	PREP'D		
	CHK'D		
	APP'D		

DESIGN NOTE

INTERMEDIATE SLAB

CHECK FOR SCAFFOLDING LOADS

REV.	DATE	PAGE	DESCRIPTION	PREP'D	CHK'D	APP'D

<div style="border:1px solid black; text-align:center;">

Intermediate slab

Check for scaffolding loads

xxxxx Design Department
CALC. NOTE No xxxxxxx

</div>

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1. Drawings
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<div style="border: 1px solid black;">

Intermediate slab
Check for scaffolding loads
xxxxx Design Department
CALC. NOTE No xxxxxxx

</div>

1 GENERAL

1.1 Introduction and scope of document

In the present note the Intermediate Slab capacity is evaluated, in order to support on it the scaffolding for the top slab.

2 REFERENCE DOCUMENTS

The design calculations are based on the following codes of practice and other references:

BS8110   Structural use of concrete - Part 1: 1997

3 EXECUTIVE SUMMARY

One of the main assumptions of the calculation is that during the casting and until the hardening of the concrete of the top slab, it is considered that the scaffolding under the intermediate slab will not be removed. However, before the casting of roof slab is done, the intermediate slab scaffolding has to be un-propped and re-propped (plywood is removed) without tensioning vertical supports. For the calculation of the actual bending moment in different sections of the slab a two stage analysis is done. In the first stage, when the formwork is un-propped the slab is allowed to support its own selfweight. In the second stage the lower formwork is put back in contact with the slab, and the loads coming from the top slab casting are divided between the intermediate slab and its formwork, according to specific rigidities. In the table below, actual bending moments in the slab are compared with the slab bending moment capacity. For detailed calculation see Sections 8 and 9 and Annexes 2 and 3.

Max. bending moments	Stage 1	Stage 2	Total	Slab capacity
At support (mxD+)	150 kN*m	300 kN*m	450 kN*m	788.55kN*m
At support (myD+)	180 kN*m	385 kN*m	565 kN*m	788.55kN*m
Midspan (mxD-)	90 kN*m	180 kN*m	270 kN*m	788.55kN*m
Midspan (myD-)	80 kN*m	150 kN*m	230 kN*m	788.55kN*m

The loads transferred to the scaffolding below the intermediate slab are not larger than 32 kN / vertical (SLS). Values presented in Annex 2 pages 16 and 24.

Shear capacity

Maximum punching shear stress at vertical support   **0.018 N/mm²**

Maximum shear stress near perimetral wall   **0.741 N/mm²**

Section shear stress capacity   **0.832 N/mm²**

Calculation in Annex 4.

Slab deflections are less than 7 mm (2.4 mm - Stage 1; 4.2 mm - Stage 2) – see Annex 2 pages 34 and 35.

Intermediate slab
Intermediate slab
Check for scaffolding loads
xxxxx Design Department
CALC. NOTE No xxxxxxx

4   STRUCTURE DESCRIPTION

The analyzed typical structure is in accordance with the drawings:

DWG No.	Sheets	Rev	Date	Title
	1	B		xxxxxxxx base slab – Concrete details
	1 - 5	G		xxxxxxxxxxxxxx walls – Concrete details
	1	0		xxxxxxxxx roof slab – Concrete details
	1 - 8	B		xxxxxxxxxxx intermediate slab – Reinforcement
	1 - 13	C		xxxxx– Slab formwork

The 500 mm thick intermediate slab is supported by 4 exterior walls (on the perimeter) and an interior one (Wall 5) as shown in the figure on the next page. Layout and position for openings are also presented. The slab is reinforced with T25 spaced at 100mm, both ways, top and down.

Two situations are analyzed (separate analysis model for each), one with the intermediate slab self supported (verticals of the framework are de-propped), the other with the verticals re-propped, acting as spring supports (verticals are de-propped and re-propped to allow the intermediate slab to take its own self weight).

PLAN VIEW (AT +2.91 DMD)

SCALE 1:75

Slab Layout
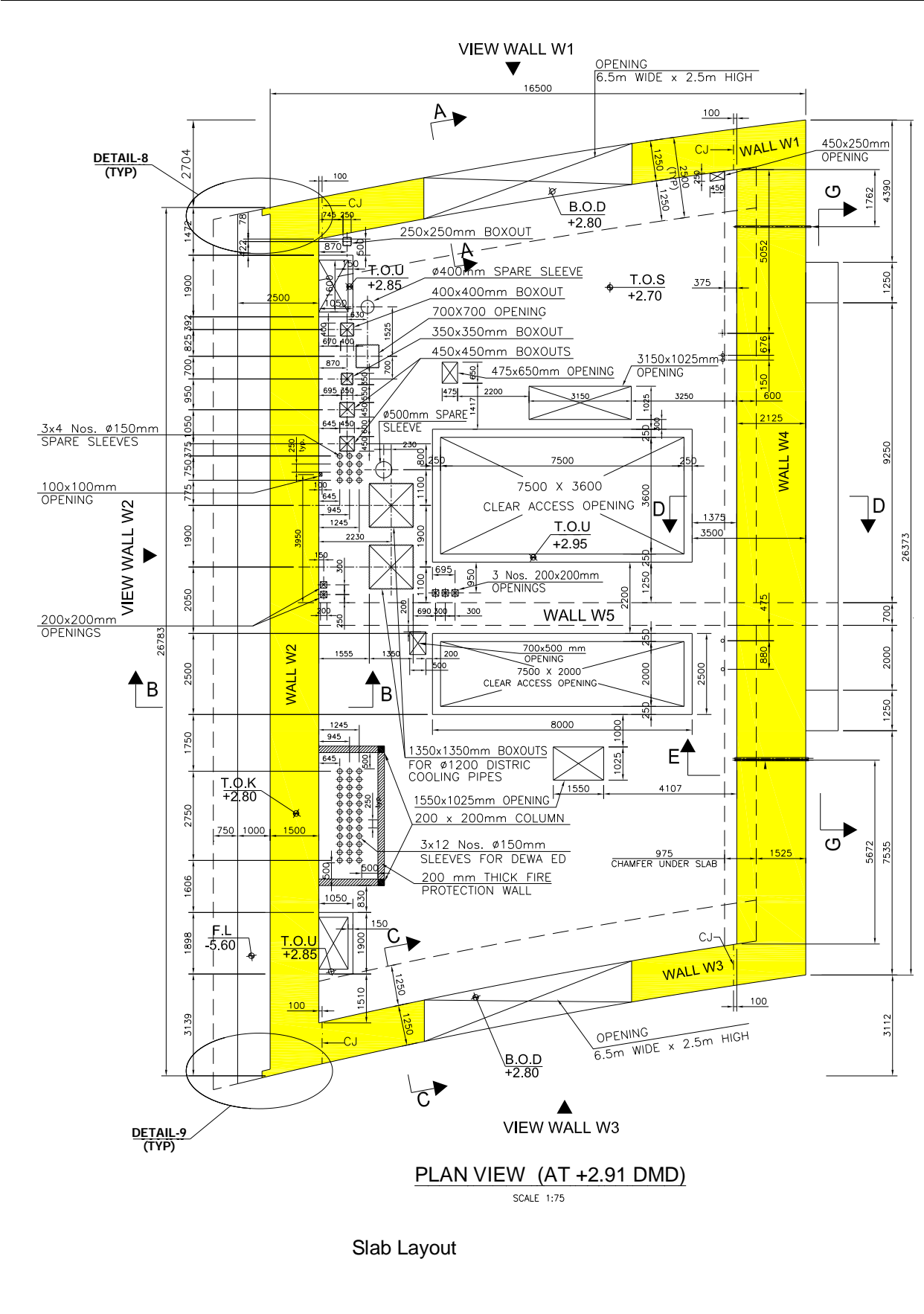
Formwork supporting slab

Plan view
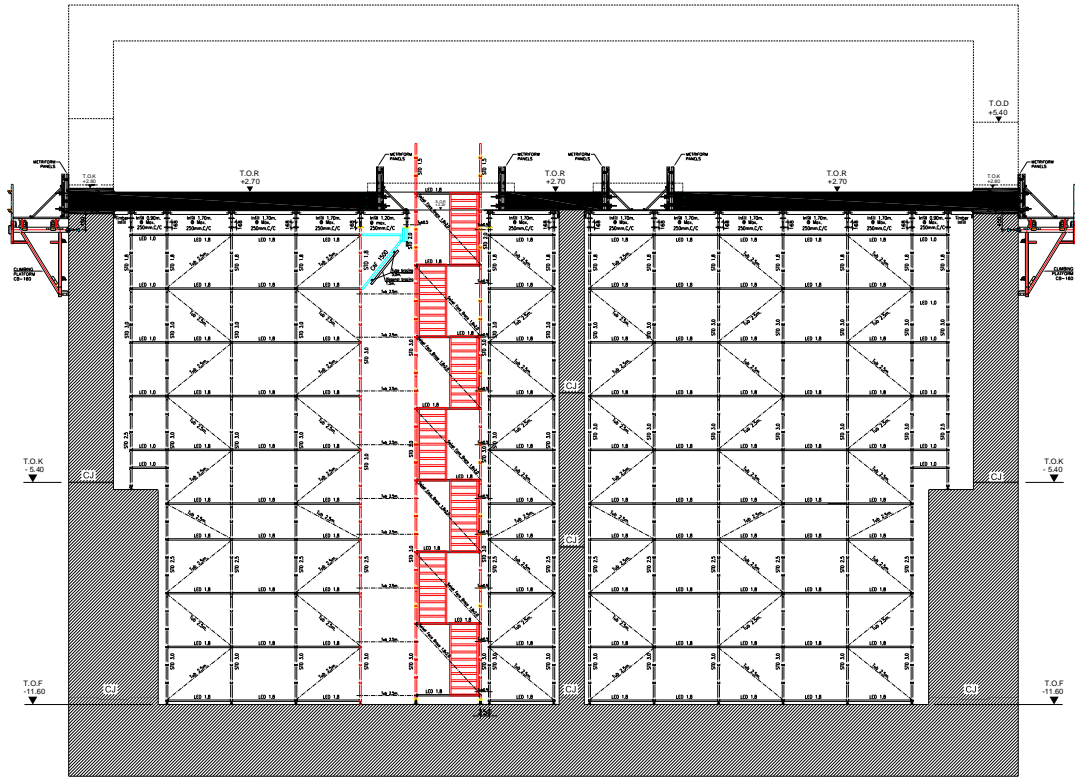
Formwork supporting slab – Longitudinal section
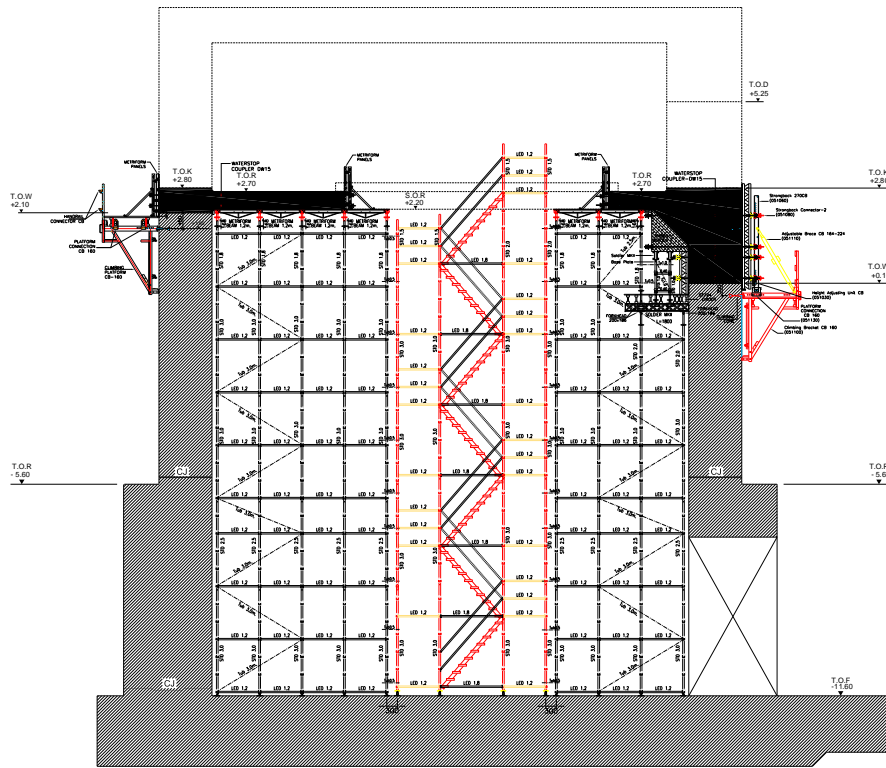
Formwork supporting slab – Transversal section
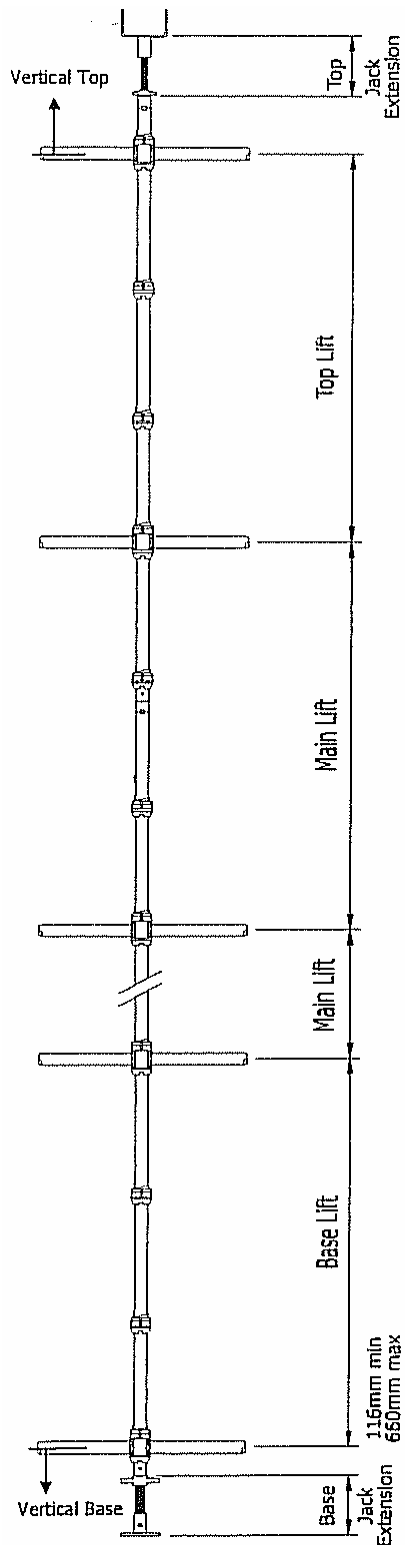
Vertical supports are introduced in the model as springs with the equivalent rigidity for the corresponding lengths.

Cross sectional area of supports is 452 mm^2.

Maximum allowable load/support is 43 kN (SLS).

CUPLOK Support – Grade 43 Verticals

5   DESIGN ASSUMPTIONS

5.1   Materials characteristics

<u>Reinforced Concrete: (Precast and cast in situ)</u>

Characteristic strength:	f_{cu} = 40 N/mm²
Elastic modulus:	E_c = 28 kN/mm²
Poisson's ratio:	ν_c = 0.20
Density:	ρ_c = 2450 kg/m³
Coefficient of thermal expansion:	α_c = 12x10^{-6} m/m°C

<u>Reinforcement bars:</u>

Characteristic strength:	f_y = 460 N/mm² for deformed high yield steel
Yield Strength:	f_y = 250 N/mm² for plain round mild steel
Elastic modulus:	E_s = 210 kN/mm²

5.2   Concrete cover

The cover to cast-in-situ concrete is 75 mm.

6 ANALYSIS & DESIGN

6.1 Structural Analysis Programs

ESA PT

The design is verified (efforts and forces distribution and magnitudes in the slab) by means of SCIA.ESA PT (version 7.0) FE computer package developed by SCIA. ESA PT is a computer program for 2-D and 3-D structural analysis integrating 1-D elements (members) and/or 2-D finite elements (walls, plates, shells). The program supports steel and concrete structures and different national standards (including BS) for the design of structural sections.

6.2 Other Computer Programs

MATHCAD Professional

7   DESIGN LOADS

7.1   Actual loads

Loading of the intermediate slab is done in two stages. In the first one the scaffolding supporting the slab is de-propped allowing the slab to support its selfweight. Then the vertical supports are re-propped (just put in contact with the slab) and they are taking additional top slab casting loads along with the slab.

7.1.1 Dead load – intermediate slab (SW IS)

The structural dead load reinforced concrete density is ρ_c = 2450 kg/m³. The intermediate slab is 0.5m thick (load is calculated in the program – SCIA.ESA PT)

7.1.2 Dead load – top slab

The weight of the concrete sustained by the scaffolding that is supported on the intermediate slab. An average 1.2 m thickness in considered for the top slab resulting in 28.8 kN/m^2 (1.2 m x 24.0 kN/m^3). A 1.0 kN/m^2 distributed load it is added to this load to account for scaffolding dead load. A total of 29.8 kN/m^2 is considered. The load is separated in two – on the left side and on the right side of Wall 5.
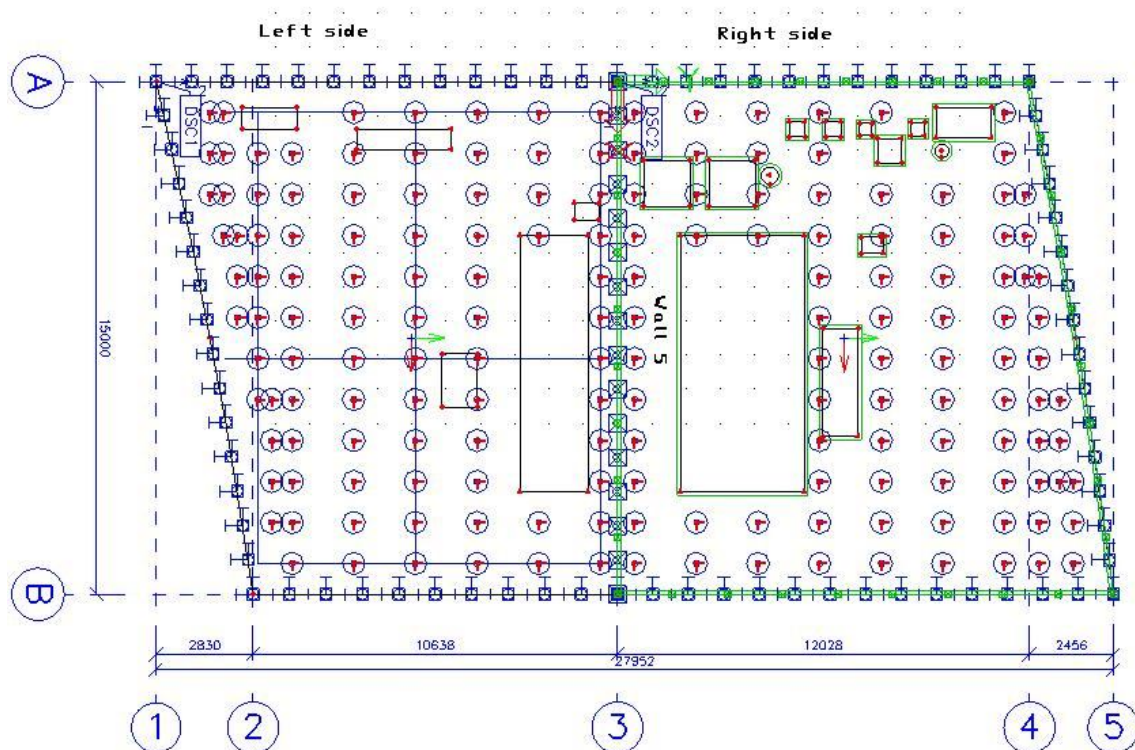
SW TS LS	SW TS RS
Top slab self weight – left side	Top slab self weight – right side

7.1.3 Live load (LL)

1.5 kN/m^2 distributed load on all the slab is considered as live load during casting. Also the load is separated in two, on each side of Wall 5.

LL LS

Live load – left side

LL RS

Live load – right side

7.2 LOAD COMBINATIONS

Model 1 (un-propped slab formwork supports):

The considered load combinations are:

ULS (Factored Loads):

1.4 * SW IS

Model 2 (slab supported by formwork):

The considered load combinations are:

ULS (Factored Loads):

1.4 * (SW TS LS + SW TS RS) + 1.6 * (LL LS + LL RS)

1.4 * SW TS LS + 1.6 * LL LS

1.4 * SW TS RS + 1.6 * LL RS

SLS (Unfactored Loads):

1.0 * (SW TS LS + SW TS RS) + 1.0 * (LL LS + LL RS)

1.0 * SW TS LS + 1.0 * LL LS

1.0 * SW TS RS + 1.0 * LL RS

8   CALCULATIONS AND RESULTS

8.1   ESA PT results

8.1.1 Critical moments on intermediate slab
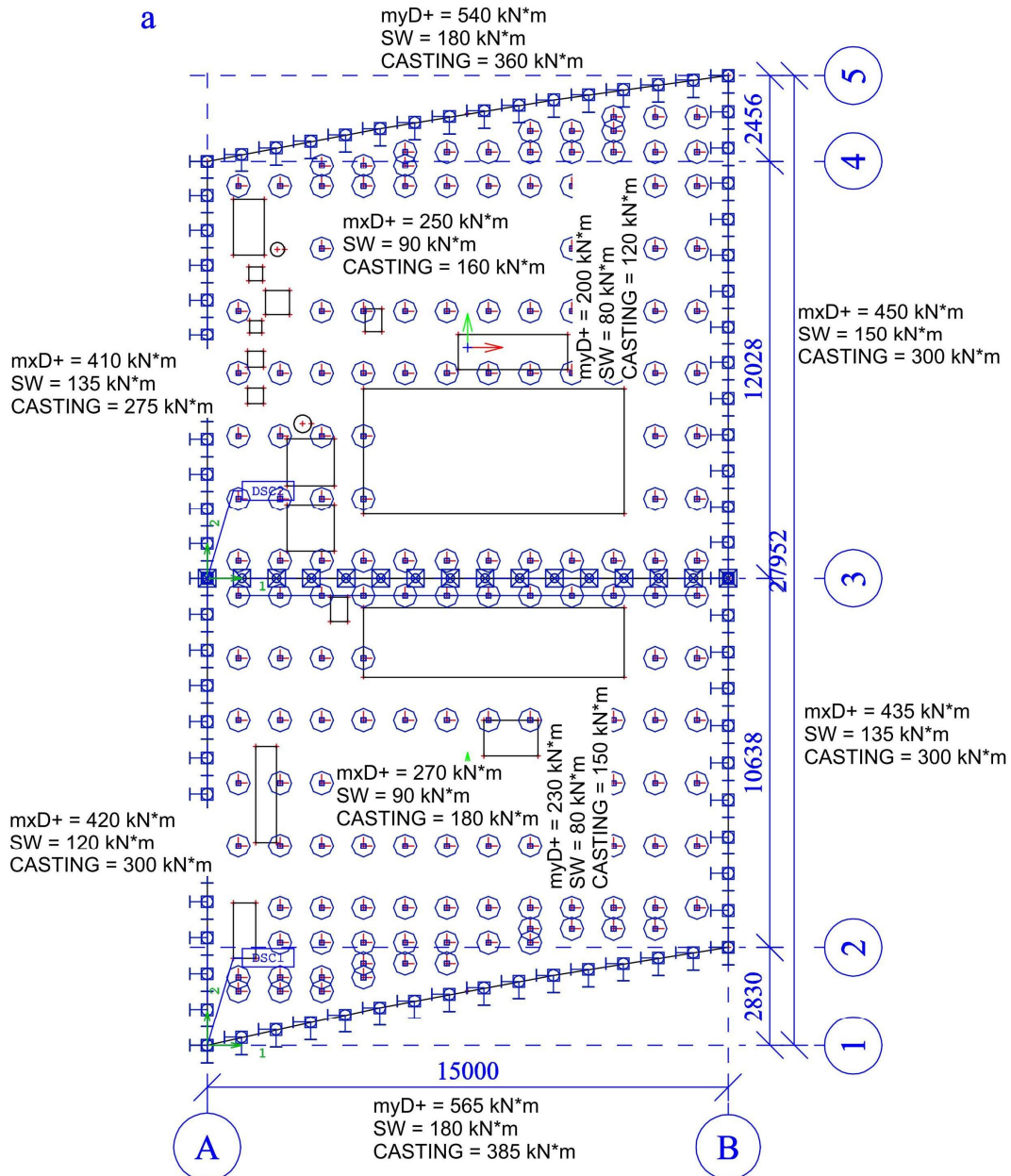
Total bending moments on the intermediate slab (From Model 1 and Model 2)

For detailed bending moment diagrams see Annex 2.

8.1.2 SLS Supports Reactions

Maximum SLS Support Reaction (axial force in formwork vertical) is 31.21 kN (not exceeding the allowable 43 kN / vertical support). Complete support reaction values are given in Annex 2.

8.1.3 ULS Supports Reactions

Maximum ULS Support Reaction (axial force in formwork vertical) is 44.00 kN. Complete support reaction values are given in Annex 2.

9 CONCRETE DESIGN

9.1 Slab bending moment capacity at critical locations

According to the drawings the slab is reinforced with T25 spaced at 100mm **top and bottom, both ways**. For detailed moment capacity calculation see Annex 3. Here below is presented the summary of the results.
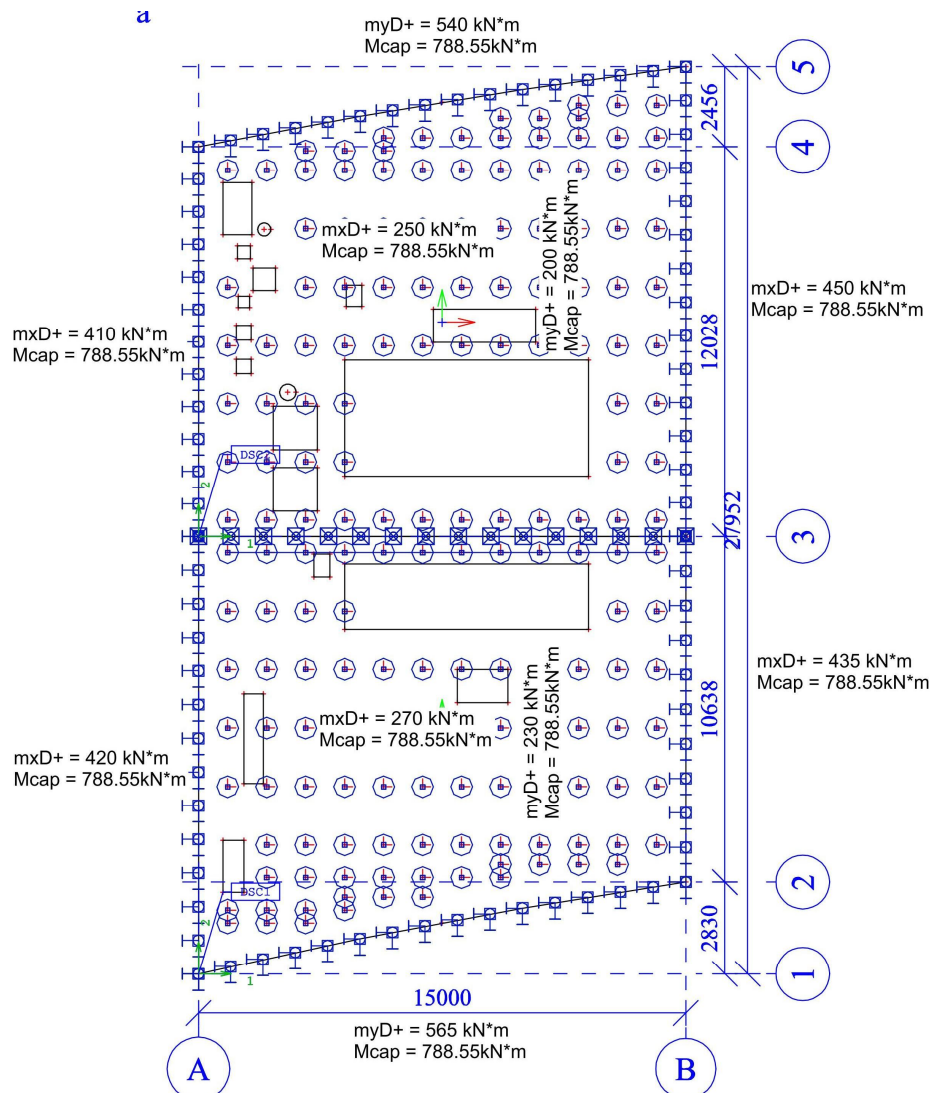
9.2 Punching shear verification at support locations

For detailed calculation see Annex 4. Here below is presented the summary of the results.

Design effective shear force:

V_{eff} = 44.00 kN

v_{max} = 0.018 N/mm^2

v_c = 0.832 N/mm^2 (allowable)

9.3 Punching shear verification at support locations

For detailed calculation see Annex 4. Here below is presented the summary of the results.
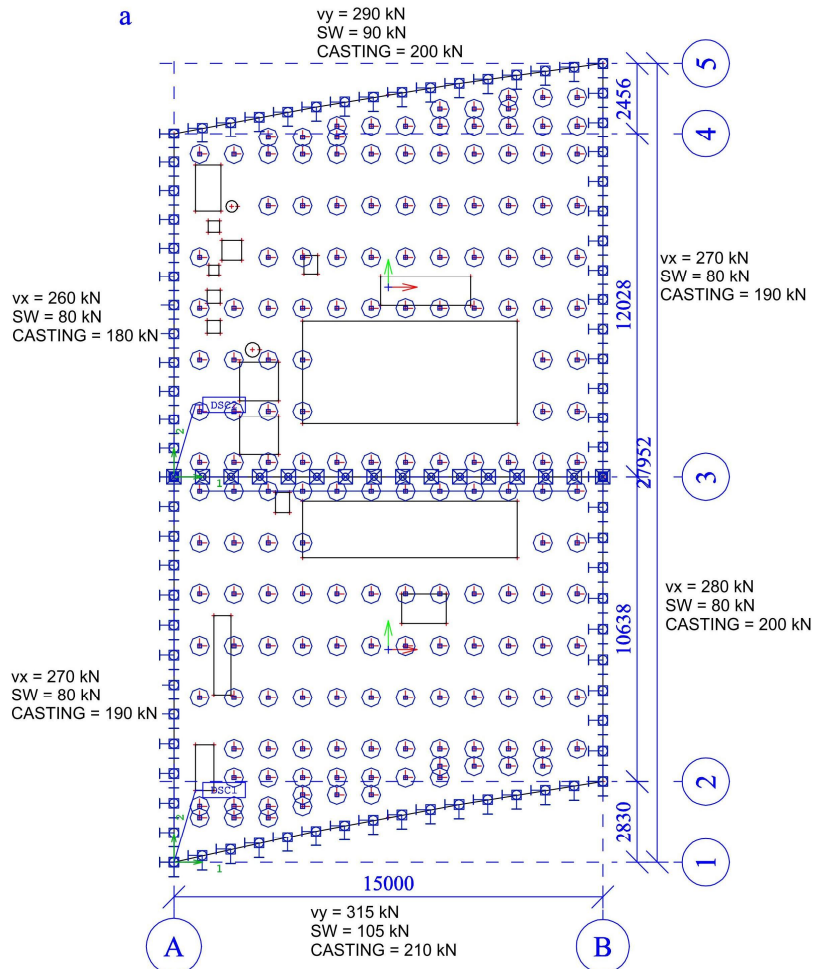
Design effective shear force (1m strip):

V_{eff} = 315.00 kN

v_{max} = 0.741 N/mm^2

v_c = 0.832 N/mm^2 (allowable)

ANNEX 1

Drawings

PLAN VIEW
SCALE 1:100

17500
LENGTH OF ARC-17746
⌒5451
⌒5846
⌒6449
3940
4390
5640
1500
1000
450
1250
2500
R204175
2500
⌒4552
1230
1700
⌒5775
⌒3360
R201675
3192
5229
4970
5643
400
DRAIN CHANNEL
400 WIDE X 300 DEEP
4950
11950
26373
3900
400
26815
4650
3900
3600
6300
6000
100
850 700
850
300
DRAIN CHANNEL
300 WIDE X 300 DEEP
2500
750
2500
6002
9829
1250
450
1000
1700
4772
1500
70083
7533
8783
VERTICAL WALL -CJ
(TYP)
2807
5964
⌒3577
⌒5790
⌒4367
2500
R180525
⌒6661
R178025
⌒5710
⌒5455
LENGTH OF ARC-17826

SECTION A-A
SCALE 1:100

DETAIL-1
(TYP)
200
KICKER
19250
750
2500
15975
CJ
300
T.O.F -11.60
EJ
2000
FOUNDATION SLAB
1700
B.O.F -13.60

SECTION B-B
SCALE 1:100

DETAIL-2
(TYP)
200
KICKER
750
2500
13500
1500
1000
CJ
CJ
T.O.F -11.60
2000
FOUNDATION SLAB
B.O.F -13.60

DETAIL-1
SCALE 1:50

2500
50
50
200
KICKER
800
800
800
CJ
50
300
FOUNDATION SLAB

DETAIL-2
SCALE 1:5

20
20

DETAIL-3
SCALE 1:20

400
300
FOUNDATION SLAB

DETAIL-4
SCALE 1:50

200
KICKER
700
850
300
CJ
300
FOUNDATION SLAB

SECTION C-C
SCALE 1:100

2500
200
KICKER
VAR
400
3900
700 850
300
VAR
2500
CJ
CJ
CJ
T.O.F -11.60
2000
FOUNDATION SLAB
B.O.F -13.60
DETAIL-3
(TYP)
DETAIL-4
(TYP)

PLAN VIEW (AT -11.39 DMD)
SCALE 1:75

PLAN VIEW (AT -5.41 DMD)
SCALE 1:75

PLAN-FLOOR SLAB B1 & T1 REINFORCEMENT

SCALE 1:60

Left side labels (top to bottom):
- 2x7-T25-123-100-B1/T1
- 2x6-T25-111-200-B1/T1
- 2x6-T25-107-200-B1/T1 (ALT)
- 2x1-T25-(106-1)-B1/T1
- 2x2-T25-107-200-B1/T1 (ALT)
- 2x16-T25-112-100-B1/T1
- 2x2-T25-(106-2)-100-B1/T1
- 2x3-T25-103-200-B1/T1
- 2X3-T25-(105-1 TO 105-3)-200-B1/T1 (ALT)
- 2x2-T25-107-200-B1/T1
- 2x3-T25-108-200-B1/T1 (ALT)
- 2x2-T25-107-200-B1/T1
- 2x2-T25-114-200-B1/T1 (ALT)
- 2x2-T25-107-200-B1/T1
- 2x1-T25-116-200-B1/T1 (ALT)
- 2x4-T25-120a-100-B1/T1
- 2X4-T25-(115-1 TO 115-4)-100-B1/T1
- 2x2-T25-107-200-B1/T1
- 2x2-T25-119-200-B1/T1 (ALT)
- 2x7-T25-122-100-B1/T1
- 2x3-T25-107-200-B1/T1 (ALT)
- 2x2-T25-121-200-B1/T1 (ALT)
- 2x3-T25-126-200-B1/T1
- 2X4-T25-130a-100-B1/T1
- 2X4-T25-(124-1 TO 124-3)-100-B1/T1
- 2x2-T25-107-200-B1/T1
- 2x3-T25-108-200-B1/T1 (ALT)
- 2X5-T25-133-100-B1/T1
- 2X5-T25-134-100-B1/T1
- 2X5-T25-(136-1 TO 136-5)-100-B1/T1
- 2X13-T25-138-100-B1/T1
- 2X5-T25-132-100-B1/T1
- 2X6-T25-134-100-B1/T1
- 2X2-T25-143-100-B1/T1
- 2X11-T25-142-100-B1/T1
- 2X4-T25-144-100-B1/T1
- 2X1-T25-147-B1/T1
- 2X1-T25-107-B1/T1(ALT)
- 2X1-T25-146-B1/T1
- 2X5-T25-108-200-B1/T1
- 2X5-T25-107-200-B1/T1 (ALT)
- 2X7-T25-150-100-B1/T1
- 2X17-T25-152-100-B1/T1
- 2X4-T25-149-100-B1/T1
- 2x6-T25-107-200-B1/T1
- 2x6-T25-108-200-B1/T1 (ALT)
- 2X10-T25-154-100-B1/T1
- 2x21-T25-107-200-B1/T1
- 2x21-T25-108-200-B1/T1 (ALT)
- 2x5-T25-107-200-B1/T1
- 2x5-T25-156-200-B1/T1 (ALT)
- 2X16-T25-157-100-B1/T1
- 2X5-T25-(159-1 TO 159-5)-100-B1/T1
- 2X17-T25-(160-1 TO 160-17)-100-B1/T1

Right side labels (top to bottom):
- 2x3-T25-(102-2 TO 102-4)-100-B1/T1
- 2x3-T25-(102-1)-100-B1/T1
- 2x1-T25-(101-1)-B1/T1
- 2x11-T25-(101-2 TO 101-12)-100-B1/T1
- 2x3-T25-(104-1 TO 104-3)-200-B1/T1)
- 2x26-T25-103-200-B1/T1 (ALT)
- 2x1-T25-109-200-B1/T1
- 2x1-T25-109a-200-B1/T1 (ALT)
- 2x2-T25-109-200-B1/T1 (ALT)
- 2x6-T25-110-200-B1/T1 (ALT)
- 2x2-T25-113-200-B1/T1
- 2x2-T25-117-200-B1/T1
- 2x2-T25-118-200-B1/T1
- 2x2-T25-116-200-B1/T1
- 2x1-T25-107-B1/T1 (ALT)
- 2x1-T25-(120-1)-200-B1/T1
- 2x3-T25-(120-2)-200-B1/T1
- 2x3-T25-125-100-B1/T1
- 2x10-T25-127-100-B1/T1
- 2x2-T25-130-200-B1/T1 (ALT)
- 2x6-T25-128-200-B1/T1
- 2x37-T25-131-100-B1/T1
- 2x3-T25-140-100-B1/T1
- 2x10-T25-141-100-B1/T1
- 2x2-T25-145-100-B1/T1
- 2x5-T25-103-200-B1/T1
- 2x5-T25-130-200-B1/T1 (ALT)
- 2x3-T25-148-100-B1/T1
- 2x1-T25-145a-B1/T1
- 2x21-T25-151-100-B1/T1
- 2x6-T25-103-200-B1/T1
- 2x6-T25-130-200-B1/T1 (ALT)
- 2x10-T25-153-200-B1/T1
- 2x21-T25-130-200-B1/T1
- 2x21-T25-103-200-B1/T1 (ALT)
- 2x5-T25-103-200-B1/T1
- 2x4-T25-155-200-B1/T1 (ALT)
- 2x1-T25-158-B1/T1

Interior labels:
- 2x1-T25-108-B1/T1
- 2x4-T25-129-100-B1/T1
- 2x1-T25-136a-B1/T1
- 2x7-T25-(135-1 TO 135-7)-100-B1/T1
- 2x13-T25-137-100-B1/T1
- 7500 X 3600 CLEAR ACCESS OPENING
- CLEAR ACCESS OPENING 7500 X 2000
- 2x1-T25-156a-B1/T1
- 2x1-T25-103-B1/T1

Wall labels: WALL W1, WALL W2, WALL W3, WALL W4, WALL W5

Dimension notes: 1575 (TYP), 1500 (TYP)

Section markers: A, A, B, B, C, C, D, D

DETAIL-1

C

WALL W1

2x4-T25-213-100-B2/T2

2x2-T25-194-400-B2/T2

2x2-T25-170-200-B2/T2
2x2-T25-212-200-B2/T2
(ALT)

2-T25-170-200-T2
2-T25-214-200-T2
(ALT)

5-T25-170-200-B2
5-T25-214-200-B2
(ALT)

2x5-T25-(196-1 t0 196-5)-100-B2/T2

2x4-T25-170-200-B2/T2
2x5-T25-211-200-B2/T2
(ALT)

A   A

2x31-T25-(204-1 to 204-31)-100-B2/T2

2x1-T25-192-200-B2/T2
2x1-T25-195-200-B2/T2
(ALT)

2x22-T25-(203-1 to 203-22)-100-B2/T2

D

2x16-T25-(209-1 to 209-16)-100-B2/T2

2x5-T25-197-100-B2/T2

2x31-T25-205-100-B2/T2

WALL W4

2x1-T25-192-200-B2/T2
2x1-T25-195-200-B2/T2
(ALT)

7500 X 3600
CLEAR ACCESS OPENING

2x1-T25-181-B2/T2

2x17-T25-181-100-T2
(STAG)

2x13-T25-188-100-B2/T2

23-T25-181-100-B2
(STAG)

2x4-T25-198-100-B2/T2

2x3-T25-181-100-B2/T2

2x69-T25-206-100-B2/T2

2x2-T25-191-200-B2/T2
2x2-T25-170-200-B2/T2
(ALT)

WALL W5

2x4-T25-201-100-B2/T2

2X1-T25-199-B2

WALL W2

2x1-T25-170-200-B2
2x1-T25-194a-200-B2
(ALT)

CLEAR ACCESS OPENING
7500 X 2000

B   B

2x16-T25-207-100-B2/T2

560-T25-240-750-CHAIRS

2x24-T25-(210-1 to 210-24)-100-B2/T2

2-T25-170-200-T2
2-T25-214-200-T2
(ALT)

2x34-T25-(202-1 to 202-34)-100-B2/T2

2x16-T25-(208-1 to 208-16)-100-B2/T2

5-T25-170-200-B2
5-T25-214-200-B2
(ALT)

2x1-T25-194-B2/T2
2x1-T25-170-B2/T2

2x2-T25-170-200-B2/T2
2x2-T25-212-200-B2/T2
(ALT)

2x5-T25-170-200-B2/T2
2x4-T25-211-200-B2/T2
(ALT)

WALL W3

2x1-T25-194a-200-B2/T2

C

PLAN-FLOOR SLAB B2 & T2 REINFORCEMENT
SCALE 1:60

Scaffolding Layout At -5.60m.
Scale = 1:75

T.O.W +2.10   WALL W1

F.L -5.60

Solder-MKII L=1125

Tub.5x3.0m.   Tub.9x3.0m.   Tub.8x3.0m.   Tub.1x2.5m.   Tub.4x3.0m.

A'   T.O.W +2.10

F.L -5.60

WALL W2

Stair
UP

CAF 1500

T.O.W +2.20   WALL W5

WALL W4   T.O.W +1.10

A'

T.O.W +2.10   WALL W3

F.L -5.60

Solder-MKII L=1125

▷B   ▷D

Tub.9x2.5m.   Tub.9x3.0m.   Tub.5x2.5m.   Tub.8x3.0m.   Tub.1x2.5m.

1200   1800   600   400   300   250   900   150   1000

Scaffolding Layout
Scale = 1:75

Infill & Beams Layout

Scale = 1:75

External & Internal Panel Layout

Scale = 1:75

Section A-A
Working Platform At -5.60

Scale = 1:75

T.O.W +2.10

T.O.R +2.70

S.O.R +2.20

T.O.R +2.70

T.O.W +0.10

SCAFFOLD BRACKET GB80 Art No :027110

SCAFFOLD BRACKET GB80 Art No :027110

SCAFFOLD BRACKET GB80 Art No :027110

CLIMBING CONE

350

GT24/600

GT24/180

GT24/600

EXTENSION SPLICE Art No :024480

Push-Pull Prop RS 900 Art No :028090

PUSHPULL PROPS RSS II Art No :028020

Push-Pull Prop RS III Art No :028090

5644

3600

PUSHPULL PROPS RSS II Art No :028020

1686

KICKER AV 210 Art No :P08135

KICKER AV 210 Art No :P08135

BASE PLATE FOR RSS Art No :028900

BASE PLATE FOR RS 1000 Art No :028900

40mm. TIMBER SPREADER BEAM

Platform Top Level - 5.60

40mm. TIMBER SPREADER BEAM

BASE PLATE FOR RSS Art No :028900

BASE PLATE FOR RSS Art No :028900

T.O.R -5.60

CJ

CJ

T.O.R -5.60

HANDRAIL CONNECTOR CB

PLATFORM CONNECTION CB 160

CLIMBING PLATFORM CB-160

WALL TIE UNIVERSAL JACK+ TUBE L=3000mm. (ALL AROUND)

WALL TIE UNIVERSAL JACK+ TUBE L=3000mm. (ALL AROUND)

METRIFORM BEAM 1.2m.

LED 1.2

Tub 3.0m.

STD 2.5

STD 3.0

LEDGER TO BE MOVED UP OF 500mm. FOR INTERMEDIATE SLAB SCAFFOLDING

CJ

T.O.F -11.60

Section A'-A'

Scale = 1:75

Labels visible in the drawing:

- T.O.D +5.25
- climbing cone added
- METRIFORM PANELS
- T.O.K +2.80
- WATERSTOP COUPLER DW15
- T.O.R +2.70
- METRIFORM PANELS
- T.O.R +2.70
- WATERSTOP COUPLER-DW15
- T.O.K +2.80
- T.O.W +2.10
- S.O.R +2.20
- Strongback 270CB (051060)
- Strongback Connector~2 (051080)
- HANDRAIL CONNECTOR CB
- METRIFORM BEAM 1.2m.
- METRIFORM BEAM 1.2m.
- METRIFORM BEAM 1.2m.
- METRIFORM BEAM 1.2m.
- METRIFORM BEAM 1.2m.
- Adjustable Brace CB 164~224 (051110)
- PLATFORM CONNECTION CB 160
- TIMBER PACKER
- Soldier MKII
- Base Plate
- T.O.W +0.10
- CLIMBING PLATFORM CB-160
- Height Adjusting Unit CB (051030)
- GT734 GIRDER
- FORKHEAD 200x186
- FORKHEAD 200x186
- SOLDIER MKII L=1800
- PLATFORM CONNECTION CB 160 (051130)
- CLIMBING CONE
- Climbing Bracket CB 160 (051100)
- T.O.R -5.60
- CJ
- CJ
- T.O.R -5.60
- T.O.F -11.60
- CJ
- 300
- 300

Repeated grid labels: STD 1.8, STD 1.5, STD 2.0, STD 2.5, STD 3.0, LED 1.2, LED 1.5, LED 1.8, LED 2.0, Tub 3.0m., Tub 2.0m., Tub 1.0m., Tub 0.5

ANNEX 2

ESA PT results

TOTAL BENDING MOMENTS
FROM STAGE 1 (SW) AND STAGE 2 (CASTING)

a

myD+ = 540 kN*m
SW = 180 kN*m
CASTING = 360 kN*m

mxD+ = 250 kN*m
SW = 90 kN*m
CASTING = 160 kN*m

myD+ = 200 kN*m
SW = 80 kN*m
CASTING = 120 kN*m

mxD+ = 450 kN*m
SW = 150 kN*m
CASTING = 300 kN*m

mxD+ = 410 kN*m
SW = 135 kN*m
CASTING = 275 kN*m

mxD+ = 435 kN*m
SW = 135 kN*m
CASTING = 300 kN*m

mxD+ = 270 kN*m
SW = 90 kN*m
CASTING = 180 kN*m

myD+ = 230 kN*m
SW = 80 kN*m
CASTING = 150 kN*m

mxD+ = 420 kN*m
SW = 120 kN*m
CASTING = 300 kN*m

myD+ = 565 kN*m
SW = 180 kN*m
CASTING = 385 kN*m

DSC2
DSC1

5
4
3
2
1

A   B

15000

2456
12028
27952
10638
2830

TOTAL SLAB SHEAR FORCES / METER
FROM STAGE 1 (SW) AND STAGE 2 (CASTING)

a

vy = 290 kN
SW = 90 kN
CASTING = 200 kN

vx = 260 kN
SW = 80 kN
CASTING = 180 kN

vx = 270 kN
SW = 80 kN
CASTING = 190 kN

vx = 270 kN
SW = 80 kN
CASTING = 190 kN

vx = 280 kN
SW = 80 kN
CASTING = 200 kN

vy = 315 kN
SW = 105 kN
CASTING = 210 kN

15000

2456
12028
27952
10638
2830

5
4
3
2
1

A
B

mxD+-max [kNm/m]

a
Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

135kN*m

120kN*m

150kN*m

135kN*m

DSC2

DSC1

15000

a

Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

180kN*m

180kN*m

DSC2

DSC1

2456

12028

27952

10638

2830

15000

A

B

1

2

3

4

5

mxD--max [kNm/m]

Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

myD--max [kNm/m]

a

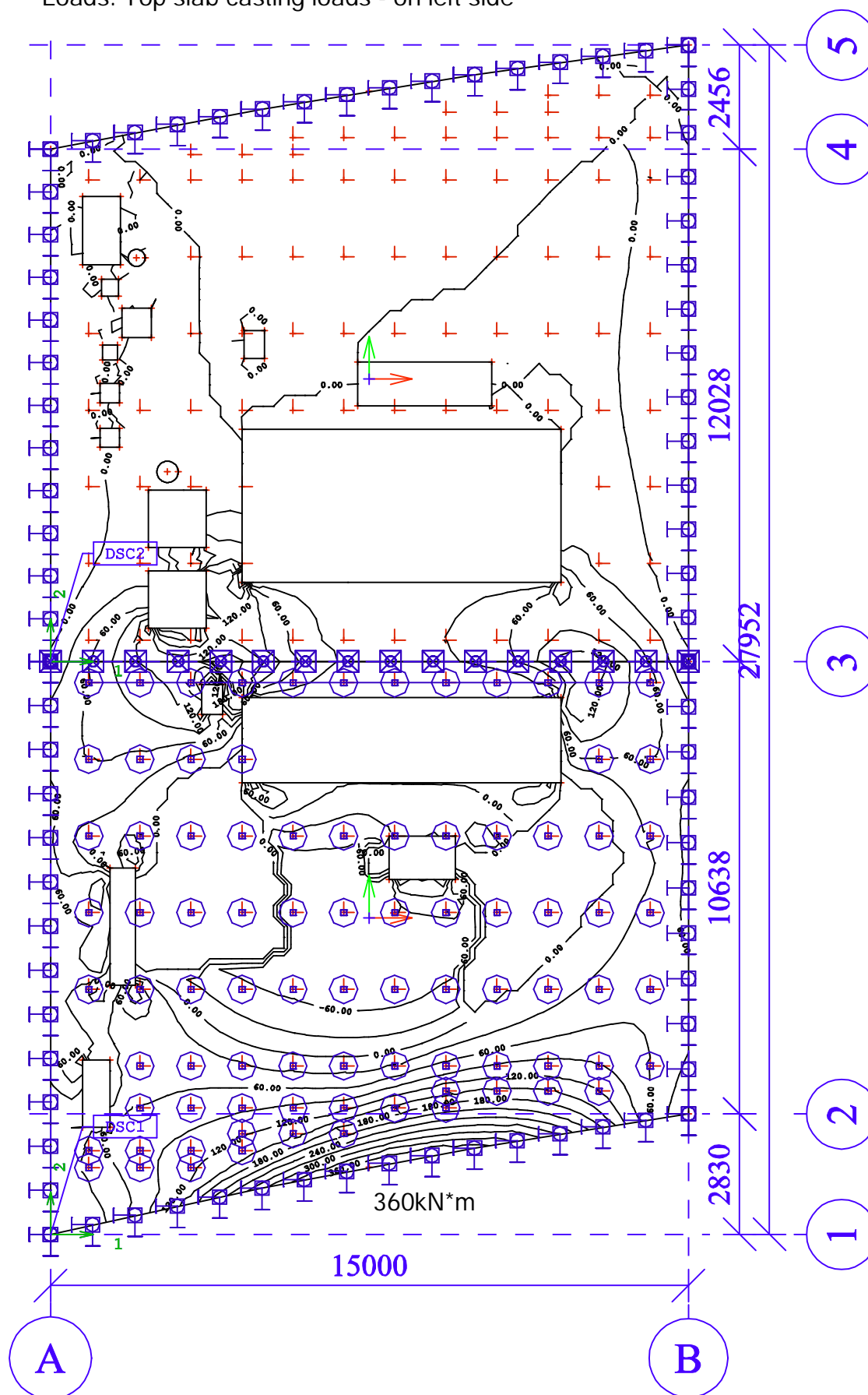Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

vx-max [kN/m]

a

Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

vy-max [kN/m]

Model: Unsupported intermediate slab
Loads: Selfweight intermediate slab

mxD+-max [kNm/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on left side

300kN*m

300kN*m

myD+-max [kNm/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on left side

mxD--max [kNm/m]

a   Model: Intermediate slab with formwork supports
    Loads: Top slab casting loads - on left side

180kN*m

a

Model: Intermediate slab with formwork supports
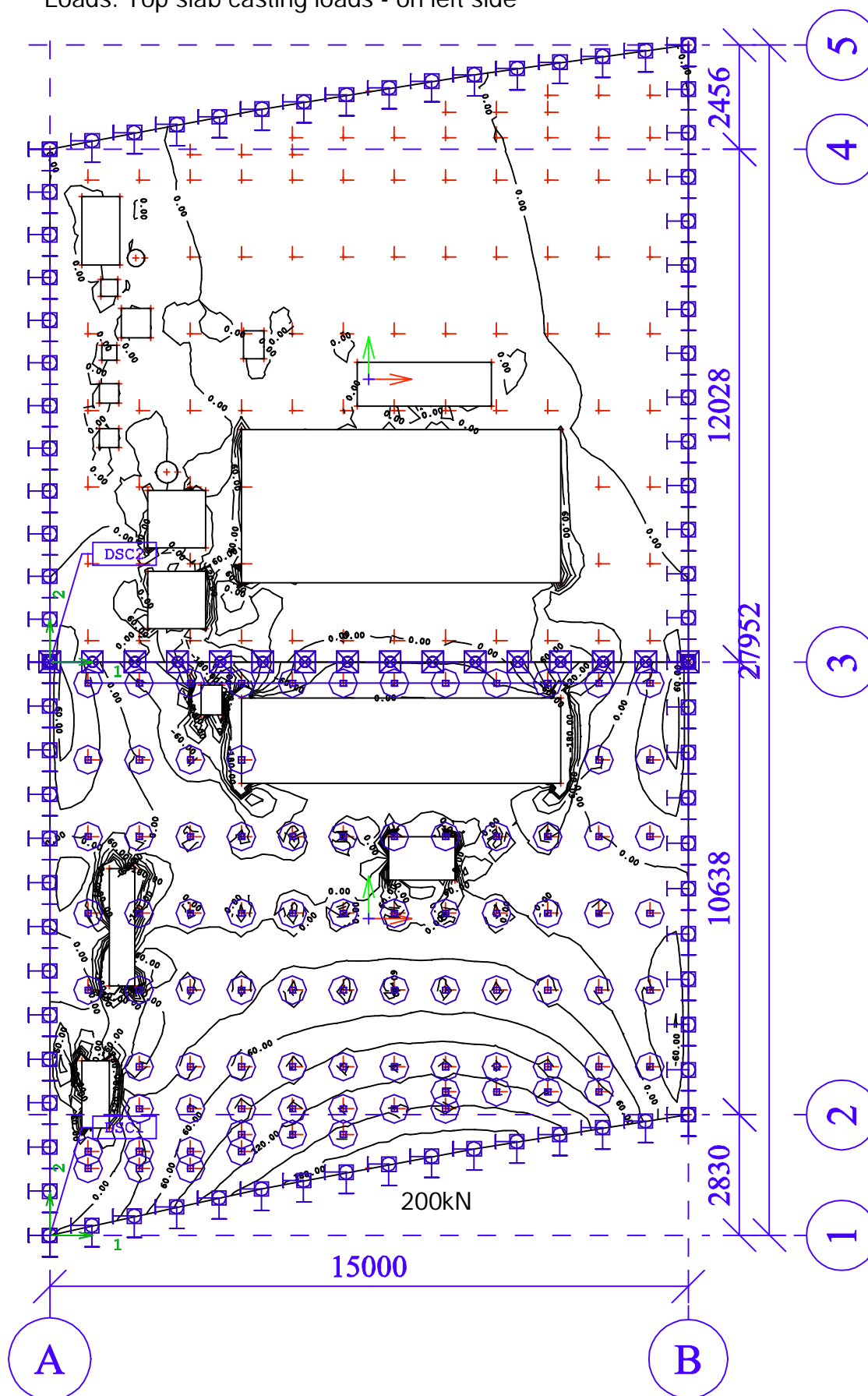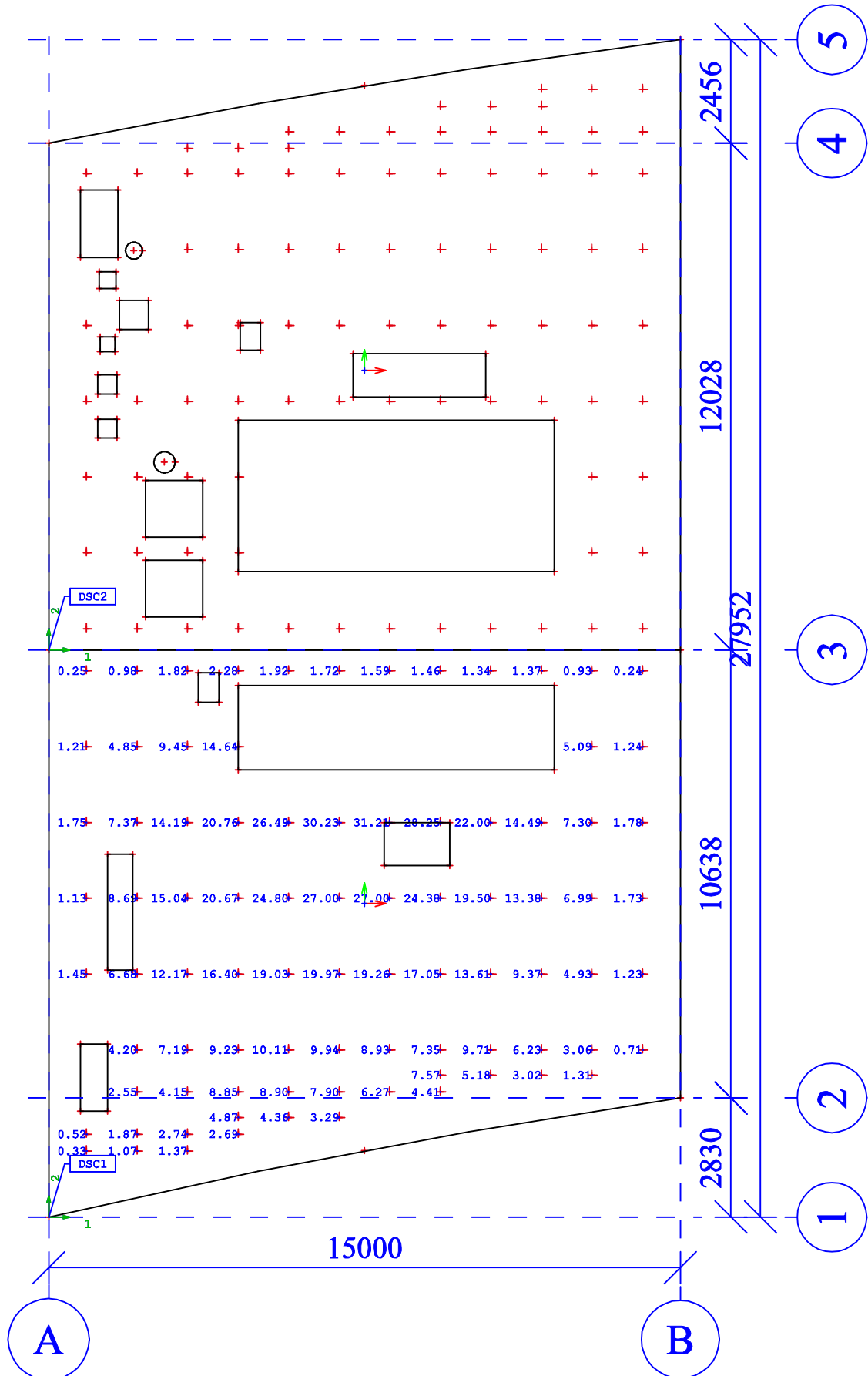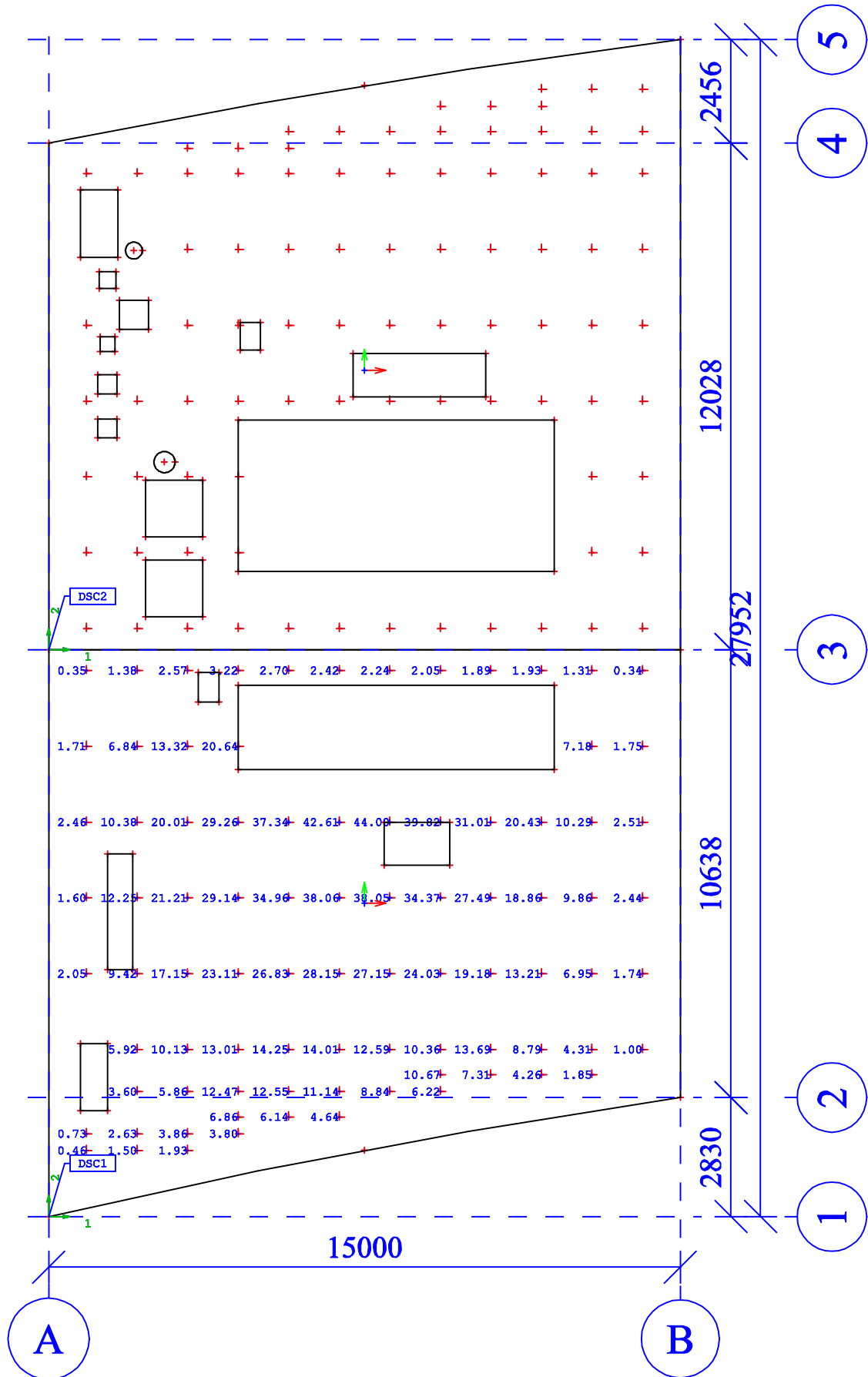Loads: Top slab casting loads - on left side

150kN*m

15000

A   B

1 2 3 4 5

2456
12028
27952
10638
2830

vx-max [kN/m]

a Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on left side

180kN

200kN

15000

2830

10638

27952

12028

2456

1

2

3

4

5

A

B

vy-max [kN/m]

a   Model: Intermediate slab with formwork supports
    Loads: Top slab casting loads - on left side

200kN

15000

2830

10638

27952

12028

2456

1

2

3

4

5

A

B

DSC2

DSC1

a

5

4

2456

12028

27952

DSC2

3

0.25 0.98 1.82 2.28 1.92 1.72 1.59 1.46 1.34 1.37 0.93 0.24

1.21 4.85 9.45 14.64   5.09 1.24

1.75 7.37 14.19 20.76 26.49 30.23 31.2 28.25 22.00 14.49 7.30 1.78

1.13 8.69 15.04 20.67 24.80 27.00 27.00 24.38 19.50 13.38 6.99 1.73

1.45 6.68 12.17 16.40 19.03 19.97 19.26 17.05 13.61 9.37 4.93 1.23

10638

4.20 7.19 9.23 10.11 9.94 8.93 7.35 9.71 6.23 3.06 0.71

7.57 5.18 3.02 1.31

2.55 4.15 8.85 8.90 7.90 6.27 4.41

2

4.87 4.36 3.29

0.52 1.87 2.74 2.69

0.33 1.07 1.37

DSC1

2830

1

15000

A   B

a

DSC2

DSC1

0.35 1.38 2.57 3.22 2.70 2.42 2.24 2.05 1.89 1.93 1.31 0.34

1.71 6.84 13.32 20.64   7.18 1.75

2.46 10.38 20.01 29.26 37.34 42.61 44.00 39.82 31.01 20.43 10.29 2.51

1.60 12.25 21.21 29.14 34.96 38.06 38.05 34.37 27.49 18.86 9.86 2.44

2.05 9.42 17.15 23.11 26.83 28.15 27.15 24.03 19.18 13.21 6.95 1.74

5.92 10.13 13.01 14.25 14.01 12.59 10.36 13.69 8.79 4.31 1.00

10.67 7.31 4.26 1.85

3.60 5.86 12.47 12.55 11.14 8.84 6.22

6.86 6.14 4.64

0.73 2.63 3.86 3.80

0.46 1.50 1.93

2456

12028

27952

10638

2830

15000

1 2 3 4 5

A B

a   Model: Intermediate slab with formwork supports
     Loads: Top slab casting loads - on right side

275kN*m

300kN*m

myD+-max [kNm/m]

a   Model: Intermediate slab with formwork supports
     Loads: Top slab casting loads - on right side
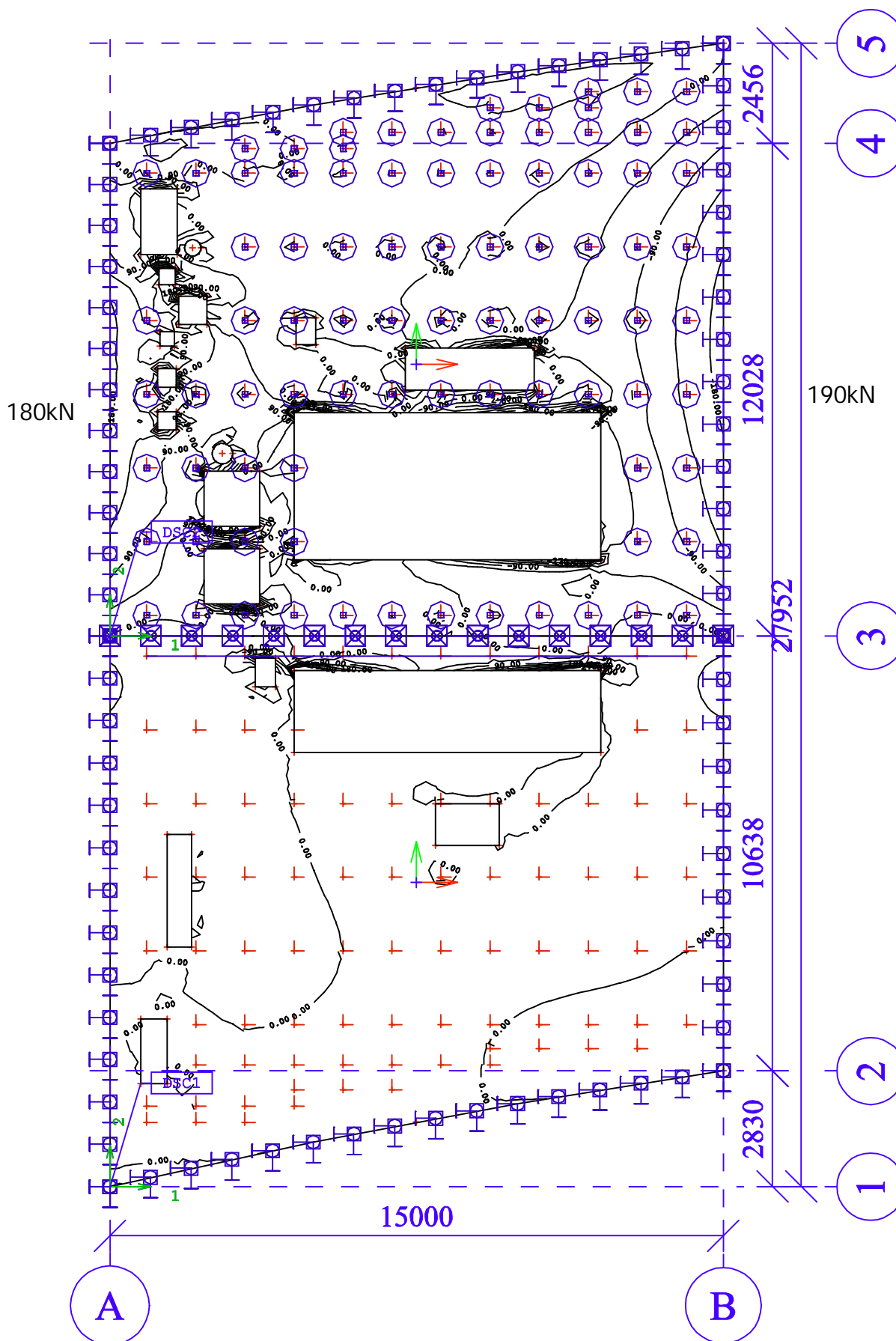
360kN*m

mxD--max [kNm/m]

a   Model: Intermediate slab with formwork supports
     Loads: Top slab casting loads - on right side
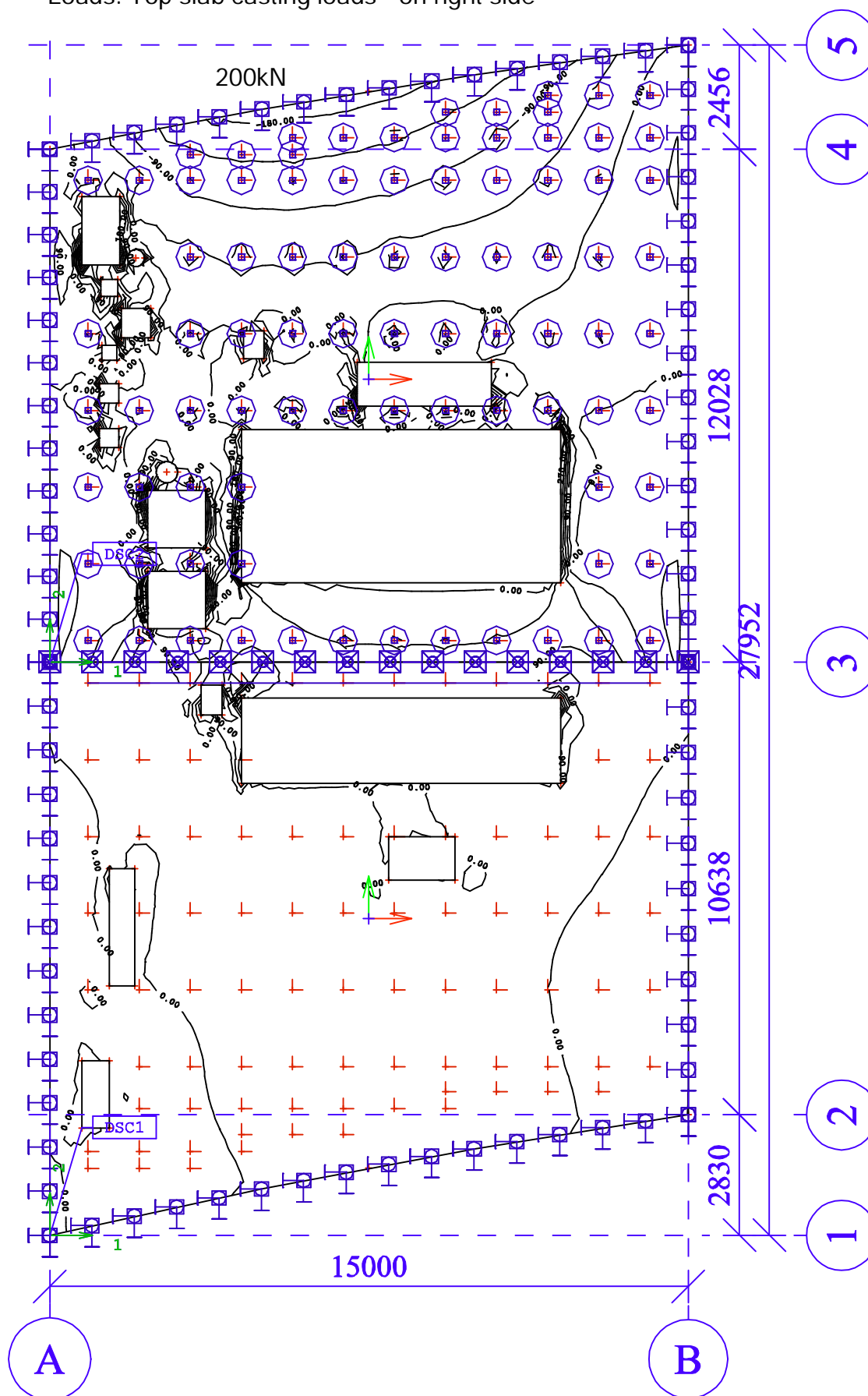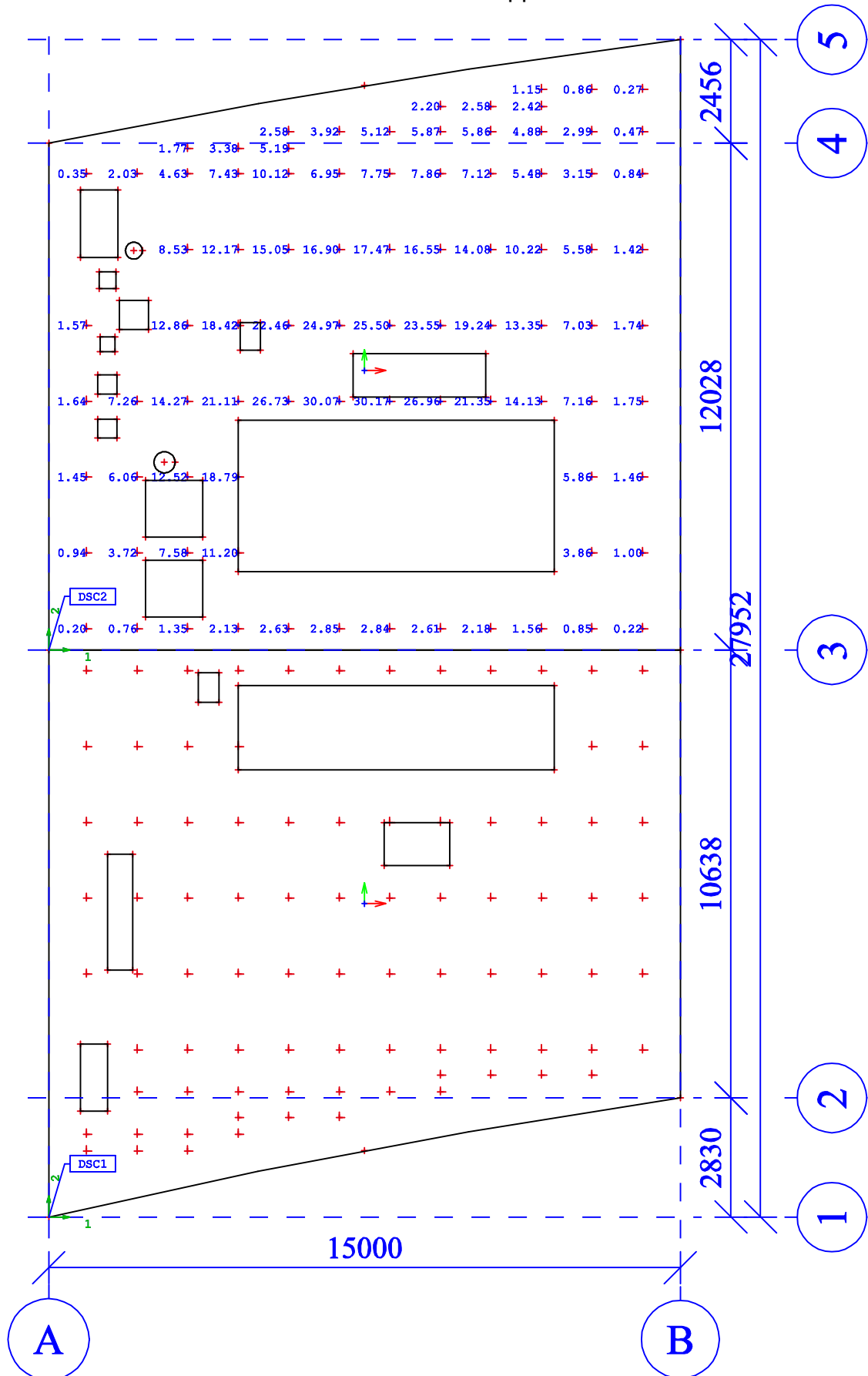
160kN*m

a Model: Intermediate slab with formwork supports
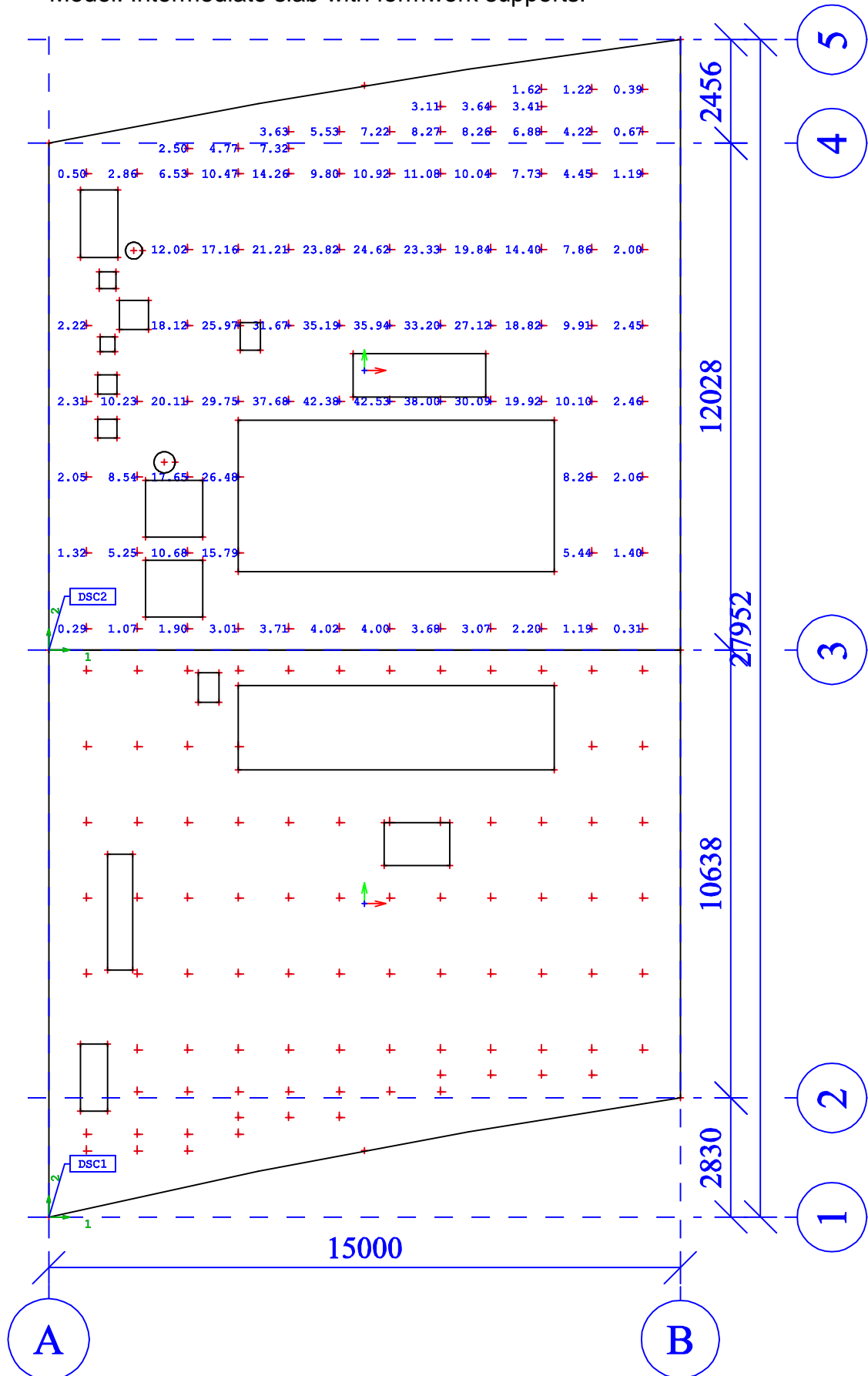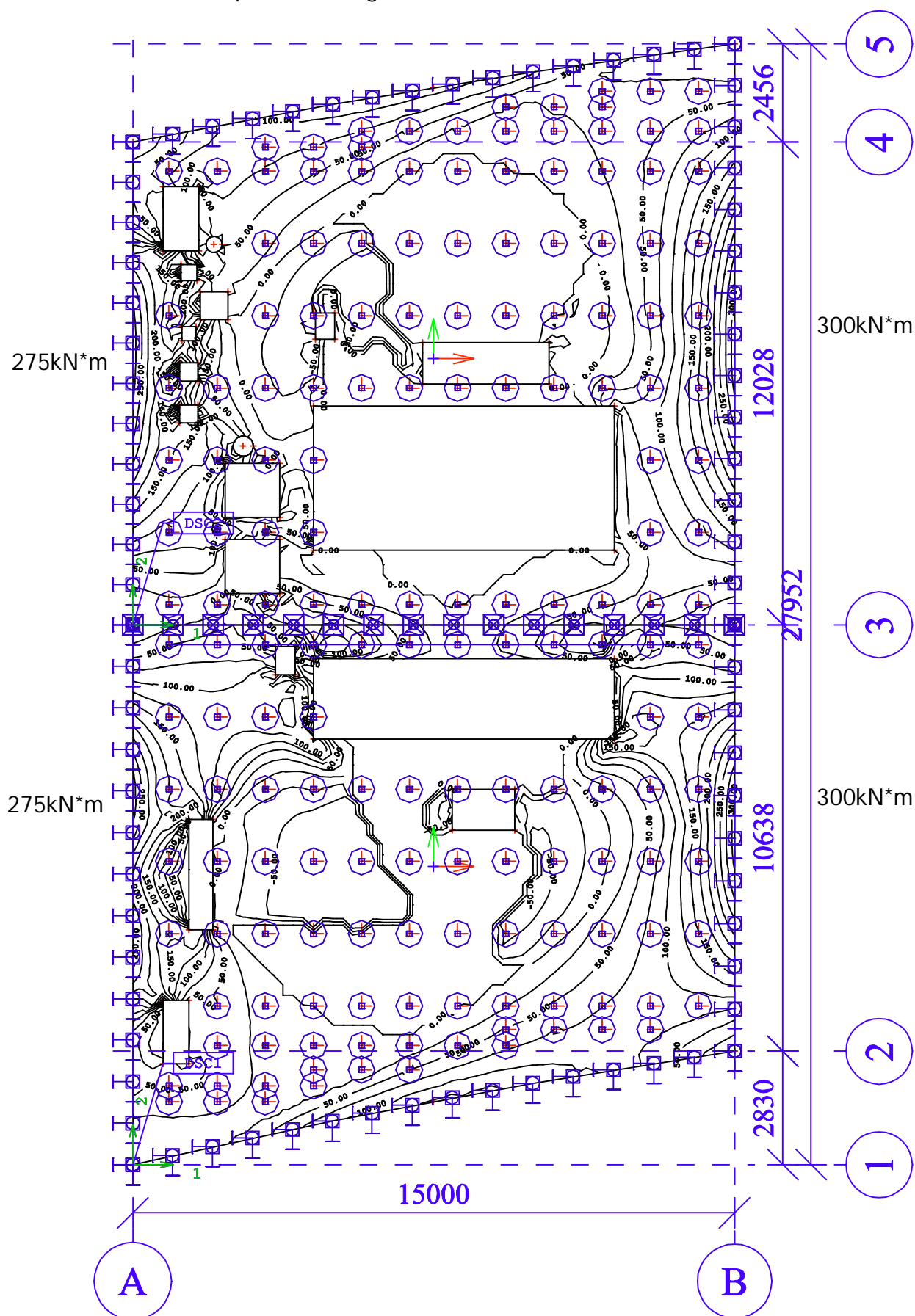Loads: Top slab casting loads - on right side

120kN*m

2456

12028

27952

10638

2830

15000

5

4

3

2

1

A

B

vx-max [kN/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on right side

180kN

190kN

2456

12028

27952

10638

2830

15000

5

4

3

2

1

A

B

vy-max [kN/m]

a   Model: Intermediate slab with formwork supports
    Loads: Top slab casting loads - on right side

200kN

a

1.15 0.86 0.27
2.20 2.58 2.42
2.58 3.92 5.12 5.87 5.86 4.88 2.99 0.47
1.77 3.38 5.19
0.35 2.03 4.63 7.43 10.12 6.95 7.75 7.86 7.12 5.48 3.15 0.84

8.53 12.17 15.05 16.90 17.47 16.55 14.08 10.22 5.58 1.42

1.57 12.86 18.42 22.46 24.97 25.50 23.55 19.24 13.35 7.03 1.74

1.64 7.26 14.27 21.11 26.73 30.07 30.17 26.96 21.35 14.13 7.16 1.75

1.45 6.06 12.52 18.79   5.86 1.46

0.94 3.72 7.58 11.20   3.86 1.00

DSC2

0.20 0.76 1.35 2.13 2.63 2.85 2.84 2.61 2.18 1.56 0.85 0.22

DSC1

2456

12028

27952

10638

2830

15000

A   B

1 2 3 4 5

a

1.62 1.22 0.39
3.11 3.64 3.41
3.63 5.53 7.22 8.27 8.26 6.88 4.22 0.67
2.50 4.77 7.32
0.50 2.86 6.53 10.47 14.26 9.80 10.92 11.08 10.04 7.73 4.45 1.19

12.02 17.16 21.21 23.82 24.62 23.33 19.84 14.40 7.86 2.00

2.22 18.12 25.97 31.67 35.19 35.94 33.20 27.12 18.82 9.91 2.45

2.31 10.23 20.11 29.75 37.68 42.38 42.53 38.00 30.09 19.92 10.10 2.46

2.05 8.54 17.65 26.48 8.26 2.06

1.32 5.25 10.68 15.79 5.44 1.40

0.29 1.07 1.90 3.01 3.71 4.02 4.00 3.68 3.07 2.20 1.19 0.31

DSC2

DSC1

5
4
3
2
1

A   B

2456
12028
27952
10638
2830

15000

mxD+-max [kNm/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on both sides

275kN*m

275kN*m

300kN*m

300kN*m

2456

12028

27952

10638

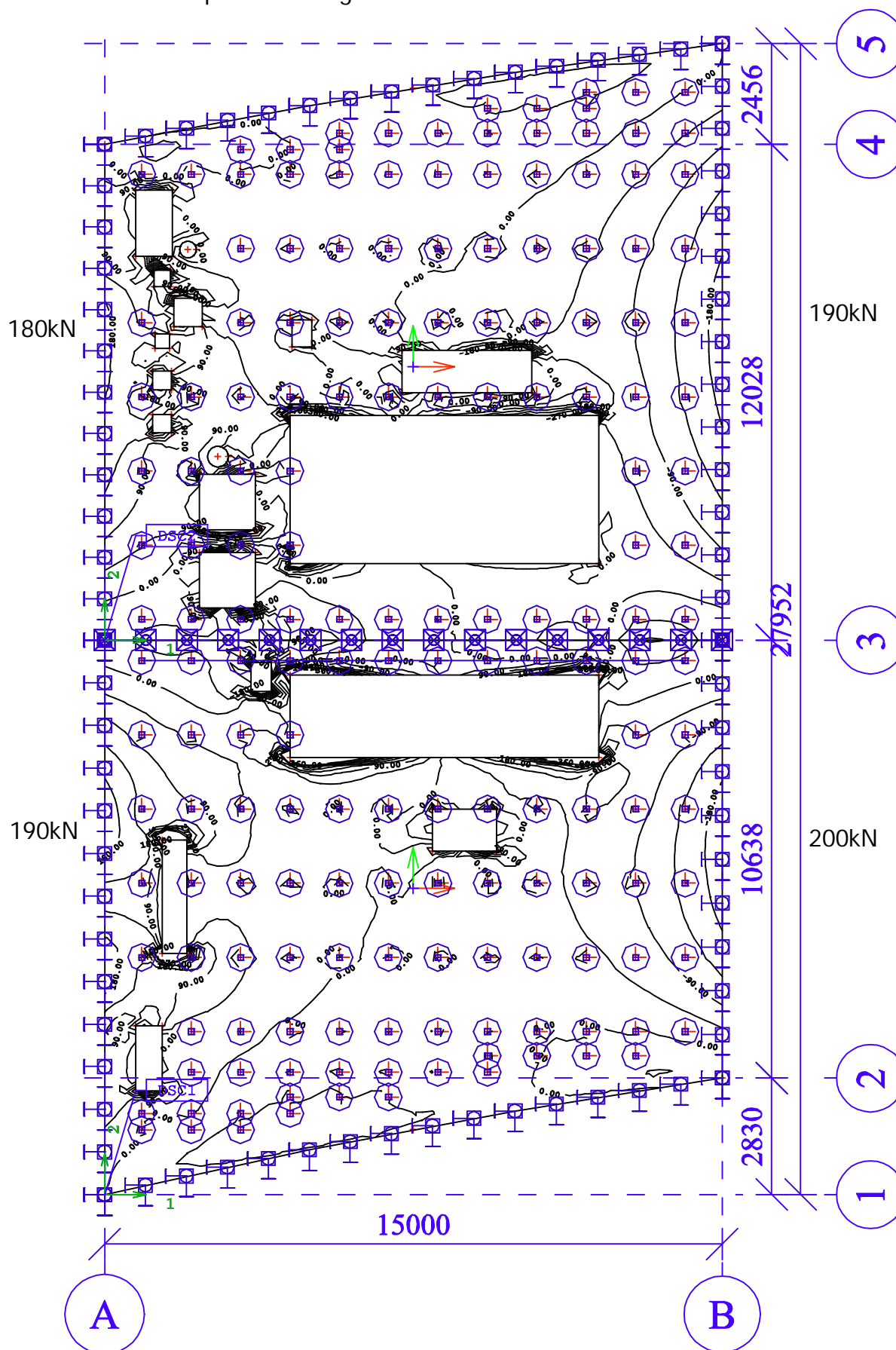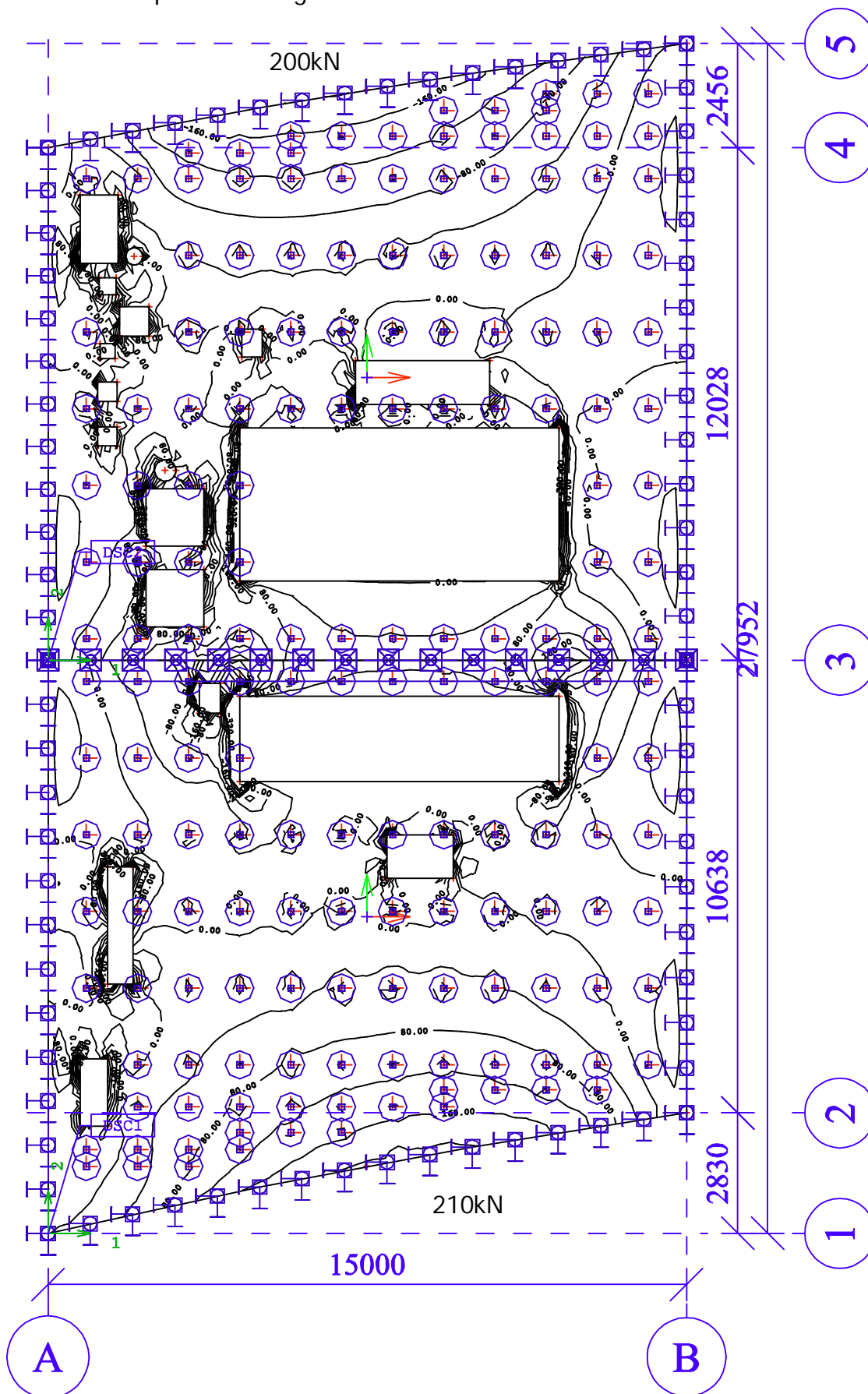2830

15000

5

4

3

2

1

A

B

myD+-max [kNm/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on both sides

a

Model: Intermediate slab with formwork supports
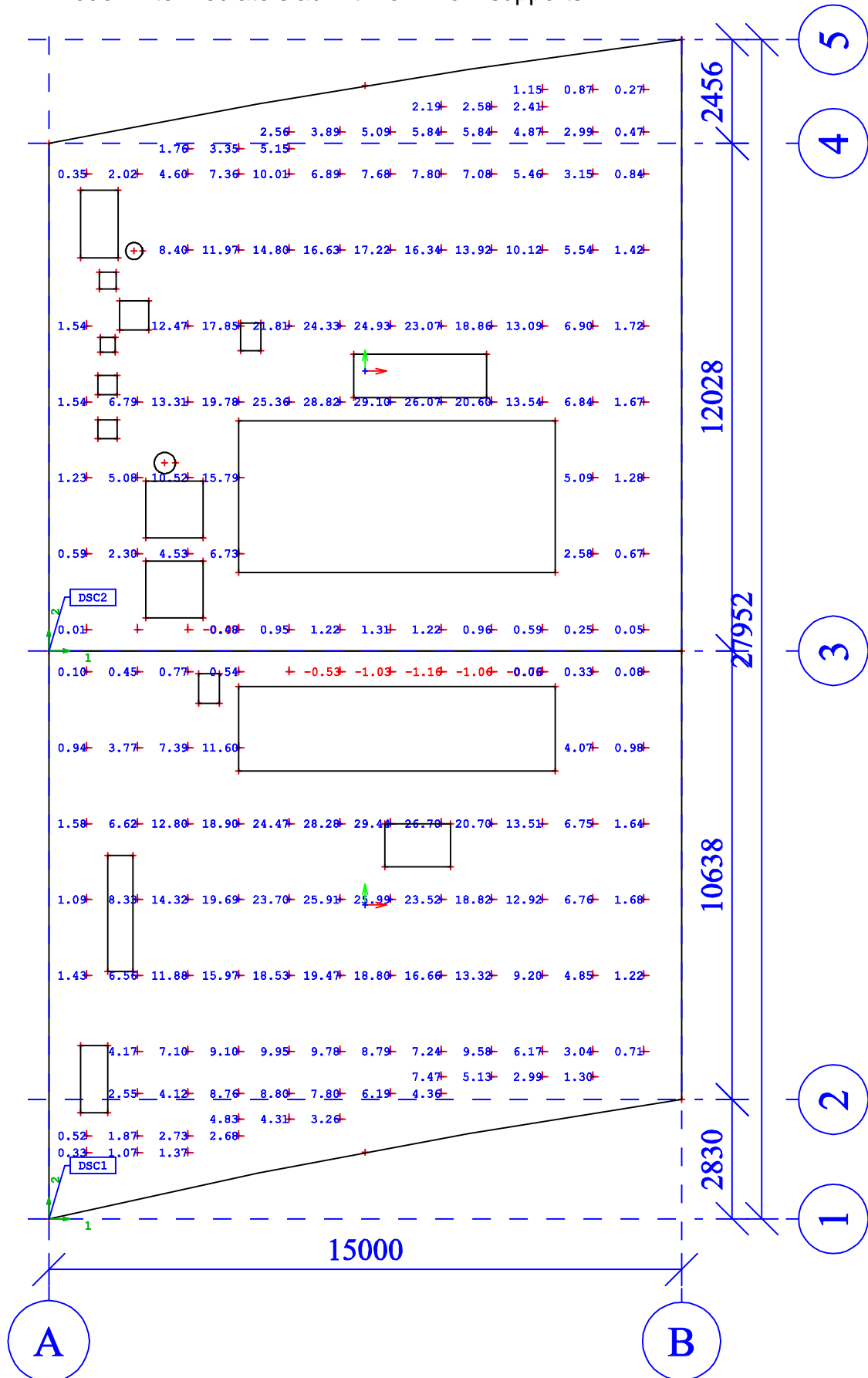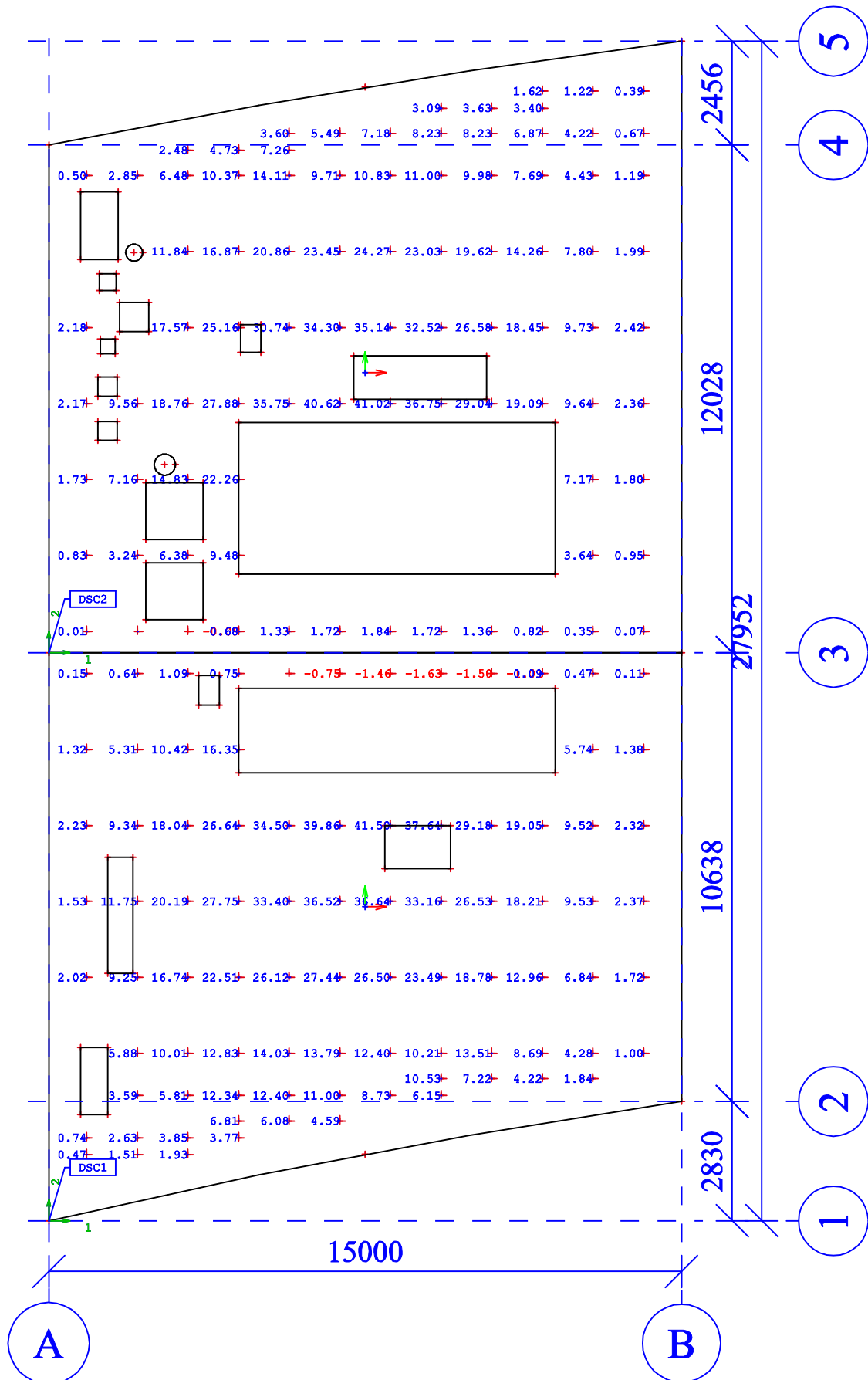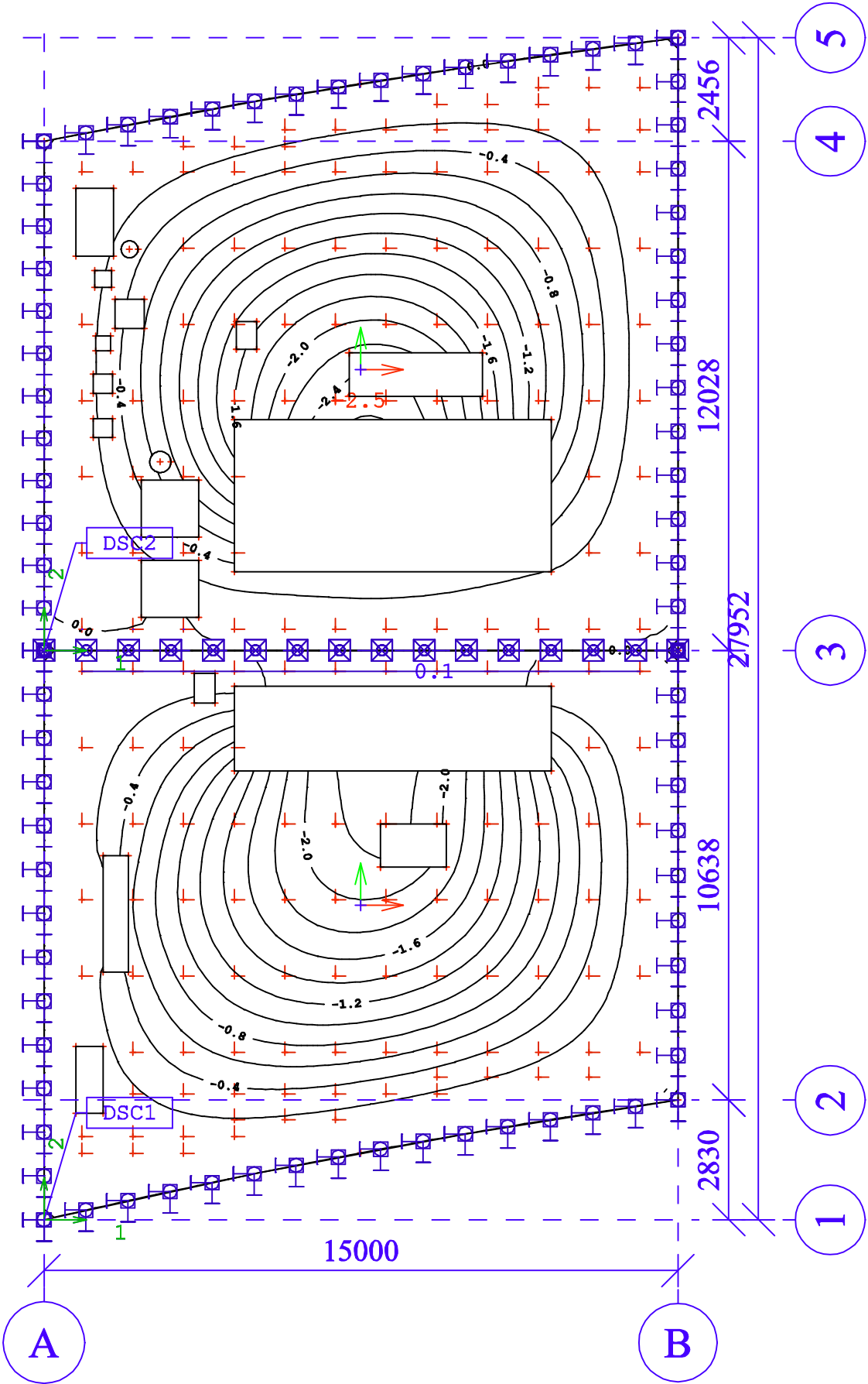Loads: Top slab casting loads - on both sides

mxD--max [kNm/m]

150kN*m

180kN*m

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on both sides

120kN*m

150kN*m

5

4

2456

12028

27952

3

10638

2

2830

1

15000

A

B

vx-max [kN/m]

a Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on both sides

180kN

190kN

190kN

200kN

2456

12028

27952

10638

2830

15000

5

4

3

2

1

A

B

vy-max [kN/m]

a

Model: Intermediate slab with formwork supports
Loads: Top slab casting loads - on both sides

200kN

210kN

15000

2456

12028

27952

10638

2830

① ② ③ ④ ⑤

Ⓐ Ⓑ

a

1.15 0.87 0.27
2.19 2.58 2.41
2.56 3.89 5.09 5.84 5.84 4.87 2.99 0.47
1.76 3.35 5.15
0.35 2.02 4.60 7.36 10.01 6.89 7.68 7.80 7.08 5.46 3.15 0.84

8.40 11.97 14.80 16.63 17.22 16.34 13.92 10.12 5.54 1.42

1.54 12.47 17.85 21.81 24.33 24.93 23.07 18.86 13.09 6.90 1.72

1.54 6.79 13.31 19.78 25.36 28.82 29.10 26.07 20.60 13.54 6.84 1.67

1.23 5.08 10.52 15.79 5.09 1.28

0.59 2.30 4.53 6.73 2.58 0.67

DSC2
0.01 -0.08 0.95 1.22 1.31 1.22 0.96 0.59 0.25 0.05

0.10 0.45 0.77 0.54 -0.53 -1.03 -1.16 -1.06 -0.06 0.33 0.08

0.94 3.77 7.39 11.60 4.07 0.98

1.58 6.62 12.80 18.90 24.47 28.28 29.44 26.70 20.70 13.51 6.75 1.64

1.09 8.33 14.32 19.69 23.70 25.91 25.99 23.52 18.82 12.92 6.76 1.68

1.43 6.56 11.88 15.97 18.53 19.47 18.80 16.66 13.32 9.20 4.85 1.22

4.17 7.10 9.10 9.95 9.78 8.79 7.24 9.58 6.17 3.04 0.71
7.47 5.13 2.99 1.30
2.55 4.12 8.76 8.80 7.80 6.19 4.36
4.83 4.31 3.26
0.52 1.87 2.73 2.68
0.33 1.07 1.37
DSC1

5
4
2456
3
27952
12028
2
10638
2830
1

15000

A   B

a

15000

2456
12028
27952
10638
2830

5
4
3
2
1

A
B

DSC2
DSC1

1.62 1.22 0.39
3.09 3.63 3.40
3.60 5.49 7.18 8.23 8.23 6.87 4.22 0.67
2.48 4.73 7.26
0.50 2.85 6.48 10.37 14.11 9.71 10.83 11.00 9.98 7.69 4.43 1.19
11.84 16.87 20.86 23.45 24.27 23.03 19.62 14.26 7.80 1.99
2.18 17.57 25.16 30.74 34.30 35.14 32.52 26.58 18.45 9.73 2.42
2.17 9.56 18.76 27.88 35.75 40.62 41.02 36.75 29.04 19.09 9.64 2.36
1.73 7.16 14.83 22.26 7.17 1.80
0.83 3.24 6.38 9.48 3.64 0.95
0.01 -0.68 1.33 1.72 1.84 1.72 1.36 0.82 0.35 0.07
0.15 0.64 1.09 0.75 -0.75 -1.46 -1.63 -1.56 -0.09 0.47 0.11
1.32 5.31 10.42 16.35 5.74 1.38
2.23 9.34 18.04 26.64 34.50 39.86 41.50 37.64 29.18 19.05 9.52 2.32
1.53 11.75 20.19 27.75 33.40 36.52 36.64 33.16 26.53 18.21 9.53 2.37
2.02 9.25 16.74 22.51 26.12 27.44 26.50 23.49 18.78 12.96 6.84 1.72
5.88 10.01 12.83 14.03 13.79 12.40 10.21 13.51 8.69 4.28 1.00
10.53 7.22 4.22 1.84
3.59 5.81 12.34 12.40 11.00 8.73 6.15
6.81 6.08 4.59
0.74 2.63 3.85 3.77
0.47 1.51 1.93

DEFLECTIONS IN STAGE 1 (SW)
max deflection = 2.4 mm

Uz [mm]

Uz-min [mm]

DEFLECTIONS IN STAGE 2 (CASTING)
a max deflection = 4.2 mm
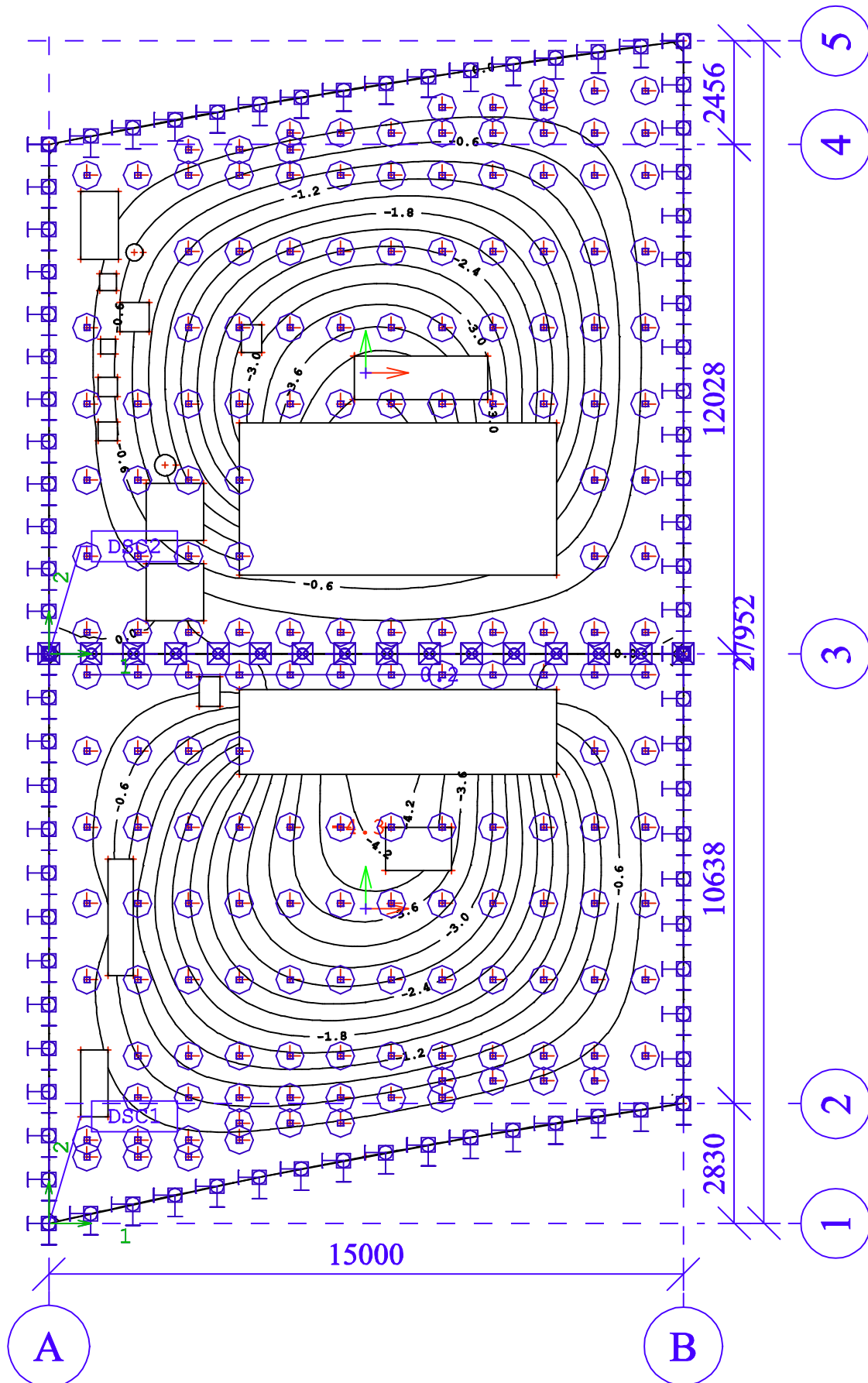
ANNEX 3

Slab bending moment capacity calculation

CALCULATION OF SECTION BENDING MOMENT CAPACITY AS PER BS 8110 : PART 1 : 1997

Units: $\quad kN := 10^3 \cdot N \quad MPa := 10^6 \dfrac{N}{m^2}$

Constants:

$f_y := 460 \dfrac{N}{mm^2}$ reinforcement yield strenght

$f_{cu} := 40 \dfrac{N}{mm^2}$ compressive strenght of concrete

$E_s := 210 \dfrac{kN}{mm^2} \quad E_s = 2.1 \times 10^5\,MPa$ modulus of elasticity of reinforcement

$\gamma_m := 1.5$ partial safety factor for strength of material according to BS 8110 : Part 1 : Section 2.4.2.2; 2.4.4.1, Table 2.2 (concrete in flexure or axial load)

$E_c := 29 \dfrac{kN}{mm^2}$ according to BS 8110 : Part 2 : Table 7.2, for $\quad f_{cu} = 40 \dfrac{N}{mm^2}$

Reinforced concrete section dimensions:

$h := 0.5 \cdot m$ element depth

$b_w := 1 \cdot m$ web width (element width)

$A_g := h \cdot b_w \quad\quad A_g = 0.5\,m^2$ gross area of section

Reinforcement

$c_c := 7.5cm$ clear cover from the nearest surface in tension to the surface of the flexural tension reinforcement

Reinforcement bars sizes / area - 4 layers of reinforcement are considered

$\phi_{b.1} := 25mm \quad\quad \phi_{b.1} = 25\,mm \quad\quad A_{b.1} := \dfrac{\pi \cdot \phi_{b.1}^2}{4} \quad\quad A_{b.1} = 490.874\,mm^2$

$\phi_{b.2} := 0mm \quad\quad \phi_{b.2} = 0\,mm \quad\quad A_{b.2} := \dfrac{\pi \cdot \phi_{b.2}^2}{4} \quad\quad A_{b.2} = 0\,mm^2$

$\phi_{b.3} := 0mm \quad\quad \phi_{b.3} = 0\,mm \quad\quad A_{b.3} := \dfrac{\pi \cdot \phi_{b.3}^2}{4} \quad\quad A_{b.3} = 0\,mm^2$

$\phi_{b.4} := 0mm \quad\quad \phi_{b.4} = 0\,mm \quad\quad A_{b.4} := \dfrac{\pi \cdot \phi_{b.4}^2}{4} \quad\quad A_{b.4} = 0\,mm^2$

$d_1 := h - \left(c_c + \dfrac{\phi_{b.1}}{2} \right) \quad\quad d_1 = 41.25\,cm$ depth of steel reinforcement layers (distance from extreme compression fiber to centroid of tension reinforcement)

$d_2 := 0cm \quad\quad d_3 := 0cm \quad\quad d_4 := 0cm$

$n_{b.1} := 10$ number of bars in each reinforcement layer

$n_{b.2} := 0$ $n_{b.3} := 0$ $n_{b.4} := 0$

$A_{s.1} := n_{b.1} \cdot A_{b.1}$ $A_{s.1} = 4.909 \times 10^3\, mm^2$ reinforcement area per layer

$A_{s.2} := n_{b.2} \cdot A_{b.2}$ $A_{s.2} = 0\, mm^2$

$A_{s.3} := n_{b.3} \cdot A_{b.3}$ $A_{s.3} = 0\, mm^2$

$A_{s.4} := n_{b.4} \cdot A_{b.4}$ $A_{s.4} = 0\, mm^2$

Stress and strain equilibrium - pure bending

$P_{cap} := 0kN$ 0 compression on the element

$\varepsilon_{c.max} := \dfrac{-3}{1000}$ maximum strain at extreme concrete compression

$F_{s.1} := -A_{s.1} \cdot f_y$ $F_{s.1} = -2.258 \times 10^3\, kN$ depth of steel reinforcement layers
$F_{s.2} := -A_{s.2} \cdot f_y$ $F_{s.2} = 0\, kN$ (distance from extreme compression fiber to centroid of tension reinforcement)

$F_{s.3} := -A_{s.3} \cdot f_y$ $F_{s.3} = 0\, kN$

$F_{s.4} := -A_{s.4} \cdot f_y$ $F_{s.4} = 0\, kN$

$F_c := -F_{s.1} - F_{s.2} - F_{s.3} - F_{s.4}$ $F_c = 2.258 \times 10^3\, kN$ forces equilibrium condition

$f_c := 0.67 \cdot \dfrac{f_{cu}}{\gamma_m}$ $f_c = 17.867\, \dfrac{N}{mm^2}$ concrete compression stress - per BS 8110 Figure 3.3

$a := \dfrac{F_c}{b_w \cdot f_c}$ $a = 0.126\, m$ concrete compression area depth - per BS 8110 Figure 3.3

$x := \dfrac{a}{0.9}$ $x = 0.14\, m$

$M_{A.cap} := \left(\dfrac{h-a}{2}\right) \cdot F_c - \left(d_1 - \dfrac{h}{2}\right) \cdot F_{s.1} - \left(d_2 - \dfrac{h}{2}\right) \cdot F_{s.2} - \left(d_3 - \dfrac{h}{2}\right) \cdot F_{s.3} - \left(d_4 - \dfrac{h}{2}\right) \cdot F_{s.4}$

$M_{A.cap} = 788.747\, kN \cdot m$

ANNEX 4

Slab shear capacity calculation

Annex 4
CALCULATION OF SHEAR CAPACITY AS PER BS 8110 : 1997

Units: $\quad kN := 10^3 \cdot N \quad MPa := 10^6 \dfrac{N}{m^2}$

Rectangular column

Constants:

$f_{cu} := 40 \dfrac{N}{mm^2}$ $\quad$ (Characteristic strength of concrete)

$f_y := 460 \dfrac{N}{mm^2}$ $\quad$ (Characteristic strength of reinforcement)

Support dimensions:

$c_x := 0.1 m \qquad c_z := 0.15 m$

$h := 50 cm$ $\qquad$ (Total height of slab)

$d := 42.5 cm$ $\qquad$ (Effective depth of tension reinforcement)

$rep := 10 cm$ $\qquad$ (Bar repartition c to c distance)

$\phi := 25 mm$ $\qquad$ (Bar size)

$A_\phi := \dfrac{\pi \cdot \phi^2}{4}$ $\qquad$ (Bar area - tension reinforcement)

$A_\phi = 490.874 \ mm^2$

$p_\% := \dfrac{100 \cdot A_\phi}{rep \cdot d}$ $\qquad$ (percent of reinforcement)

$p_\% = 1.155$

$\beta b := 1$ $\qquad$ (Redistribution ratio)

$V_t := 44.0 kN$ $\qquad$ (Design ultimate resitance shear)

$M_t := 0 kN \cdot m$ $\qquad$ (Design ultimate resitance associated moment - Figure 3.14 a.)

failure perimeter

$l_p := 1.5 \cdot d$ $\qquad$ (Section 1.3.3.1, Figure 3.16)

$l_p = 0.638 \ m$

sides of the failure perimeter

$x := 2 \cdot l_p + c_x$ $\qquad$ (length of the side of the perimeter considered parallel to the axis of bending - Section 3.7.6.2)

$z := 2 \cdot l_p + c_z$ $\qquad$ (length of the side of the perimeter considered perpendicular to the axis of bending)

$u_0 := 2 \cdot x + 2 \cdot z$ (Effective length of the perimeter)

$u_0 = 5.6\,m$

bibliography: BS8110 Part 1 Section 3

$$V_{eff} := V_t \cdot \left(1 + 1.5\,\frac{M_t}{V_t \cdot x}\right)$$ equation 25

$V_{eff} = 44\,kN$

$$v_{max} := \frac{V_{eff}}{u_0 \cdot d} \qquad\qquad v_{max} = 0.018\,\frac{N}{mm^2}$$ equation 27

Shear capacity without shear reinforcement (Section 3.7.7.4):

v_c from table 3.8

$p_\% = 1.155$

For $d = 0.425\,m$

$p_{1.00} := 1 \qquad\qquad v_{c.1.00} := 0.63\,\frac{N}{mm^2}$

$p_{1.50} := 1.5 \qquad\qquad v_{c.1.50} := 0.72\,\frac{N}{mm^2}$

Interpolation for v_c

$$v_c := \frac{\left(p_\% - p_{1.00}\right)\left(v_{c.1.50} - v_{c.1.00}\right)}{p_{1.50} - p_{1.00}} + v_{c.1.00}$$

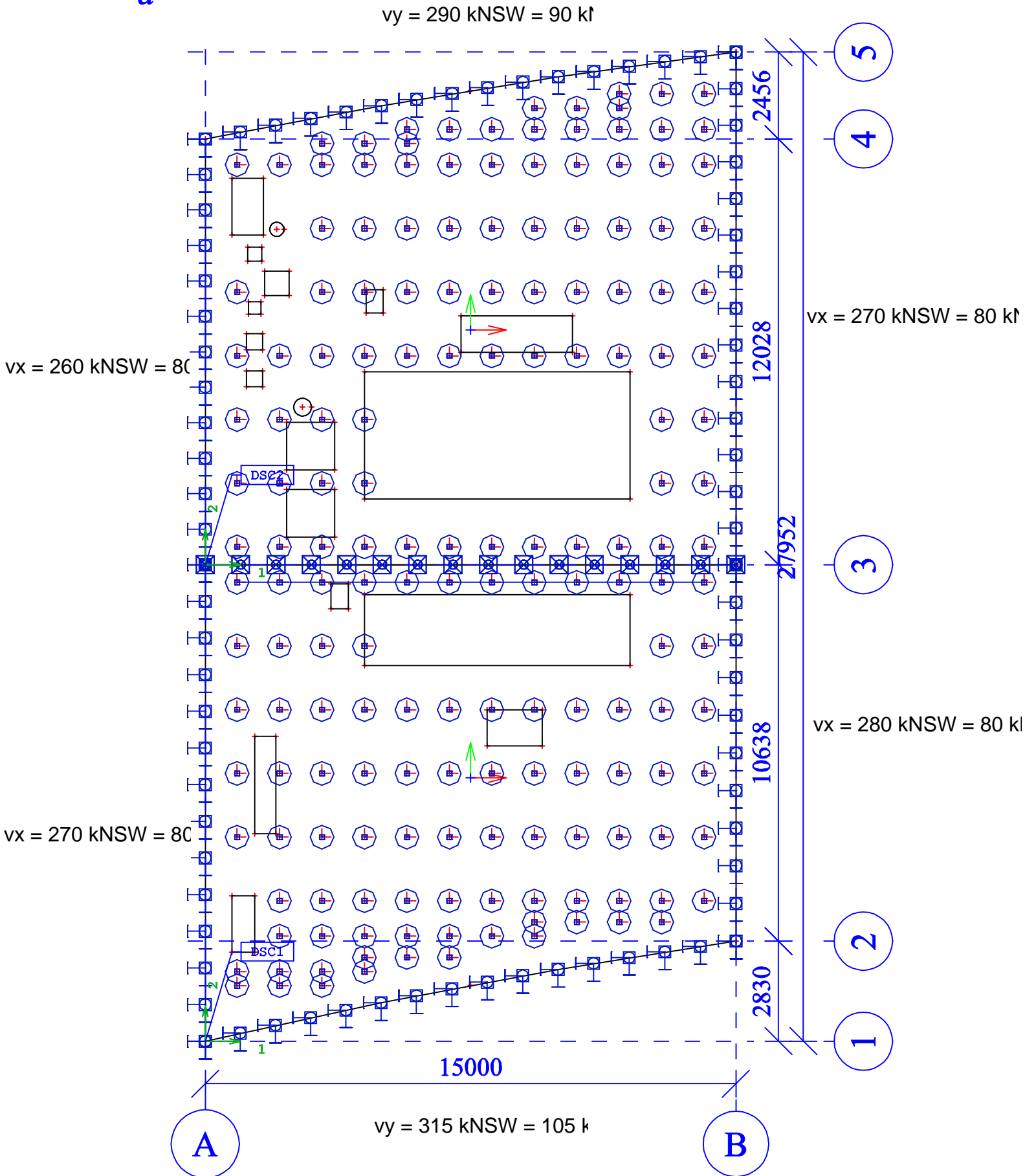$v_c = 0.658\,\frac{N}{mm^2}$

*multiplication factor for $f_{cu} = 40\,\frac{N}{mm^2}$ $\sqrt{\dfrac{\frac{f_{cu}}{\frac{N}{mm^2}}}{25}} = 1.265$

$v_c := v_c \cdot \sqrt{\dfrac{\frac{f_{cu}}{\frac{N}{mm^2}}}{25}} \qquad v_c = 0.832\,\frac{N}{mm^2}$

$v_{max} = 0.018\,\frac{N}{mm^2}$

verification: $v_{max} < v_c = 1$

a

A   B

1   2   3   4   5

15000

2830   10638   27952   12028   2456

DSC1   DSC2

Annex 4
CALCULATION OF SLAB SHEAR CAPACITY AS PER BS 8110 : 1997

Units: $kN := 10^3 \cdot N$ $MPa := 10^6 \dfrac{N}{m^2}$

Rectangular column

Constants:

$f_{cu} := 40 \dfrac{N}{mm^2}$ (Characteristic strength of concrete)

$f_y := 460 \dfrac{N}{mm^2}$ (Characteristic strength of reinforcement)

Support dimensions:

$h := 50 cm$ (Total height of slab)

$d := 42.5 cm$ (Effective depth of tension reinforcement)

$rep := 10 cm$ (Bar repartition c to c distance)

$\phi := 25 mm$ (Bar size)

$A_\phi := \dfrac{\pi \cdot \phi^2}{4}$ (Bar area - tension reinforcement)

$A_\phi = 490.874\ mm^2$

$p_\% := \dfrac{100 \cdot A_\phi}{rep \cdot d}$ (percent of reinforcement)

$p_\% = 1.155$

$\beta b := 1$ (Redistribution ratio)

$V_t := 315 kN$ (Design ultimate resitance shear)

failure section length

$b := 1 m$

bibliography: BS8110 Part 1 Section 3

$v_{max} := \dfrac{V_t}{b \cdot d}$ $v_{max} = 0.741 \dfrac{N}{mm^2}$ equation 21

Shear capacity without shear reinforcement (Section 3.7.7.4):

v_c from table 3.8

$p_\% = 1.155$

For $d = 0.425\ m$

$$p_{1.00} := 1 \qquad v_{c.1.00} := 0.63 \frac{N}{mm^2}$$

$$p_{1.50} := 1.5 \qquad v_{c.1.50} := 0.72 \frac{N}{mm^2}$$

Interpolation for $\quad v_c$

$$v_c := \frac{\left(p_\% - p_{1.00}\right)\left(v_{c.1.50} - v_{c.1.00}\right)}{p_{1.50} - p_{1.00}} + v_{c.1.00}$$

$$v_c = 0.658 \frac{N}{mm^2}$$

*multiplication factor for $\qquad f_{cu} = 40 \frac{N}{mm^2} \qquad\qquad \sqrt{\dfrac{\frac{f_{cu}}{\frac{N}{mm^2}}}{25}} = 1.265$

$$v_c := v_c \cdot \sqrt{\frac{\frac{f_{cu}}{\frac{N}{mm^2}}}{25}} \qquad v_c = 0.832 \frac{N}{mm^2}$$

$$v_{max} = 0.741 \frac{N}{mm^2}$$

verification: $\qquad v_{max} < v_c = 1 \qquad\qquad \dfrac{v_{max}}{v_c} = 0.891$