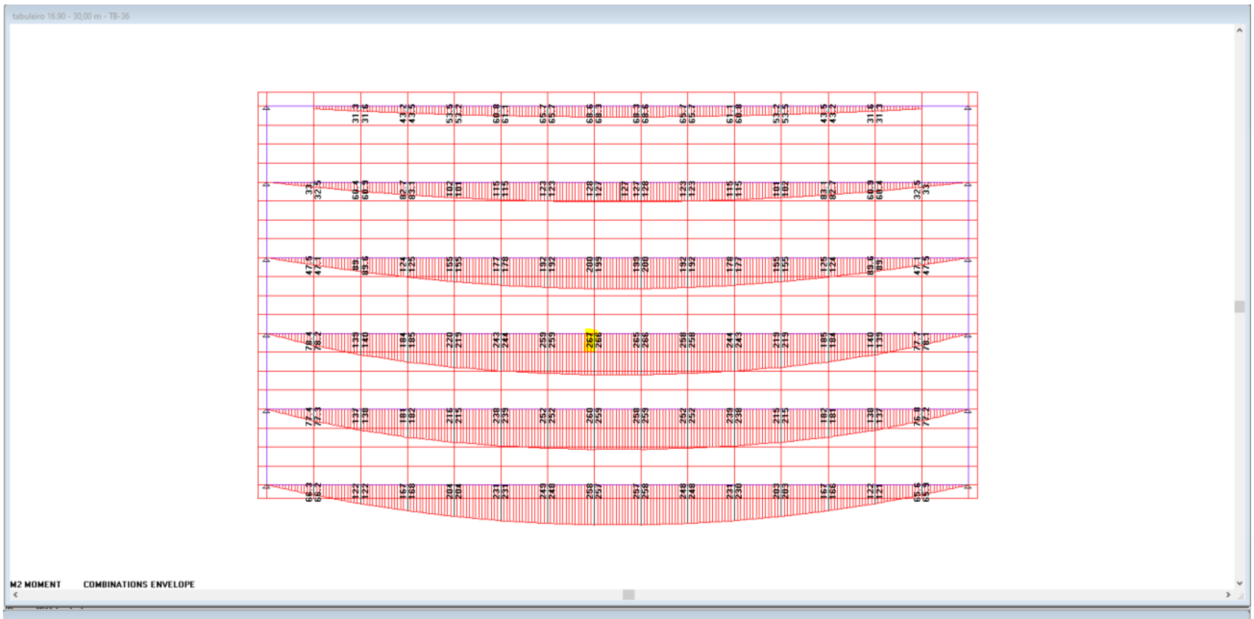

tabuleiro 16,90 - 25,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE

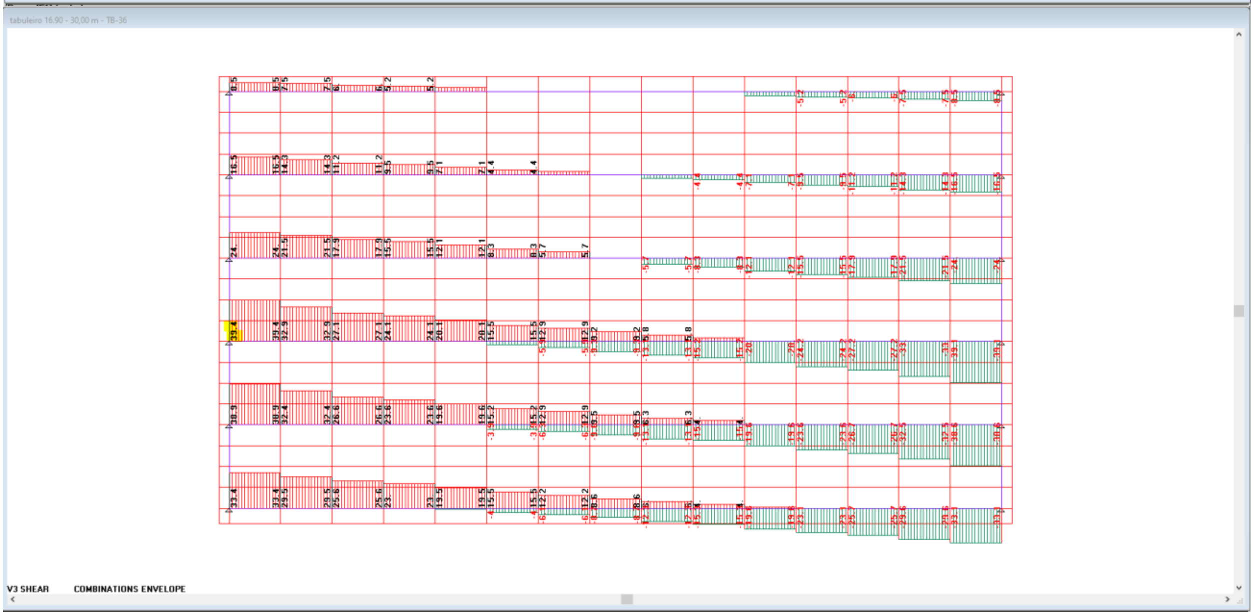

M2 MOMENT
COMBINATIONS ENVELOPE

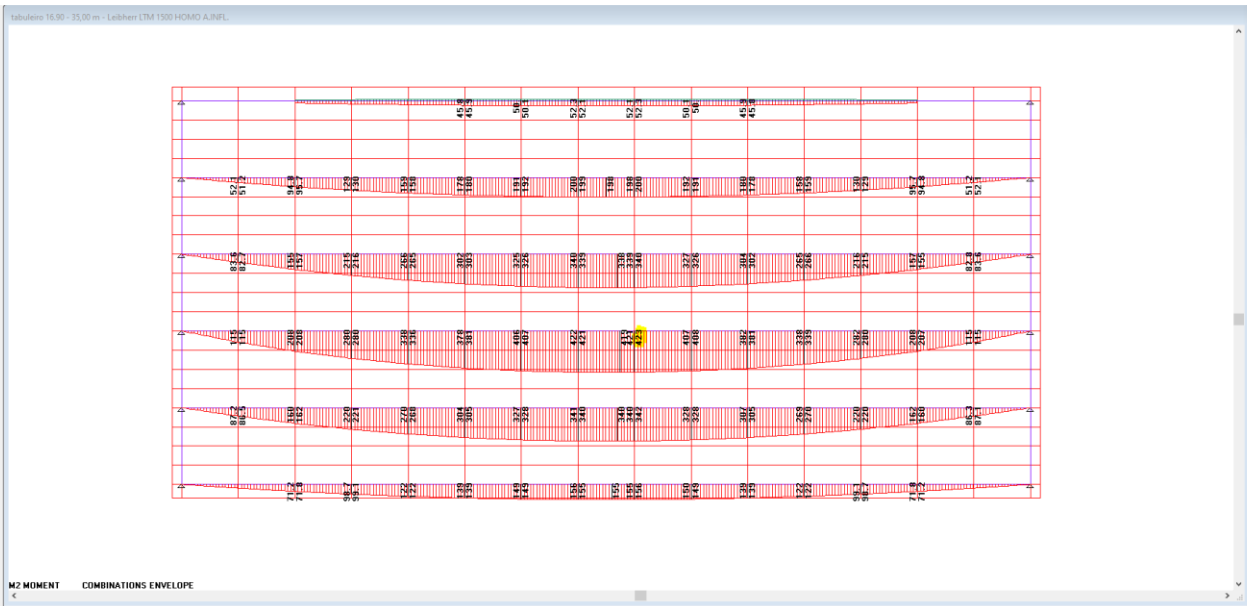

V3 SHEAR
COMBINATIONS ENVELOPE

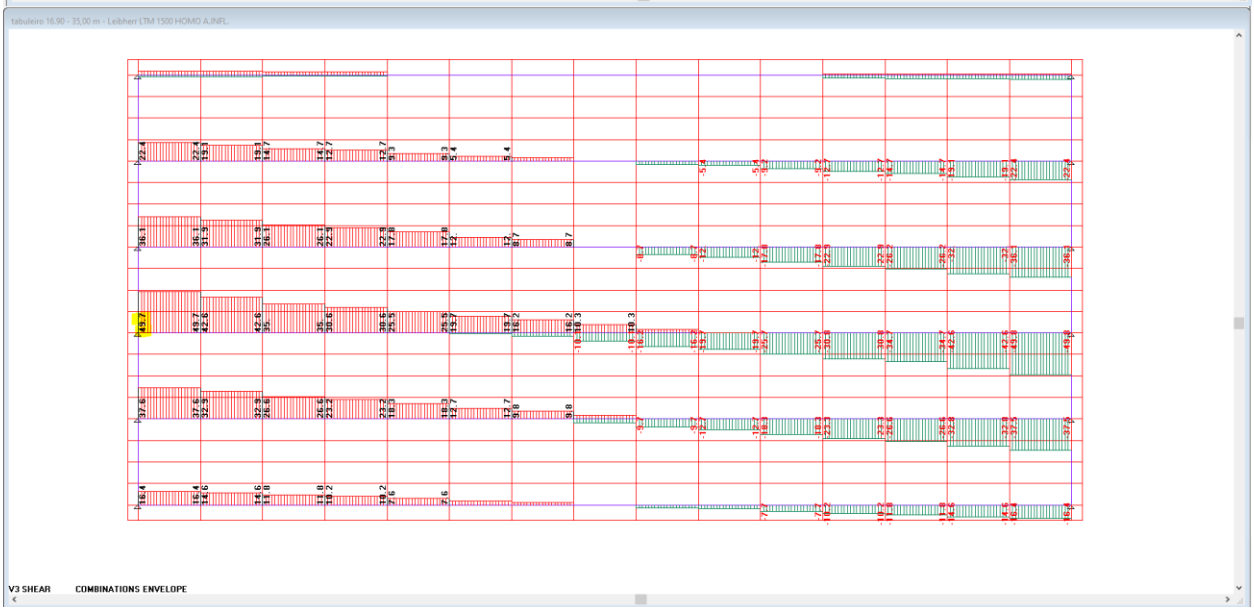

tabuleiro 16,90 - 30,00 m - permanentes
M2 MOMENT COMBINATIONS ENVELOPE

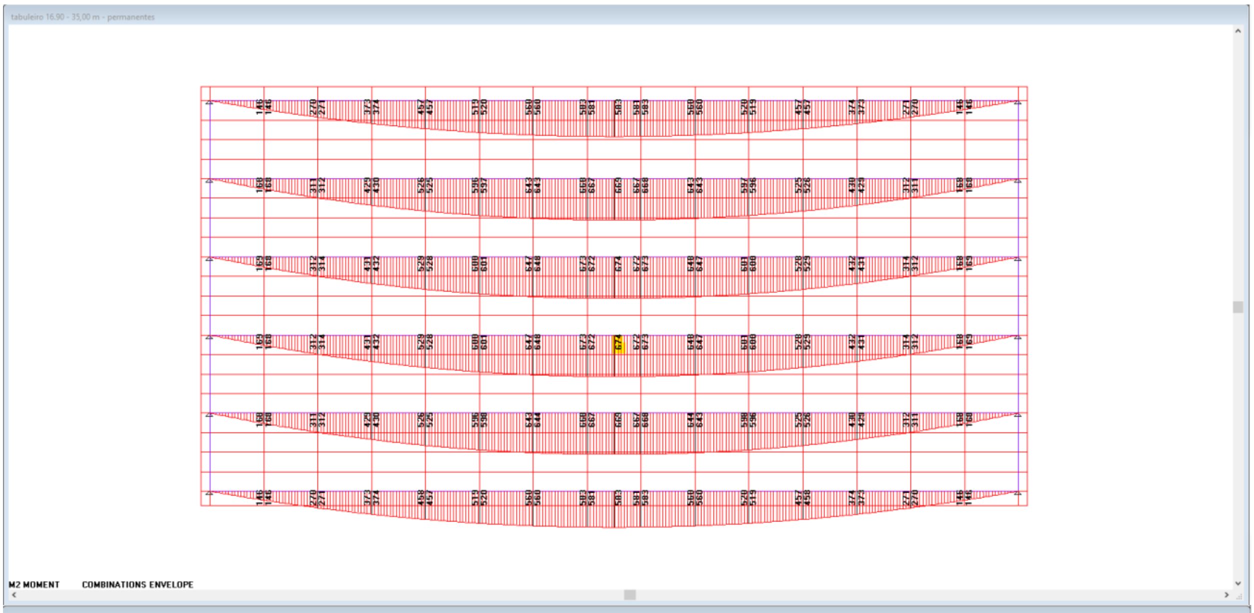

tabuleiro 16,90 - 30,00 m - permanentes
V3 SHEAR COMBINATIONS ENVELOPE

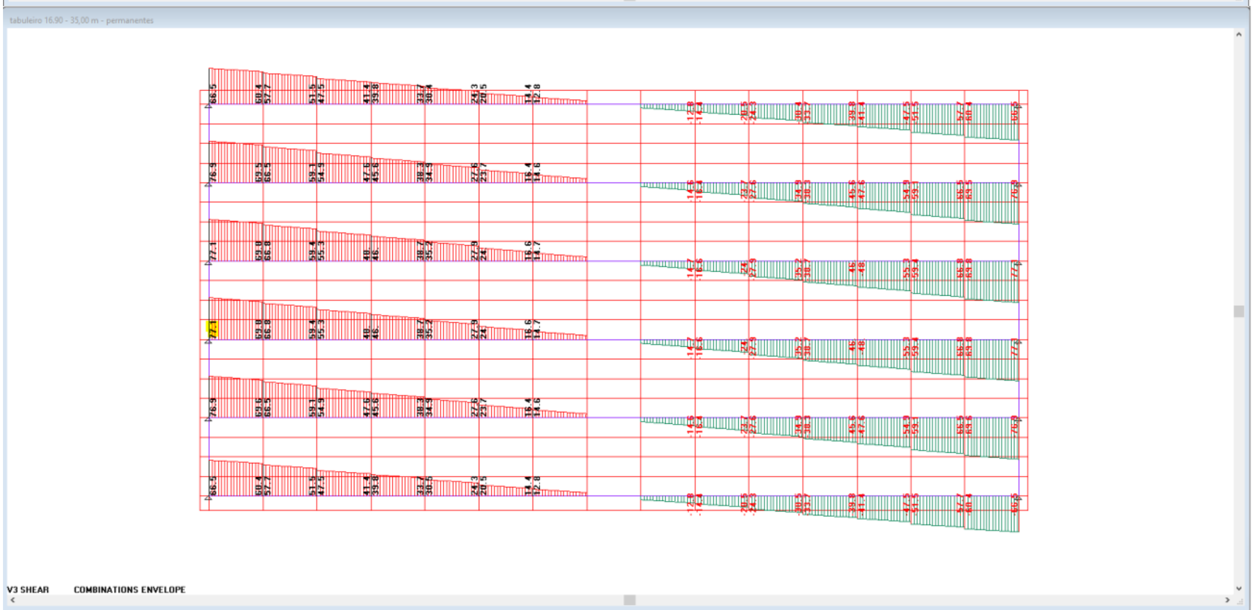

M2 MOMENT
COMBINATIONS ENVELOPE

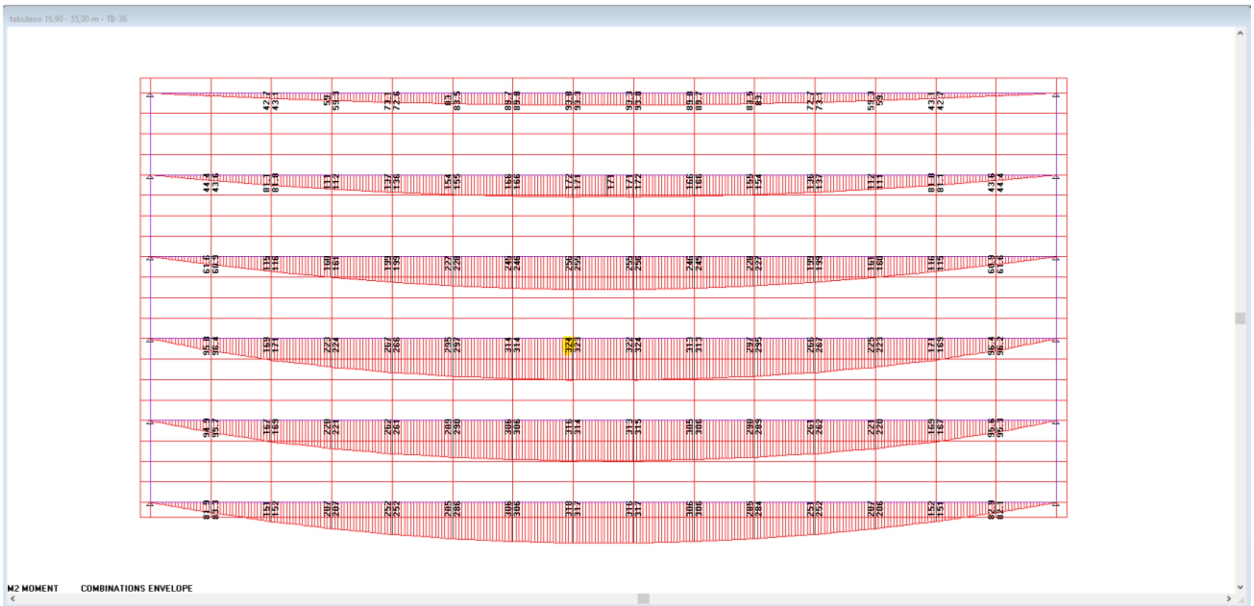

V3 SHEAR
COMBINATIONS ENVELOPE

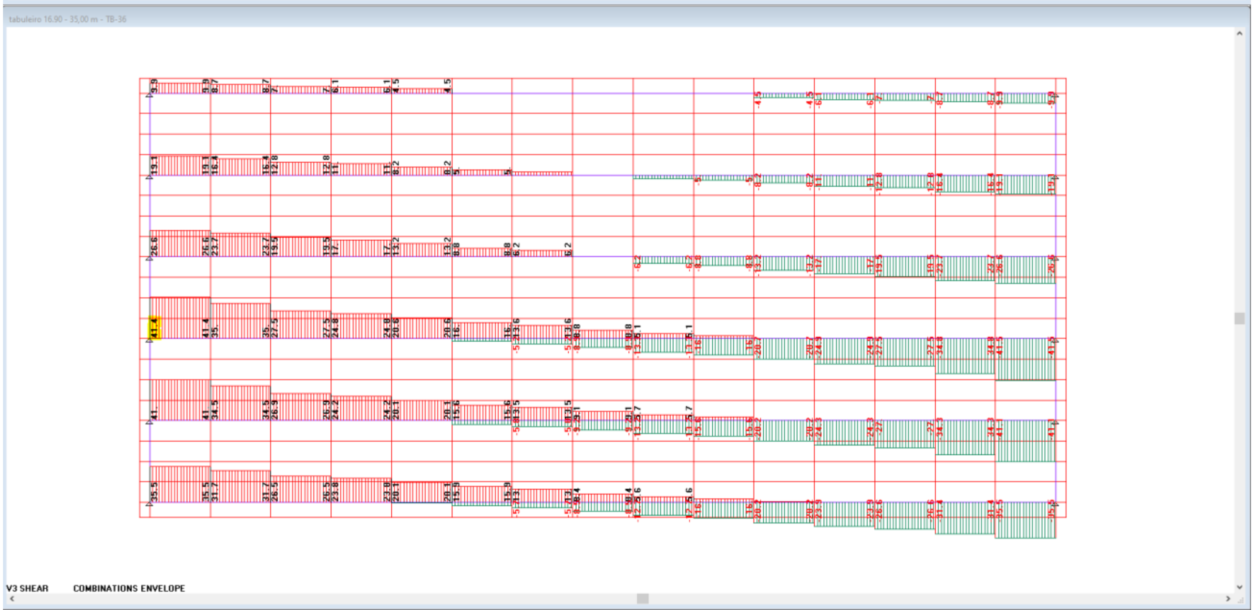

M2 MOMENT COMBINATIONS ENVELOPE

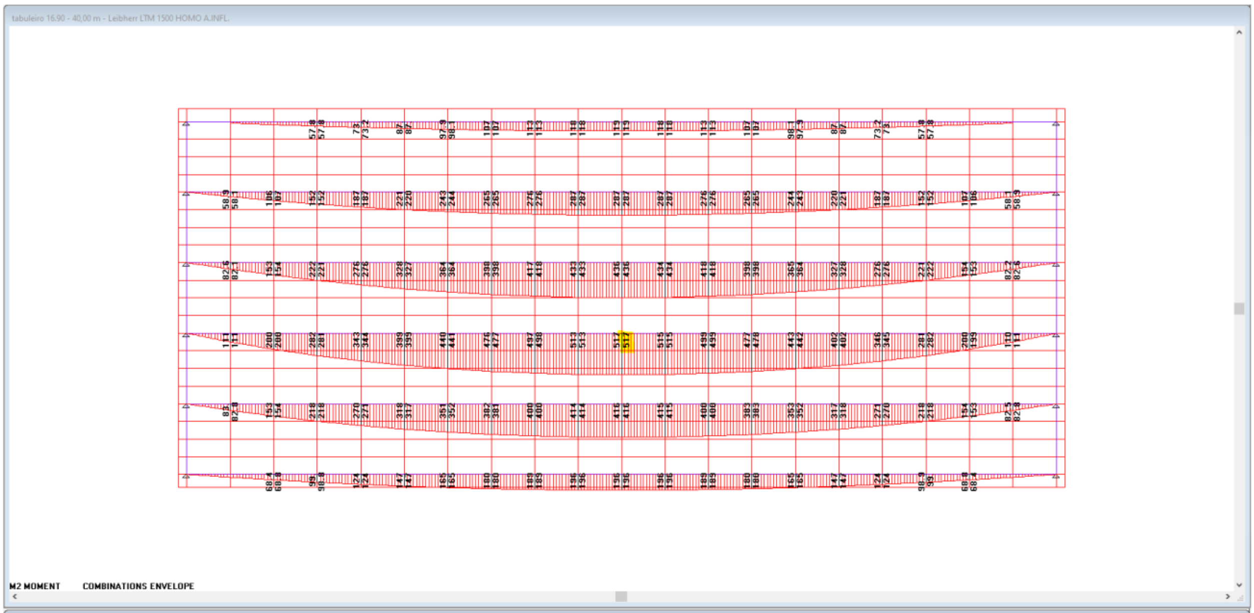

V3 SHEAR COMBINATIONS ENVELOPE

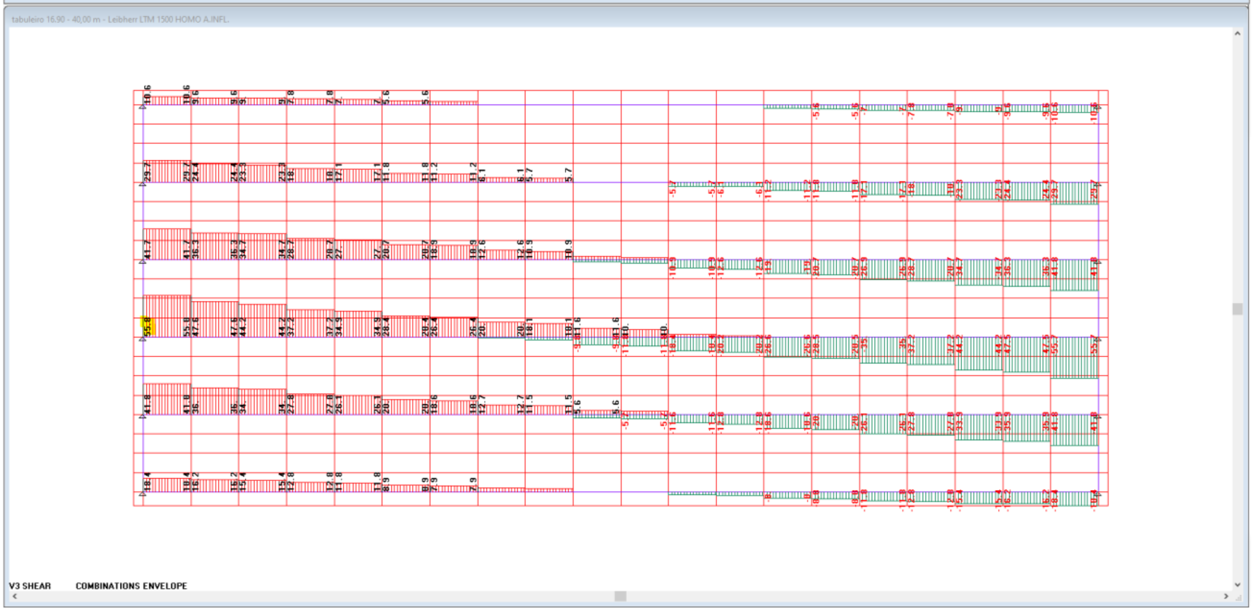

tabuleiro 16,90 - 35,00 m - permanentes
M2 MOMENT COMBINATIONS ENVELOPE

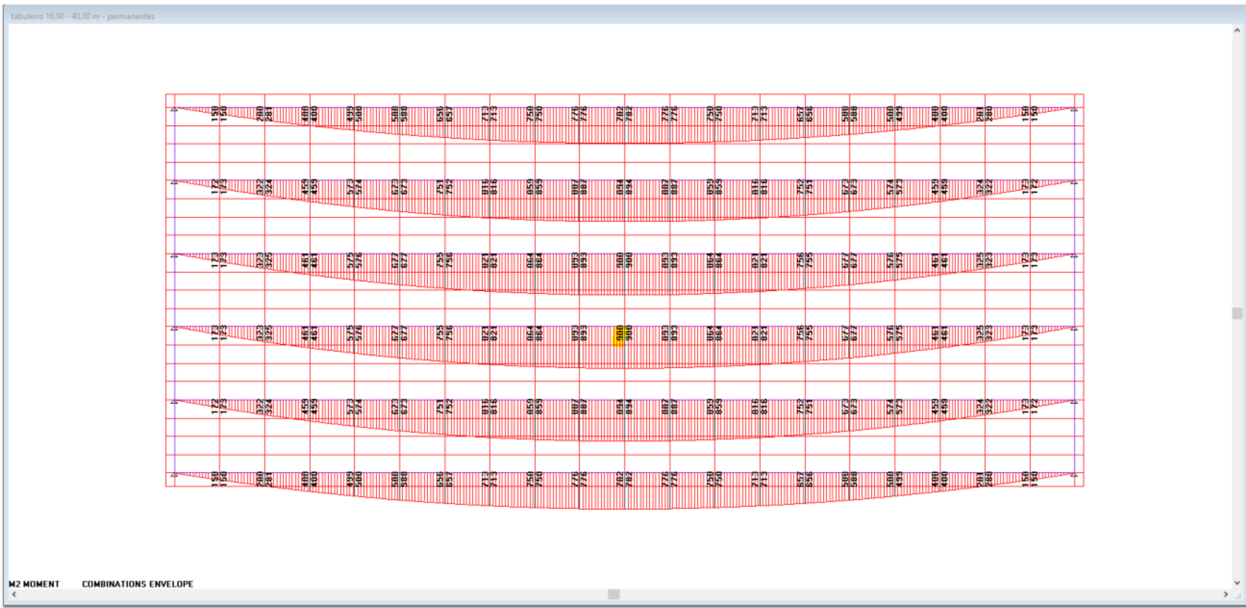

tabuleiro 16,90 - 35,00 m - permanentes
V3 SHEAR COMBINATIONS ENVELOPE

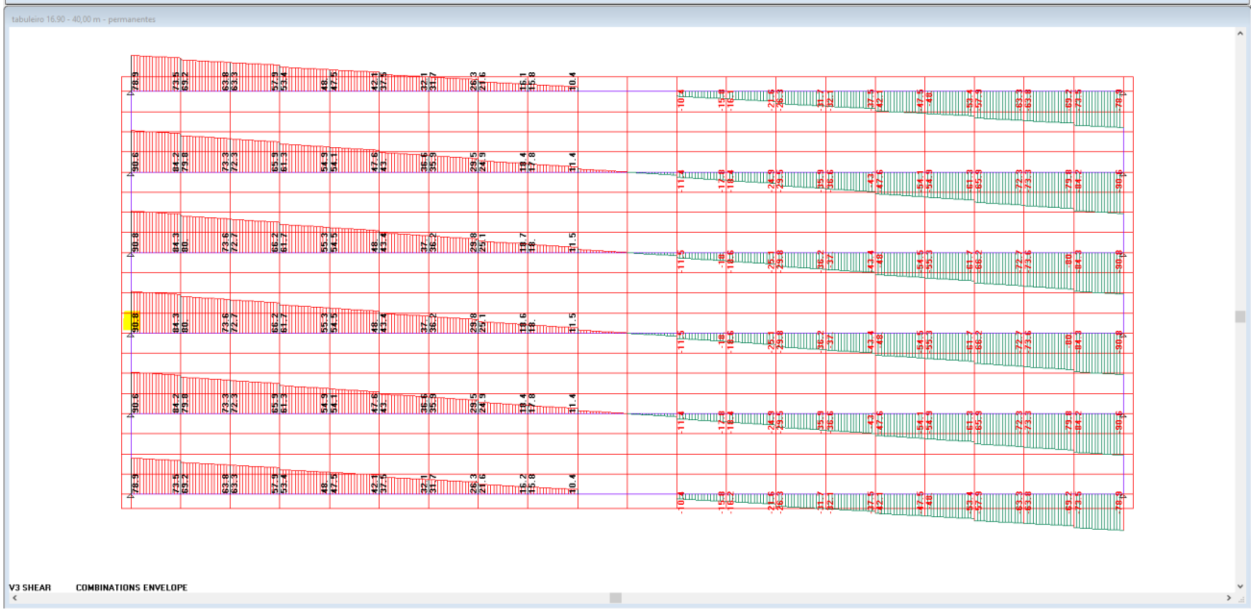

tabuleiro 16,90 - 35,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE


tabuleiro 16,90 - 35,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


tabuleiro 16.90 - 40,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE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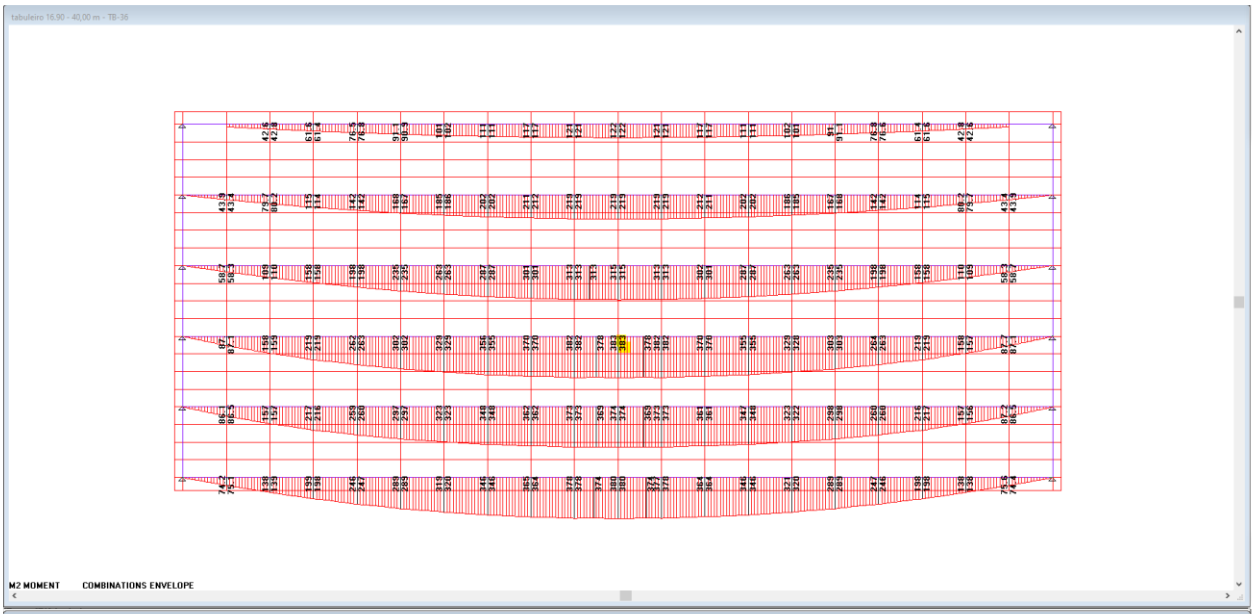
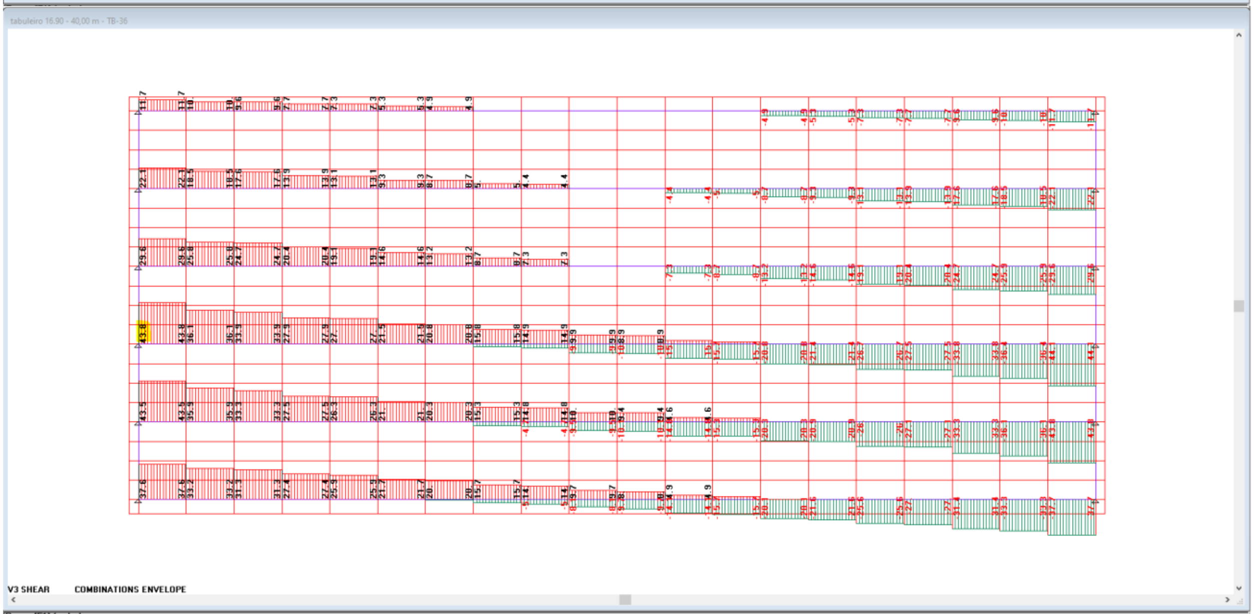
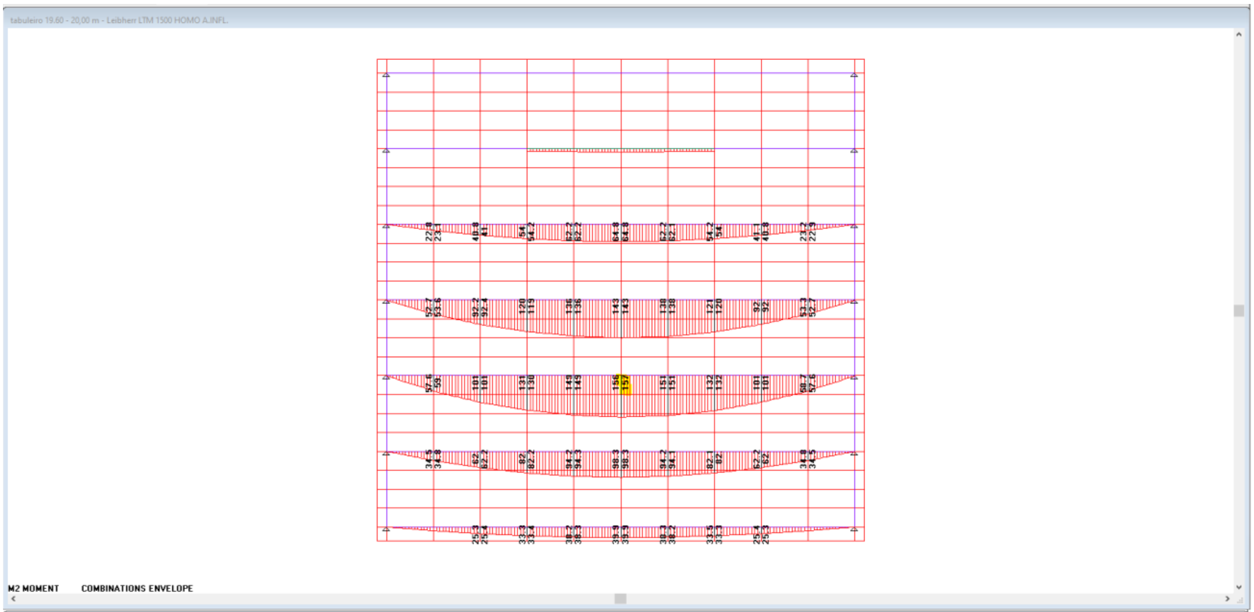
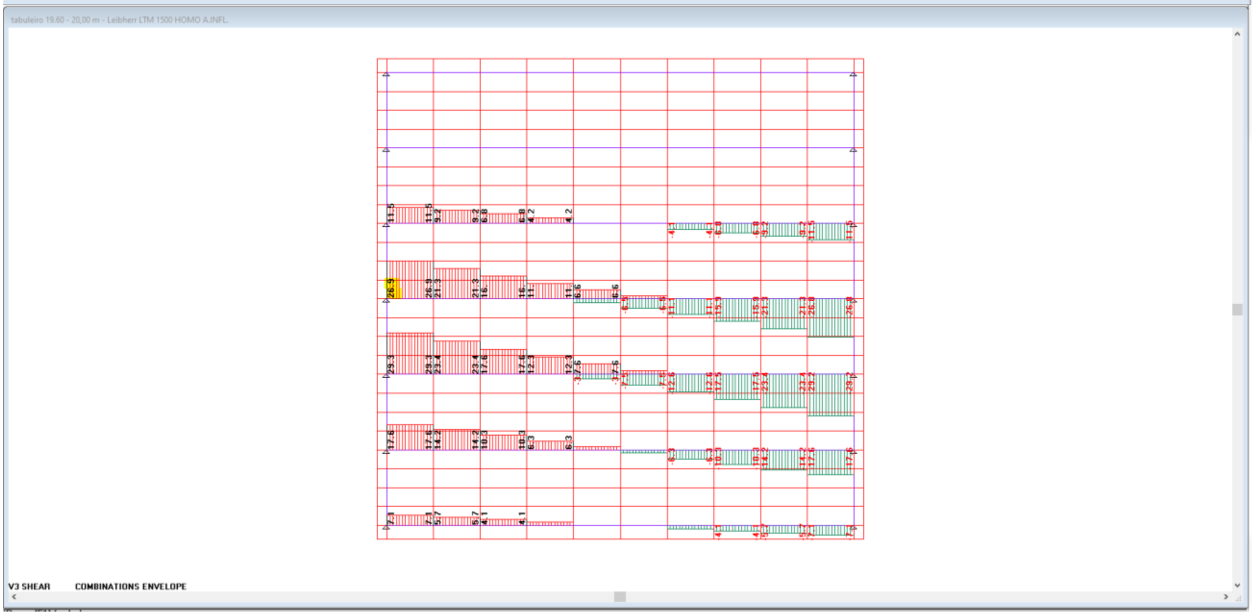
V3 SHEAR
COMBINATIONS ENVELOPE

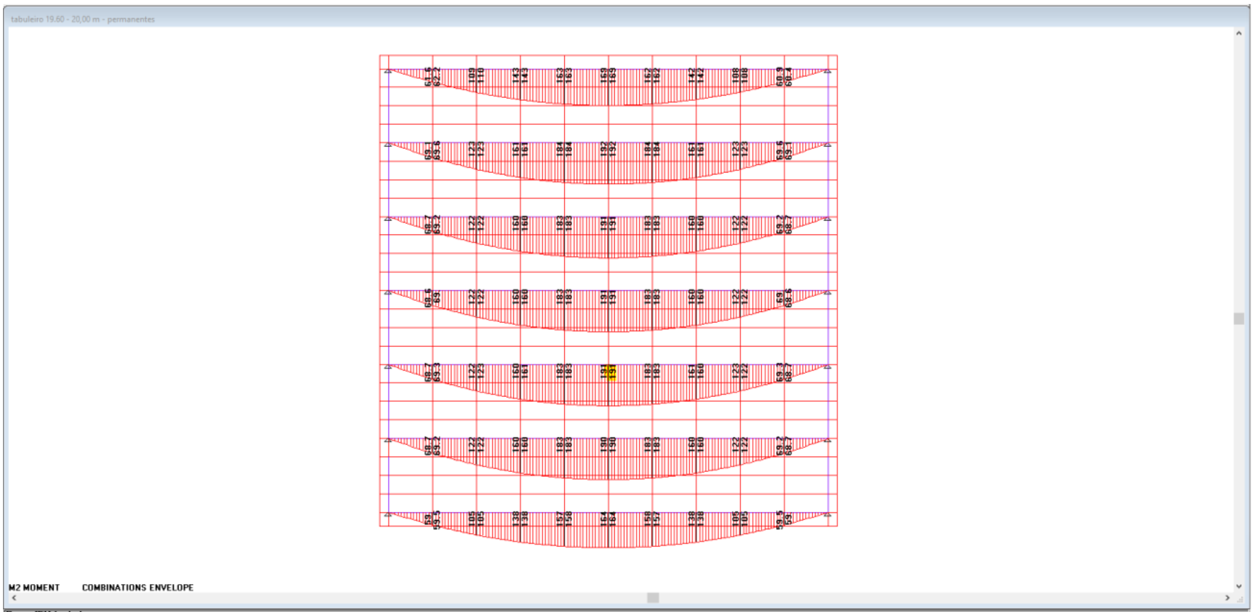

tabuleiro 16,90 - 40,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE

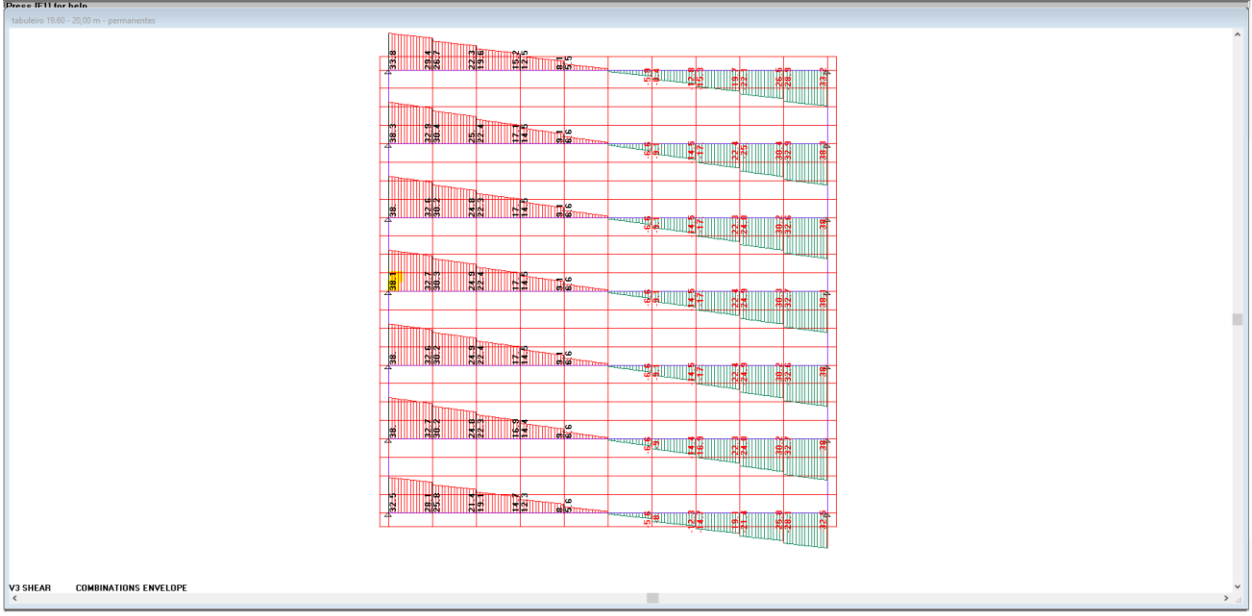

tabuleiro 16,90 - 40,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE

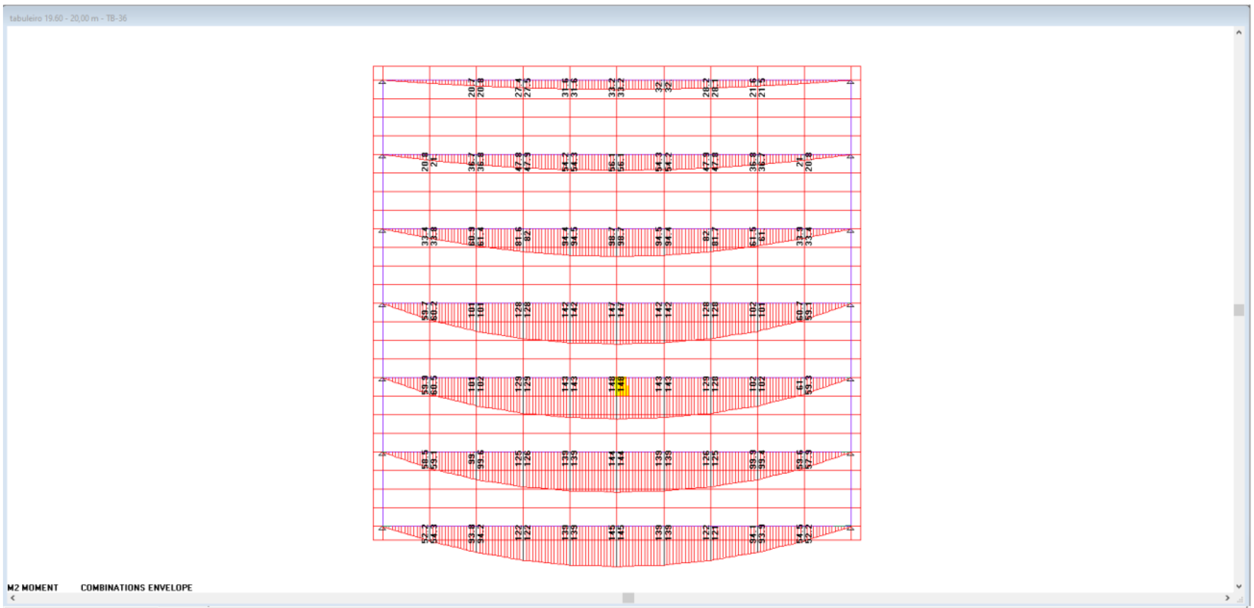
4.6.6. Tabuleiro 19,60 m

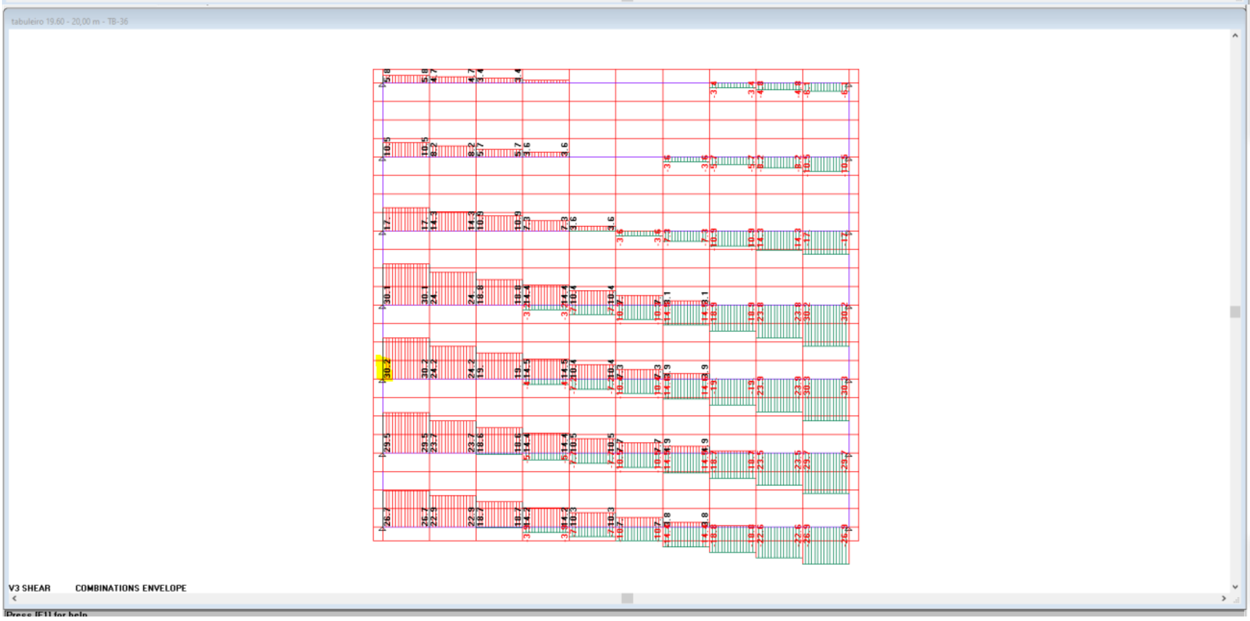


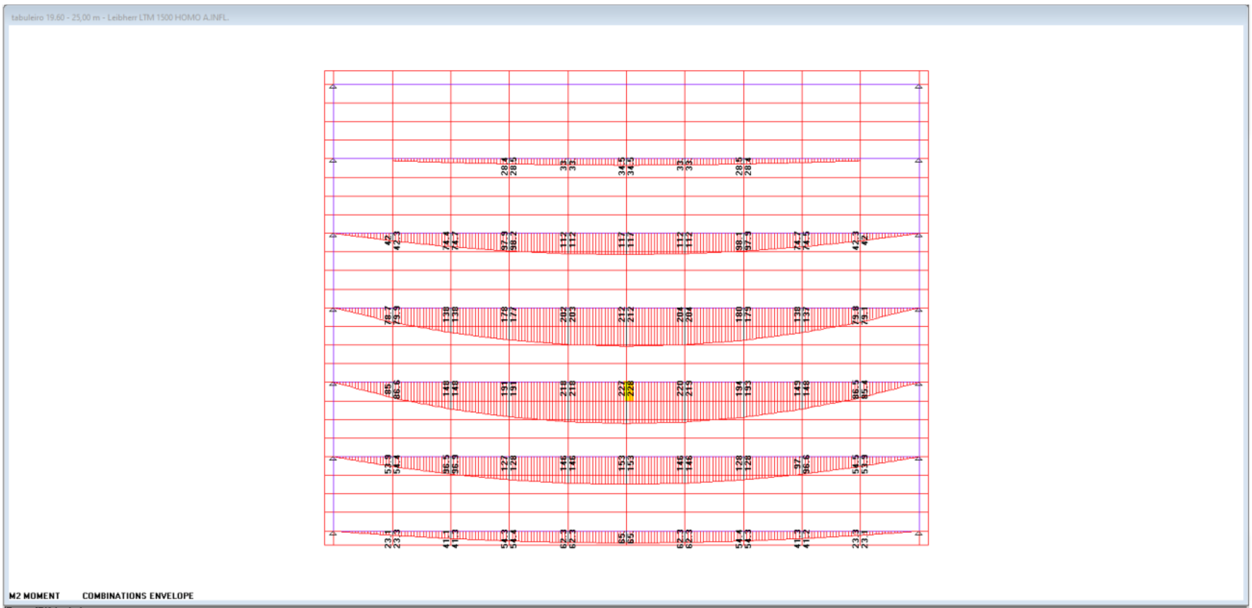


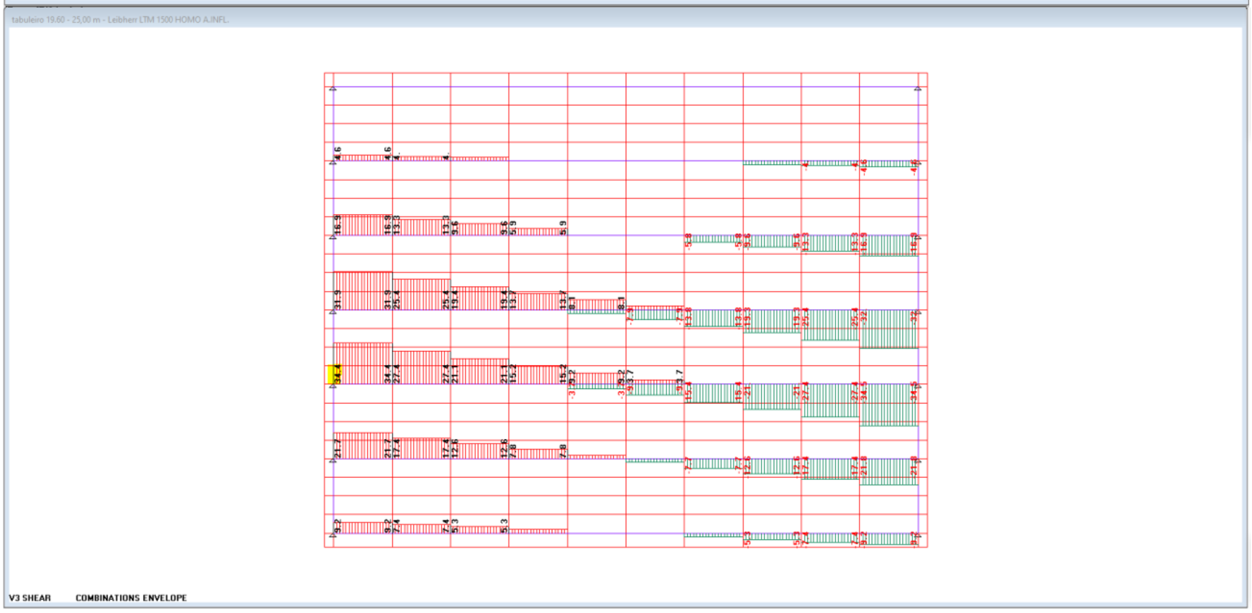

M2 MOMENT COMBINATIONS ENVELOPE

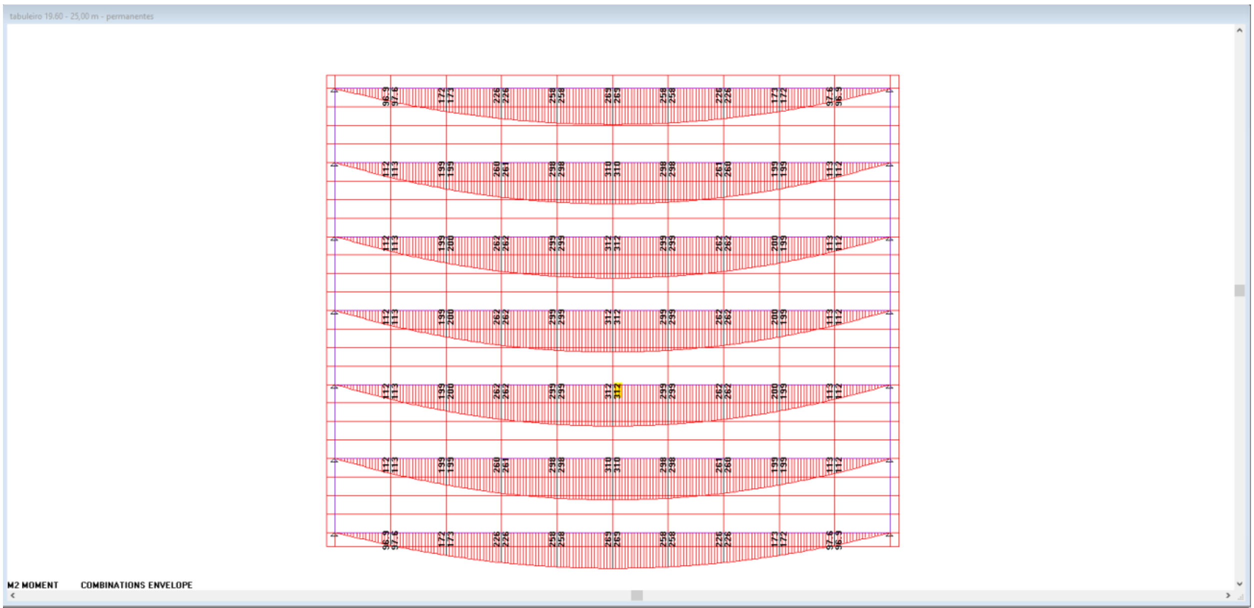

V3 SHEAR COMBINATIONS ENVELOPE

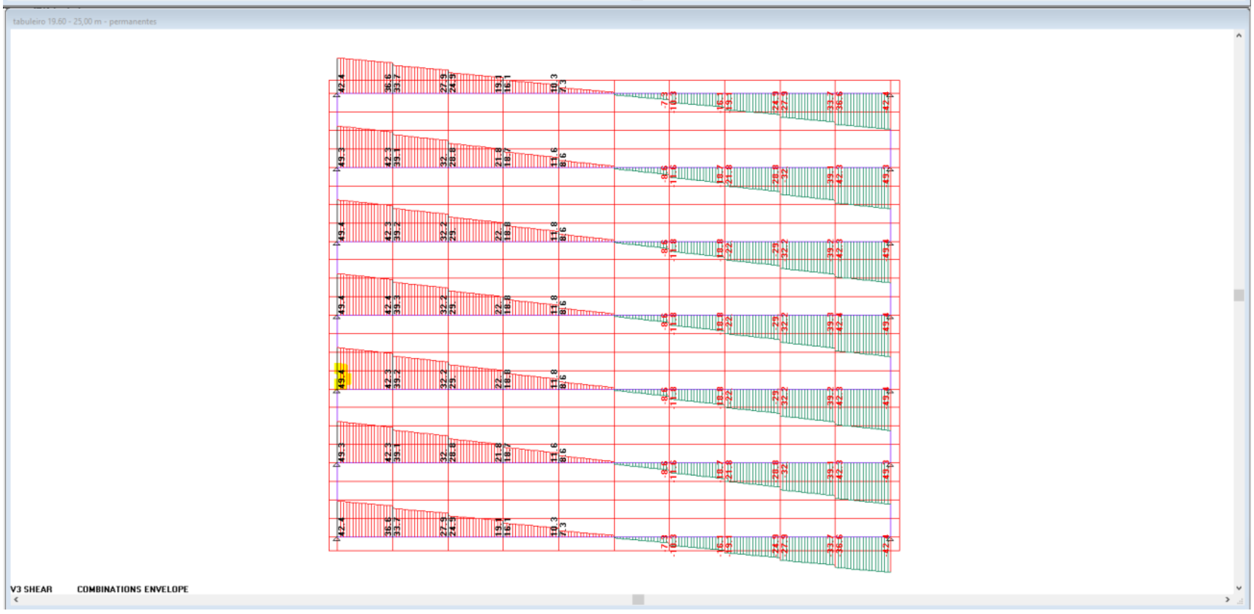

tabuleiro 19.60 - 20,00 m - TB-36
M2 MOMENT COMBINATIONS ENVELOPE

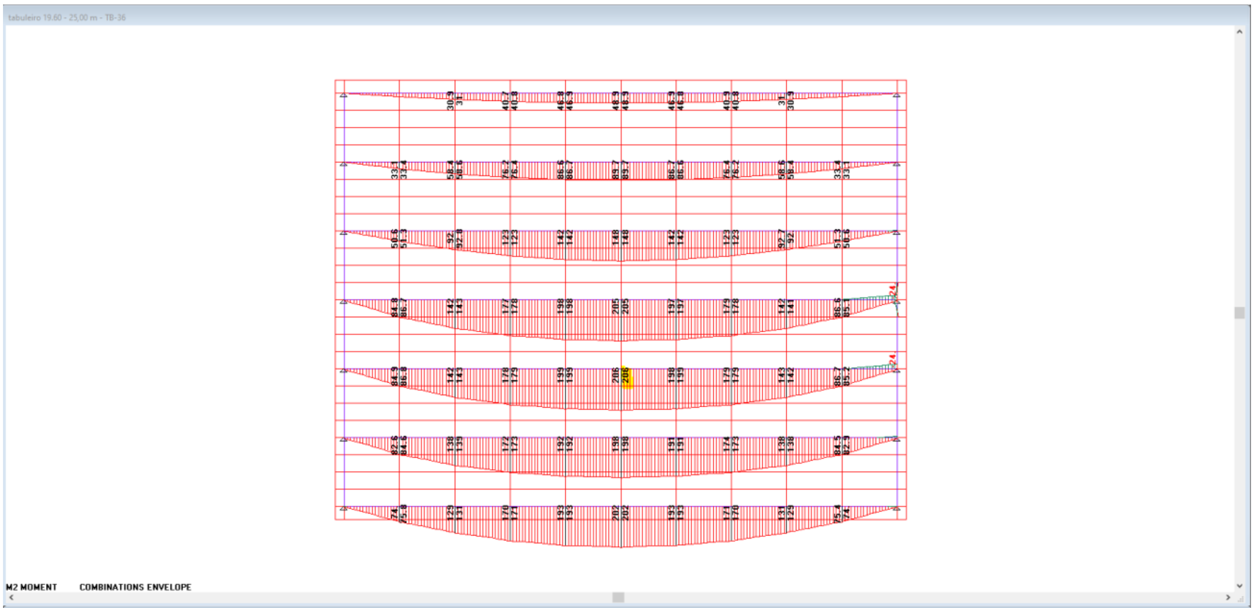

tabuleiro 19.60 - 20,00 m - TB-36
V3 SHEAR COMBINATIONS ENVELOPE
Press [F1] for help

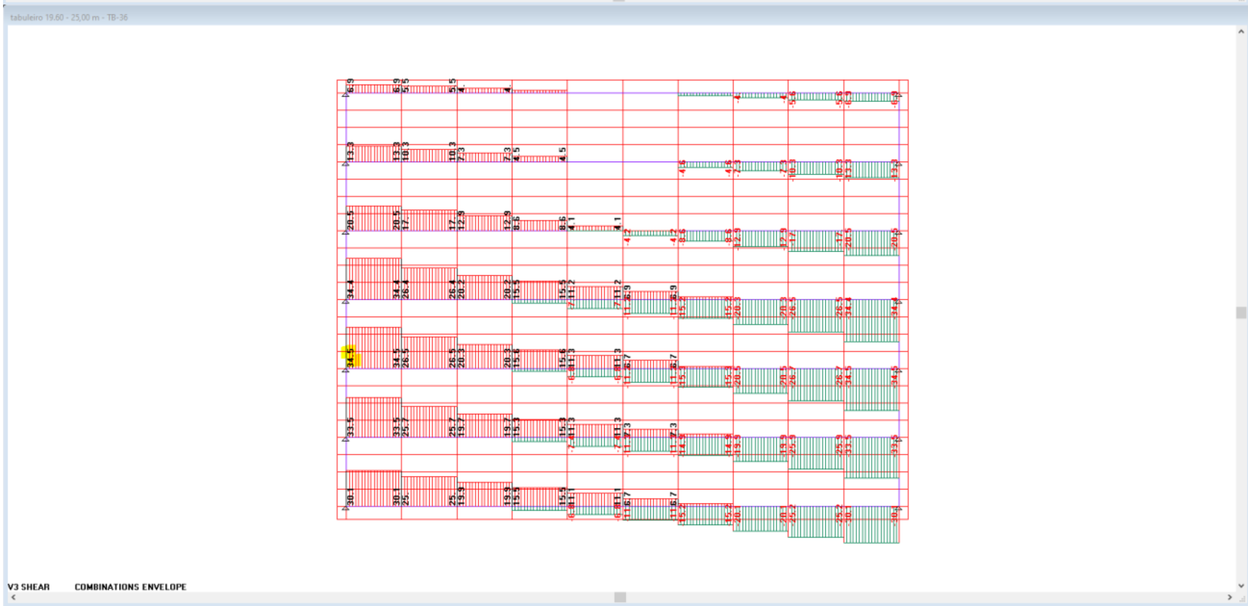

M2 MOMENT COMBINATIONS ENVELOPE

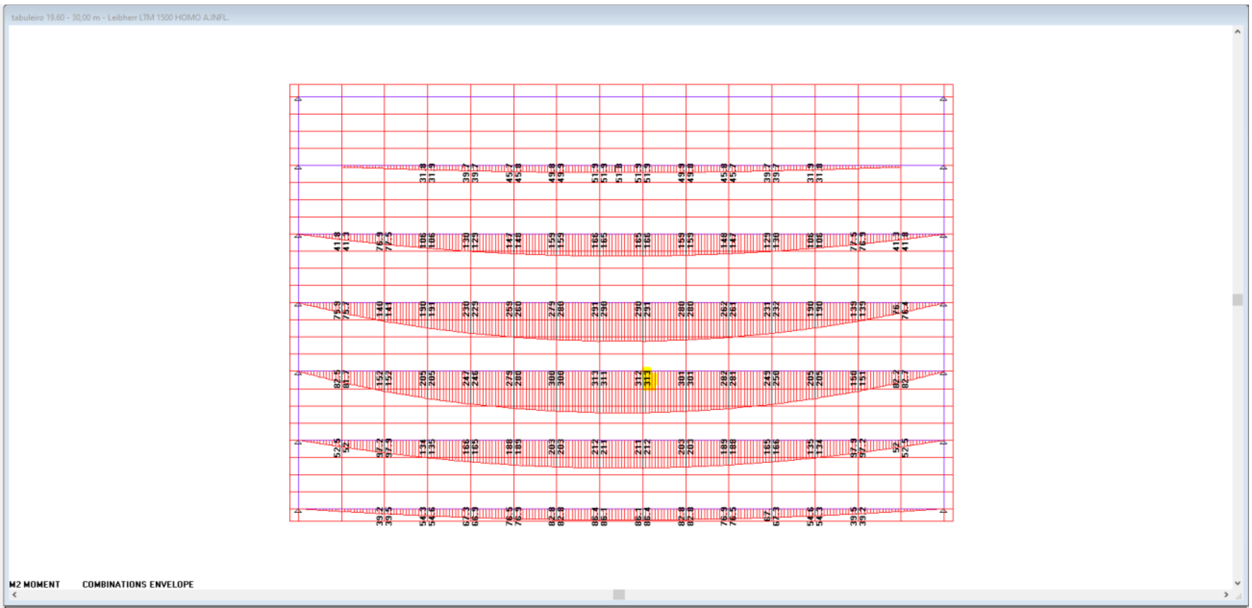

V3 SHEAR COMBINATIONS ENVELOPE

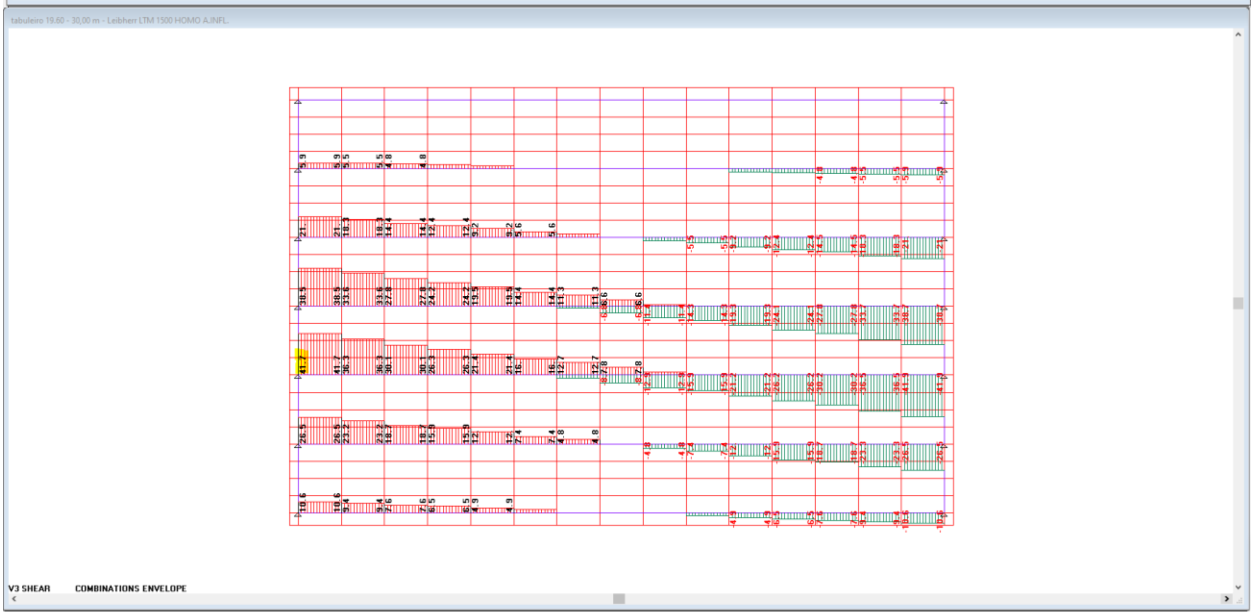

M2 MOMENT
COMBINATIONS ENVELOPE

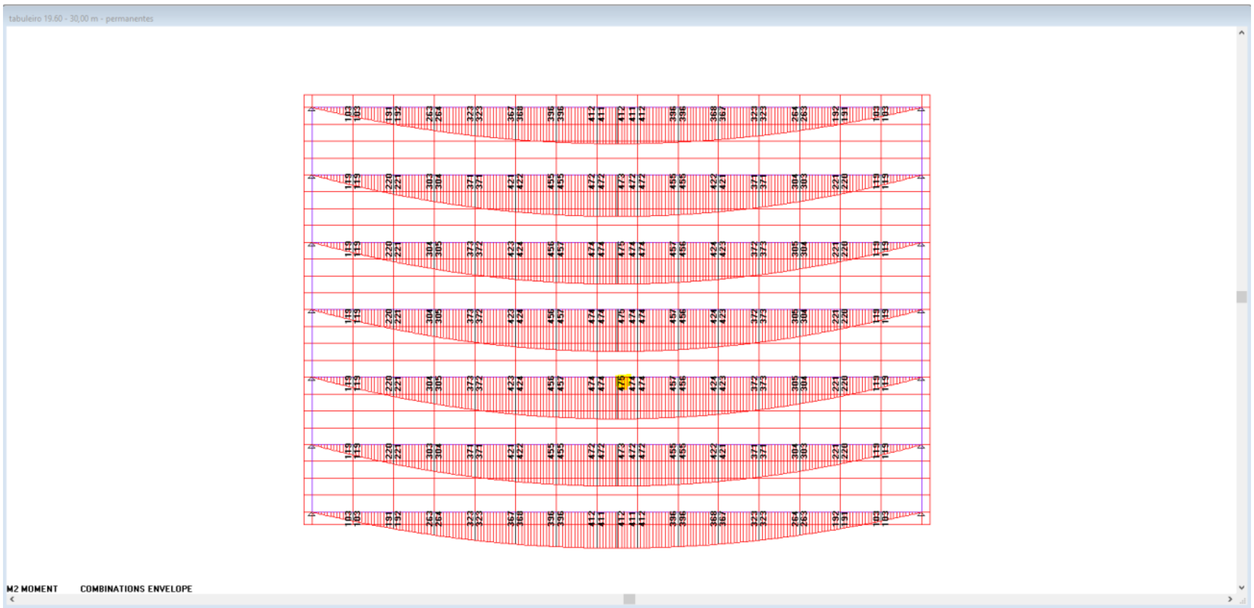

V3 SHEAR
COMBINATIONS ENVELOPE

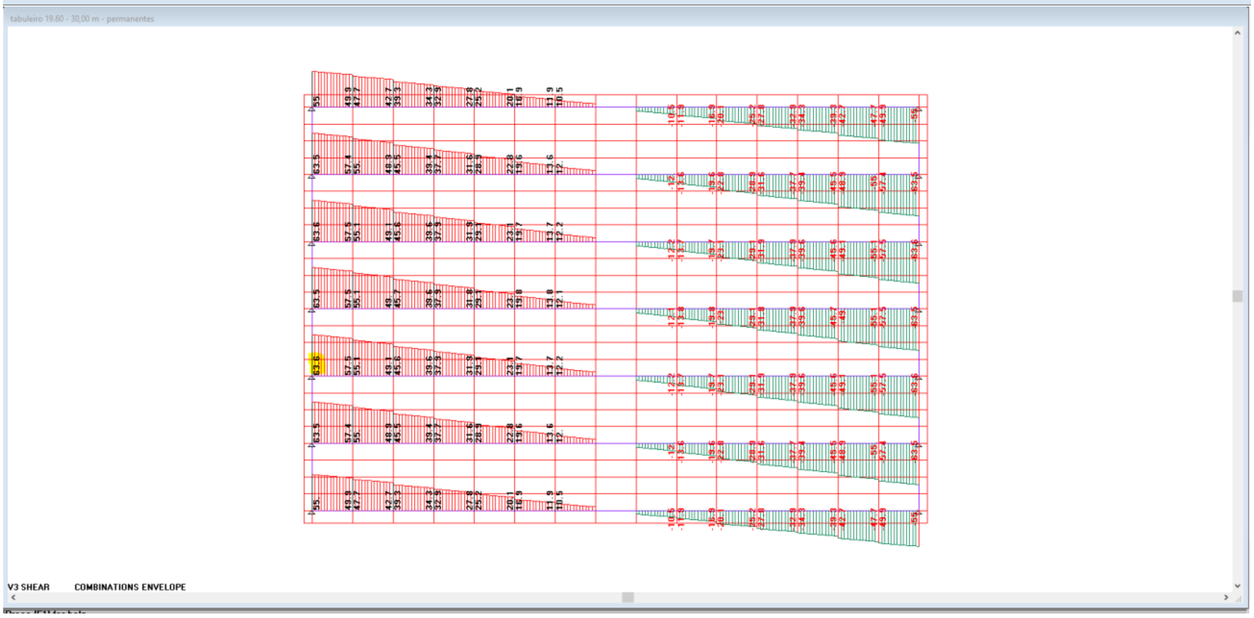

M2 MOMENT
COMBINATIONS ENVELOPE

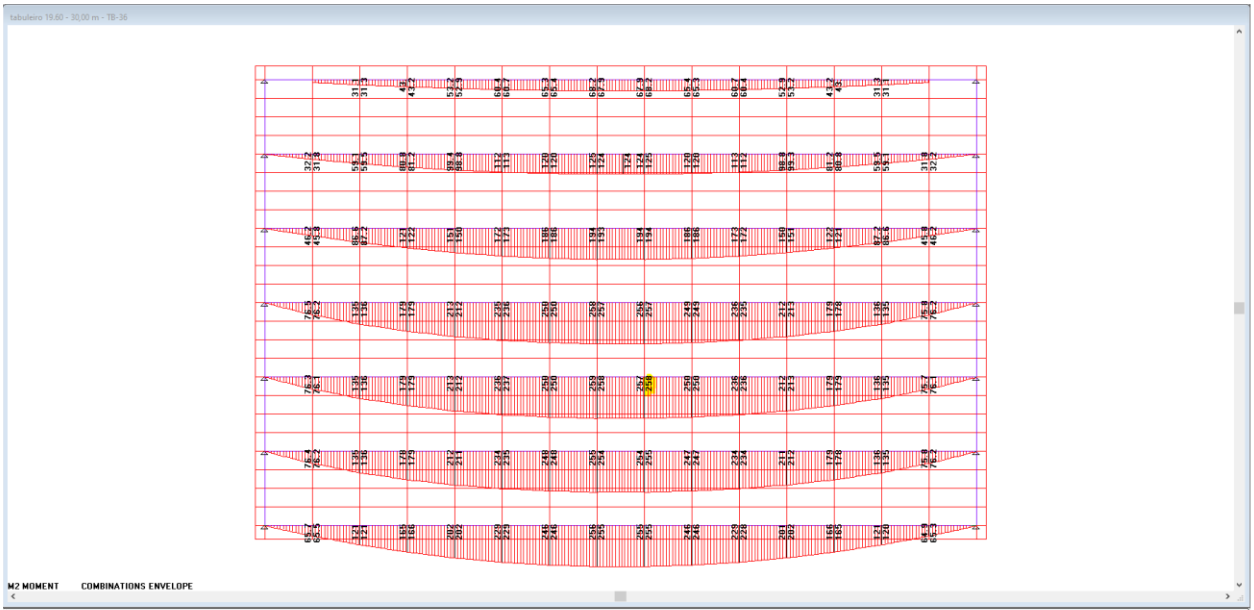

V3 SHEAR
COMBINATIONS ENVELOPE

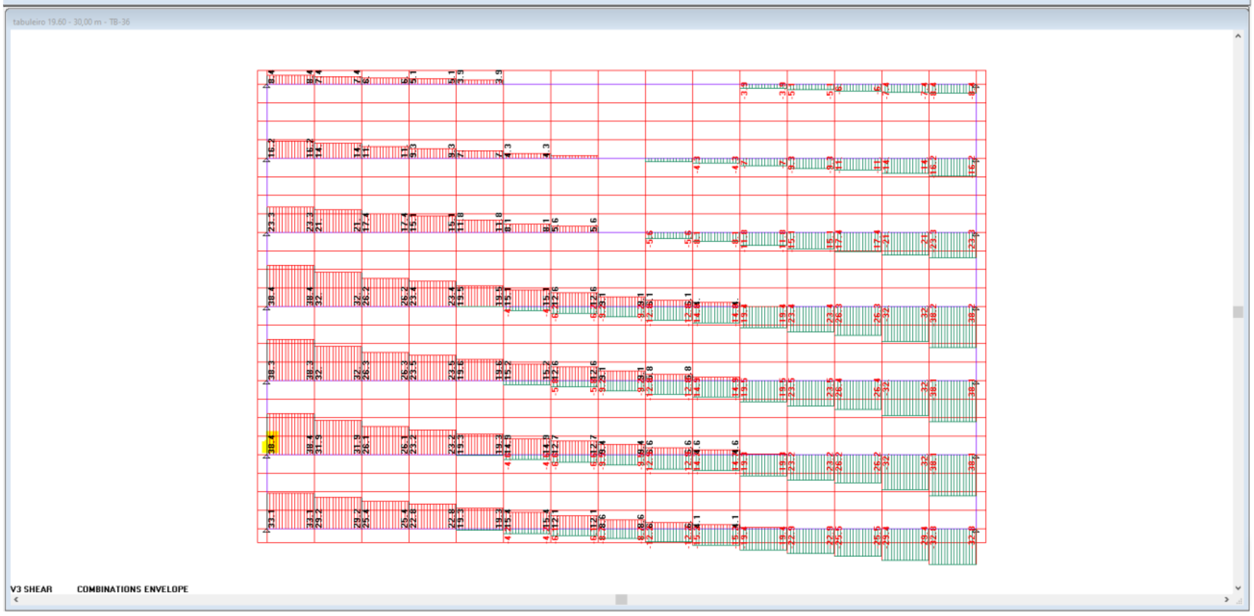

M2 MOMENT COMBINATIONS ENVELOPE

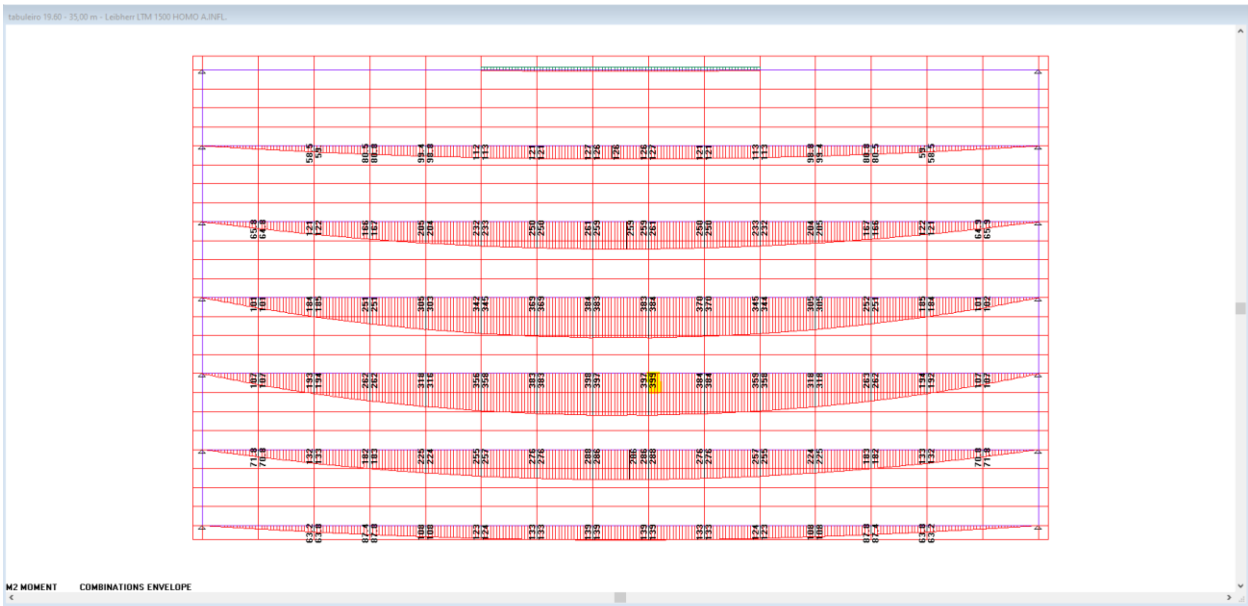

V3 SHEAR COMBINATIONS ENVELOPE

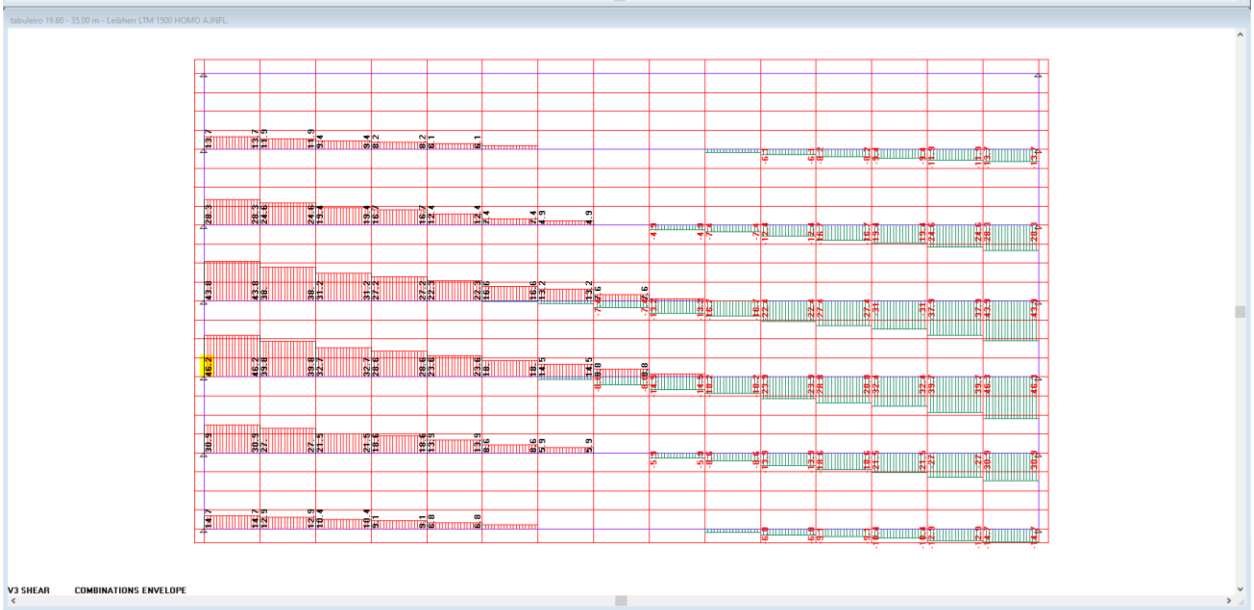

tabuleiro 19,60 - 30,00 m - permanentes
M2 MOMENT COMBINATIONS ENVELOPE

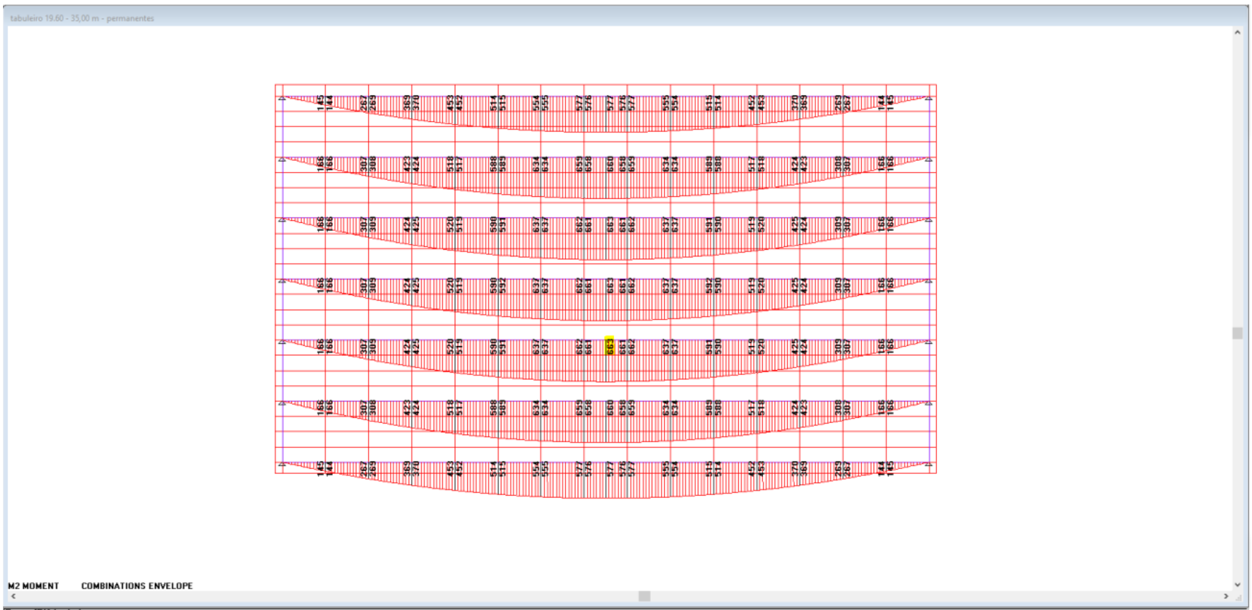

tabuleiro 19,60 - 30,00 m - permanentes
V3 SHEAR COMBINATIONS ENVELOPE

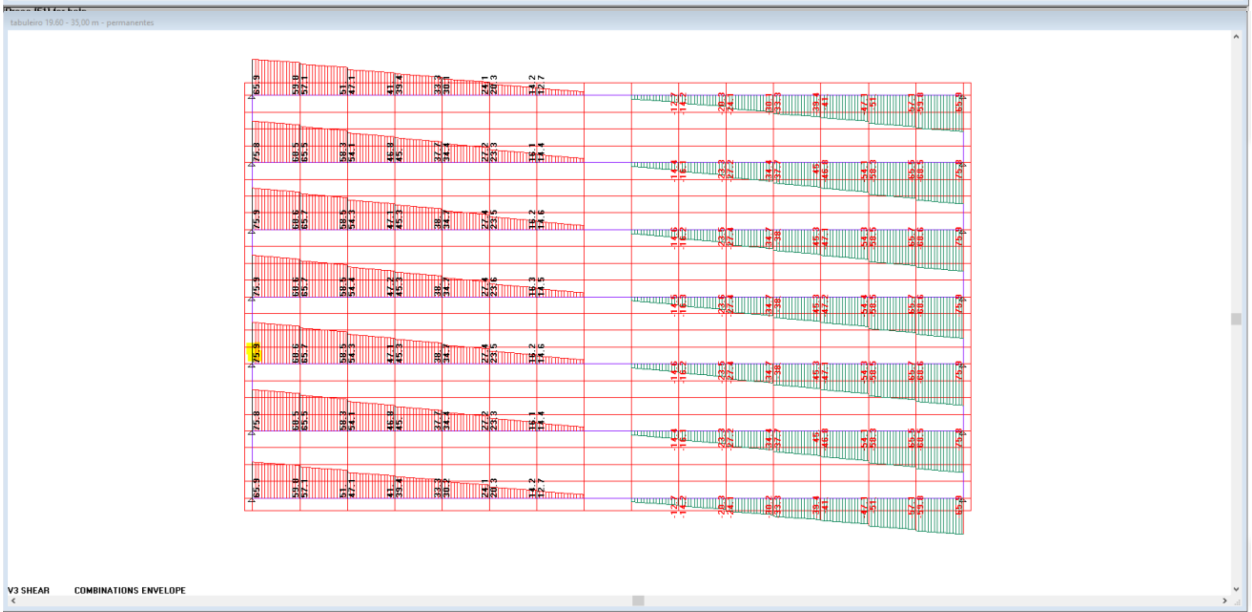

M2 MOMENT
COMBINATIONS ENVELOPE

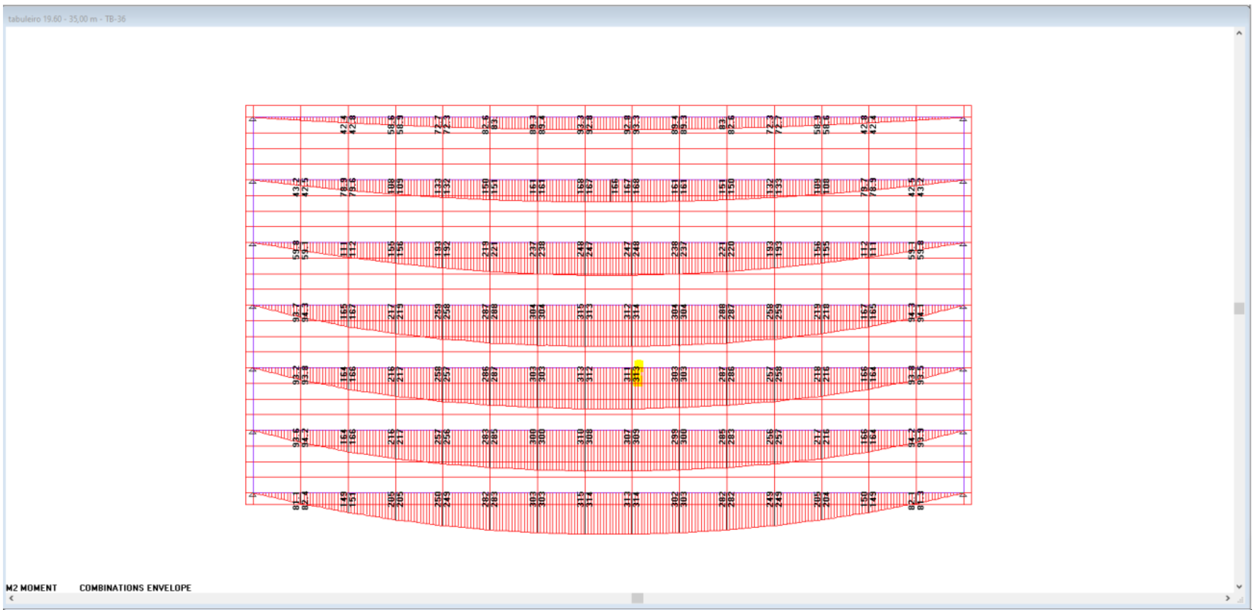

V3 SHEAR
COMBINATIONS ENVELOPE

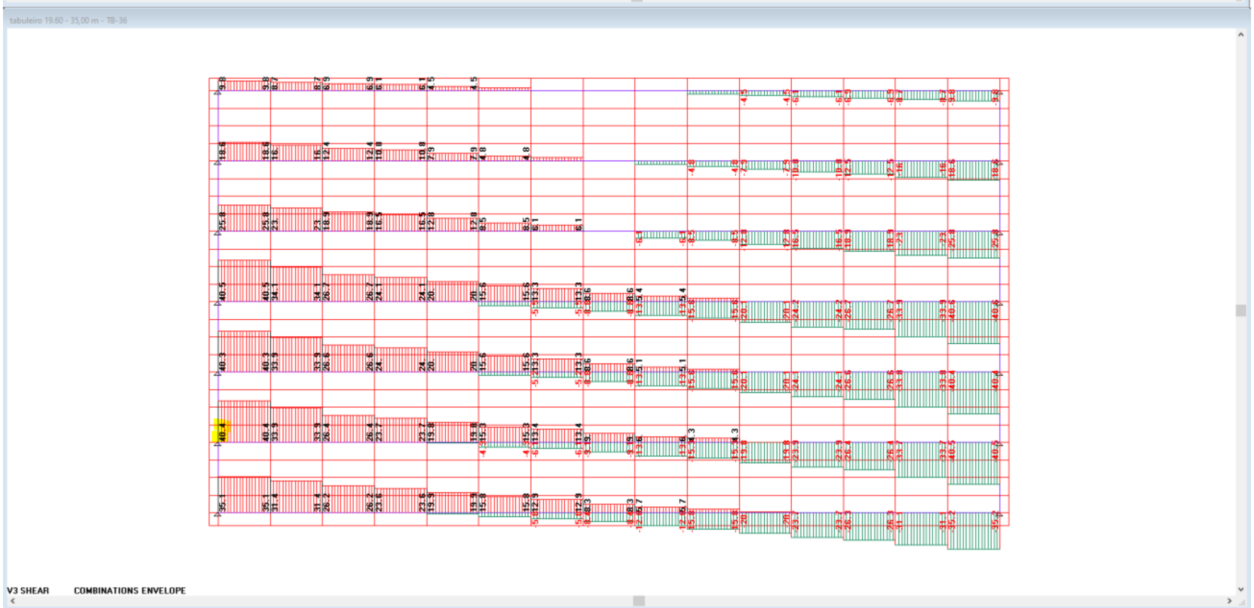

tabuleiro 19.60 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
M2 MOMENT
COMBINATIONS ENVELOPE

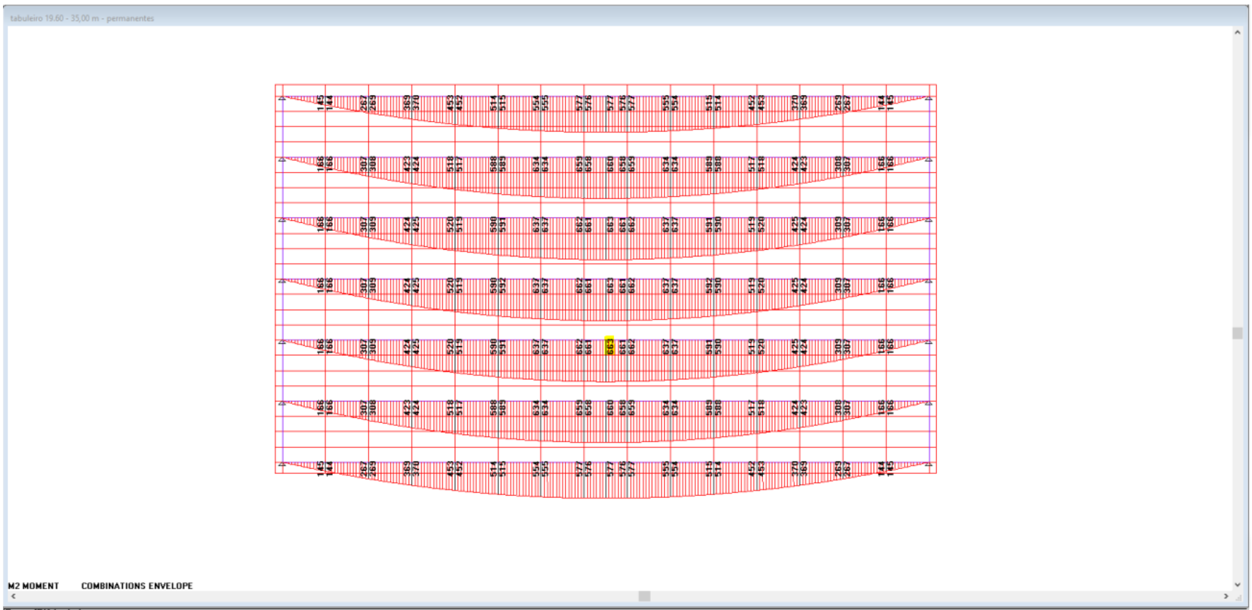

tabuleiro 19.60 - 35,00 m - Leibherr LTM 1500 HOMO A.INFL.
V3 SHEAR
COMBINATIONS ENVELOPE

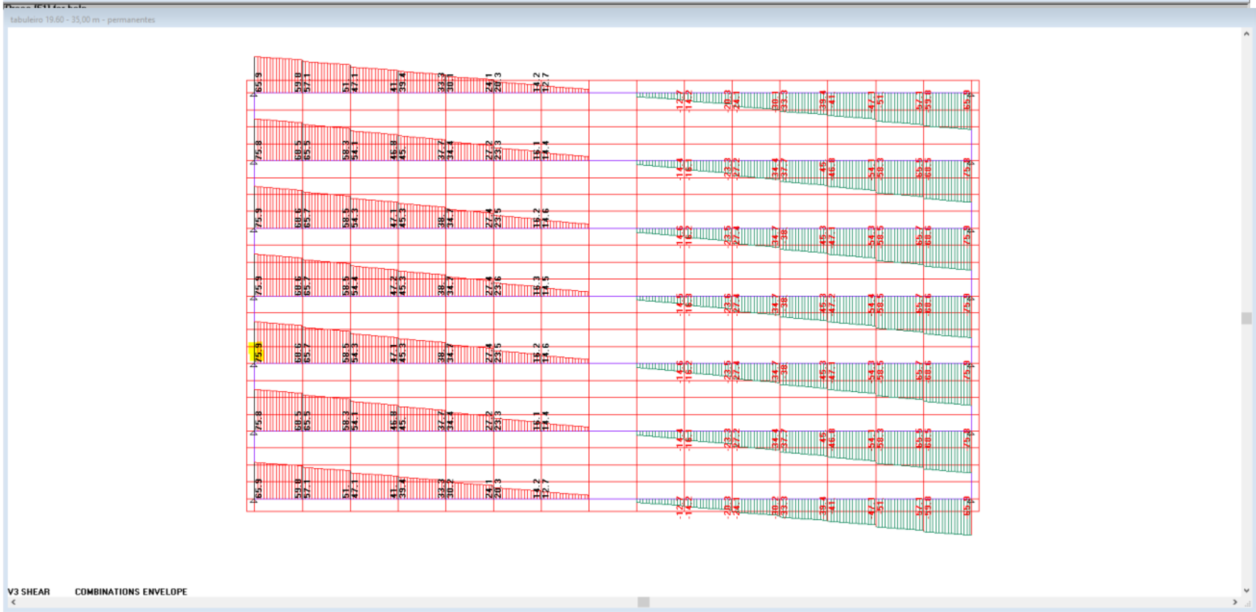

tabuleiro 19.60 - 35,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE

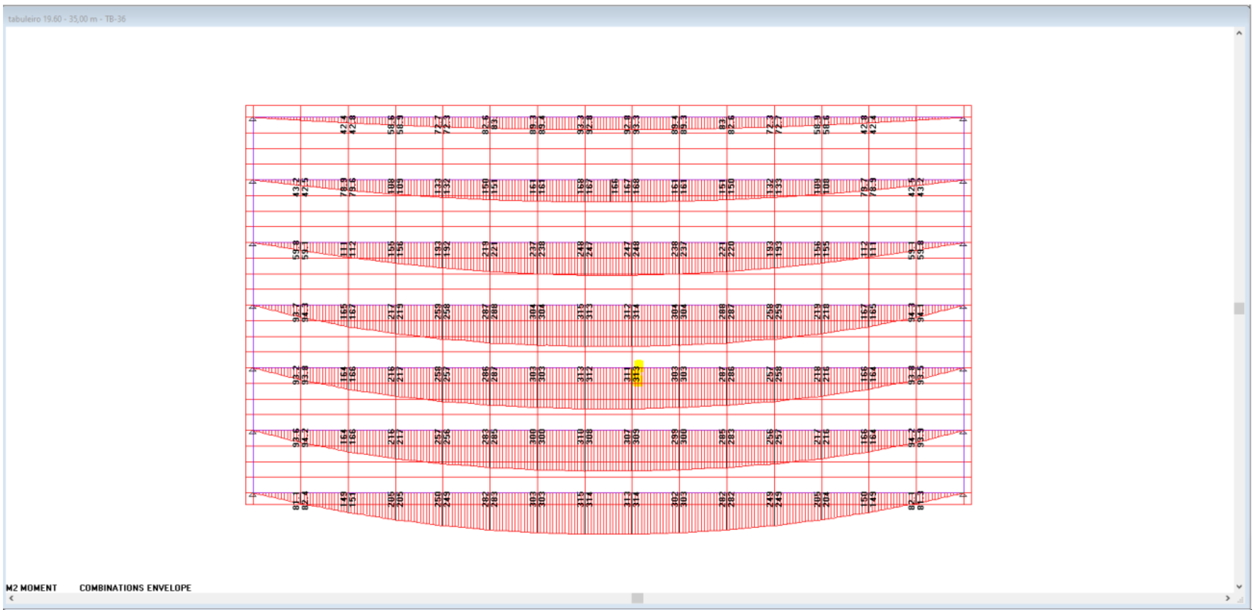

tabuleiro 19.60 - 35,00 m - permanentes
V3 SHEAR
COMBINATIONS ENVELOPE

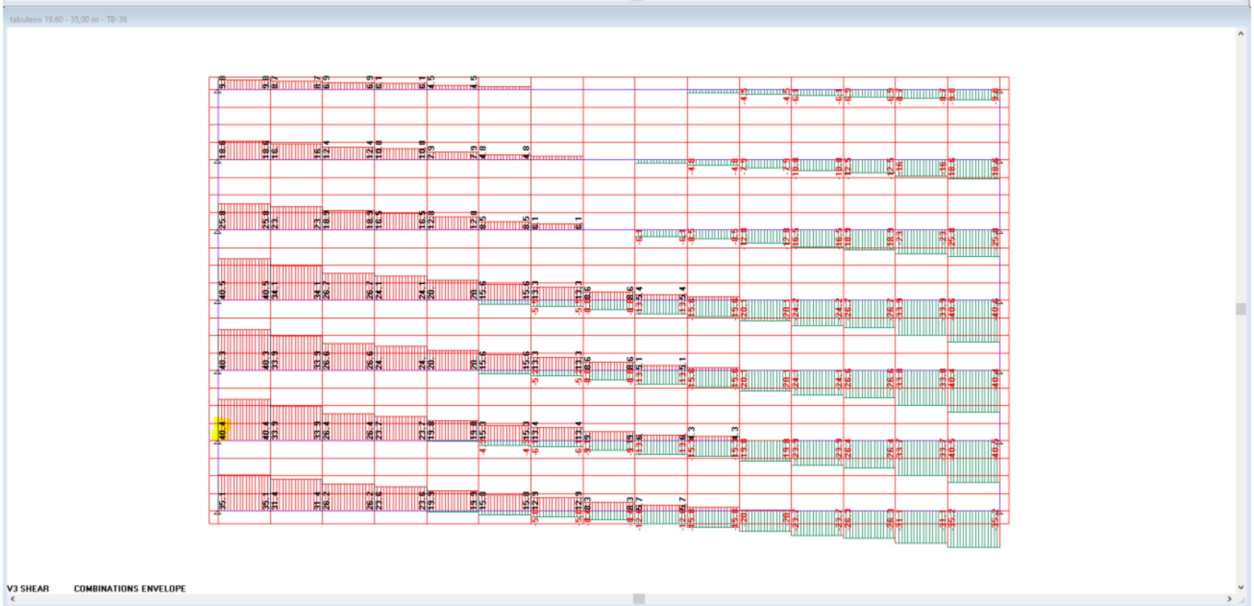

M2 MOMENT
COMBINATIONS ENVELOPE

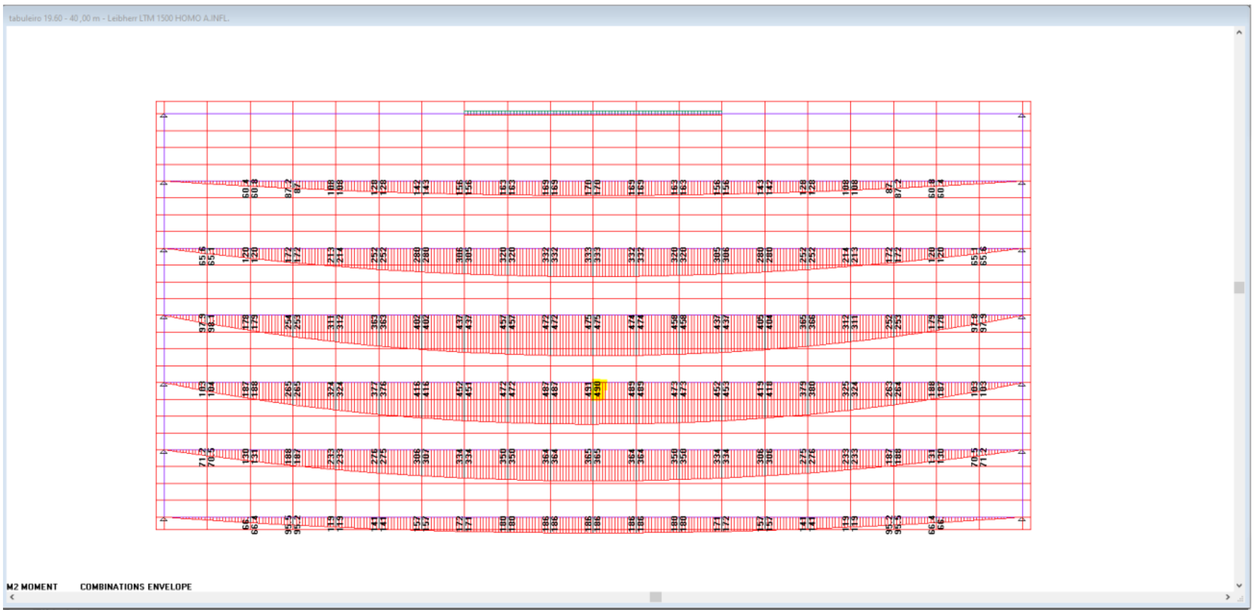

V3 SHEAR
COMBINATIONS ENVELOPE

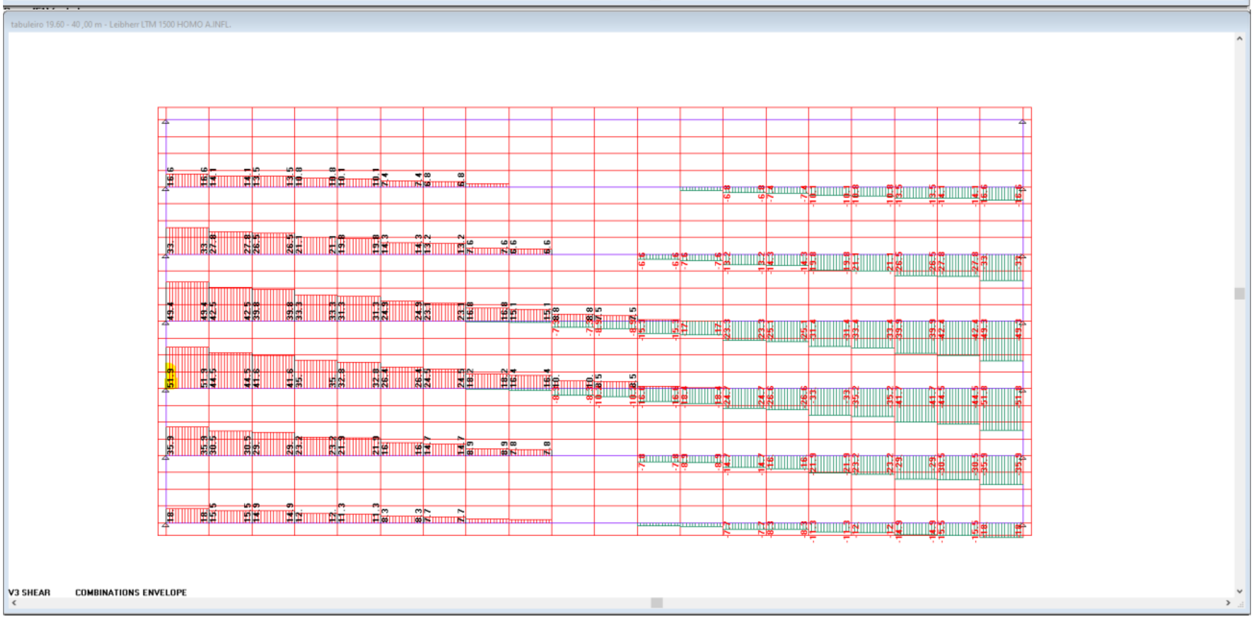

tabuleiro 19,60 - 35,00 m - permanentes
M2 MOMENT
COMBINATIONS ENVELOPE

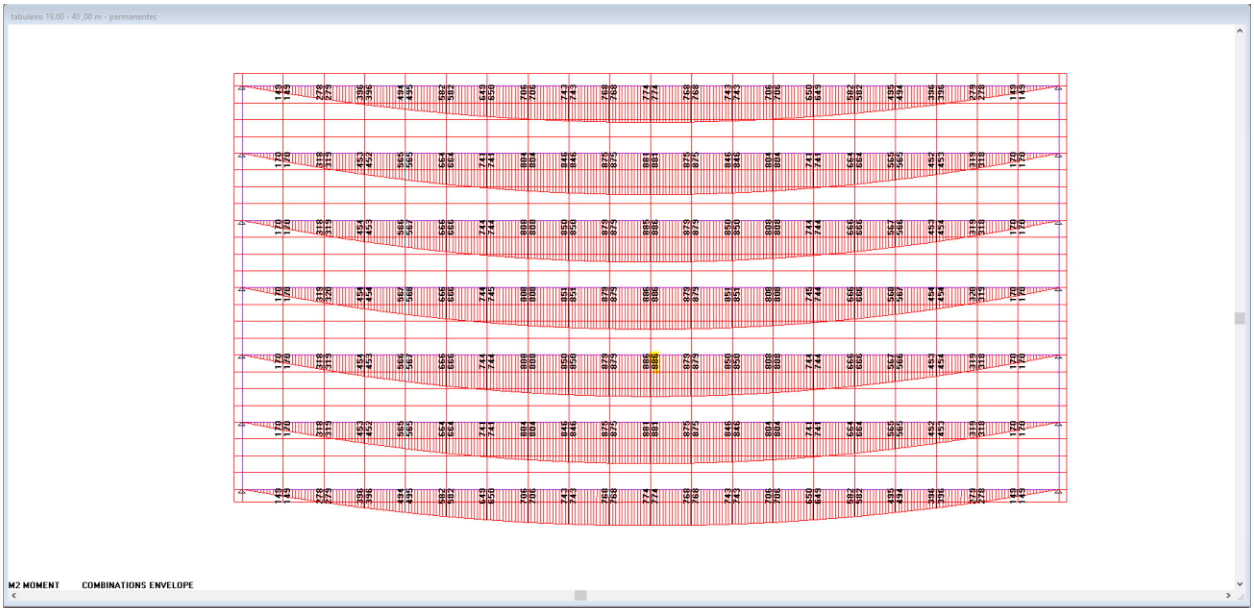

tabuleiro 19,60 - 35,00 m - permanentes
V3 SHEAR
COMBINATIONS ENVELOPE

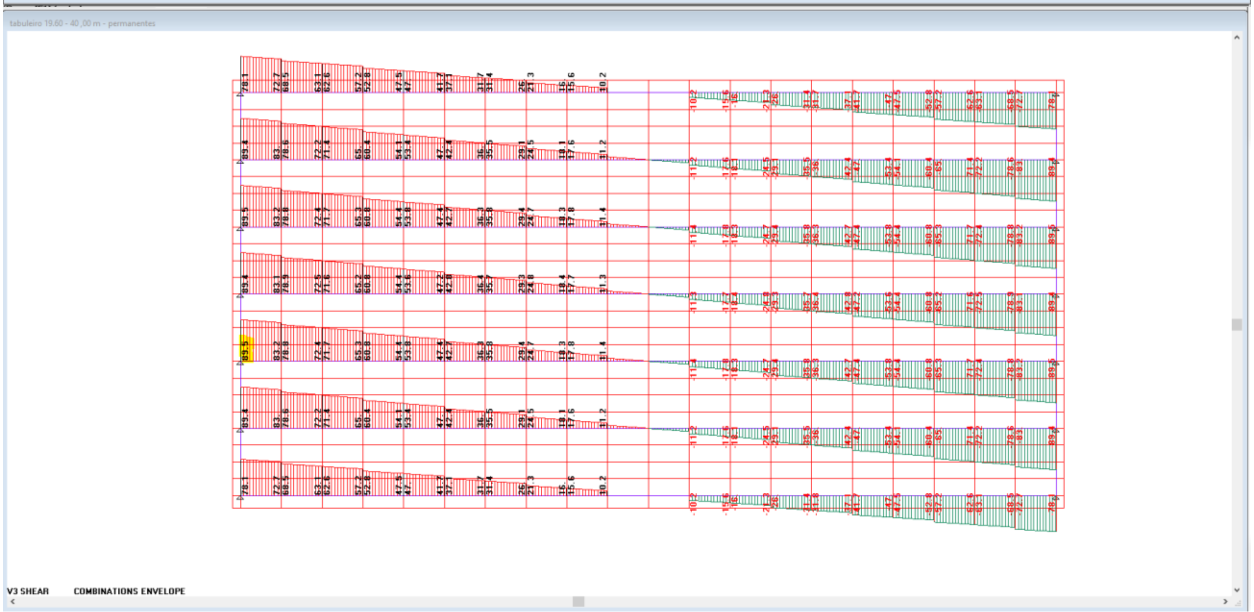

tabuleiro 19.60 - 35,00 m - TB-36
M2 MOMENT
COMBINATIONS ENVELOPE

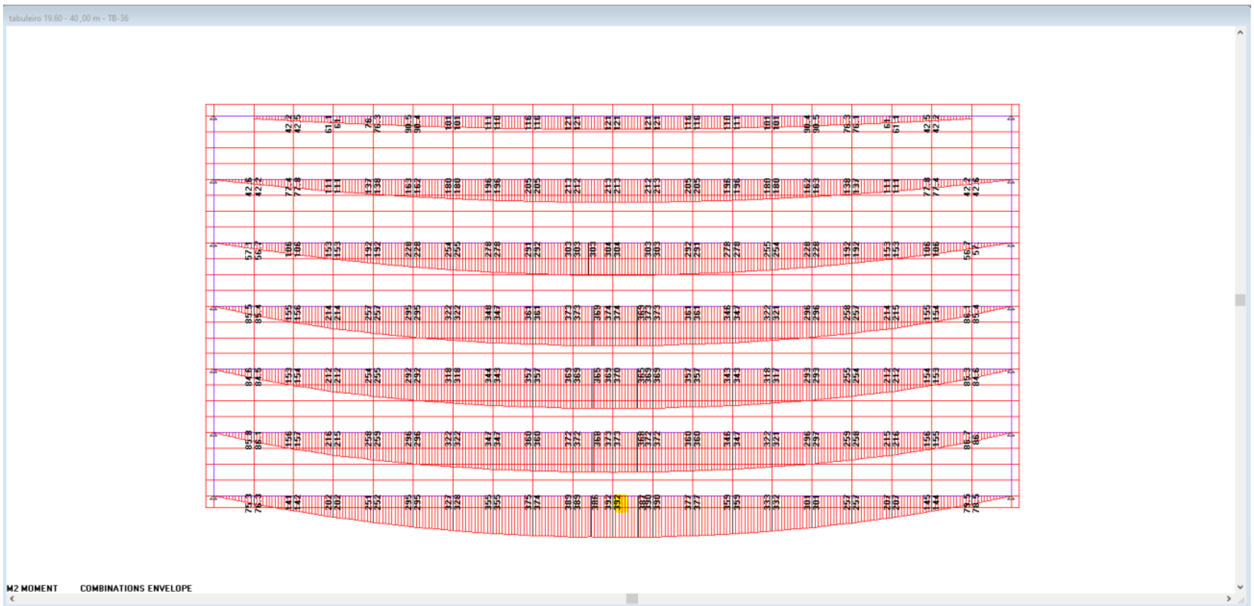

tabuleiro 19.60 - 35,00 m - TB-36
V3 SHEAR
COMBINATIONS ENVELOPE

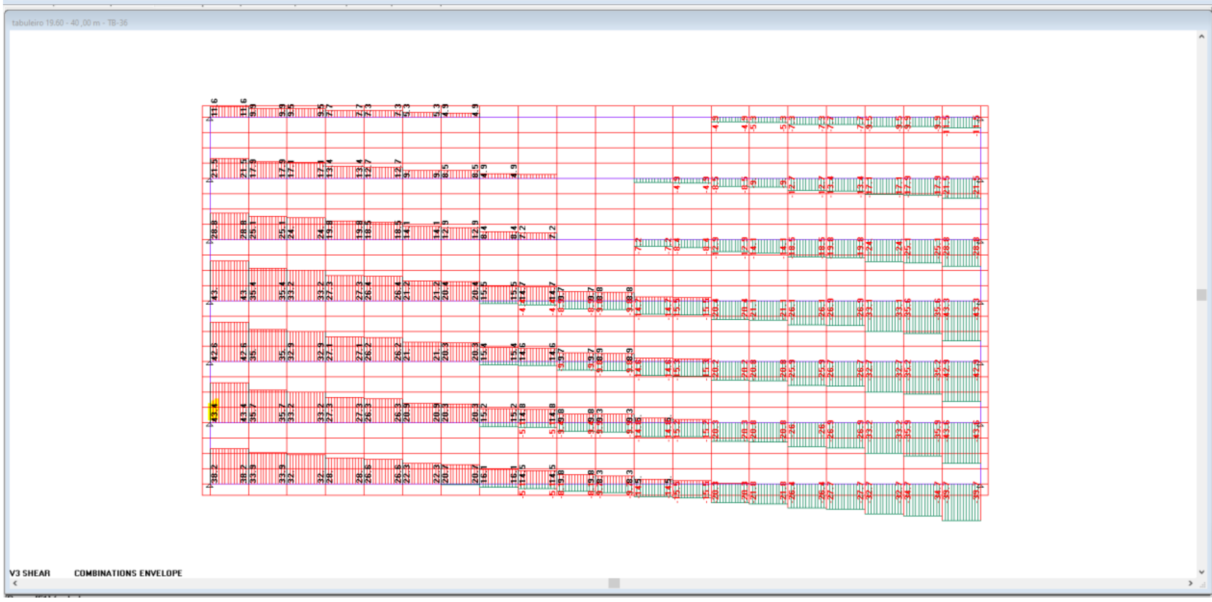

tabuleiro 19.60 - 40 ,00 m - Leibherr LTM 1500 HOMO A.INFL.
M2 MOMENT COMBINATIONS ENVELOPE


tabuleiro 19.60 - 40 ,00 m - Leibherr LTM 1500 HOMO A.INFL.
V3 SHEAR COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE

4.7. Resultados

4.7.1. Cálculo do CS (Coeficiente de Segurança)

Com base nos momentos e cortantes máximos obtidos para cada largura e comprimento de tabuleiro é possível calcular o Coeficiente de Segurança (CS), isto a partir da comparação dos esforços de cálculo de projeto com os esforços provocados pela passagem do guindaste.

A fórmula adotada para o coeficiente de segurança foi baseada no formulário definido na portaria SUP/DER-138-20/12/2021, que aprova norma para concessão de autorização especial de trânsito ao veículo ou combinação de veículos utilizados no transporte de carga indivisível e veículos especiais nas rodovias estaduais.

A carga especial passa centrada e sozinha sobre a obra, com velocidade controlada e neste caso o objetivo é que a liberação do guindaste ocorra de forma que ele trafegue junto com trânsito.

Segue o formulário para liberação exclusiva de cargas especiais adotado pelo DER/SP:

$$FS = \frac{1,40 \times S_g + 1,68 \times \varphi \times S_q}{1,2 \times S_g + 1,30 \times S_e}$$

O peso próprio da obra no numerador da fração e no denominador multiplicados por quantis diferentes levam o coeficiente de segurança a resultados mais favoráveis, condizentes com a passagem da carga especial centrada, controlada e isolada sobre a obra.

O guindaste não é considerado carga especial, já que trafega junto ao tráfego usual da rodovia, por isso o critério do coeficiente de segurança deve ser o mesmo adotado para as Combinações de Veículos de Carga (CVC), onde a comparação para obtenção do coeficiente é feita entre os esforços acidentais de cálculo e os esforços acidentais provocadas pelo CVC.

Desta forma, a comparação entre os esforços acidentais fica semelhante a fórmula acima suprimindo-se a parcela das cargas permanentes $\frac{1,40 \times S_g}{1,20 \times S_g}$, resultando em:

$$Cs = \frac{1,20 \times 1,40 \times \varphi_{TB} \times S_{Q-TB}}{CIV \times CNF \times 1,10 \times S_{Q-GUIN_{96-8}}}$$

$$Cs = \frac{1,68 \times \varphi_{TB} \times S_{Q-TB}}{CIV \times CNF \times 1,10 \times S_{Q-GUIN_{96-8}}}$$

Em que,

1,20: Coeficiente adotado a partir do estudo "Análise estrutural de pontes utilizadas por veículos de carga especial", apresentado na XXXII Jornada Sul-americana de Engenharia Estrutural de Campinas.
O coeficiente 1,2 permite ampliar as solicitações de carga dos TB-24 e TB-36 de modo que o cálculo da armadura da época seja equivalente à armadura calculada para o TB-45.
O coeficiente 1,20 é utilizado no estudo do IPT feito para os CVCs na comparação dos esforços.

1,40: Este é o coeficiente padrão utilizado na época para majoração dos esforços (Mq).

1,10: Utilizado para cargas truncadas, conforme norma, onde o valor é mais preciso e a majoração não precisa ser tão alta.

$\boldsymbol{\varphi_{TB}}$ **e** $\boldsymbol{CIV}$:

Para o TB-24 → $\boldsymbol{\varphi_{TB} = 1,30}$ (coeficiente de impacto constante);

Para o TB-36 → $\boldsymbol{\varphi_{TB} = 1,4 - 0,007 \times L_{vão}}$ **ou** $\boldsymbol{\varphi_{TB} = 1,4 - 0,007 \times 2 \times L_{bal}}$;

Para o Guindaste → $\boldsymbol{CIV = 1 + 1,06 \times \left(\frac{20}{50+L_{vão}}\right)}$ **ou** $\boldsymbol{CIV = 1 + 1,06 \times \left(\frac{20}{50+L_{bal}}\right)}$.

Os coeficientes de impacto das normas TB-36 e TB-24 foram multiplicados pelos coeficientes de impacto adotados em suas respectivas épocas ($\boldsymbol{\varphi_{TB}}$), para que os resultados estejam de acordo com a capacidade de suporte das pontes.

Em contrapartida, os esforços do guindaste foram multiplicados pelo coeficiente de impacto da norma atual TB-45 (**CIV**), com o intuito de verificar se, com as considerações atuais, uma ponte mais antiga seria capaz de suportar essas cargas.

CNF: Cálculo de Número de Faixas. Neste estudo, consideramos o número de faixas igual a 2, isto a favor da segurança.

$$\boldsymbol{CNF = 1 - 0,05 \times (N - 2) > 0,9}$$

Na segunda linha do quadro temos o CIV x CNF que equivale ao CIV puro, conforme norma NBR-7188 (1984) para efeito de comparação.

	Liv	5	8	10	20	30	40	50	60	80	100	120	140	160	180	200
	NBR - 7188 (1984)	1,37	1,34	1,33	1,26	1,19	1,12	1,05	1	1	1	1	1	1	1	1
	CIV	**1,35**	**1,35**	**1,35**	**1,3**	**1,27**	**1,24**	**1,21**	**1,19**	**1,16**	**1,14**	**1,12**	**1,11**	**1,1**	**1,09**	**1,08**
n	CIV/NBR	0,99	1	1,02	1,03	1,06	1,1	1,15	1,19	1,16	1,14	1,12	1,11	1,1	1,09	1,08
1	CIV x CNF	1,42	1,42	1,42	1,42	1,33	1,3	1,27	1,25	1,22	1,2	1,18	1,17	1,16	1,15	1,14
2	CIV x CNF	1,35	1,35	1,35	1,35	1,27	1,24	1,21	1,19	1,16	1,14	1,12	1,11	1,1	1,09	1,08
3	CIV x CNF	1,28	1,28	1,29	1,29	1,2	1,7	1,15	1,13	1,1	1,08	1,07	1,06	1,05	1,04	1,03
4	CIV x CNF	1,28	1,28	1,29	1,29	1,2	1,17	1,15	1,13	1,1	1,08	1,07	1,06	1,05	1,04	1,03

Coeficiente de impacto aplicado nos modelos de cálculo.

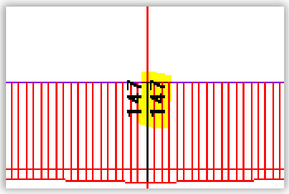
O coeficiente de impacto aplicado na modelagem 2D foi aplicado diretamente no carregamento do STRAP, portanto os esforços do processamento já trazem embutido os coeficientes de impacto.

Já para os esforços provocados pelo guindaste, os esforços obtidos no processamento são puros e sem impacto, para exemplificar este processo:

Tabuleiro de 11,20 x 20,00 m:

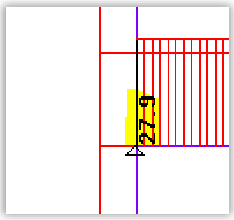
$$\varphi = 1{,}0 + 1{,}06 \times \left(\frac{20}{20 + 50}\right)$$

$$\varphi = 1{,}30$$



$$Mq = 1{,}30 \times 147$$

$$Mq = 191{,}10\ ton/m$$



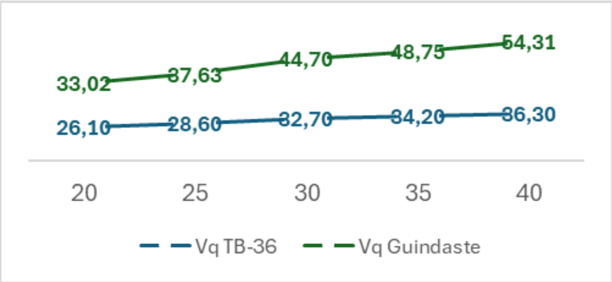
$$Vq = 1{,}30 \times 27{,}9$$

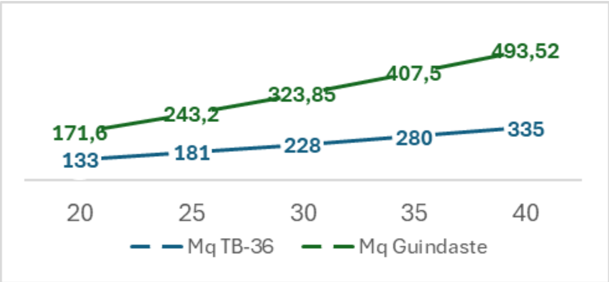
$$Vq = 36{,}27\ ton/m$$

Com todos os dados coletados, segue abaixo os quadros de resumo de carga e a aplicação da fórmula para cada largura de tabuleiro.

TABULEIROS		TB-36		GUINDASTE	
LARG (m)	COMP (m)	MOMENTO Mq (txm)	CORTANTE Vq (t)	MOMENTO Mq (txm)	CORTANTE Vq (t)
	20	133	26,10	171,6	33,02
	25	181	28,60	243,2	37,63
11,20 x	30	228	32,70	323,85	44,70
	35	280	34,20	407,5	48,75
	40	335	36,30	493,52	54,31

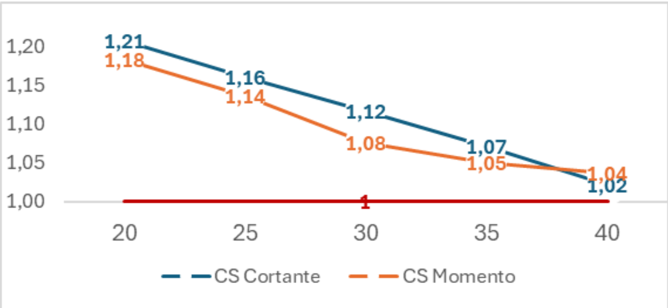
Consolidação e validação dos valores:



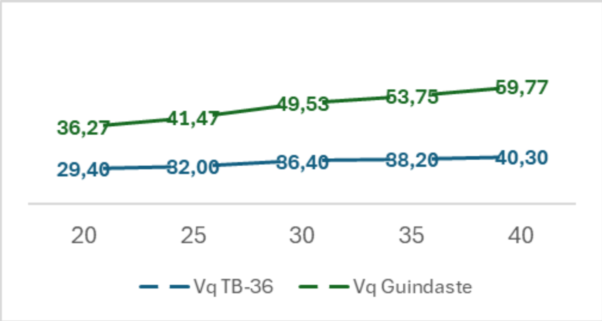


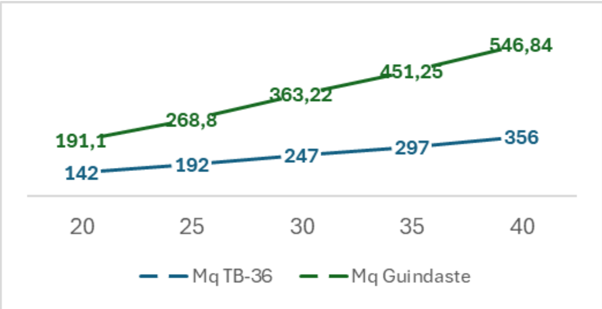
Cálculo do CS:

LARG (m)	COMP (m)	MOMENTO	CORTANTE
11,20 x	20	1,18	1,21
	25	1,14	1,16
	30	1,08	1,12
	35	1,05	1,07
	40	1,04	1,02

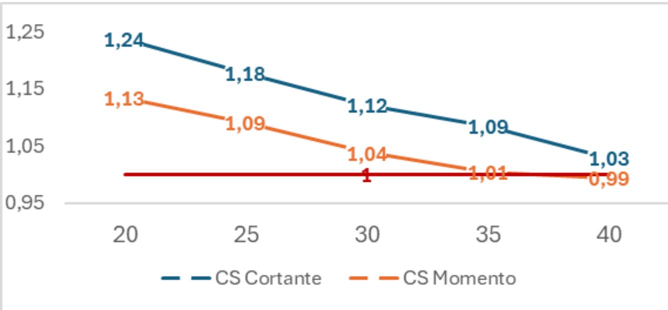


TABULEIROS		TB-36		GUINDASTE	
LARG (m)	COMP (m)	MOMENTO Mq (txm)	CORTANTE Vq (t)	MOMENTO Mq (txm)	CORTANTE Vq (t)
	20	142	29,40	191,1	36,27
	25	192	32,00	268,8	41,47
12,60 x	30	247	36,40	363,22	49,53
	35	297	38,20	451,25	53,75
	40	356	40,30	546,84	59,77

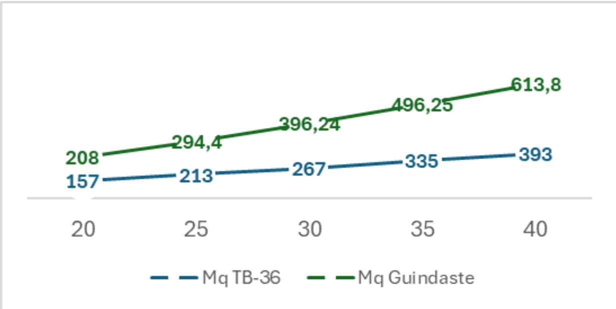


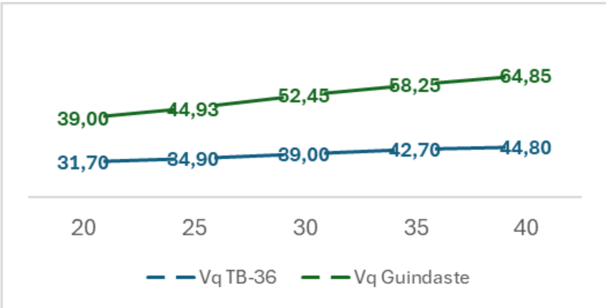


LARG (m)	COMP (m)	MOMENTO	CORTANTE
12,60 x	20	1,13	1,24
	25	1,09	1,18
	30	1,04	1,12
	35	1,01	1,09
	40	0,99	1,03

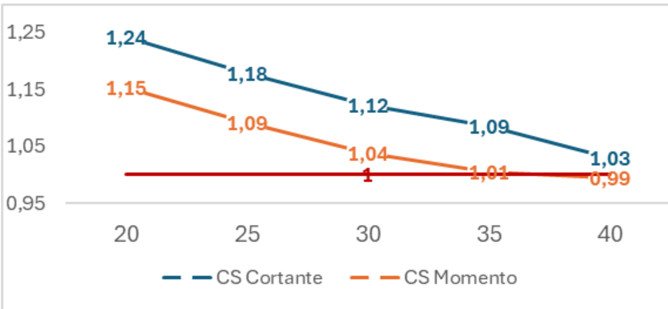


TABULEIROS		TB-36		GUINDASTE	
LARG (m)	COMP (m)	MOMENTO Mq (txm)	CORTANTE Vq (t)	MOMENTO Mq (txm)	CORTANTE Vq (t)
	20	157	31,70	208	39,00
	25	213	34,90	294,4	44,93
14,10 x	30	267	39,00	396,24	52,45
	35	335	42,70	496,25	58,25
	40	393	44,80	613,8	64,85

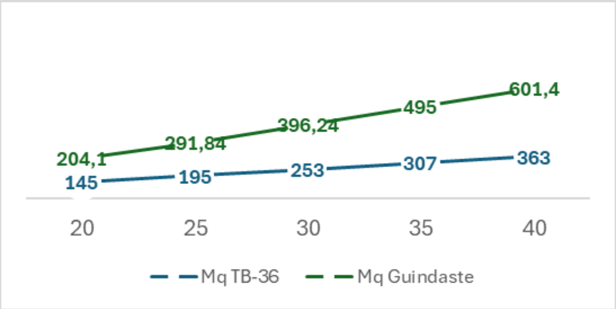


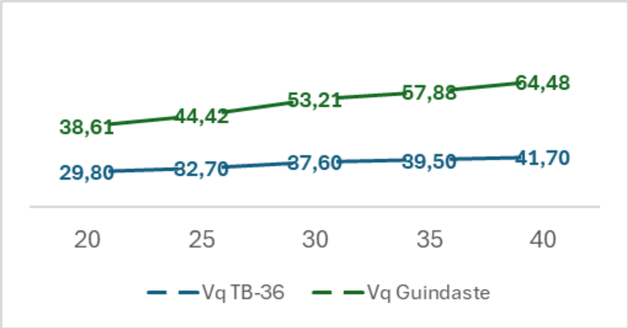


LARG (m)	COMP (m)	MOMENTO	CORTANTE
14,10 x	20	1,15	1,24
	25	1,09	1,18
	30	1,04	1,12
	35	1,01	1,09
	40	0,99	1,03

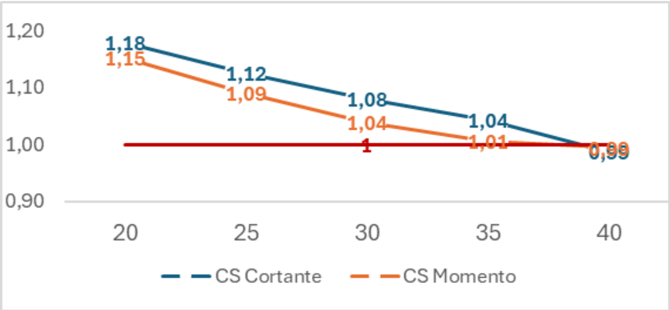


TABULEIROS		TB-36		GUINDASTE	
LARG (m)	COMP (m)	MOMENTO Mq (txm)	CORTANTE Vq (t)	MOMENTO Mq (txm)	CORTANTE Vq (t)
	20	145	29,80	204,1	38,61
	25	195	32,70	291,84	44,42
16,10 x	30	253	37,60	396,24	53,21
	35	307	39,50	495	57,88
	40	363	41,70	601,4	64,48

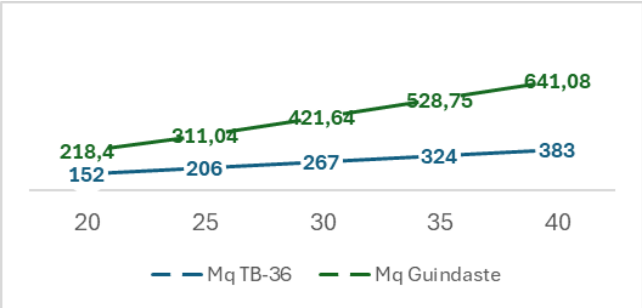


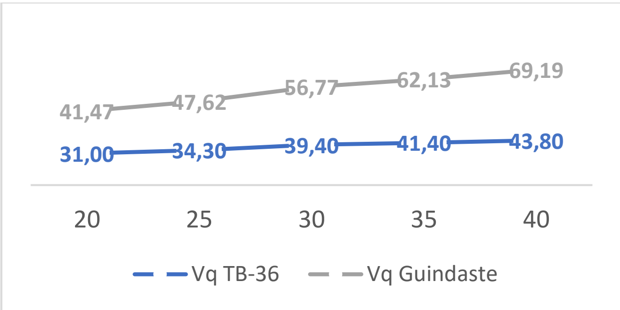


LARG (m)	COMP (m)	MOMENTO	CORTANTE
16,10 x	20	1,09	1,18
	25	1,02	1,12
	30	0,98	1,08
	35	0,95	1,04
	40	0,92	0,99

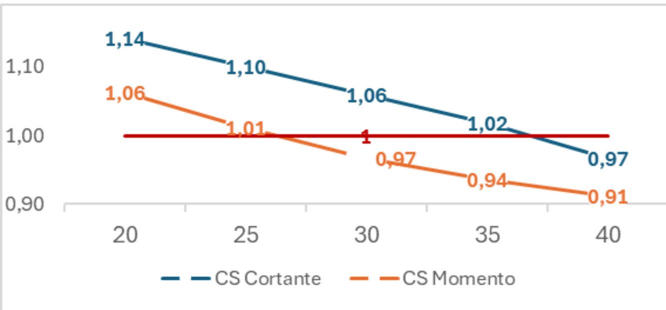


TABULEIROS		TB-36		GUINDASTE	
LARG (m)	COMP (m)	MOMENTO Mq (txm)	CORTANTE Vq (t)	MOMENTO Mq (txm)	CORTANTE Vq (t)
	20	152	31,00	218,4	41,47
	25	206	34,30	311,04	47,62
16,90 x	30	267	39,40	421,64	56,77
	35	324	41,40	528,75	62,13
	40	383	43,80	641,08	69,19

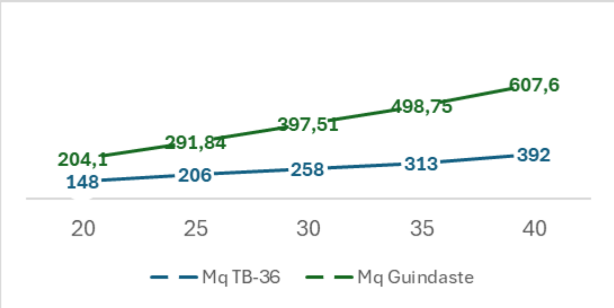


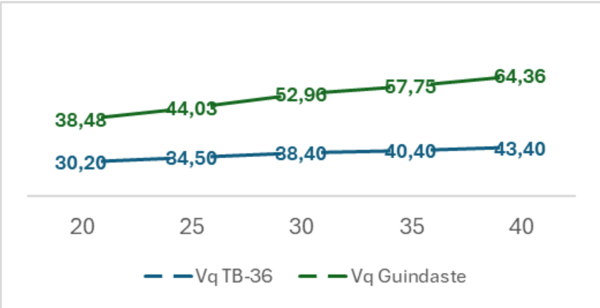


LARG (m)	COMP (m)	COEFICIENTE DE SEGURANÇA MOMENTO	CORTANTE
16,90 x	20	1,06	1,14
	25	1,01	1,10
	30	0,97	1,06
	35	0,94	1,02
	40	0,91	0,97

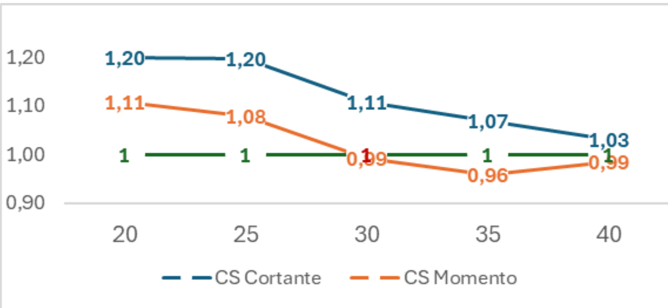


TABULEIROS		TB-36		GUINDASTE	
LARG	COMP	MOMENTO	CORTANTE	MOMENTO	CORTANTE
(m)	(m)	Mq (txm)	Vq (t)	Mq (txm)	Vq (t)
	20	148	30,20	204,1	38,48
	25	206	34,50	291,84	44,03
19,60 x	30	258	38,40	397,51	52,96
	35	313	40,40	498,75	57,75
	40	392	43,40	607,6	64,36





LARG (m)	COMP (m)	MOMENTO	CORTANTE
19,60 x	20	1,11	1,20
	25	1,08	1,20
	30	0,99	1,11
	35	0,96	1,07
	40	0,99	1,03



4.7.2. Cálculo da área de aço – armadura cortante

Também foi realizada a comparação entre a armadura de cortante suficiente para passar o guindaste com a que foi calculada para o TB-36. Para o TB-36, utilizamos a seguinte planilha:

CÁLCULO DO AÇO - NBR 1980 - 1984

Cálculo de τ_{wd}

$$\tau_{wd} = \frac{1{,}4 \times V_{máx}}{bw \times d}$$

$V_g =$		ton
$V_q =$		ton
$V_{máx} =$	0,00	ton
$bw =$		cm
$h =$		cm
d =	0,00	cm
$fck =$		kgf/cm²
$fcd =$	0,00	kgf/cm²
$\tau_{wd} =$		kgf/cm²

$$\tau_{wd_{último}} = 0{,}25 \times fcd \le 45\frac{kgf}{cm^2}$$

$\tau_{wd_{último}} =$	0,00	OK
$\tau_{wd_{último}} =$	0,00	

VERIFICAÇÃO:

$\tau_{wd} \le \tau_{wd_{último}}$ NÃO OK

Cálculo de τ_d

$$\tau_d = 1{,}15 \times \tau_{wd} - \tau_c$$

$$\tau_c = \varphi_1 \times \sqrt{fck}$$

considerando o mínimo, que está sempre a favor do concreto

$$\varphi_1 = \frac{0{,}24kgf}{cm^2}\ para\ \rho_1 \le 0{,}001$$

$\varphi_1 =$	0,24	kg/cm²
$\tau_c =$	0,00	kg/cm²
$\tau_d =$		kg/cm²

Cálculo de ρ_t

$$\rho_t = \frac{\tau_d}{fyd}$$

$fyk =$		kgf/cm²
$fyd =$	0,00	kg/cm²
$\rho_t =$		

Cálculo de A_{t_e}

$$A_{t_e} = \rho_t \times bw \times d$$

$A_{t_e} =$ cm²/m

E seguindo os critérios atuais, utilizamos a planilha abaixo para o guindaste:

CÁLCULO DO AÇO - NBR 6118

FÓRMULAS:

$$V_{sd} = 1{,}35 \times V_g + 1{,}50 \times V_p$$

$$V_{sd} \le V_{Rd2} = 0{,}27 \times \left(1 - \frac{fck}{250}\right) \times fcd \times bw \times d - fck\ em\ Mpa$$

$$\tau_{wd} = \frac{0{,}126 \times fck^{2/3}}{\gamma c}$$

$$\tau_{wd} = \frac{V_{sd}}{bw \times d}$$

$$A_{sw} = \frac{(\tau_{wd} - \tau_c) \times 100 \times bw}{0{,}9 \times fyd} \quad \left(\frac{cm^2}{m}\right)$$

$fck =$		Mpa	
$bw =$		cm	
$h =$		cm	
$d =$	0,00	cm	
$V_{sd} =$		ton	$V_{Liebherr_d} = 1{,}20 \times V_g + 1{,}10 \times V_q$
$V_{Rd2} =$	0,00	ton/cm2	NÃO OK
$\tau_{wd} =$		kgfcm2	
$\tau_c =$	0,00	kgf/cm2	
$A_{sw} =$		cm2/m	

Para utilizar a planilha de dimensionamento do aço necessário para a cortante, para o guindaste, foi adotado o valor de Vsd com a seguinte formulação:

$$\boldsymbol{V_d = 1,20 \times V_g + 1,1 \times V_q}$$

Em que,

Carga permanente (Vg): Considera-se um fator de 1,20, assumindo que a obra está íntegra e classificada como nível 3 ou maior de acordo com a norma de vistoria NBR 9452. Uma vez a obra integra, podemos adotar o coeficiente = 1,20, baseado no estudo: “Safety of Existing Bridges” que em função do estado de conservação da obra adota um coeficiente menor que o atual = 1,35 preconizado na norma atual para esforços de dimensionamento.

Carga acidental (Vq): Utiliza-se um fator de 1,10, uma vez que o peso do guindaste é uma carga bem definida, ou seja, seu peso ao trafegar pelas rodovias é conhecido.

O valor de Vsd para o TB-36, foi obtido conforme a fórmula da NB 1/78:

$$\boldsymbol{V_d = 1,40 \times V_g + 1,40 \times V_q}$$

Todos os resultados, para todos os tabuleiros, podem ser vistos nas tabelas abaixo:

$\boldsymbol{V_d = 1,40 \times V_g + 1,40 \times V_q}$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
11,2	33,30	26,10	43,40	28,60	56,20	32,70	67,40	34,20	79,70	36,30
5 longarinas										
Vsd =	83,16		100,80		124,46		142,24		162,40	
Asw (cm²/m) =	19,39		24,06		29,20		33,63		38,68	

$\boldsymbol{V_d = 1,20 \times V_g + 1,1 \times V_q}$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
11,2	33,30	33,02	43,4	37,632	56,2	44,70	67,4	48,75	79,7	54,312
5 longarinas										
Vsd =	76,28		93,48		116,61		134,51		155,38	
Asw (cm²/m) =	13,18		16,67		14,26		15,47		16,89	

$\boldsymbol{V_{d_{Liebherr}} < V_{d_{TB-36}}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

$$V_d = 1,40 \times V_g + 1,40 \times V_q$$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
12,6	36,40	29,40	47,10	32,00	60,80	36,40	72,40	38,20	85,80	40,30
5 longarinas										
Vsd =	92,12		110,74		136,08		154,84		176,54	
Asw (cm²/m) =	21,76		26,69		32,28		36,96		42,42	

$$V_d = 1,20 \times V_g + 1,1 \times V_q$$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
12,6	36,40	36,27	47,1	41,472	60,80	49,53	72,40	53,75	85,80	59,77
5 longarinas										
Vsd =	83,58		102,14		127,44		146,01		168,70	
Asw =	14,66		18,42		15,80		16,99		18,56	

$V_{d_{Liebherr}} < V_{d_{TB-36}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

$$V_d = 1,40 \times V_g + 1,40 \times V_q$$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
14,1	39,60	31,70	51,30	34,90	64,20	39,00	78,50	42,70	92,40	44,80
5 longarinas										
Vsd =	99,82		120,68		144,48		169,68		192,08	
Asw (cm²/m) =	23,80		29,42		34,50		40,88		46,32	

$$V_d = 1,20 \times V_g + 1,1 \times V_q$$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
14,1	39,60	39,00	51,3	44,928	64,20	52,45	78,50	58,25	92,40	64,85
5 longarinas										
Vsd =	90,42		110,98		134,74		158,28		182,22	
Asw (cm²/m) =	16,05		20,21		16,84		18,61		20,09	

$V_{d_{Liebherr}} < V_{d_{TB-36}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

$$V_d = 1,40 \times V_g + 1,40 \times V_q$$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
16,1	37,40	29,80	48,50	32,70	62,40	37,60	74,50	39,50	87,90	41,70
6 longarinas										
Vsd =	94,08		113,68		140,00		159,60		181,44	
Asw (cm²/m) =	22,28		27,34		33,83		39,40		43,72	

$$V_d = 1,20 \times V_g + 1,1 \times V_q$$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
16,1	37,40	38,61	48,5	44,416	62,40	53,21	74,50	57,88	87,90	64,48
6 longarinas										
Vsd =	87,35		107,06		133,41		153,06		176,41	
Asw =	15,31		19,42		16,65		17,92		19,48	

$V_{d_{Liebherr}} < V_{d_{TB-36}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

$$V_d = 1,40 \times V_g + 1,40 \times V_q$$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
16,9	38,80	31,00	50,30	34,30	64,60	39,40	77,10	41,40	90,80	43,80
6 longarinas										
Vsd =	97,72		118,44		145,60		165,90		188,44	
Asw (cm²/m) =	22,95		28,59		34,79		39,88		45,35	

$$V_d = 1,20 \times V_g + 1,1 \times V_q$$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
16,9	38,80	41,47	50,3	47,616	64,60	56,77	77,10	62,13	90,80	69,19
6 longarinas										
Vsd =	92,18		112,74		139,97		160,86		185,07	
Asw =	16,29		20,57		17,58		18,95		20,55	

$V_{d_{Liebherr}} < V_{d_{TB-36}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

$V_d = 1,40 \times V_g + 1,40 \times V_q$

TB-36

	20		25		30		35		40	
TABULEIROS	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq	Vg	Vq
19,6	38,10	30,20	49,40	34,50	63,60	38,40	75,90	40,40	89,50	43,40
7 longarinas										
Vsd =	95,62		117,46		142,80		162,82		186,06	
Asw (cm²/m) =	22,69		28,34		34,04		39,07		44,94	

$V_d = 1,20 \times V_g + 1,1 \times V_q$

LIEBHERR

	20		25		30		35		40	
TABULEIROS	Vg	Vq			Vg	Vq			Vg	Vq
19,6	38,10	38,48	49,4	44,032	63,60	52,96	75,90	57,75	89,50	64,36
7 longarinas										
Vsd =	88,05		107,72		134,57		154,61		178,19	
Asw =	15,45		19,55		16,81		18,13		19,70	

$V_{d_{Liebherr}} < V_{d_{TB-36}}$

VERIFICAÇÃO	RESISTE	RESISTE	RESISTE	RESISTE	RESISTE

4.7.3. Considerações para o TB-36

Concluímos que o guindaste trafega sobre obras TB-36 com o coeficiente de segurança maior que 1. A análise do TB-45 não é necessária, visto que a capacidade de suporte é maior que a do TB-36.

5. DESENVOLVIMENTO: TB-24 (1943 A 1950)

5.1. Introdução

Utilizamos a mesma fórmula de CS para o TB-24, que possui o processo de cálculo diferente para dois períodos – 1943 a 1950 e 1950 a 1960.

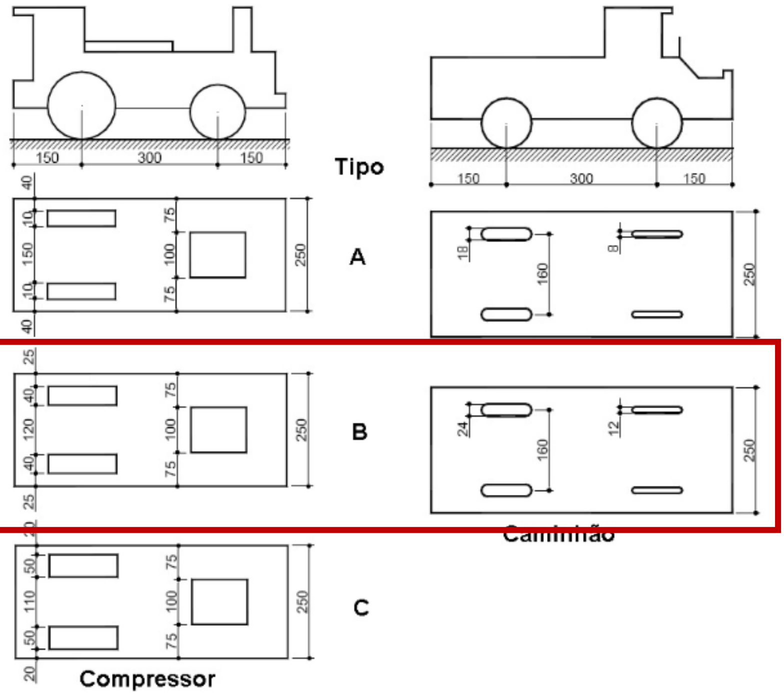
Para ambos, optamos por realizar o estudo a partir da Classe I, que são estradas tronco-federais, as mais robustas e importantes. Para estruturas Classe II e III, que são pontes localizadas em rodovias secundárias é necessário um estudo caso a caso.

As pontes rodoviárias são agrupadas em três classes:

- Classe I: Pontes situadas em estradas-tronco federais e estaduais ou nas estradas de ligação principais entre esses troncos.
- Classe II: Pontes situadas em estradas de ligação secundárias, mas que podem prever a passagem de veículos pesados.
- Classe III: Pontes situadas em estradas de ligação secundárias não incluídas na Classe II.

Para o estudo do primeiro período (1943 a 1950), a norma exige a verificação dos esforços com a passagem do rolo compressor tipo B mais próximo do acostamento em conjunto com um caminhão do tipo B.

Figura 1 - Compressor e caminhão utilizado no trem-tipo segundo NB6/43 (ABNT, 1943)



O trem-tipo para pontes da Classe I compõe-se de multidão com $g_o = 450$ kgf/m², de um compressor Tipo B e de tantos caminhões tipo B quantas forem as faixas de tráfego, menos uma, e dispostos como no caso do item 2.2.2. A resistência da estrutura deve ainda ser verificada para um compressor Tipo C (Tabela 1), colocado como no caso do item 2.2.2.

FONTE: "Evolução dos trens-tipos de projeto de cargas rodoviárias das normas brasileiras", elaborado pelo Prof. Paulo de Sá Pereira Cavalcanti.

Para a verificação, foi adotado homogeneização das cargas do rolo compressor e do caminhão:

- Área do veículo: 2,5 x 6 = 15 m²
- Alívio: 0,45 x 15 = 6,75 toneladas

Exemplo de Cálculo para o Compressor tipo B:

- Peso total: 16 toneladas
- Peso da roda dianteira: 7 toneladas
- Peso da roda traseira: 4,5 toneladas
- Peso homogeneizado: 16 - 6,75 = 9,25 toneladas

Aplicando uma regra de três:

- Eixo Dianteiro (ED):
  - 7 tf (peso de cada roda) - 16 tf (peso total do veículo)
  - x - 9,25 tf (peso homogeneizado)
  - x = 4,05 tf
- Eixo Traseiro (ET):
  - 4,5 tf - 16 tf
  - x - 9,25 tf
  - x = 2,60 tf

O mesmo critério foi adotado para a homogeneização do caminhão

Desenhamos as seções transversais mais comuns de três tabuleiros utilizados na época do estudo e realizamos o cálculo a partir da LI (Linha de Influência).

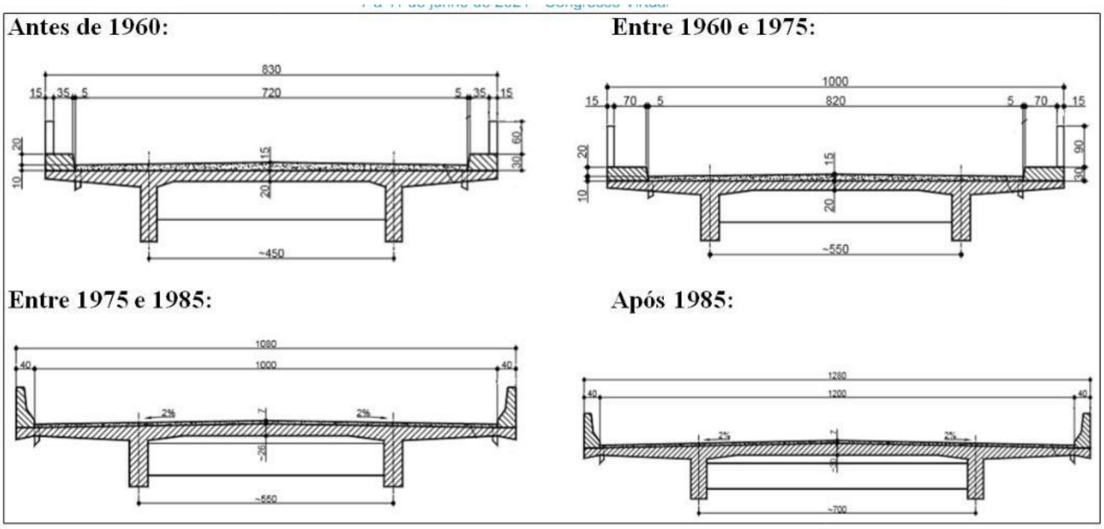
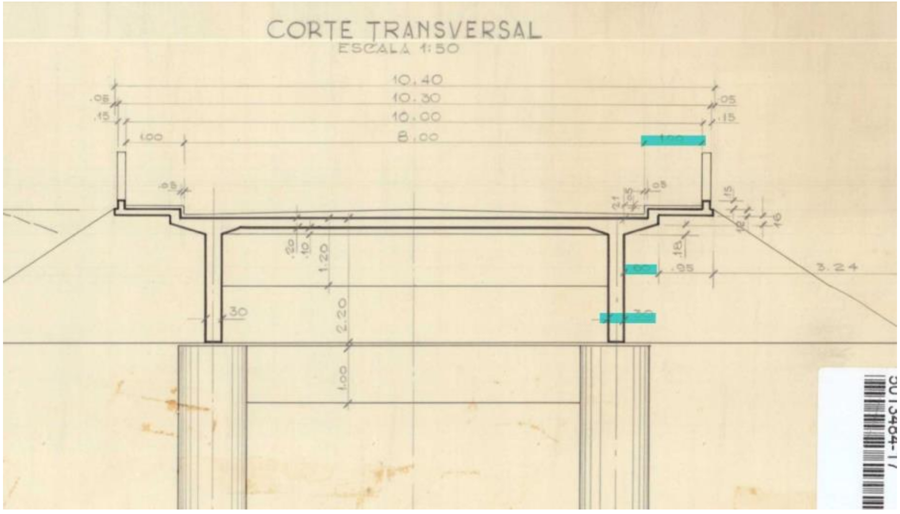
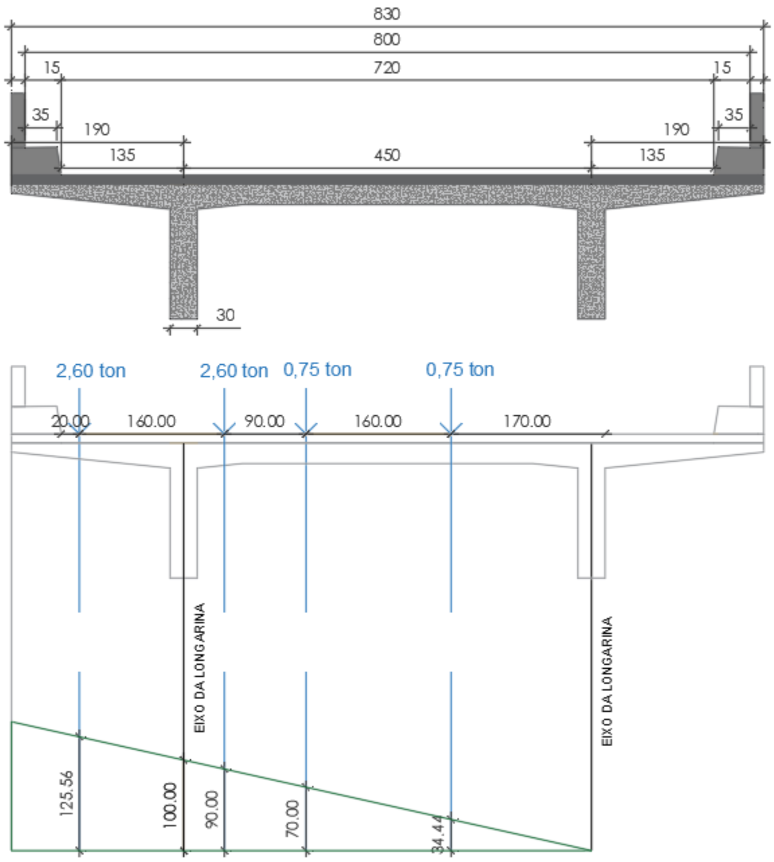


Figura 3 – Correspondência das seções transversais tipo com a época de construção (adaptado de MANUAL 709 (BRASIL, 2004).

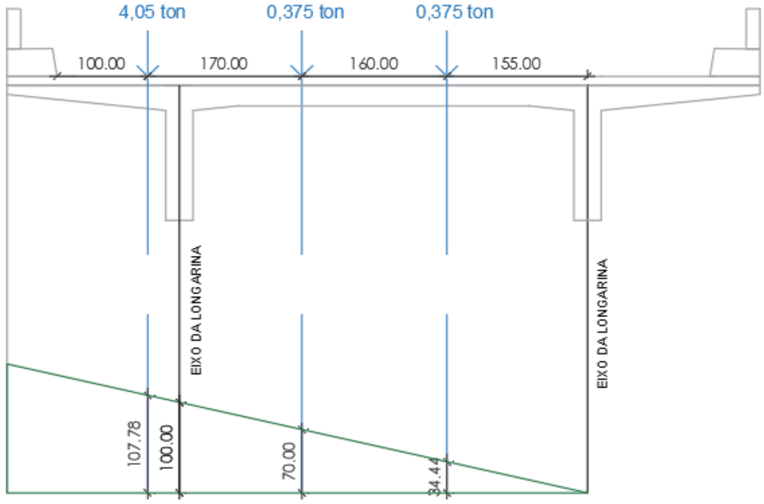


5.2. Linhas de influência de reação de apoio – Rolo compressor + caminhão

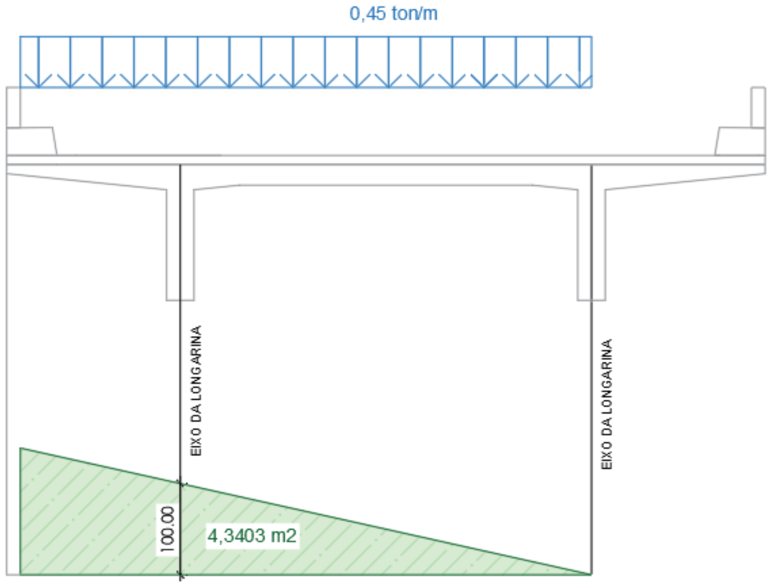
5.2.1. Tabuleiro 8,30 m



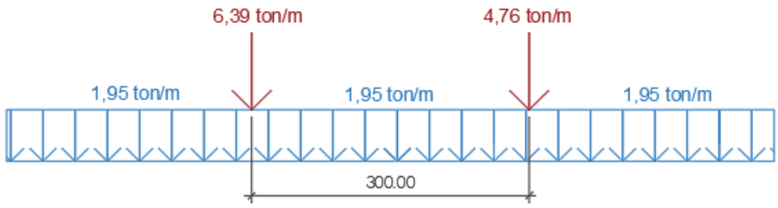
RODAS TRASEIRAS = 2,60 x (1,2556 + 0,9000) + 0,75 x (0,7000 + 0,3444) = 6,39 ton



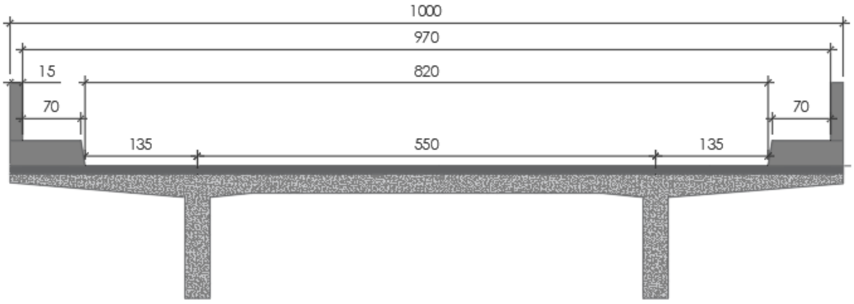
RODAS DIANTEIRAS = (4,05 x 1,0778) + 0,375 x (0,7000 + 0,3444) = 4,76 ton

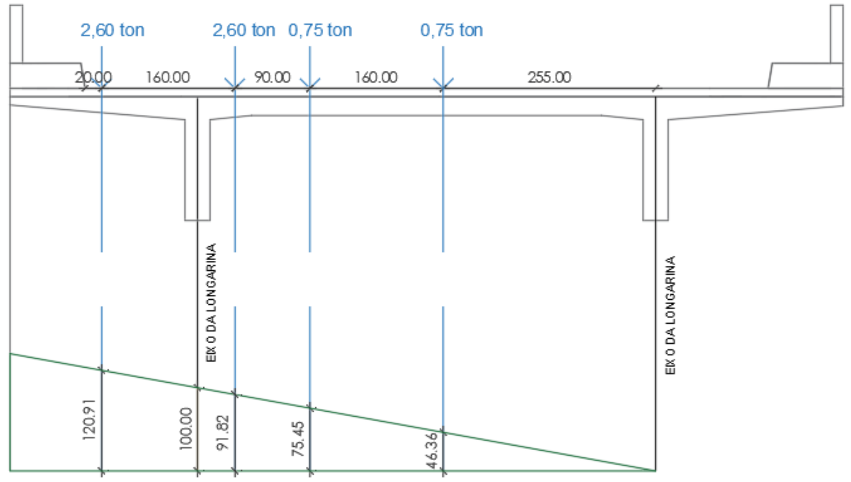


MULTIDÃO 1 = 0,45 x 4,3403 = 1,95 ton/m

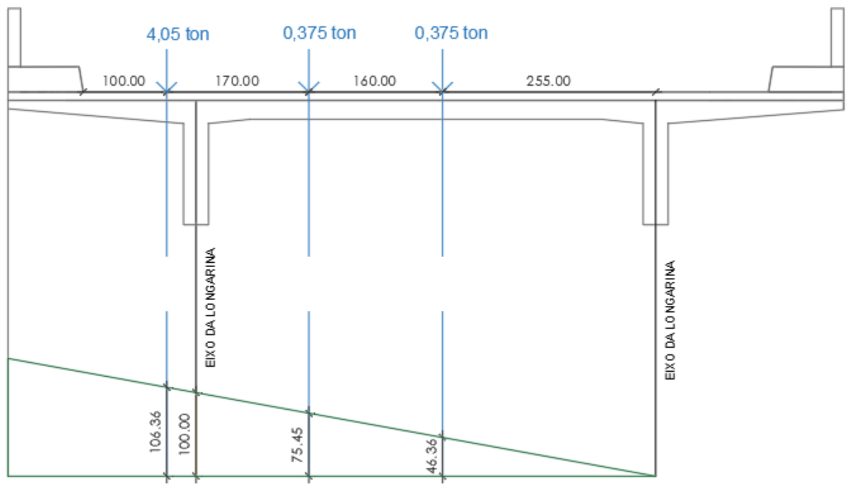


5.2.2. Tabuleiro 10,00m

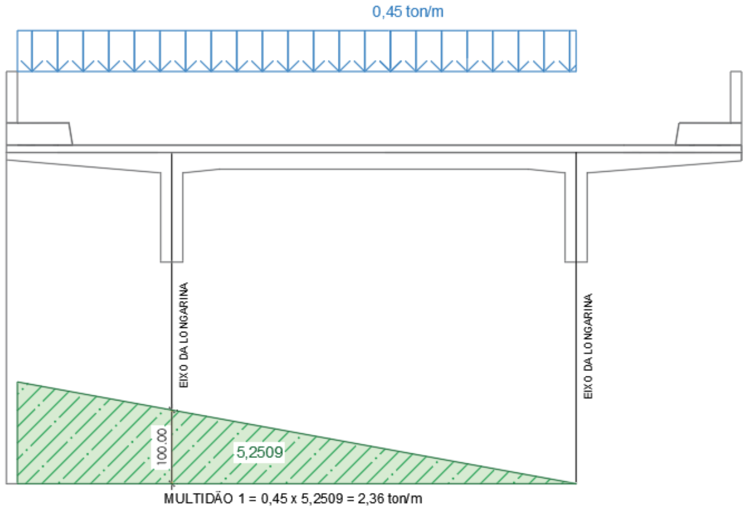


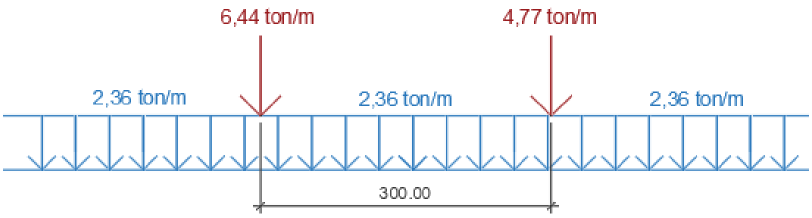


RODAS TRASEIRAS = 2,60 x (1,2091 + 0,9182) + 0,75 x (0,7545 + 0,4636) = 6,44

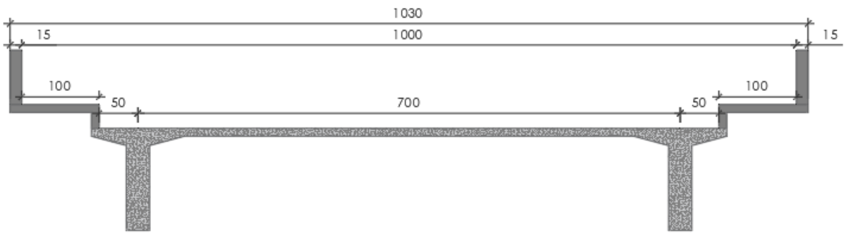


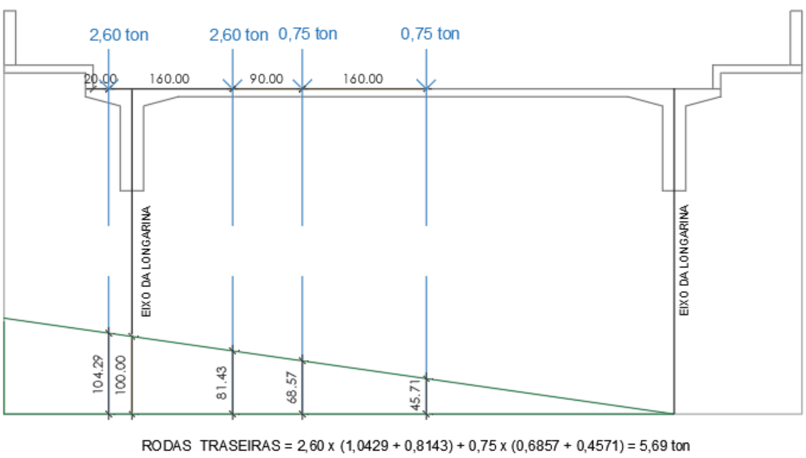
RODAS DIANTEIRAS = 4,05 x 1,0636 + 0,375 x (0,7545 + 0,4636) = 4,77 ton

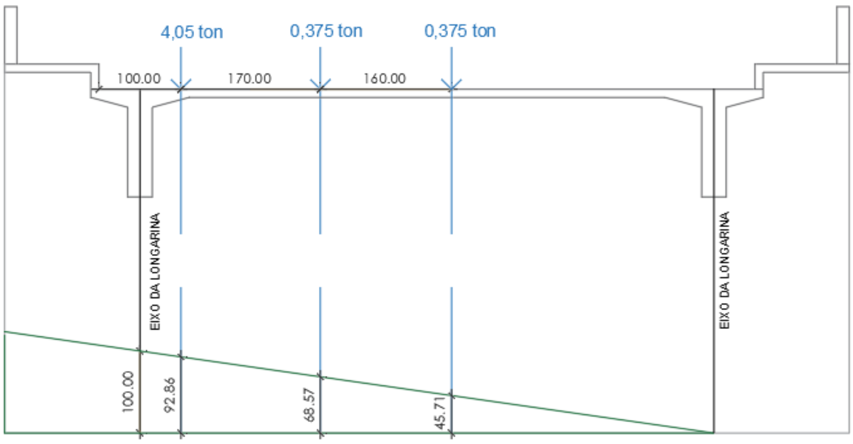




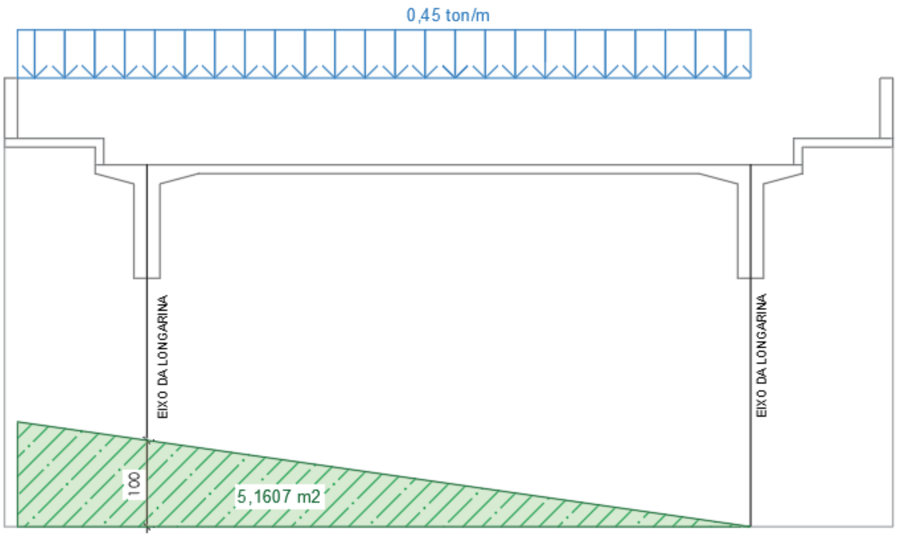
5.2.3. Tabuleiro 10,30 m



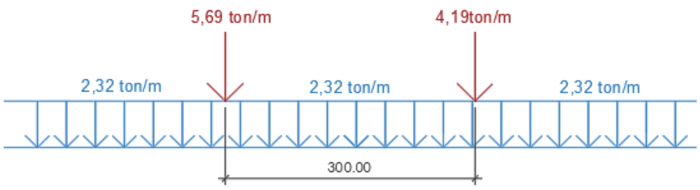




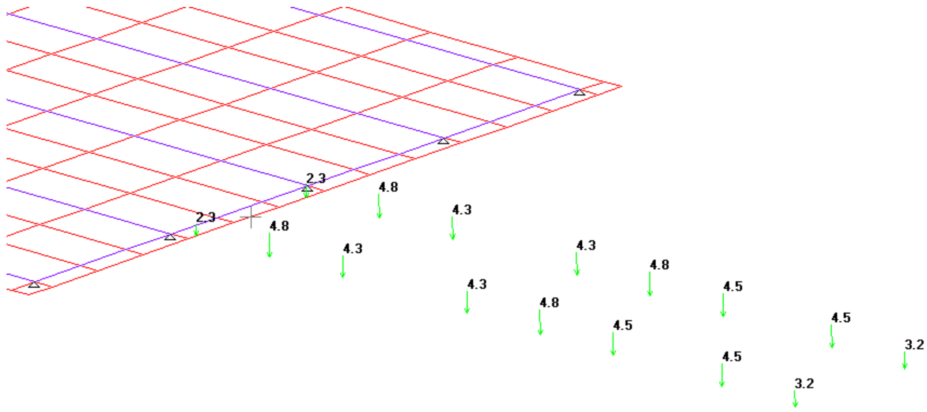
RODAS DIANTEIRAS = 4,05 x 0,9286 + 0,375 x (0,6857+ 0,4571) = 4,19 ton



MULTIDÃO 1 = 0,45 x 5,1607 = 2,32 ton/m



GUINDASTE LEIBHERR HOMOGENIZADO - LTM1500-C-HOAIpu



LTM1500-C-HOAIpu

CONC -2.27 C 0.00 1.305

CONC -2.27 C 0.00 -1.305

CONC -4.76 C 1.65 1.305

CONC -4.76 C 1.65 -1.305

CONC -4.33 C 3.30 1.305

CONC -4.33 C 3.30 -1.305

CONC -4.33 C 6.10 1.305

CONC -4.33 C 6.10 -1.305

CONC -4.76 C 7.75 1.305

CONC -4.76 C 7.75 -1.305

CONC -4.48 C 9.40 1.305

CONC -4.48 C 9.40 -1.305

CONC -4.48 C 11.85 1.305

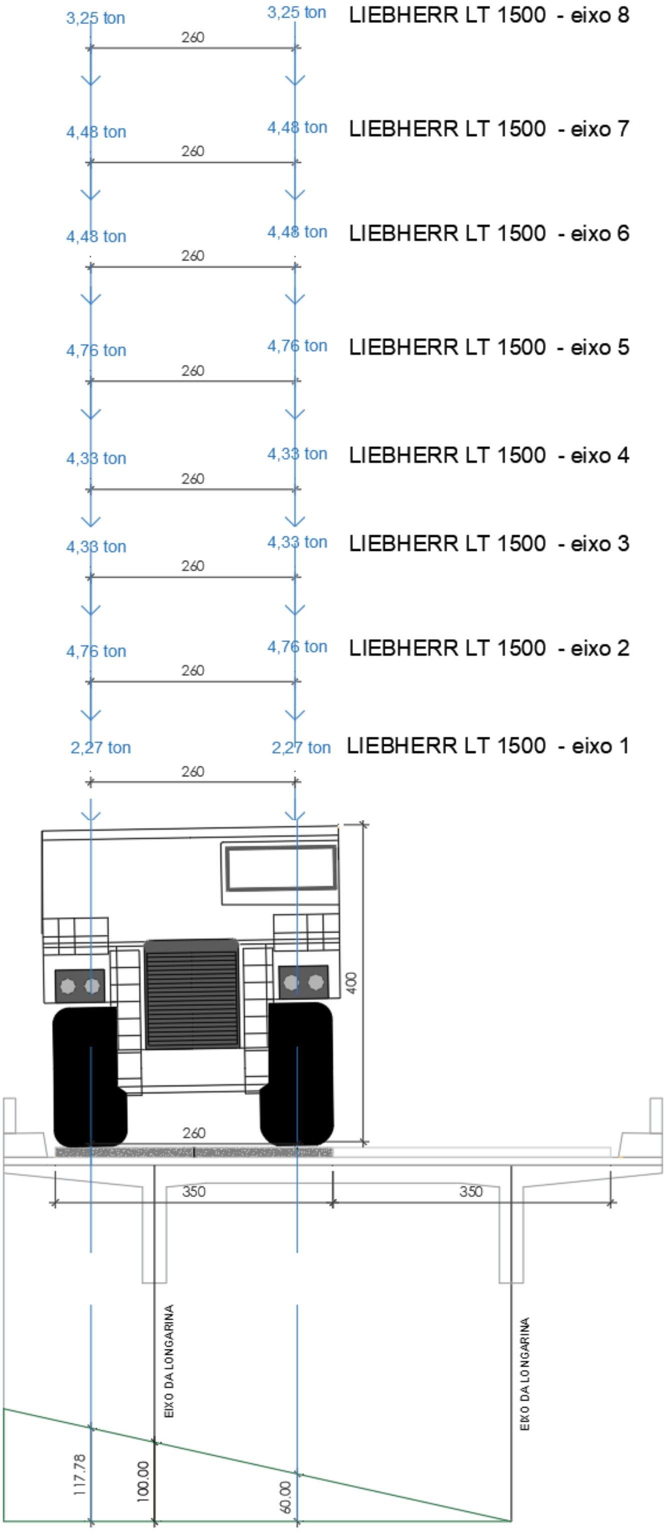
CONC -4.48 C 11.85 -1.305

CONC -3.25 C 13.50 1.305

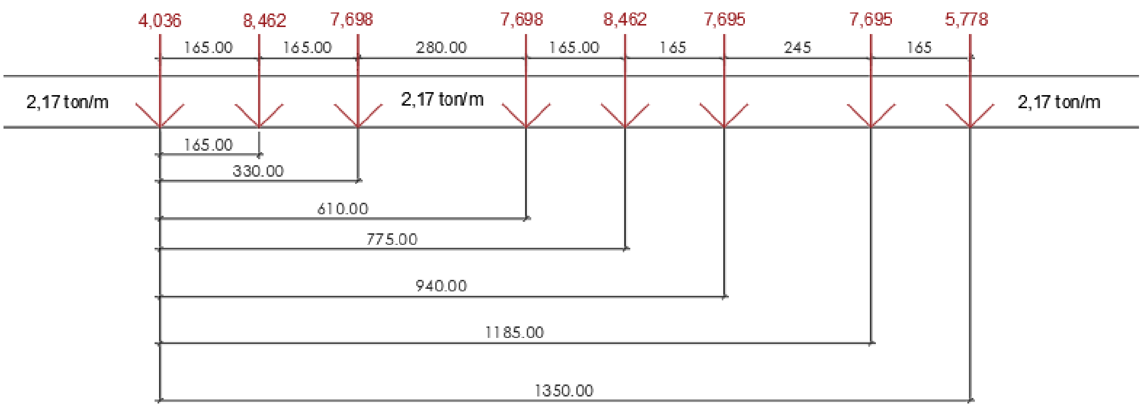
CONC -3.25 C 13.50 -1.305

5.3. Linhas de influência de reação de apoio – Guindaste

5.3.1. Tabuleiro 8,30 m

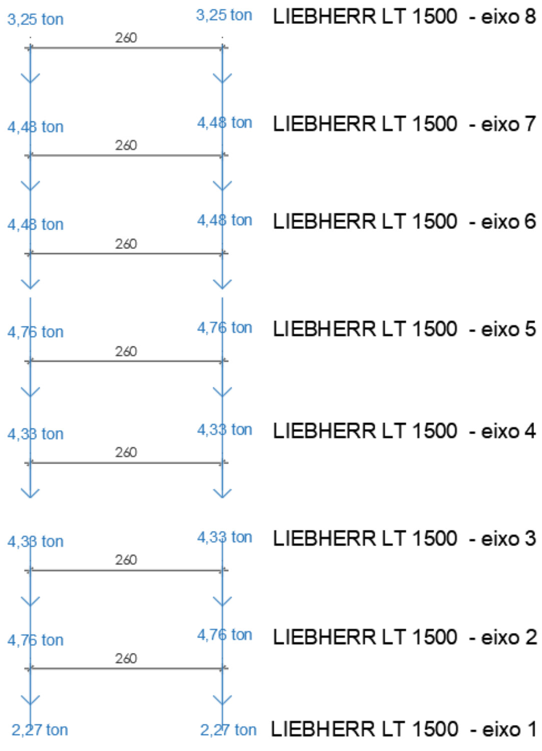


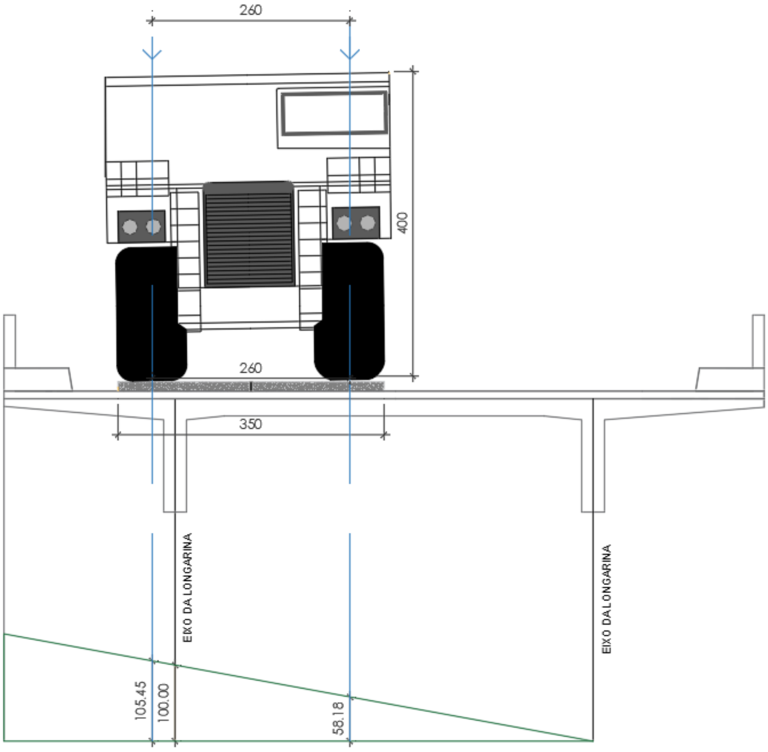
MULTIDÃO = 0,5 x 4,3403 = 2,17 ton/m



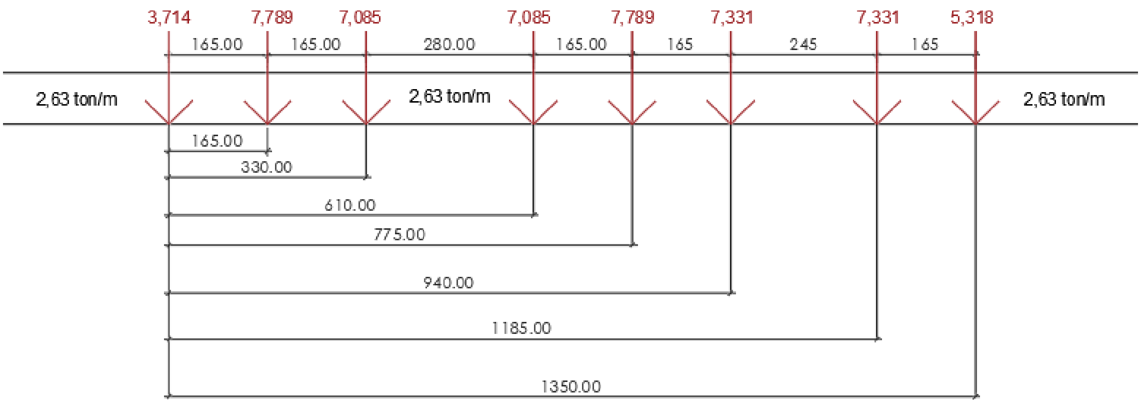
EIXO 1 = 2,27 x (1,1778 + 0,6000) = 4,036 ton
EIXO 2 = 4,76 x (1,1778 + 0,6000) = 8,462 ton
EIXO 3 = 4,33 x (1,1778 + 0,6000) = 7,698 ton
EIXO 4 = 4,33 x (1,1778 + 0,6000) = 7,698 ton
EIXO 5 = 4,76 x (1,1778 + 0,6000) = 8,462 ton
EIXO 6 = 4,48 x (1,1778 + 0,6000) = 7,965 ton
EIXO 7 = 4,48 x (1,1778 + 0,6000) = 7,965 ton
EIXO 8 = 3,25 x (1,1778 + 0,6000) = 5,778 ton

5.3.2. Tabuleiro 10,00 m



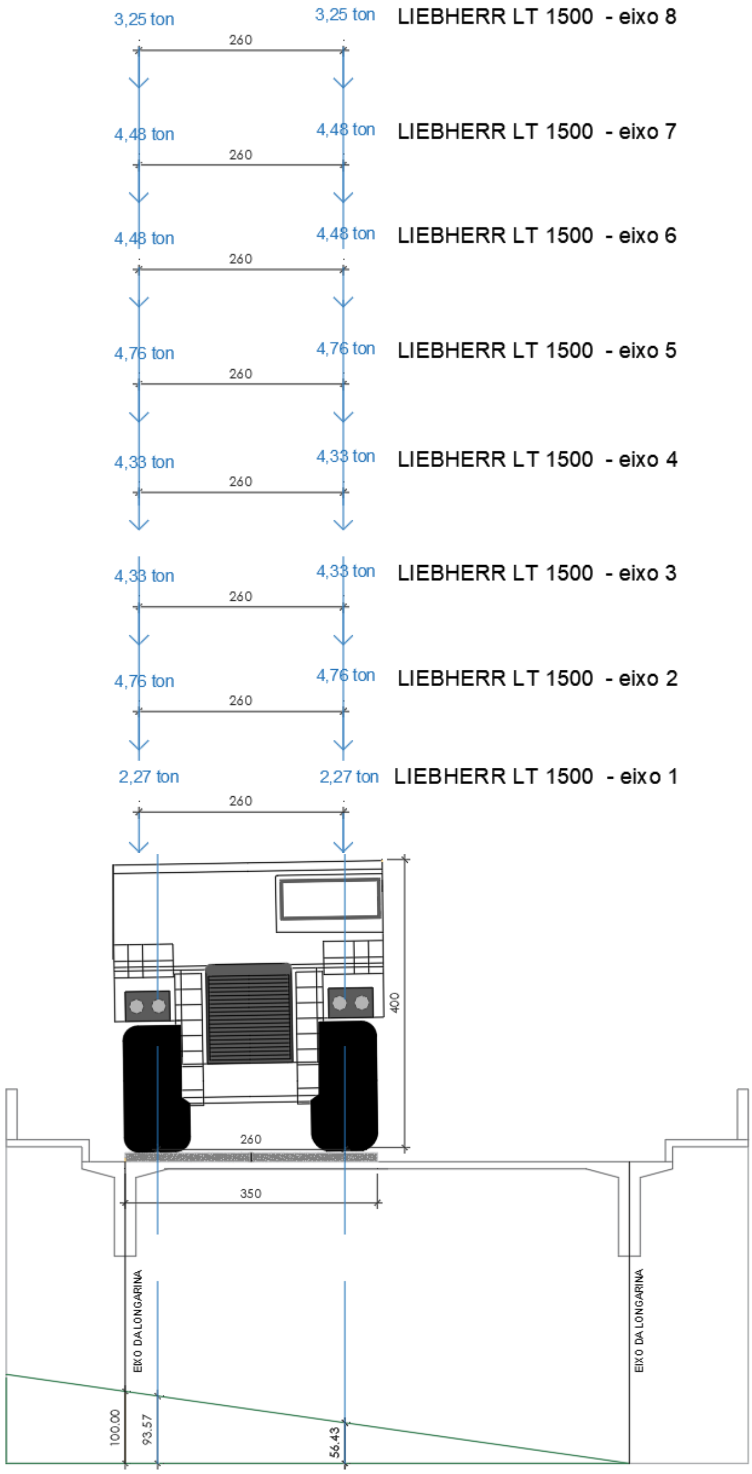


MULTIDÃO = 0,5 x 5,2509 = 2,63 ton/m

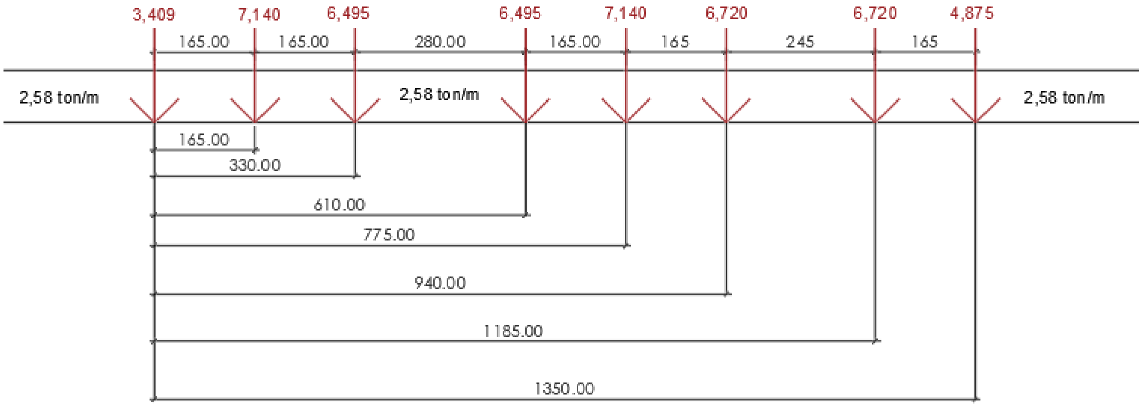


EIXO 1 = 2,27 x (1,0545 + 0,5818) = 3,714 ton
EIXO 2 = 4,76 x (1,0545 + 0,5818) = 7,789 ton
EIXO 3 = 4,33 x (1,0545 + 0,5818) = 7,085 ton
EIXO 4 = 4,33 x (1,0545 + 0,5818) = 7,085 ton
EIXO 5 = 4,76 x (1,0545 + 0,5818) = 7,789 ton
EIXO 6 = 4,48 x (1,0545 + 0,5818) = 7,331 ton
EIXO 7 = 4,48 x (1,0545 + 0,5818) = 7,331 ton
EIXO 8 = 3,25 x (1,0545 + 0,5818) = 5,318 ton

5.3.3. Tabuleiro 10,30 m



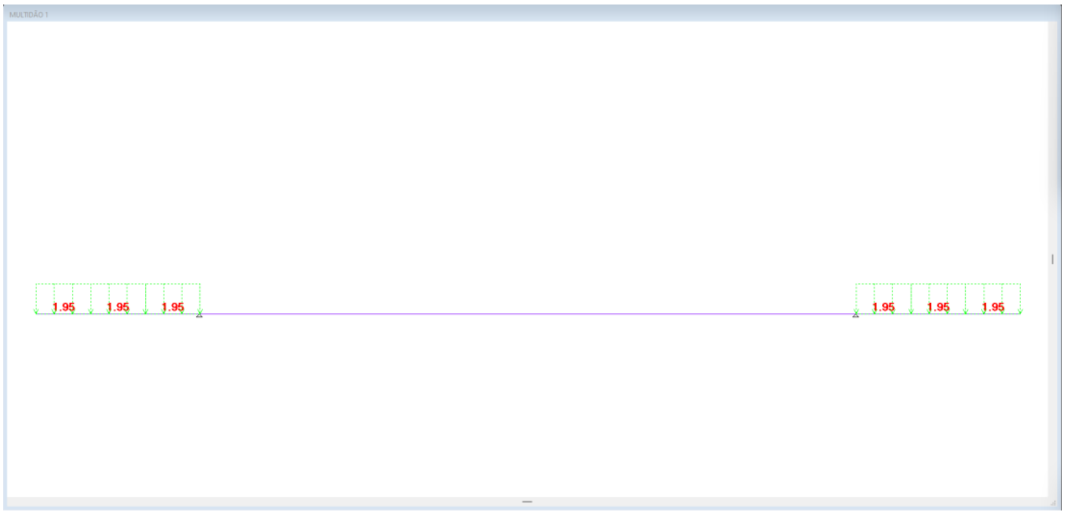
MULTIDÃO = 0,5 x 5,1607 = 2,58 ton/m

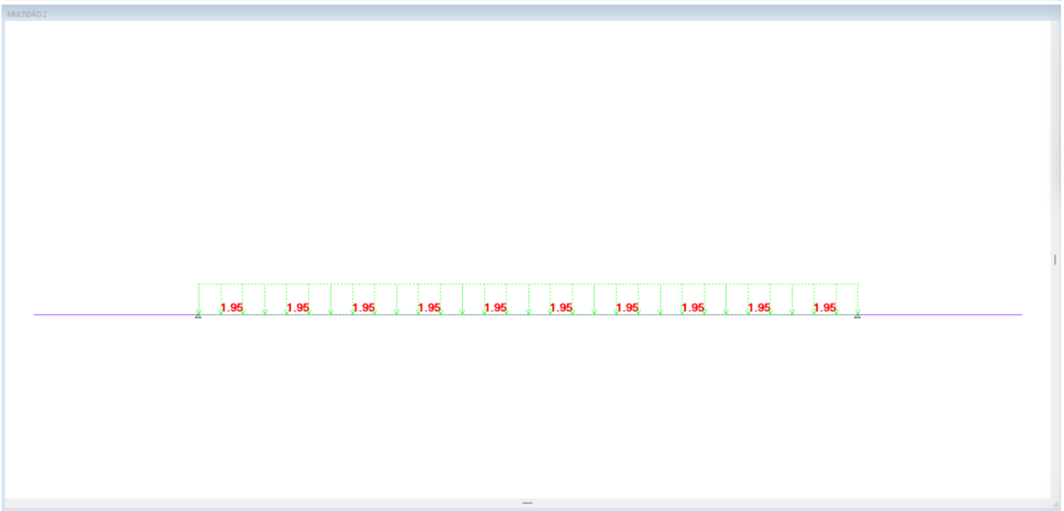


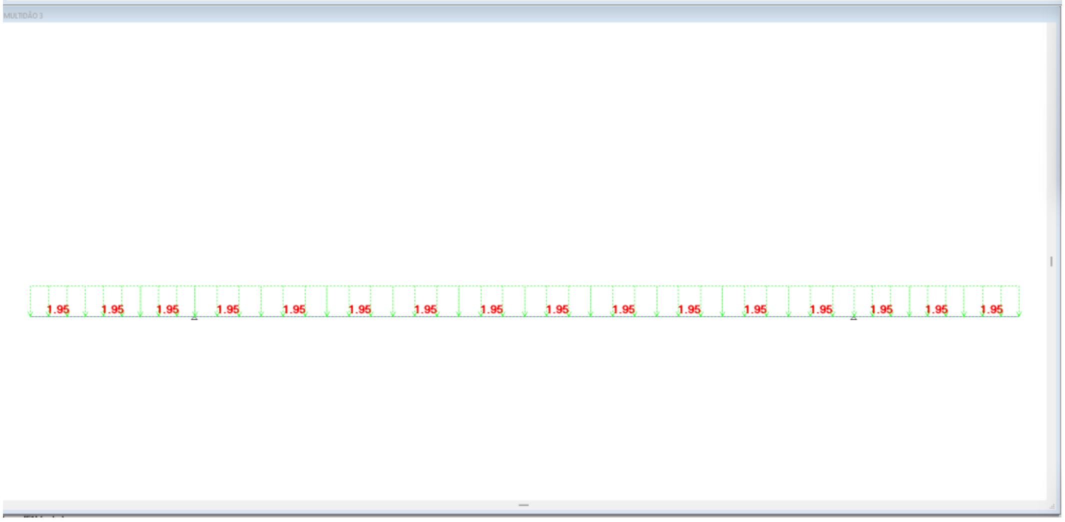
EIXO 1 = 2,27 x (0,9357 + 0,5643) = 3,405 ton
EIXO 2 = 4,76 x (0,9357 + 0,5643) = 7,140 ton
EIXO 3 = 4,33 x (0,9357 + 0,5643) = 6,495 ton
EIXO 4 = 4,33 x (0,9357 + 0,5643) = 6,495 ton
EIXO 5 = 4,76 x (0,9357 + 0,5643) = 7,140 ton
EIXO 6 = 4,48 x (0,9357 + 0,5643) = 6,720 ton
EIXO 7 = 4,48 x (0,9357 + 0,5643) = 6,720 ton
EIXO 8 = 3,25 x (0,9357 + 0,5643) = 4,875 ton

5.4. Cargas acidentais (TB-24 e Guindaste) – Momentos e cortantes

5.4.1. Tabuleiro 8,30 m








VEÍCULO
6.4
4.8


MULTIDÃO 1
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2.17


MULTIDÃO 2
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2.17
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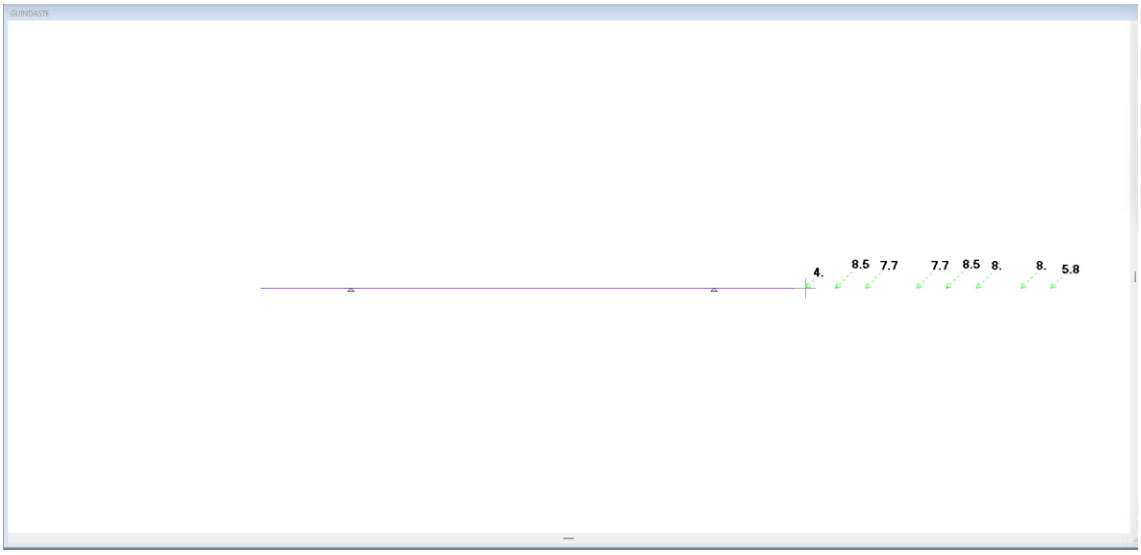
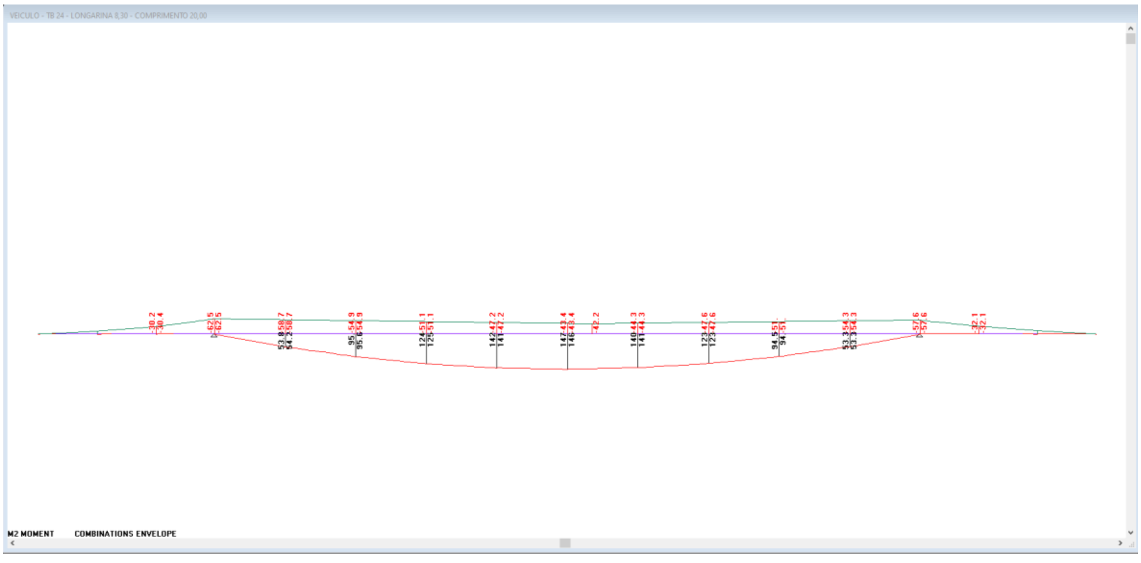
2.17
2.17
2.17
2.17
2.17
2.17
2.17


MULTIDÃO 3
2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17 2.17


GUINDASTE
4. 8.5 7.7 7.7 8.5 8. 8. 5.8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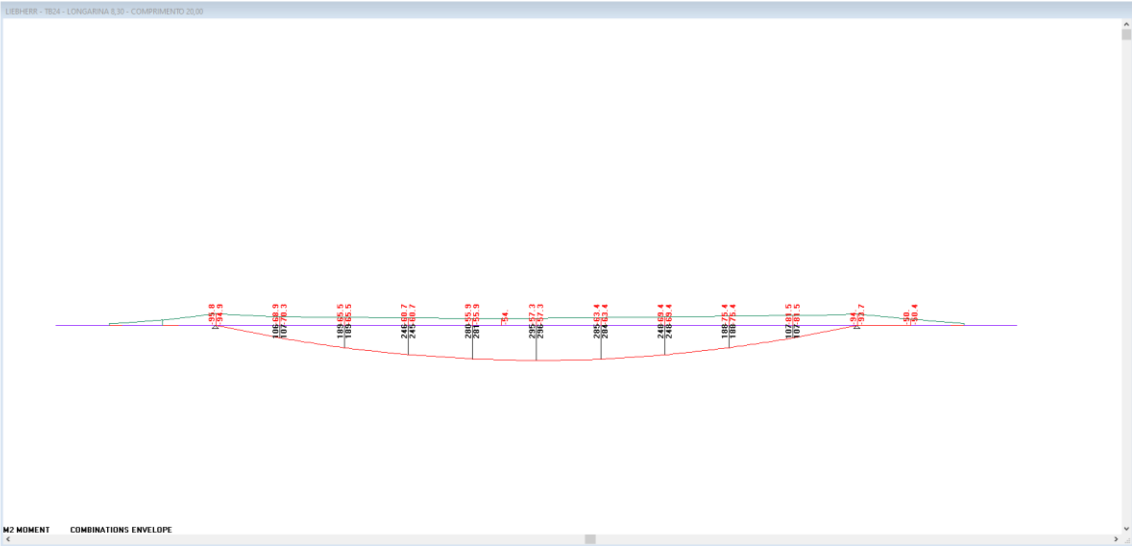
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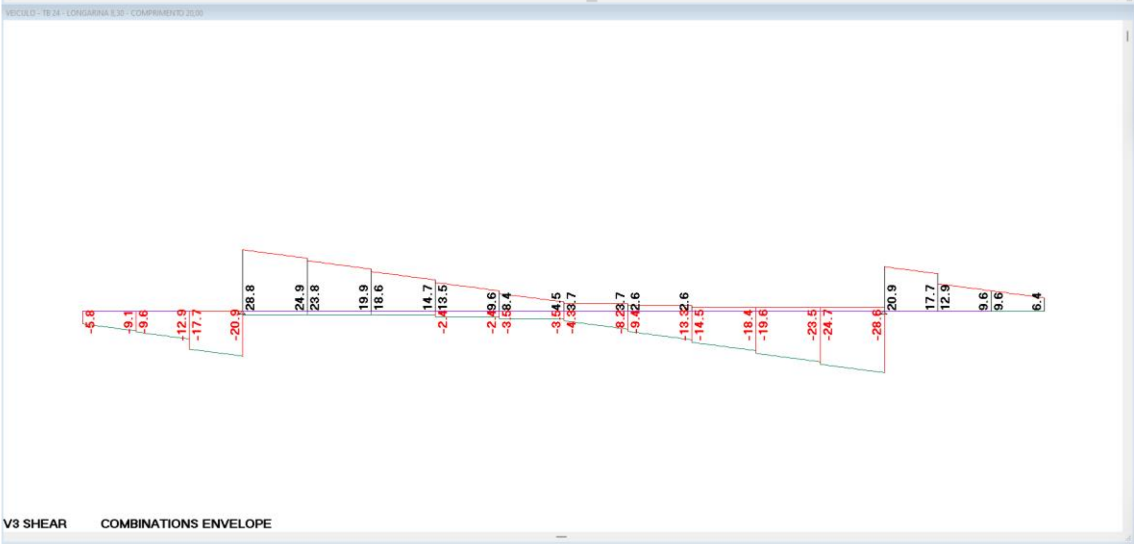
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-9.6
-12.9
-17.7
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28.8
24.9
23.8
19.9
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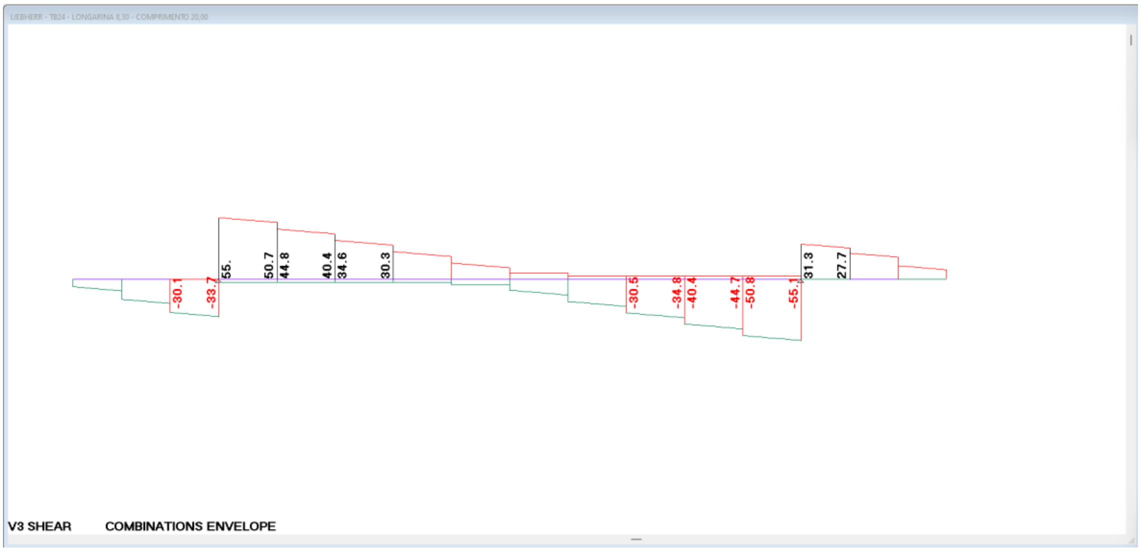
20.9
17.7
12.9
9.6
9.6
6.4
-18.4
-19.6
-23.5
-24.7
-28.6
V3 SHEAR COMBINATIONS ENVELOPE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30.3
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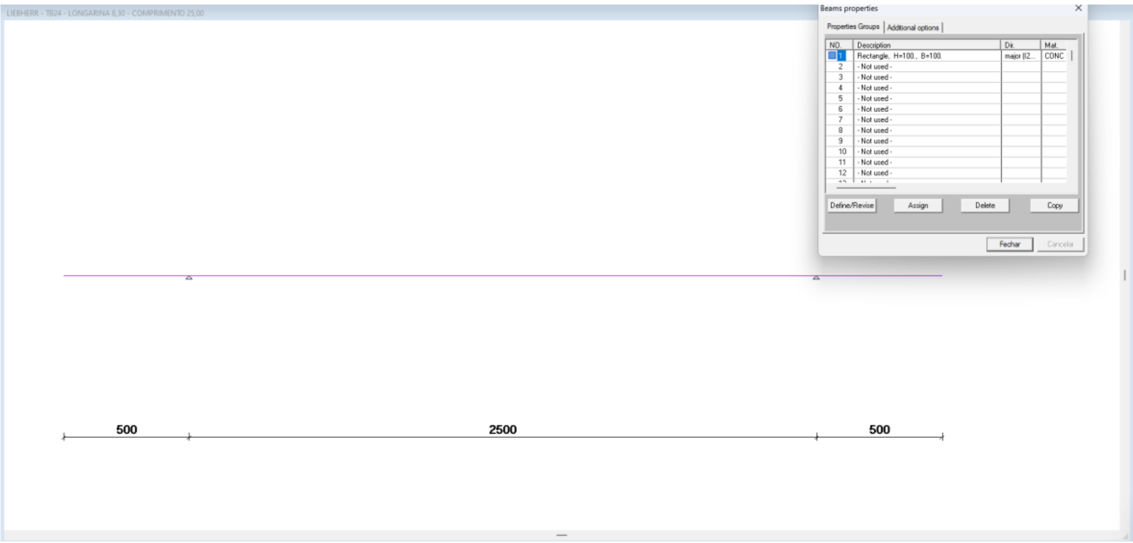
-55.1
31.3
27.7
V3 SHEAR COMBINATIONS ENVELOPE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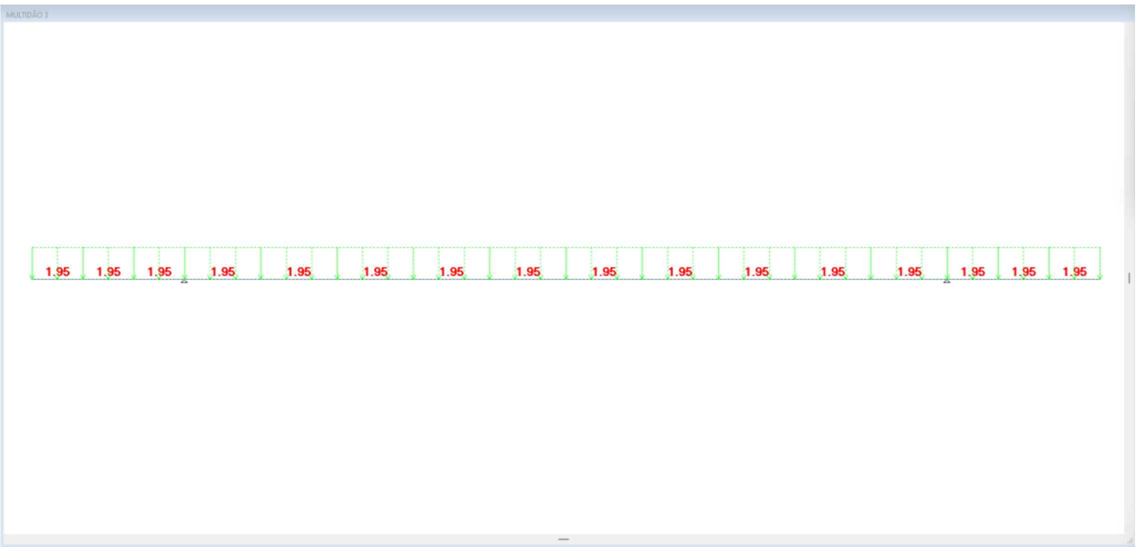
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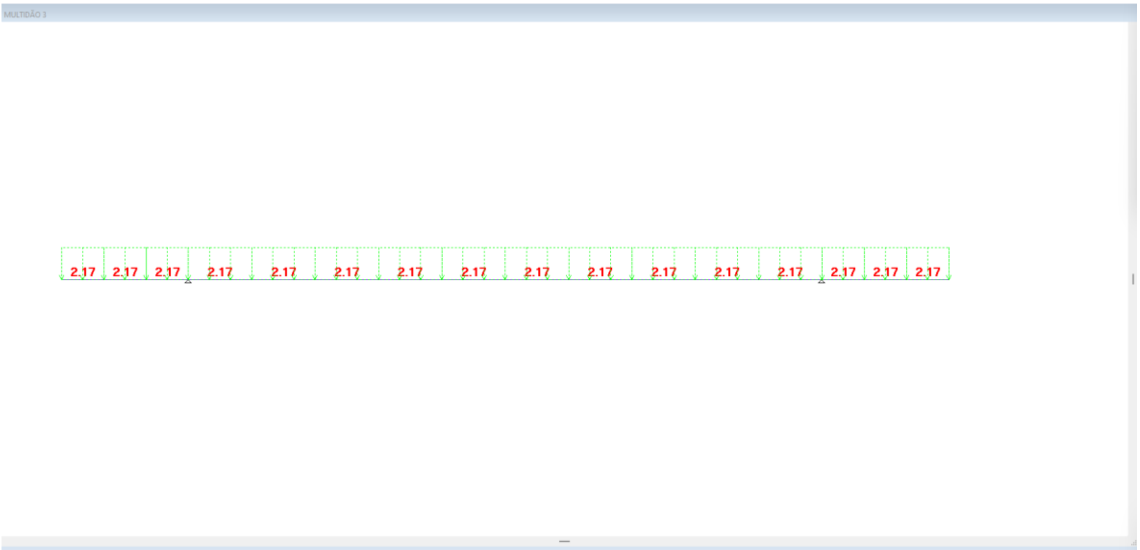
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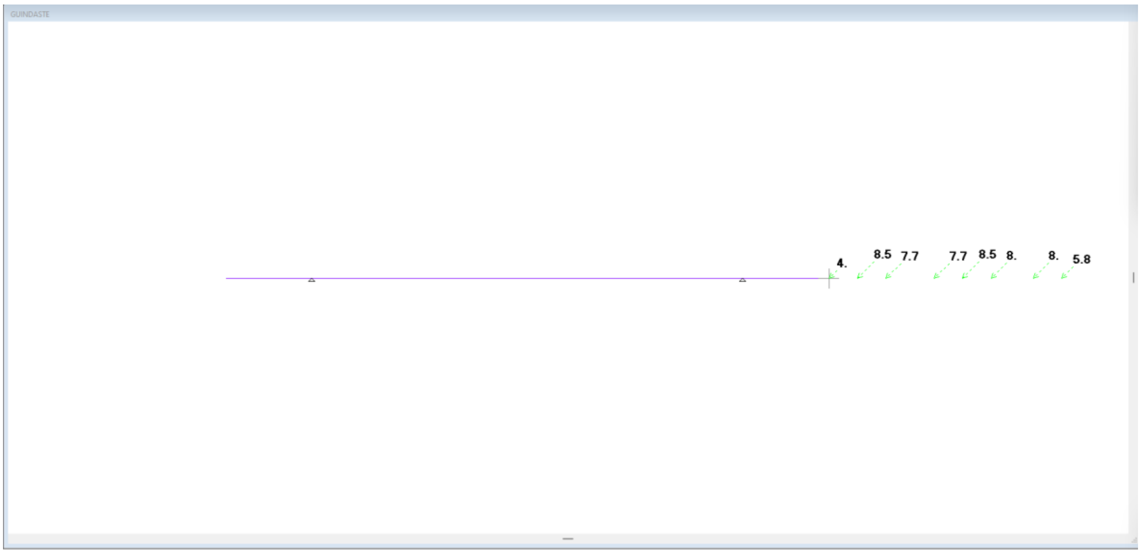
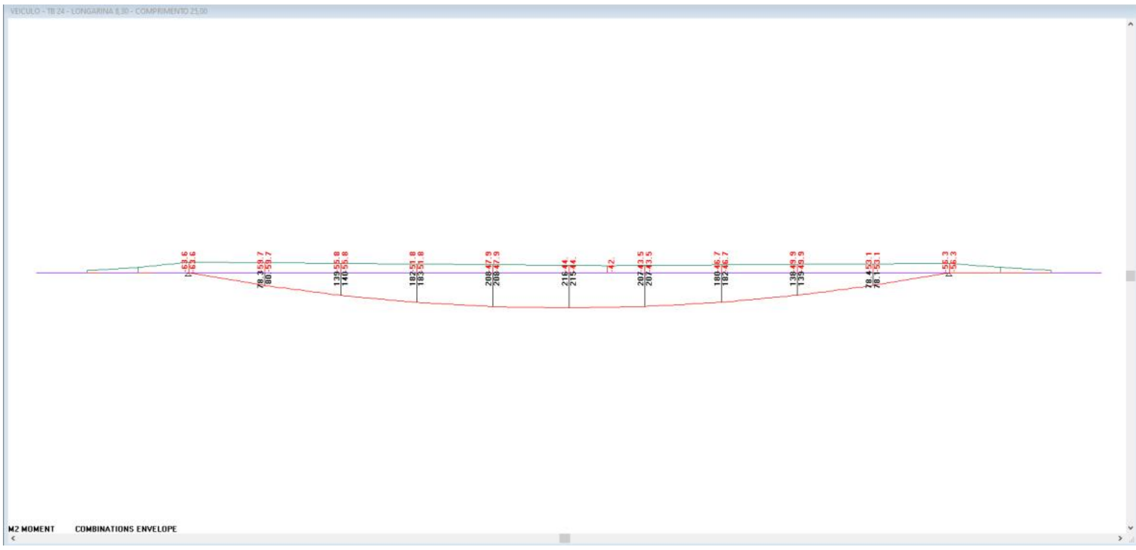

4.
8.5 7.7
7.7 8.5 8.
8. 5.8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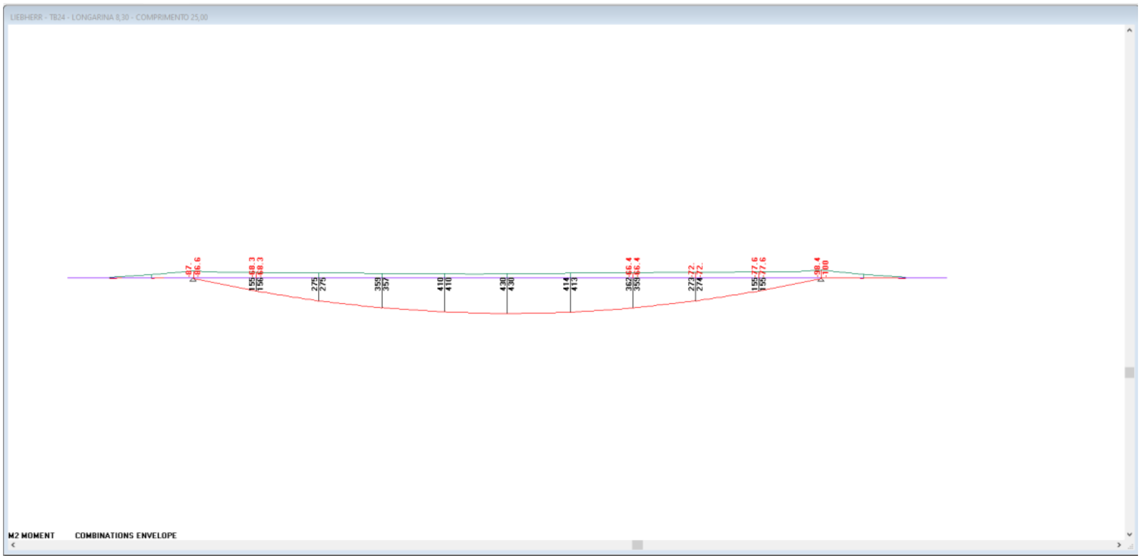
COMBINATIONS ENVELOPE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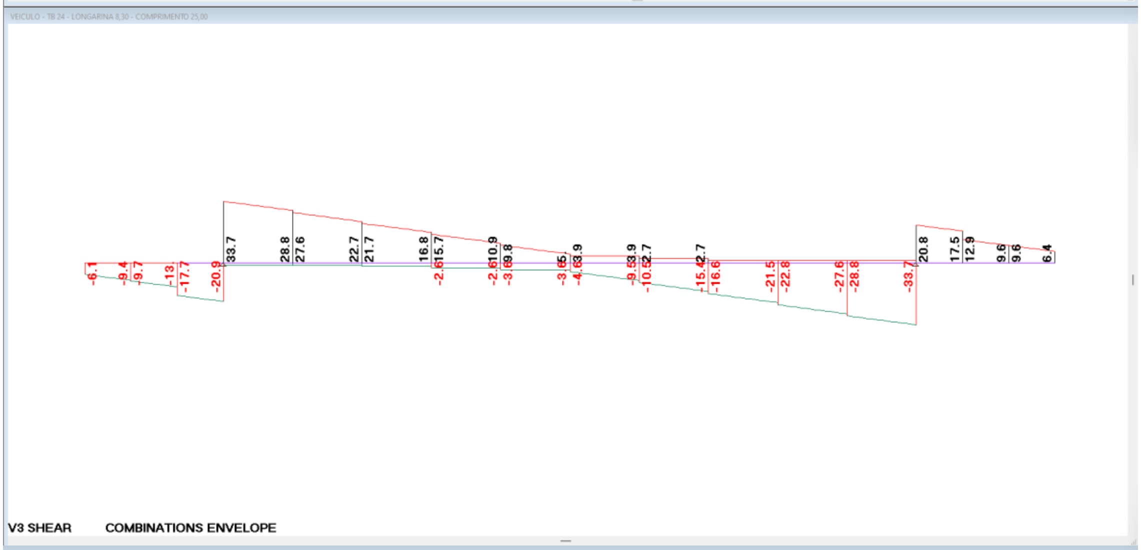
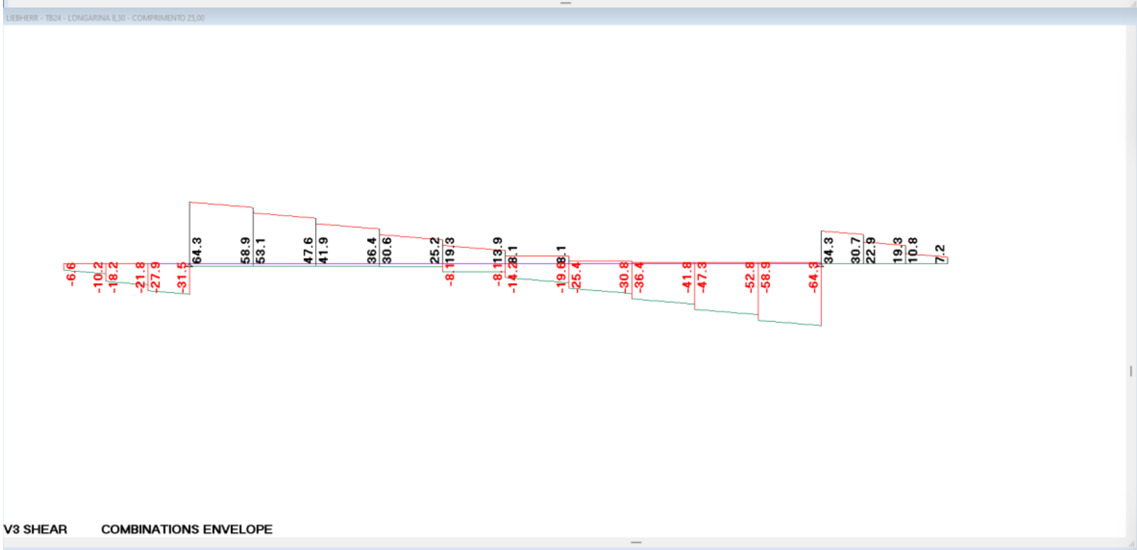
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE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Additional options
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CONC
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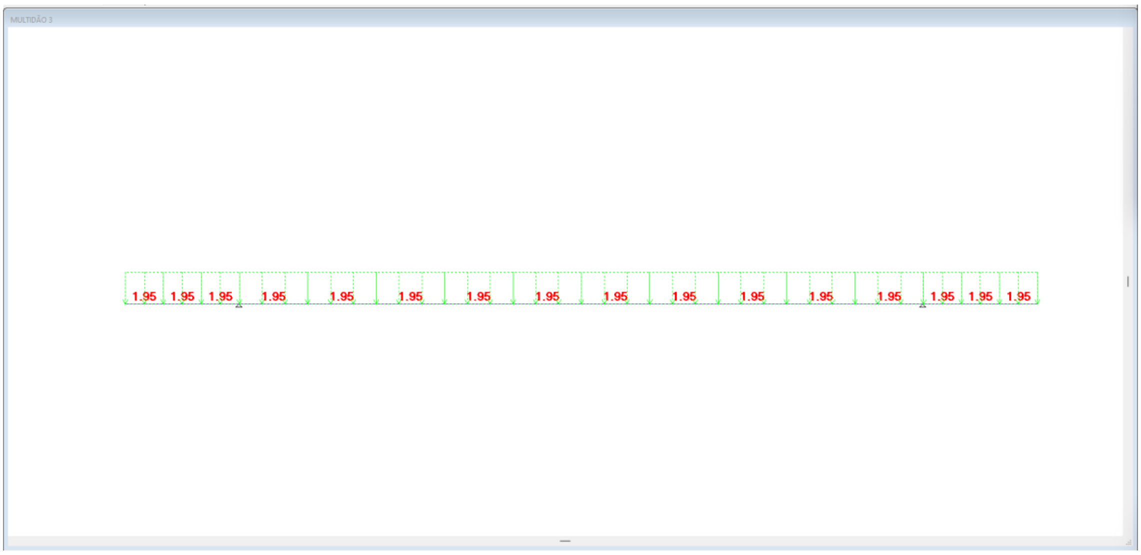
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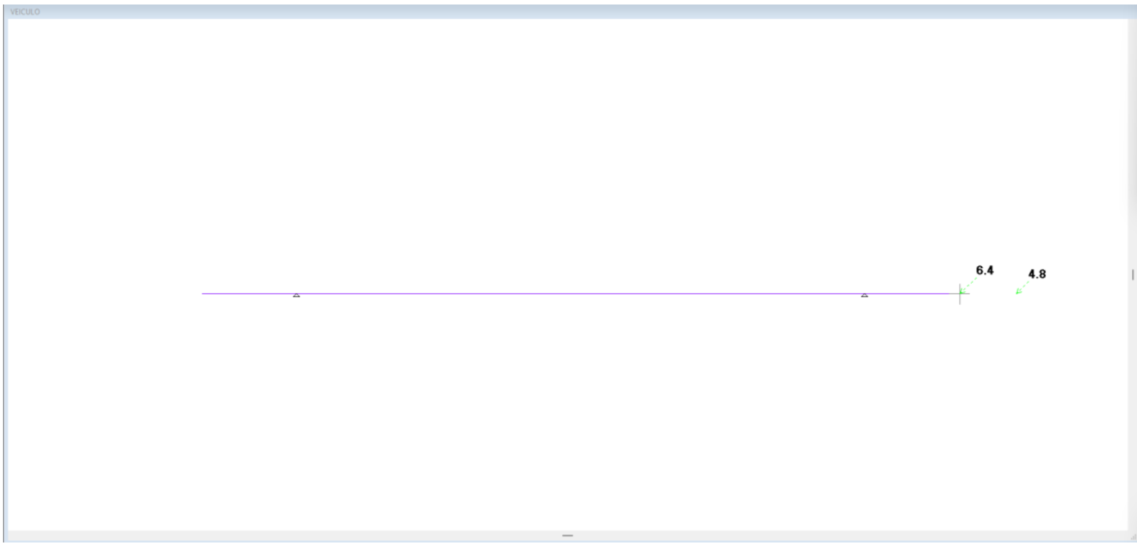
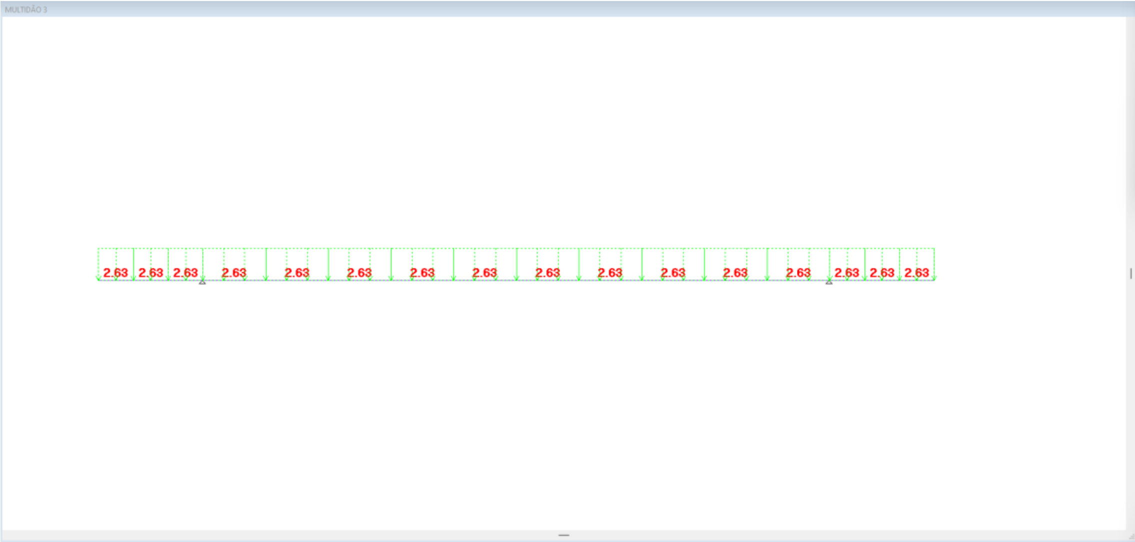

VEICULO
6.4
4.8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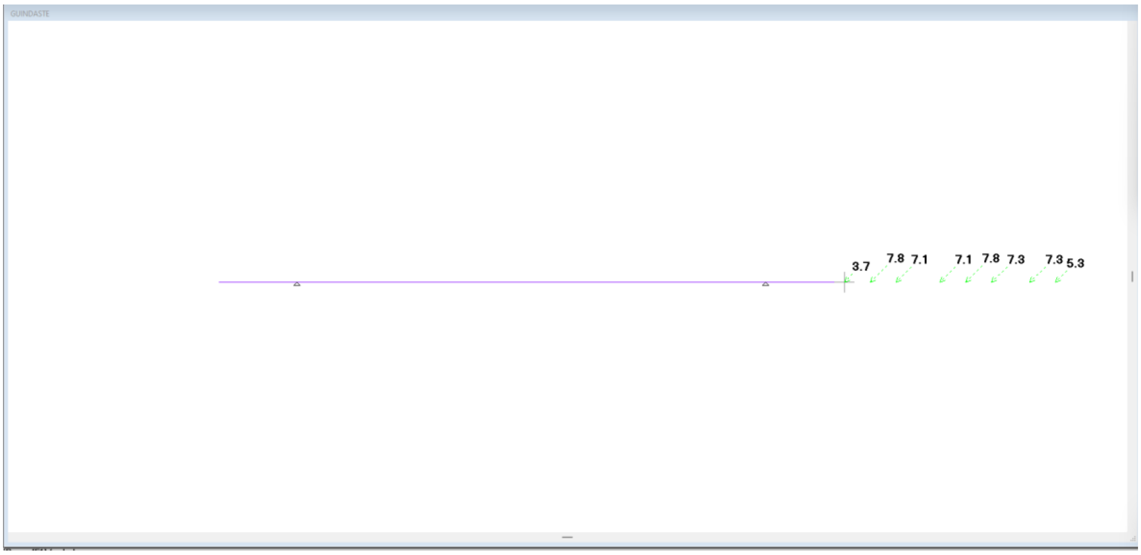
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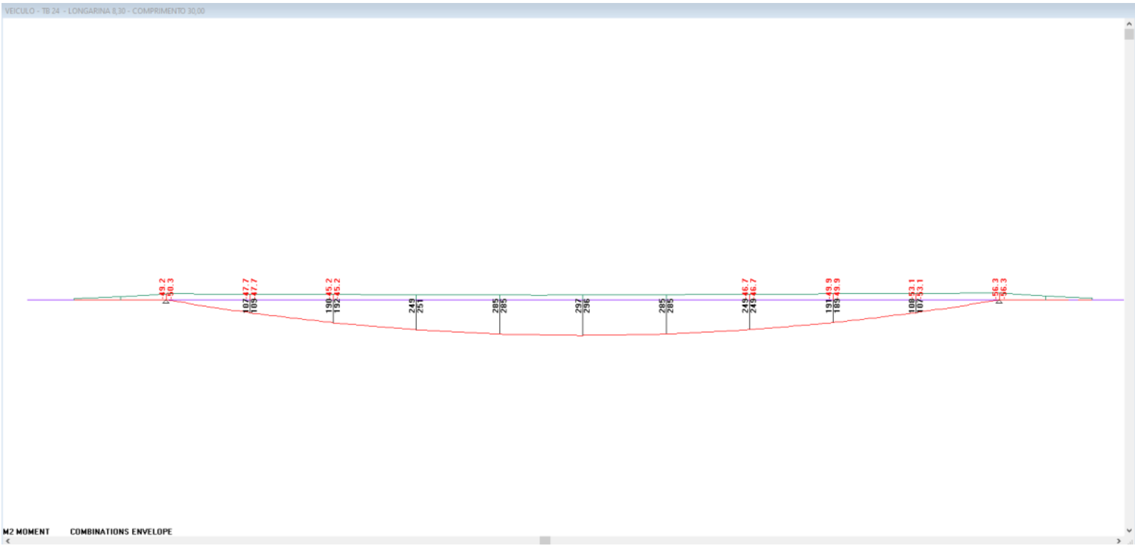
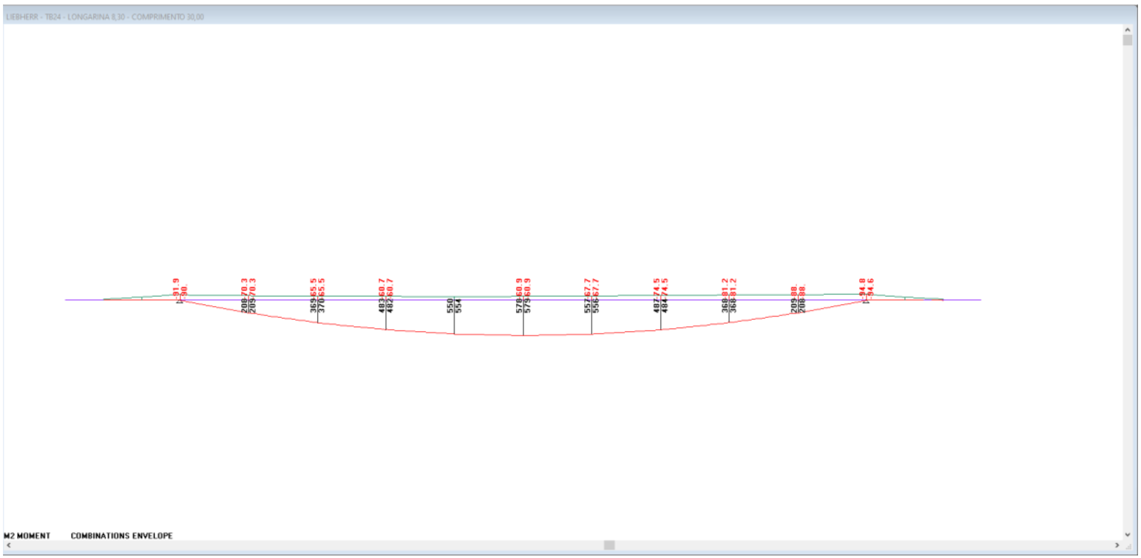
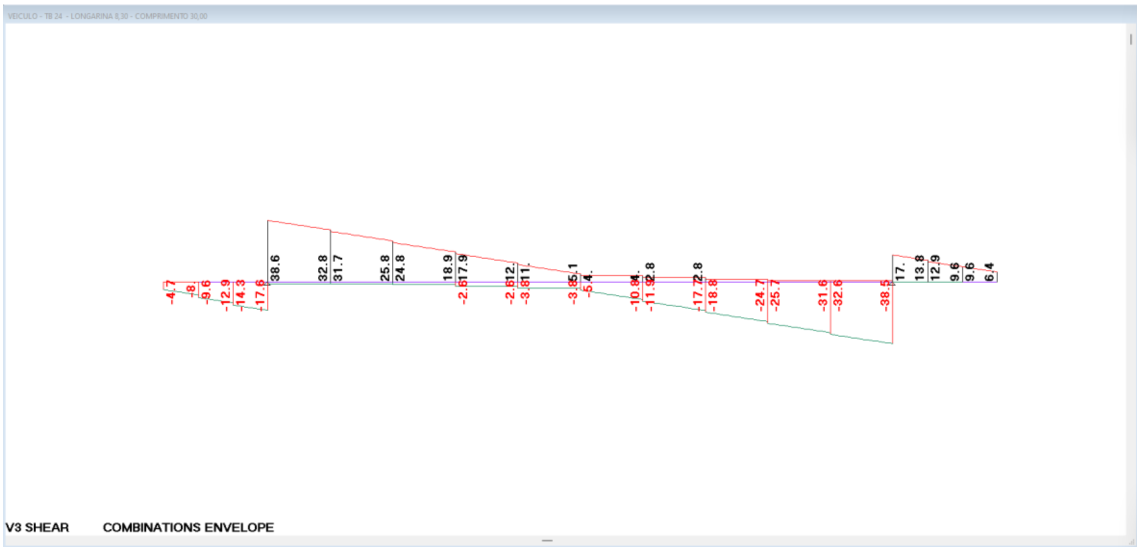
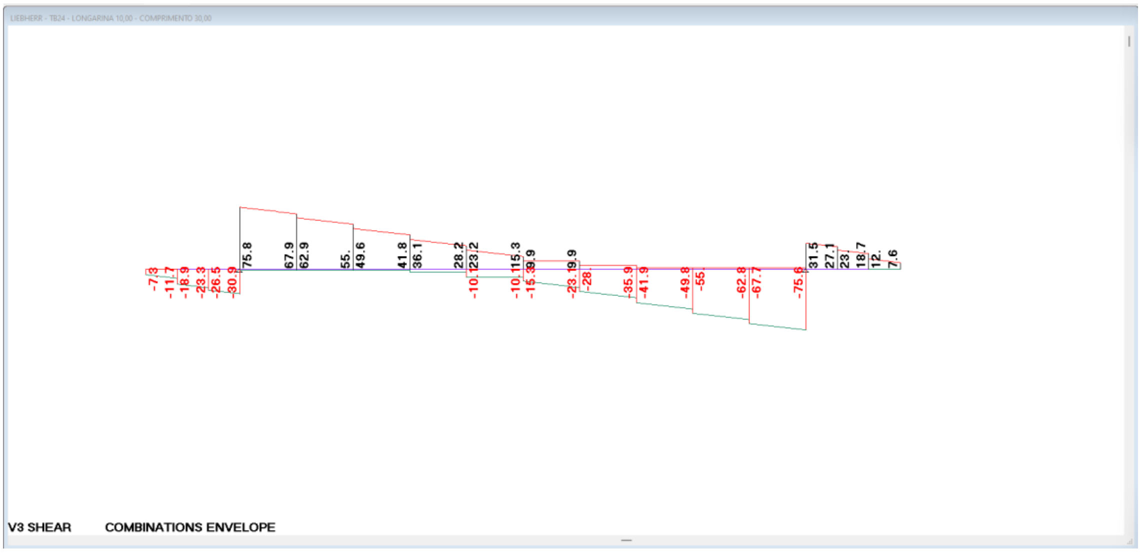
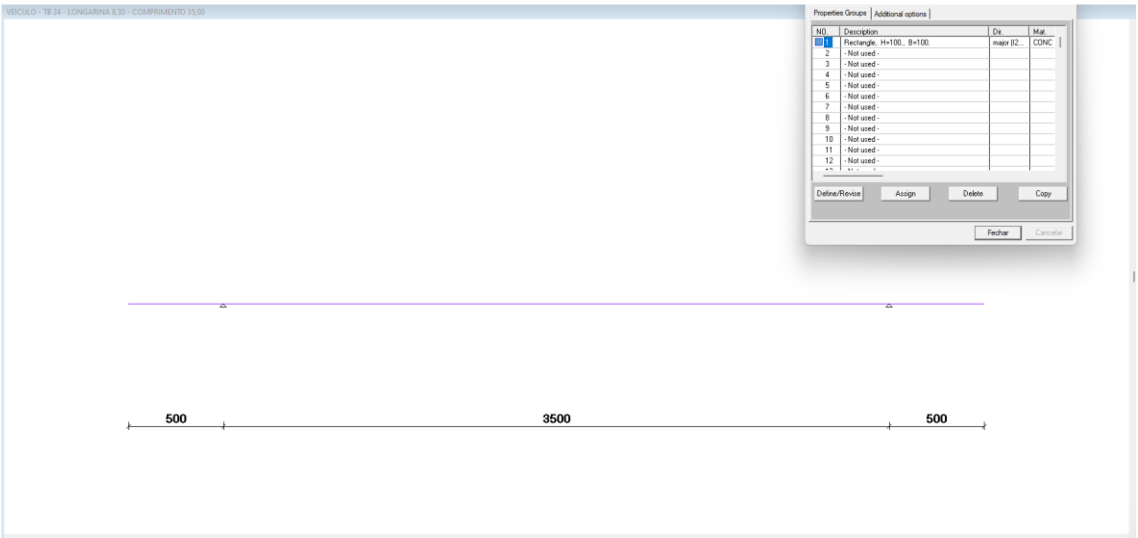

M2 MOMENT
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE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3500
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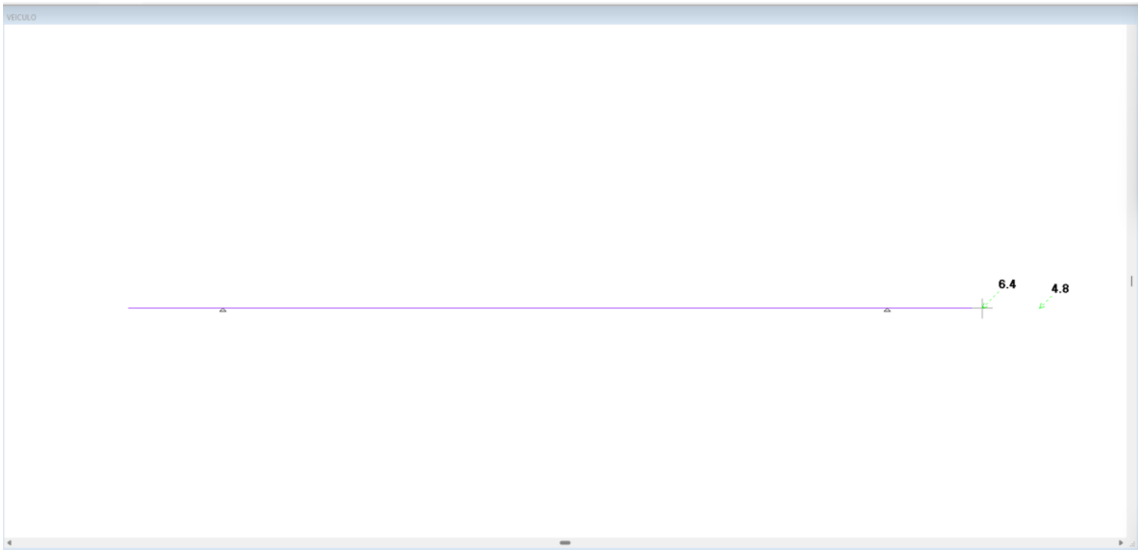
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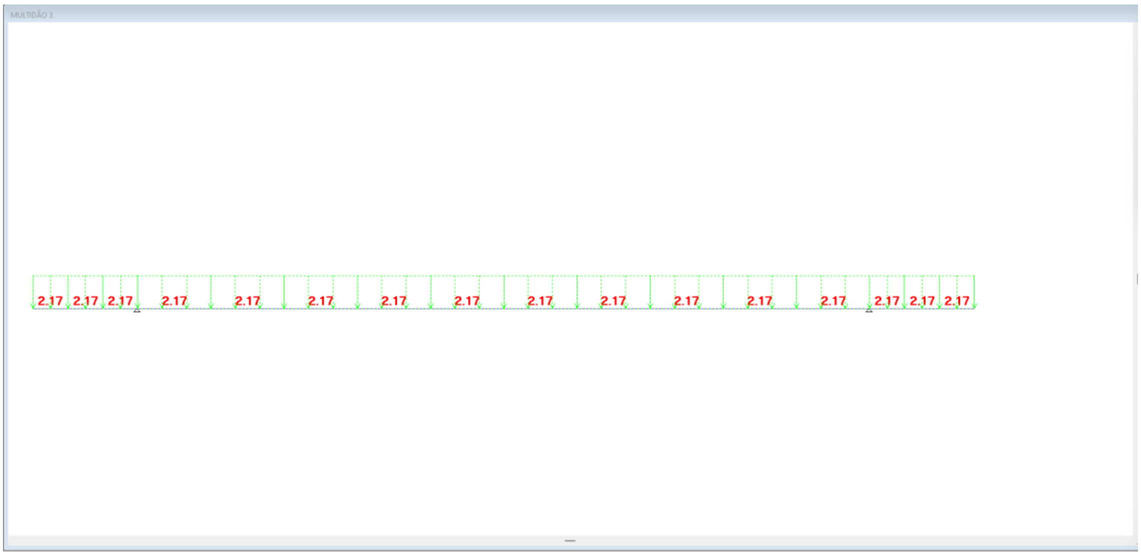
4.8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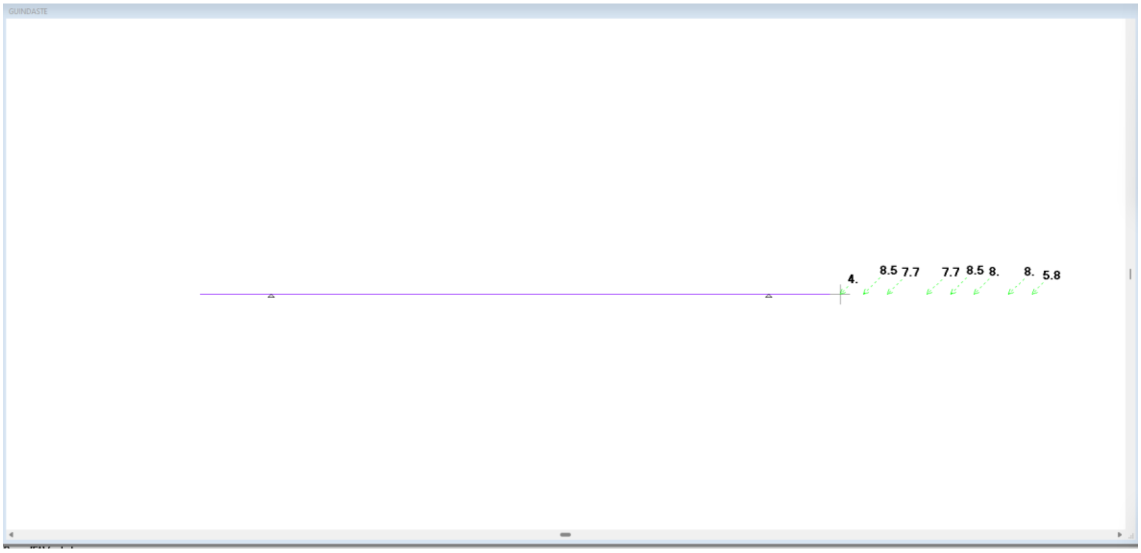
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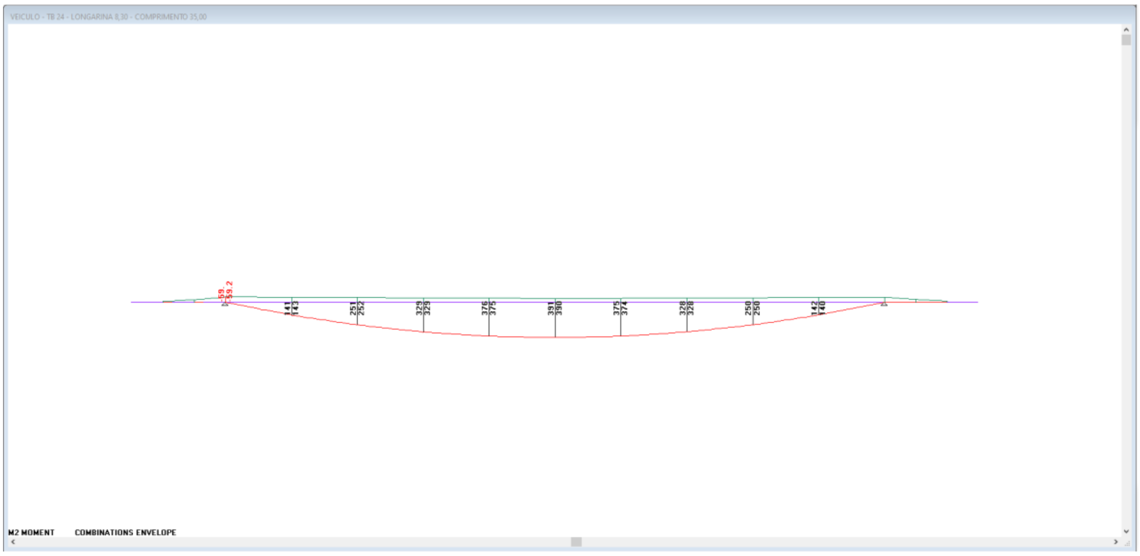
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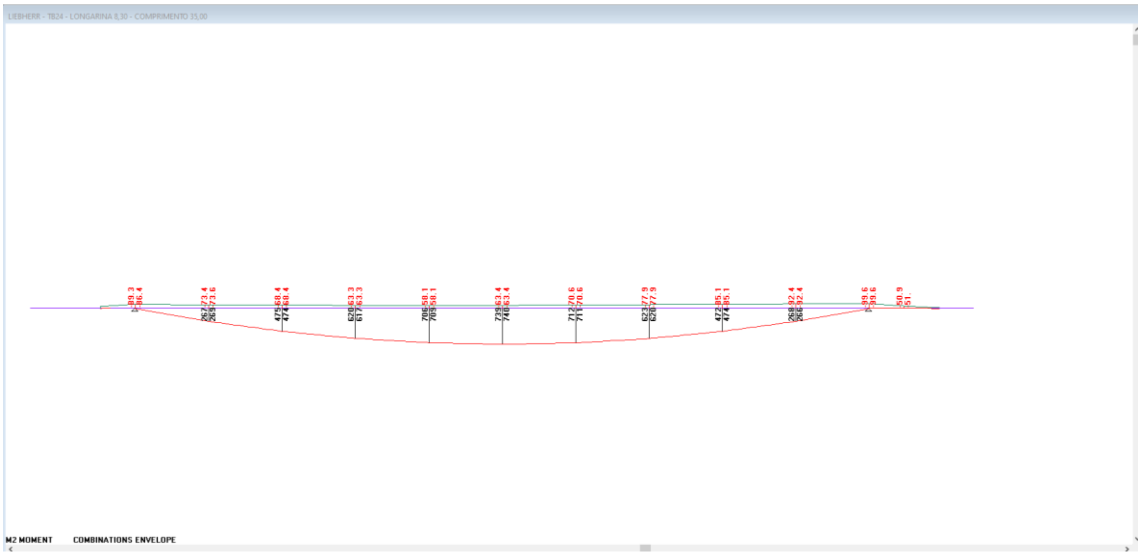
COMBINATIONS ENVELOPE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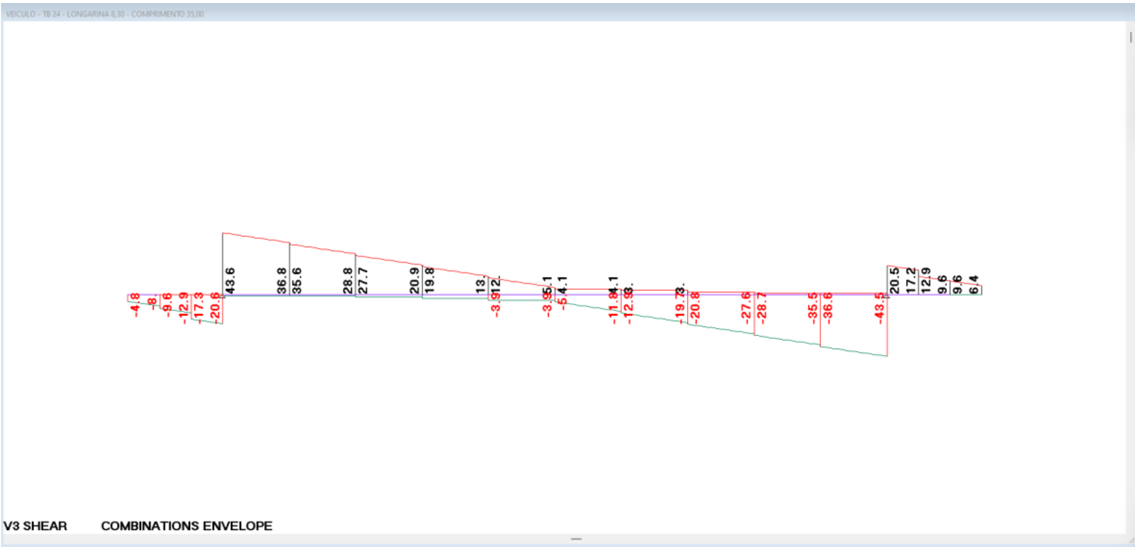
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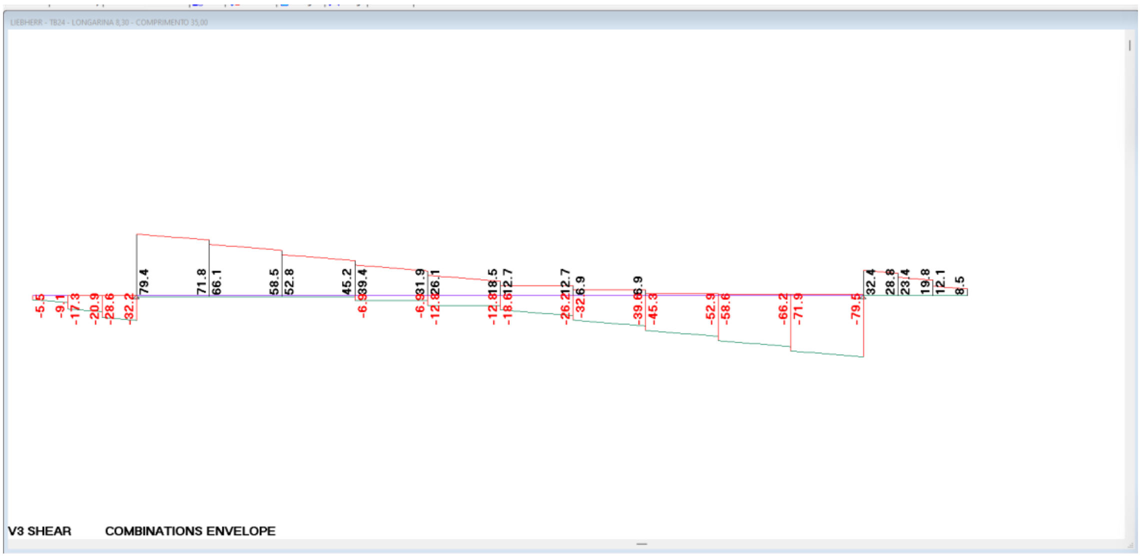
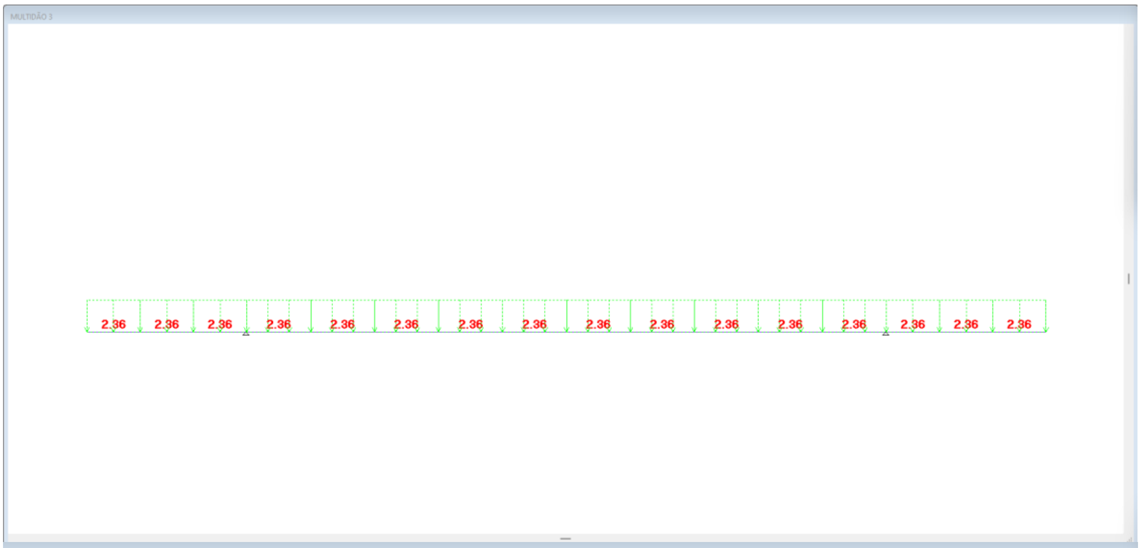
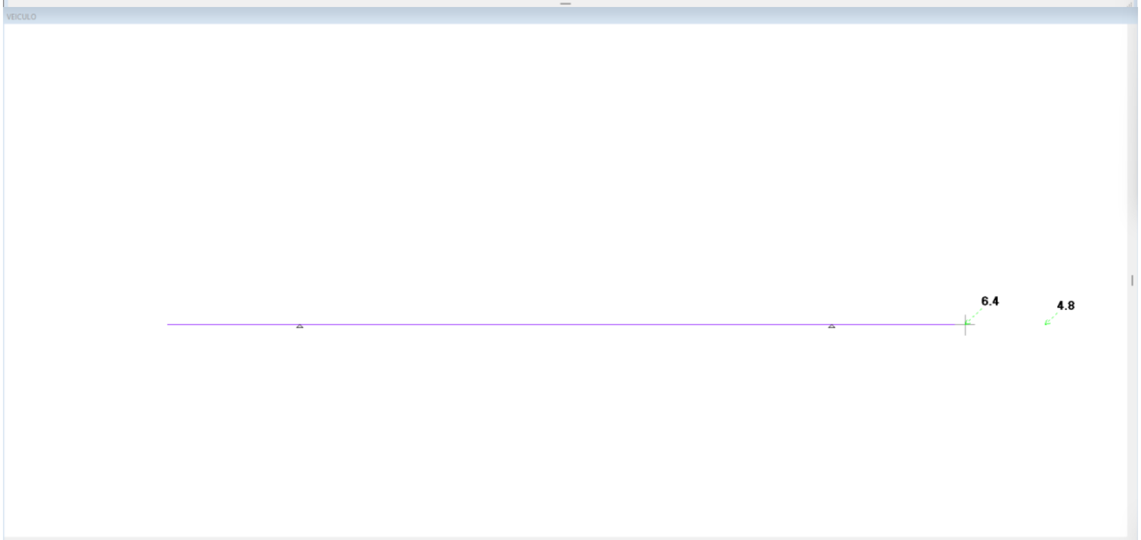
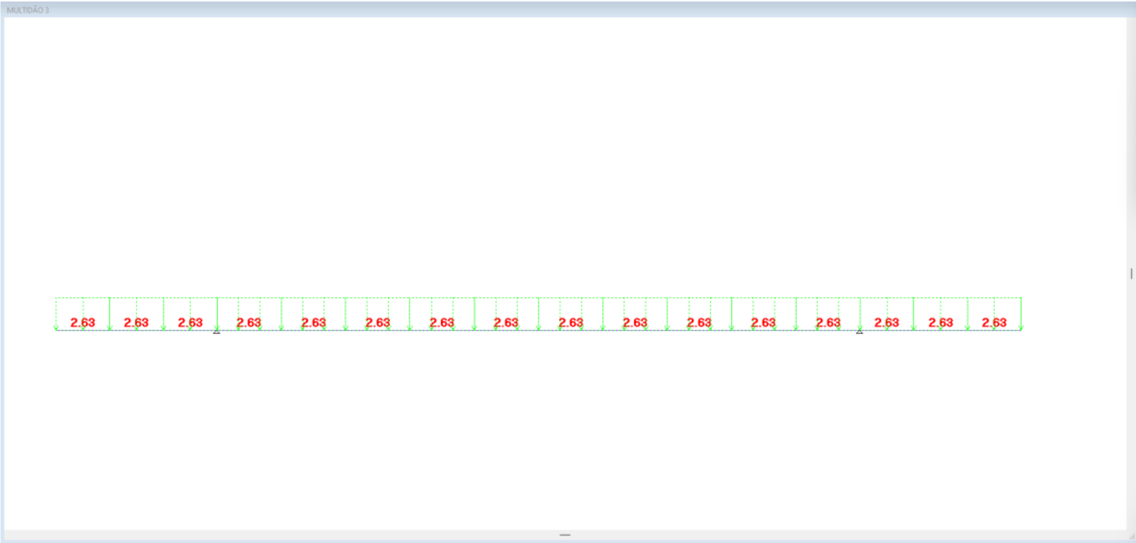

V3 SHEAR COMBINATIONS ENVELOPE

5.4.2. Tabuleiro 10,00 m



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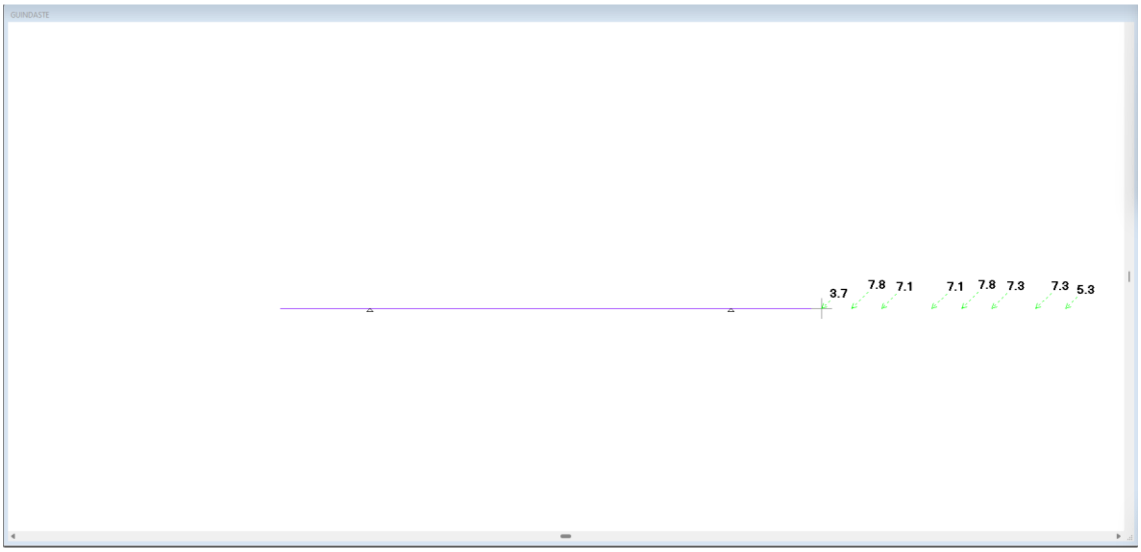
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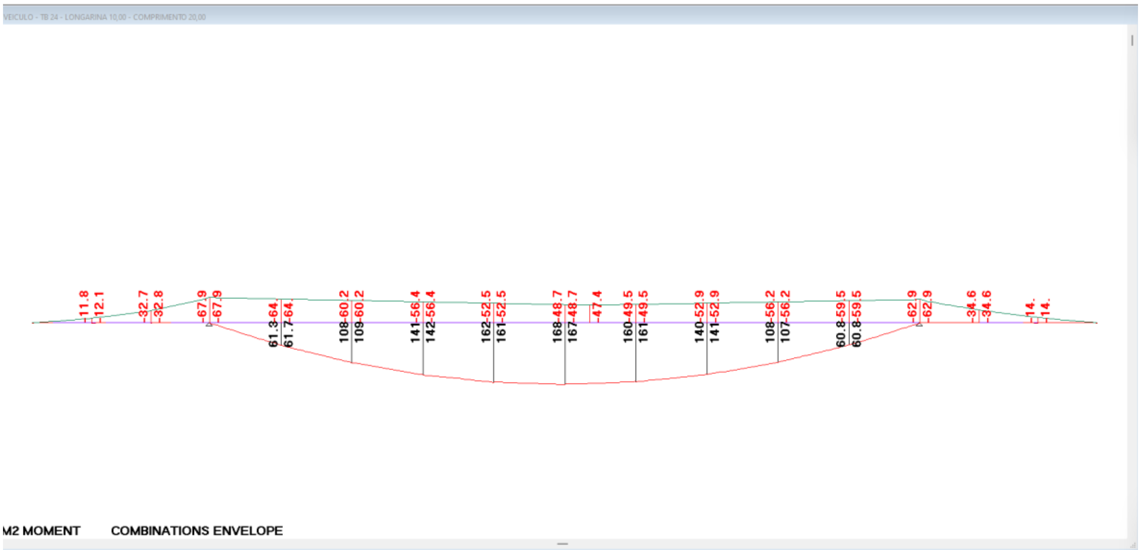
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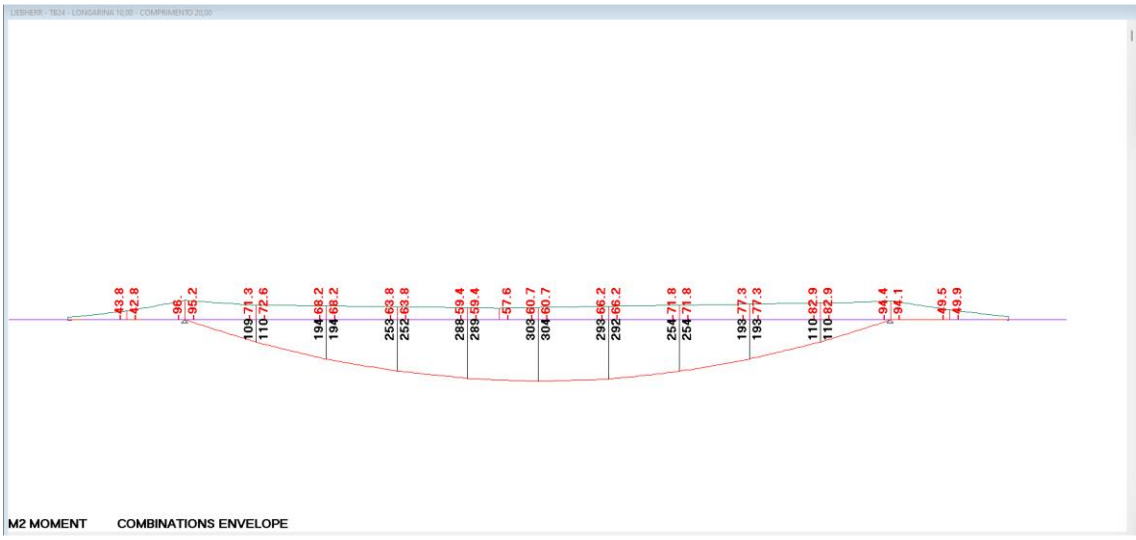
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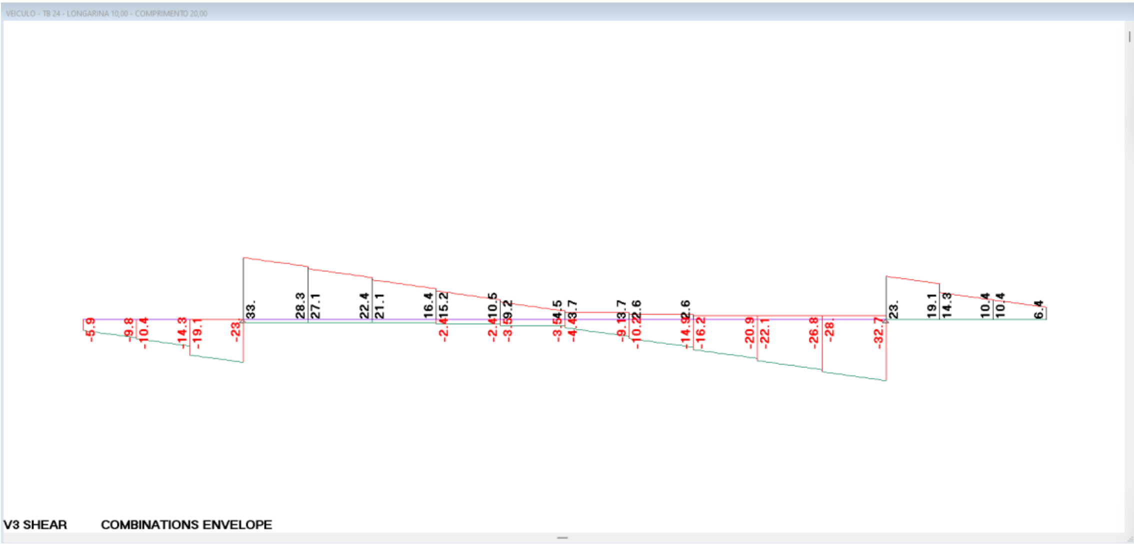
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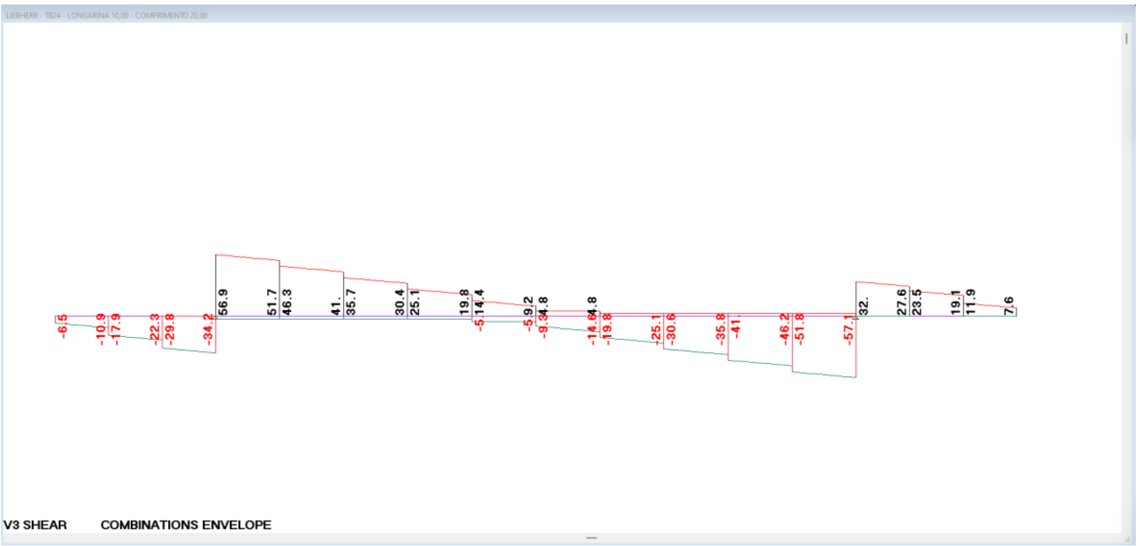
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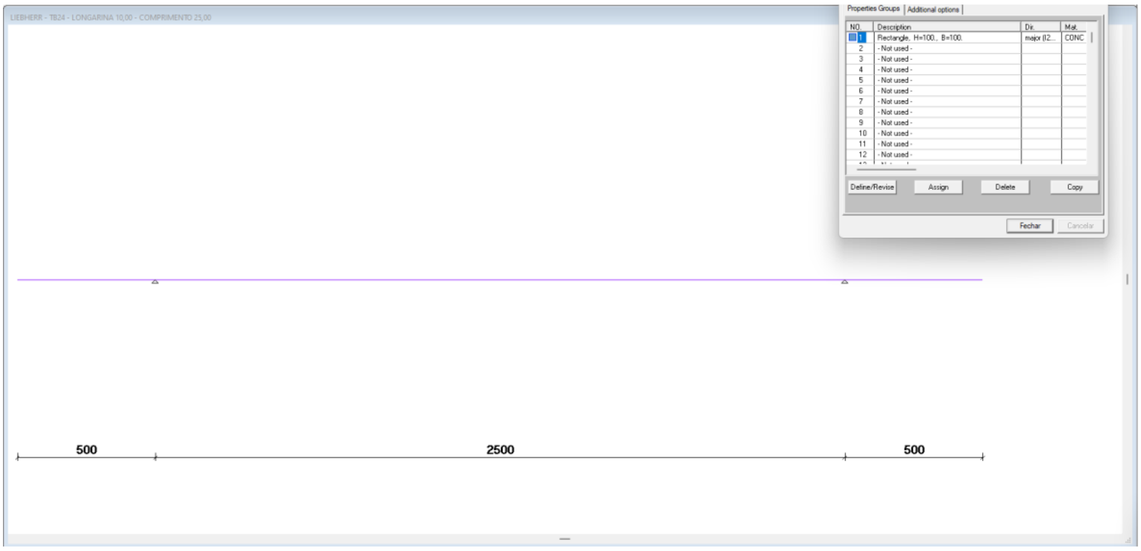
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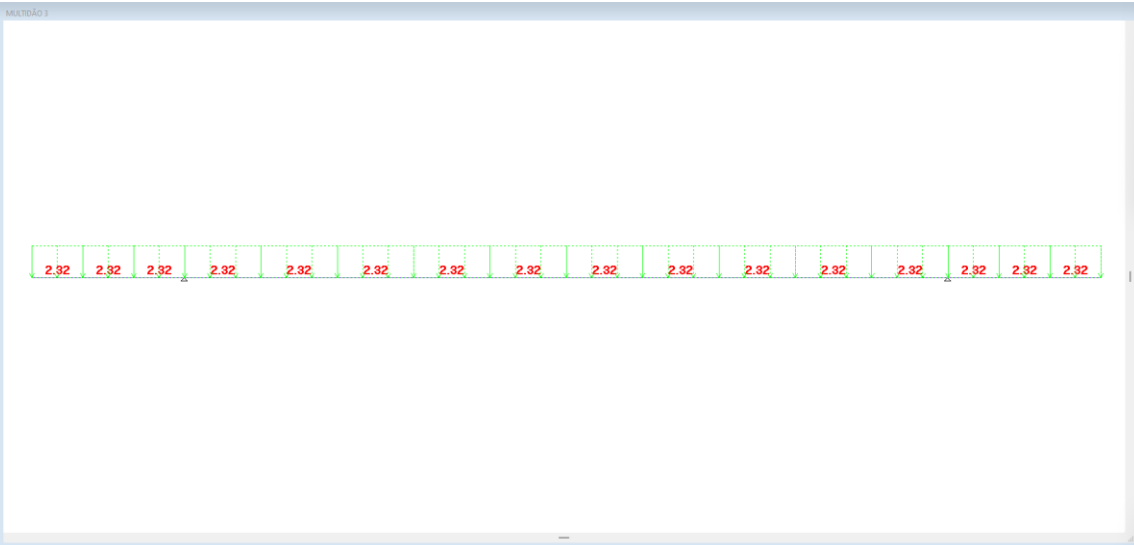
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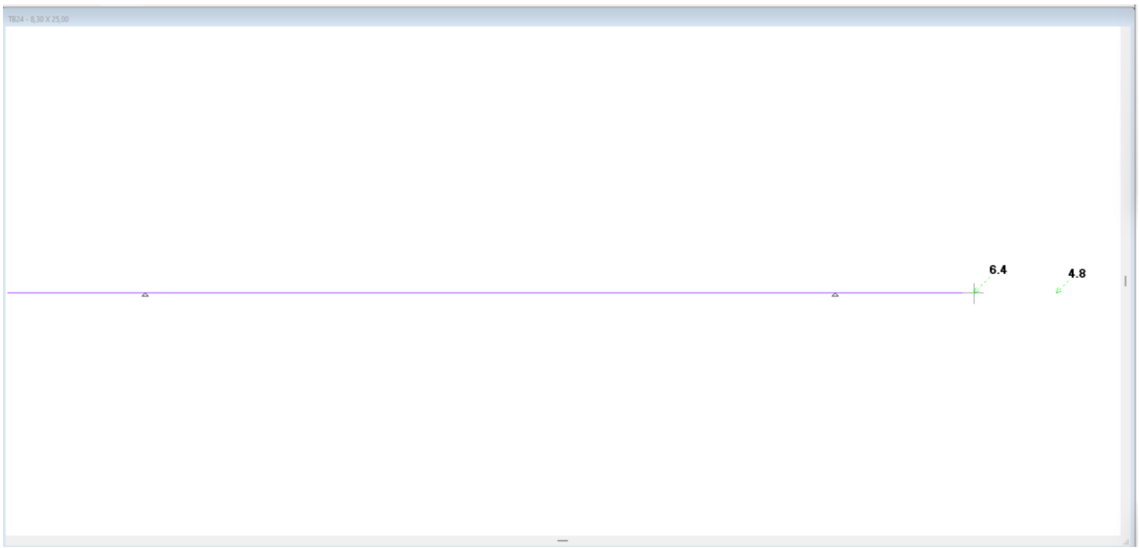
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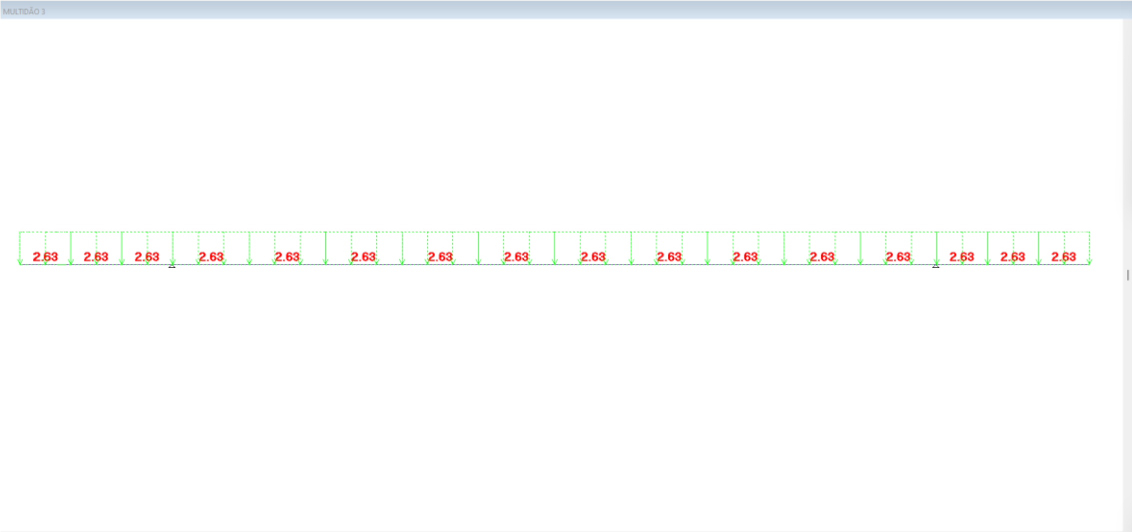
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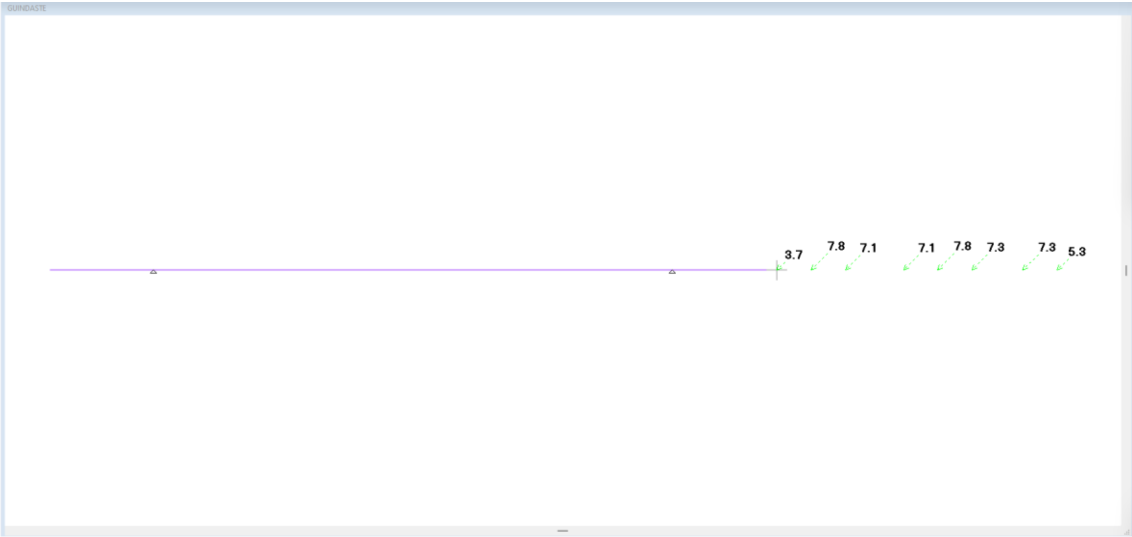
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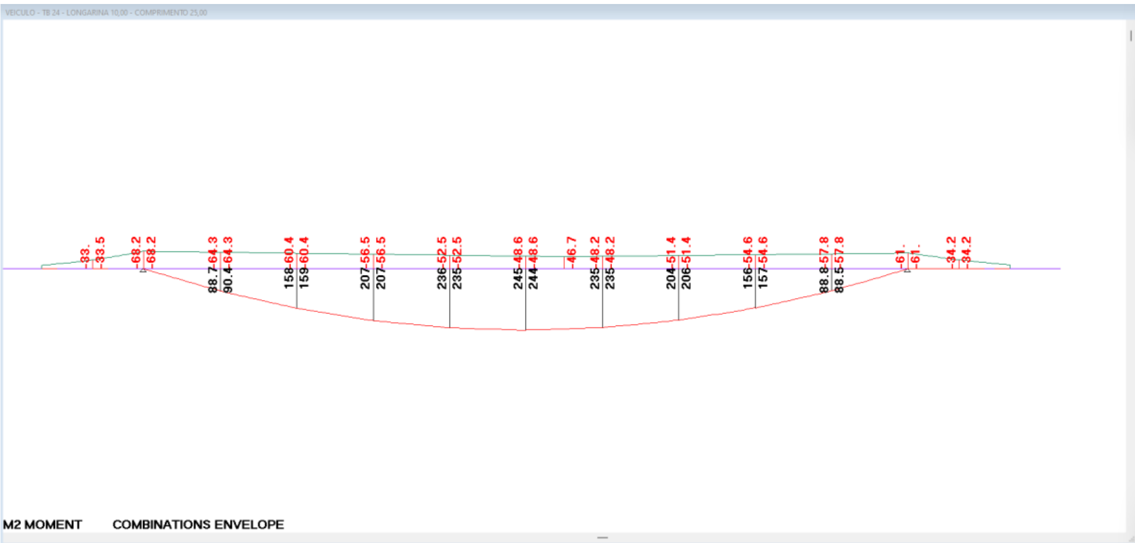
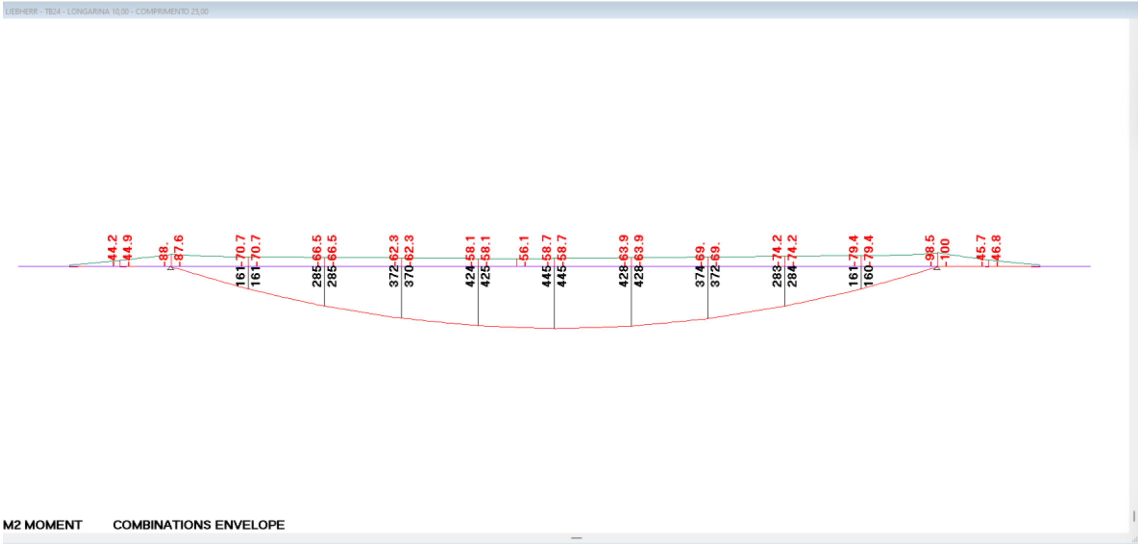
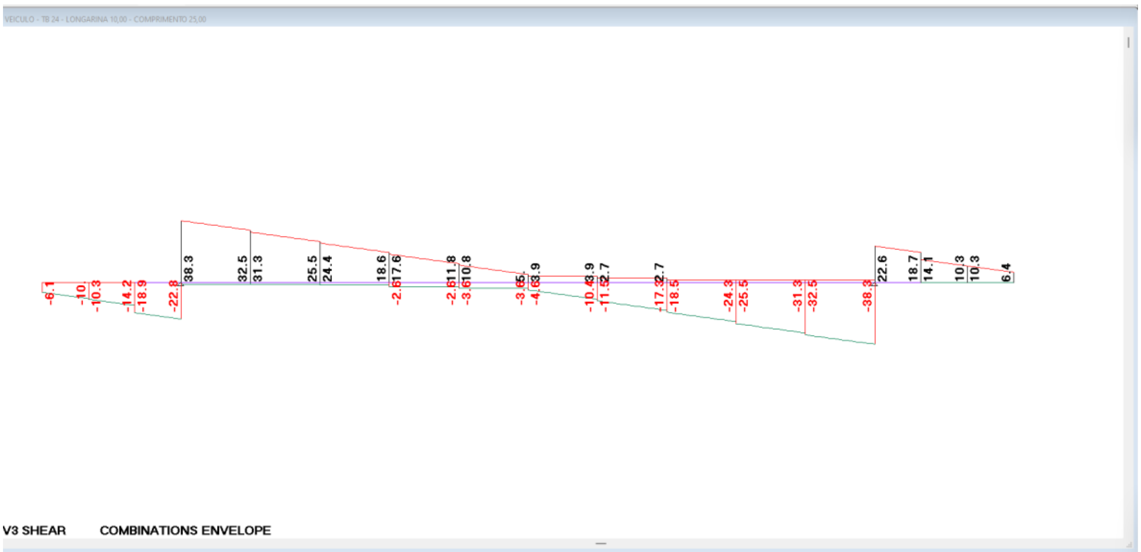
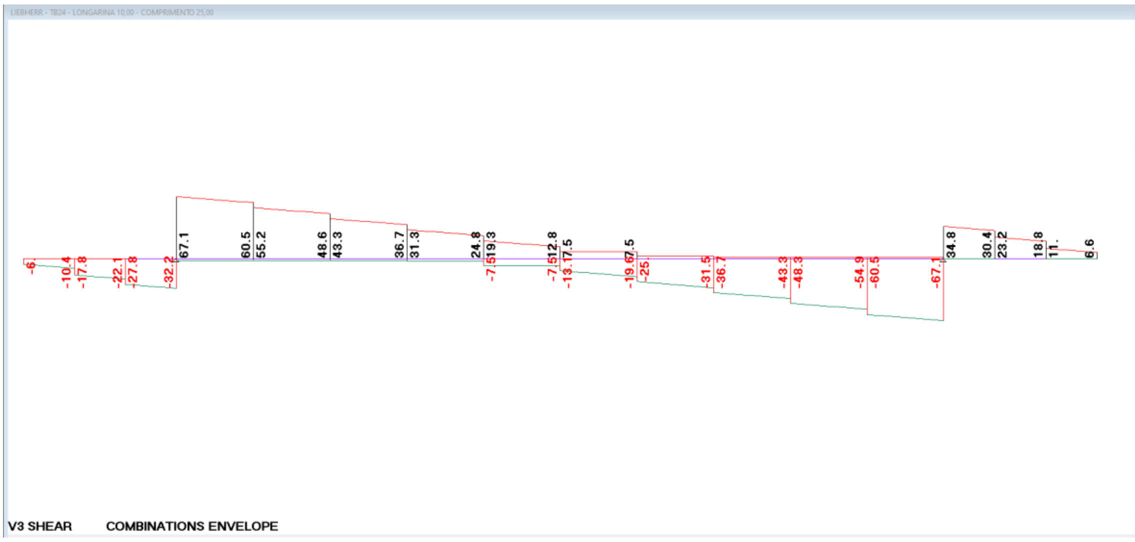
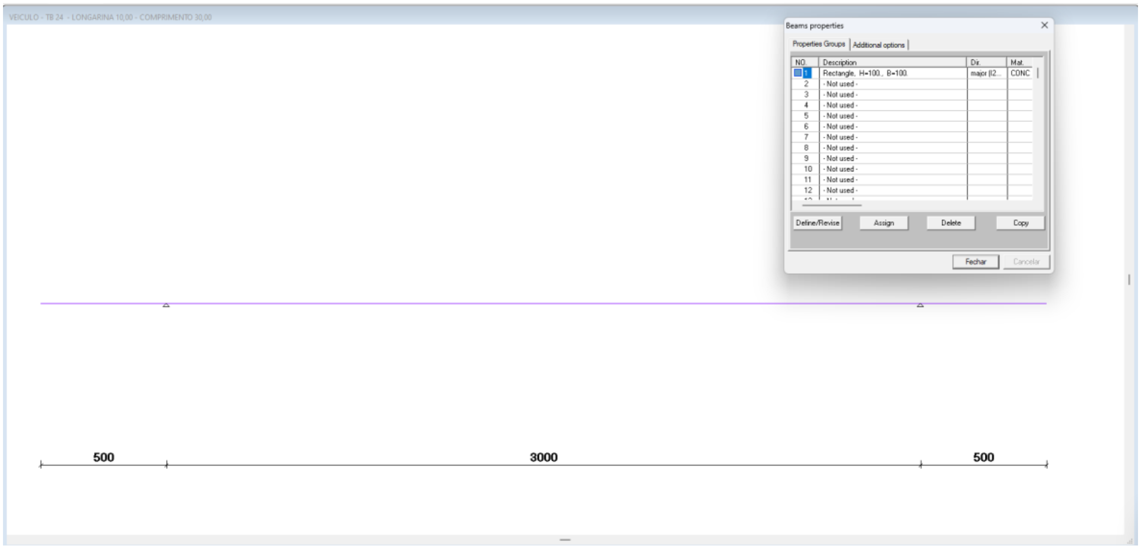

M2 MOMENT
COMBINATIONS ENVELOPE

NOTA TÉCNICA





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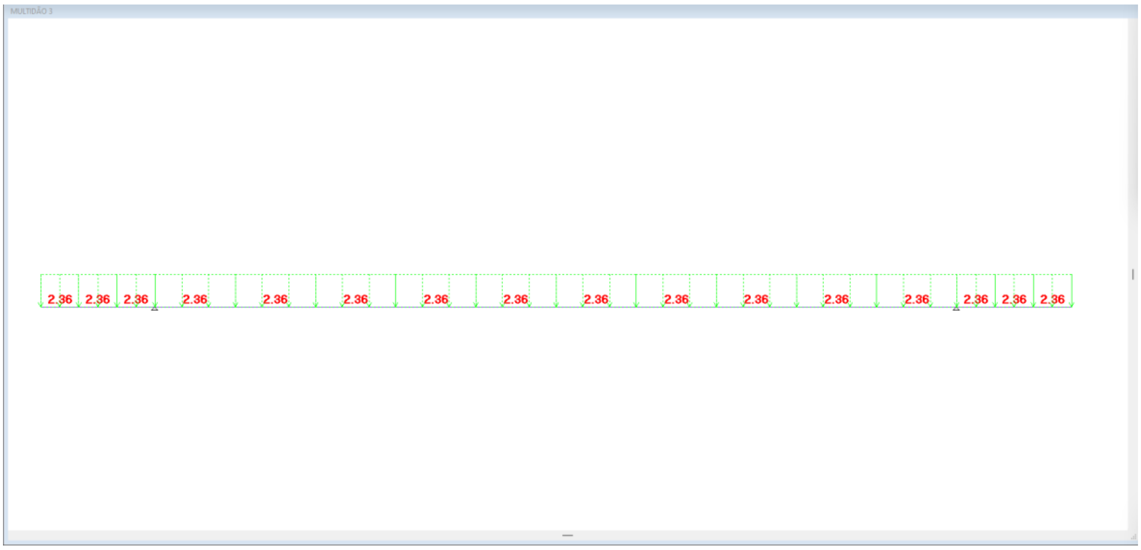
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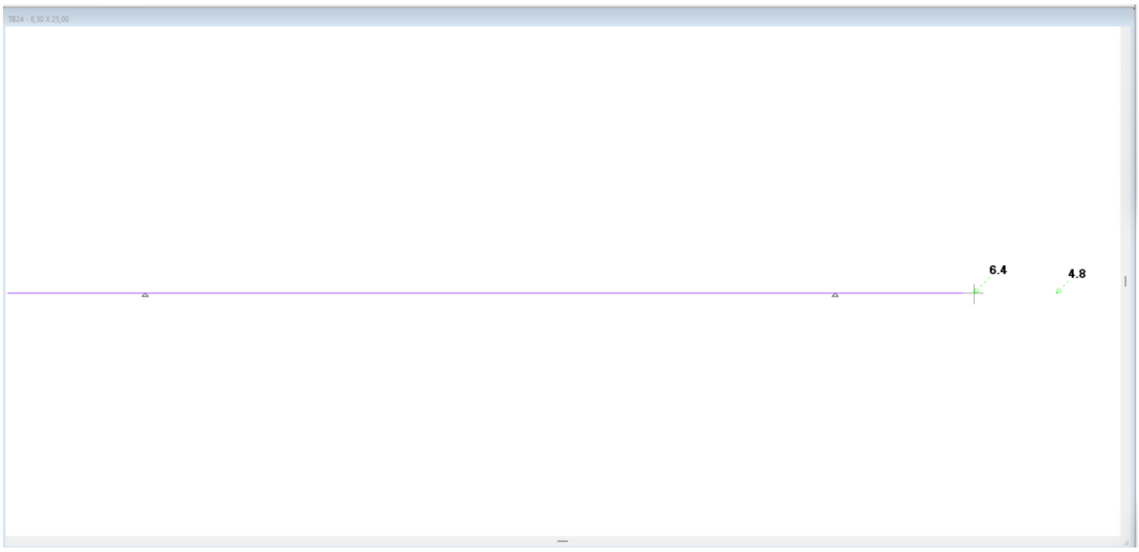
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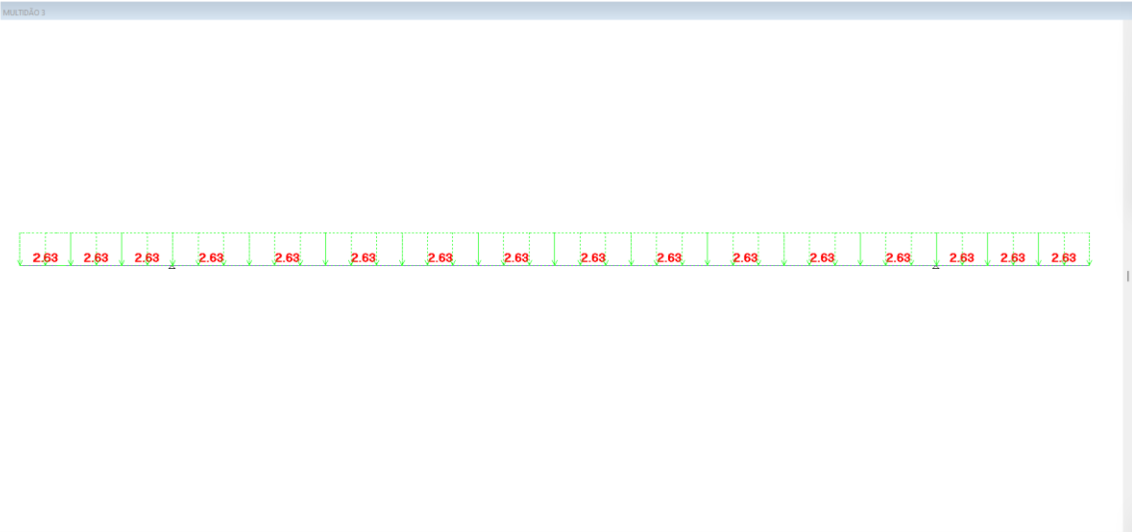
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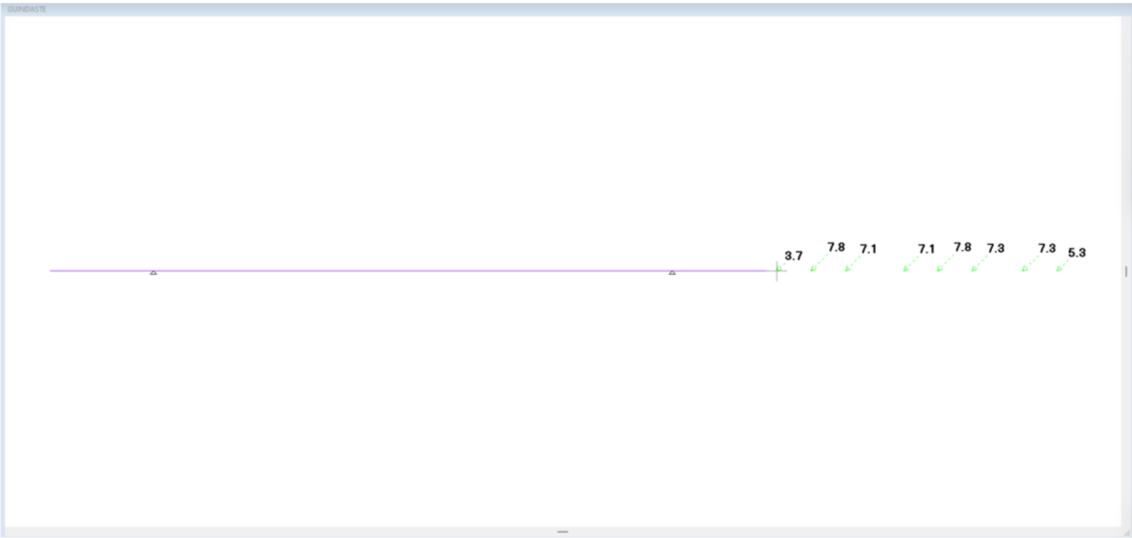
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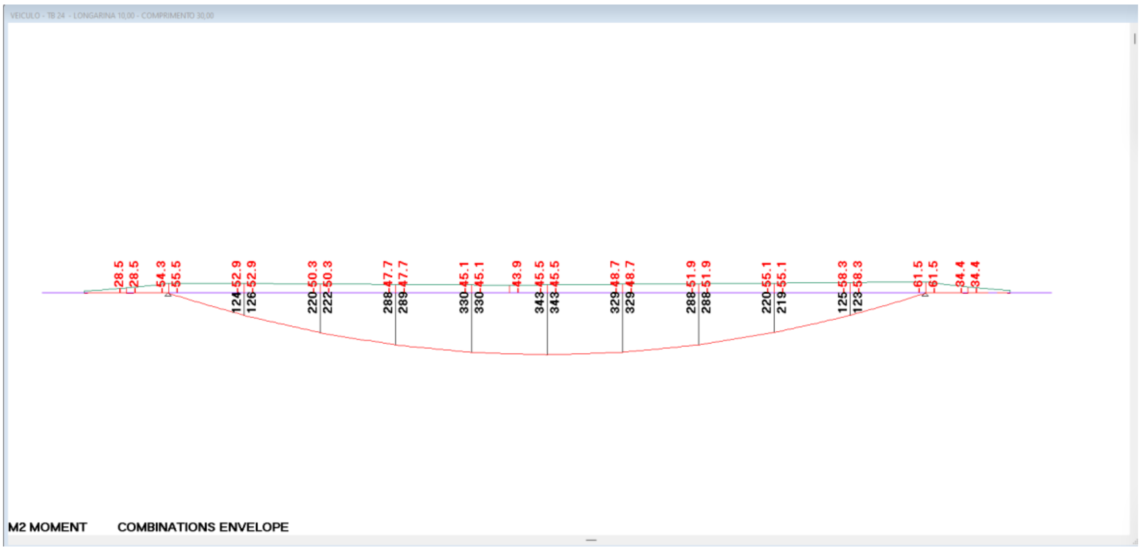
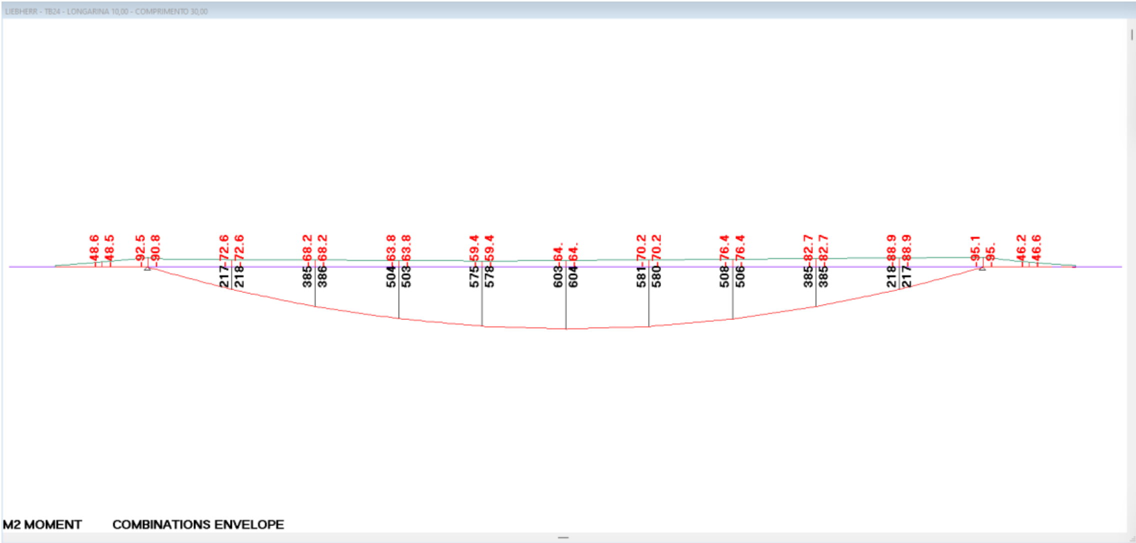
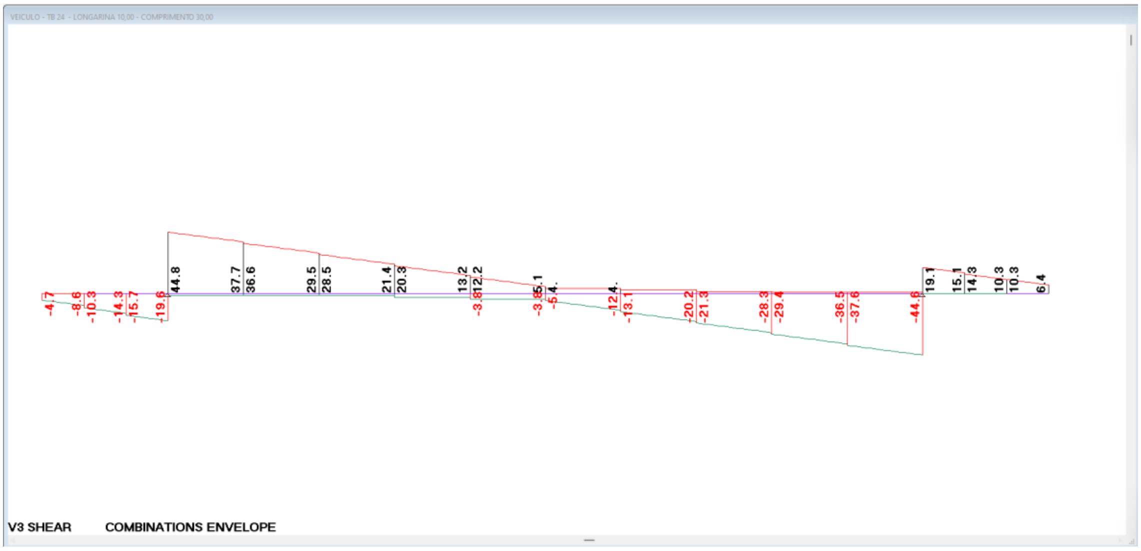

M2 MOMENT
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE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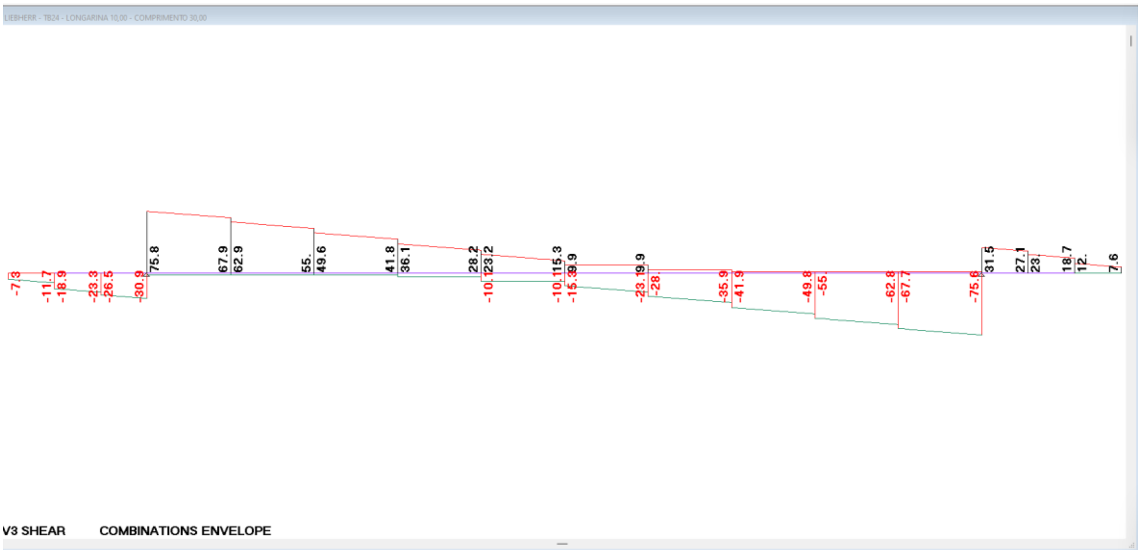
COMBINATIONS ENVELOPE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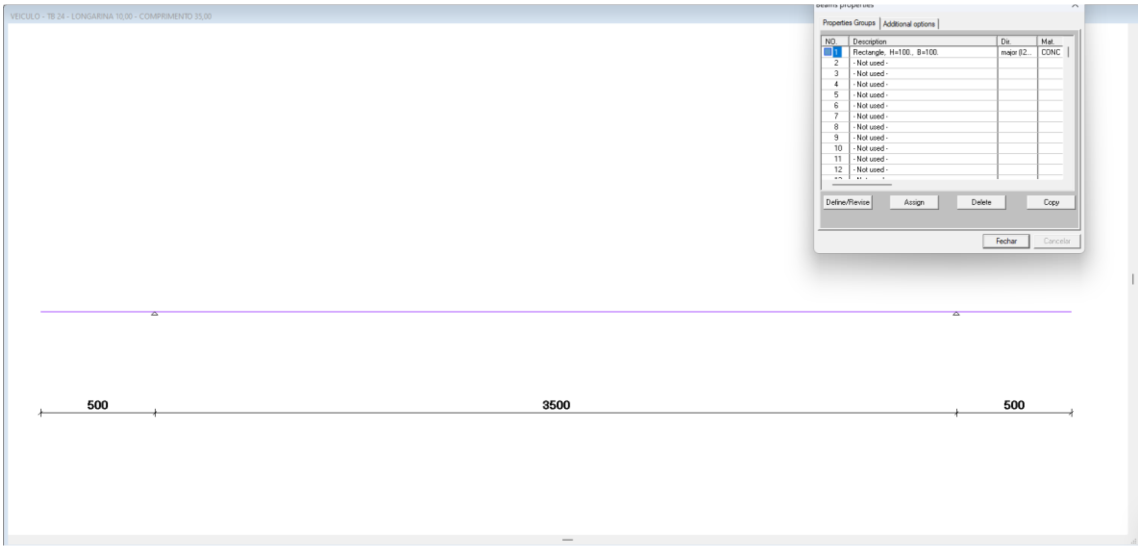
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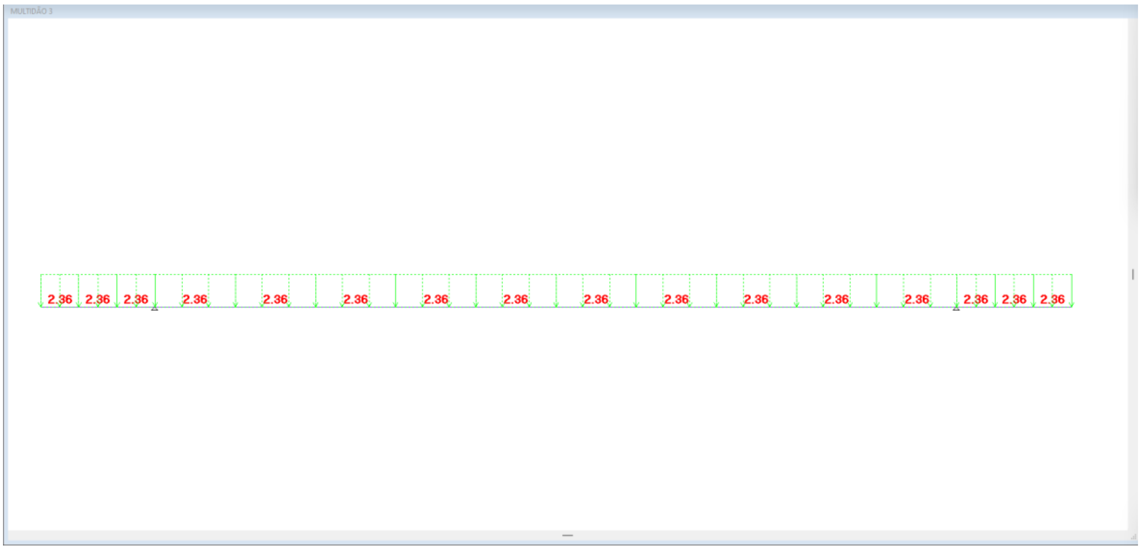
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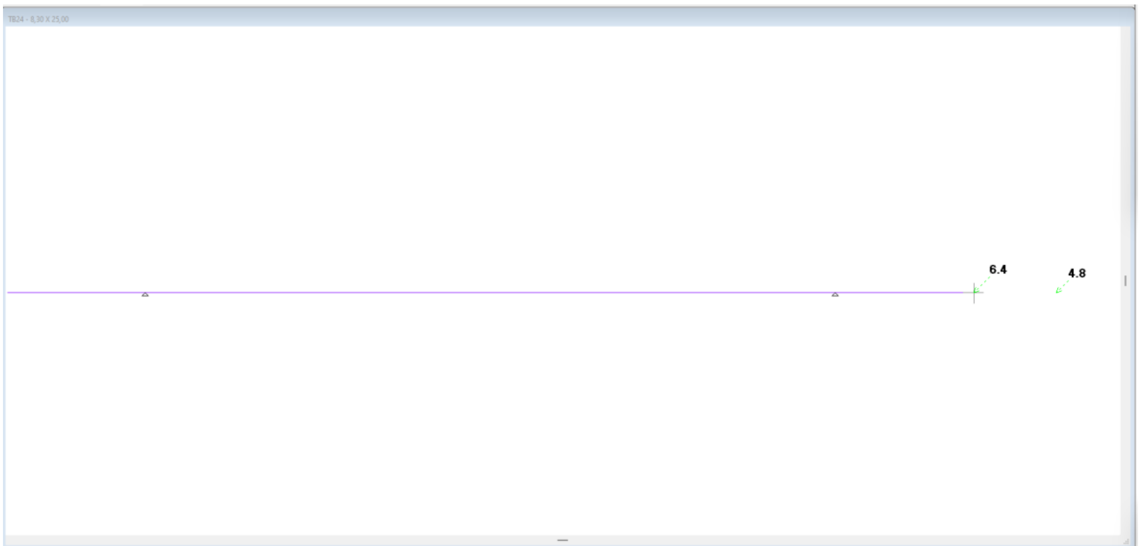
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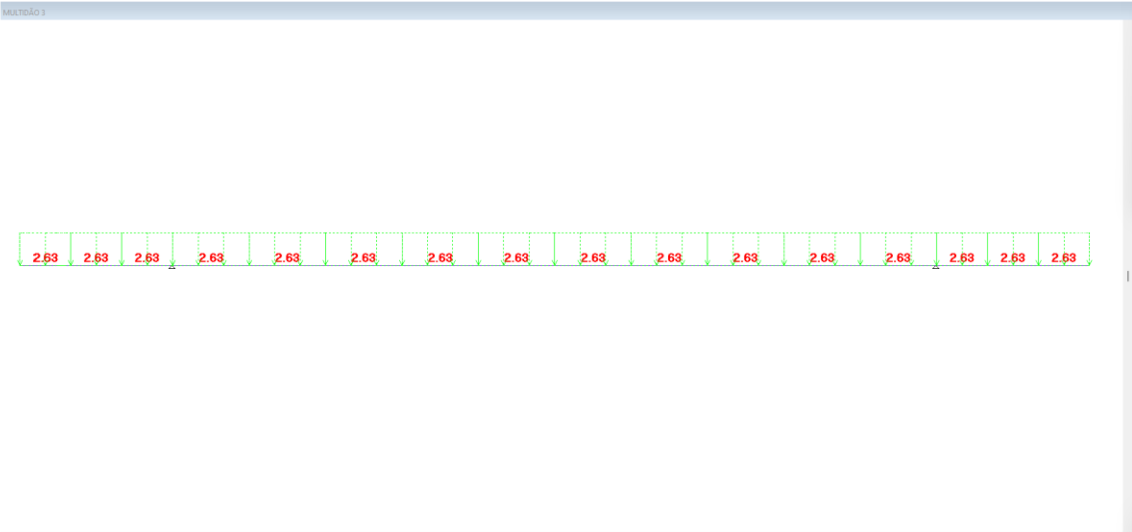
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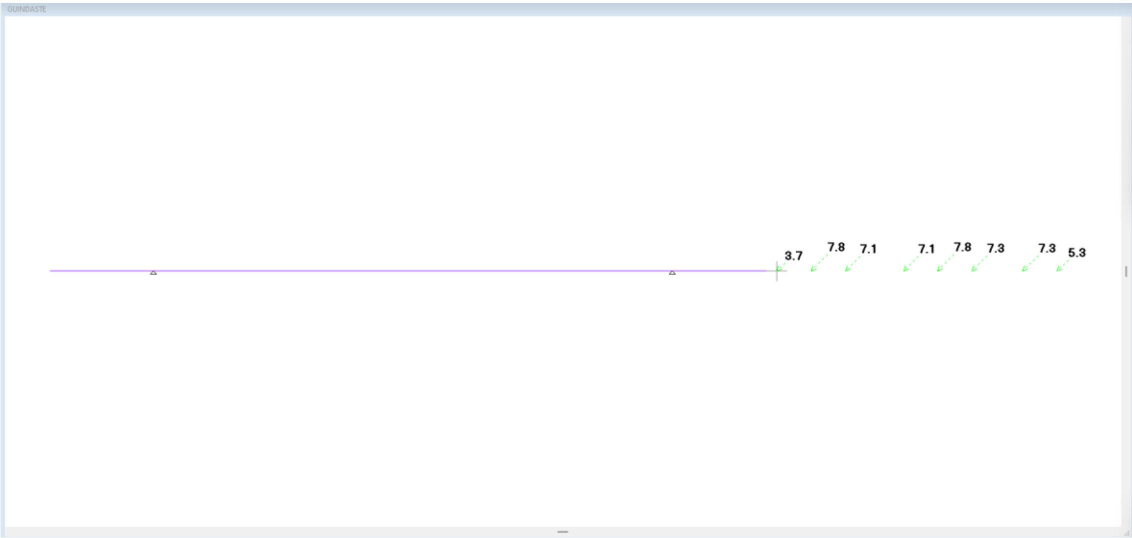
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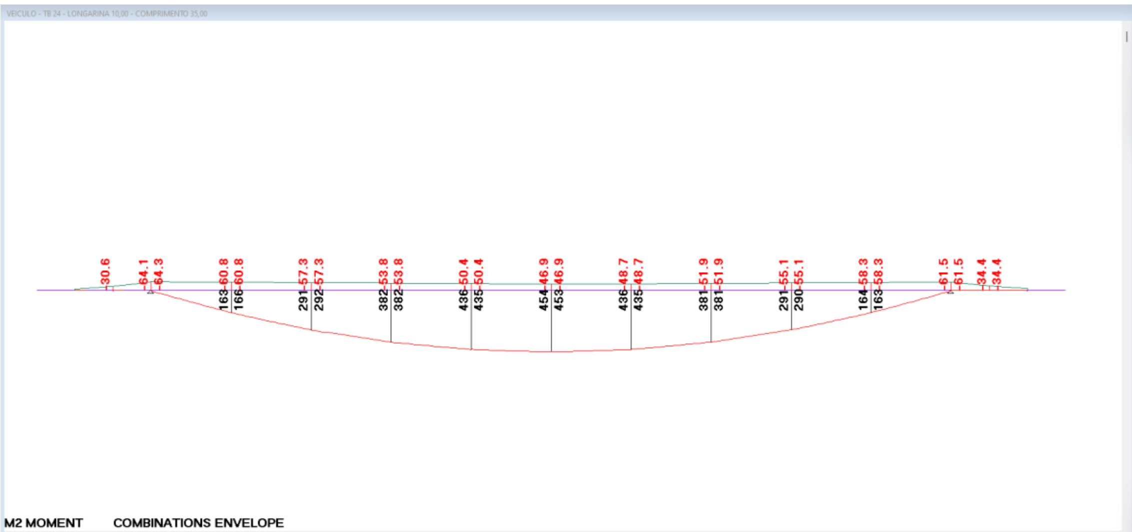
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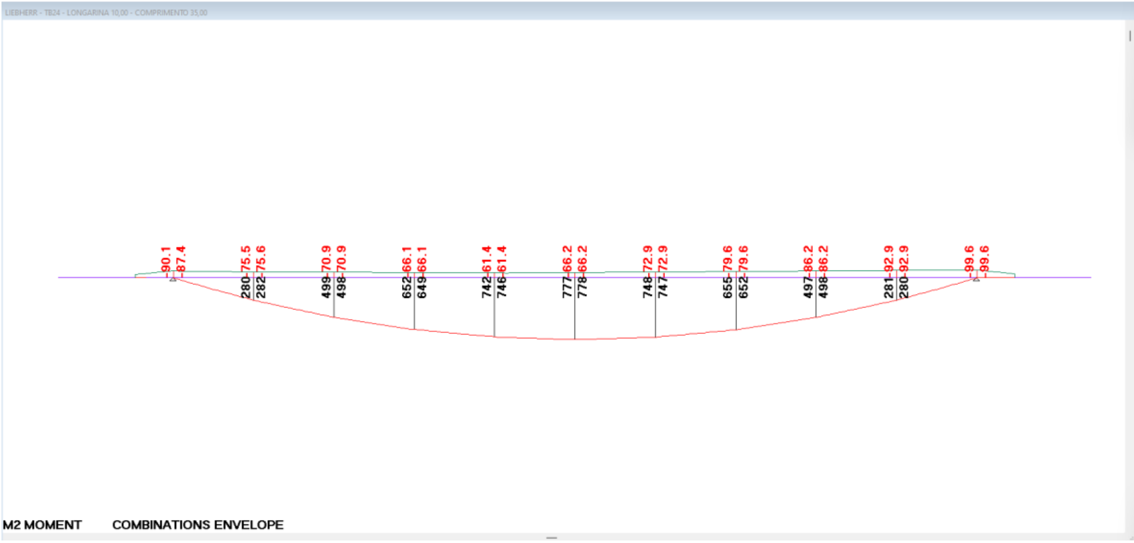
M2 MOMENT
COMBINATIONS ENVELOPE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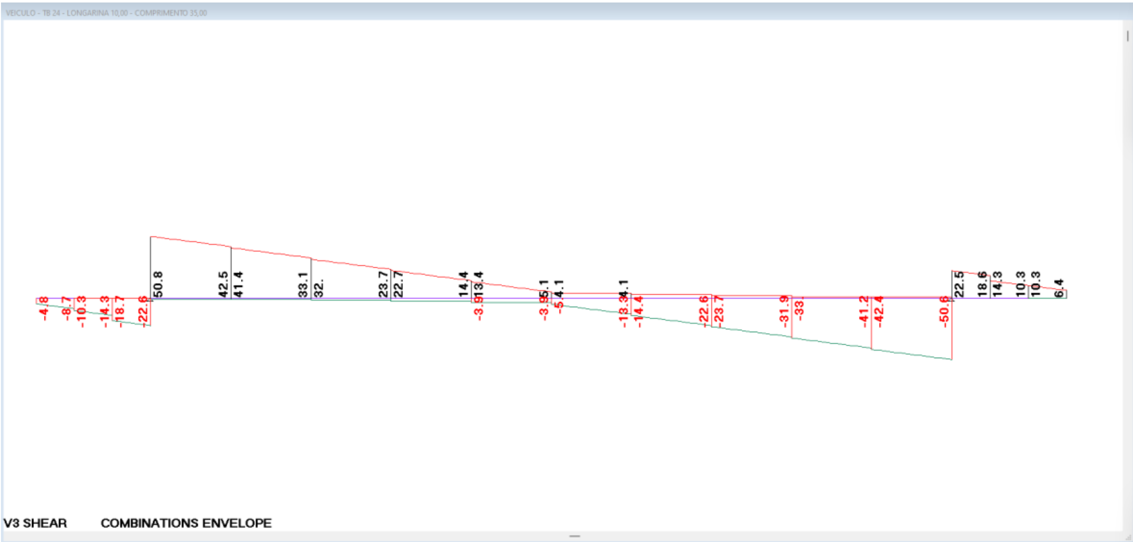
COMBINATIONS ENVELOPE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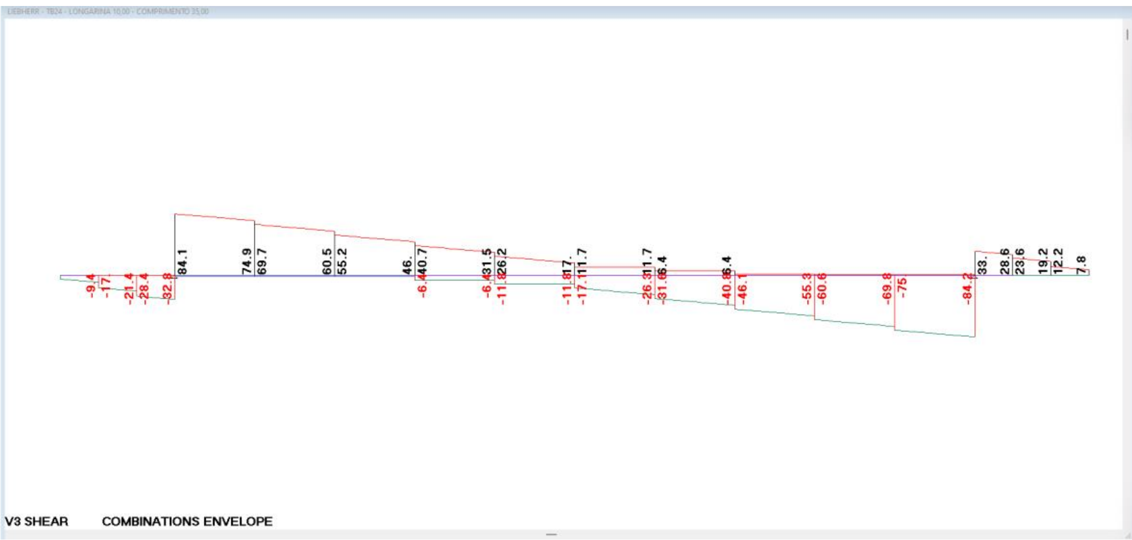
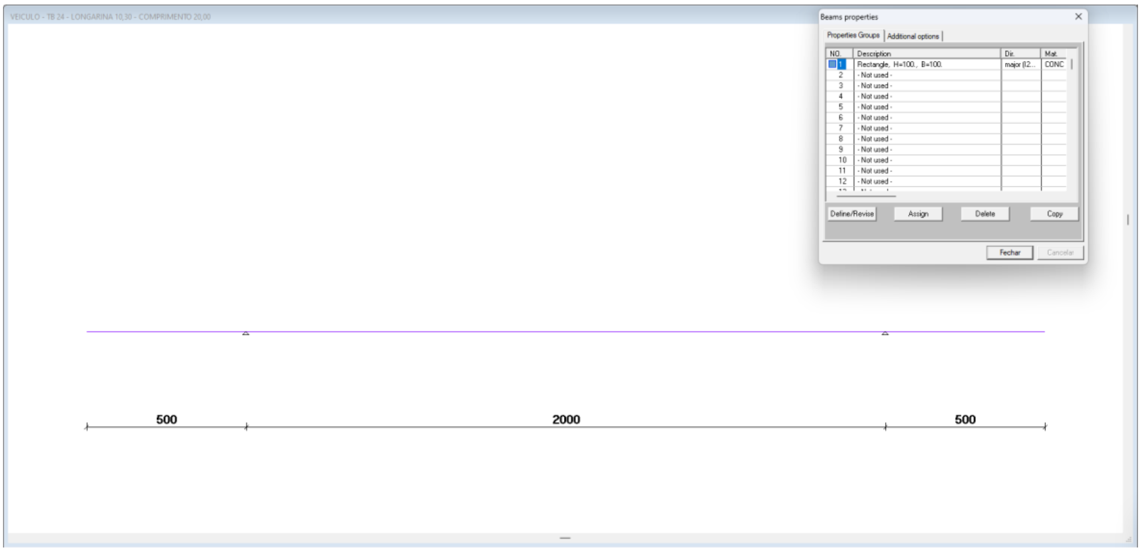
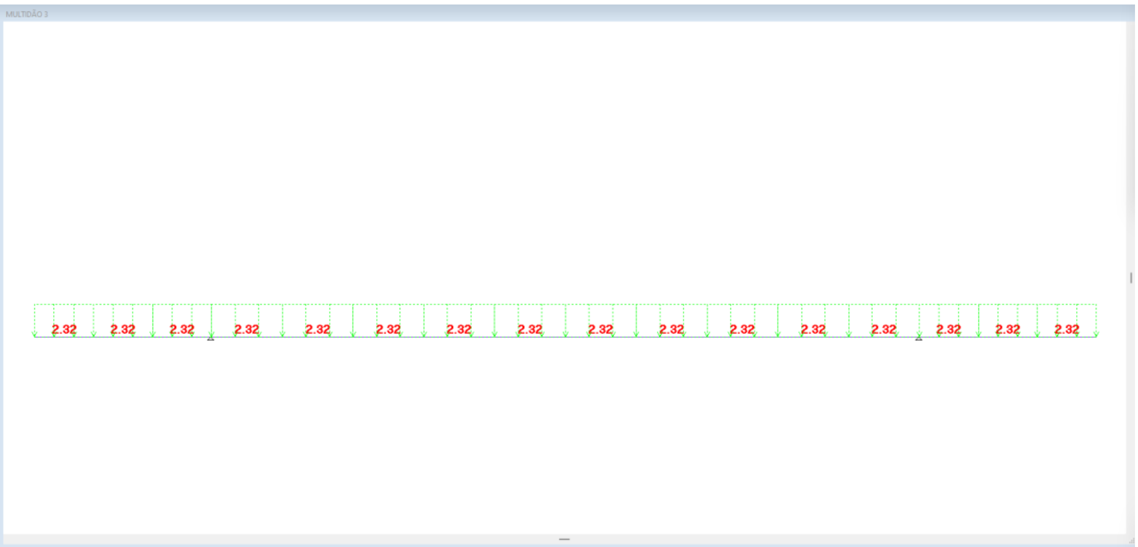
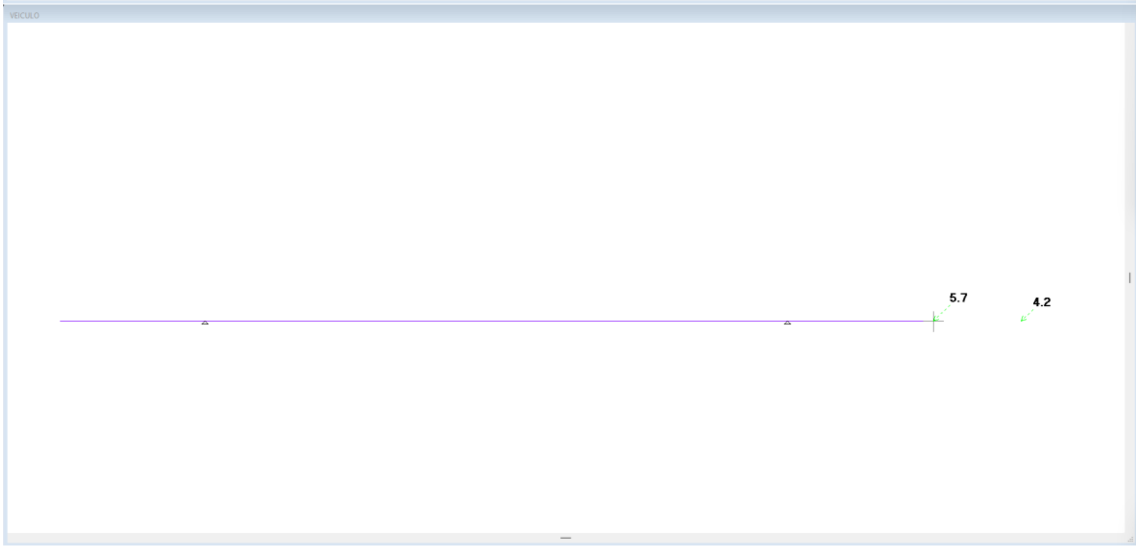
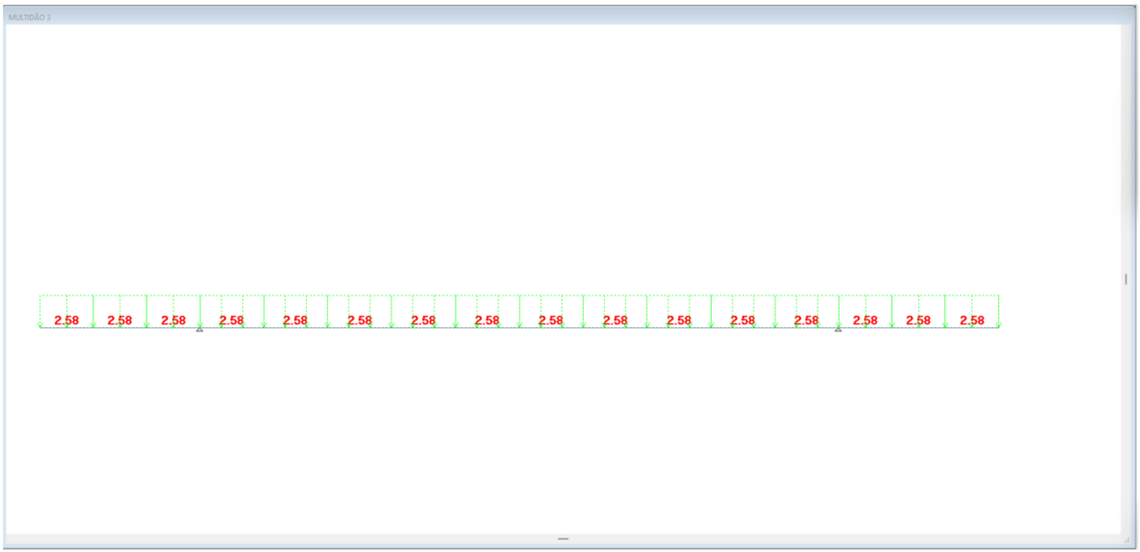

V3 SHEAR
COMBINATIONS ENVELOPE

5.4.3. Tabuleiro 10,30 m





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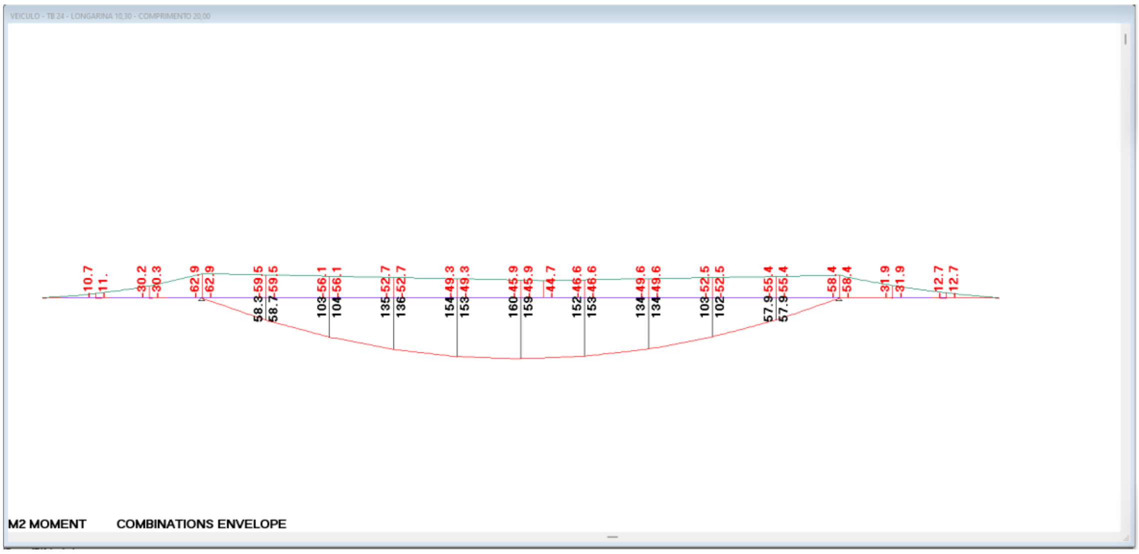
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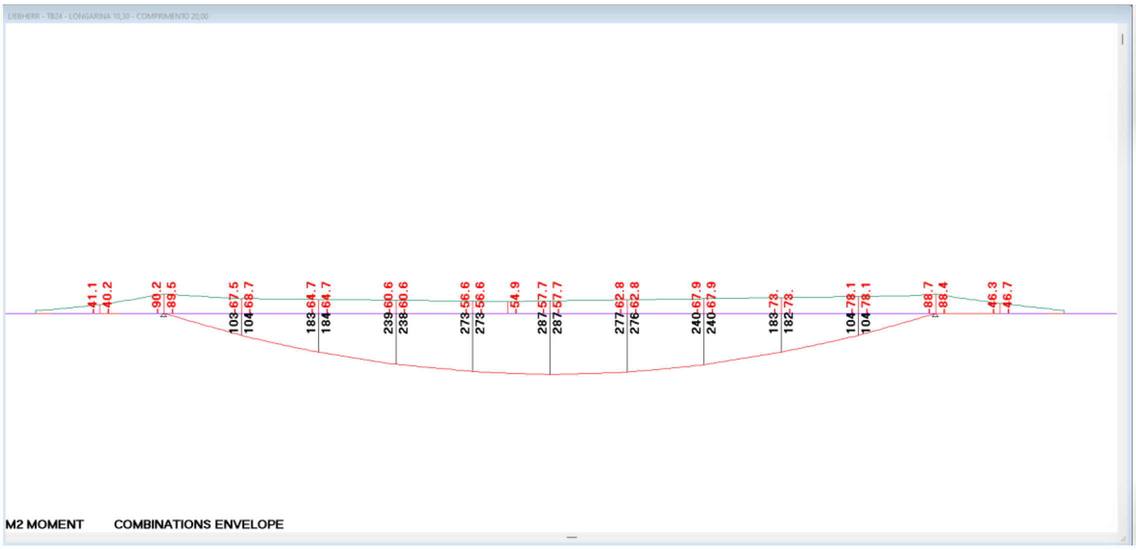
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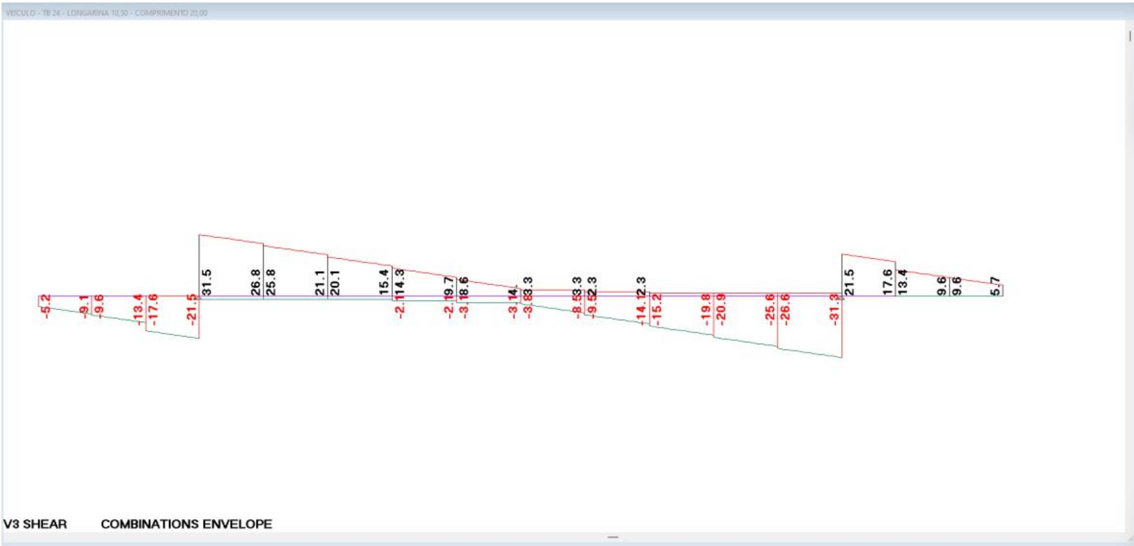
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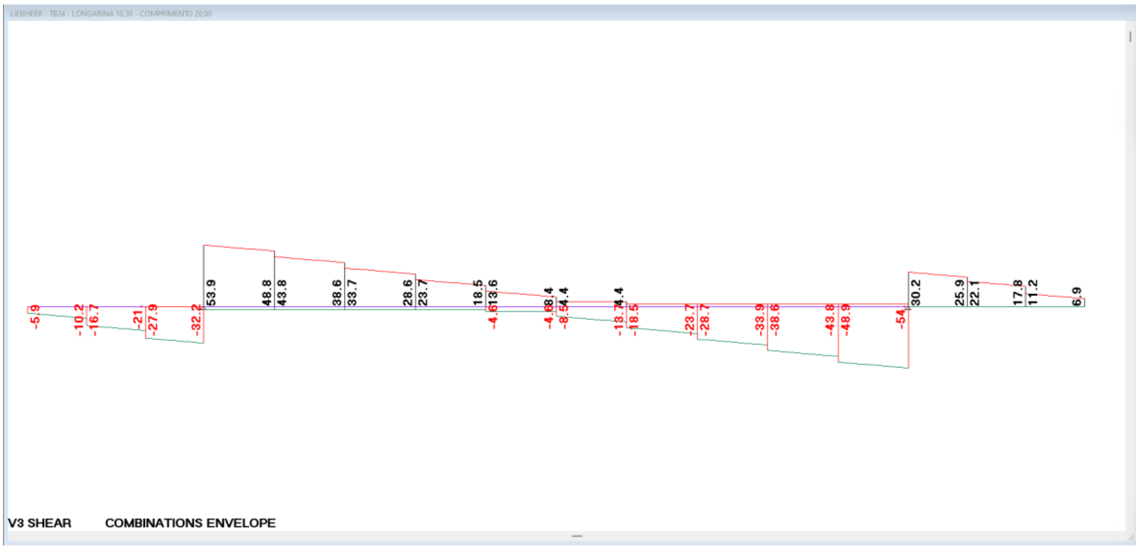
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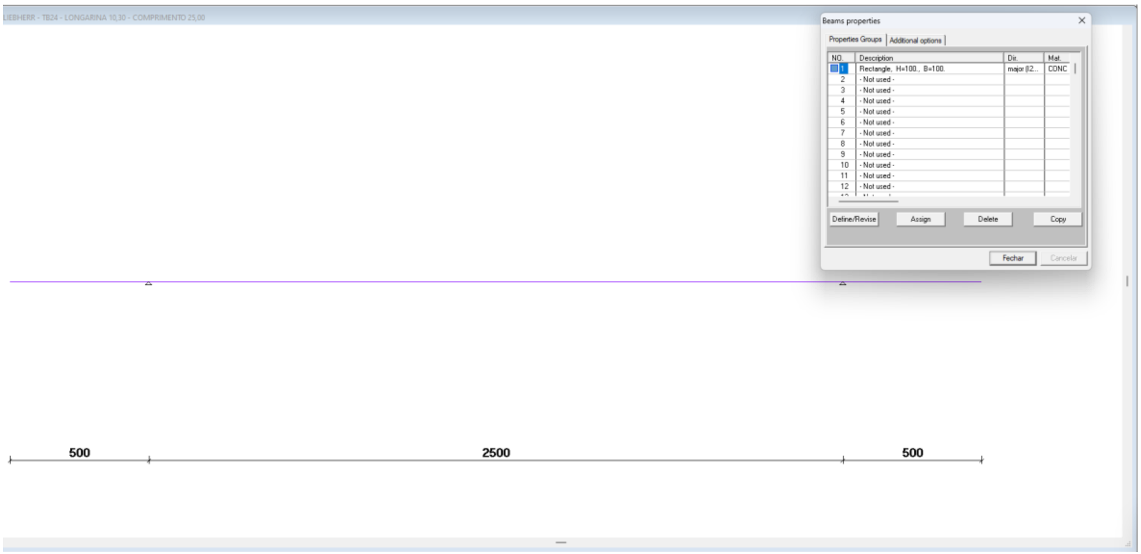
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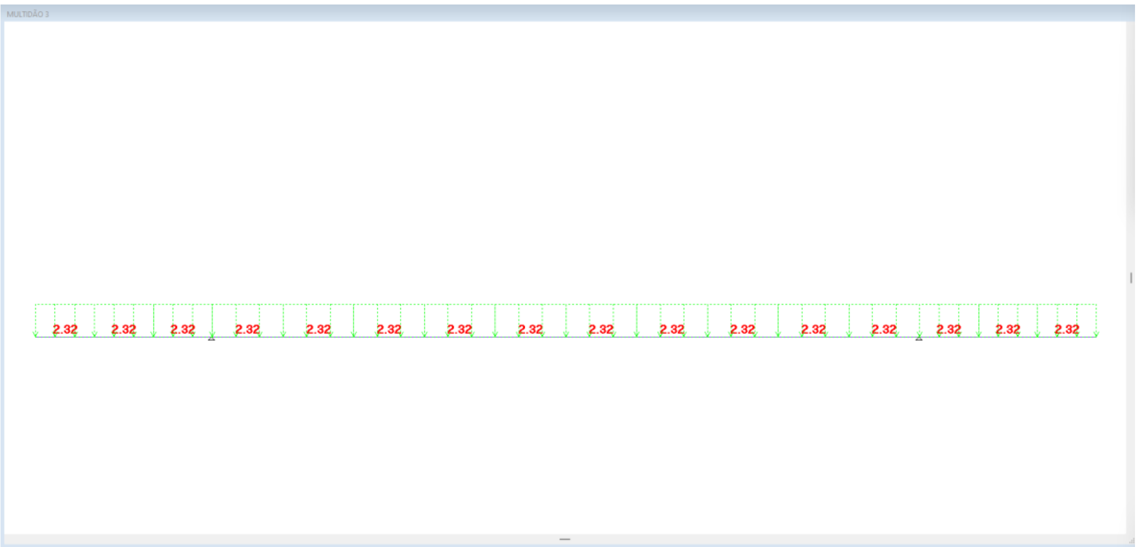
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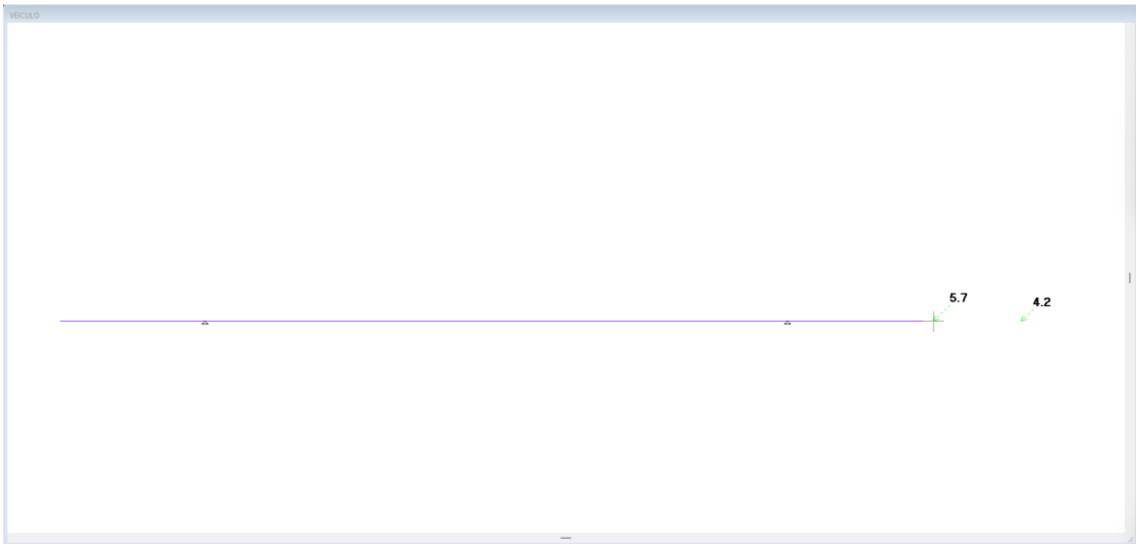
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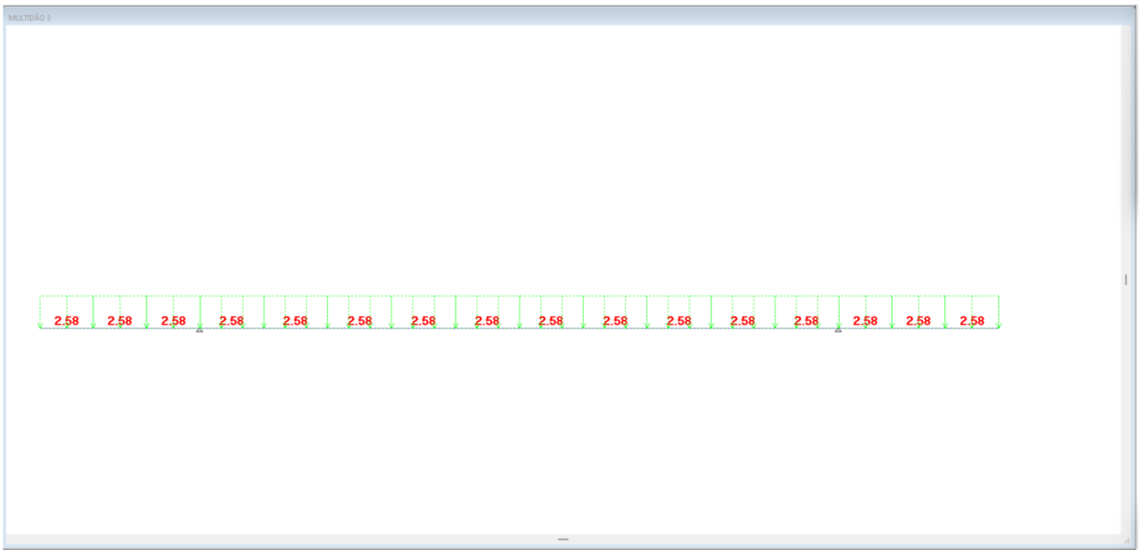
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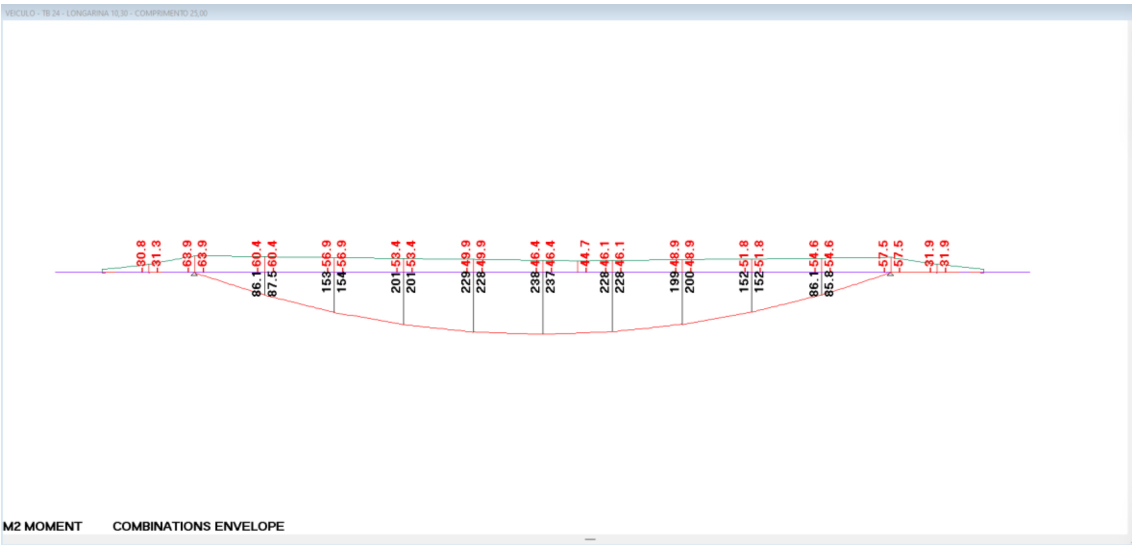
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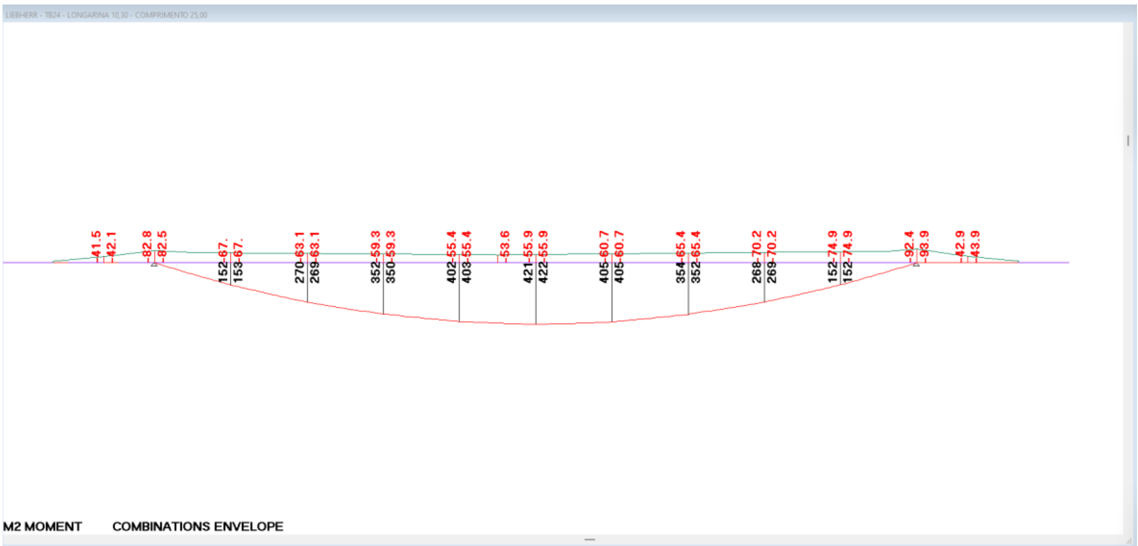
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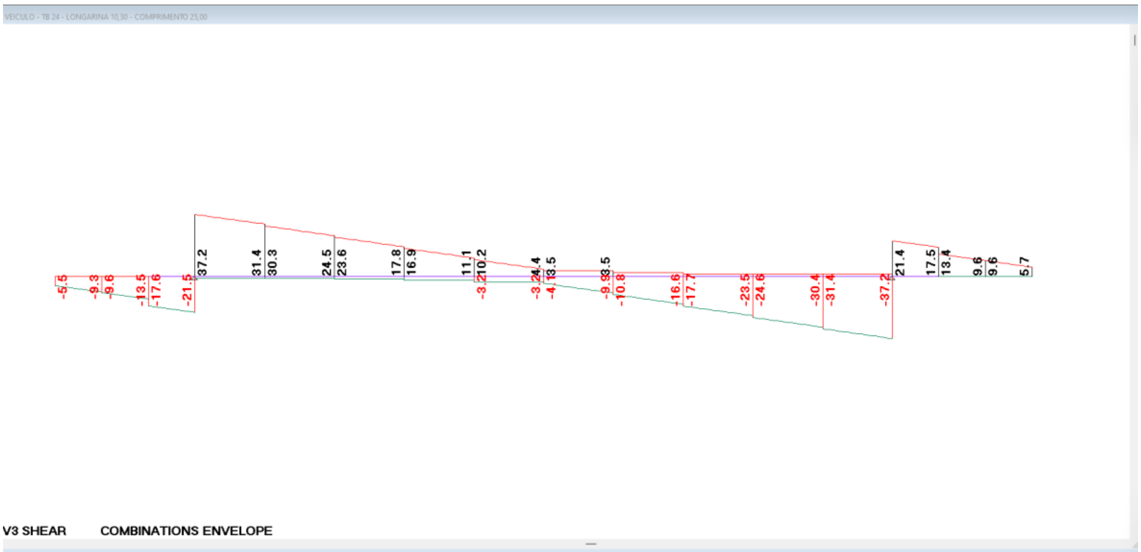
COMBINATIONS ENVELOPE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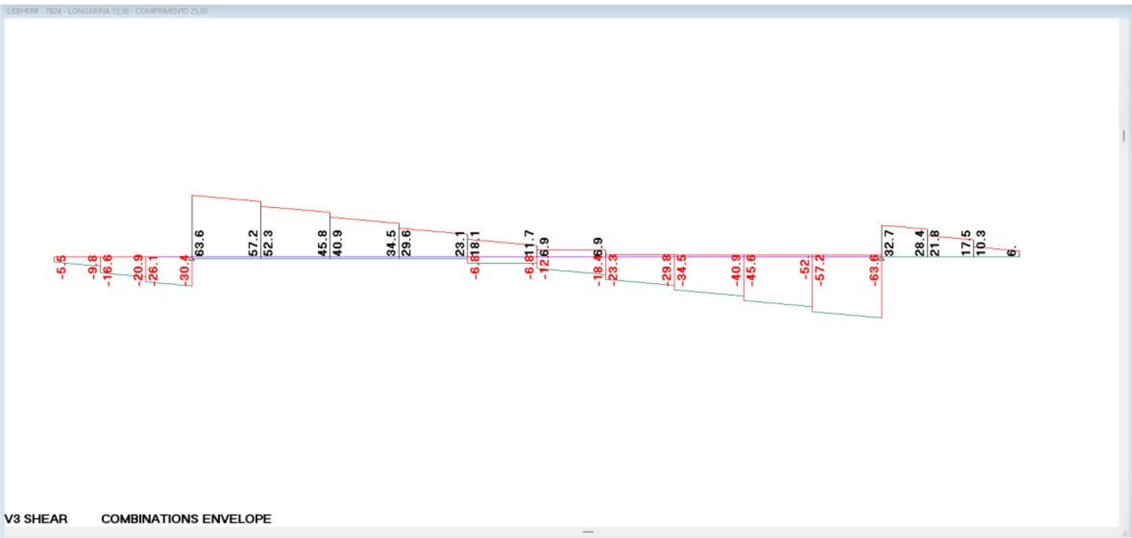
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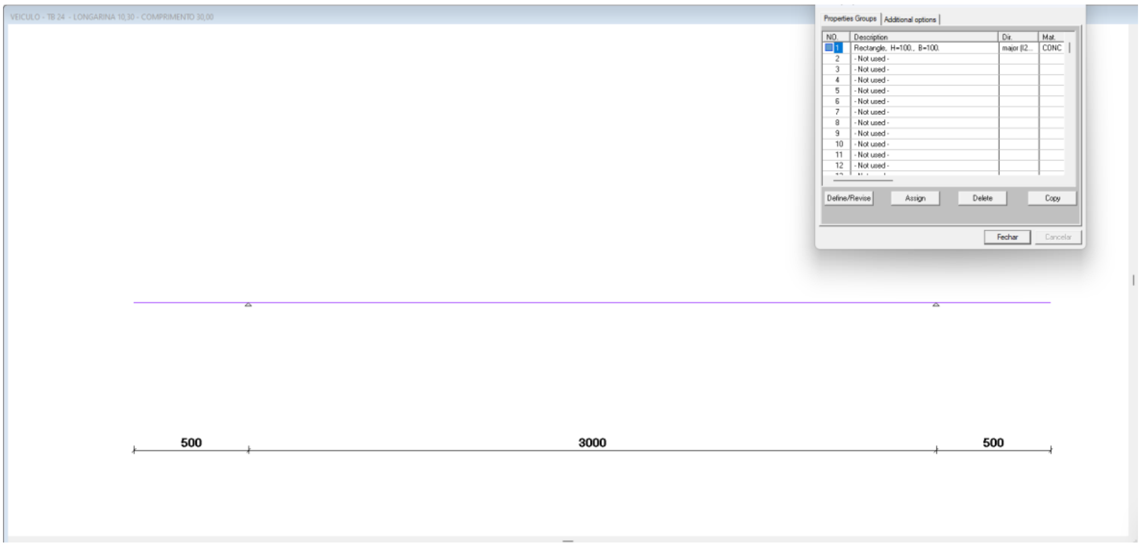
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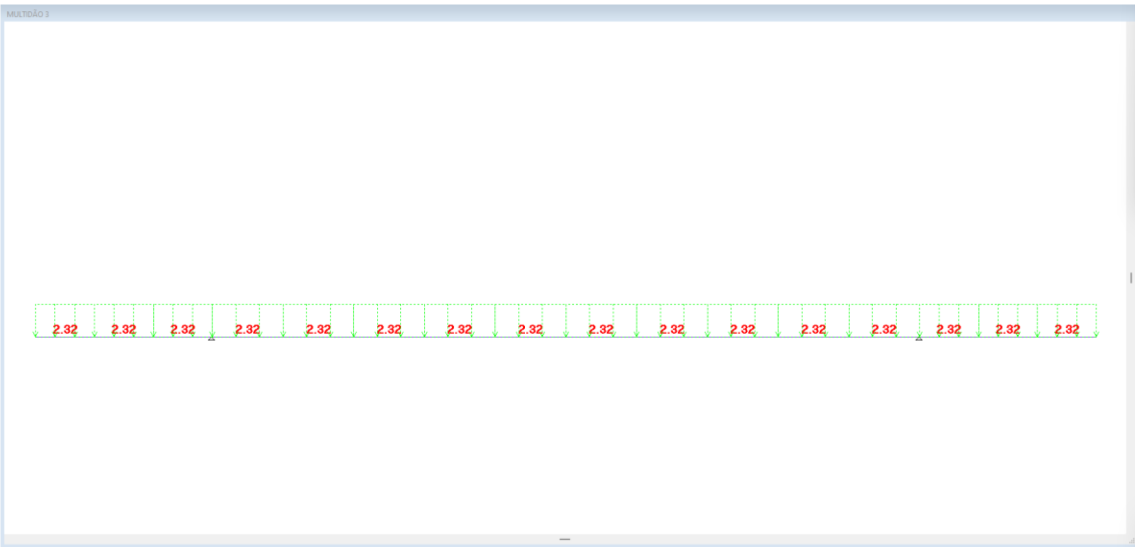
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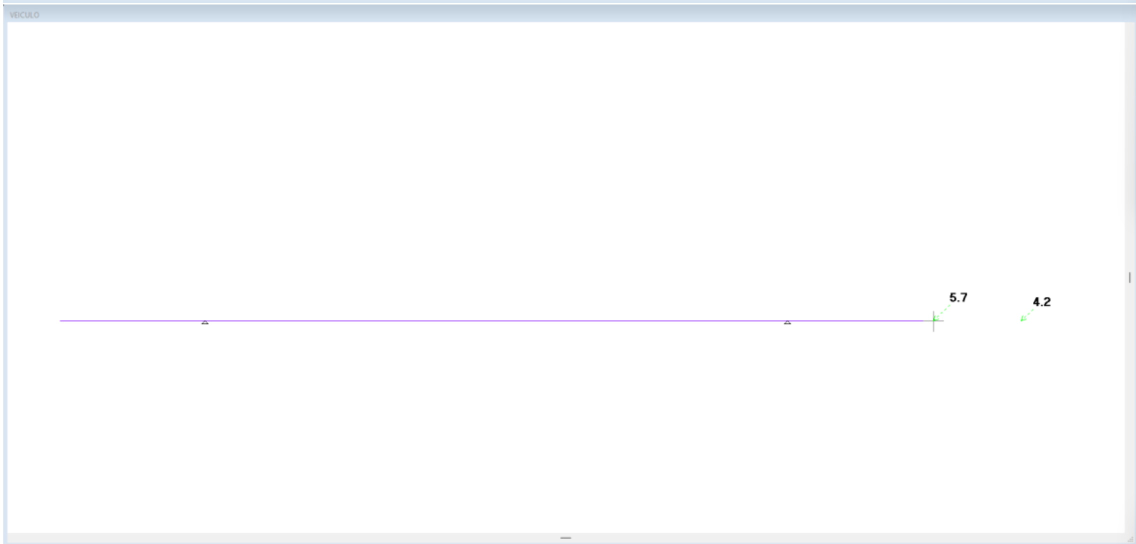
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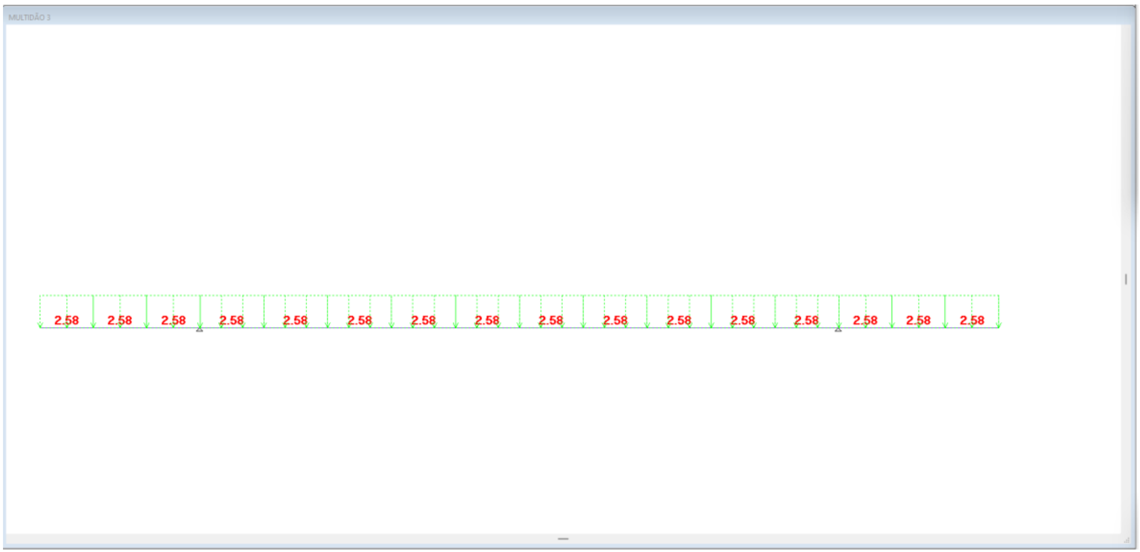
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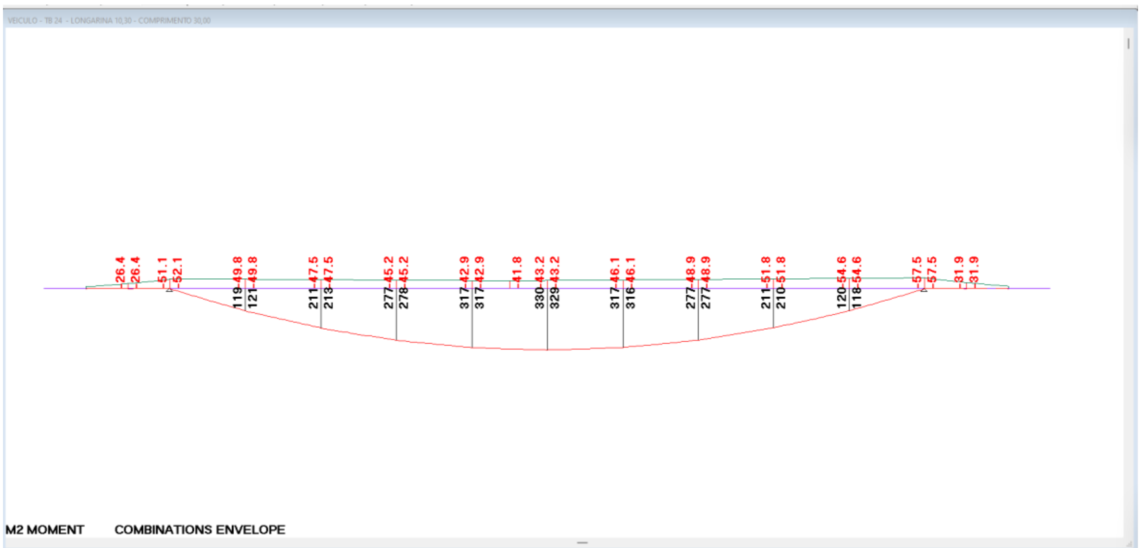
6.5
7.1
6.7
6.7
4.9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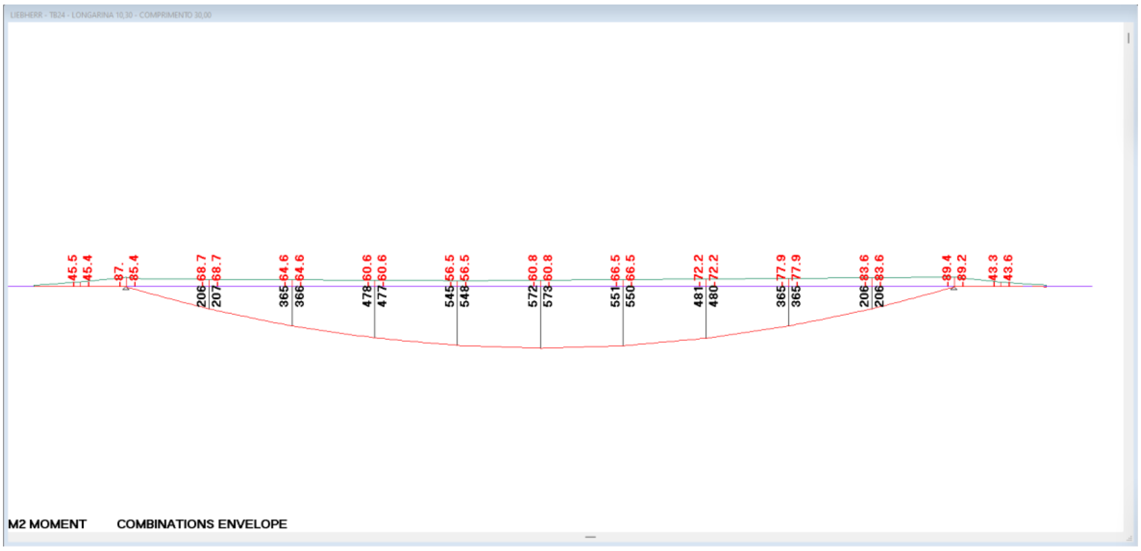
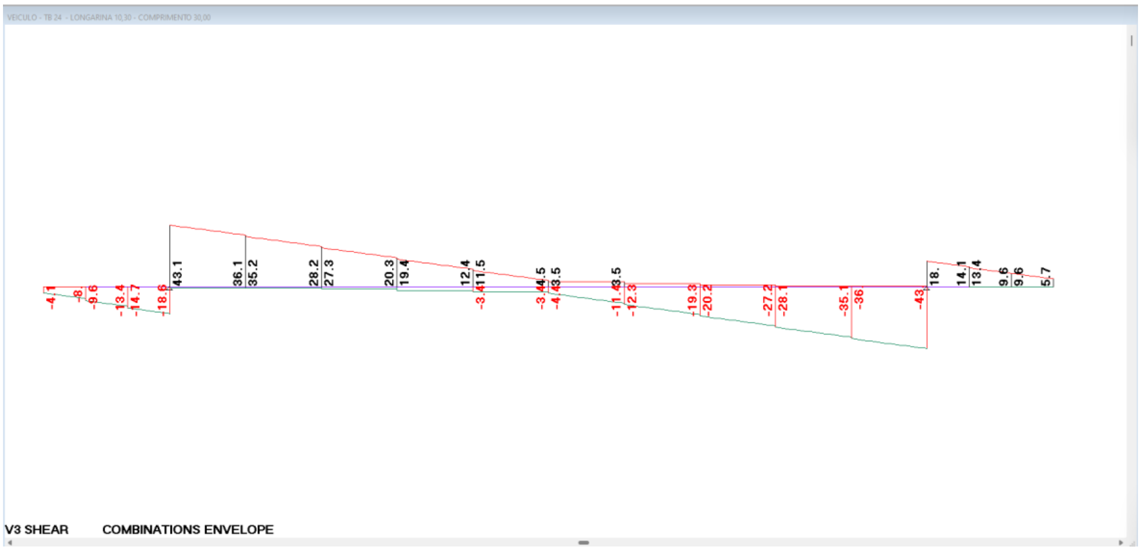
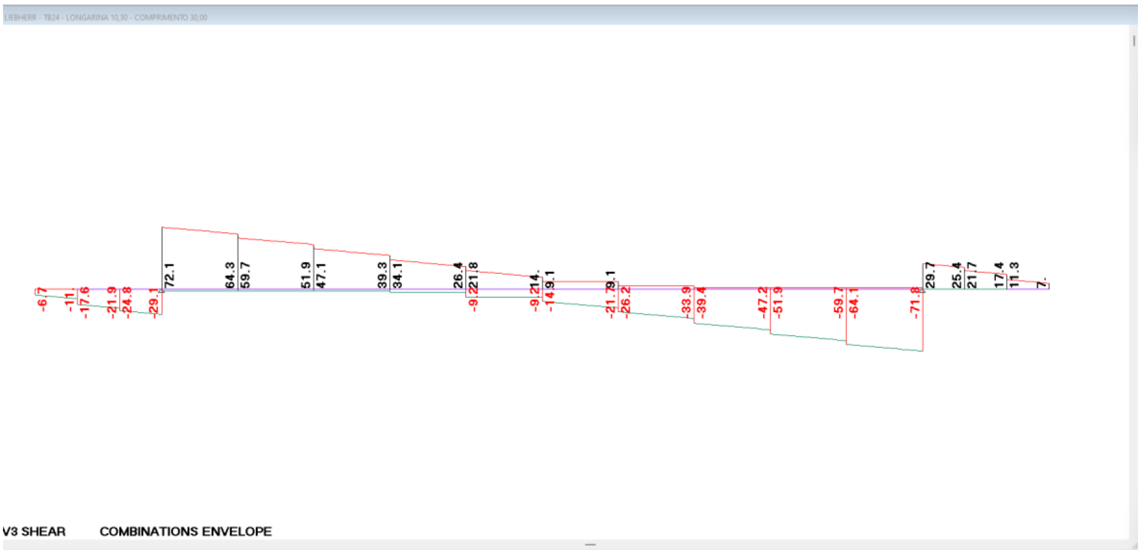
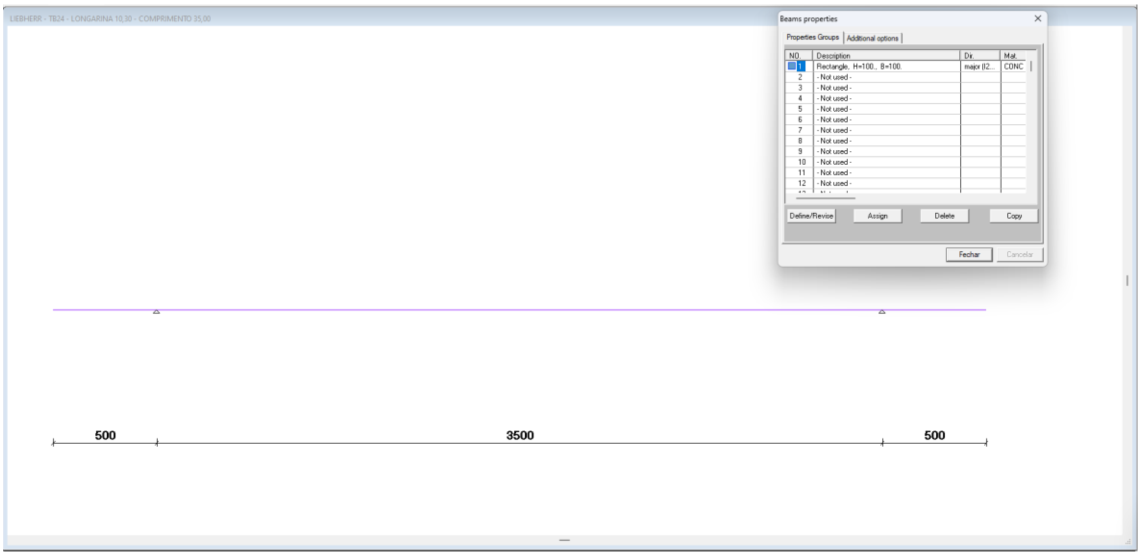
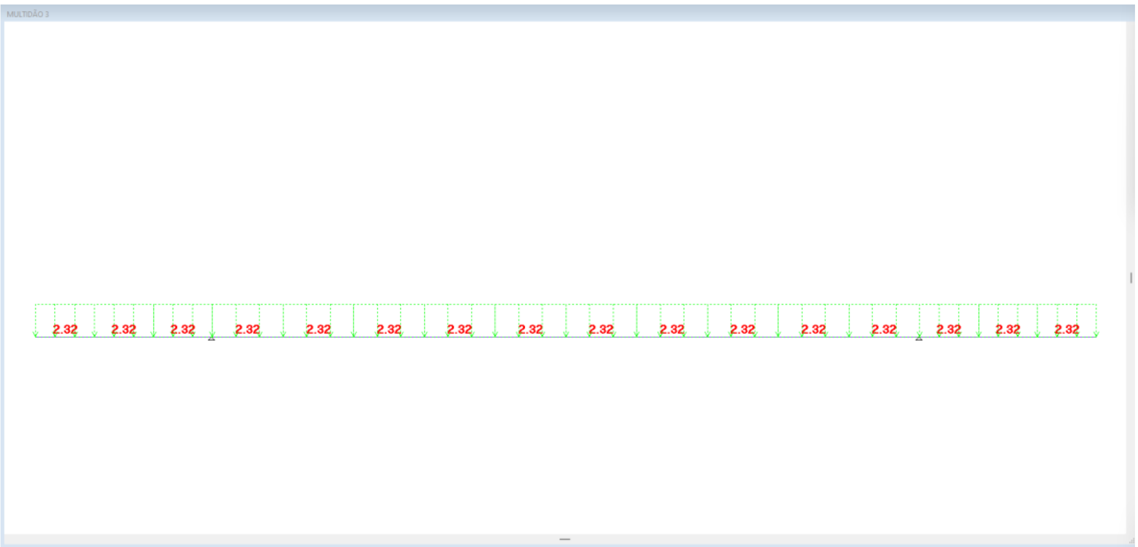
-26.4
-51.1
-52.1
119-49.8
121-49.8
211-47.5
213-47.5
277-45.2
278-45.2
317-42.9
317-42.9
-41.8
330-43.2
329-43.2
317-46.1
316-46.1
277-48.9
277-48.9
211-51.8
210-51.8
120-54.6
118-54.6
-57.5
-57.5
-31.9
-31.9
M2 MOMENT
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


LIEBHERR - TB24 - LONGARINA 10,30 - COMPRIMENTO 35,00
Beams properties
Properties Groups
Additional options
NO.
Description
Dir.
Mat.
1 Rectangle, H=100., B=100. major (I2... CONC
2 - Not used -
3 - Not used -
4 - Not used -
5 - Not used -
6 - Not used -
7 - Not used -
8 - Not used -
9 - Not used -
10 - Not used -
11 - Not used -
12 - Not used -
Define/Revise
Assign
Delete
Copy
Fechar
Cancelar
500
3500
500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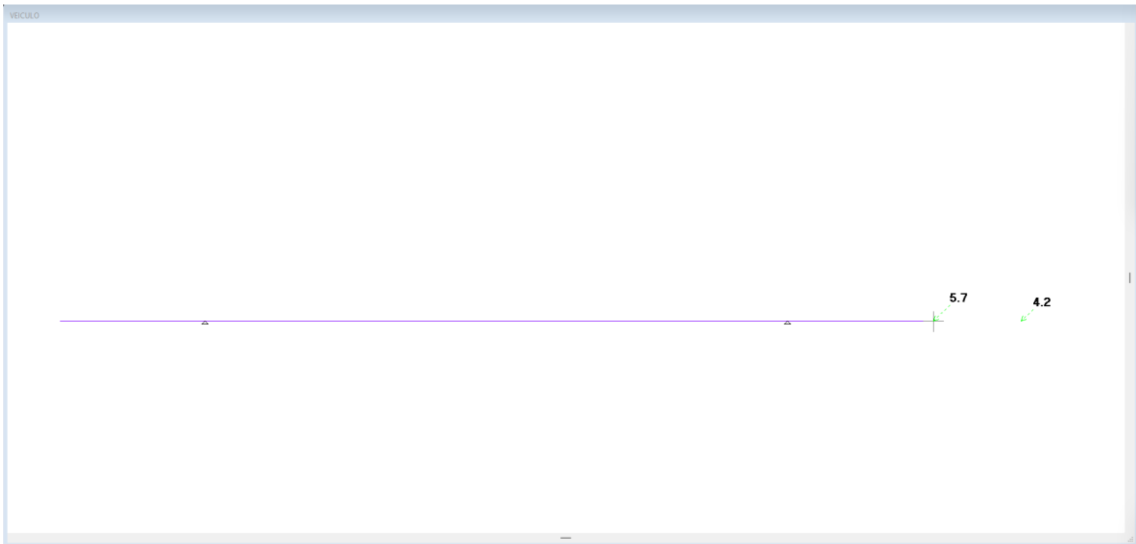
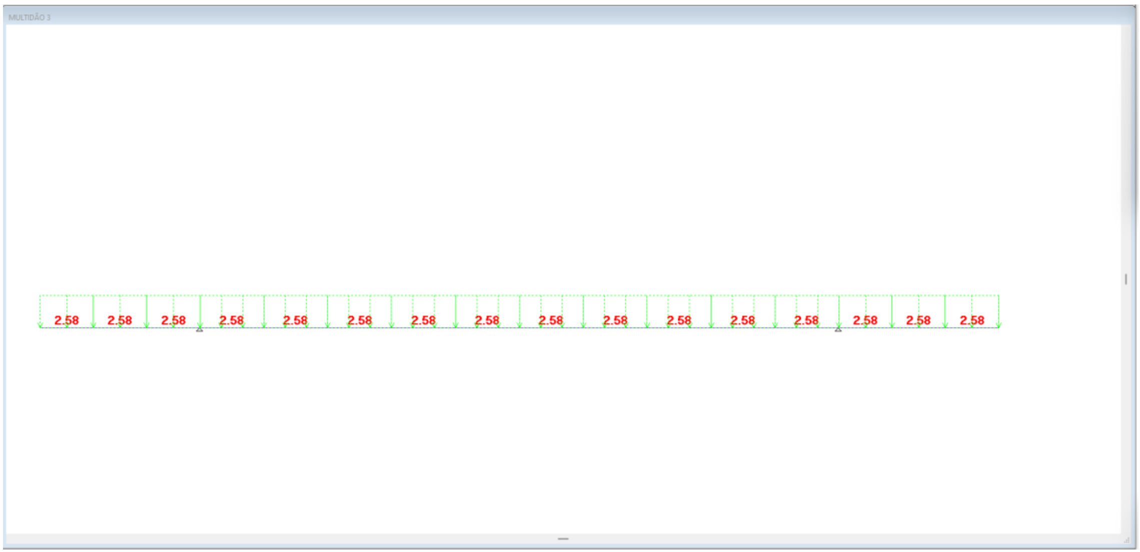
2.32
2.32


5.7
4.2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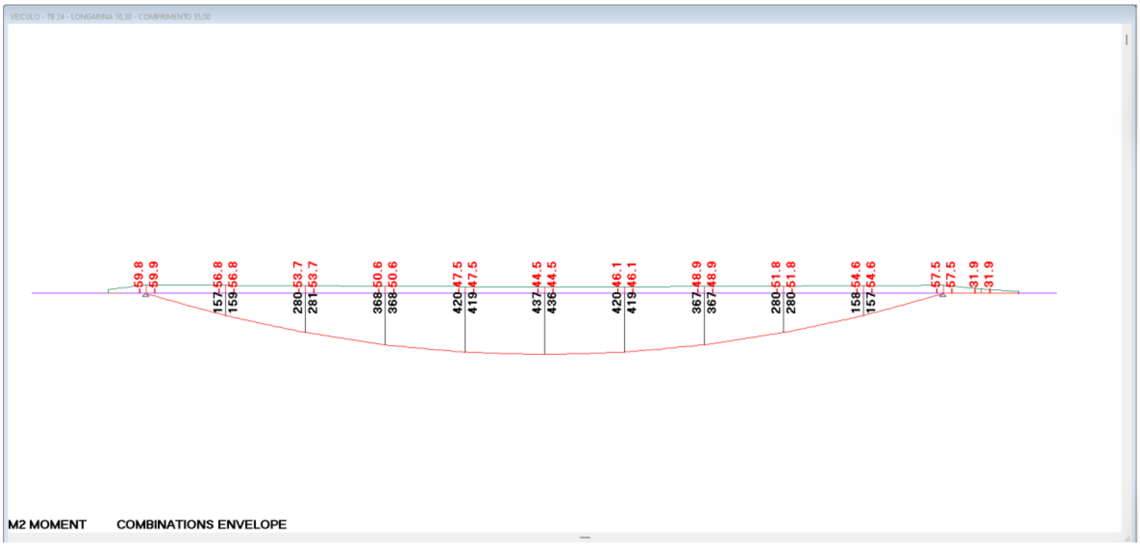
6.7
6.7
4.9


-59.8
-59.9
157 -56.8
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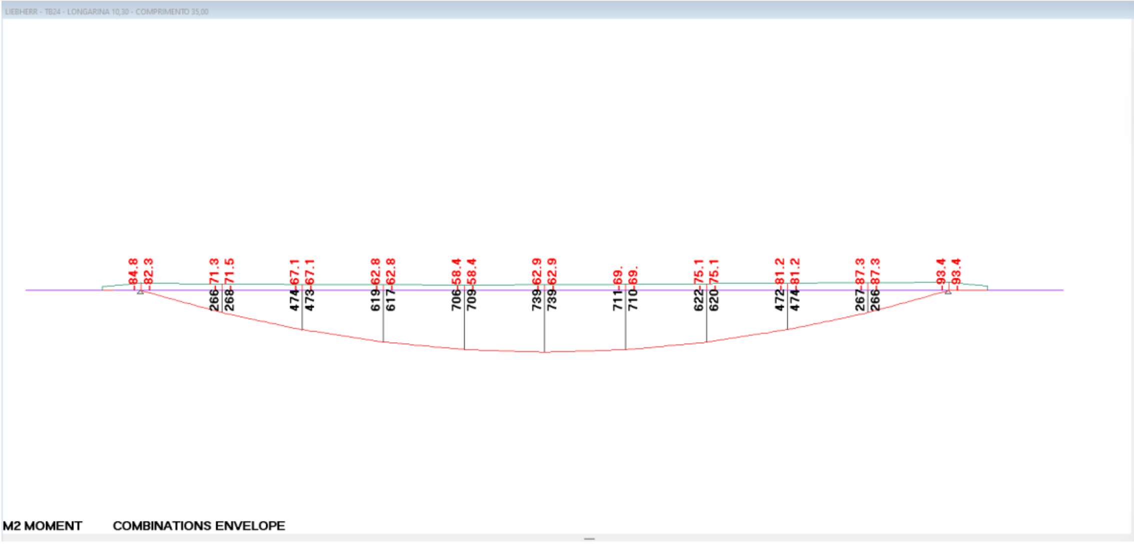
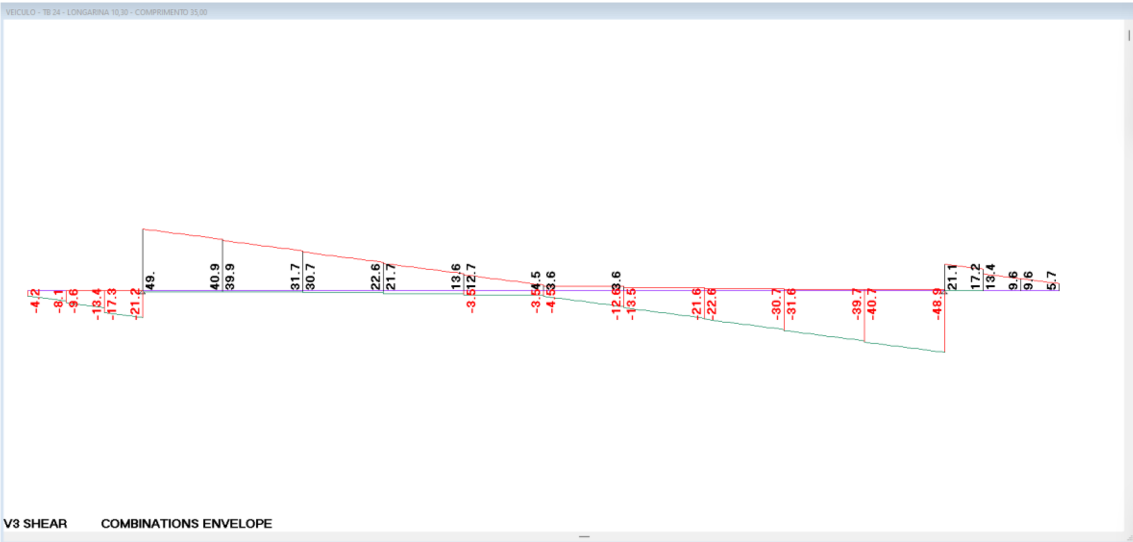
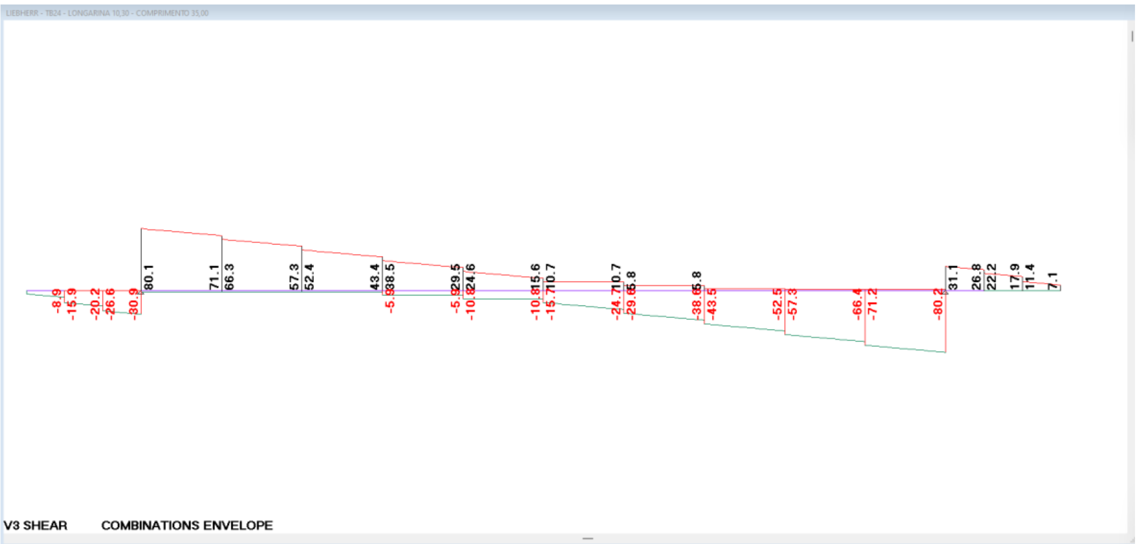
280 -53.7
281 -53.7
368 -50.6
368 -50.6
420 -47.5
419 -47.5
437 -44.5
436 -44.5
420 -46.1
419 -46.1
367 -48.9
367 -48.9
280 -51.8
280 -51.8
158 -54.6
157 -54.6
-57.5
-57.5
-31.9
-31.9
M2 MOMENT
COMBINATIONS ENVELOPE


M2 MOMENT COMBINATIONS ENVELOPE


V3 SHEAR COMBINATIONS ENVELOPE


V3 SHEAR COMBINATIONS ENVELOPE

5.5. Resultados

5.5.1. Cálculo do CS (Coeficiente de Segurança)

CIV DO LIEBHERR		COMPRIMENTO			
		20	25	30	35
P/ VÃO ->	$\varphi = 1{,}00 + 1{,}06 \times \left(\frac{20}{L+50}\right)$	1,30	1,28	1,27	1,25
P/ BAL ->	$\varphi = 1{,}00 + 1{,}06 \times \left(\frac{20}{5+50}\right)$	1,39	1,39	1,39	1,39

TB-24

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
M(+) (tonxm)	147	216	297	391
M(-) (tonxm)	63,6	63,6	63,6	63,6
Ve (tonxm)	20,9	20,9	20,9	20,9
Vd (tonxm)	28,8	33,7	38,6	43,6

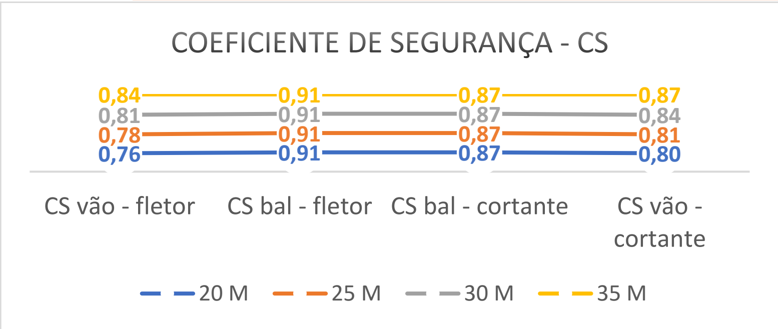
LIEBHERR

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
M(+) (tonxm)	295	430	578	740
M(-) (tonxm)	100	100	100	100
Ve (tonxm)	34,4	34,4	34,4	34,4
Vd (tonxm)	55,1	64,3	72,3	79,5

$$CS = \frac{1{,}20 \times 1{,}40 \times 1{,}30 \times M_{q\,TB-24}}{1{,}10 \times CIV_{vão/bal} \times M_{q\,Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
CS vão - fletor	0,76	0,78	0,81	0,84
CS bal - fletor	0,91	0,91	0,91	0,91
CS bal - cortante	0,87	0,87	0,87	0,87
CS vão - cortante	0,80	0,81	0,84	0,87



TB-24

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
M(+) (tonxm)	167	248	344	453
M(-) (tonxm)	69,6	69,6	69,6	69,6
Ve (tonxm)	23	23	23	23
Vd (tonxm)	33	38,7	45	50,8

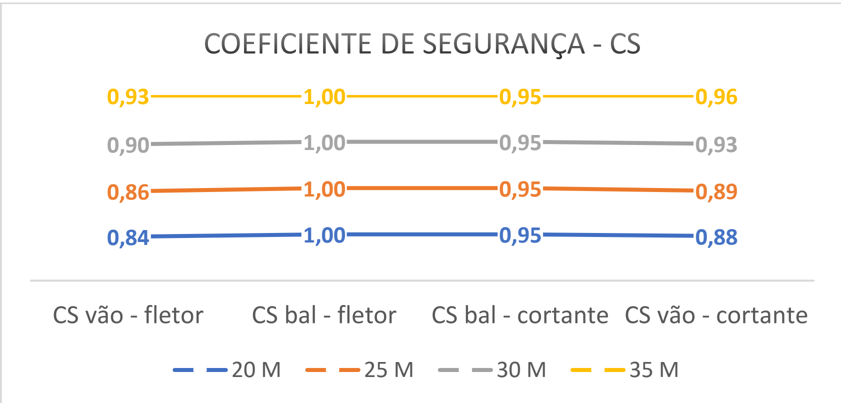
LIEBHERR

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
M(+) (tonxm)	304	445	603	776
M(-) (tonxm)	100	100	100	100
Ve (tonxm)	34,8	34,8	34,8	34,8
Vd (tonxm)	57	67,1	76	84,5

$$CS = \frac{1{,}20 \times 1{,}40 \times 1{,}30 \times M_{q\,TB-24}}{1{,}10 \times CIV_{vão/bal} \times M_{q\,Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
CS vão - fletor	0,84	0,86	0,90	0,93
CS bal - fletor	1,00	1,00	1,00	1,00
CS bal - cortante	0,95	0,95	0,95	0,95
CS vão - cortante	0,88	0,89	0,93	0,96



TB-24

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
M(+) (tonxm)	160	237	330	437
M(-) (tonxm)	63,9	63,9	63,9	63,9
Ve (tonxm)	21,5	21,5	21,5	21,5
Vd (tonxm)	31,5	37,1	43,1	49,1

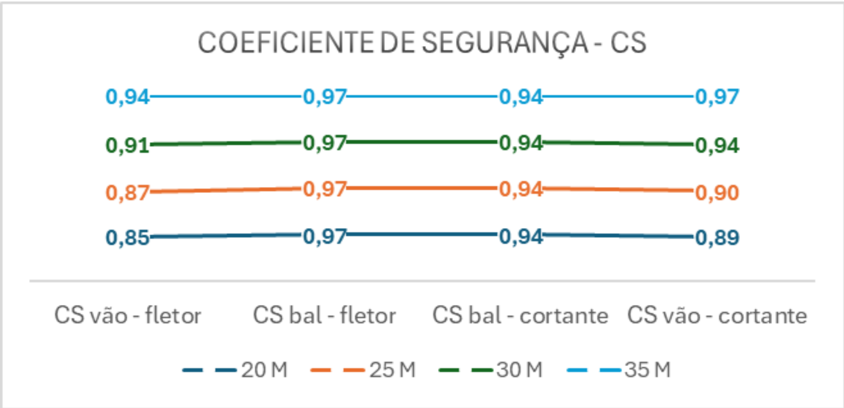
LIEBHERR

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
M(+) (tonxm)	287	421	572	740
M(-) (tonxm)	94,2	94,2	94,2	94,2
Ve (tonxm)	32,7	32,7	32,7	32,7
Vd (tonxm)	54	63,6	72,3	80,4

$$CS = \frac{1{,}20 \times 1{,}40 \times 1{,}30 \times M_{q\,TB-24}}{1{,}10 \times CIV_{vão/bal} \times M_{q\,Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
CS vão - fletor	0,85	0,87	0,91	0,94
CS bal - fletor	0,97	0,97	0,97	0,97
CS bal - cortante	0,94	0,94	0,94	0,94
CS vão - cortante	0,89	0,90	0,94	0,97

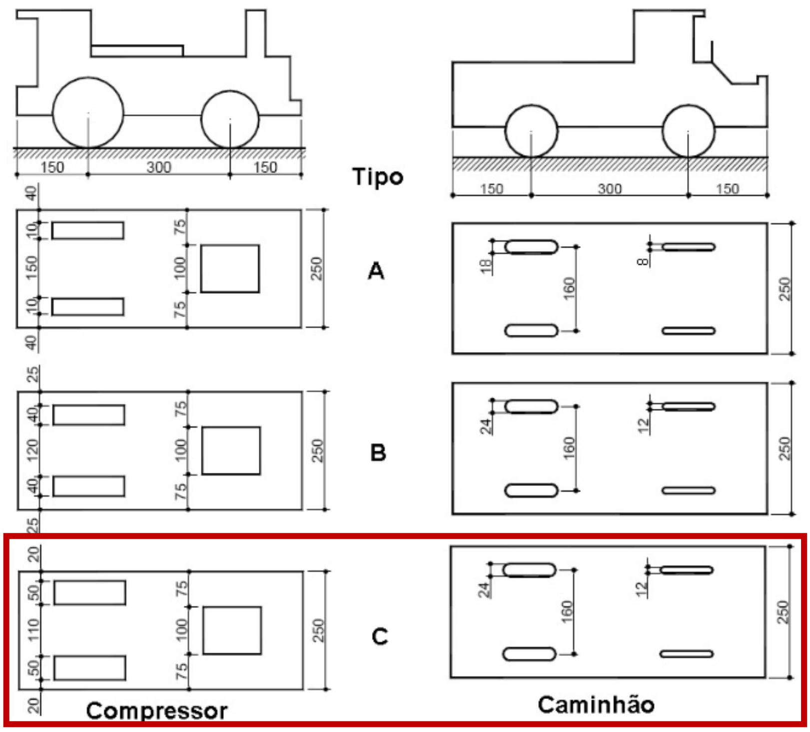


5.5.2. Considerações para o TB-24 (1943 a 1950)

Os coeficientes de segurança ficaram com valores < 1, então a passagem do guindaste de 96 toneladas e 8 eixos não está liberada para o TB-24 no período de (1943 a 1950). Será necessário realizar o mesmo processo de cálculo para o segundo período (1950 a 1960).

6. DESENVOLVIMENTO: TB-24 (1950 A 1960)

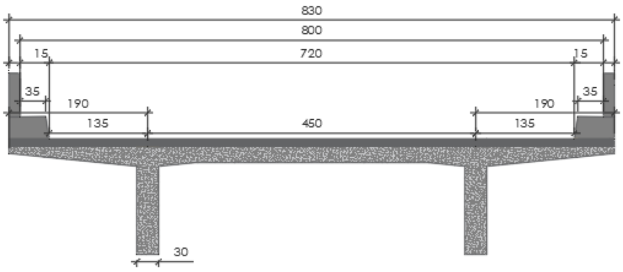
Figura 2 - Compressor e caminhão utilizado no trem-tipo segundo NB6/50 (ABNT, 1950)

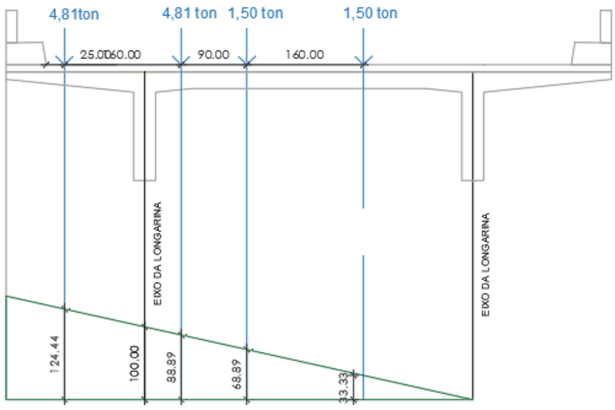


Art. 10 - O trem-tipo para pontes da Classe I compõe-se de multidão com g_o = 500 kgf/m², de um compressor Tipo C e de tantos caminhões tipo C quantas forem as faixas de tráfego, menos uma, e dispostos como no caso do **Art. 8** da norma.

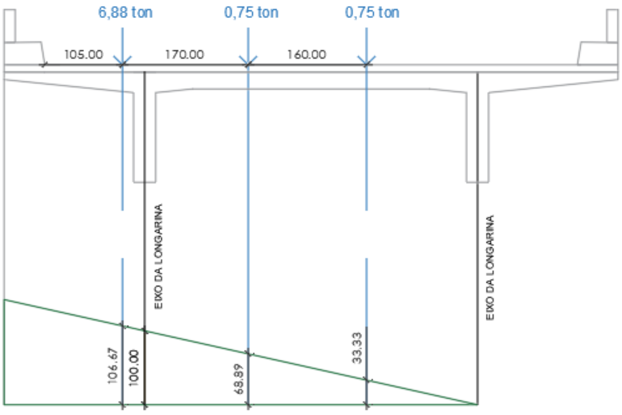
6.1. Linhas de influência – Rolo compressor + caminhão

6.1.1. Tabuleiro 8,30 m

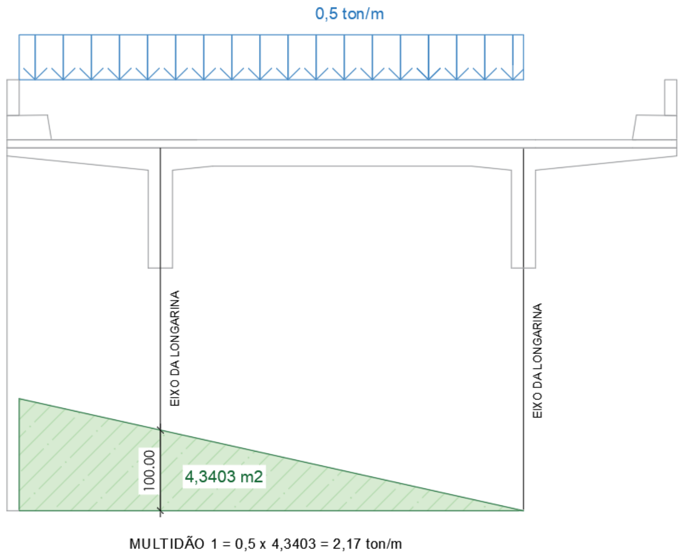


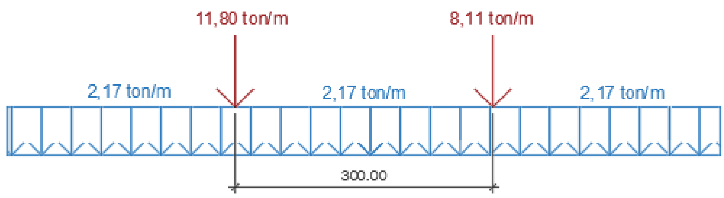


RODAS TRASEIRAS = 4,81 x (1,2444 + 0,8899) + 1,50 x (0,6889 + 0,3333) = 11,80 ton

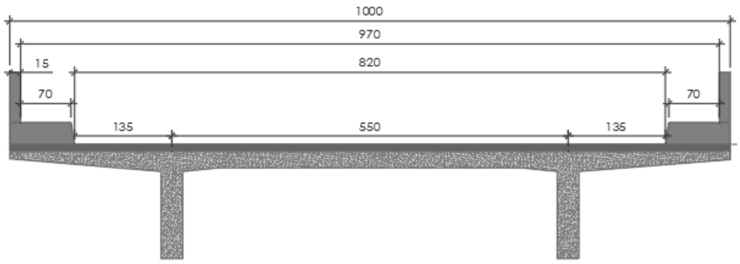


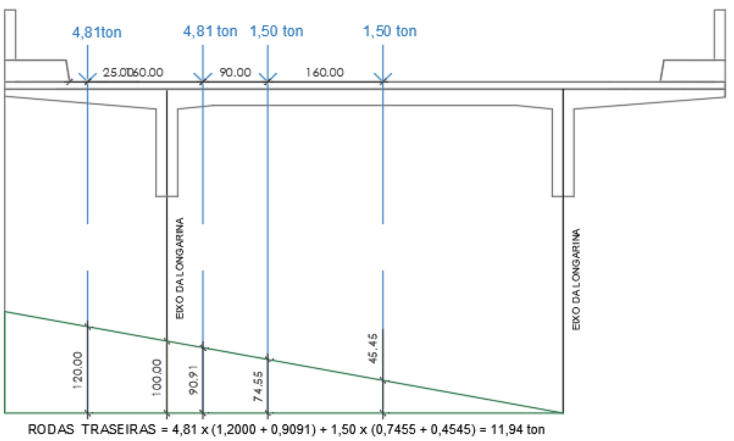
RODAS DIANTEIRAS = (6,88 x 1,0667) + 0,75 x (0,6889 + 0,3333) = 8,11 ton

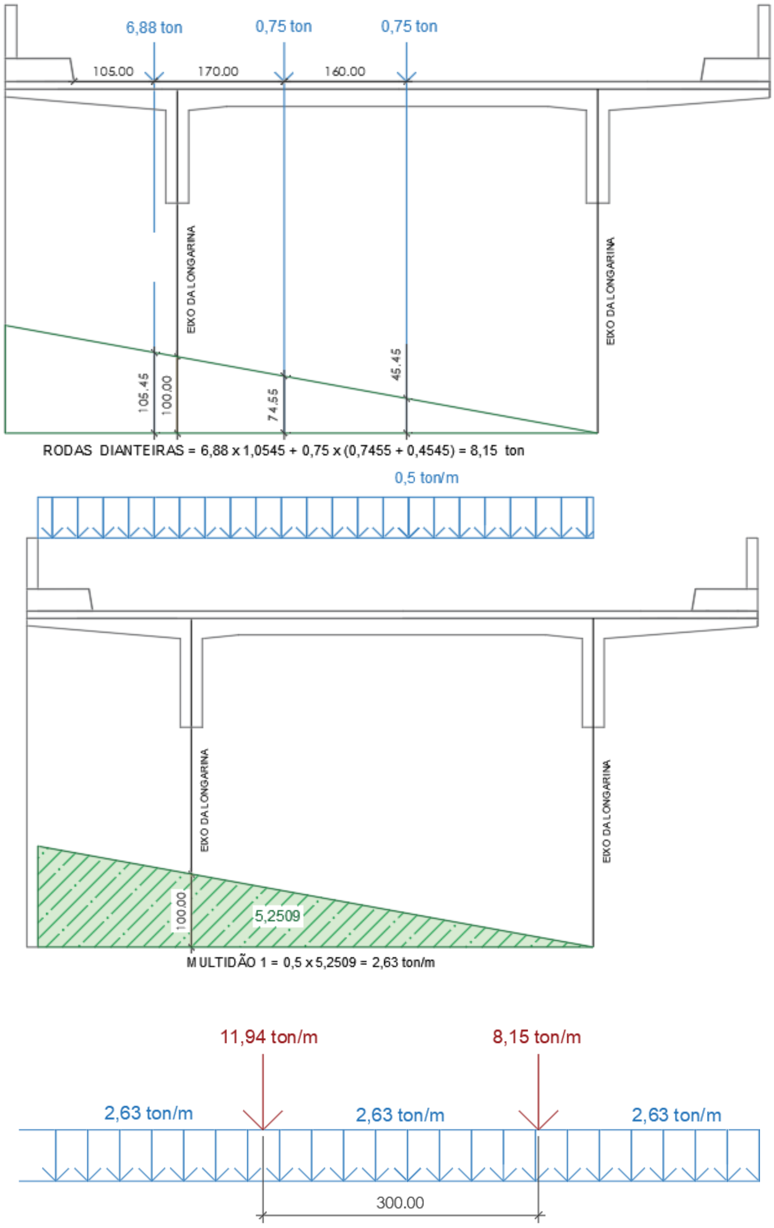




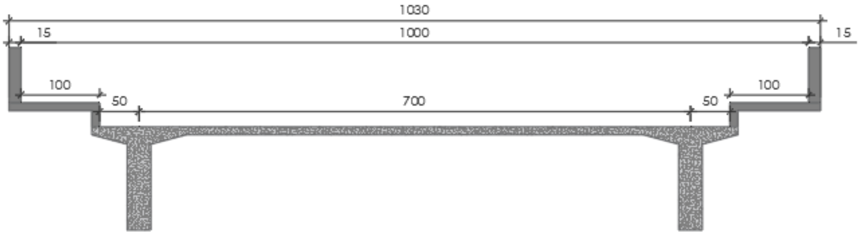
6.1.2. Tabuleiro 10,00 m

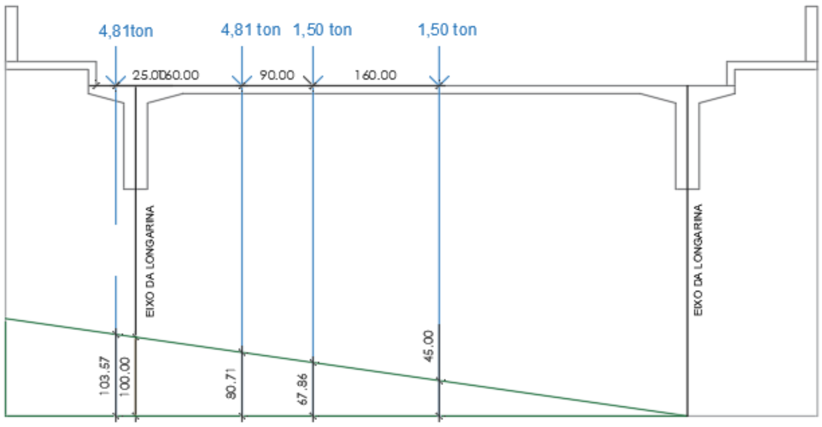




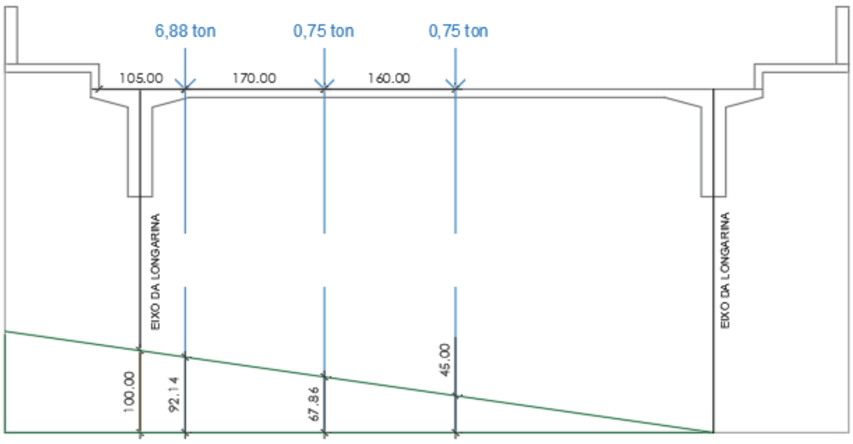

6,88 ton
0,75 ton
0,75 ton
105.00
170.00
160.00
EIXO DA LONGARINA
EIXO DA LONGARINA
105,45
100.00
74,55
45,45
RODAS DIANTEIRAS = 6,88 x 1,0545 + 0,75 x (0,7455 + 0,4545) = 8,15 ton
0,5 ton/m
EIXO DA LONGARINA
EIXO DA LONGARINA
100.00
5,2509
MULTIDÃO 1 = 0,5 x 5,2509 = 2,63 ton/m
11,94 ton/m
8,15 ton/m
2,63 ton/m
2,63 ton/m
2,63 ton/m
300.00

6.1.3. Tabuleiro 10,30 m

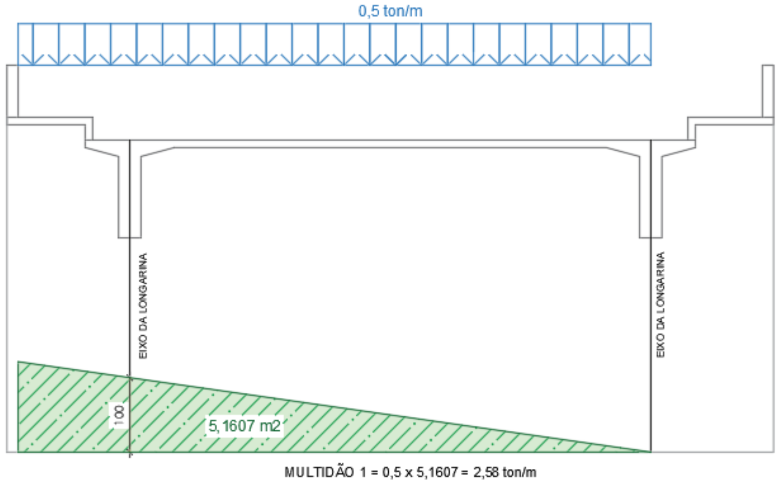


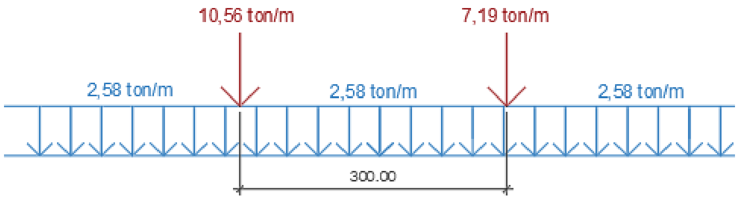


RODAS TRASEIRAS = 4,81 x (1,0357 + 0,8071) + 1,50 x (0,6786 + 0,4500) = 10,56 ton



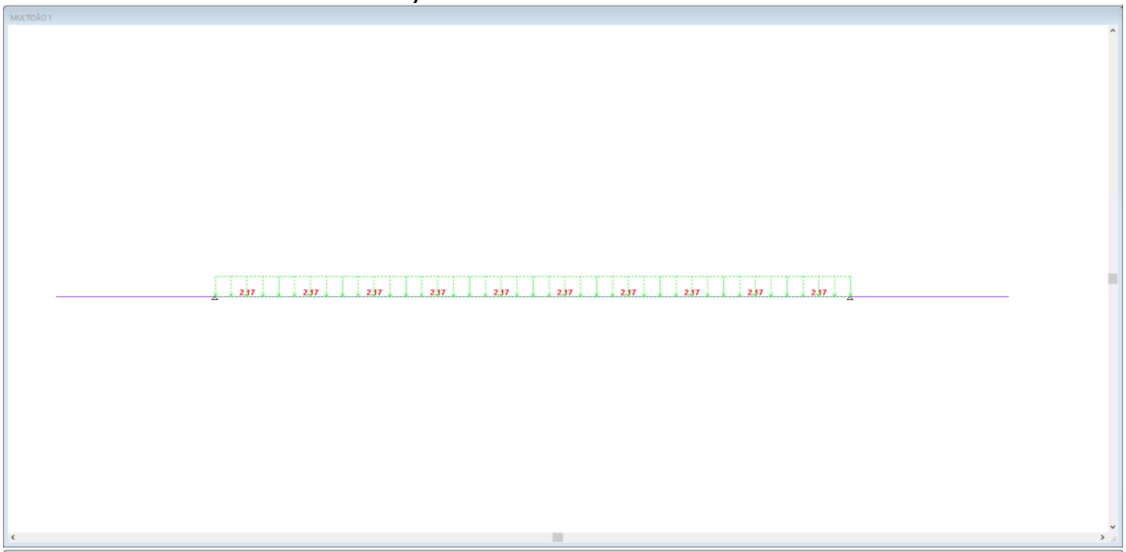
RODAS DIANTEIRAS = 6,88 x 0,9214 + 0,75 x (0,6786+ 0,4500) = 7,19 ton

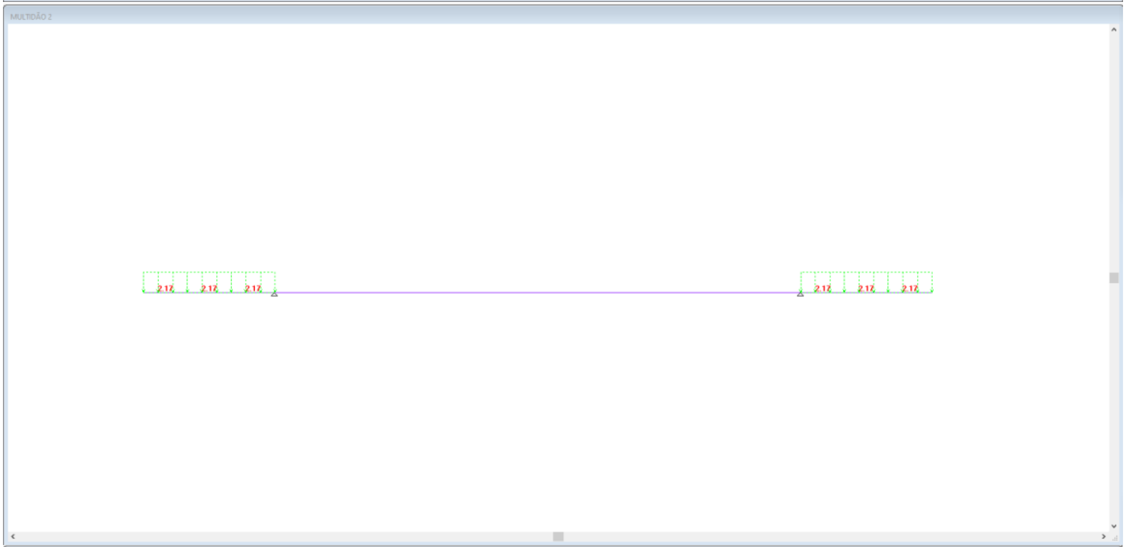

0,5 ton/m
EIXO DA LONGARINA
EIXO DA LONGARINA
1.00
5,1607 m2
MULTIDÃO 1 = 0,5 x 5,1607 = 2,58 ton/m

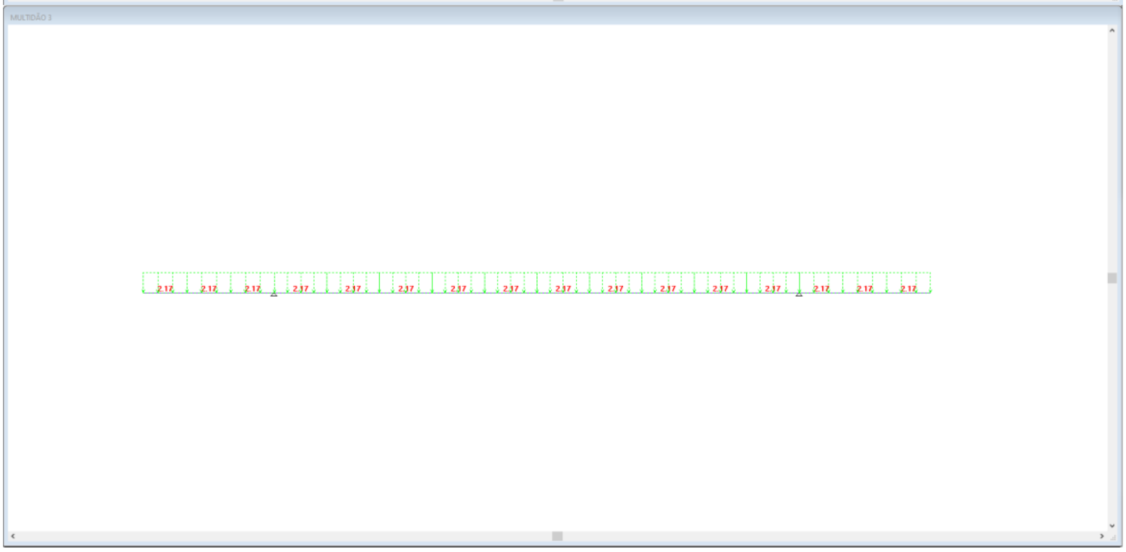

10,56 ton/m
7,19 ton/m
2,58 ton/m
2,58 ton/m
2,58 ton/m
300.00

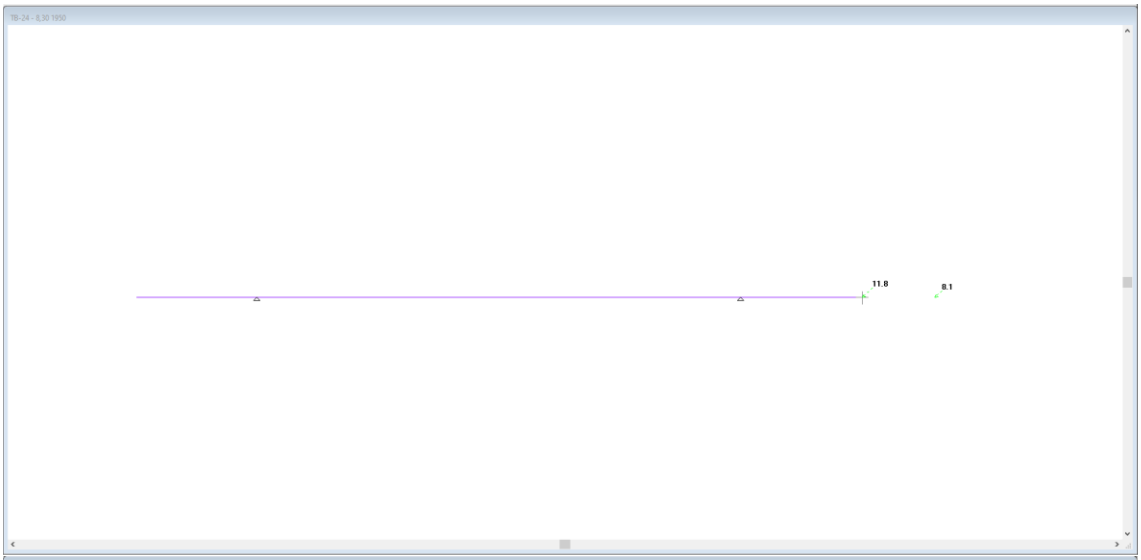
6.2. Cargas acidentais – (TB-24 e Guindaste) – Momentos e cortantes

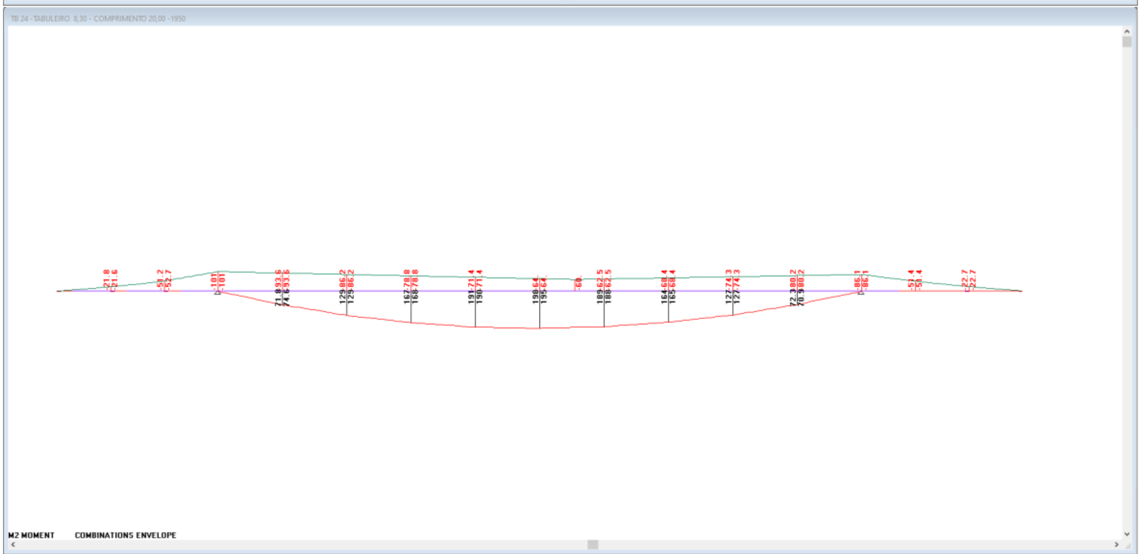
6.2.1. Tabuleiro 8,30 m

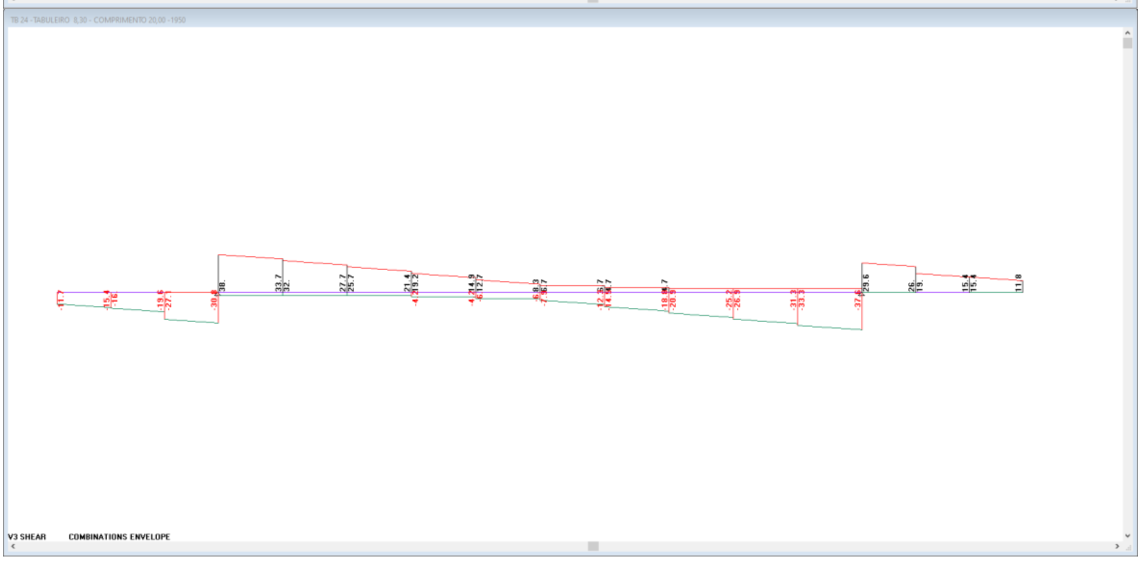


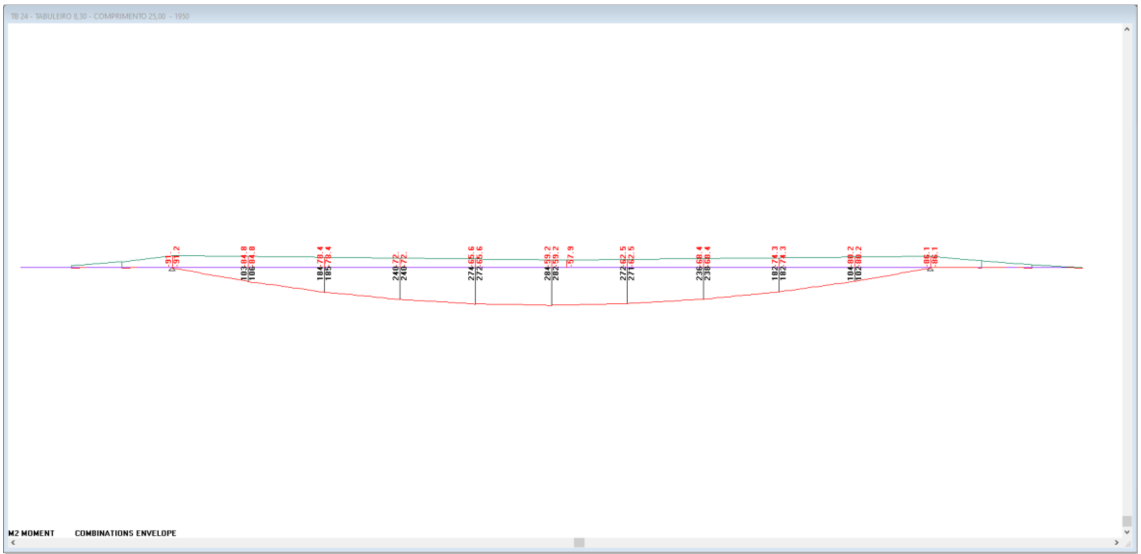


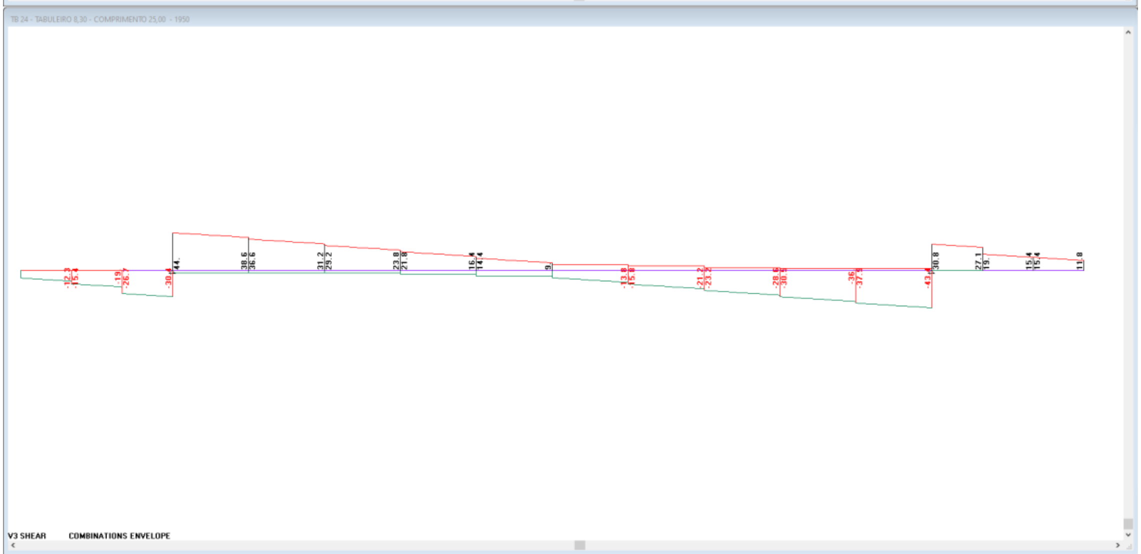


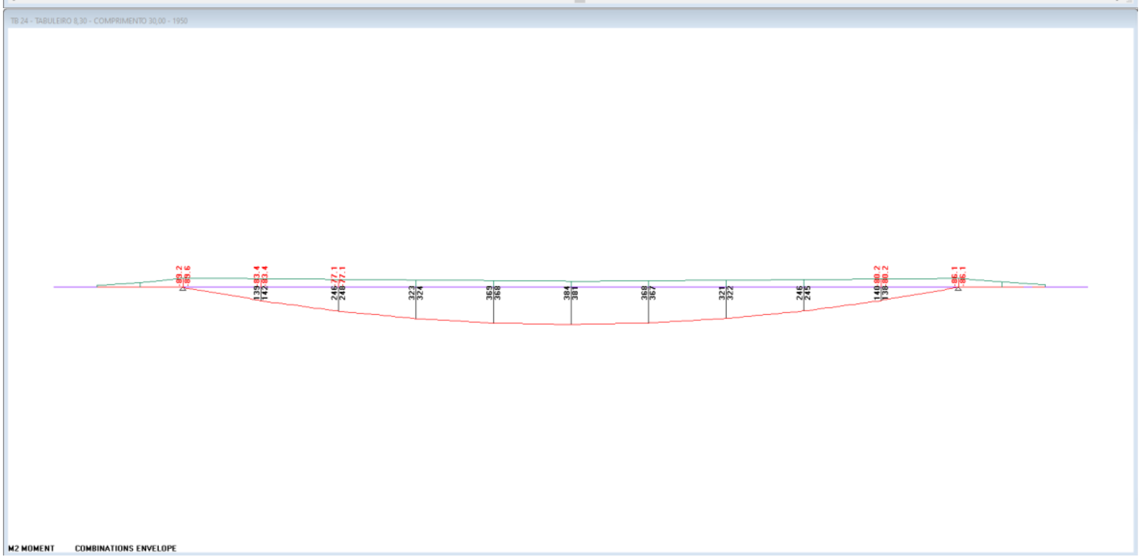


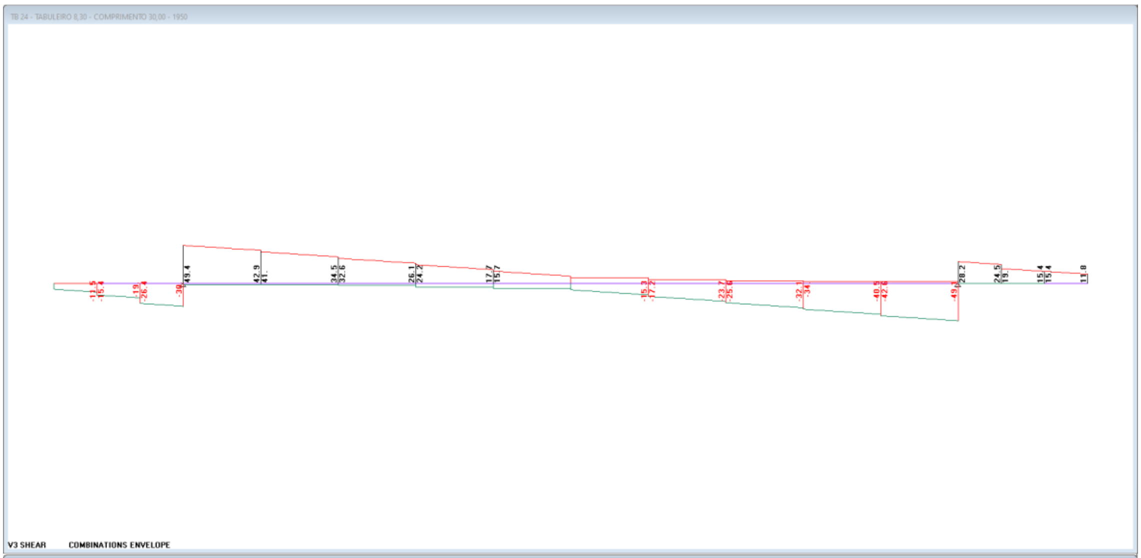

M2 MOMENT
COMBINATIONS ENVELOPE

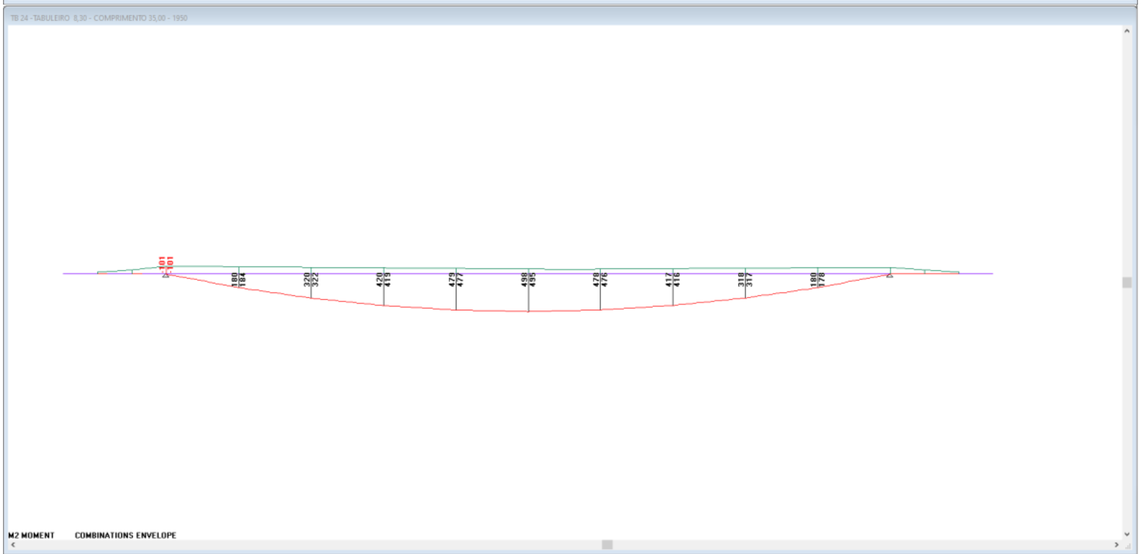

V3 SHEAR
COMBINATIONS ENVELOPE

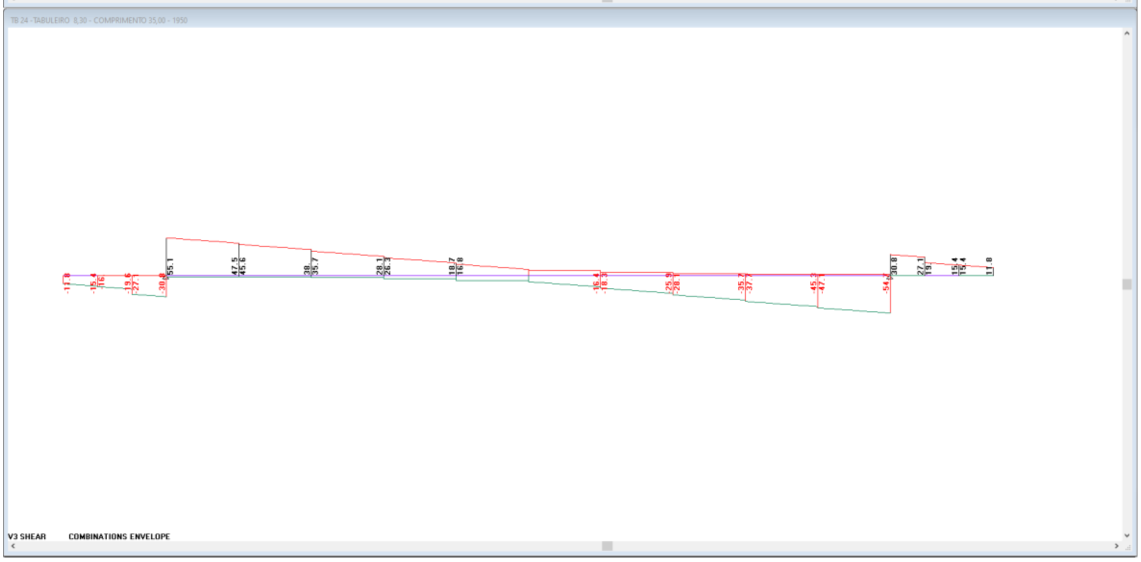

M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE

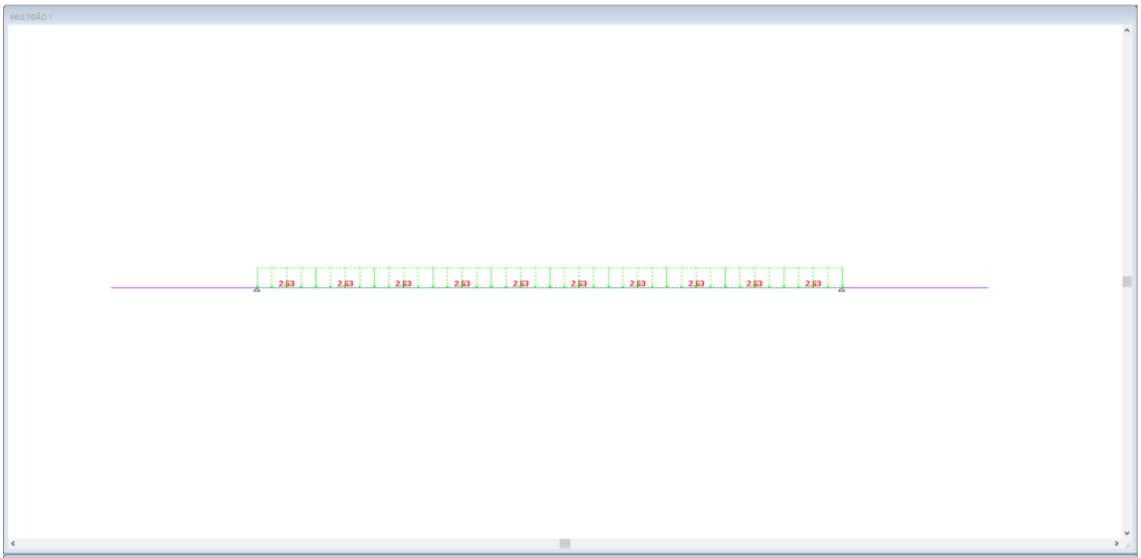

M2 MOMENT
COMBINATIONS ENVELOPE

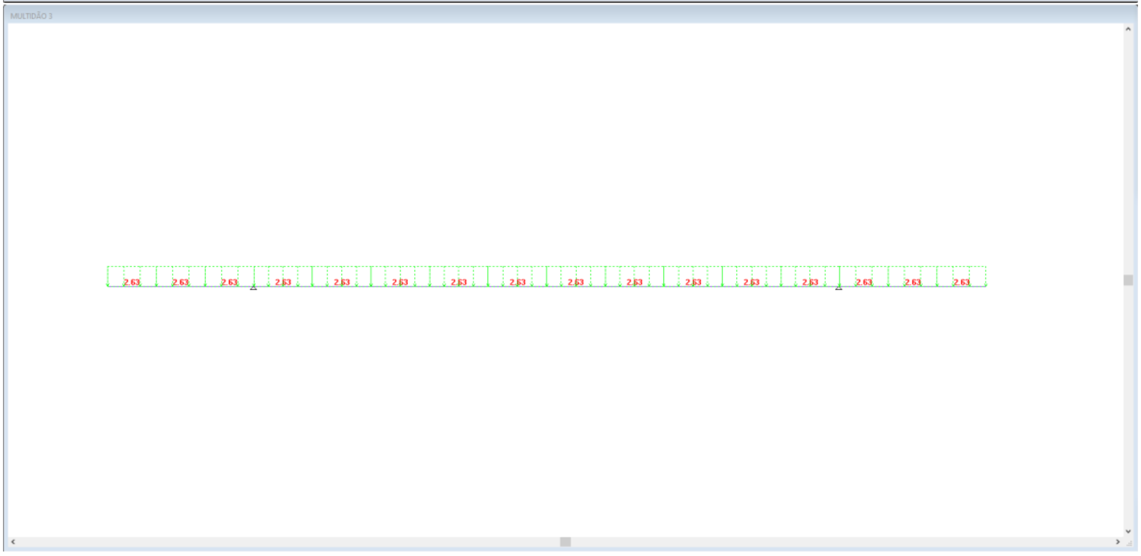

V3 SHEAR
COMBINATIONS ENVELOPE

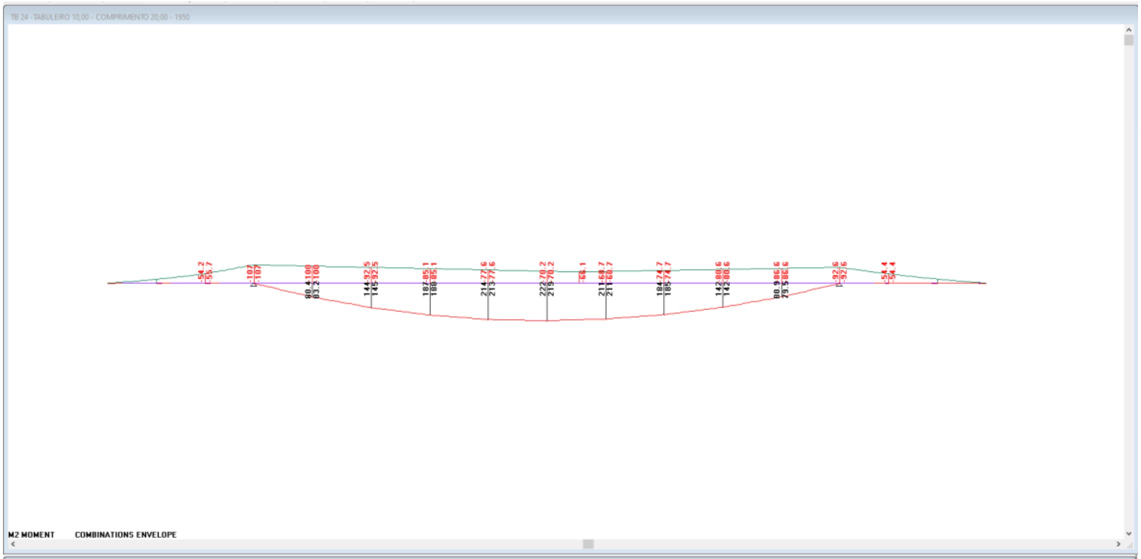

M2 MOMENT
COMBINATIONS ENVELOPE

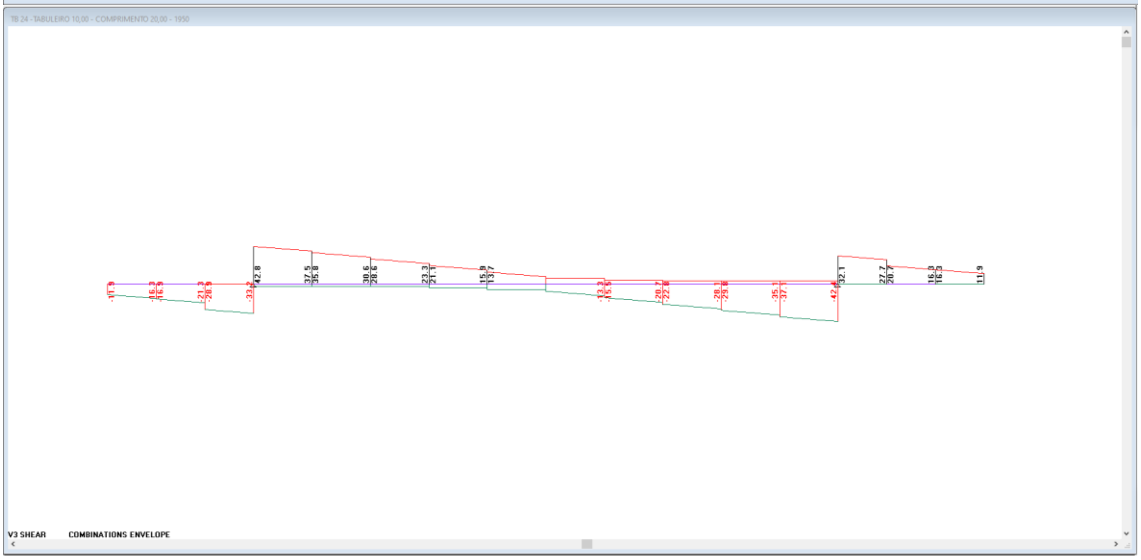

V3 SHEAR
COMBINATIONS ENVELOPE

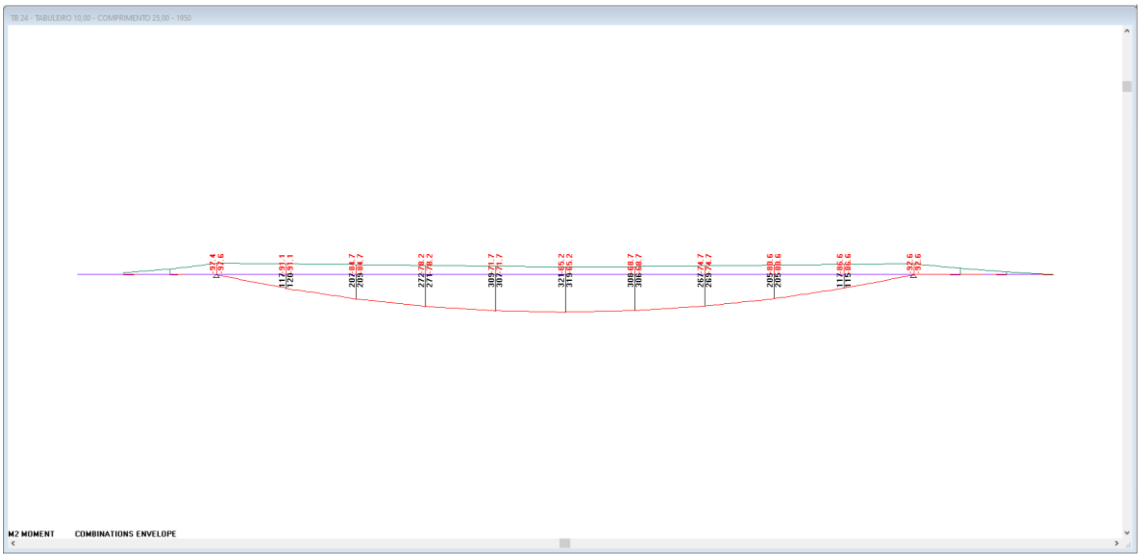
6.2.2. Tabuleiro 10,00 m

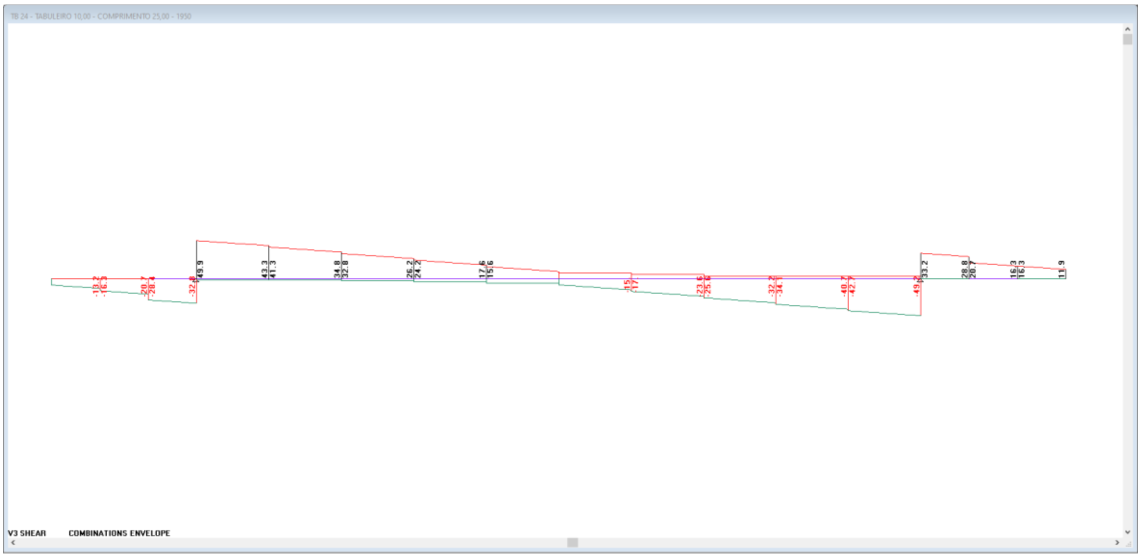




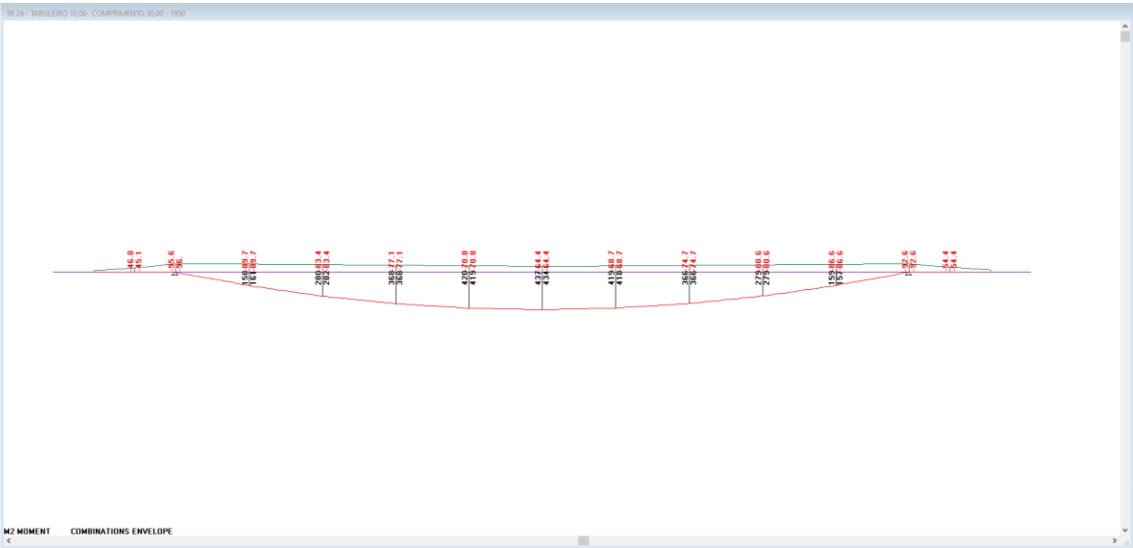

M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE

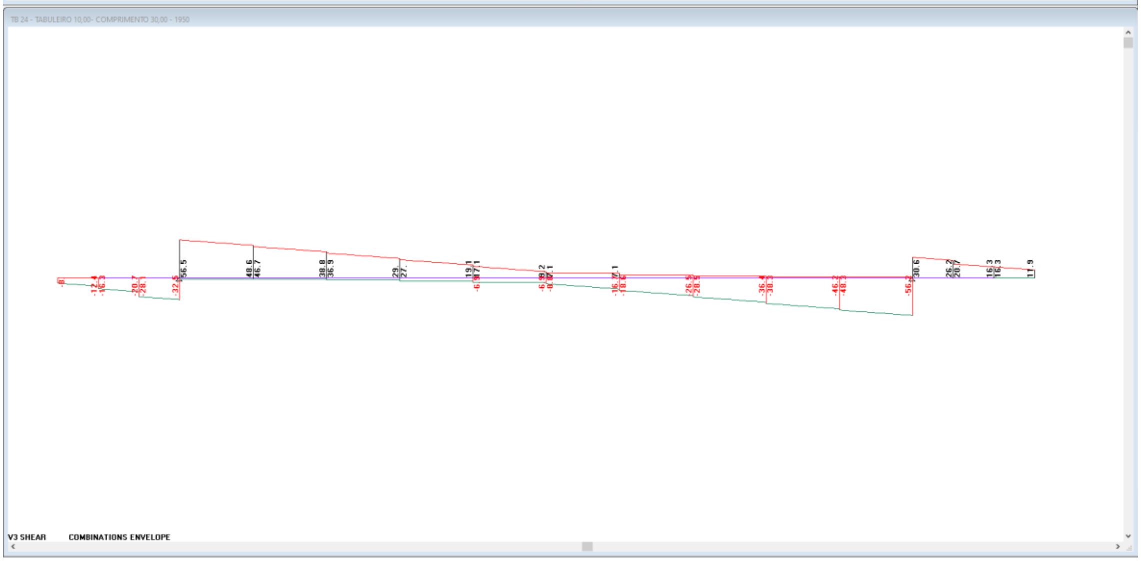

M2 MOMENT
COMBINATIONS ENVELOPE



TB 24 - TABULEIRO 10,00 - COMPRIMENTO 25,00 - 1950
V3 SHEAR COMBINATIONS ENVELOPE



TB 24 - TABULEIRO 10,00- COMPRIMENTO 30,00 - 1950
M2 MOMENT COMBINATIONS ENVELOPE



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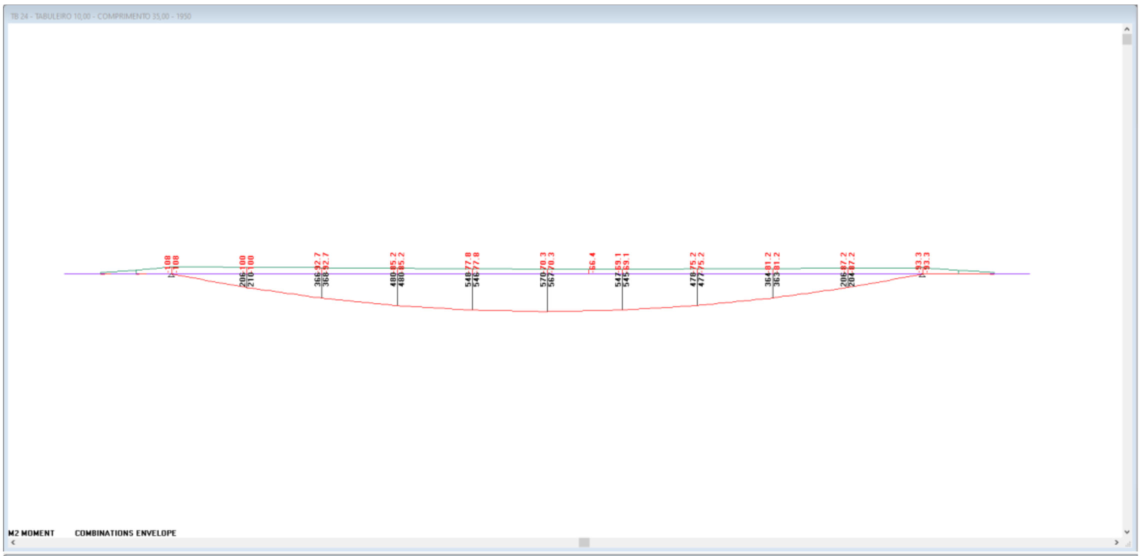
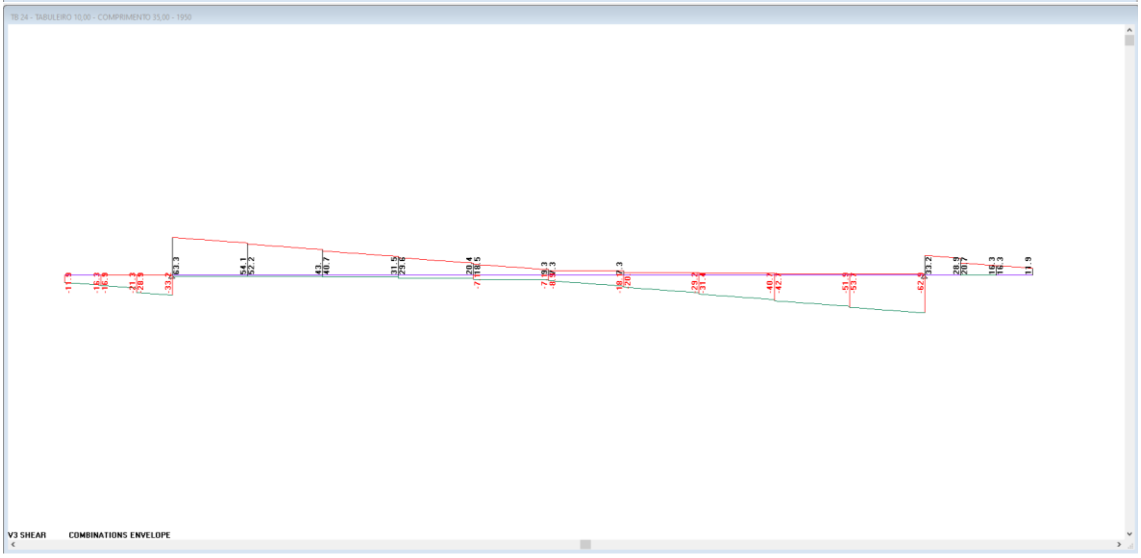
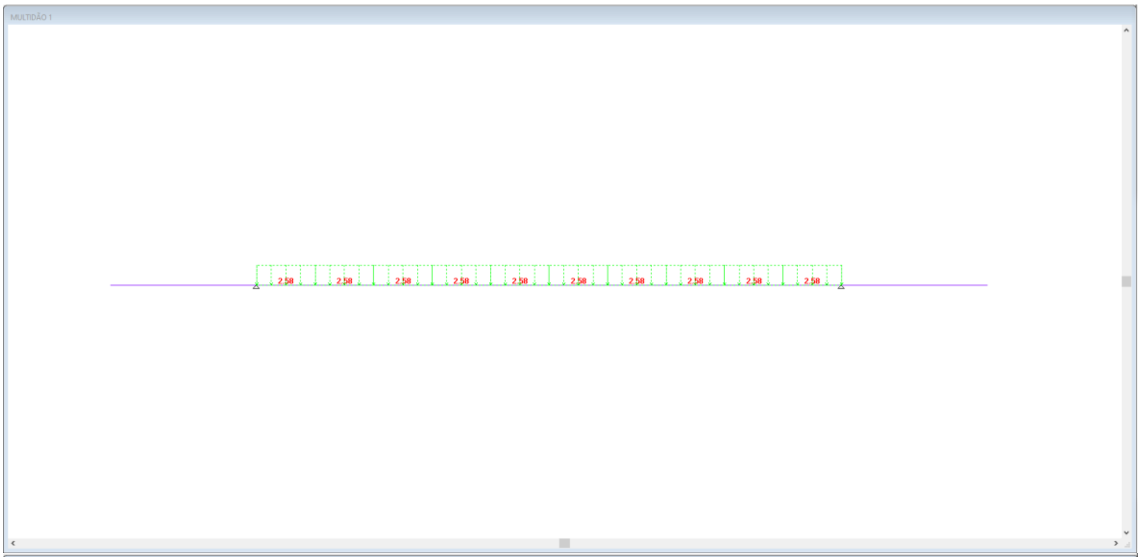
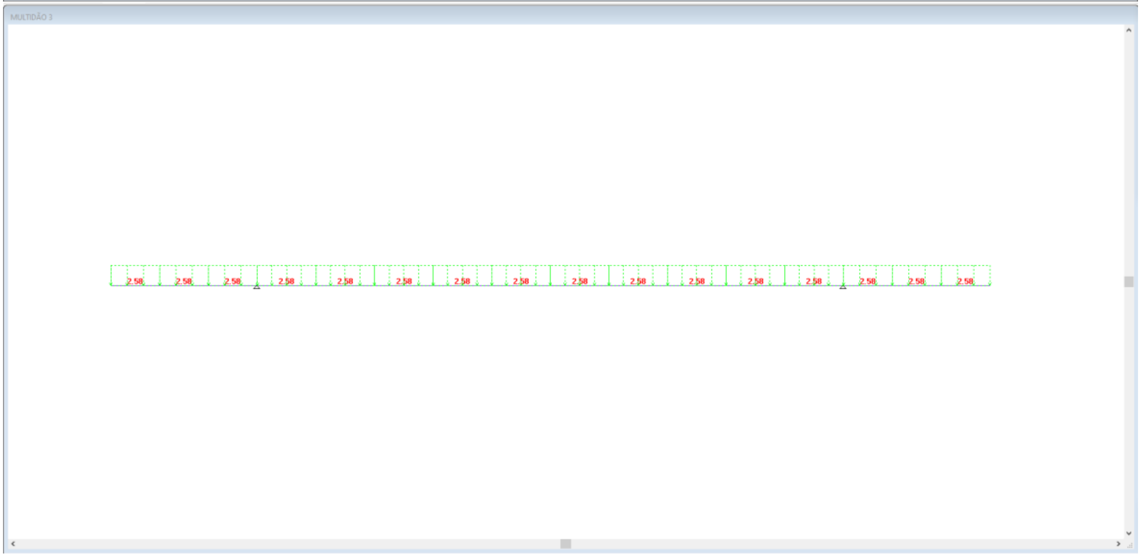
V3 SHEAR COMBINATIONS ENVELOPE

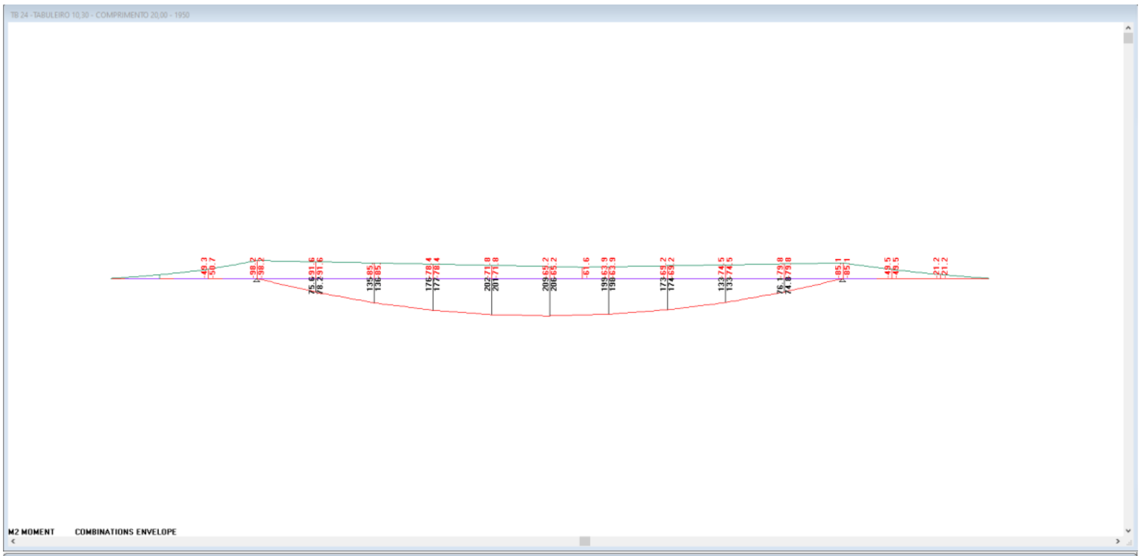

TB 24 - TABULEIRO 10,00 - COMPRIMENTO 35,00 - 1950
M2 MOMENT
COMBINATIONS ENVELOPE

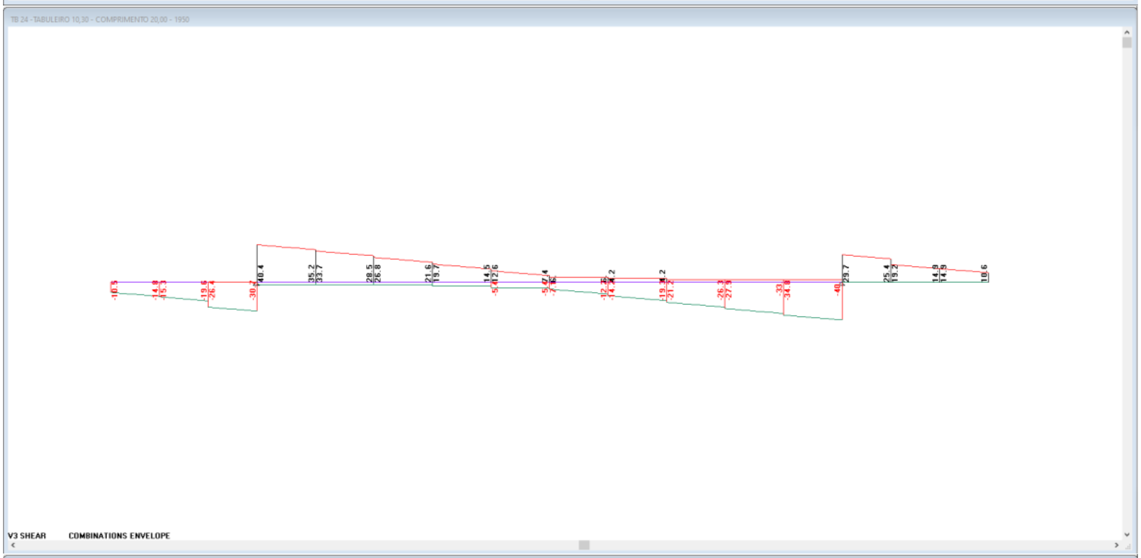

TB 24 - TABULEIRO 10,00 - COMPRIMENTO 35,00 - 1950
V3 SHEAR
COMBINATIONS ENVELOPE

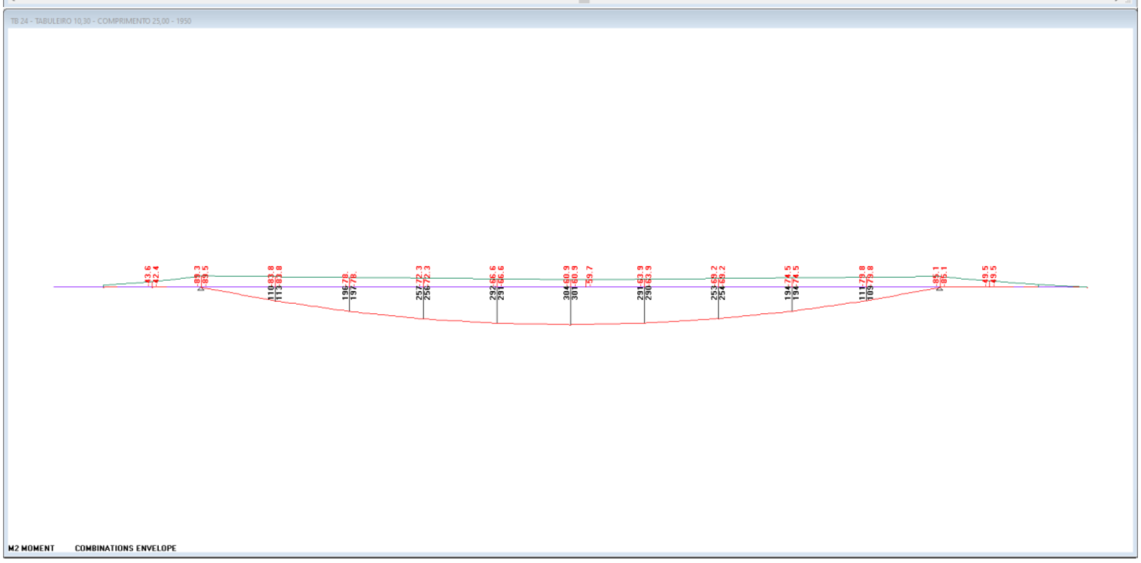
6.2.3. Tabuleiro 10,30 m

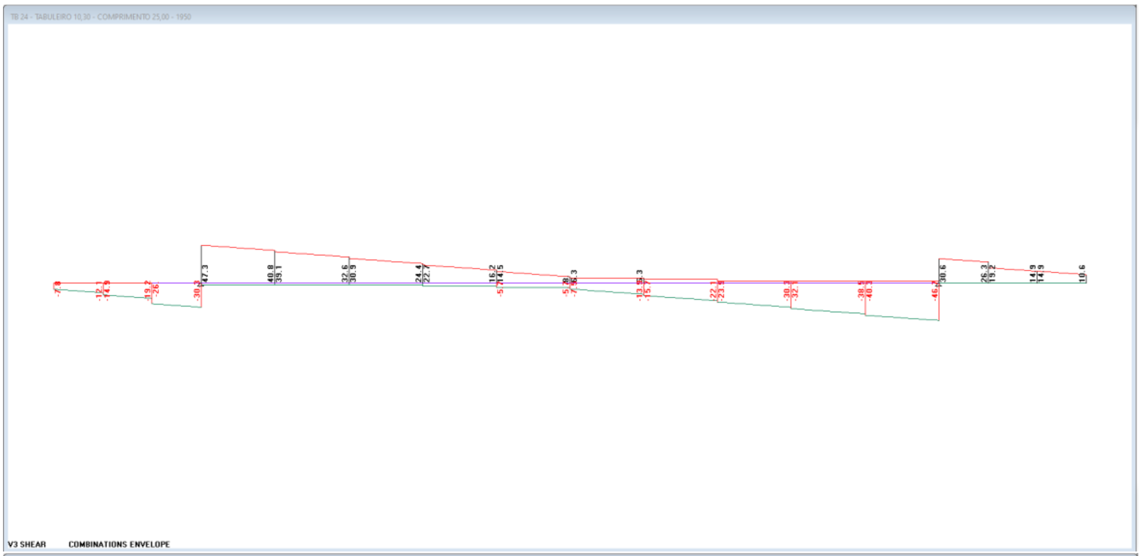


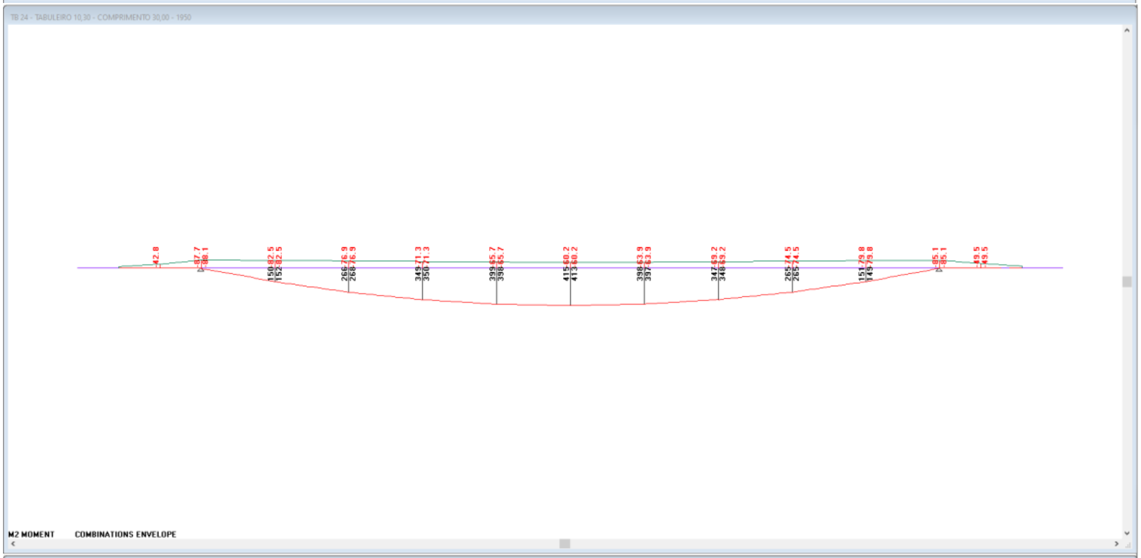


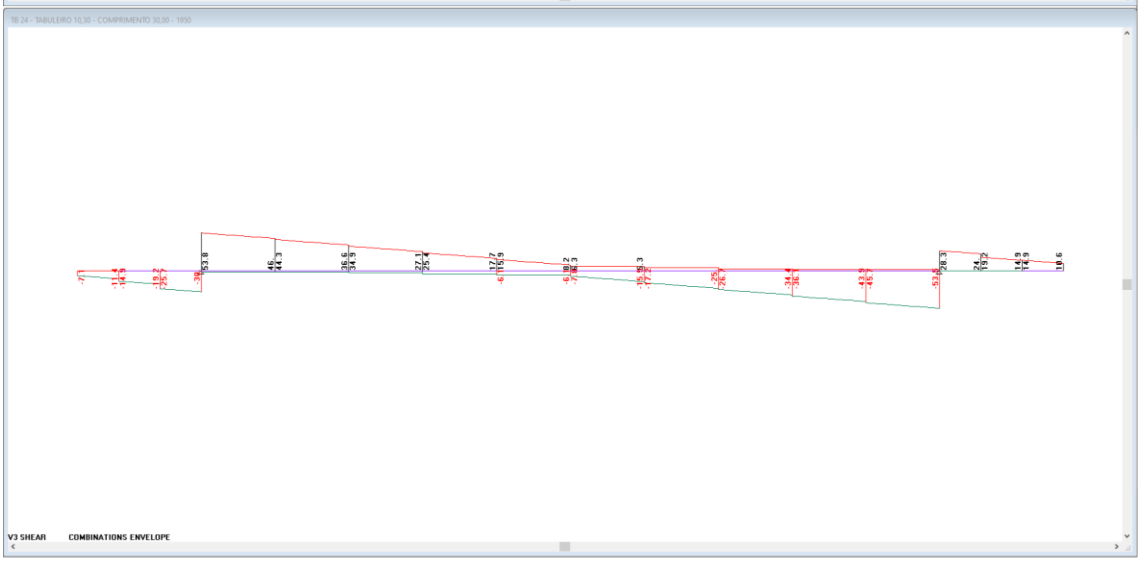

TB 24 - TABULEIRO 10,30 - COMPRIMENTO 20,00 - 1950
M2 MOMENT COMBINATIONS ENVELOPE

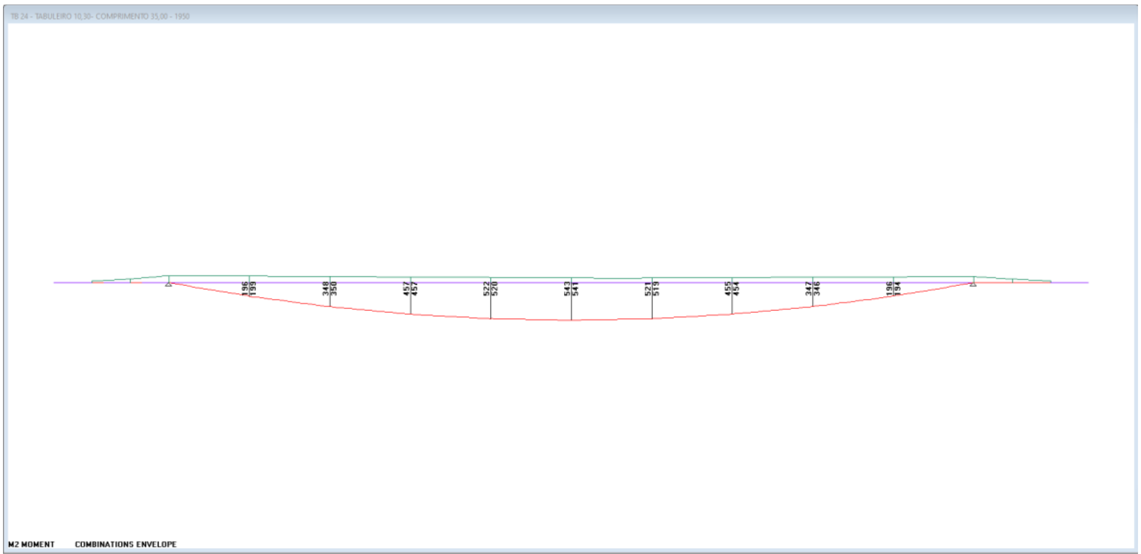

TB 24 - TABULEIRO 10,30 - COMPRIMENTO 20,00 - 1950
V3 SHEAR COMBINATIONS ENVELOPE

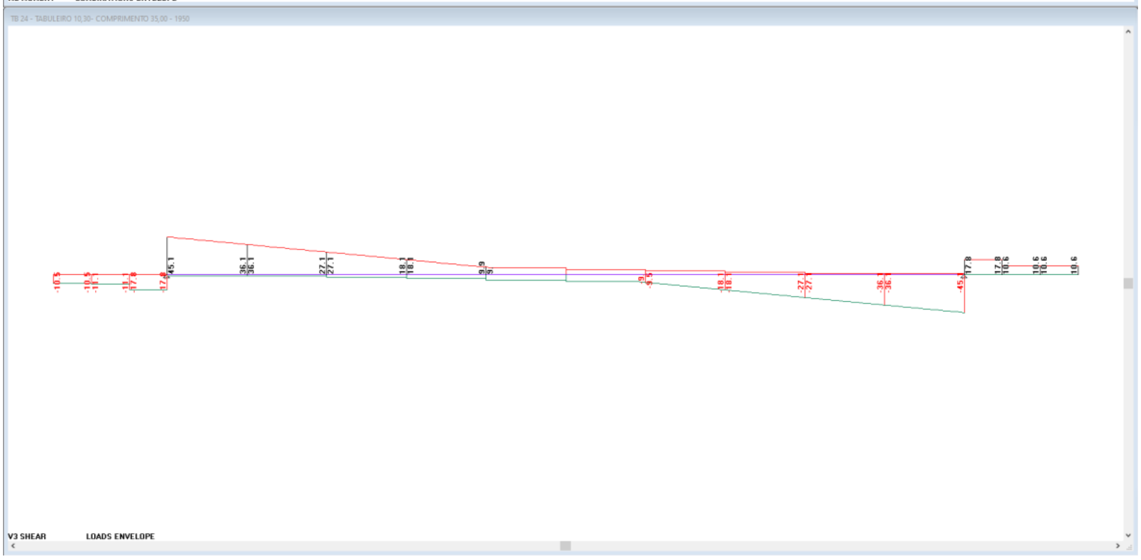

TB 24 - TABULEIRO 10,30 - COMPRIMENTO 25,00 - 1950
M2 MOMENT COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
COMBINATIONS ENVELOPE


M2 MOMENT
COMBINATIONS ENVELOPE


V3 SHEAR
LOADS ENVELOPE

6.3. Resultados

6.3.1. Cálculo do CS (Coeficiente de Segurança)

CIV DO LIEBHERR		COMPRIMENTO			
		20	25	30	35
P/ VÃO ->	$\varphi = 1{,}00 + 1{,}06 \times \left(\frac{20}{L+50}\right)$	1,30	1,28	1,27	1,25
P/ BAL ->	$\varphi = 1{,}00 + 1{,}06 \times \left(\frac{20}{5+50}\right)$	1,39	1,39	1,39	1,39

TB-24

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
M(+) (tonxm)	195	284	384	499
M(-) (tonxm)	101	101	101	101
Ve (tonxm)	30,8	30,8	30,8	30,8
Vd (tonxm)	38	44	49,4	55,1

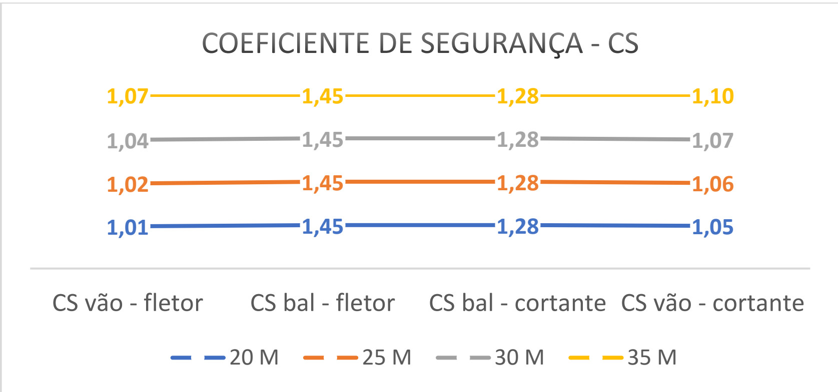
LIEBHERR

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
M(+) (tonxm)	295	430	578	740
M(-) (tonxm)	100	100	100	100
Ve (tonxm)	34,4	34,4	34,4	34,4
Vd (tonxm)	55,1	64,3	72,3	79,5

$$CS = \frac{1{,}20 \times 1{,}40 \times 1{,}30 \times M_{q\,TB-24}}{1{,}10 \times CIV_{vão/bal} \times M_{q\,Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
8,30 x	20	25	30	35
CS vão - fletor	1,01	1,02	1,04	1,07
CS bal - fletor	1,45	1,45	1,45	1,45
CS bal - cortante	1,28	1,28	1,28	1,28
CS vão - cortante	1,05	1,06	1,07	1,10



TB-24

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
M(+) (tonxm)	222	319	437	570
M(-) (tonxm)	108	108	108	108
Ve (tonxm)	33,2	33,2	33,2	33,2
Vd (tonxm)	42,8	49,9	56,5	63,3

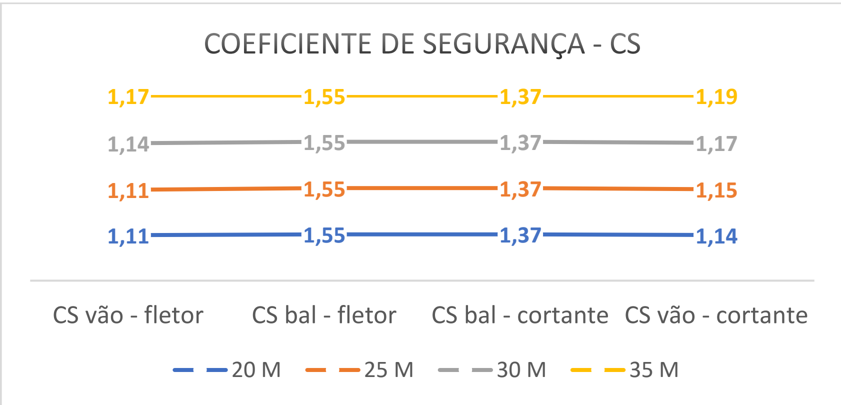
LIEBHERR

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
M(+) (tonxm)	304	445	603	776
M(-) (tonxm)	100	100	100	100
Ve (tonxm)	34,8	34,8	34,8	34,8
Vd (tonxm)	57	67,1	76	84,5

$$CS = \frac{1{,}68 \times CIV \times M_{q\,TB-24}}{1{,}10 \times CIV \times M_{q\,Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
10,00 x	20	25	30	35
CS vão - fletor	1,11	1,11	1,14	1,17
CS bal - fletor	1,55	1,55	1,55	1,55
CS bal - cortante	1,37	1,37	1,37	1,37
CS vão - cortante	1,14	1,15	1,17	1,19



TB-24

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
M(+) (tonxm)	209	304	415	543
M(-) (tonxm)	98,4	98,4	98,4	98,4
Ve (tonxm)	30,7	30,7	30,7	30,7
Vd (tonxm)	40,4	47,3	53,8	60,4

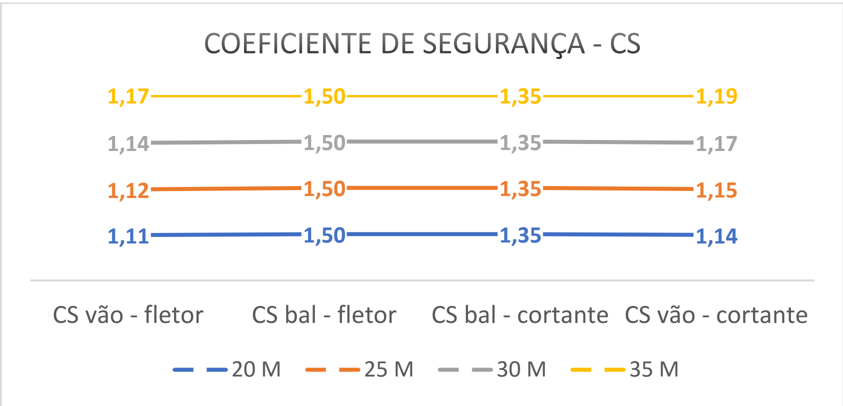
LIEBHERR

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
M(+) (tonxm)	287	421	572	740
M(-) (tonxm)	94,2	94,2	94,2	94,2
Ve (tonxm)	32,7	32,7	32,7	32,7
Vd (tonxm)	54	63,6	72,3	80,4

$$CS = \frac{1{,}68 \times CIV \times M_{q\ TB-24}}{1{,}10 \times CIV \times M_{q\ Liebherr}}$$

COEFICIENTE DE SEGURANÇA

LARGURA	COMPRIMENTO			
10,30 x	20	25	30	35
CS vão - fletor	1,11	1,12	1,14	1,17
CS bal - fletor	1,50	1,50	1,50	1,50
CS bal - cortante	1,35	1,35	1,35	1,35
CS vão - cortante	1,14	1,15	1,17	1,19



6.3.2. Considerações para o TB-24 (1950 a 1960)

Os coeficientes de segurança tiveram resultados superiores a 1, portanto a passagem do guindaste de 8 eixos e 96 toneladas está liberada.

7. CONCLUSÃO E CRITÉRIOS

Fica liberada a passagem de guindastes de 7 e 8 eixos para obras verificadas a partir do veículo padrão **TB-24**, desde que pertençam à Classe I (pontes situadas em estradas tronco federais e estaduais ou nas estradas de ligação principais entre esses troncos) e tenham um tabuleiro de no mínimo 8,30 x 20,00 metros. Para essa condição de tabuleiros o tamanho mínimo do guindaste é de 3,00 metros de largura por 19,00 metros de comprimento. Guindastes com dimensões menores podem passar desde que a capacidade não seja maior do que 96 t.

Para obras verificadas a partir do veículo padrão **TB-36**, pode-se adotar o mesmo critério de comprimento e largura da ponte.

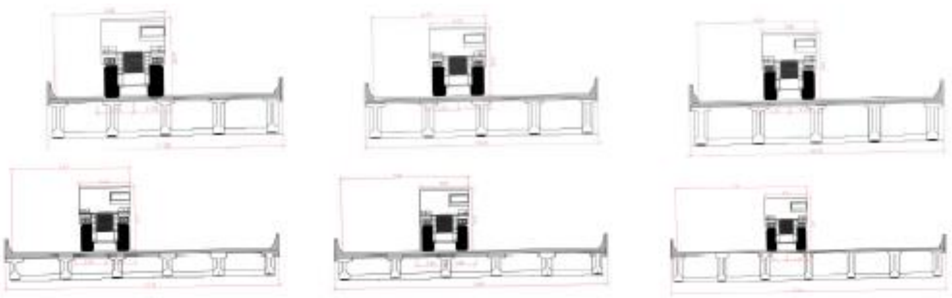
Para ambos **(TB-36 e TB-24)** a passagem dos guindastes supra, deve seguir os mesmos critérios, conforme segue abaixo:

- Realizar vistorias anuais em todos as obras do roteiro com relatório conclusivo da data de construção da obra, largura e comprimento dos tabuleiros e estado geral da OAE, que deve estar classificada com, no mínimo, a nota 3 no requisito durabilidade e estrutural da NBR 9452:2023 – Inspeção de pontes, viadutos e passarelas – Procedimento.

CLASSFICAÇÃO (NOTA)	CONDIÇÃO	ESTRUTURAL	FUNCIONAL	DURABILIDADE
5	Excelente	A estrutura se encontra em condições satisfatórias, apresentando defeitos irrelevantes e isolados	A OAE apresenta segurança e conforto aos usuários	A OAE se encontra em condições satisfatórias, apresentando defeitos irrelevantes e isolados
4	Boa	A estrutura apresenta danos de baixa gravidade, localizados e em pequenas áreas, sem comprometer a segurança estrutural	A OAE apresenta pequenos danos que não chegam a causar desconforto ou insegurança ao usuário	A OAE apresenta pequenas e poucas anomalias, que não comprometem sua vida útil, em região de baixa agressividade ambiental
3	Regular	Há danos que pode vir a gerar alguma deficiência estrutural, mas não há sinais de comprometimento da estabilidade da obra. Recomenda-se acompanhamento dos problemas	A OAE apresenta desconforto ao usuário, com defeitos que requerem ações	A OAE apresenta anomalias de moderada gravidade, que comprometem sua vida útil, em região de moderada a alta agressividade ambiental A OAE apresenta de moderada a muitas anomalias, que comprometem sua vida útil, em região de baixa agressividade ambiental

CLASSFICAÇÃO (NOTA)	CONDIÇÃO	ESTRUTURAL	FUNCIONAL	DURABILIDADE
2	Ruim	Há danos comprometendo a segurança estrutural da OAE sem aparente risco iminente de colapso. Sua evolução pode levar ao colapso estrutural. A OAE necessita de intervenções significativas	A OAE possui funcionalidade visivelmente comprometida, com riscos de segurança ao usuário	A OAE apresenta de moderadas a muitas anomalias, que comprometem sua vida útil, em região de alta agressividade ambiental A OAE apresenta muitas anomalias, que comprometem sua vida útil, em região de baixa agressividade ambiental
1	Crítica	Há danos gerando grave insuficiência estrutural na OAE. Há elementos estruturais em estado crítico, com risco tangível de colapso estrutural localizado. A OAE necessita de intervenção imediata, podendo ser necessária restrição de carga, interdição parcial, escoramento provisório, instrumentação, associada ou não	A OAE apresenta condições funcionais limitadas de utilização	A OAE se encontra em elevado grau de deterioração, em regiões localizada, apontando problema já de risco estrutural e/ou funcional, requerendo intervenção imediata, podendo ser necessárias restrição de carga e interdição parcial ao tráfego
0	Emergencial	Há elementos estruturais principais colapsados, evoluindo para instabilidade da estrutura. É necessária a interdição total, até que haja avaliação e reclassificação por consultoria especializada ou intervenção	A OAE não apresenta condições funcionais de utilização. A OAE deve ser interditada	A OAE se encontra em elevado grau de deterioração, gerando grave insuficiência estrutural e/ou funcional, requerendo intervenção emergencial e interdição total

- **Velocidade constante do guindaste:** Isto irá evitar forças dinâmicas causadas por acelerações ou frenagens repentinas que maximizam os esforços nas estruturas de suporte do tabuleiro.
- **Evitar comboio com CVC (Combinação de Veículos de Carga):** Isso é importante para evitar a sobrecarga estrutural devido à presença simultânea de múltiplas cargas pesadas. Esperar até que o CVC saia antes de o guindaste entrar na OAE assegura que a carga sobre o tabuleiro seja conforme a viabilização, sem exceder os limites de esforços previstos.
- **Navegação deverá ser na pista adjacente ao eixo do lado carroçável:** Seguir estritamente o caminho para o qual os cálculos foram realizados é fundamental para garantir que a distribuição de carga no tabuleiro corresponda exatamente ao esperado. Desvios do trajeto calculado podem resultar em riscos à estrutura, situações que não foram consideradas nos cálculos.



- **Respeitar o afastamento necessário:** Manter um espaço claro de 0,40 m nas laterais e 0,50 m na frente e atrás do guindaste, não só ajuda a evitar colisões, mas também garante que o guindaste tenha espaço suficiente para operações seguras e eficazes, permitindo manobras em caso de emergência.
- **Operador de guindaste credenciado e instruído:** A operação de guindastes por motoristas treinados e certificados é vital. A adesão às normas de segurança e às melhores práticas operacionais por parte de operadores qualificados reduz significativamente o risco de acidentes. O operador do guindaste deverá seguir as recomendações de operação, integralmente.

Dessa forma, considera-se segura a passagem dos guindastes, desde que atendidas as condições aqui estabelecidas. Ressalta-se que o estudo foi desenvolvido com base em um guindaste de 8 eixos, com carga total de 96 tf (12 tf por eixo), estendendo-se, por compatibilidade de carregamento, à operação de guindastes de 7 eixos (84 tf), desde que igualmente respeitados os limites de carga por eixo e condições operacionais previstas.

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