ESKOM HOLDINGS LIMITED

PANEL B CONSULTANTS JOINT VENTURE

KUSILE POWER STATION

SDD SETTLING TANKS

DETAILED DESIGN REPORT 5452/80/021 REV 0

Task Order Number: PBC JV – TO #31

MAY 2010

ARCUS GIBB ENGINEERING & SCIENCE

SSI A DHV COMPANY

Knight Piésold CONSULTING

ESKOM HOLDINGS LIMITED

KUSILE POWER STATION

SDD SETTLING TANKS

DETAILED DESIGN REPORT 5452/80/021 REV 0

TABLE OF CONTENTS

APPENDICES:

ESKOM HOLDINGS LIMITED

KUSILE POWER STATION

SDD SETTLING TANKS

DETAILED DESIGN REPORT 5452/80/021 REV 0

MAY 2010

1 INTRODUCTION

The Panel B Consultants Joint Venture (CJV) has been appointed by Eskom Enterprises to carry out the civil design of the water license structures for the Kusile Power Station.

This report details the design of the Station Dirty Dams Settling Tanks (SDD ST).

1.1 Background

Eskom is the principal supplier of electricity in South Africa. In order to meet the growing need for electricity, and in support of the growth and development strategy of the national government, Eskom has embarked on an expansion program to build new power stations. Part of this expansion program includes the construction of two large coal-fired power stations.

Located near Witbank and Kendal Power Station in the Mpumalanga province, Kusile Power Station will be a 4,800 MW coal-fired power plant. Kusile Power Station is currently under construction with a target commissioning date of June 2014 for the first of its six units.

1.2 Scope

Panel B CJV is responsible for the engineering design and construction drawings for the Pollution Control Dams (PCDs) at Kusile Power Station. This is the detailed design report for the SDD ST. It addresses all client requirements, as well as all relevant South African regulatory requirements. These include:

- The National Water Act, No. 36 of 1998.
- Section 117(c)(i) of the National Water Act, 1998, relating to dams with a safety risk.
- Government Notice No. 704, Regulations on use of water for mining and related activities aimed at the protection of water resources, in terms of the National Water Act (Act 36 of 1998)
- SANS 1200: Standardised Specifications for Civil Engineering Construction

1.3 Client User Requirement Specification

The design criteria for the CSY ST satisfy the requirements of the Eskom User Requirement Specification (URS) as detailed in *Section 5.2.2: Water Management*.

1.4 Drawings

All SDD ST detailed design drawings are listed below. Those that are relevant to the water use license application are marked with an asterisk and are provided in Appendix A.

- *K5452-80-033: Settling Tanks: Typical Details Sheet 1 of 2;
- *K5452-80-034: Settling Tanks: Typical Details Sheet 2 of 2;
- *K5452-80-035: SDD Settling Tanks: General Arrangement;
- *K5452-80-036: SDD Settling Tanks: Typical Sections and Details;
- *K5452-80-037: SDD Settling Tanks: Surface Bed Layout and Details;
- *K5452-80-038: SDD Settling Tanks: Energy Dissipator – GA and Details;
- *K5452-80-039: SDD Settling Tanks: Outlet – GA and Details;
- K5452-80-061: Settling Tanks Floor Reinforcement Details Sheet 1;
- K5452-80-062: Settling Tanks Floor Reinforcement Details Sheet 2;
- K5452-80-063: Settling Tanks Wall Reinforcement Details;
- K5452-80-064: Settling Tanks Inlet Reinforcement Details;
- K5452-80-065: Settling Tanks Outlet Reinforcement Details;
- K5452-80-066: SDD Settling Tanks: Dissipator Reinforcement Details;
- K5452-80-068: Settling Tanks Typical Reinforcement Details;
- *K5452-80-071: SDD Settling Tanks Inlet and Outlet Pipeworks: General Arrangement;
- *K5452-80-072: SDD Settling Tanks Inlet and Outlet Pipeworks: Sections and Details;
- *K5452-80-100: SDD Settling Tanks Inlet and Outlet Pipeworks: Sections;
- K5452-80-103: SDD Settling Tanks Junction Box Details: GA, Sections and Reinforcement JBK9A;
- K5452-80-104: SDD Settling Tanks Junction Box Details: Reinforcement Sections, Elevations, and Schedules JBK9A;
- K5452-80-105: SDD Settling Tanks Junction Box Details: GA, Sections and Reinforcement JBK9B;
- K5452-80-106: SDD Settling Tanks Junction Box Details: Reinforcement Sections, Elevations, and Schedules JBK9B;
- K5452-80-107: SDD Settling Tanks Junction Box Details: GA, Sections and Reinforcement JBK10;
- K5452-80-108: SDD Settling Tanks Junction Box Details: Reinforcement Sections, Elevations, and Schedules JBK10;
- K5452-80-109: SDD Settling Tanks Junction Box Details: GA, Sections and Reinforcement JBK11;
- K5452-80-111: SDD Settling Tanks Junction Box Details: Reinforcement Sections, Elevations, and Schedules JBK11;
- K5452-80-112: SDD Settling Tanks Junction Box Details: GA, Sections and Slab Reinforcement JBK12;

- K5452-80-113: SDD Settling Tanks Junction Box Details: Sections and Walls Reinforcement JBK12;
- K5452-80-114: SDD Settling Tanks Junction Box Details: GA, Sections and Slab Reinforcement JBK13;
- K5452-80-115: SDD Settling Tanks Junction Box Details: Sections and Walls Reinforcement JBK13;
- K5452-80-116: SDD Settling Tanks Junction Box Details: GA, Sections and Reinforcement JBK14;
- K5452-80-117: SDD Settling Tanks Junction Box Details: Reinforcement Sections, Elevations, and Schedules JBK14;
- K5452-80-118: SDD Settling Tanks Junction Box Details: Reinforcement Bending Schedules JBK12;
- K5452-80-119: SDD Settling Tanks Junction Box Details: Reinforcement Bending Schedules JBK13;

2 SDD SETTLING TANKS DESIGN

2.1 Overview

The Station Dirty Dams Settling Tanks (SDD ST) are located to the north-west of the main power block, and south-east of the Station Dirty Dams (SDD).

All potentially contaminated water on the Kusile Power Station is managed in a closed system.

The SDD ST consists of two equal capacity concrete basins that clarify contaminated water from the power station terrace before it travels by gravity pipeline to the Station Dirty Dams (SDD). The SDD ST will receive dirty water inflows from the main power station terrace, via the *Black and* Veatch pipeline that terminates at JB 509. At JB 509, *Knight* Piesold continues the pipeline design to the SDD ST and ultimately to the SDD.

The SDD ST general arrangement and typical sections are provided on Drawings K5452-80-035 and K5452-80-036.

2.2 Design Parameters

The SDD ST was designed to meet the following location and capacity requirements:

2.2.1 Location and Size

The SDD ST will receive gravity discharges of dirty water from the power station terrace. The overall site layout dictated an optimal location north-west of the power station terrace, and south-east of the SDD. This position is down-gradient of the power station terrace and in close proximity to the SDD.

The SDD ST terrace is at elevation 1462.5 masl. The two compartments of the settling tank are partially excavated into the natural ground and partially built in a fill terrace. The terrace elevation was carefully planned in conjunction with the inlet and outlet pipe hydraulic requirements. Refer to *Appendix B: Calculation Records* for inlet and outlet pipeworks calculations.

The layout of the SDD ST is shown on K5406-80-035. The structure was designed with the exact same geometrical parameters as the Coal Stockyard Settling Tanks (CSY ST) for consistency and reduced costs in terms of design and construction efforts. Refer to *5452/80/009 Rev1: Coal Stockyard Settling Tanks – Detailed Design Report* for reference.

2.2.2 Capacity

Government Notice Regulation 704 specifies that a dirty water system may not spill into a clean water system more than once in 50 years, and that 800 mm freeboard be supplied above the maximum operating level.

The plant terrace hydrology calculations were performed by *Black and Veatch* and yielded a 1:50 year, peak instantaneous storm inflow of 10.8 m^3/s. The SDD ST

hydraulic design, including gate sizing, freeboard checks, and flow velocities was performed based on the *Black and Veatch* hydrology. The calculations are presented in *Appendix B: Calculation Records*.

The SDD ST is designed to pass all of the dirty water runoff from its inflow sources for the 1:50 year, peak instantaneous storm event. The SDD ST is designed with an emergency spillway to accommodate larger events, as indicated in schematic on *Figure 2-2*.

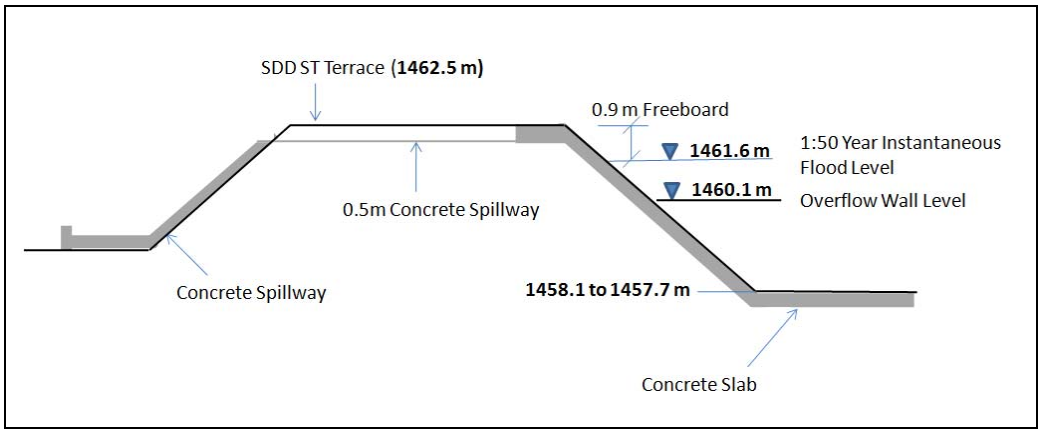


Figure 2-2: SDD ST Operating Levels

The SDD ST is designed with two equal capacity compartments which can each pass 6.55 m^3/s. The water enters each compartment of the SDD ST via four sluice gates, 1.75 m square (K5452-80-036). Having two compartments allows for occasional maintenance and inspection access (preferably during the dry season) without interrupting the functionality of the structure under normal circumstances.

2.2.3 Operation

Normally the gates to both compartments of the SDD ST will be open, and each compartment will receive half of the total inflow. Except during maintenance, the SDD ST settling chambers will be full at all times due to the presence of the overflow wall at the outlet end of the tanks. A compartment can be emptied by first closing the gates at the entrance, and then installing a submersible pump that discharges to the outlet chamber.

The settling efficiency is at its highest with very low inflows, because the detention time of the impounded water is large. As flow increases towards the design inflow event, the detention time decreases and the particle size that can be settled increases. *Section 2.3* describes the particle size settling calculations.

2.3 Particle Size Settlement Calculations

The particle size settling calculations are based on standard industry theory for viscous fluids. The tank parameters used for calculating particle settling are presented in *Table 2-1*. Note that although the main settling chamber is 125 m long, the effective settling length has been reduced by 10 percent to account for turbulence at the inlet and outlet ends of the tank. This is considered to be a conservative

design approach. The effective width accounts for the average equivalent rectangular shape of the trapezoidal tank.

Figure 2-1 indicates the particle size settling characteristics for various inflow rates to one compartment of the SDD ST, as per the tank geometry presented in *Table 2-1*. These calculations are based on an assumed water temperature of 15^{o}C, a particle specific gravity of 1.5 and a particle shape factor of 0.9. *Appendix B: Calculation Records* contains all the relevant particle settling calculations.

Table 2-1 : Settling Compartment Parameters

Settling Compartment Parameters	
Effective Width (m)	16.0
Length (m)	125.0
Effective Length (m)	112.5
Depth (m)	2.0
Length/Width Ratio	7.8
Storage Volume (m^3)	3987.5
Cross Sectional Area (m^2)	31.9

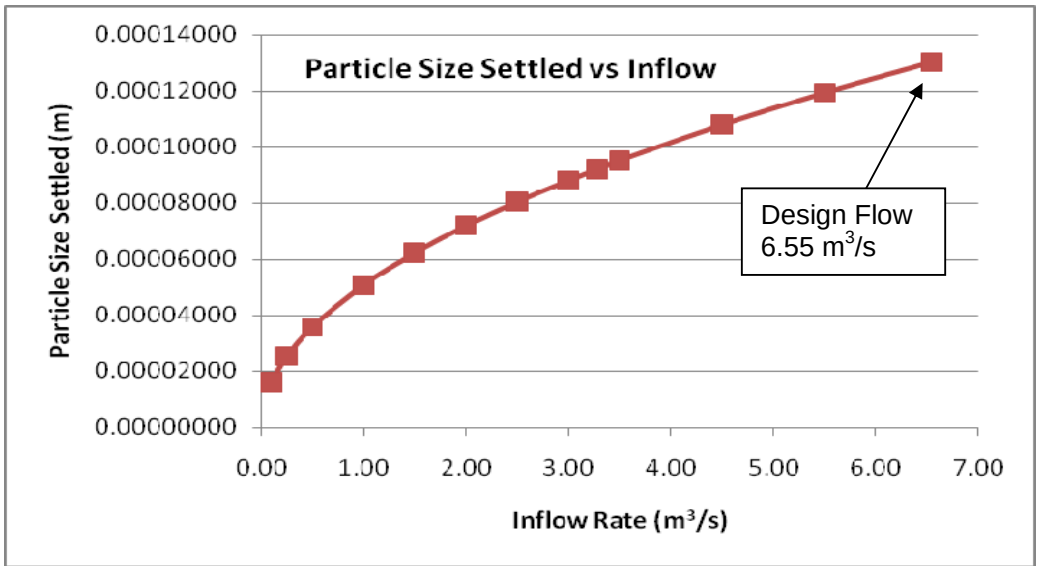


Figure 2-3: Particle Size Settled vs. Inflow Rate

2.4 Concrete Works

The SDD ST are required to be fully concrete structures due to the maintenance equipment that will be used to clean the floors. The structures consist of 250 mm thick base and side wall slabs and maintenance access ramps, concrete cantilever end walls, overflow walls, and central dividing wall, and a concrete energy dissipator at the inlet end. The structural reinforcement design is included in *Appendix B: Calculation Records*.

The concrete reinforcing drawings for the SDD ST are K5452-80-

2.5 Geotechnical Conditions

The SDD ST will be excavated into a terrace built primarily above the natural ground level. However, in some areas, the floor of the tank will be below natural ground level.

The geotechnical information supplied by Partridge Maud and Associates, report reference number 1-6/07 entitled *Project Bravo - Report on Geotechnical Investigations Undertaken at the Power Station Site* indicates the overall geotechnical conditions of the plant site.

It is anticipated that poor geotechnical conditions could be encountered in the area of the SDD ST. This could include organic material underlain by saturated decomposed diabase.

Foundation preparations will depend on the geotechnical conditions encountered, and will likely include the complete removal of organics and decomposed diabase in the vicinity of the SDD ST, down to refusal on competent bedrock, or a minimum bearing capacity of 300 kPa. Selected backfill will then be placed in 200 mm lifts and compacted to 96% Mod. AASHTO.

The possibility of a high water table necessitates the installation of groundwater finger drains beneath the concrete to prevent possible uplift forces. The configuration of the groundwater finger drains is shown on K5452-80-035.

The drains will be formed by excavating a 500 mm deep, trapezoidal trench. A 160 mm diameter HDPE flexible slotted drainage pipe (Drainex or similar approved) will be installed, the trench filled with 19 mm washed stone and the pipe and stone wrapped in a non-woven needled punched geofabric (Bidim A4 or similar approved) with a minimum overlap of 300 mm. (Refer to K5452-80-023 for details). The drains will conform to the bottom slope of the SDD ST. Where the drains exit from beneath the footprint of the structure, the perforated pipe will change to an un-perforated 160 mm OD PVC-U class 12 outlet pipe. The outlet pipe will daylight to a groundwater finger drain outlet structure at a 1 percent grade. Refer to Drawing K5452-80-033 for the finger drain outlet structure details.

2.6 Inlet Details

Inflow to the SDD ST will be through one 1,950 mm ND Class 100D concrete pipe (Rocla or similar), as indicated on Drawing K5452-80-071. The inflow will impact an energy dissipator that prevents damage to the SDD ST. The energy dissipator has been sized to handle the 1:50 year, design instantaneous inflow of 10.8 m^3/s. The energy dissipator is detailed on Drawing K5452-80-038.

2.7 Oil/Water Separation

At the end of the settling chambers of the SDD ST, water spills over a wall and into the oil/water separation chamber. A Drizit TPCS300 oil/water separator with floating weir skimmer and process pump (or equally approved equipment) will extract oils and other floating contaminants before the water exits the chamber through a submerged 4m x 1m opening.

2.8 Outlet Details

At the north end of the SDD ST, the water spills over a wall and into the outlet chamber. The outlet chamber has a 1950 ND Class 100D Rocla (or similar) outlet pipe that is the start of the long pipeline to the SDD. Drawing K5452-80-039 details the outlet configuration.

2.9 Emergency Spillway

A 5 m wide, 500 mm deep trapezoidal spillway is provided at the west side of the SDD ST to protect the SDD ST terrace in flood events that exceed the 1:50 year, instantaneous discharge event. The spillway is detailed on Drawing K5452-80-037.

2.10 Inlet and Outlet Pipes and Junction Boxes

Drawings K5452-50-071, K5452-80-072, and K5452-80-100 show the arrangement and details for the inlet and outlet pipes of the SDD ST and the SDD. Dirty water inlet pipes have been designed with a minimum of 2% gradient when possible to ensure they are self cleaning of sludge or grit that may be in the water. In some instances, pipe battery limits and required invert levels along the pipeline required a shallower gradient. Calculations for pipe capacities are included in *Appendix B: Calculation Records*.

Drawings K5452-80-103 through K5452-80-119 (except drawing K5452-80-110) detail the junction boxes along the inlet and outlet pipelines of the SDD and SDD ST. The structural reinforcement design calculations are included in Appendix B: Calculation Records.

2.11 Perimeter Access Road

The SDD ST perimeter access roads willl be 5 m wide. The road layer works will comprise a base, sub-base and wearing course layers. The layer specifications are summarised in Table 2-1.

Table 2-2: Access Road Layer Specifications

Layer name	Thickness (mm)	Type
Base	150	G3
Upper Sub-Base	150	G4
Lower Sub-Base	150	G7
Upper Selected	150	G9
Lower Selected/Sub-Grade	150	G10

2.12 Construction

All construction activities are to comply with the terms of SANS 1200, Standard Specifications for Civil Engineering Construction. Particular attention to the foundation preparation (removal of organics and weathered diabase, compaction of selected granular backfill) must be paid in order to ensure the stability of the structure.

3 REFERENCES

1. National Water Act, 1998.

2. Government Notice No.704, Regulations on use of water for mining and related activities aimed at the protection of water resources, in terms of the National Water Act (Act 36 of 1998)

3. Project Bravo – Report on Geotechnical Investigations undertaken at the Power Station site, No. 1-6/07, Partridge Maude and Associates, March 2008.

4. SANS 1200: Standardised Specifications for Civil Engineering Construction

5. 5452/80/009 Rev1: Coal Stockyard Settling Tanks – Detailed Design Report

4 DOCUMENT CONTROL SHEET

CLIENT : ESKOM HOLDINGS LIMITED

PROJECT : KUSILE POWER STATION **PROJECT No : 5452/80**

TITLE : STATION DIRTY DAMS – DESIGN REPORT

	Prepared by	Reviewed by	Approved by
ORIGINAL	NAME **S REES**	NAME **JRG WILLIAMSON**	NAME **D GRANT-STUART**
DATE 11 May 2010	SIGNATURE	SIGNATURE	SIGNATURE

	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

APPENDIX A

DRAWINGS

K5452-80-033: Settling Tanks: Typical Details Sheet 1 of 2;

K5452-80-034: Settling Tanks: Typical Details Sheet 2 of 2;

K5452-80-035: SDD Settling Tanks: General Arrangement;

K5452-80-036: SDD Settling Tanks: Typical Sections and Details;

K5452-80-037: SDD Settling Tanks: Surface Bed Layout and Details;

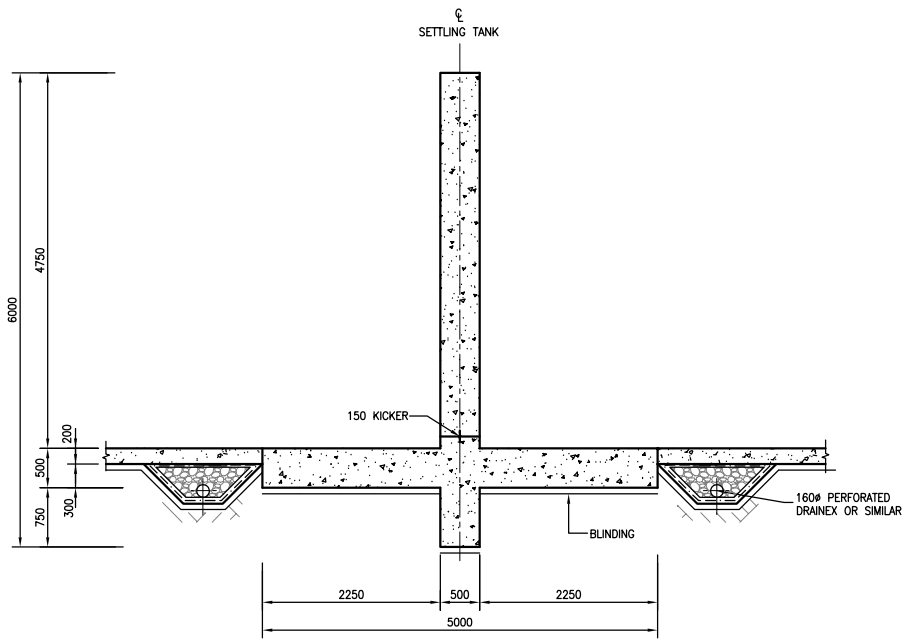
K5452-80-038: SDD Settling Tanks: Energy Dissipator – GA and Details;

K5452-80-039: SDD Settling Tanks: Outlet – GA and Details;

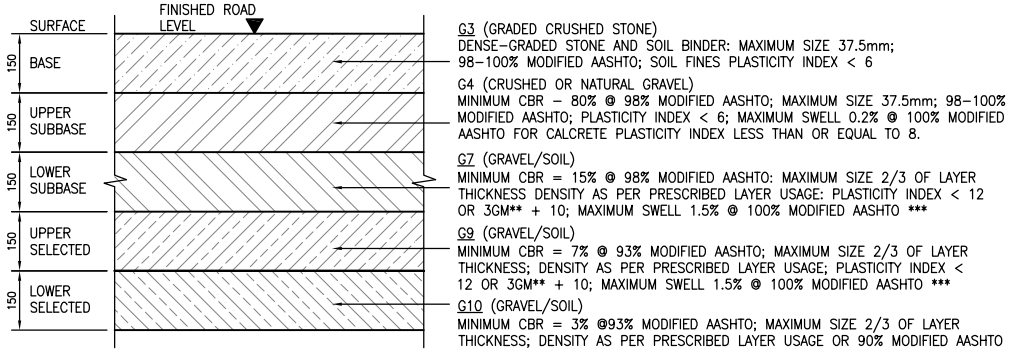
K5452-80-071: SDD Settling Tanks Inlet and Outlet Pipeworks: General Arrangement;

K5452-80-072: SDD Settling Tanks Inlet and Outlet Pipeworks: Sections and Details;

K5452-80-100: SDD Settling Tanks Inlet and Outlet Pipeworks: Sections;



DETAIL 5
SCALE 1:50



G3 (GRADED CRUSHED STONE)
DENSE-GRADED STONE AND SOIL BINDER: MAXIMUM SIZE 37.5mm; 98-100% MODIFIED AASHTO; SOIL FINES PLASTICITY INDEX < 6

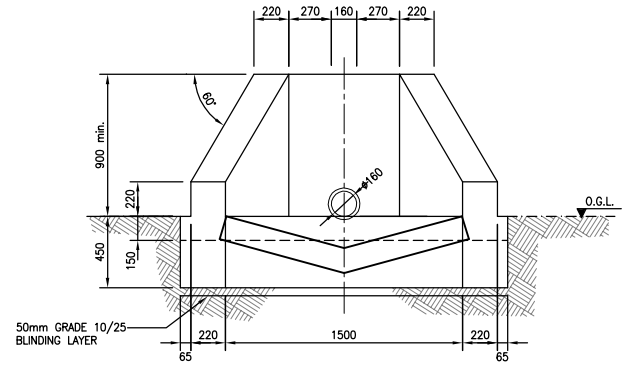
G4 (CRUSHED OR NATURAL GRAVEL)
MINIMUM CBR - 80% @ 98% MODIFIED AASHTO; MAXIMUM SIZE 37.5mm; 98-100% MODIFIED AASHTO; PLASTICITY INDEX < 6; MAXIMUM SWELL 0.2% @ 100% MODIFIED AASHTO FOR CALCRETE PLASTICITY INDEX LESS THAN OR EQUAL TO 8.

G7 (GRAVEL/SOIL)
MINIMUM CBR = 15% @ 98% MODIFIED AASHTO: MAXIMUM SIZE 2/3 OF LAYER THICKNESS DENSITY AS PER PRESCRIBED LAYER USAGE: PLASTICITY INDEX < 12 OR 3GM** + 10; MAXIMUM SWELL 1.5% @ 100% MODIFIED AASHTO ***

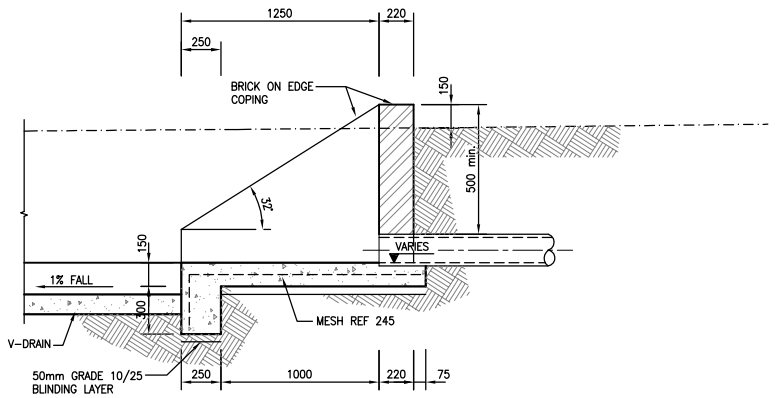
G9 (GRAVEL/SOIL)
MINIMUM CBR = 7% @ 93% MODIFIED AASHTO; MAXIMUM SIZE 2/3 OF LAYER THICKNESS; DENSITY AS PER PRESCRIBED LAYER USAGE; PLASTICITY INDEX < 12 OR 3GM** + 10; MAXIMUM SWELL 1.5% @ 100% MODIFIED AASHTO ***

G10 (GRAVEL/SOIL)
MINIMUM CBR = 3% @93% MODIFIED AASHTO; MAXIMUM SIZE 2/3 OF LAYER THICKNESS; DENSITY AS PER PRESCRIBED LAYER USAGE OR 90% MODIFIED AASHTO

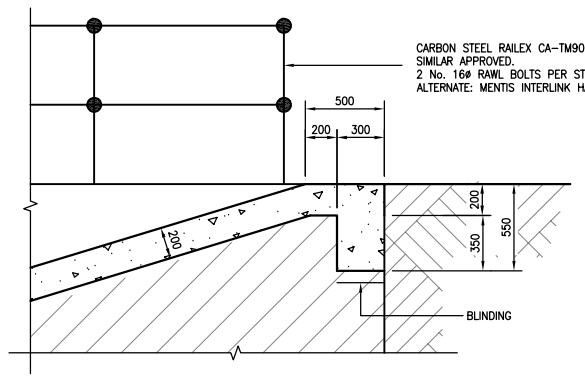
LAYERWORKS DETAIL
TYPICAL AGGREGATE SURFACED ROAD (5m)
SCALE 1:10



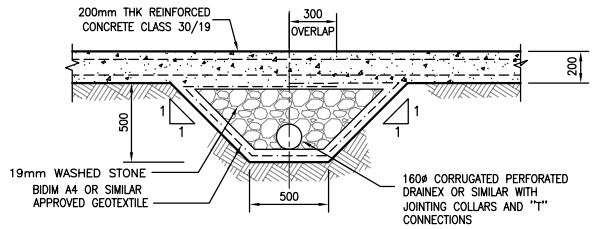
ELEVATION



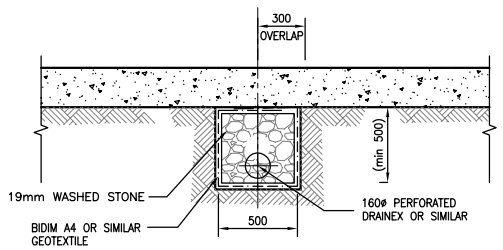
SECTION X
SCALE 1:25



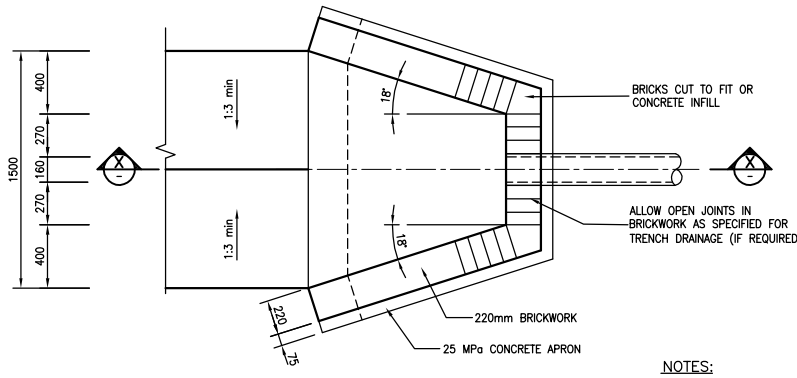
DETAIL 6
SCALE 1:25



TYPICAL FINGER DRAIN DETAIL - UNDER SLAB
(FOR GROUNDWATER INTERCEPTION)
SCALE 1:25



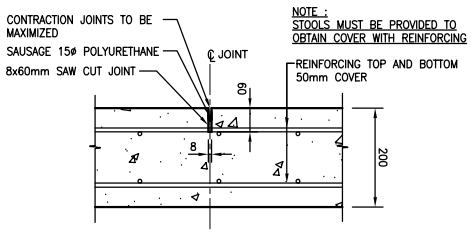
TYPICAL DRAIN DETAIL - UNDER LINER
(FOR GROUNDWATER INTERCEPTION)



TYPICAL PLAN ON GROUNDWATER DRAIN OUTLET

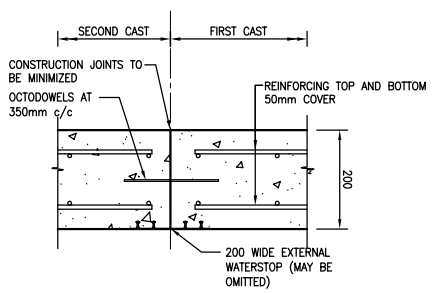
NOTES:

1. ALL BRICKWORK TO BE ENGINEERING UNITS TO SANS 227.
2. ALLOW EXPOSED CONCRETE TO BE STEEL TROWEL FINISH.



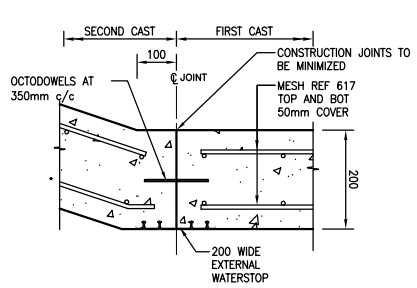
DETAIL 1
SCALE 1:10

TYPICAL CONTRACTION (SAW-CUT)
JOINT IN FLOOR SLABS (S.C.J.)



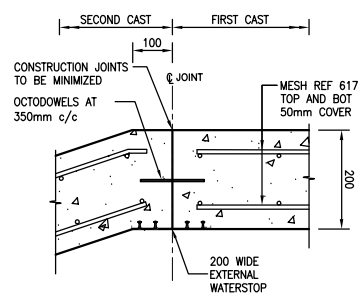
DETAIL 2
SCALE 1:10

TYPICAL CONSTRUCTION
JOINT IN FLOOR SLABS (C.J.)



DETAIL 3
SCALE 1:10

TYPICAL CONSTRUCTION JOINT IN FLOOR
SLABS ON INCLINED SLOPE (C.J.)



DETAIL 4
SCALE 1:10

TYPICAL CONSTRUCTION JOINT IN FLOOR
SLABS ON INCLINED SLOPE (C.J.)

REV	DATE	REVISION / INDEX REFERENCE	DRN BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
							5452-80-044 CSY SETTLING TANKS - OUTLET DETAILS
							5452-80-043 CSY SETTLING TANKS - INLET DETAILS
							5452-80-042 CSY SETTLING TANKS - SURFACE BED
							5452-80-041 CSY SETTLING TANKS-TYPICAL SECTIONS
							5452-80-040 CSY SETTLING TANKS - G.A.
							5452-80-039 SSO SETTLING TANKS - OUTLET
							5452-80-038 SSO SETTLING TANKS - INLET
							5452-80-037 SSO SETTLING TANKS - SURFACE BED
1	16/04/10	APPROVED FOR CONSTRUCTION	Z.L	SR	JRW		5452-80-036 SSO SETTLING TANKS - TYP. SECTIONS
0	05/03/10	ISSUED FOR COMMENT AND APPROVAL	D.E.M. Z.L	FB/SR	JRW		5452-80-035 SSO SETTLING TANKS - G.A.

DRG REGISTER		APPROVED FOR ESKOM BY: MDB	DATE: 16/04/10
DESIGN APPROVED	24/08/09	JRW	
KKS APP			
QC AUTH	16/04/10	DO	
CHKD BY	24/08/09	JRW	
DRAWN BY	24/08/09	D.E.M.	
SCALE	AS SHOWN		

PANEL B CONSULTANTS (Pty) LTD
Knight Piésold CONSULTING

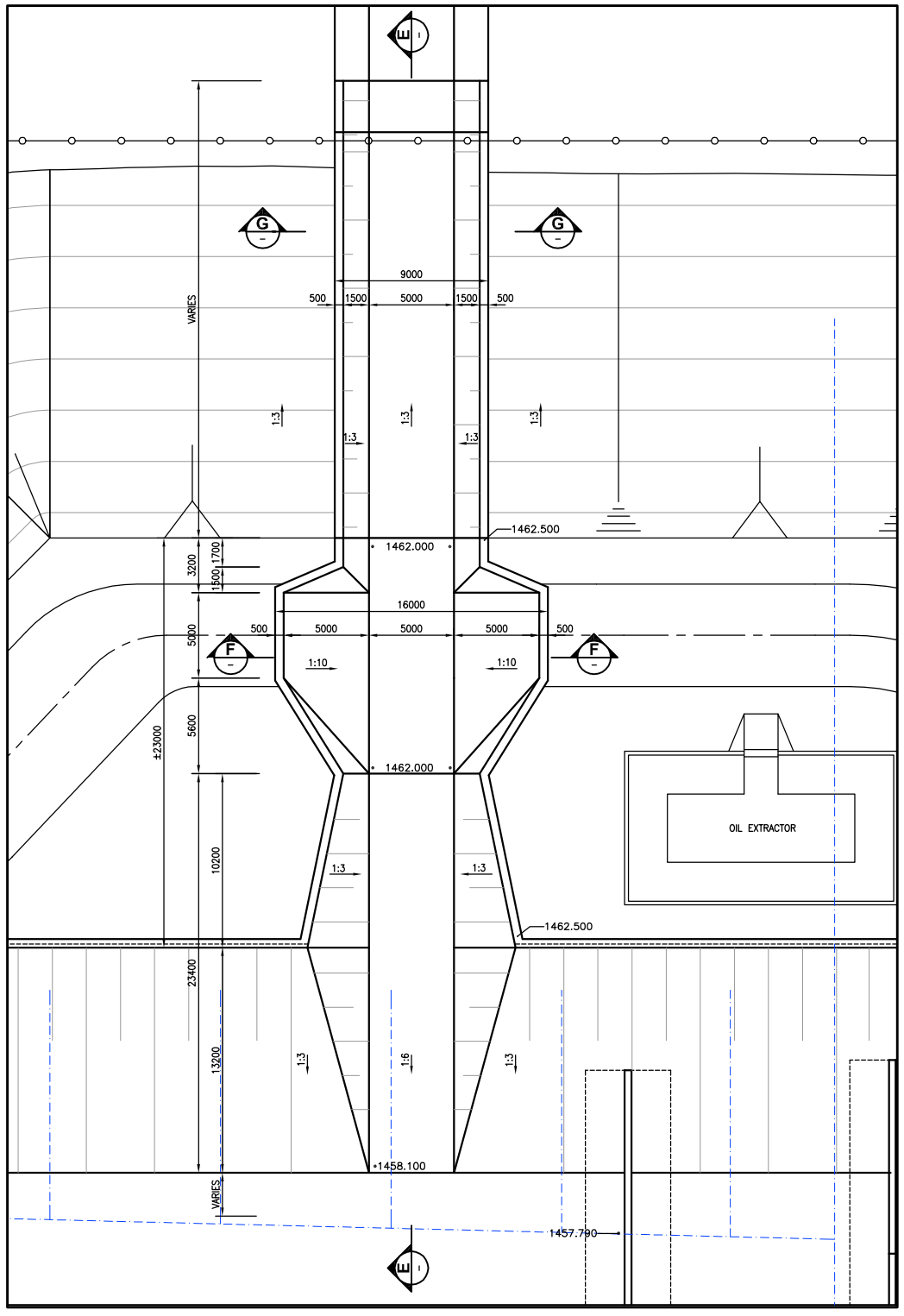
Eskom

KUSILE POWER STATION

SETTLING TANKS
TYPICAL DETAILS SHEET 1/2

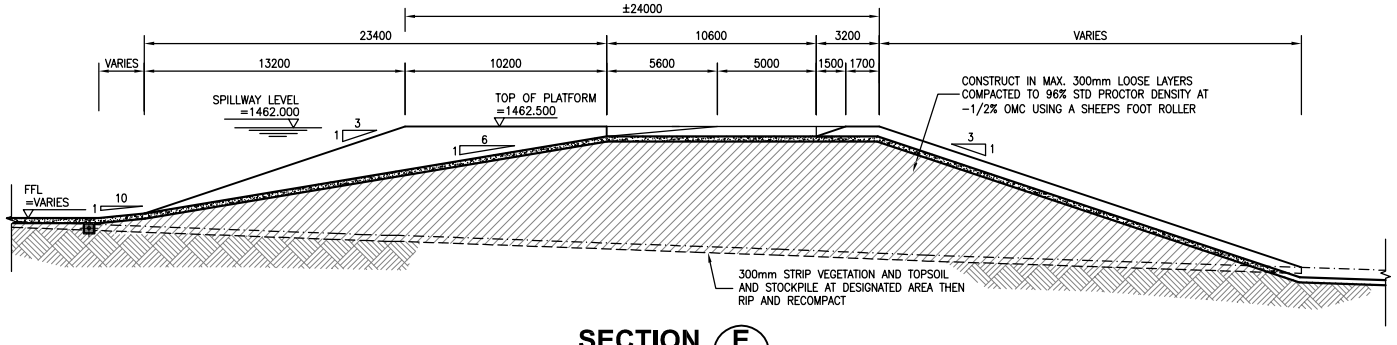
DRG. No. K 5452-80-033 REV 1

0.90/2404 SHEET A1 REV 1

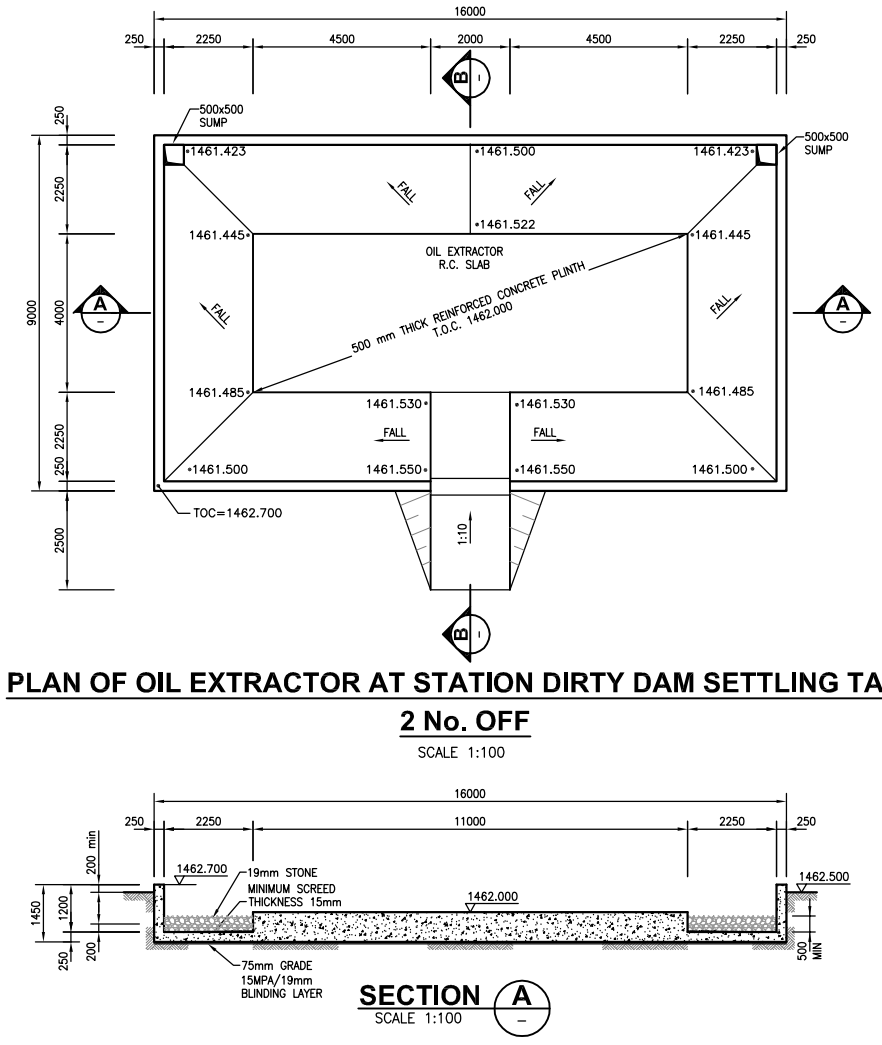


PLAN OF SPILLWAY STATION DIRTY DAM SETTLING TANKS
1 No. OFF + 1 No. SIMILAR

SCALE 1:200



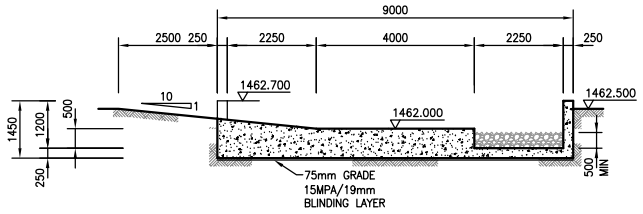
SECTION E
SCALE 1:200



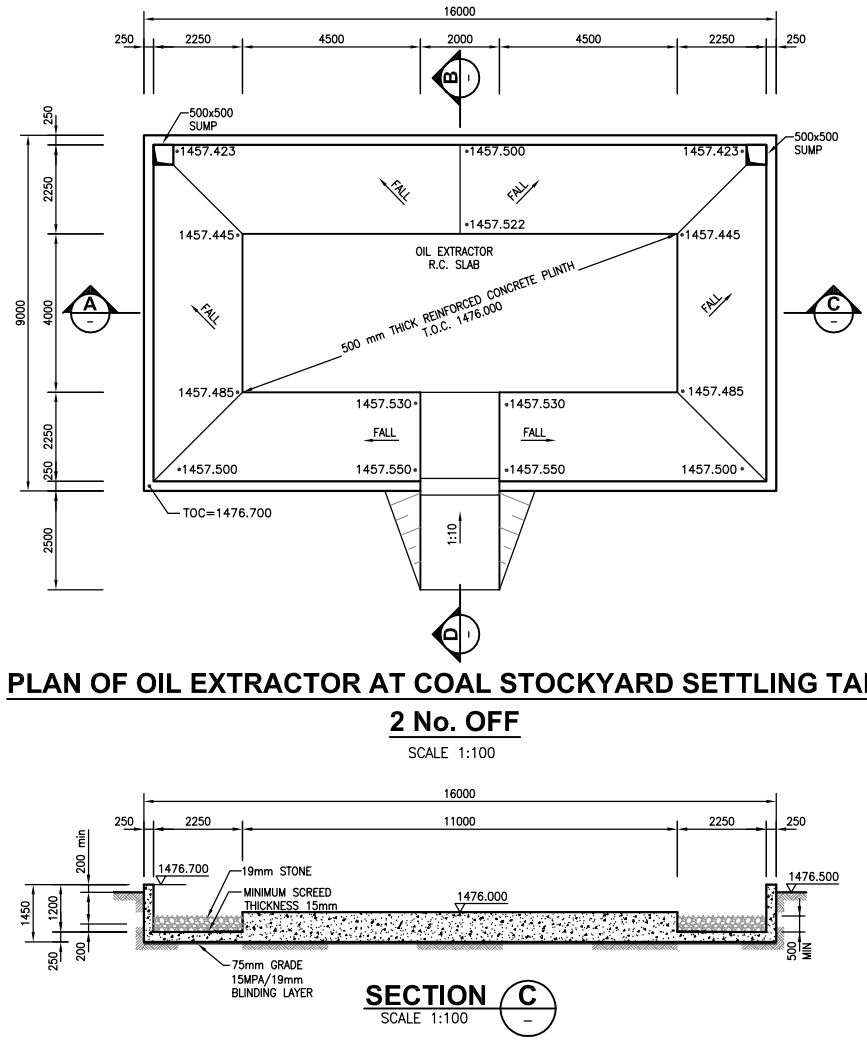
PLAN OF OIL EXTRACTOR AT STATION DIRTY DAM SETTLING TANK
2 No. OFF

SCALE 1:100

SECTION A
SCALE 1:100



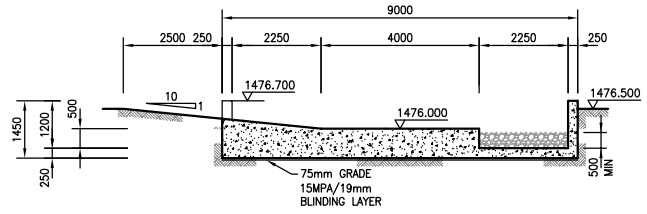
SECTION B
SCALE 1:100



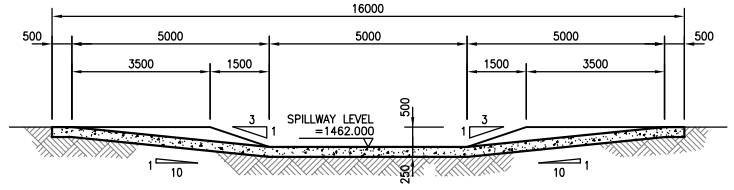
PLAN OF OIL EXTRACTOR AT COAL STOCKYARD SETTLING TANK
2 No. OFF

SCALE 1:100

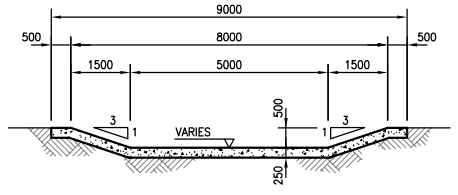
SECTION C
SCALE 1:100



SECTION D
SCALE 1:100



SECTION F
SCALE 1:100



SECTION G
SCALE 1:100

	1	16/04/10	APPROVED FOR CONSTRUCTION		ZJL	SR	JRW		5452-80-040 C.S.V. SETTLING TANKS – G.A.
	-	0	05/03/10	ISSUED FOR COMMENT AND APPROVAL	N.E.M. Z.L.	FB/SR	JRW	-	5452-80-035 S.D.D. SETTLING TANKS – G.A.
D.O. REV		DATE	** REVISION **		REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
DRG REGISTER			INDEX REFERENCE : STANDARD FOR ENGIN SH.	DATE					
DESIGN APPROVED	24/08/09	JRW		MDB 16/04/10					
KKS APP									
DO. AUTH	16/04/10	DO							
CHKD BY	24/08/09	JRW	PANEL & CONSULTANTS JOINT VENTURE Knight Piésold CONSULTING						
DRAWN BY	24/08/09	N.E.M.							
SCALE	1:100		Eskom						

KUSILE POWER STATION

SETTLING TANKS
TYPICAL DETAILS SHEET 2/2

DRG. No. K 5452-80-034 REV 1

0.90/2405 SHEET A1 REV 1

GENERAL ARRANGEMENT OF STATION DIRTY DAMS SETTLING TANKS

SCALE 1:500

COORDINATE LIST

PLANT GRID

STATION DIRTY DAM SETTLING TANKS		
POINT	N-COORD	E-COORD
CONST:		
ST10	10711.861	8656.414
ST11	10711.861	8754.714
ST12	10653.361	8754.714
ST13	10641.861	8743.214
ST14	10533.461	8743.214
ST15	10533.461	8669.914
ST16	10631.861	8669.914
ST17	10645.361	8656.414
ST18	10698.461	8679.914
ST19	10698.461	8733.214
ST20	10701.461	8706.564
ST21	10669.061	8719.514
ST22	10666.061	8719.514
ST23	10669.061	8693.614
ST24	10664.061	8693.614
ST25	10669.061	8744.714
ST26	10666.061	8744.714
ST27	10669.061	8671.414
ST28	10664.061	8671.414
ST29	10553.661	8679.914
ST30	10553.661	8733.214
ST31	10543.911	8706.564

NOTES:

1. All works to be carried out in accordance with SABS 1200 D – as amended 1998
2. Contour values are given for descriptive purposes only.
3. All setting out shall be from tabulated points and levels or from dimensions given.
4. All levels indicated are to finished surface.
5. Co-ordinate system is PLANT

CONCRETE NOTES:

1. CONCRETE TO BE GRADE 35/19. MIX DESIGNS FOR CONCRETE TO BE SUBMITTED TO THE ENGINEER FOR APPROVAL PRIOR TO COMMENCEMENT OF CONCRETE WORK
2. FINISHING:
   2.1 SMOOTH FINISH TO ALL SHUTTERED SIDES.
   2.2 WOODFLOAT TO TOPS OF WALLS AND SLABS.
   2.3 25x25mm CORNER FILLETS TO ALL EXPOSED EDGES.
3. TOLERANCES TO BE IN ACCORDANCE WITH SABS 1200G CLASS 1.
4. COVER TO REINFORCEMENT: AS INDICATED.
5. CURING OF ALL CONCRETE SURFACES TO BE DONE USING SAMSON'S WAX BASED WHITE PIGMENTED CURING COMPOUND.
6. ALL WORK TO BE CARRIED OUT IN CONFORMANCE WITH THE RELEVANT SABS 1200 SPECIFICATIONS.
7. ALL CONCRETE IS TO BE PROPERLY VIBRATED. HEAPING OF CONCRETE TO BE AVOIDED. CASTING OF CONCRETE MUST BE CONTINUOUS.
8. ALL WORK TO BE CHECKED BY SUPERVISING ENGINEER PRIOR TO POURING OF CONCRETE (MINIMUM 24 HOURS NOTICE.
9. AN ALLOWABLE FOUNDATION BEARING PRESSURE OF 300KPa ON COMPETENT SOIL IS REQUIRED. REMOVE AND REPLACE IN SITU MATERIAL AS REQUIRED.
10. ALL DIMENSIONS TO BE CONFIRMED ON SITE.
11. ALL STRUCTURES SHALL BE CONSTRUCTED ON A SUB-FOUNDATION CARPET OF 15MPa/19mm BLINDING CONCRETE, NOT LESS THAN 75mm THICK.

SECTION A

SCALE 1:250

PART SECTION E

SCALE 1:250

REV	DATE	REVISION / INDEX REFERENCE	CHECKED / APPROVED FOR ISSUE BY	DATE
2	16/04/10	APPROVED FOR CONSTRUCTION	WDN	16/04/10
1	30/09/09	SECTIONS UPDATED APPROVED FOR CONSTRUCTION		
0	24/04/09	ISSUED FOR CONSTRUCTION		

DRG REGISTER		
DESIGN APPROVAL	24/04/09	JRM
KDS APP		
DO AUTH	16/04/10	DO
CHKD BY	24/04/09	JRM
DRAWN BY	24/04/09	D.E.M.
SCALE	1:500	

PANEL & CONSULTANTS JOINT VENTURE
Knight Piésold CONSULTING
Eskom

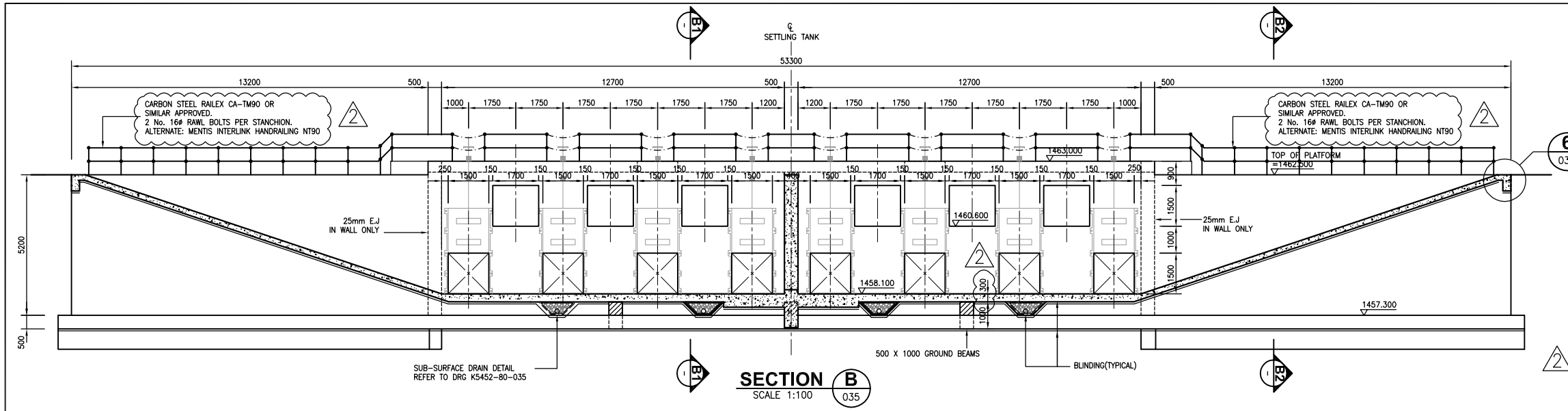
REFERENCE DRAWINGS	
5452-80-071	SDD PIPEWORK DETAILS
5452-80-036	SDD SETTLING TANKS - OUTLET
5452-80-036	SDD SETTLING TANKS - DISSIPATOR
5452-80-036	SDD SETTLING TANKS - TYPICAL DETAILS
5452-80-035	LOCALITY PLAN

KUSILE POWER STATION

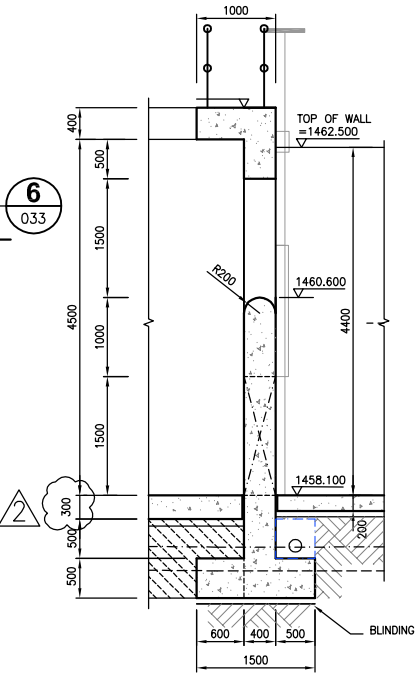
STATION DIRTY DAM SETTLING TANKS GENERAL ARRANGEMENT

DRG. No. K 5452-80-035 REV 2

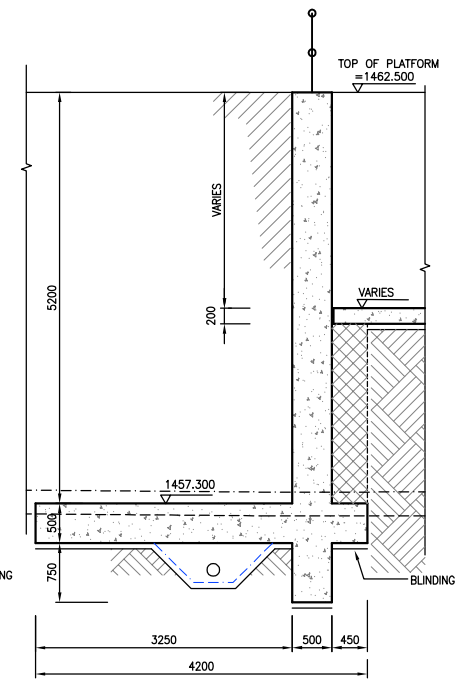
0.90/2406 SHEET A1 REV 2



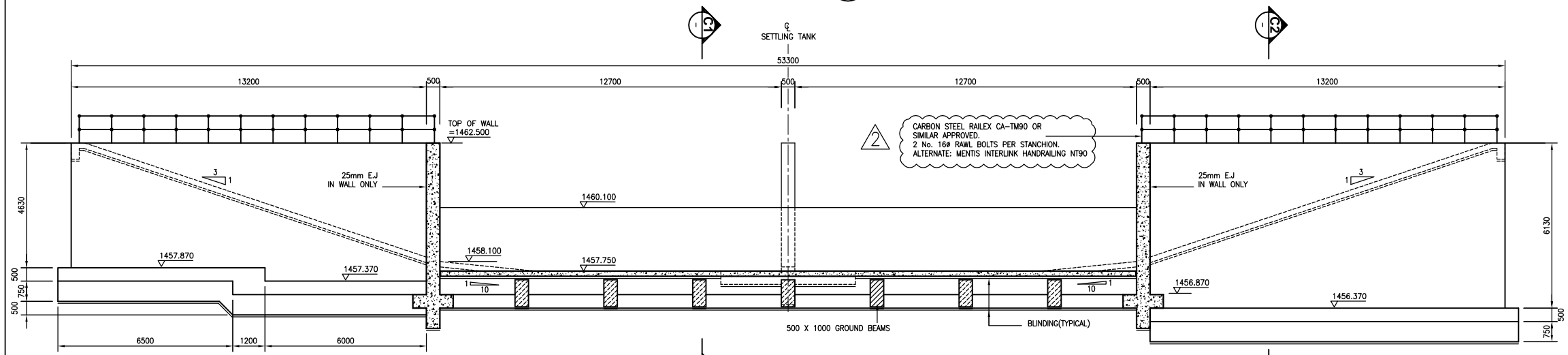
SECTION B (035)
SCALE 1:100



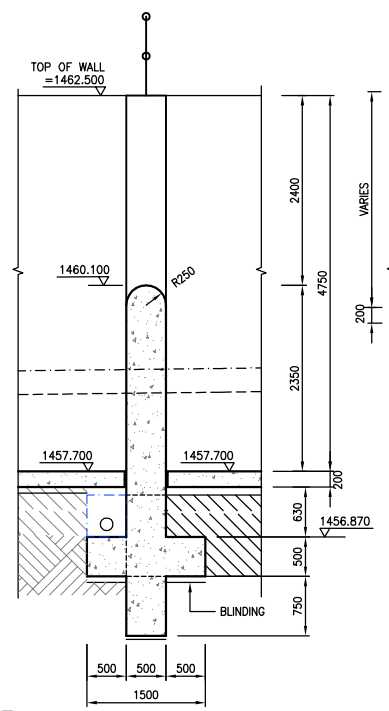
SECTION B1
SCALE 1:50



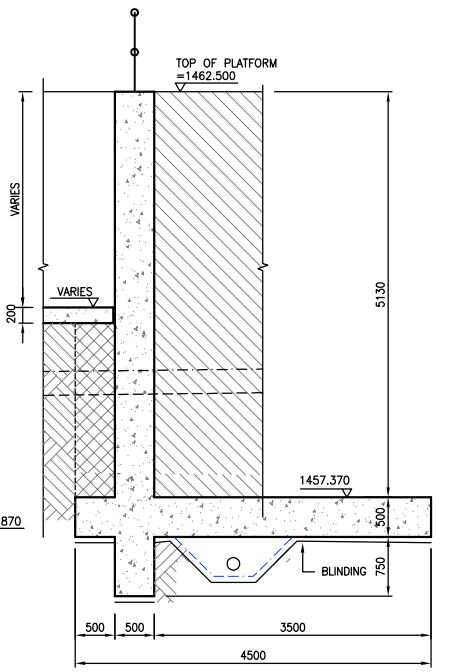
SECTION B2
SCALE 1:50



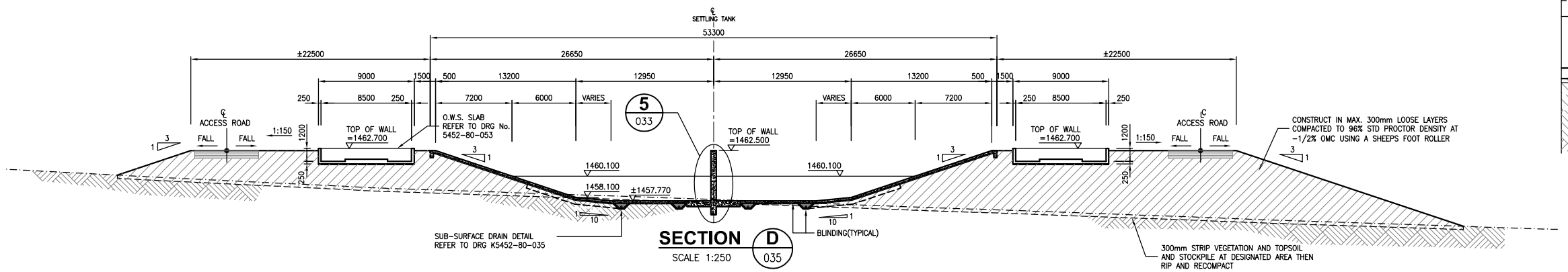
SECTION C (035)
SCALE 1:100



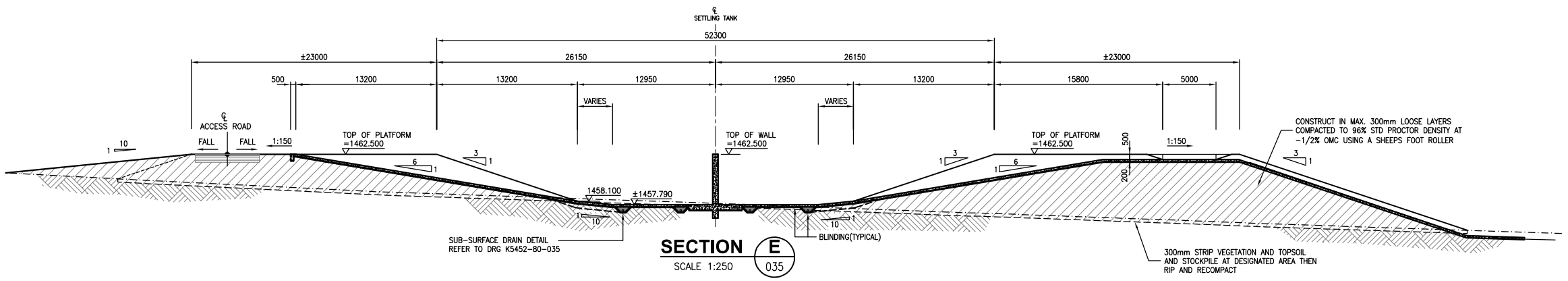
SECTION C1
SCALE 1:50



SECTION C2
SCALE 1:50



SECTION D (035)
SCALE 1:250



SECTION E (035)
SCALE 1:250

D.C.	REV	DATE	** REVISION ** INDEX REFERENCE :	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
	2	16/04/10	APPROVED FOR CONSTRUCTION	JJL	DD	JRM		
	1	11/08/09	REVISED FOR REVIEW	D.E.N.	JRM	JRM		
	0	24/04/09	ISSUED FOR CONSTRUCTION	D.E.N.	JRM	JRM	5452-80-036	SDD SETTLING TANKS - G.A.

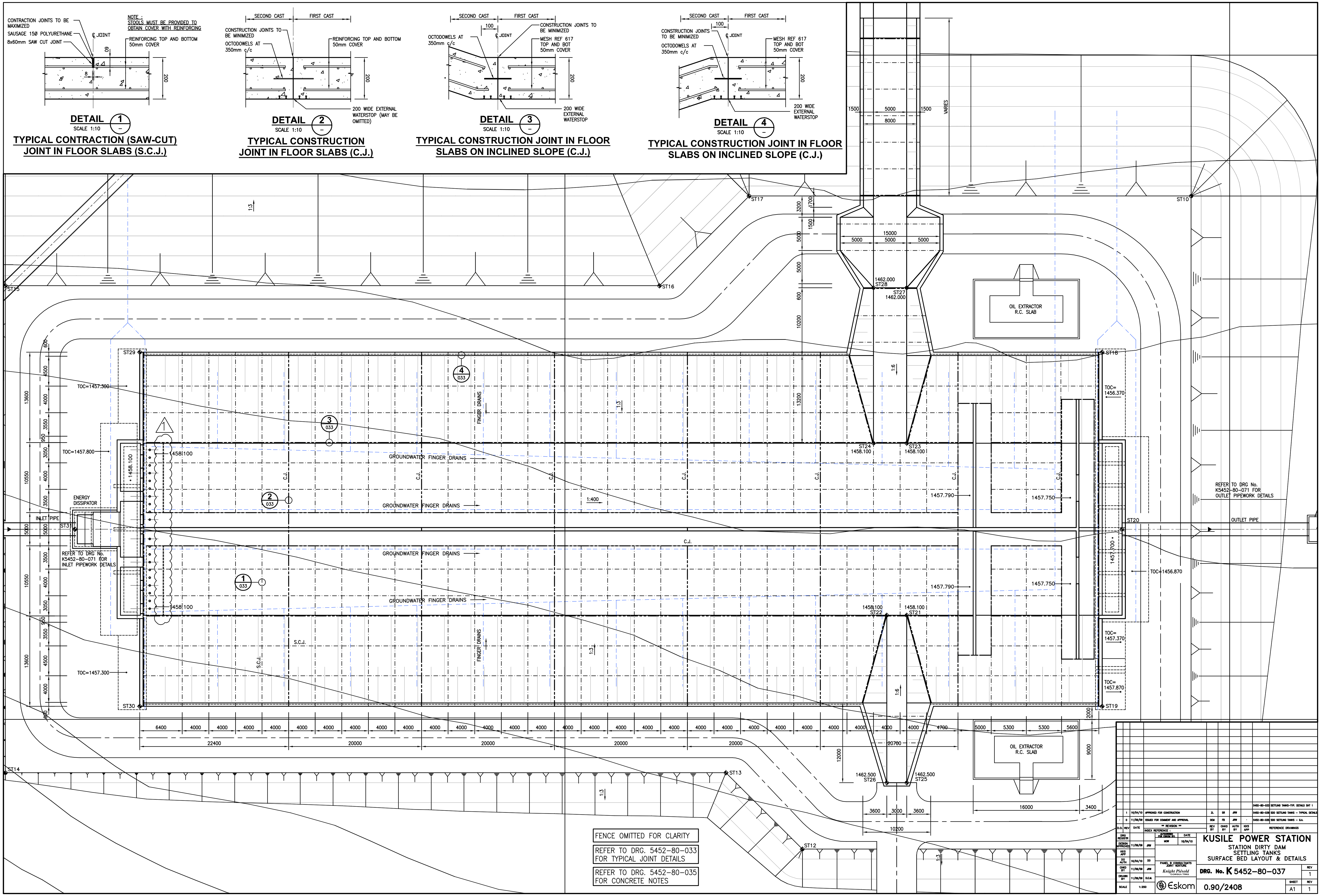
DRG REGISTER		ATTENDING FOR ESKOM INI.	DATE: MDM 16/04/10
DESIGN APPROVAL	24/04/09	JRM	
KKS APP			
DD. AUTH	16/04/10	DD	
CHKD BY	24/04/09	JRM	
DRAWN BY	24/04/09	D.E.N.	
SCALE	1:250		

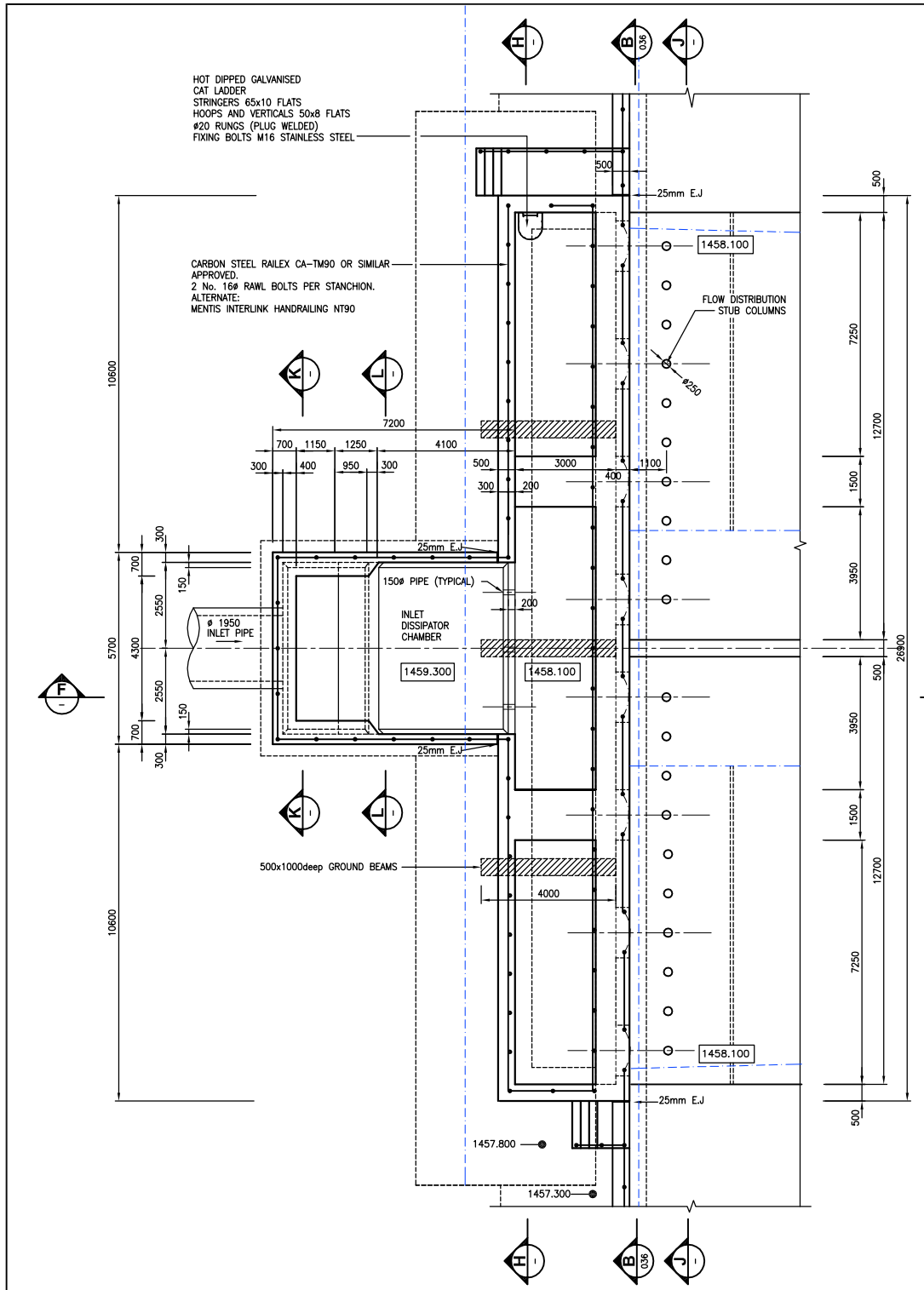
PANEL & CONSULTANTS JOINT VENTURE
Knight Piésold CONSULTING
Eskom

KUSILE POWER STATION
STATION DIRTY DAMS
SETTLING TANKS
TYPICAL SECTIONS & DETAILS

DRG. No. K 5452-80-036 — REV 2

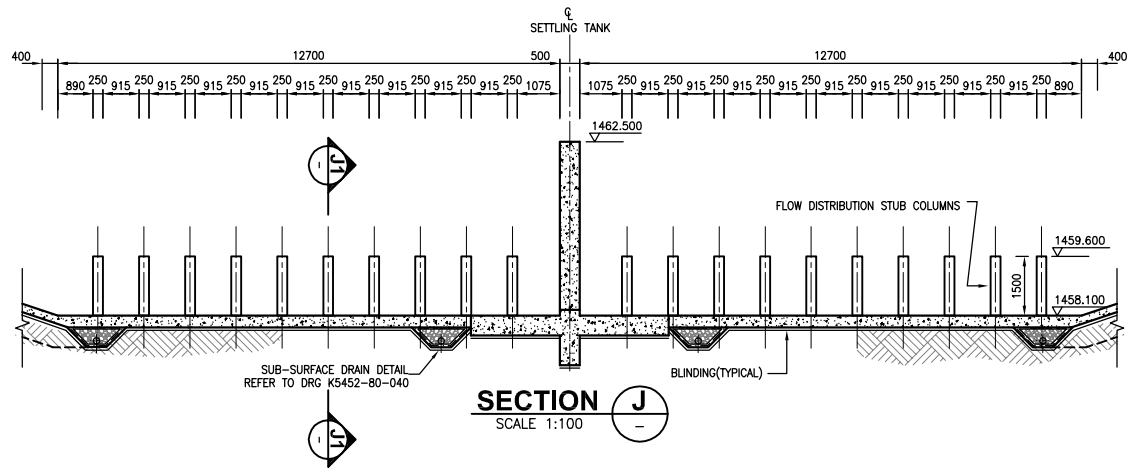
0.90/2407 — SHEET A1 — REV 2


DETAIL 1 SCALE 1:10
TYPICAL CONTRACTION (SAW-CUT) JOINT IN FLOOR SLABS (S.C.J.)
CONTRACTION JOINTS TO BE MAXIMIZED
SAUSAGE 15Ø POLYURETHANE
8x60mm SAW CUT JOINT
NOTE : STOOLS MUST BE PROVIDED TO OBTAIN COVER WITH REINFORCING
REINFORCING TOP AND BOTTOM 50mm COVER
DETAIL 2 SCALE 1:10
TYPICAL CONSTRUCTION JOINT IN FLOOR SLABS (C.J.)
SECOND CAST
FIRST CAST
CONSTRUCTION JOINTS TO BE MINIMIZED
OCTODOWELS AT 350mm c/c
200 WIDE EXTERNAL WATERSTOP (MAY BE OMITTED)
DETAIL 3 SCALE 1:10
TYPICAL CONSTRUCTION JOINT IN FLOOR SLABS ON INCLINED SLOPE (C.J.)
MESH REF 617 TOP AND BOT 50mm COVER
200 WIDE EXTERNAL WATERSTOP
DETAIL 4 SCALE 1:10
TYPICAL CONSTRUCTION JOINT IN FLOOR SLABS ON INCLINED SLOPE (C.J.)
OIL EXTRACTOR R.C. SLAB
GROUNDWATER FINGER DRAINS
FINGER DRAINS
ENERGY DISSIPATOR
INLET PIPE
OUTLET PIPE
REFER TO DRG No. K5452-80-071 FOR INLET PIPEWORK DETAILS
REFER TO DRG No. K5452-80-071 FOR OUTLET PIPEWORK DETAILS
TOC=1457.300
TOC=1457.800
TOC=1456.370
TOC=1456.870
TOC=1457.370
TOC=1457.870
FENCE OMITTED FOR CLARITY
REFER TO DRG. 5452-80-033 FOR TYPICAL JOINT DETAILS
REFER TO DRG. 5452-80-035 FOR CONCRETE NOTES
5452-80-033 SETTLING TANKS-TYP. DETAILS SHT 1
1 16/04/10 APPROVED FOR CONSTRUCTION ZL SR JRW 5452-80-036 SDD SETTLING TANKS - TYPICAL DETAILS
0 11/09/09 ISSUED FOR COMMENT AND APPROVAL DEM FB JRW 5452-80-035 SDD SETTLING TANKS - G.A.
D.O. REV DATE ** REVISION ** INDEX REFERENCE : REV BY CHKD BY AUTH BY KKS APP REFERENCE DRAWINGS
DRG REGISTR
DESIGN APPROVED 11/09/09 JRW
KKS APP
DO AUTH 16/04/10 DO
CHKD BY 11/09/09 JRW
DRAWN BY 11/09/09 D.E.M.
SCALE 1:250
AUTHORISED FOR ESKOM BY: MOW DATE 16/04/10
PANEL B CONSULTANTS JOINT VENTURE
Knight Piésold CONSULTING
Eskom
KUSILE POWER STATION
STATION DIRTY DAM
SETTLING TANKS
SURFACE BED LAYOUT & DETAILS
DRG. No. K 5452-80-037
REV 1
0.90/2408
SHEET A1
REV 1



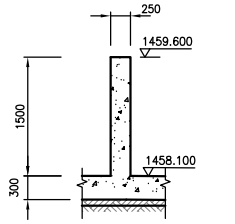
PLAN ON INLET ENERGY DISSIPATOR

SCALE 1:100



SECTION J

SCALE 1:100

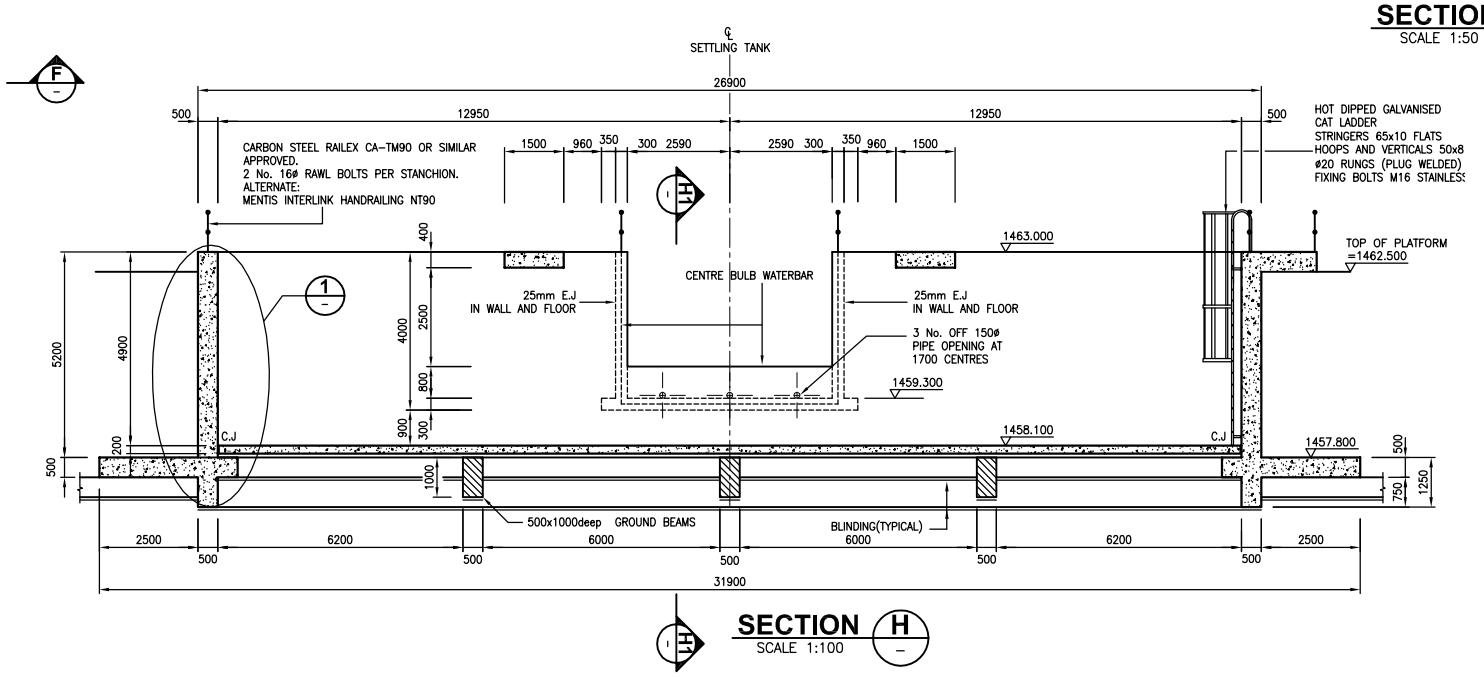


SECTION J1

SCALE 1:50

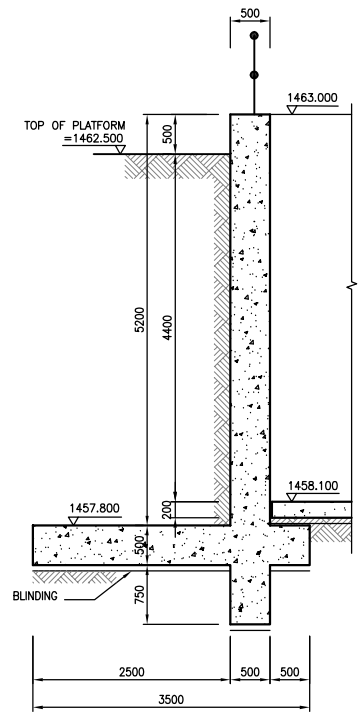
CONCRETE NOTES:

1. CONCRETE TO BE GRADE 35/19. MIX DESIGNS FOR CONCRETE TO BE SUBMITTED TO THE ENGINEER FOR APPROVAL PRIOR TO COMMENCEMENT OF CONCRETE WORK
2. FINISHING:
   2.1 SMOOTH FINISH TO ALL SHUTTERED SIDES.
   2.2 WOODFLOAT TO TOPS OF WALLS AND SLABS.
   2.3 25x25mm CORNER FILLETS TO ALL EXPOSED EDGES.
3. TOLERANCES TO BE IN ACCORDANCE WITH SABS 1200G CLASS 1.
4. COVER TO REINFORCEMENT: AS INDICATED.
5. CURING OF ALL CONCRETE SURFACES TO BE DONE USING SAMSON'S WAX BASED WHITE PIGMENTED CURING COMPOUND.
6. ALL WORK TO BE CARRIED OUT IN CONFORMANCE WITH THE RELEVANT SABS 1200 SPECIFICATIONS.
7. ALL CONCRETE IS TO BE PROPERLY VIBRATED. HEAPING OF CONCRETE TO BE AVOIDED. CASTING OF CONCRETE MUST BE CONTINUOUS.
8. ALL WORK TO BE CHECKED BY SUPERVISING ENGINEER PRIOR TO POURING OF CONCRETE (MINIMUM 24 HOURS NOTICE.
9. AN ALLOWABLE FOUNDATION BEARING PRESSURE OF 300KPa ON COMPETENT SOIL IS REQUIRED. REMOVE AND REPLACE IN SITU MATERIAL AS REQUIRED.
10. ALL DIMENSIONS TO BE CONFIRMED ON SITE.
11. ALL STRUCTURES SHALL BE CONSTRUCTED ON A SUB-FOUNDATION CARPET OF 15MPa/19mm BLINDING CONCRETE, NOT LESS THAN 75mm THICK.



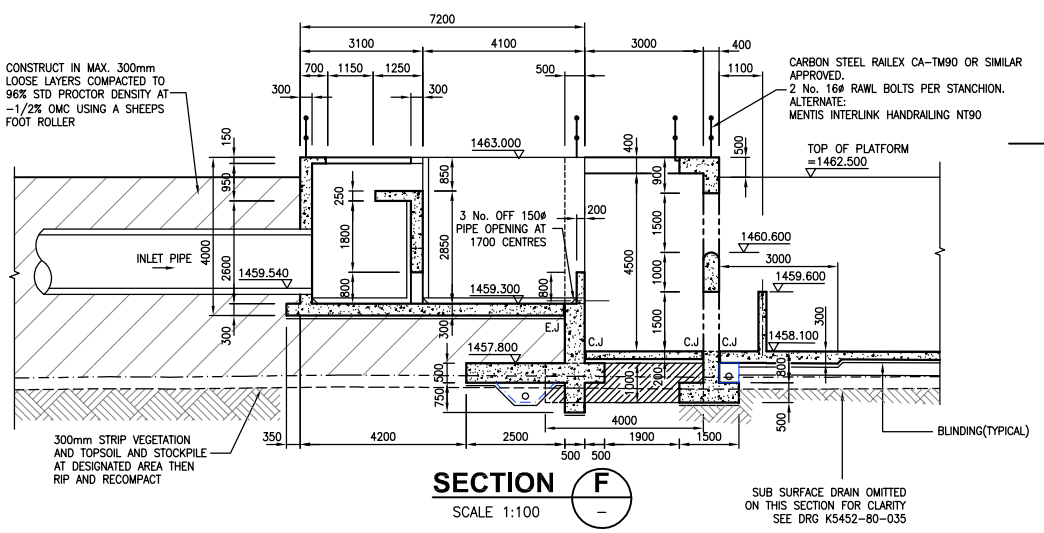
SECTION H

SCALE 1:100



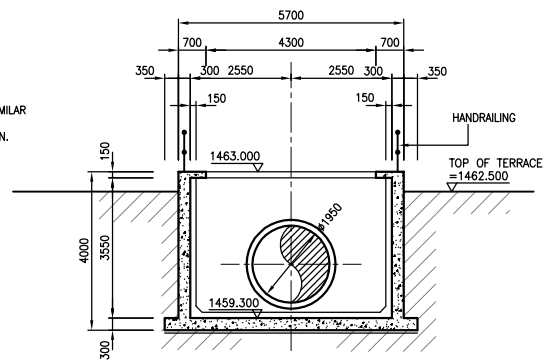
DETAIL 1

SCALE 1:50



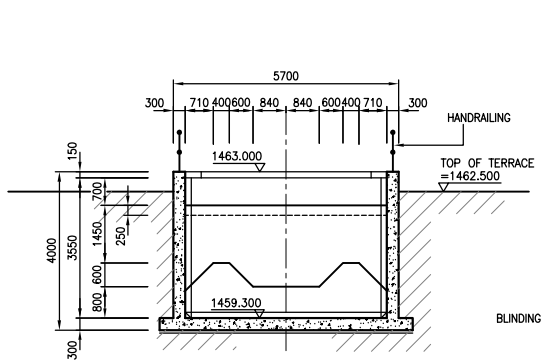
SECTION F

SCALE 1:100



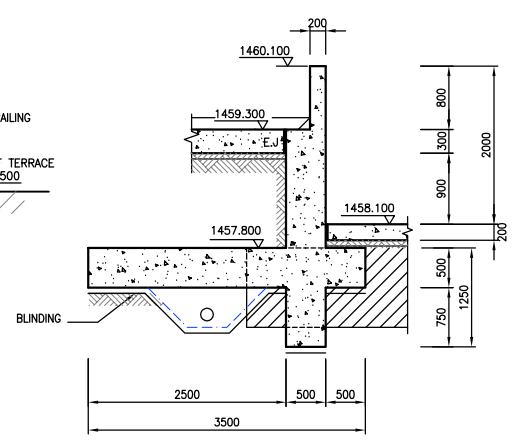
SECTION K

SCALE 1:100



SECTION L

SCALE 1:100



SECTION H1

SCALE 1:50

REV	DATE	DESCRIPTION	Z.L	SR	JRM	5452-80-036	500 SETTLING TANKS - TYP. SECTIONS
0	30/05/08	ISSUED FOR CONSTRUCTION	D.E.M.	JRM	JRM	5452-80-035	500 SETTLING TANKS - G.A.
D.O. REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

INDEX REFERENCE :

DRG REGISTR		AS BUILT DRG FINISH BY:	DATE
DESIGN APPROVAL	30/05/08	JRM	MDM 16/04/10
KKS APP			
DO AUTH	16/04/10	DO	
CHKD BY	30/05/08	JRM	
DRAWN BY	30/05/08	D.E.M.	
SCALE	1:100		

PANEL & CONSULTANTS (PTY) LTD
Knight Piésold CONSULTING

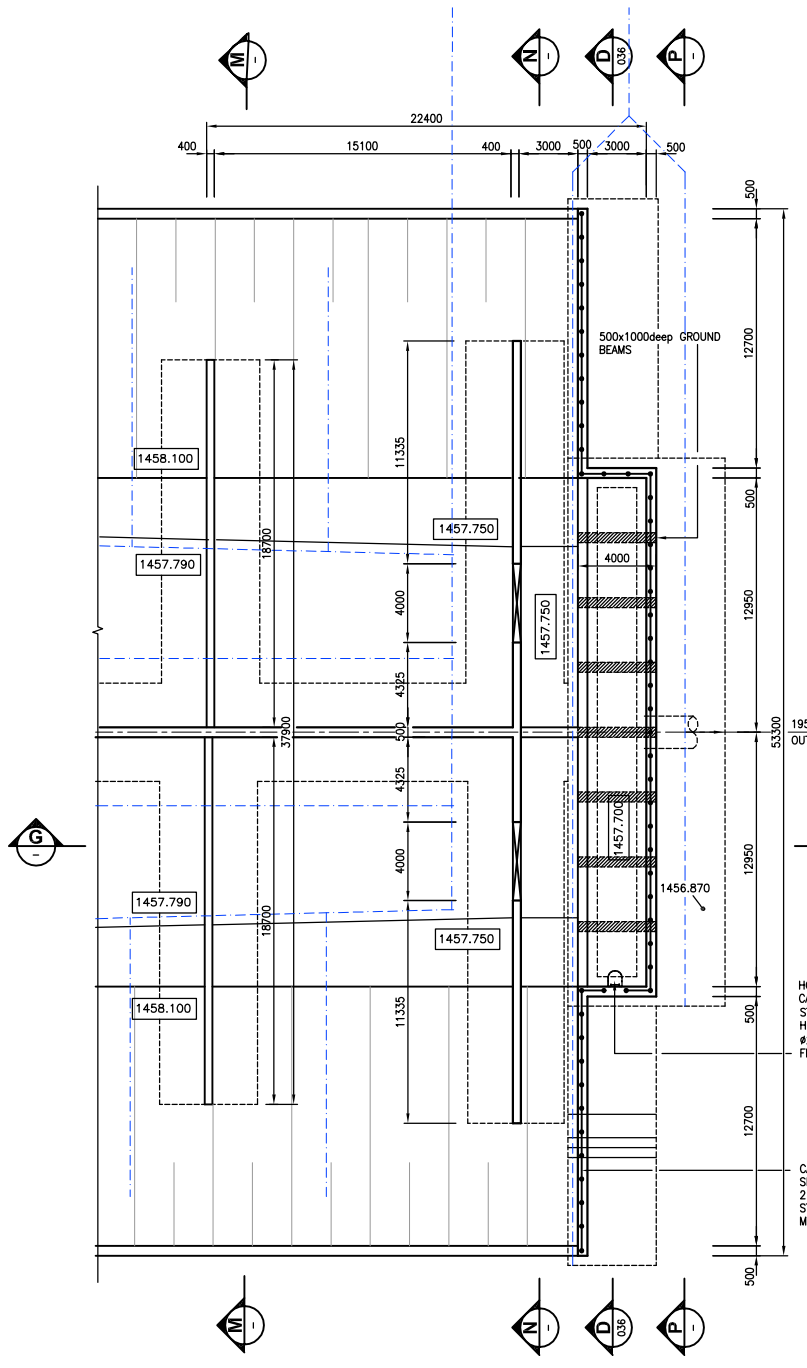
Eskom

KUSILE POWER STATION

STATION DIRTY DAMS
SETTLING TANKS - ENERGY DISSIPATOR
GENERAL ARRANGEMENT & DETAILS

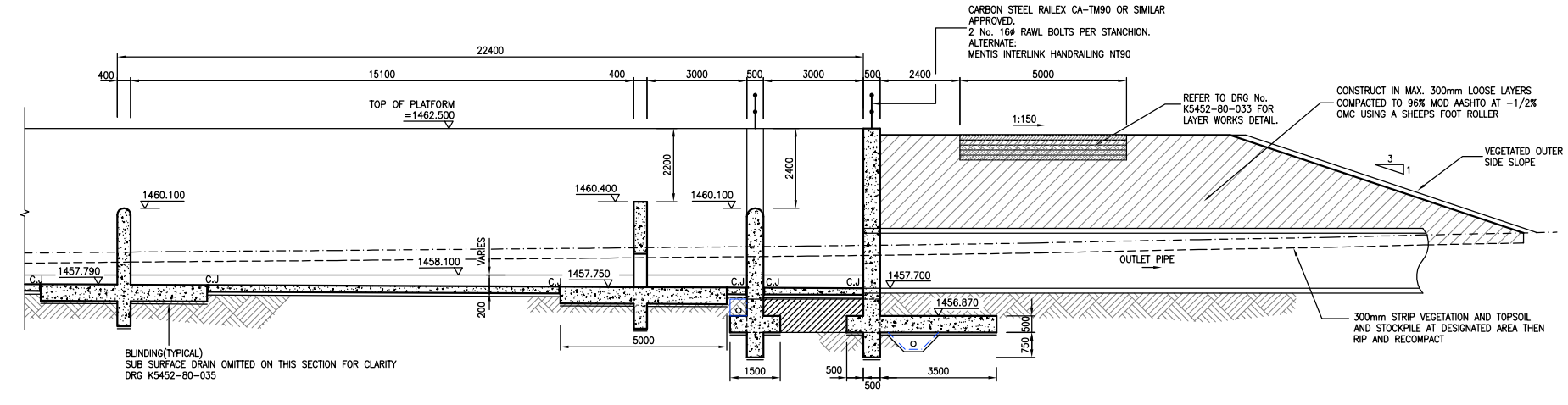
DRG. No. K 5452-80-038 REV 1

0.90/2409 SHEET A1 REV 1

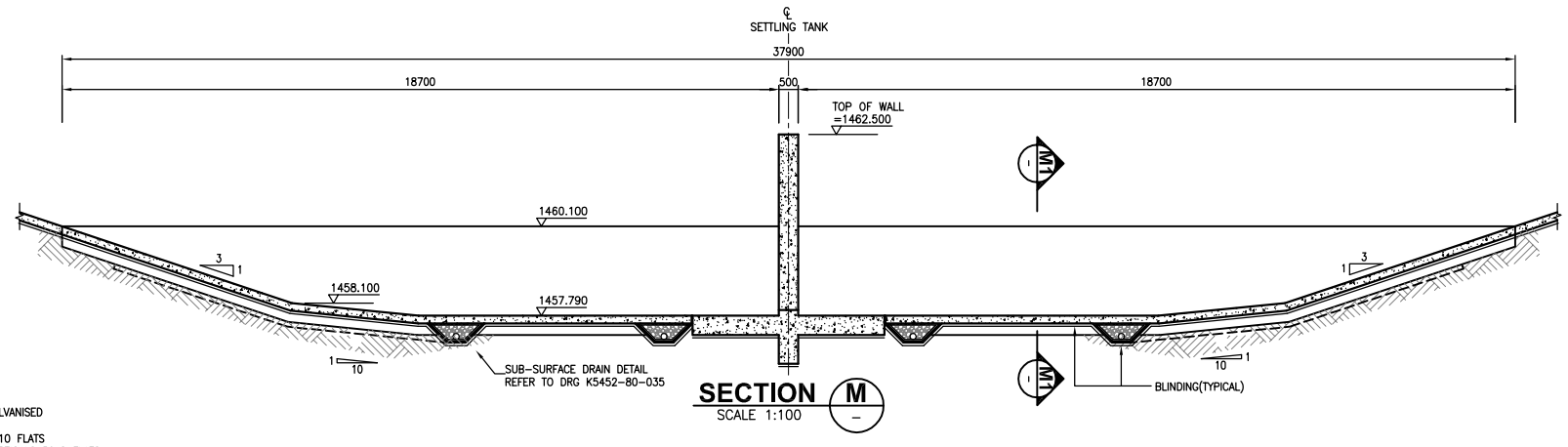


PLAN ON OUTLET STRUCTURE

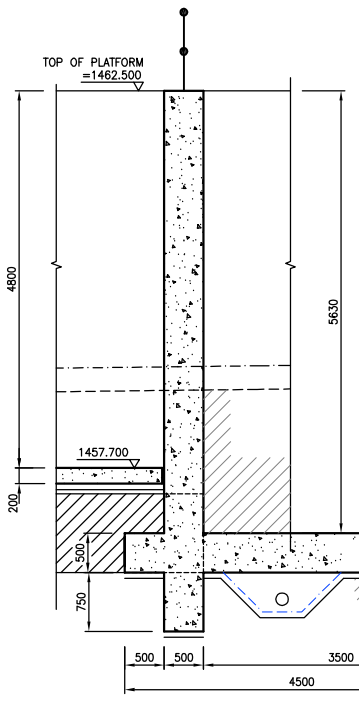
SCALE 1:200



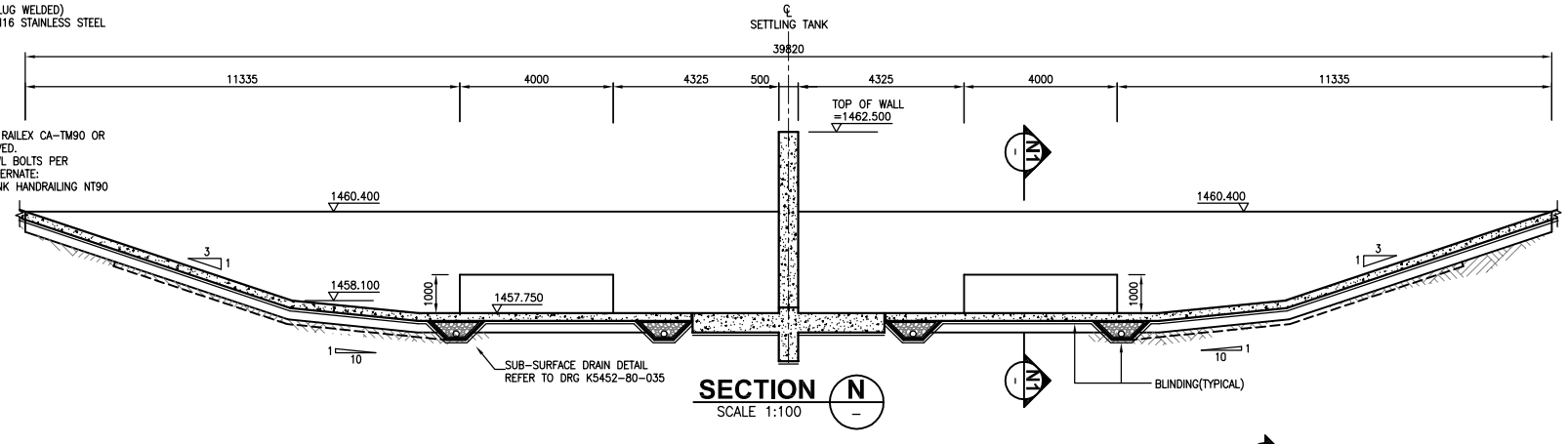
SECTION G
SCALE 1:100 — G 035



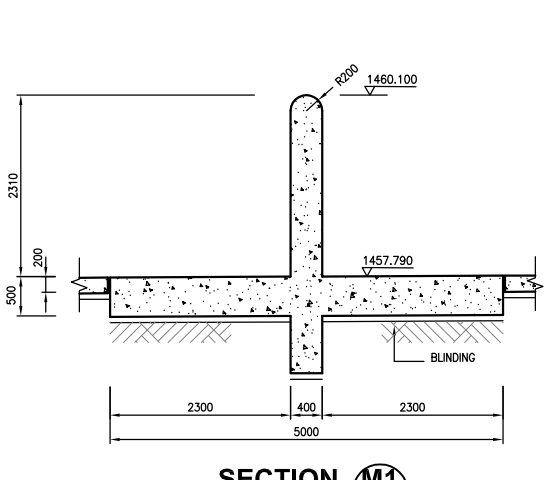
SECTION M
SCALE 1:100 — M –



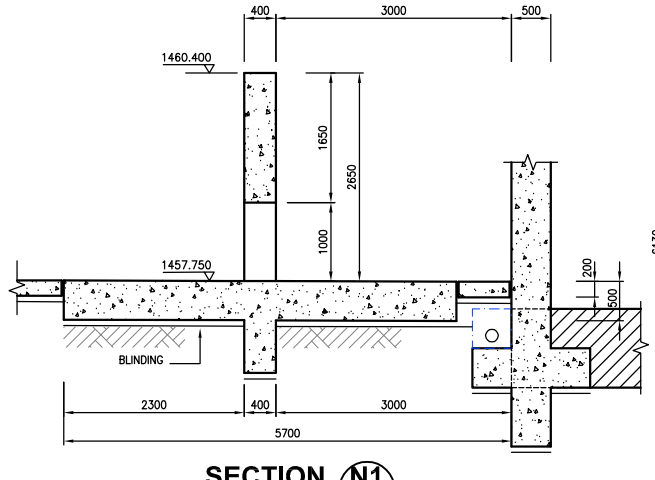
SECTION P1
SCALE 1:50 — P1 –



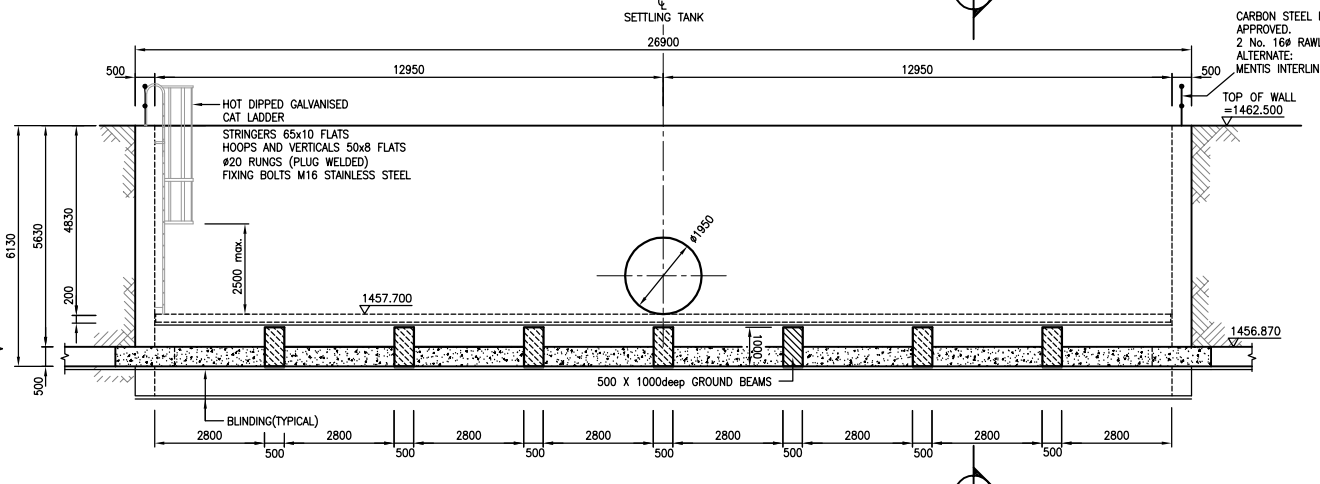
SECTION N
SCALE 1:100 — N –



SECTION M1
SCALE 1:50 — M1 –



SECTION N1
SCALE 1:50 — N1 –



SECTION P
SCALE 1:100 — P –

CONCRETE NOTES:

1. CONCRETE TO BE GRADE 35/19. MIX DESIGNS FOR CONCRETE TO BE SUBMITTED TO THE ENGINEER FOR APPROVAL PRIOR TO COMMENCEMENT OF CONCRETE WORK
2. FINISHING:
   2.1 SMOOTH FINISH TO ALL SHUTTERED SIDES.
   2.2 WOODFLOAT TO TOPS OF WALLS AND SLABS.
   2.3 25x25mm CORNER FILLETS TO ALL EXPOSED EDGES.
3. TOLERANCES TO BE IN ACCORDANCE WITH SABS 1200G CLASS 1.
4. COVER TO REINFORCEMENT: AS INDICATED.
5. CURING OF ALL CONCRETE SURFACES TO BE DONE USING SAMSON'S WAX BASED WHITE PIGMENTED CURING COMPOUND.
6. ALL WORK TO BE CARRIED OUT IN CONFORMANCE WITH THE RELEVANT SABS 1200 SPECIFICATIONS.
7. ALL CONCRETE IS TO BE PROPERLY VIBRATED. HEAPING OF CONCRETE TO BE AVOIDED. CASTING OF CONCRETE MUST BE CONTINUOUS.
8. ALL WORK TO BE CHECKED BY SUPERVISING ENGINEER PRIOR TO POURING OF CONCRETE (MINIMUM 24 HOURS NOTICE.
9. AN ALLOWABLE FOUNDATION BEARING PRESSURE OF 300KPa ON COMPETENT SOIL IS REQUIRED. REMOVE AND REPLACE IN SITU MATERIAL AS REQUIRED.
10. ALL DIMENSIONS TO BE CONFIRMED ON SITE.
11. ALL STRUCTURES SHALL BE CONSTRUCTED ON A SUB-FOUNDATION CARPET OF 15MPa/19mm BLINDING CONCRETE, NOT LESS THAN 75mm THICK.

D.G. REV	DATE	** REVISION ** INDEX REFERENCE :	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
							5452-80-036 SDD SETTLING TANKS – TYP. DETAILS
1	16/04/10	APPROVED FOR CONSTRUCTION	Z.L	SR	JRM		5452-80-036 SDD SETTLING TANKS – TYP. SECTIONS
0	20/05/09	ISSUED FOR CONSTRUCTION	D.E.M.	JRM	JRM		5452-80-036 SDD SETTLING TANKS – G.A.

DRG REGISTR		APPROVED BY: MDR	DATE: 16/04/10
DESIGN APPROVED	20/05/09	JRM	
KKS APP.			
DG AUTH	16/04/10	DD	
CHKD BY	20/05/09	JRM	
DRAWN BY	20/05/09	D.E.M.	
SCALE	1:200		

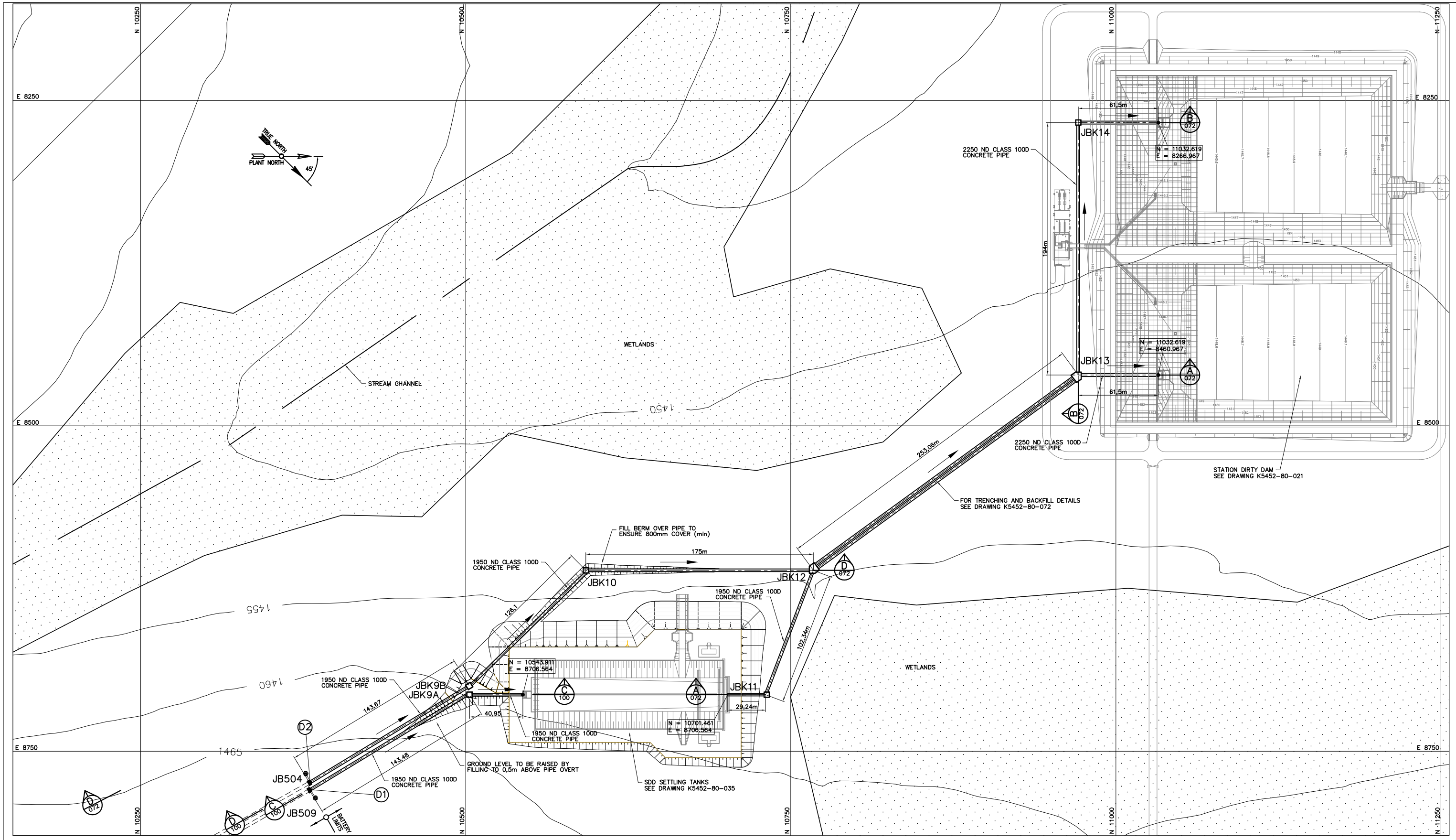
PANEL & CONSULTANTS JOINT VENTURE
Knight Piésold CONSULTING

Eskom

KUSILE POWER STATION
STATION DIRTY DAMS
SETTLING TANKS – OUTLET
GENERAL ARRANGEMENT & DETAILS

DRG. No. K 5452-80-039 — REV 1

0.90/2410 — SHEET A1 — REV 1



PLAN
1 : 1000

KEY

KP — KNIGHT PIESOLD/ESKOM BATTERY LIMIT

ESKOM

WETLANDS AREA

CONCRETE PIPE DIMENSIONS

PIPE CLASS	NOMINAL DIAMETER (ND) mm	INSIDE DIAMETER (ID) mm	OUTSIDE DIAMETER (OD) mm	WALL THICKNESS (T) mm	INSIDE SOCKET (S) mm	NOMINAL LENGTH (L) mm
100D	1950	1800	2184	192	30	2440
100D	2250	2250	2700	225	175	1220

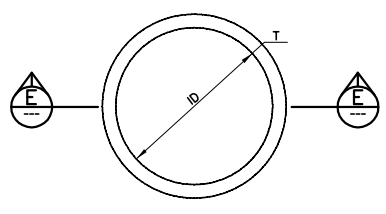
BATTERY LIMITS CO-ORDINATES

POINT NAME	N-COORDINATE	E-COORDINATE
D1	10380.244	8779.661
D2	10380.282	8773.985

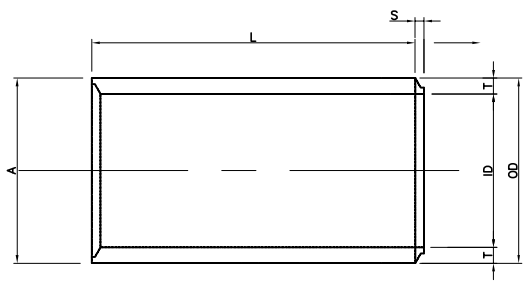
JUNCTION BOX CO-ORDINATES

POINT NAME	N-COORDINATE	E-COORDINATE
K9A	10502.961	8706.564
K9B	10485.745	8692.229
K10	10592.332	8611.003
K11	10731.461	8706.564
K12	10768.298	8609.391
K13	10969.427	8462.599
K14	10971.119	8266.967

NOTE:
REFER TO K5452-80-070 FOR JUNCTION BOX DETAILS



TYPICAL SECTION – CONCRETE PIPE
NOT TO SCALE



SECTION E TYPICAL SECTION
NOT TO SCALE CONCRETE INTERLOCKING JOINT PIPE

REV	DATE	DESCRIPTION	DRN	CHKD	AUTH	KKS	REFERENCE DRAWINGS
			BY	BY	BY	APP	
							K5452-80-160 INLET AND OUTLET PIPEWORK SECTIONS
							63041 TERRACING SITE PLAN – AREA 45
							63001 TERRACING SITE PLAN – AREA 1
							K5452-80-070 INLET AND OUTLET PIPEWORK SECTIONS AND DETAILS
							K5452-80-072 JUNCTION BOX DETAILS
							K5452-80-035 SDD SETTLING TANK SECTIONS AND DETAILS
							K5452-80-036 SDD SETTLING TANK GENERAL ARRANGEMENT
1	07/05/10	ISSUED FOR COMMENT AND APPROVAL REV. PIPEWORK AND JB POSITIONS	KV	SR	JFW		K5452-80-040 STATION DIRTY DAM TYPICAL SECTIONS
0	24/04/09	ISSUED FOR CONSTRUCTION	DK/dmd	JFW	JFW		K5452-80-021 STATION DIRTY DAM GENERAL ARRANGEMENT
D.O. REV.	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

INDEX REFERENCE

CHKD REGISTR		ATTENTION FOR ESKOM BY:	DATE
DESIGN APPROVAL	24/04/09 JFW	NOM	-
KKS APP			
DG AUTH	07/05/10 DO		
CHKD BY	20/04/09 JFW		
DRAWN BY	20/04/09 SR		
SCALE			

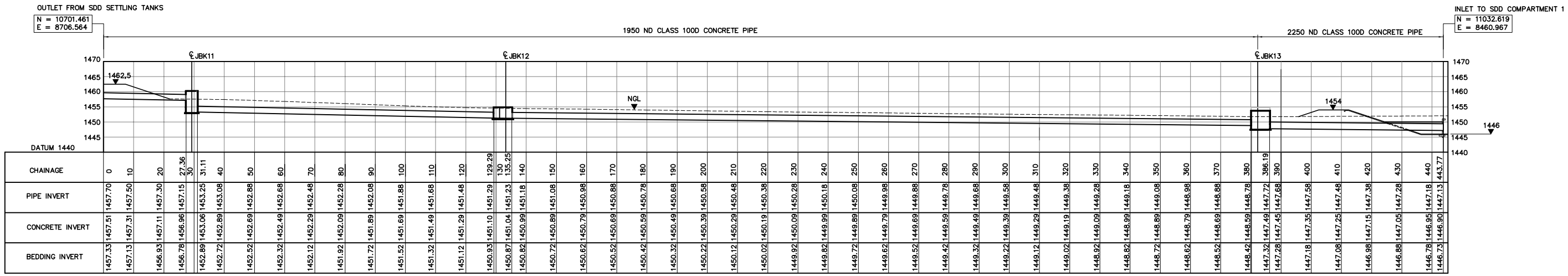
PANEL E CONSULTANTS Joint Venture
Knight Piésold (Pty) Ltd CONSULTING

Eskom

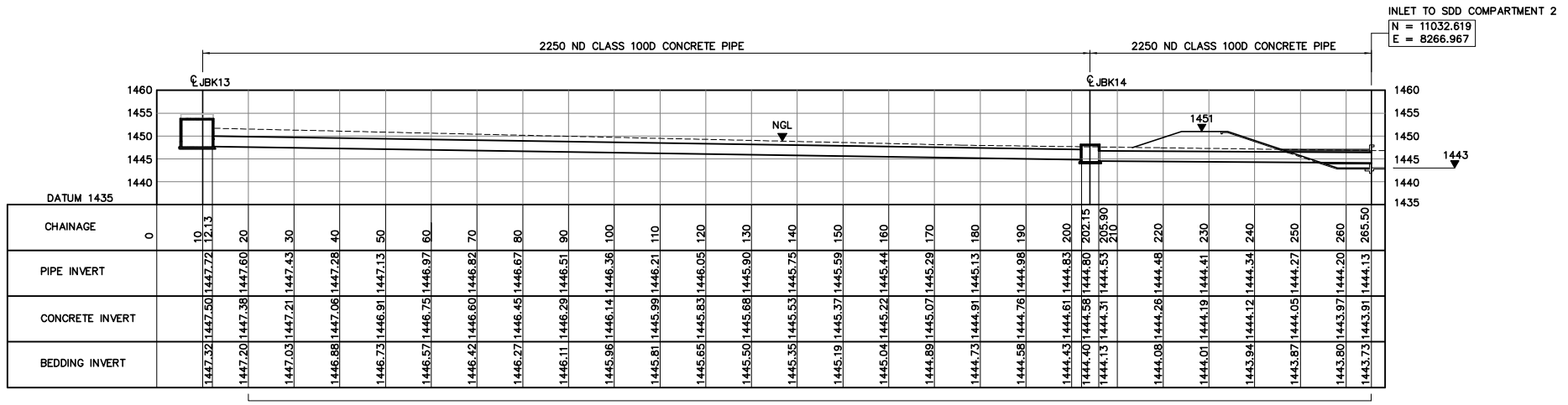
KUSILE POWER STATION
SDD SETTLING TANKS INLET AND OUTLET PIPEWORKS GENERAL ARRANGEMENT

DRG. No. K 5452-80-071 REV 1

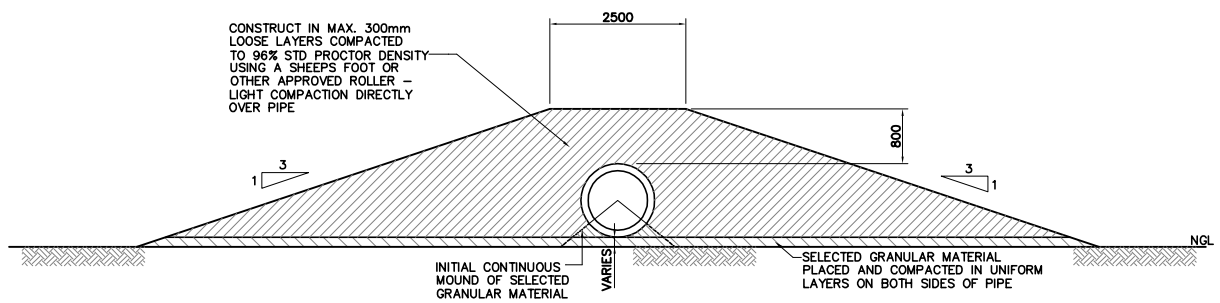
0.90/2442 SHEET A0 REV 1



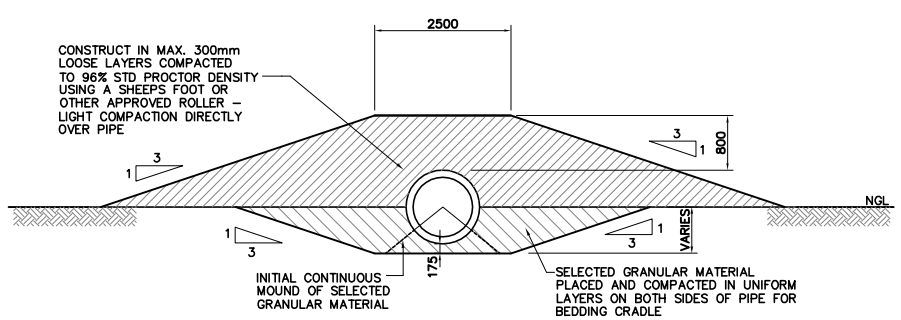
SECTION A 071 LONGITUDINAL SECTION
SCALE 1:500 SDD SETTLING TANK OUTLET TO SDD1



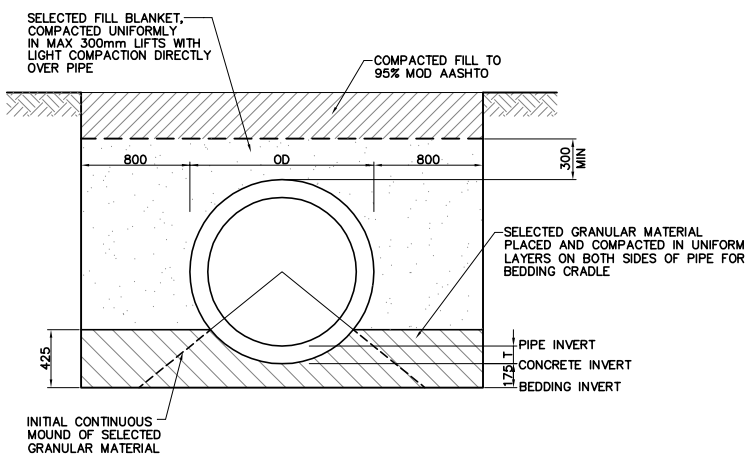
SECTION B 071 LONGITUDINAL SECTION
SCALE 1:500 JBK13 TO SDD2



SCHEMATIC SECTION – PIPE ABOVE NGL
NOT TO SCALE



SCHEMATIC SECTION – PIPE PARTIALLY BELOW NGL
NOT TO SCALE



SCHEMATIC SECTION – PIPE BEDDING
CLASS C BED
NOT TO SCALE

NOTES:

THE CONTRACTOR SHALL COMPLY WITH ALL RELEVANT CLAUSES FOR PIPE BEDDING AS STIPULATED IN SABS 1200 LB–1983.

WHEN TWO PIPES ARE IN THE SAME TRENCH, PROVIDE 800 CLEARANCE TO ALLOW FOR PROPER COMPACTION.

D.O.	REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
		INDEX REFERENCE :						K5452-80-100 INLET AND OUTLET PIPEWORK: LONG SECTIONS
								K5452-80-101 INLET AND OUTLET PIPEWORK: GENERAL ARRANGEMENT
								K5452-80-102 JUNCTION BOX DETAILS
	2	07/05/09	ISSUED FOR COMMENT AND APPROVAL TOP OF CONCRETE JBK'S UPDATED.	FD	JRW	JRW		K5452-80-105 SDD SETTLING TANK SECTIONS AND DETAILS
	1	14/09/08	REV. LONGITUDINAL SECTIONS AND ADDED DETAILS	KV	JRW	JRW		K5452-80-106 SDD SETTLING TANK GENERAL ARRANGEMENT
	0	24/04/08	ISSUED FOR CONSTRUCTION	SR/AMK	JRW	JRW		K5452-80-222 STATION DIRTY DAM TYPICAL SECTIONS
								K5452-80-223 STATION DIRTY DAM GENERAL ARRANGEMENT

DRG REGISTER					
DESIGN APPROVED	24/04/08	JRW			
KKS APP					
CVL AUTH	27/05/10	DO			
CHKD BY	12/09/08	JRW			
DRAWN BY	12/09/08	SR			
SCALE					

AS CONSTRUCTED / FOR ENGR REV.	DATE
MOW	-

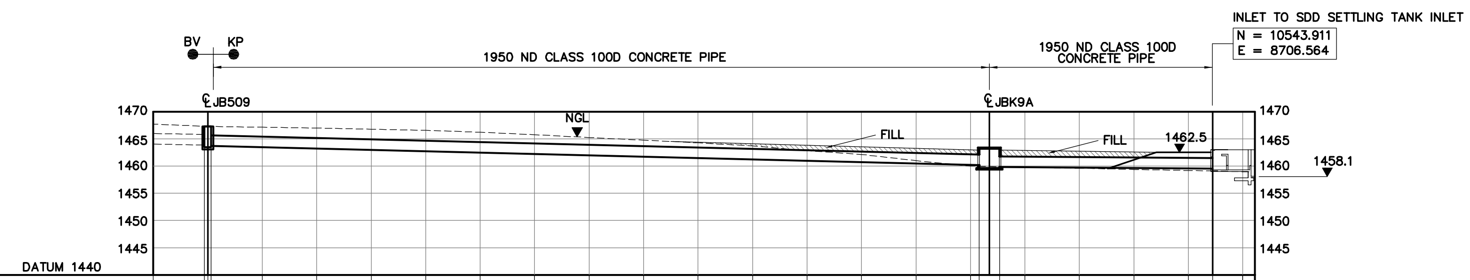
PANEL B CONSULTANTS JOINT VENTURE
Knight Piésold Consulting

Eskom

KUSILE POWER STATION
SDD SETTLING TANKS INLET AND OUTLET PIPEWORKS SECTIONS AND DETAILS

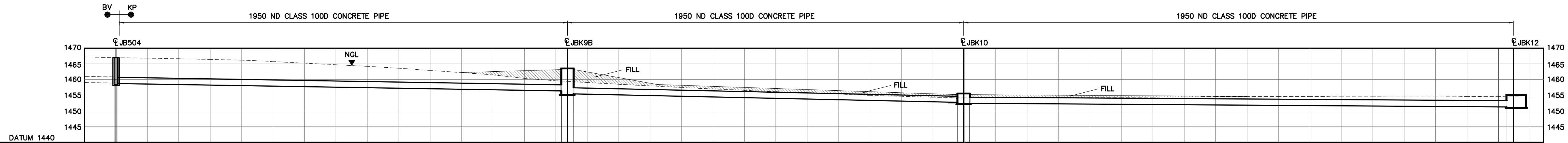
DRG. No. K 5452–70–072 REV 2

0.90/2443 SHEET A0 REV 2



CHAINAGE	PIPE INVERT	CONCRETE INVERT	BEDDING INVERT
0	1463.85	1463.66	1463.45
0.6	1463.70	1463.51	1463.45
10	1463.46	1463.27	1463.09
20	1463.21	1463.02	1462.84
30	1462.96	1462.77	1462.59
40	1462.71	1462.52	1462.34
50	1462.46	1462.27	1462.09
60	1462.21	1462.02	1461.84
70	1461.96	1461.77	1461.59
80	1461.71	1461.52	1461.34
90	1461.46	1461.27	1461.09
100	1461.21	1461.02	1460.84
110	1460.96	1460.77	1460.59
120	1460.71	1460.52	1460.34
130	1460.46	1460.27	1460.09
140	1460.21	1460.02	1459.84
141.6	1460.17	1459.98	1459.80
145.35	1459.80	1459.61	1459.43
150	1459.77	1459.58	1459.40
160	1459.70	1459.51	1459.34
170	1459.64	1459.45	1459.27
180	1459.57	1459.38	1459.20
184.43	1459.54	1459.35	1459.18

SECTION C/071 LONGITUDINAL SECTION
SCALE 1:500
JB509 TO SDD SETTLING TANK INLET



CHAINAGE	PIPE INVERT	CONCRETE INVERT	BEDDING INVERT
0	1458.90	1458.71	1458.50
0.6	1458.75	1458.56	1458.50
10	1458.58	1458.39	1458.21
20	1458.41	1458.22	1458.04
30	1458.24	1458.05	1457.87
40	1458.08	1457.89	1457.71
50	1457.91	1457.72	1457.54
60	1457.74	1457.55	1457.37
70	1457.58	1457.39	1457.21
80	1457.41	1457.22	1457.04
90	1457.24	1457.05	1456.87
100	1457.08	1456.89	1456.71
110	1456.91	1456.72	1456.54
120	1456.74	1456.55	1456.37
130	1456.58	1456.39	1456.21
140	1456.41	1456.22	1456.04
141.8	1456.40	1456.21	1456.03
145.55	1455.43	1455.24	1455.06
150	1455.33	1455.14	1454.96
160	1455.10	1454.91	1454.73
170	1454.88	1454.68	1454.51
180	1454.65	1454.45	1454.27
190	1454.43	1454.23	1454.05
200	1454.21	1454.01	1453.83
210	1453.99	1453.79	1453.61
220	1453.76	1453.56	1453.38
230	1453.55	1453.35	1453.17
240	1453.32	1453.13	1452.95
250	1453.10	1452.91	1452.73
260	1452.88	1452.69	1452.51
267.89	1452.71	1452.52	1452.34
270			
271.64	1452.45	1452.26	1452.09
280	1452.39	1452.20	1452.03
290	1452.32	1452.12	1451.95
300	1452.25	1452.05	1451.88
310	1452.18	1451.98	1451.81
320	1452.12	1451.92	1451.75
330	1452.05	1451.85	1451.68
340	1451.98	1451.78	1451.61
350	1451.92	1451.72	1451.55
360	1451.84	1451.65	1451.48
370	1451.77	1451.58	1451.41
380	1451.71	1451.52	1451.35
390	1451.64	1451.45	1451.28
400	1451.57	1451.38	1451.21
410	1451.51	1451.32	1451.15
420	1451.44	1451.25	1451.08
430	1451.37	1451.18	1451.01
440	1451.31	1451.12	1450.95
442.73	1451.29	1451.10	1450.93

SECTION D/071 LONGITUDINAL SECTION
SCALE 1:500
JB504 TO JBK12

D.O.	REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS	
								K5452-80-072	INLET AND OUTLET PIPEWORK SECTIONS AND DETAILS
								K5452-80-071	INLET AND OUTLET PIPEWORK GENERAL ARRANGEMENT
								K5452-80-070	JUNCTION BOX DETAILS
								K5452-80-036	SDD SETTLING TANK SECTIONS AND DETAILS
								K5452-80-035	SDD SETTLING TANK GENERAL ARRANGEMENT
	1	07/05/10	ISSUED FOR COMMENT AND APPROVAL TOP OF CONCRETE JBK'S UPDATED.	KV	SR	JRW		K5452-80-022	STATION DIRTY DAM TYPICAL SECTIONS
	0	16/09/09	ISSUED FOR COMMENT	KV	DO	JRW		K5452-80-021	STATION DIRTY DAM GENERAL ARRANGEMENT

INDEX REFERENCE :

DRG REGISTR		
DESIGN APPROVED	14/09/09	JRW
KKS APP		
DO AUTH	07/05/10	DO
CHKD BY	14/09/09	SR
DRAWN BY	14/09/09	KV
SCALE		

AUTHORISED FOR ESKOM BY: MOW — DATE: –

PANEL B CONSULTANTS JOINT VENTURE
Knight Piésold CONSULTING
Eskom

KUSILE POWER STATION
SDD SETTLING TANKS INLET AND OUTLET PIPEWORKS SECTIONS

DRG. No. K 5452-80-100 — REV 1

0.90/2472 — SHEET A0 — REV 1

APPENDIX B

CALCULATION RECORDS

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 10

Project Name: Kusile Power Station **Job No:** 303-00098/06

Calculation Title: Hydraulic Calculations : Station Dirty Dam Settling Tank

Calculation No./File No.:

Calculation is: ☐ Preliminary ☒ Final

Objective: Detailed hydraulic design of the Station Dirty Dam Settling Tank, including energy Dissipators, baffle walls, spillways and sluice gates.

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
	None		

This section applies to computer generated calculations			
Program Name/Number: N/A		**Version:**	
Program Name/Number: N/A		**Version:**	
Evidence of or reference to computer program verification, if applicable:			
Bases or reference thereto supporting application of the computer program to the physical problem:			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
0	Nicholas Pilz	Mar 10				

1. PURPOSE:

To calculate the size of various hydraulic structures involved in Station Dirty Dam settling tanks. The detailed calculations include energy dissipators, the overspill sections, submerged openings and the sizing of the isolating sluice gates.

2. REFERENCES:

1.	SETTLING TANKS TYPICAL DETAILS SHEET 1	5452-80-033	Rev	
2.	SETTLING TANKS TYPICAL DETAILS SHEET 2	5452-80-034	Rev	
3.	SDD SETTLING TANKS - GENERAL ARRANGEMENT	5452-80-035	Rev	
4.	SDD SETTLING TANKS - TYPICAL SECTIONS & DETAILS	5452-80-036	Rev	
5.	SDD SETTLING TANKS -SURFACE BED LAYOUT & DETAILS	5452-80-037	Rev	
6.	SDD SETTLING TANKS ENERGY DISSIPATOR GA & DETAILS	5452-80-038	Rev	
7.	SDD SETTLING TANKS OUTLET GA & DETAILS	5452-80-039	Rev	
8.	SETTLING TANKS - FLOOR REINFORCING DETAILS SHEET 1	5452-80-061	Rev	
9.	SETTLING TANKS - FLOOR REINFORCING DETAILS SHEET 2	5452-80-062	Rev	
10.	SETTLING TANKS - WALL REINFORCING DETAILS SHEET 1	5452-80-063	Rev	
11.	SETTLING TANKS - TYPICAL REINFORCING DETAILS SHEET 1	5452-80-068	Rev	
12.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS - GA	5452-70-071	Rev	
13.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS - SECTIONS & DETAILS	5452-70-072	Rev	
14.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS SECTIONS	5452-80-100	Rev	

3. ASSUMPTIONS

Density of water = $1000kg/m^3$
Acceleration due to gravity = $9.81m/s^2$

Additional assumptions are listed in the detailed hydraulic calculations, where applicable.

4. HYDRAULIC CALCULATIONS

APPENDICES

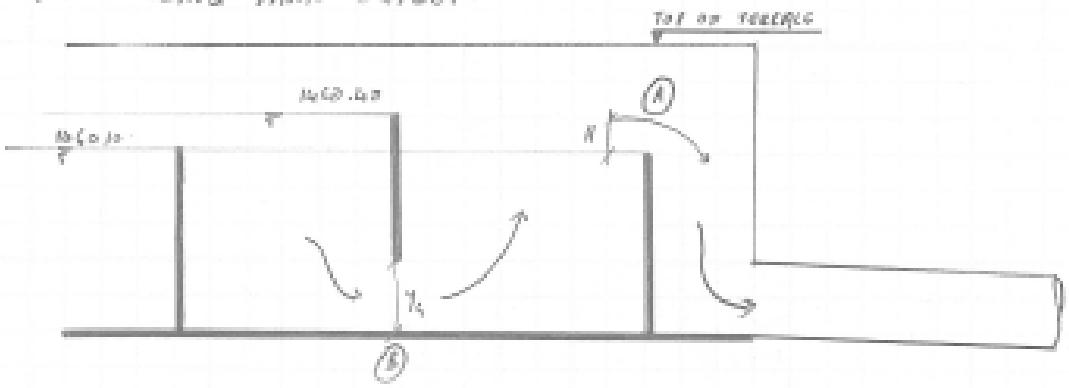
Appendix A – Energy Dissipator Design Calculations
Appendix B – Sluice Gate Design

4.1 Calculation title

STATION DIRTY DAM SETTLING TANK

- SETTLING TANK DESIGNED TO FUNCTION PROPERLY UP TO DESIGN FLOW = 6.55 m^3/s
  = 3.275 m^3/s per TANK
- ANY FLOW GREATER WILL PASS THROUGH TANK
- SETTLING FLOW CAPABLE OF PASSING 1:50 yr 24hr STORM

* SETTLING TANK OUTLET:



AT (A)

$Q = C_d B H^{3/2}$

$3.275 = 1.704 \times 12.750 \times H^{1/2}$

$\therefore H = 0.28_m \approx 0.30_m$

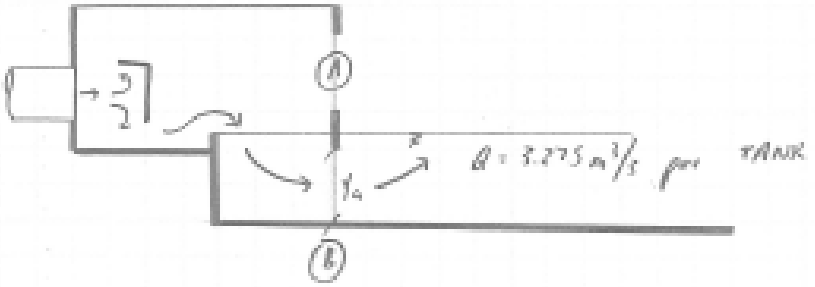
AT (B)

$\frac{Y_1 + Q^2}{2gA^2} = \frac{Y_2 + Q^2}{2g(Y_2+t)^2}$

$\therefore 2.64 + \frac{3.275^2}{2(9.81)} = 2.59 + \frac{3.275^2}{(0.6Y_2+t)^2 2g}$

$\therefore Y_2 = 1.05 \times 100_m$

* SETTLING TANK INLET



AT (B)

ASSUMING $y_A = 1.540\,m$

$$\frac{y_1 + \frac{Q^2}{A_1^2 2g}}{y_1} = \frac{y_2 + \frac{Q^2}{(y_2 \times 1.5)^2 2g}}{y_2}$$

$$\therefore y_1 + \frac{0.243}{y_1^2} = 2.364$$

$$\therefore y_1 = 2.32\,m$$

∴ TOTAL OF 4 OPENINGS PER TANK, EACH FITTED WITH SLUICE GATE

∴ CRITICAL SCENARIO WHEN ALL GATES CLOSED AND 1:50 yr EVENT

1:50 yr FLOOD = $10.78\ m^3/s$ (FROM PLANS)

∴ TOP OF TERRACE = 1:50 yr FLOOD EVENT + 300 mm FREEBOARD

∴ OVERSPILL SECTION AT (A)

$$Q = C_d B H^{3/2}$$

$$\therefore H = 0.90\,m$$

∴ 1:50 yr FLOOD LEVEL = RL 10.60 m + 300 mm FREEBOARD

APPENDIX A

Energy Dissipator Design Calculations

Inlet flow from Plant Terrace

Q =	10.78m^3/s
Area Culvert 1950Ø =	3.976m^2
v =	2.71m/s
$y_e = (A/2)^{1/2}$ =	1.409m
Fr = u / √gL =	0.729
$H_0 = y_e + v^2/2g$ =	1.783m

From Figure 8-C-2,

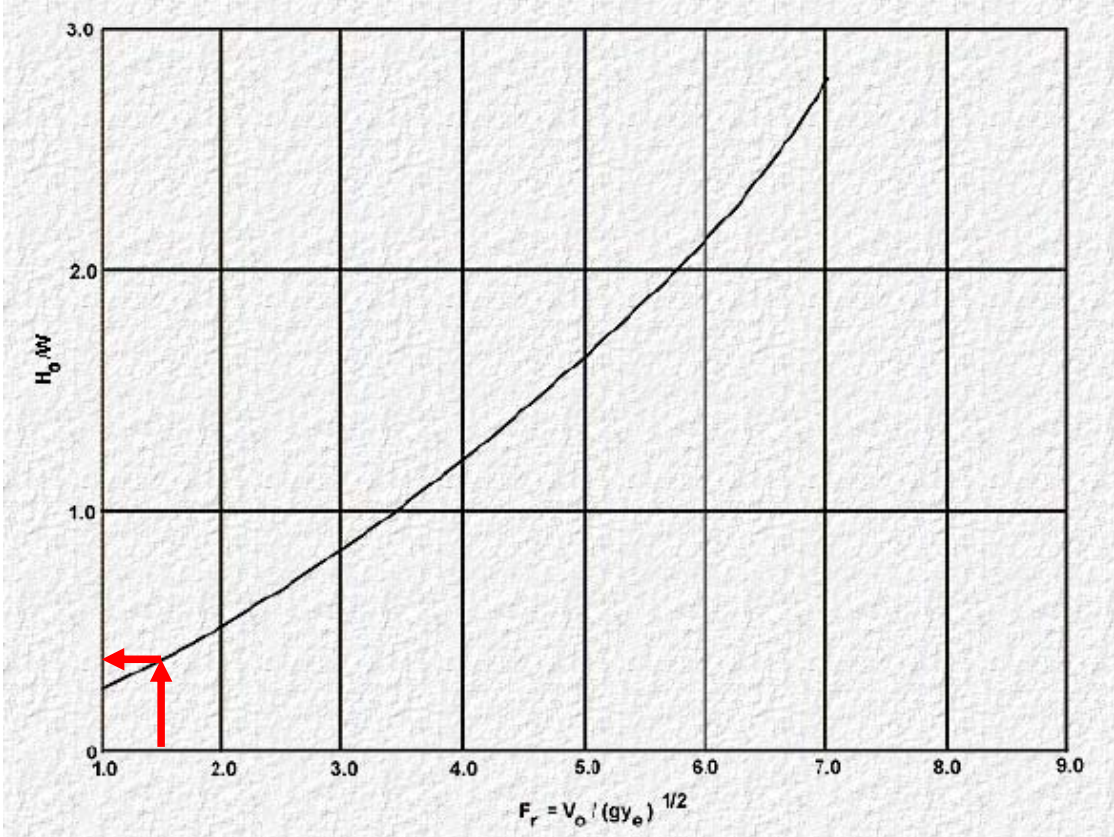


Figure 8-C-2. Design Curve - Baffle Wall Dissipator

H_0/W =	0.4053
W =	4.88m

The energy dissipator has the following dimensions based on Figure 8-C-1 :

h_1 =	3.70m	w_2 =	1.00m
L =	6.50m	t_3 =	0.30m
h_2 =	1.80m	t_2 =	0.30m
h_3 =	0.80m	t_1 =	0.25m
L_1 =	2.75m	t_4 =	0.30m
L_2 =	3.75m	t_5 =	0.15m
h_4 =	2.00m	w_1 =	0.40m

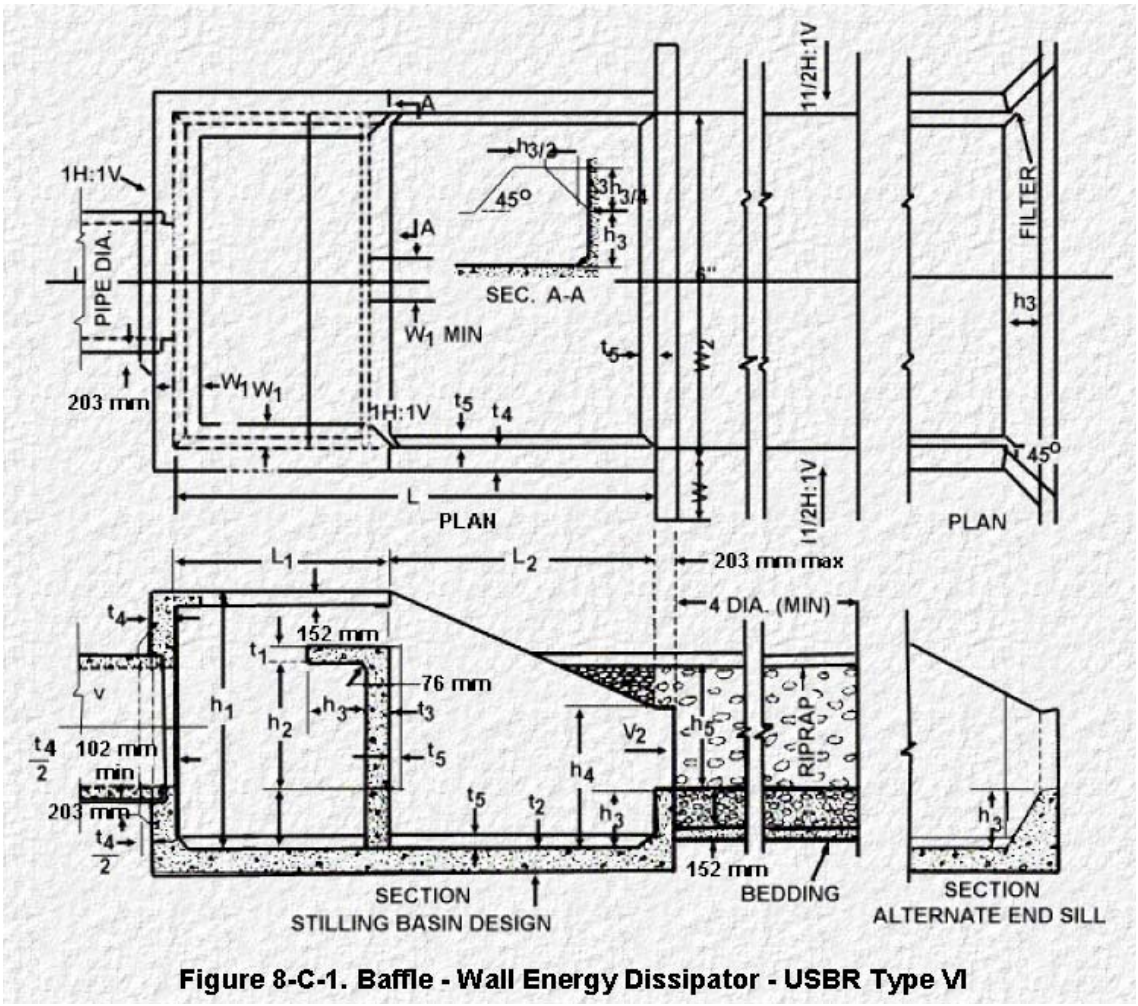


Figure 8-C-1. Baffle - Wall Energy Dissipator - USBR Type VI

APPENDIX B

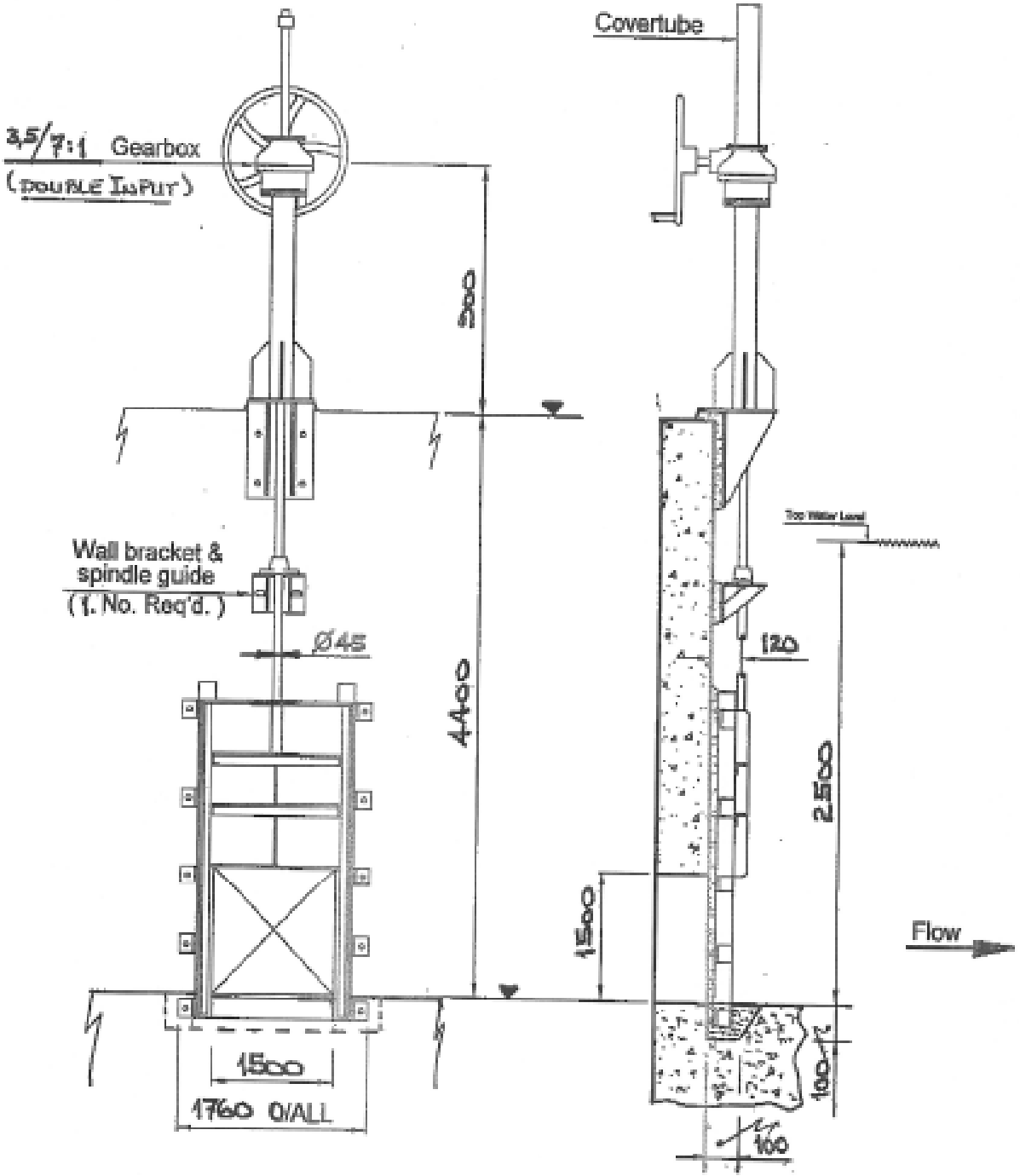
Sluice Gate Design

Technical

		Item no : 1.
G.A. Sketch No.		Q-5297 / 1.
Opening width x height (w x h)	mm	1500 x 1500
Invert to top of wall (X)	mm	4400
Max. Unbalanced head on gate (Hm)	m	2,50
Max. Operating head (Ho)	m	2,50
Direction of flow		Off-seating
Type of Invert		Flush
Spindle type		Rising
Spindle diameter	mm	45
Operating gear		Manual
Handwheel diameter	mm	600
Gearbox ratio (Twin Input)		3,5 & 7 : 1
Force to raise gate	N	92
Electric actuator		N/A

Materials of construction

Gate and Frame	3CR12
Seals	E.P.D.M.
Pedestal / Bracket	3CR12
Wall bracket	3CR12
Spindle	S/S (304)
Spindle guide	BRONZE
Cover tube	PERSPEX
Handwheel	ALUMINIUM
Fasteners and or Anchor bolts	S/S (304)



Wall-mounted Sluice Gate

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 5

Project Name: Kusile Power Station **Job No:** 303-00098/06

Calculation Title: Particle Settling Calculations : SDD Settling Tanks

Calculation No./File No.:

Calculation is: ☐ Preliminary ☒ Final

Objective: Particle Settling calculations for the CSY Settling Tanks to quantify the size of particle that can be removed in the tank.

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
	None		

This section applies to computer generated calculations			
Program Name/Number: N/A		**Version:**	
Program Name/Number: N/A		**Version:**	
Evidence of or reference to computer program verification, if applicable:			
Bases or reference thereto supporting application of the computer program to the physical problem:			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
0	Scott Rees	Mar 10	JRW	Mar 10		

1. PURPOSE:

To calculate the size of particle that can be settled for the design inflow rate.

2. REFERENCES:

1.	SDD SETTLING TANKS GENERAL ARRANGEMENT	5452/80/035	Rev	
.				

3. ASSUMPTIONS

Density of water = $1000kg/m^3$
Acceleration due to gravity = $9.81m/s^2$

Additional assumptions are listed in the detailed hydraulic calculations, where applicable.

4. HYDRAULIC CALCULATIONS

APPENDICES

None

Calculations

Settling Compartment Parameters	
Effective Width (m)	16.0
Length (m)	125.0
Effective Length (m)	112.5
Depth (m)	2.0
Length/Width Ratio	7.8
Storage Volume (m^3)	3987.5
Cross Sectional Area (m^2)	31.9

- Width is the average rectangular section representing the trapezoidal shape of the settling tank cross section

UNHINDERED PARTICLE SETTLING

Parameters	Variable	Units	Input
Specific Gravity of Solids	S_s	Dimensionless	1.5
Specific Gravity of Fluid	S_f	Dimensionless	1.0
Kinematic Viscosity of Fluid	ν	m^2/s	1.141E-06
Gravity	g	m/s^2	9.81
Particle Diameter	D	m	9.212E-05
Particle Shape Factor	S_f	Dimensionless	0.90

Terminal Velocity of Settling Particles , V_T

$$V_T = S_f * Y * [\nu * g * (S_s - S_f)]^{1/3}$$

where

$Y = 0.0556 * X^2$, if X < 4 (Laminar Flow / Stokes' Law),
$Y = 0.21 * X$, if 4 < X < 70 (Transitional Flow / Allen's Law)
$Y = 1.739 * X^{0.5}$, if X > 70 (Turbulent Flow / Newton's Law)

and

$$X = [(S_s - S_f) * g / \nu^2]^{1/3} * D$$

Drag Coefficient, C_D

$C_D = 24 / Re_p$, if Laminar Flow

$C_D = 14 / Re_p^{0.5}$, if Transitional Flow

$C_D = 0.44$, if Turbulent Flow

TERMINAL SETTLING VELOCITY OF PARTICLES

X =	**1.433**

Y =	0.114
Y =	0.000
Y =	0.000
Y =	**0.114**

V_T =	**1.83E-03**	**m/s**

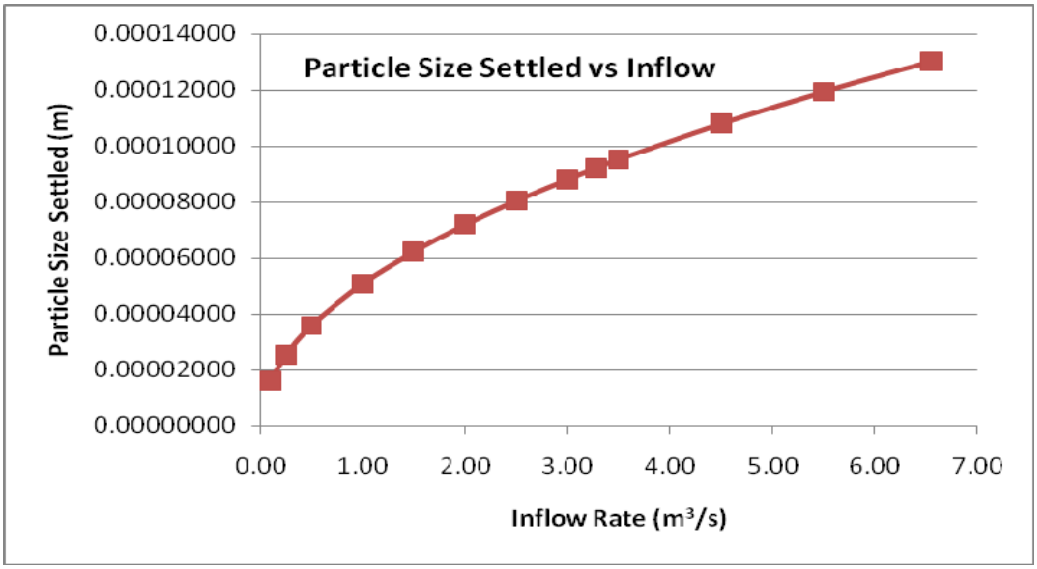
Re =	**1.47E-01**	**LAMINAR SETTLING**

C_D =	**162.86**

Impoundment Time (s):	**1095.802**
Impoundment Time (min):	**18.26**
Impoundment time (hrs):	**0.30**

Settling Velocity V_T (m/s):	**1.83E-03**
Time Required to Settle Selected Particles (s):	**1095.70**
Distance Required to Settle Selected Particles (m):	**112.49**
Required Settling Achieved?	**YES**

Figure illustrating particle size settled versus inflow rate to the settling tank (note as inflow rate increases the particle size settled becomes larger, ie. The tank becomes less effective due to shorter retention time)



ARCUS GIBB CONSULTING • DESIGN • MANAGEMENT SSI A DHV COMPANY Knight Piésold CONSULTING

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 28

Project Name: SDD SETTLING TANKS **Job No:** K5452-80-035

Calculation Title: INLET & OUTLET WALLS

Calculation No./File No.: K5452-80-035 R2 (REPORT 1 OF 3)

Calculation is: ☐ Preliminary ☒ Final

Objective: Determine concrete sizes and required reinforcement areas for ULS & SLS on retaining walls

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
1	Fluid density – 10kN/m^3	KG	01/08/2009
2	Soil pressure (see "Annexure A")	KG	01/08/2009
3	Founding on non-yielding material	KG	01/08/2009

See page ____ of this calculation for additional assumptions.

This section applies to computer generated calculations			
Program Name/Number:	Autodesk Robot Structural Analysis 2010	**Version:**	V23.0.1.3128
Program Name/Number:	Autodesk Revit Structure 2010	**Version:**	V2010
Evidence of or reference to computer program verification, if applicable: See "Annexure B"			
Bases or reference thereto supporting application of the computer program to the physical problem: Finite element analysis (FEA) method can be implemented with acceptable standards to South Africa			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
1	C Vorster	01/08/09	AR Gorman PrEng	01/08	K Georgala PrEng	05/08

1. PURPOSE:

Determination of structure dimensions and required reinforcement under specified load.

2. REFERENCES:

	1. Concrete layout drawing	K5452-80-035	Rev	R2
	2.		Rev	

3. LOAD CASES AND COMBINATIONS

Load Cases:

1. **Self Weight**
2. **Soil Pressure**

Load Combinations:

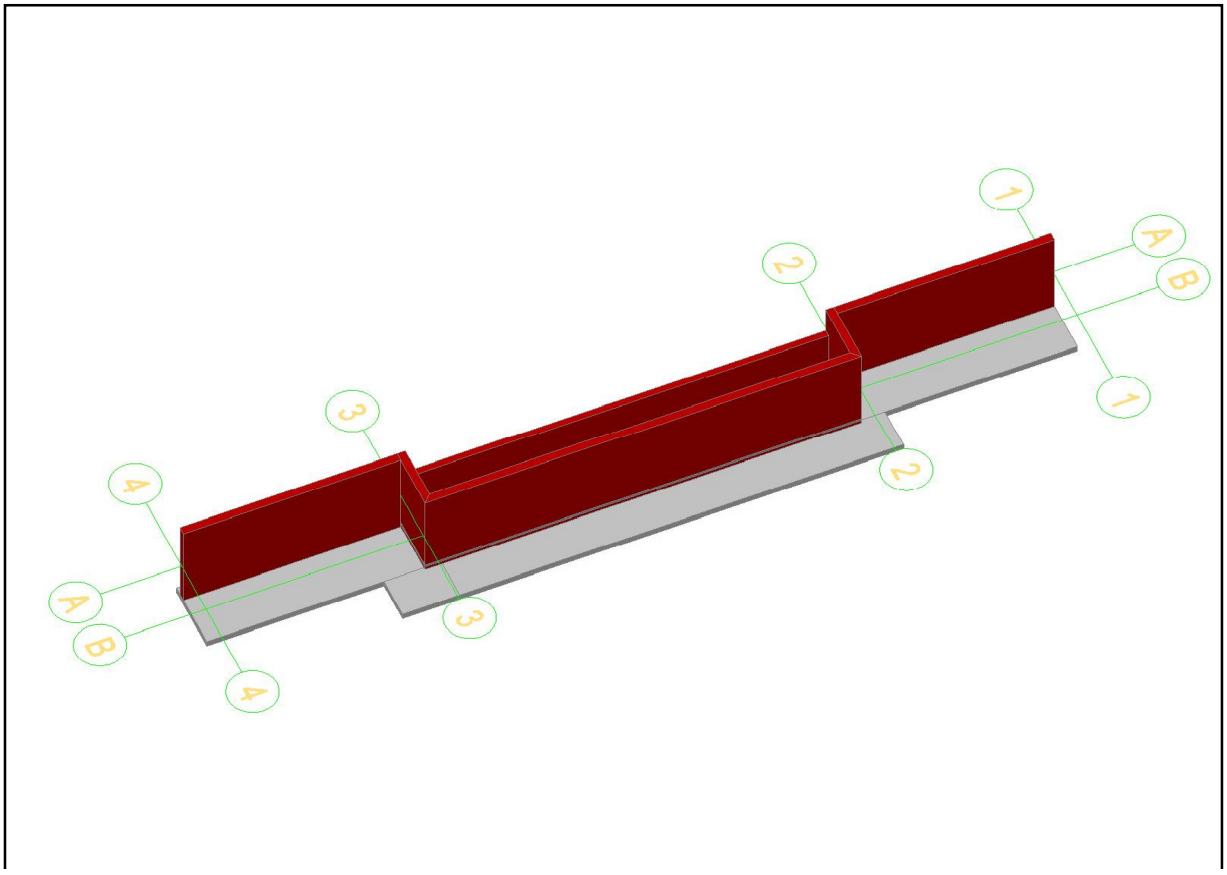
10. Self+Soil-ULS

11. Self+Soil-SLS

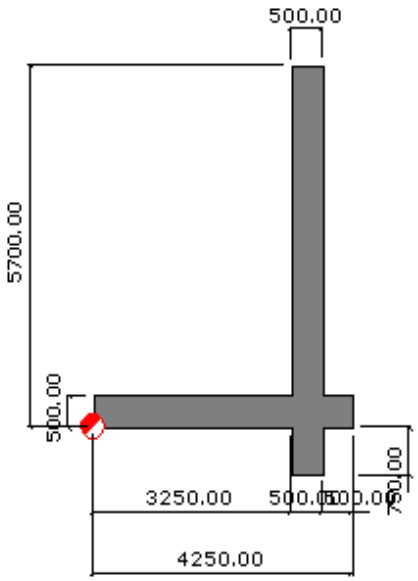
4. APPLICATIONS:

INLET WALLS:

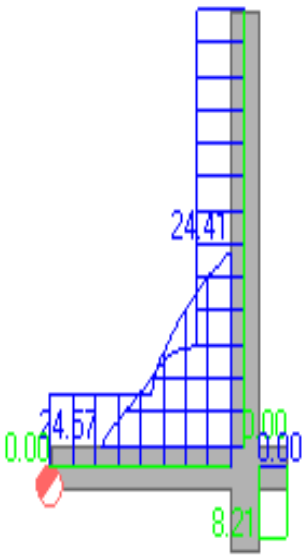
STRUCTURAL MODEL VIEW:



Note:
A 25mm expansion joint (in walls only), present at gridlines 2 & 3.
Concrete sizes & Reinforcement:
-Side walls on gridline A, between gridlines 1-3 & 3-4:

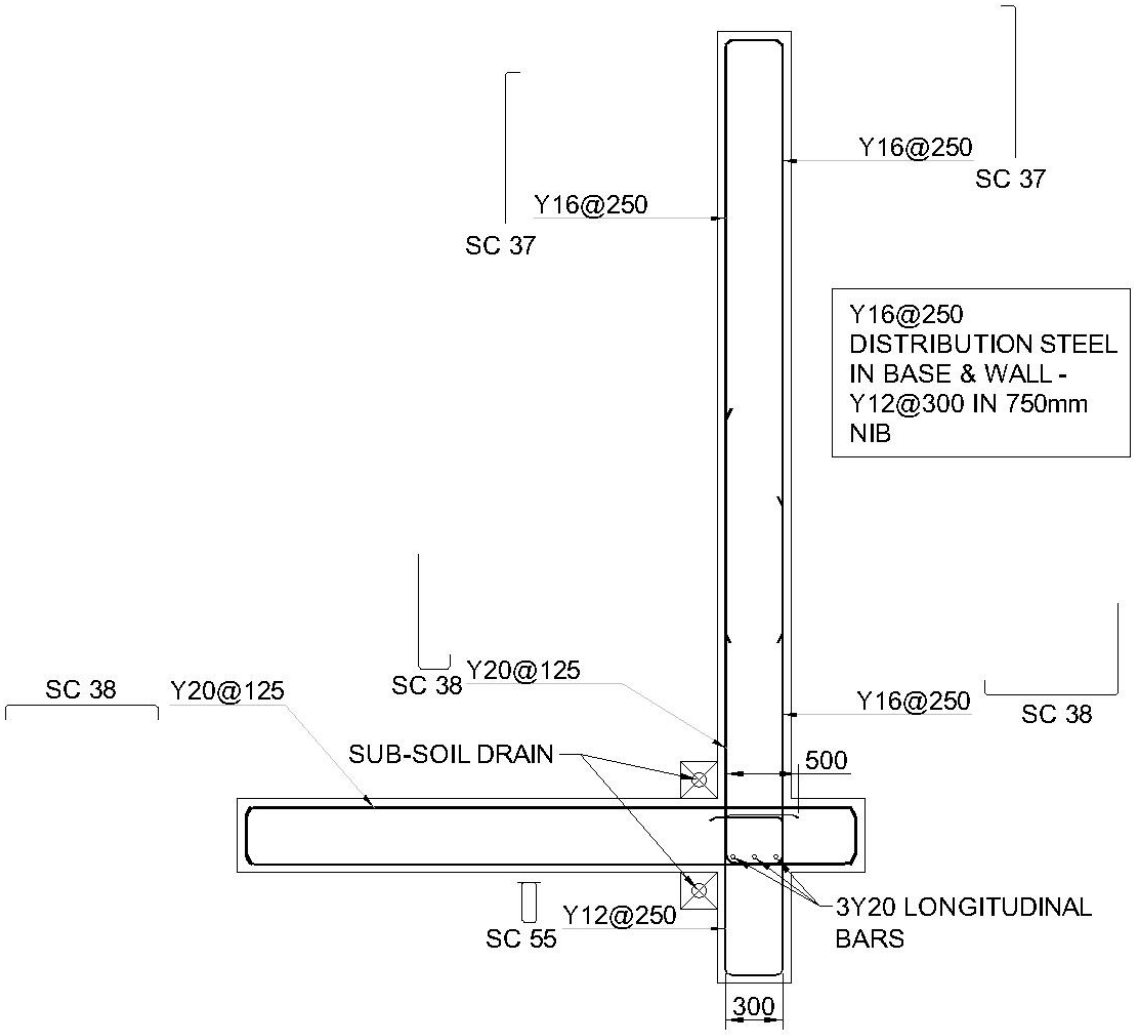


Reinforcement area diagram:

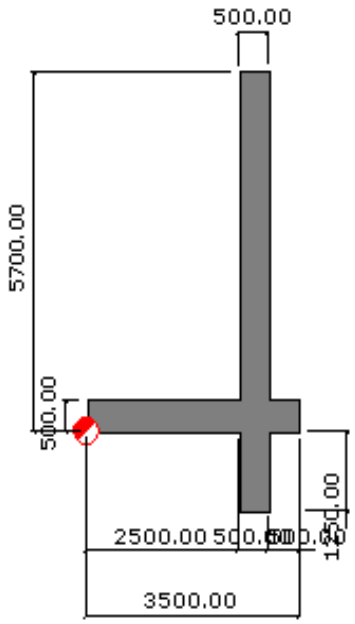


(cm2/m)

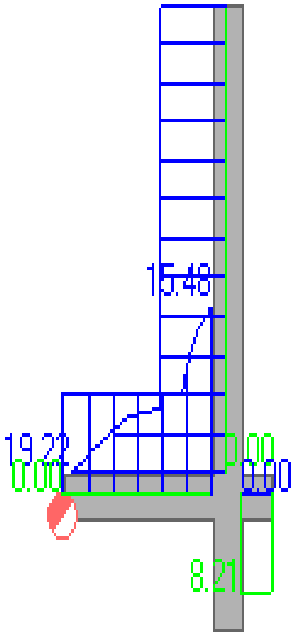
Suggested reinforcement:


Y16@250
SC 37
Y16@250
SC 37
Y16@250
DISTRIBUTION STEEL
IN BASE & WALL -
Y12@300 IN 750mm
NIB
SC 38
Y20@125
SC 38
Y20@125
Y16@250
SC 38
SUB-SOIL DRAIN
500
3Y20 LONGITUDINAL
BARS
SC 55
Y12@250
300

-Inlet box walls between gridlines 2 & 3, excluding baffle wall:

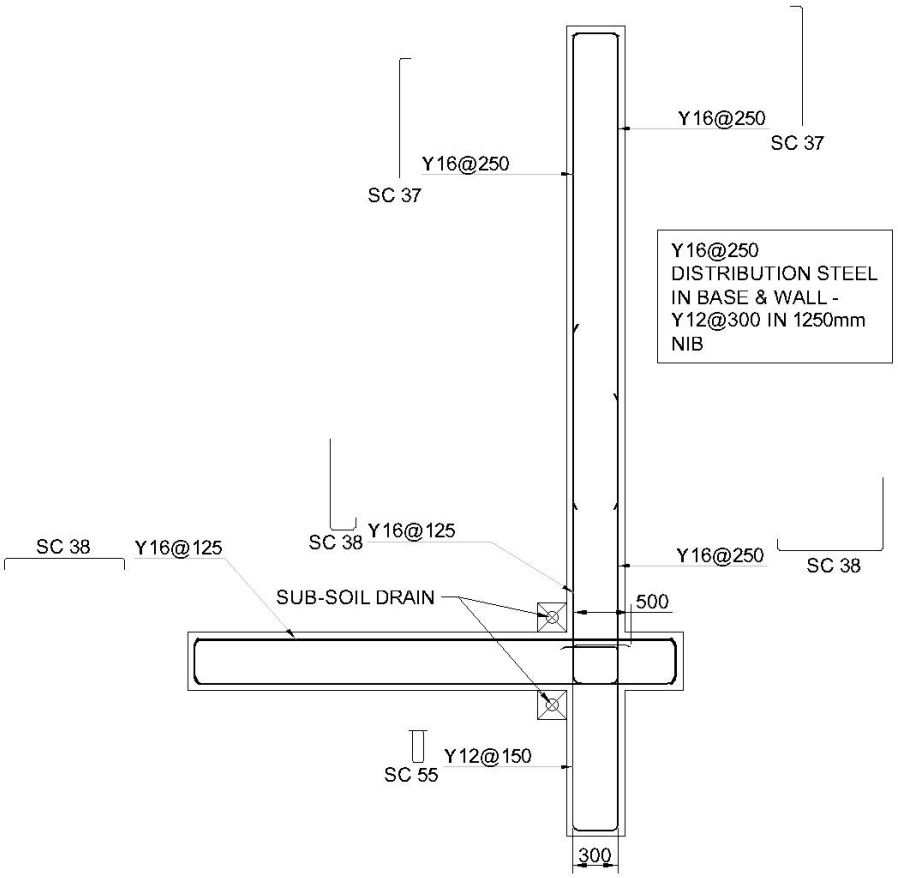


Reinforcement area diagram:

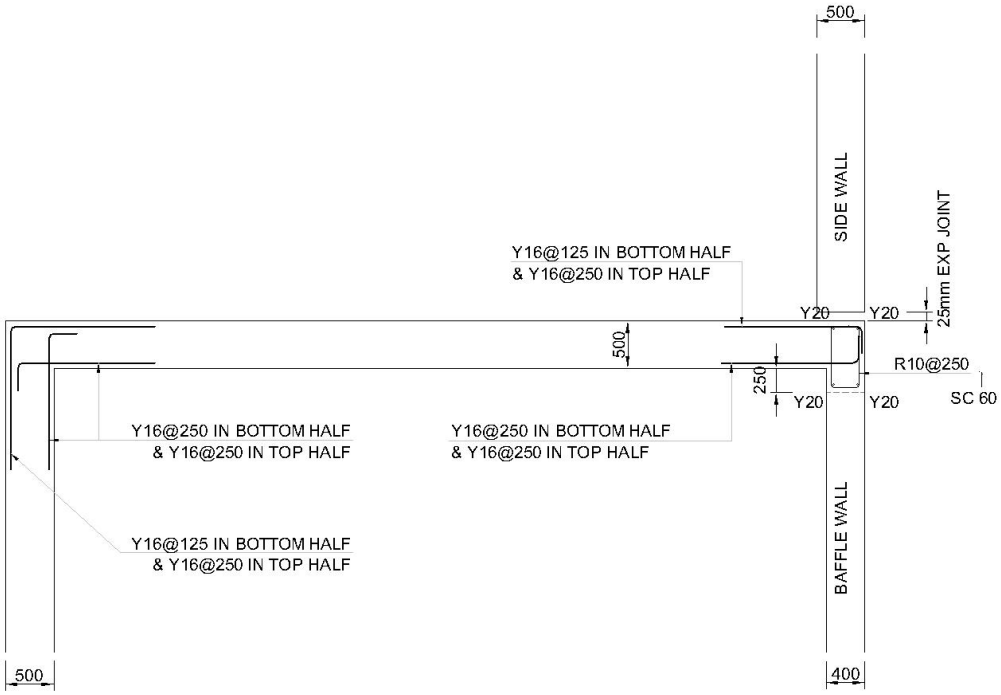


(cm2/m)

Suggested reinforcement:

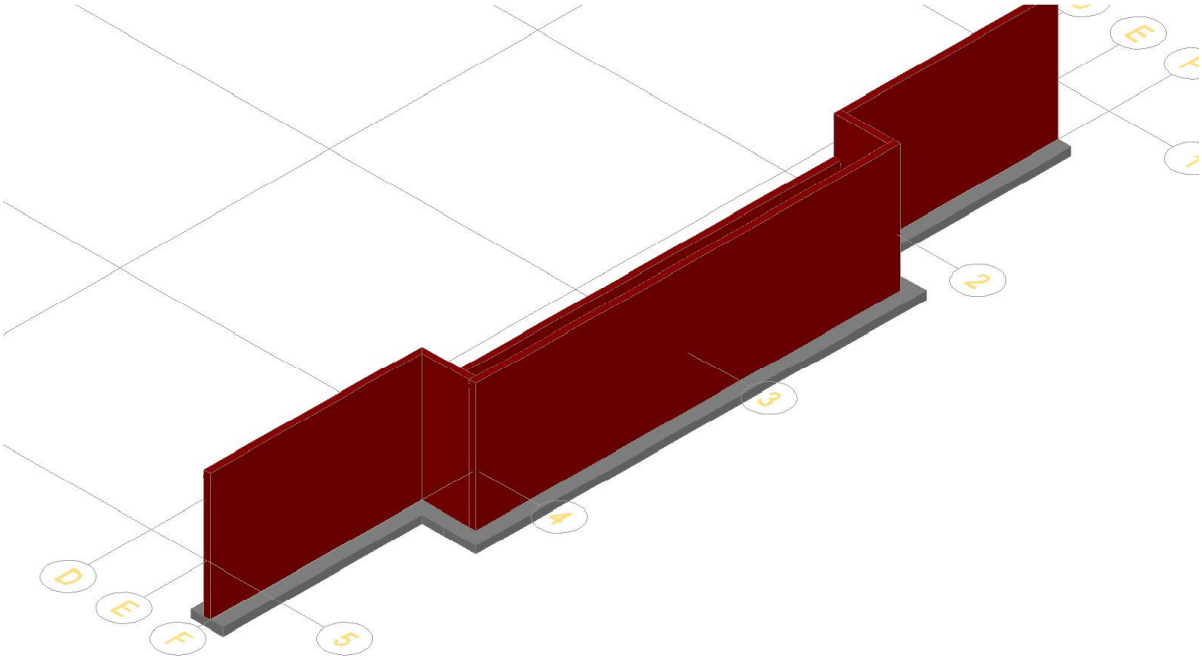


Wall corner details:



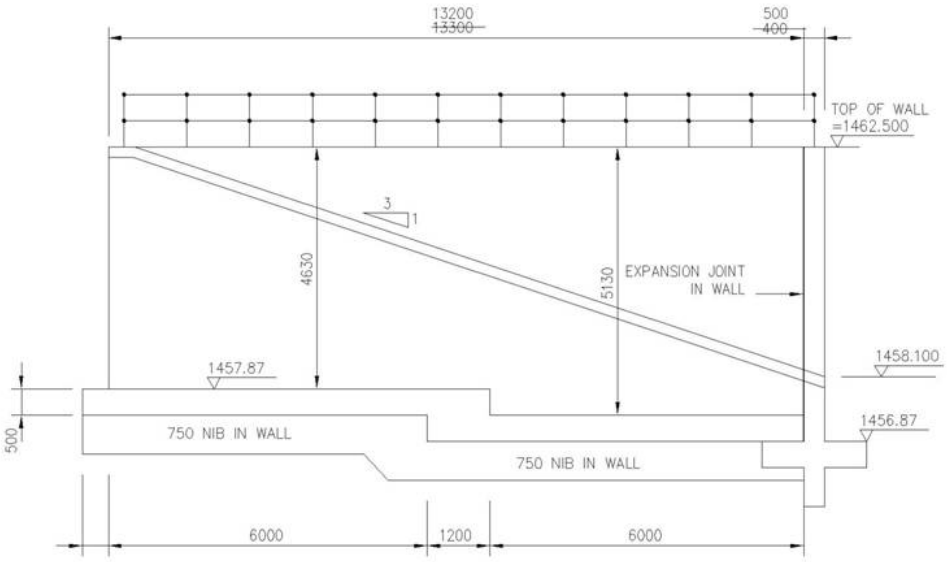
OUTLET WALLS:

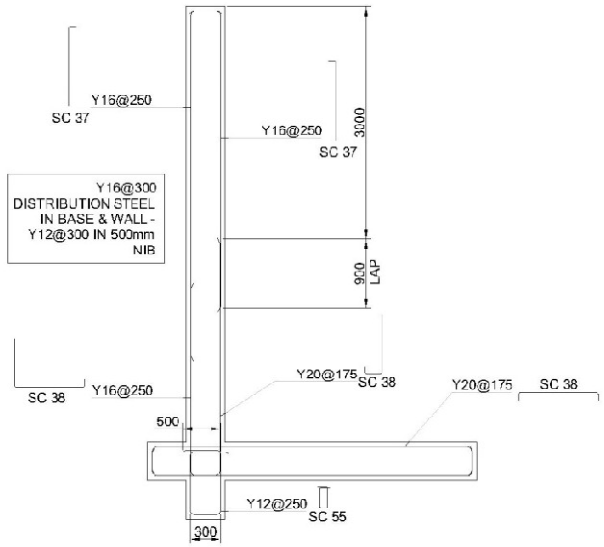
STRUCTURAL MODEL VIEW:



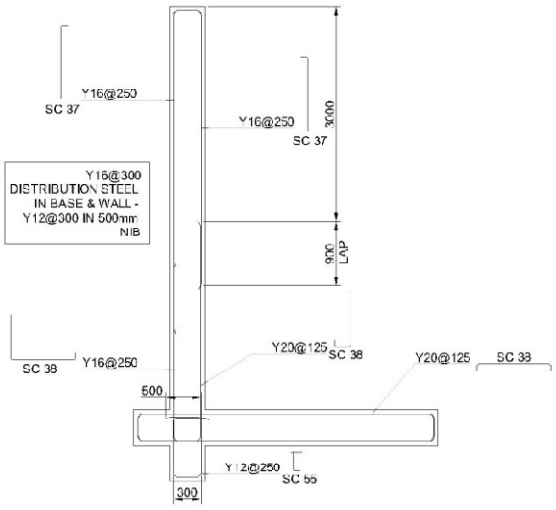
Concrete sizes & Reinforcement:

-Side wall on Eastern side, on gridline E, between gridlines 1 & 2:



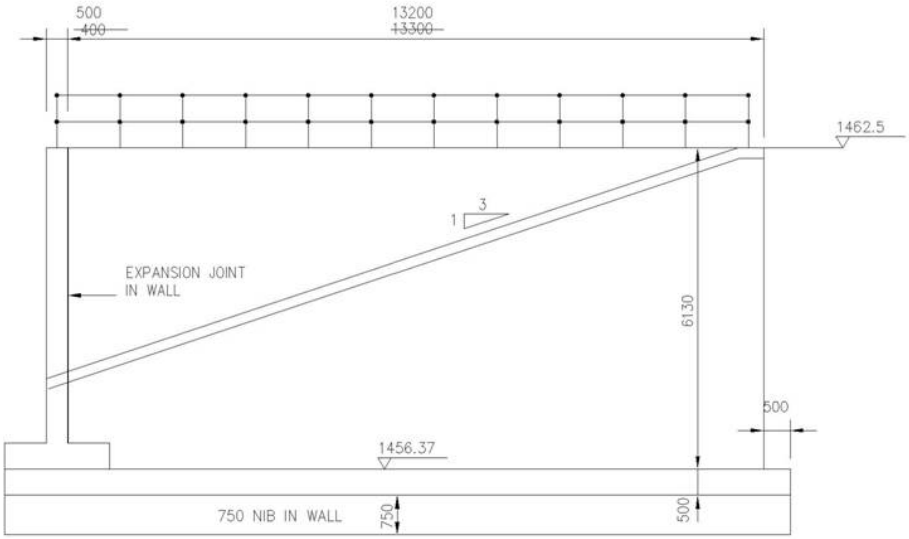


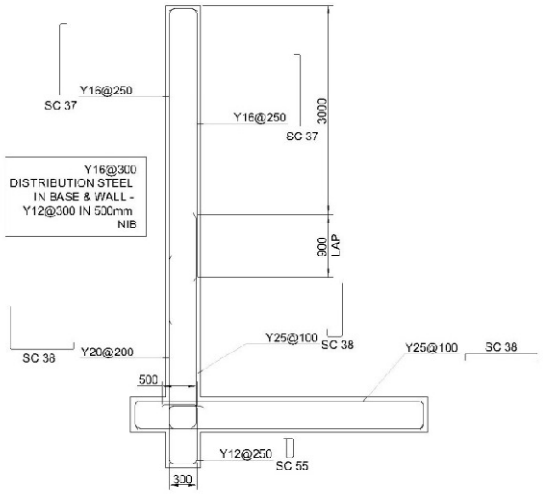
EAST OUTLET WALL LOWER PORTION



EAST OUTLET WALL
UPPER PORTION

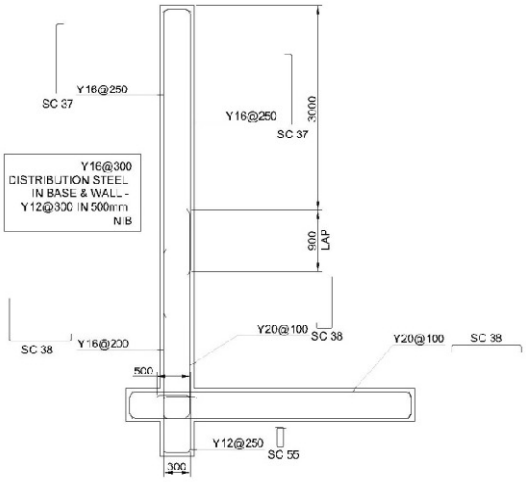
-Side wall on Western side, on gridline E, between gridlines 4 & 5:





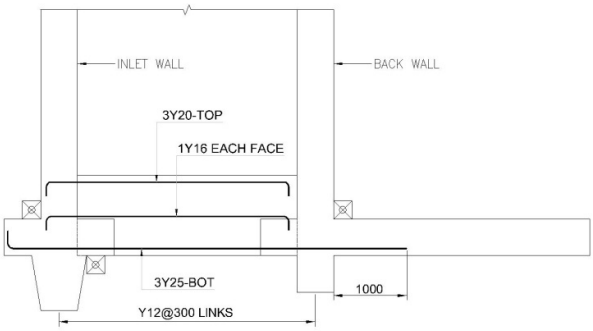
WEST OUTLET WALL

-Outlet back wall, on gridline F, between gridlines 2 & 4:



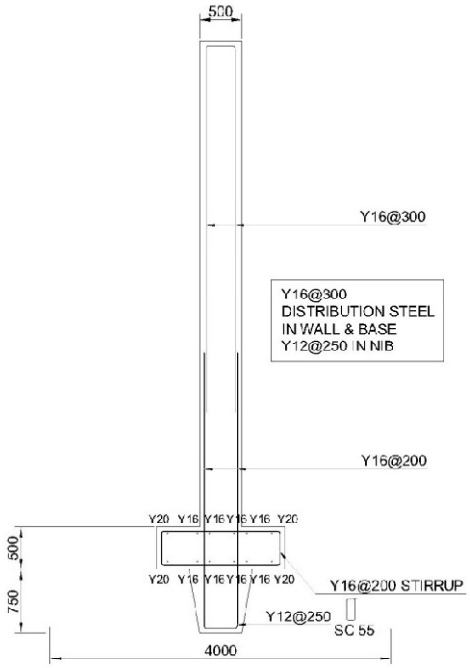
OUTLET BACK WALL

-Strap beams between gridline E & F:



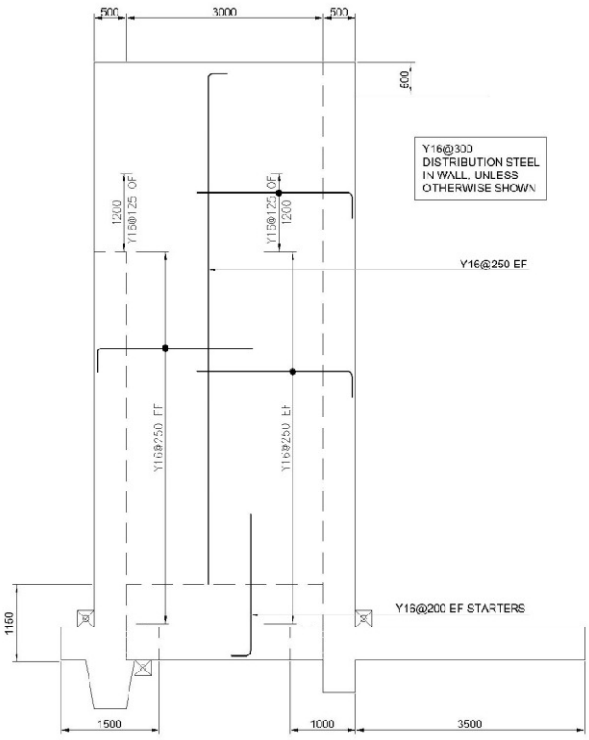
STRAP BEAMS

-Inlet wall on gridline E, between gridlines 2 & 4:



INLET WALL

-Side walls on gridlines 2 and 4, between gridlines E & F :



SIDE WALLS

5. PROCEDURE/METHODOLOGY OF DESIGN:

5.1 The Robot Retaining wall module has been applied for this analysis
5.2 2 Load cases and 2 Load combinations have been analyzed, as indicated in “Annexure A”

6. ASSUMPTIONS:

6.1 Assumptions requiring verification will be listed on the cover sheet

7. DEFINITION OF UNITS AND CONSTANTS:

Refer to “Annexure A”

8. ANALYSIS/SOLUTION:(see body of calculation for analysis and solutions)

Note: Detailed calculations output data to be provided on request.

9. METHOD OF RESULTS GENERATION:

All loads and load combinations are defined as load cases within Robot Structural Analysis, combinations have the addition of factors applied as explained on pages 14-28 of this document, and are governed by ULS or SLS criteria.
The results displayed in this document, represents the worst cases of all possible cases, where each case has been analyzed individually as well as specified in combination cases.

10. APPENDICES TO CALCULATIONS:

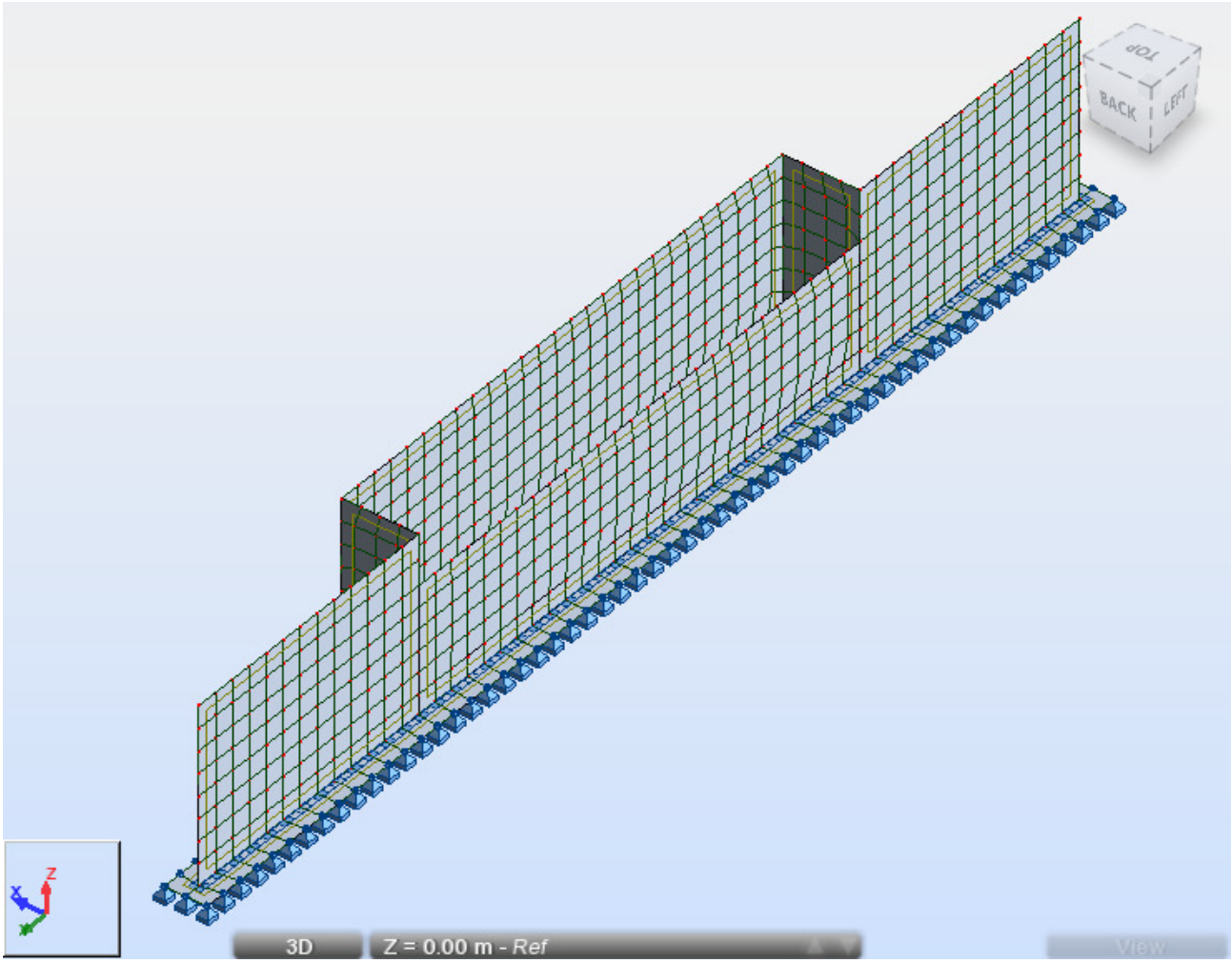
10.1 Appendix A – Calculations
10.2 Appendix B – Autodesk Robot Structural Analysis 2010 verification report

APPENDIX A

CALCULATIONS

8.1 SDD WALL DESIGN

STRUCTURE VIEW:



CALCULATION NOTE

Code preferences:

- **BS 8110 –** CONCRETE DESIGN
- **BS8004** / **PN-83/B-03010 –** SOIL CODE
- **SABS 1060 –** CODE COMBINATIONS
- **PN-B-03264(2002) –** RETAINING WALL DESIGN

Retaining wall : SIDE WALL

1. Calculation parameters:

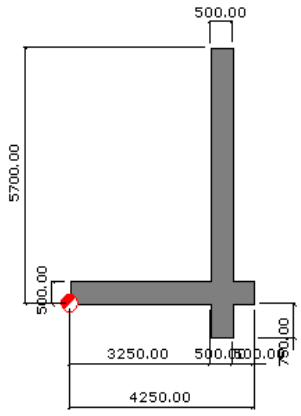
MATERIAL:

- **CONCRETE: class B 30, fck = 30.00 (MN/m2), unit weight = 24.00 (kN/m3)**
- **STEEL: class A - III, fyk = 450.00 (MN/m2)**

OPTIONS:

- Calculations according to: concrete code: **BS8110**
  soil code: **BS8004**
- Cover: c1 = 50.0 (mm), c2 = 50.0 (mm)
- Exposure: X0
- Retainig wall design according to:
  - Capacity m = 0.810 g = 2.000
  - Sliding m = 0.720 g = 2.000
  - Overturning m = 0.720 g = 2.000
- Retainig wall verification according to:
  - Average settlement:
    S_{dop} = 100.00 (mm)
  - Settlement differences:
    DS_{dop} = 50.00 (mm)
- Reduction factors for:
  - Soil cohesion 100.000 %
  - Soil frictions 0.000 %
  - Wall passive pressure 50.000 %
  - Key passive pressure 100.000 %
- Wall/soil friction angle:
  - Passive pressure for cohesive soils $-1/3\times\phi$
  - Cohesive soil pressure $1/2\times\phi$
  - Passive pressure for non-cohesive soils $-1/3\times\phi$
  - Pressure for non-cohesive soils $1/2\times\phi$

2. Geometry:



3. Soil:

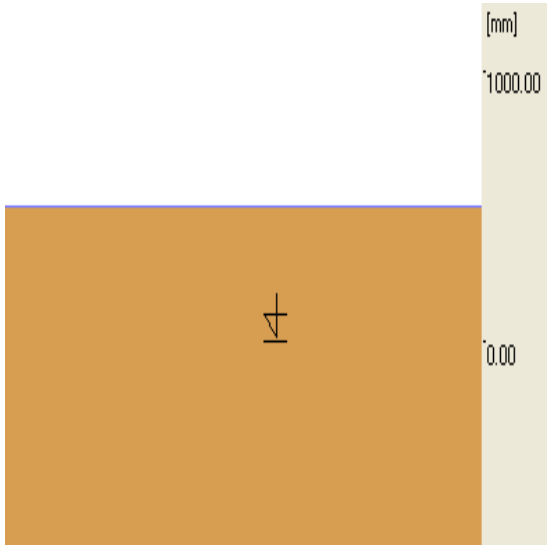
- **Soil parameter selection - method: B**
- **Backfill** Soil depth (behind the wall) Ho = 3000.00 (mm)
- **Original layers:**

Description:

No.	Soil name	Level *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1.	clayey fine sands	500.00	-	-	-	0.000

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1.	67.03	18.00	21.21	29.65	29.65



- **Soils (behind the wall):**

Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	500.00	500.00	-	-	0.000

* With respect to the lower right footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50

- **Soils (before the wall):**

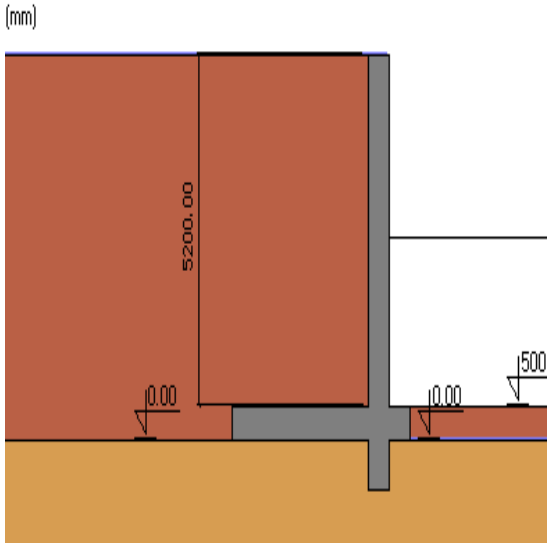
Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	5700.00	5700.00	-	-	0.000

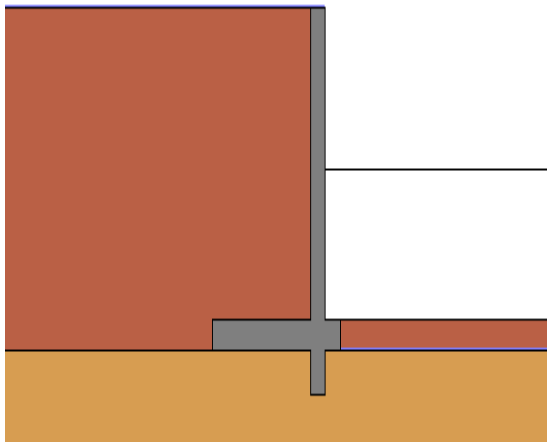
* With respect to the lower left footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50



4. Loads



- **Load report**

5. Results (soils)

PRESSURES

Soil pressure and passive pressure : according to wall displacements
Factors for pressures and passive pressures for soils:

Average backfill slope angle ε = 0.00 (Deg)
Wall inclination angle β = 0.00 (Deg)

$$K_a = \frac{\cos^2 \cdot (\beta - \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta_2) \cdot \sin(\phi - \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_p = \frac{\cos^2 \cdot (\beta + \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 - \sqrt{\frac{\sin(\phi - \delta_2) \cdot \sin(\phi + \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_o = \frac{\sigma_x}{\sigma_z} = \frac{\nu}{1 - \nu}$$

$$K_a \le K_o \le K_p$$

Soils (behind the wall):

No.	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravels	500.00	42.00	0.183	0.331	9.569

- Generalized limit displacements
  - passive pressure 0.132
  - pressure 0.013

Soils (before the wall):

	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravels	0.00	42.00	0.528	0.691	1.894
2.	well graded gravels	5700.00	42.00	0.198	0.331	5.045

- Generalized limit displacements
  - passive pressure 0.117
  - pressure 0.012

CAPACITY

- Soil type under footing: not layered
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-372.82 (kN/m) My=286.76 (kN*m) Fx=213.00 (kN/m)
- Equivalent footing dimension: A = 2467.02 (mm)
- Coefficient of load capacity and influence of load inclination:

N_B = 0.745 i_B = 0.059
N_C = 11.768 i_C = 0.266
N_D = 4.419 i_D = 0.442

- Soil limit pressure: Qf = 1049.17 (kN/m)
- Safety factor: Qf * m / Nr = 2.279 > 2.000

SETTLEMENT

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W
- Reduced design load:
  N=-407.17 (kN/m) My=348.60 (kN*m) Fx=218.72 (kN/m)
- Unit load of total loads: q = 0.10 (MN/m2)
- Thickness of the actively settling soil: z = 3000.00 (mm)
- Stress on the level z:
  - additional: szd = 0.01 (MN/m2)
  - caused by soil weight: szg = 0.08 (MN/m2)
- Settlement: S = 3.29 (mm) < Sdop = 100.00 (mm)

OVERTURNING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-372.82 (kN/m) My=286.76 (kN*m) Fx=213.00 (kN/m)
- Overturning moment: Mo= 187.38 (kN*m)
- Moment preventing foundation overturning: M_{uf} = 1311.98 (kN*m)
- Safety factor: M_{uf} * m / M_0 = 5.041 > 2.000

SLIDING

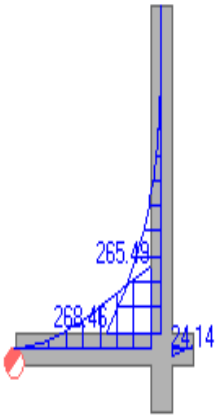
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-372.82 (kN/m) My=286.76 (kN*m) Fx=213.00 (kN/m)
- Equivalent footing dimension: A = 4250.00 (mm)
- Friction coefficient:
  - of soil (on the settlement level): μ = 0.034
- Soil cohesion reduction factor = 100.000 %
- Cohesion: C = 7.10 (kN/m2)
- Sliding force value: Q_{tr} = 213.00 (kN/m)
- Value of force preventing wall sliding:
- $Q_{tf} = N * \mu + C * A$
- - on the foundation level: Q_{tf} = 42.91 (kN/m)
- Safety factor: Q_{tf} * m / Q_{tr} = 1.768 < 2.000

OVERTURNING ANGLES

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W
- Reduced design load:
  N=-407.17 (kN/m) My=348.60 (kN*m) Fx=218.72 (kN/m)
- Maximum unit stresses from total loads:
  qmax = 0.20 (MN/m2)
- Minimum unit stresses from total loads:
  qmin = 0.00 (MN/m2)
- Overturning angle: ro = -0.13 (Deg)
- Coordinates of wall rotation point:
  X = 237.28 (mm)
  Z = 0.00 (mm)
- Safety factor: 5.544 > 2.000

6. Results of RC design

- Moments



(kN*m)

Element	Moments	Value *[kN*m]*	Position *[mm]*	Combination
Wall	maximum	0.00	5700.00	0.900*PM + 1.100*P'a + 0.900*Pa + 1.000*W
Wall	minimum	-268.67	500.00	0.900*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	maximum	24.14	3750.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	minimum	-266.58	3250.00	0.900*PM + 1.100*P'a + 1.320*Pa + 1.000*W

Retaining wall : INLET BOX WALLS

1. Calculation parameters:

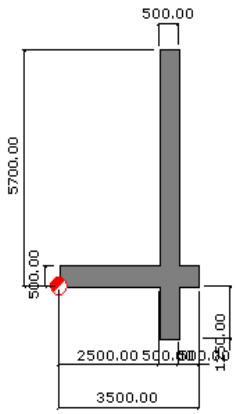
MATERIAL:

- **CONCRETE: class B 30, fck = 30.00 (MN/m2), unit weight = 24.00 (kN/m3)**
- **STEEL: class A - III, fyk = 450.00 (MN/m2)**

OPTIONS:

- Calculations according to: concrete code: **BS8110**
  soil code: **BS8004**
- Cover: c1 = 50.0 (mm), c2 = 50.0 (mm)
- Exposure: X0
- Retainig wall design according to:
  - Capacity m = 0.810 g = 2.000
  - Sliding m = 0.720 g = 2.000
  - Overturning m = 0.720 g = 2.000
- Retainig wall verification according to:
  - Average settlement:
    S_{dop} = 100.00 (mm)
  - Settlement differences:
    DS_{dop} = 50.00 (mm)
- Reduction factors for:
  - Soil cohesion 100.000 %
  - Soil frictions 0.000 %
  - Wall passive pressure 50.000 %
  - Key passive pressure 100.000 %
- Wall/soil friction angle:
  - Passive pressure for cohesive soils $-1/3\times\phi$
  - Cohesive soil pressure $1/2\times\phi$
  - Passive pressure for non-cohesive soils $-1/3\times\phi$
  - Pressure for non-cohesive soils $1/2\times\phi$

2. Geometry:



3. Soil:

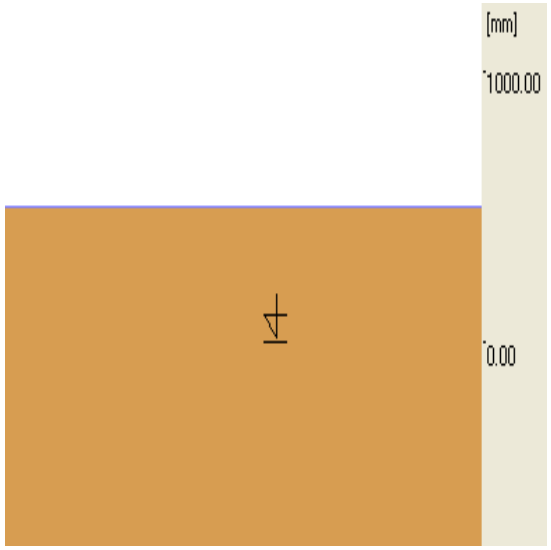
- **Soil parameter selection - method: B**
- **Backfill** Soil depth (behind the wall) Ho = 3000.00 (mm)
- **Original layers:**

Description:

No.	Soil name	Level *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1.	clayey fine sands	500.00	-	-	-	0.000

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1.	67.03	18.00	21.21	29.65	29.65



- **Soils (behind the wall):**

Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	500.00	500.00	-	-	0.000

* With respect to the lower right footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50

- **Soils (before the wall):**

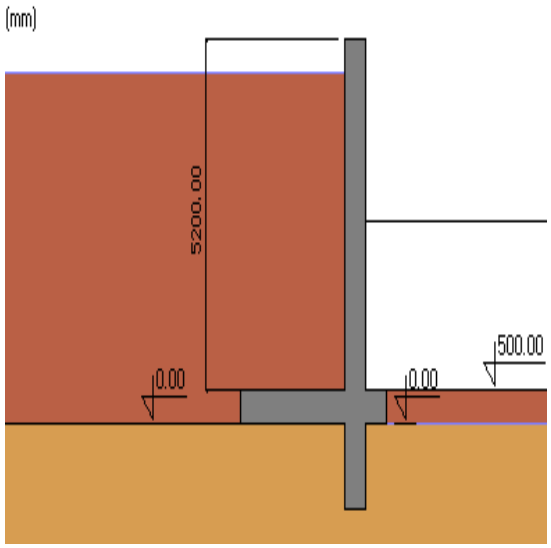
Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	5200.00	5200.00	-	-	0.000

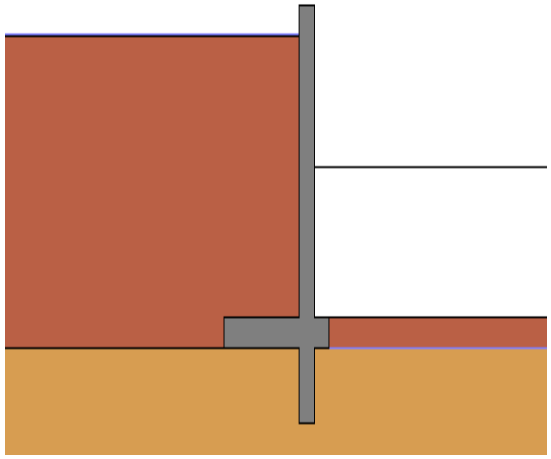
* With respect to the lower left footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50



4. Loads



- **Load report**

5. Results (soils)

PRESSURES

Soil pressure and passive pressure : according to wall displacements
Factors for pressures and passive pressures for soils:

Average backfill slope angle ε = 0.00 (Deg)
Wall inclination angle β = 0.00 (Deg)

$$K_a = \frac{\cos^2 \cdot (\beta - \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta_2) \cdot \sin(\phi - \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_p = \frac{\cos^2 \cdot (\beta + \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 - \sqrt{\frac{\sin(\phi - \delta_2) \cdot \sin(\phi + \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_o = \frac{\sigma_x}{\sigma_z} = \frac{\nu}{1 - \nu}$$

$$K_a \le K_o \le K_p$$

Soils (behind the wall):

No.	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravels	500.00	42.00	0.183	0.331	9.569

- Generalized limit displacements
  - passive pressure 0.132
  - pressure 0.013

Soils (before the wall):

	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravels	0.00	42.00	0.528	0.691	1.894
2.	well graded gravels	5200.00	42.00	0.198	0.331	5.045

- Generalized limit displacements
  - passive pressure 0.117
  - pressure 0.012

CAPACITY

- Soil type under footing: not layered
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-288.30 (kN/m) My=171.33 (kN*m) Fx=208.95 (kN/m)
- Equivalent footing dimension: A = 1963.77 (mm)
- Coefficient of load capacity and influence of load inclination:

N_B = 0.745 i_B = 0.059
N_C = 11.768 i_C = 0.266
N_D = 4.419 i_D = 0.442

- Soil limit pressure: Qf = 816.41 (kN/m)
- Safety factor: Qf * m / Nr = 2.294 > 2.000

SETTLEMENT

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W
- Reduced design load:
  N=-311.92 (kN/m) My=205.45 (kN*m) Fx=214.09 (kN/m)
- Unit load of total loads: q = 0.10 (MN/m2)
- Thickness of the actively settling soil: z = 2625.00 (mm)
- Stress on the level z:
  - additional: szd = 0.01 (MN/m2)
  - caused by soil weight: szg = 0.08 (MN/m2)
- Settlement: S = 2.54 (mm) < Sdop = 100.00 (mm)

OVERTURNING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-288.30 (kN/m) My=171.33 (kN*m) Fx=208.95 (kN/m)
- Overturning moment: Mo= 152.37 (kN*m)
- Moment preventing foundation overturning: M_{uf} = 878.36 (kN*m)
- Safety factor: M_{uf} * m / M_0 = 4.150 > 2.000

SLIDING

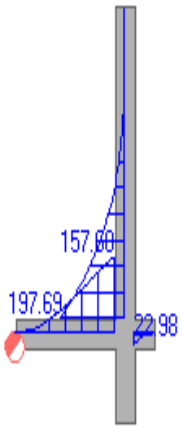
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-288.30 (kN/m) My=171.33 (kN*m) Fx=208.95 (kN/m)
- Equivalent footing dimension: A = 3500.00 (mm)
- Friction coefficient:
  - of soil (on the settlement level): μ = 0.042
- Soil cohesion reduction factor = 100.000 %
- Cohesion: C = 8.62 (kN/m2)
- Sliding force value: Q_{tr} = 208.95 (kN/m)
- Value of force preventing wall sliding:
- Q_{tf} = N * μ + C * A
- - on the foundation level: Q_{tf} = 42.13 (kN/m)
- Safety factor: Q_{tf} * m / Q_{tr} = 1.895 < 2.000

OVERTURNING ANGLES

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W
- Reduced design load:
  N=-311.92 (kN/m) My=205.45 (kN*m) Fx=214.09 (kN/m)
- Maximum unit stresses from total loads:
  qmax = 0.20 (MN/m2)
- Minimum unit stresses from total loads:
  qmin = 0.00 (MN/m2)
- Overturning angle: ro = -0.14 (Deg)
- Coordinates of wall rotation point:
  X = 303.59 (mm)
  Z = 0.00 (mm)
- Safety factor: 6.368 > 2.000

6. Results of RC design

- Moments



(kN*m)

Element	Moments	Value *[kN*m]*	Position *[mm]*	Combination
Wall	maximum	0.00	5200.00	1.100*PM + 0.765*P'a + 1.320*Pa + 1.000*W
Wall	minimum	-197.86	500.00	0.900*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	maximum	22.98	3000.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	minimum	-159.20	2500.00	0.900*PM + 1.100*P'a + 1.320*Pa + 1.000*W

APPENDIX B

AUTODESK ROBOT STRUCTURES 2010 VERIFICATION

CONCRETE

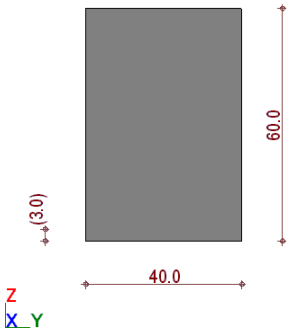
1. BS 9/1/96 – RC columns

VERIFICATION EXAMPLE 1
- Column subjected to axial load and biaxial bending

DESCRIPTION OF THE EXAMPLE:

Following example illustrates the procedure of dimensioning of biaxial bending of column, which is non-sway in one direction, whereas sway in the other. The results of the program are accompanied by the „manual" calculations.

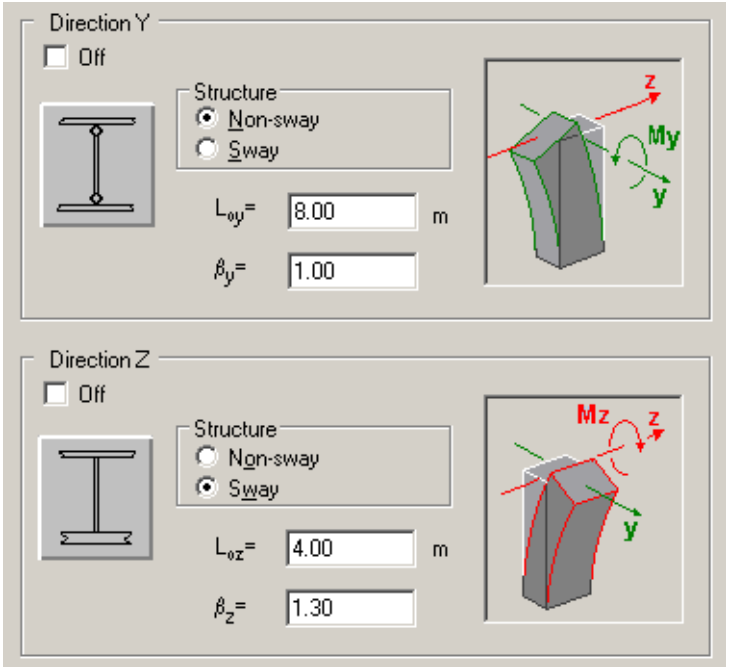
1. SECTION DIMENSIONS



2. MATERIALS

Concrete	: C20	f_{cu} = 20.00 (MPa)
Longitudinal reinforcement	: T	f_y = 460.00 (MPa)
Transversal reinforcement	: R	f_y = 250.00 (MPa)

3. BUCKLING MODEL



As can be seen the sway column is assumed for Z direction, and the non-sway column for Y direction.

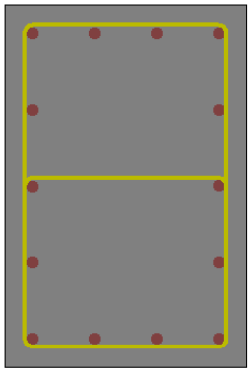
4. LOADS

No.	Case	Nature	Group	N (kN)	MyA (kN'm)	MyB (kN'm)	MyC (kN'm)	MzA (kN'm)	MzB (kN'm)	MzC (kN'm)	γ
1	DL1	dead load	1	400.00	150.00	30.00	102.00	20.00	30.00	50.00	1.40
2	LL1	Live	1	150.00	120.00	30.00	84.00	10.00	20.00	40.00	1.60
*											

NOTE: Let us assume, the moments in Y direction are linearly distributed along the height of the column. Thus, we define only the ends' moments for Y direction. In Z direction however, we assume the mid-height moment is not a result of the linear distribution. For such a case, Robot let the user define the moments in the mid-section explicitly.

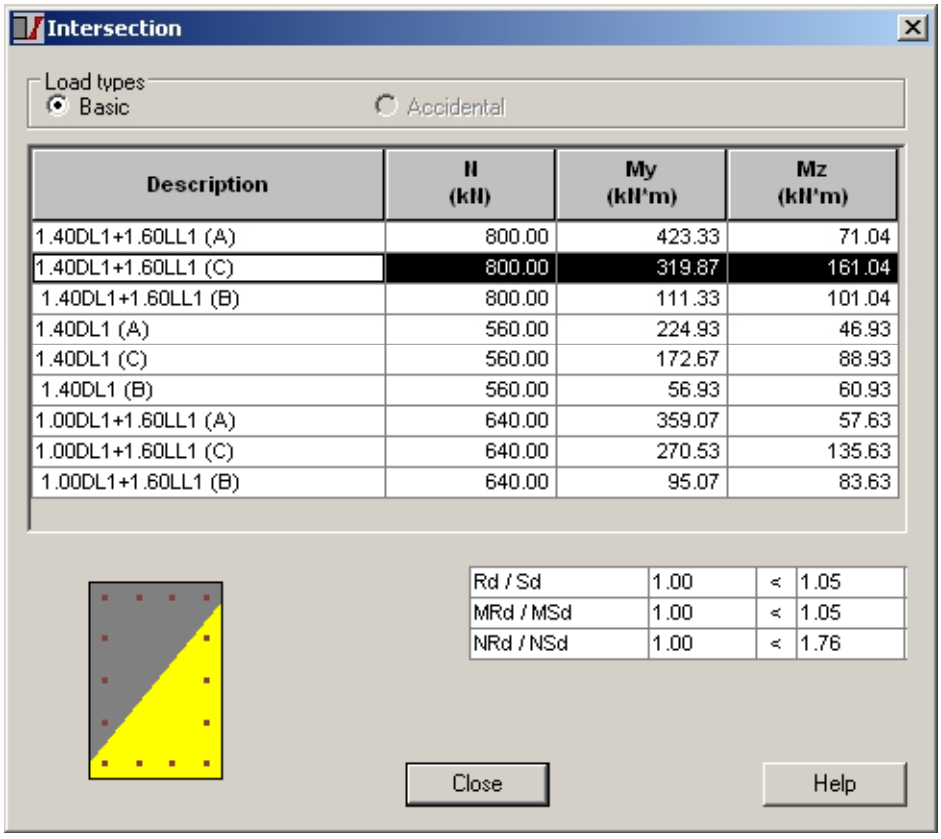
5. CALCULATED REINFORCEMENT:

Program generates the reinforcement 14 ϕ 20.



6. RESULTS OF THE SECTION CALCULATIONS:

The dimensioning combination is 1.4DL1+1.6LL1
The dimensioning section (where the most unfavorable set of forces is found) is for that combination the section in the mid-height of the column (marked as (C)).



Since the column is found as slender, in both direction the second-order effects are taken into account.

In parallel the other sections (at the ends of the column) are checked for all combinations of loads.
All the results of total forces for each combination and each section of the column may be seen in the table “Intersection” at the Column-results layout.

7. CALCULATIONS OF TOTAL MOMENT:

7.1. LOADS

For the dimensioning combination, the loads are:

	Case	N (kN)	MyA (kN*m)	MyB (kN*m)	MyC (kN*m)	MzA (kN*m)	MzB (kN*m)	MzC (kN*m)
1	DL1	400	150	30	102	20	30	50*
2	LL1	150	120	30	84	10	20	40*
Dimensioning combination	1.4DL1+1.6LL1	800	402	90	277.2	44	74	134

,where A, B and C denote upper, lower and mid-height sections of the column respectively.
* - the values are written “by hand” by the user (see point 4 – Loads)

7.2. THE INFLUENCE OF SLENDERNESS

Two independent calculations of the total moment for both directions are carried out.

Slenderness analysis acc. to 3.8.1.3:

l_{ey} / h = 13.33 < 15 (non-sway for Y direction)

l_{ez} / b = 13.0 > 10 (sway for Z direction)

Since the ratio l_{ez} / b exceeds the limit, the column is found as **slender**.

Y DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot h; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have:

$M_i = 0.4 \cdot M_1 + 0.6 \cdot M_2$ = 277.2 (kNm) > $0.4 \cdot M_2$ = 160.8 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.053 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{h}\right)$ = 0.088

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c} A_c + \frac{f_y}{\gamma_s} A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 42.67 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**
- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment My :

$M_y = M_i + M_{add}$ = 319.87 (kNm) > 16.00 (kNm) = $M_{\min}$

Z DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot b; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have the moment fixed directly by the user:

M_i = 134 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.034 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{b}\right)$ = 0.0845

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c}A_c + \frac{f_y}{\gamma_s}A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 27.04 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**

- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment Mz :

$M_z = M_i + M_{add}$ = 161.04 (kNm) > 16.00 (kNm) = $M_{\min}$

7.3. FINAL RESULT

M_y = 320 (kNm)

M_z = 161 (kNm)

8. CONCLUSIONS

The algorithm of calculations of the total moments (i.e. slenderness effects) in non-sway/sway column has been presented. The results obtained with the program (see point 6 – Results of the Section Calculations) are in agreement with the manual calculations (see point 7.3 – Final Result)

LITERATURE

[1] British Standard BS 8110: 1985. Structural use of concrete. British Standard Institution, 1985.

ARCUS GIBB CONSULTING • DESIGN • MANAGEMENT SSI A DHV COMPANY Knight Piésold CONSULTING

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 24

Project Name: SDD SETTLING TANK **Job No:** K5452-035

Calculation Title: INTERNAL WALLS

Calculation No./File No.: K5452-035 R1d (REPORT 2 OF 3)

Calculation is: ☐ Preliminary ☒ Final

Objective: Determine concrete sizes and required reinforcement areas for ULS & SLS on retaining walls

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
1	Fluid density – 10kN/m^3	KG	18/06/2009
2	Soil pressure (see "Annexure A")	KG	18/06/2009
3	Founding on non-yielding material	KG	18/06/2009

See page ____ of this calculation for additional assumptions.

This section applies to computer generated calculations			
Program Name/Number:	Autodesk Robot Structural Analysis 2010	**Version:**	V23.0.1.3128
Program Name/Number:	Autodesk Revit Structure 2010	**Version:**	V2010
Evidence of or reference to computer program verification, if applicable: See "Annexure B"			
Bases or reference thereto supporting application of the computer program to the physical problem: Finite element analysis (FEA) method can be implemented with acceptable standards to South Africa			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
1	C Vorster	18/06/09	AR Gorman PrEng		K Georgala PrEng	

1. PURPOSE:

Determination of structure dimensions and required reinforcement under specified load.

2. REFERENCES:

	1. Concrete layout drawing	K5452-035	Rev	P1
	2.		Rev	

3. LOAD CASES AND COMBINATIONS

Load Cases:

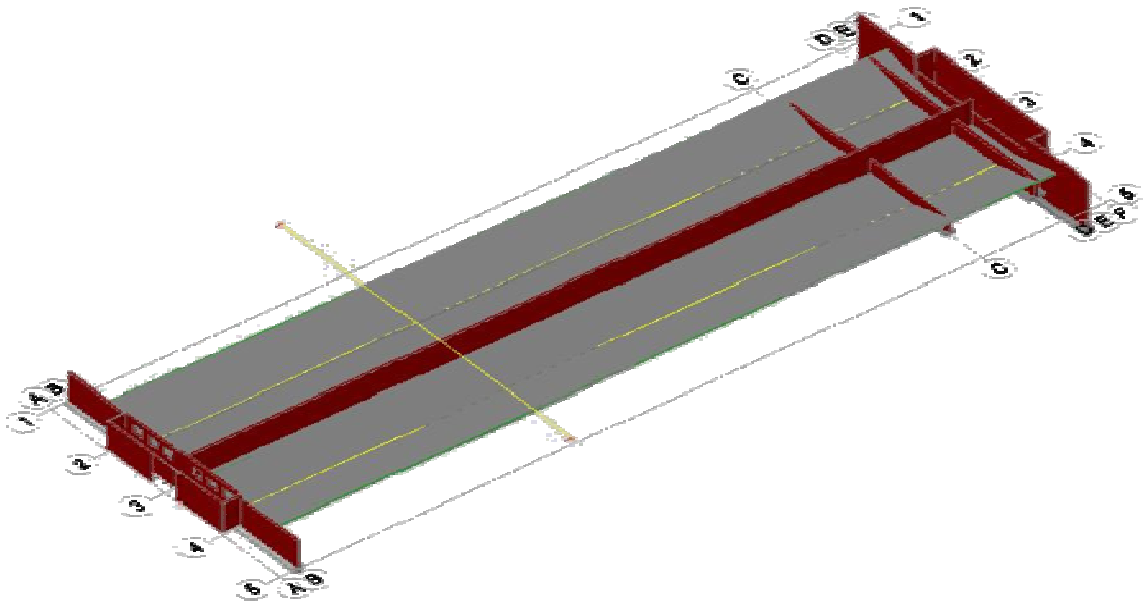
1. **Self Weight**
2. **Water Pressure**
3. **Soil Pressure**

Load Combinations:

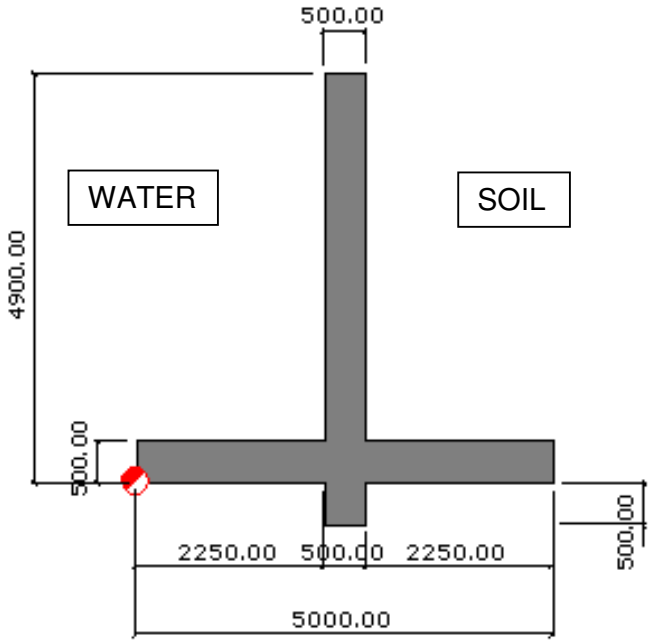
4. **ULS**
5. **SLS**

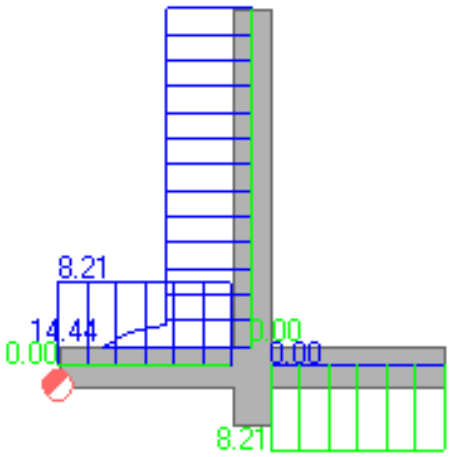
4. APPLICATIONS:

KEY PLAN:



REINFORCING:
RETAINING WALL ON GRIDLINE 3:
*NOTE: REFER TO APPENDIX A FOR DESIGN CALCULATION (PAGE 10-24)





(cm2/m)
REINFORCEMENT AREA DIAGRAM

INTERPRETATION:

The diagram indicates required reinforcement in the retaining wall as follows:

wall from the left:
Required reinf. area
144.4 cm2/m
Provided reinf. area
Y16 every 250.00 mm =804mm² – (Vertical)

wall from the left (h/3):
Required reinf. area
82.1 cm2/m
Provided reinf. area
Y12 every 300.00 mm =377mm² – (Horizontal)

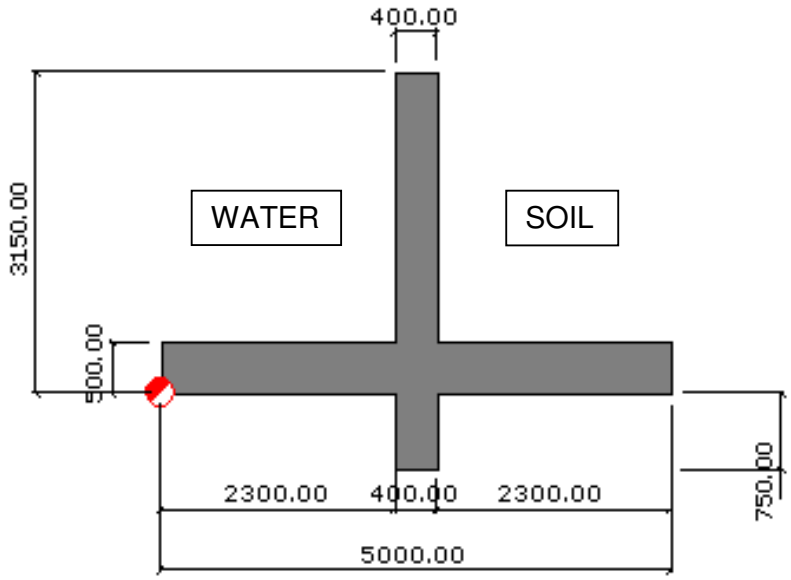
wall from the left (h/2):
Required reinf. area
82.1 cm2/m
Provided reinf. area
Y12 every 300.00 mm =377mm² – (Horizontal)

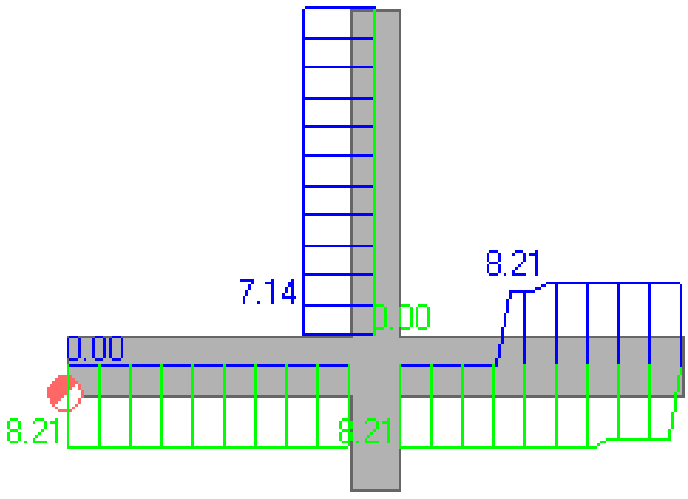
wall from the right:
Required reinf. area
0.00 (Use minimum reinforcement) cm2/m
Provided reinf. area
Y16 every 250.00 mm =804mm² – (Vertical)

footing (+):
Required reinf. area
82.1 cm2/m
Provided reinf. area
Y12 every 250.00 mm =452mm² – (Main bars Top & Bot)

footing (-):
Required reinf. area
82.1 cm2/m
Provided reinf. area
Y12 every 250.00 mm =452mm² - (Distribution bars Top & Bot)

RETAINING WALL ON GRIDLINES C & D:
*NOTE: REFER TO APPENDIX A FOR DESIGN CALCULATION (PAGES 10-24)





(cm2/m)

REINFORCEMENT AREA DIAGRAM

INTERPRETATION:

wall from the left:

Required reinf. area

7.14 cm2/m

Provided reinf. area

Y16 every 250.00 mm =804mm² – (Vertical)

wall from the left (h/3):

Required reinf. area

7.14 cm2/m

Provided reinf. area

Y12 every 250.00 mm =452mm² – (Horizontal)

wall from the left (h/2):

Required reinf. area

7.14 cm2/m

Provided reinf. area

Y12 every 250.00 mm =452mm² – (Horizontal)

wall from the right

Required reinf. area

0.00 (Use minimum required reinforcement) cm2/m

Provided reinf. area

Y16 every 250.00 mm =804mm² – (Vertical)

footing (-):

Required reinf. area

8.21 cm2/m

Provided reinf. area

Y16 every 250.00 mm =804mm² m - (Distribution bars Top & Bot)

footing (+):

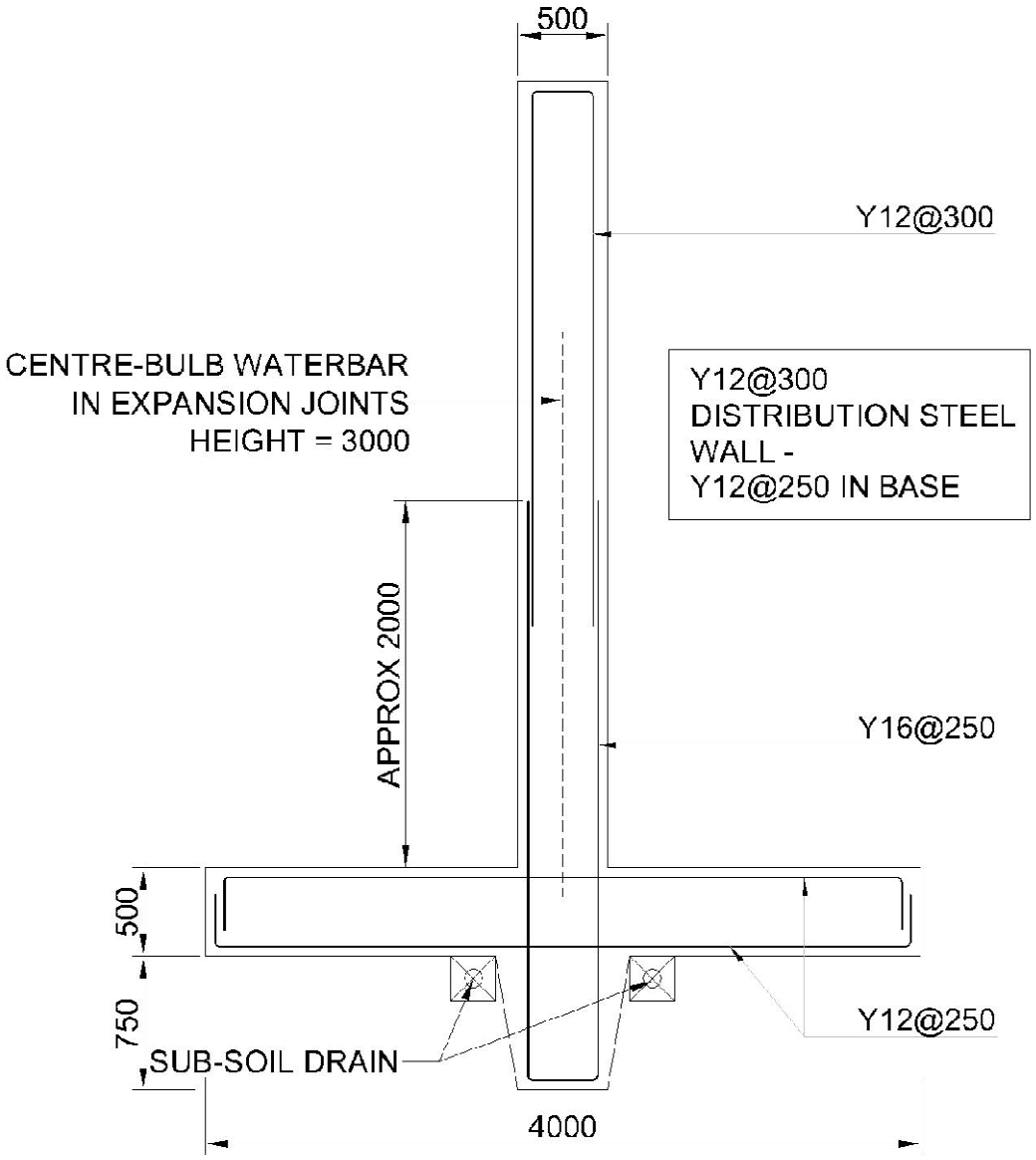
Required reinf. area

8.21 cm2/m

Provided reinf. area

Y16 every 250.00 mm =804mm² – (Main bars Top & Bot)

TYPICAL REINFORCEMENT LAYOUT OF WALL ON GRIDLINE 3:



JOINT LAYOUT:

Provide expansion joints through base of wall on gridline 3 at 40m c/c, and expansion joints at 20m c/c in wall.

5. PROCEDURE/METHODOLOGY OF DESIGN:

4.1 The Robot Retaining wall module has been applied for this analysis
4.2 3 Load cases and 2 Load combinations have been analyzed, as indicated in “Annexure A”

6. ASSUMPTIONS:

5.1 Assumptions requiring verification will be listed on the cover sheet

7. DEFINITION OF UNITS AND CONSTANTS:

Refer to “Annexure A”

7. ANALYSIS/SOLUTION:(see body of calculation for analysis and solutions)

Note: Detailed calculations output data to be provided on request.

8. METHOD OF RESULTS GENERATION:

All loads and load combinations are defined as load cases within Robot Structural Analysis, combinations have the addition of factors applied as explained on pages 8-24 of this document, and are governed by ULS or SLS criteria.
The results displayed in this document, represents the worst cases of all possible cases, where each case has been analyzed individually as well as specified in combination cases.

9. APPENDICES TO CALCULATIONS:

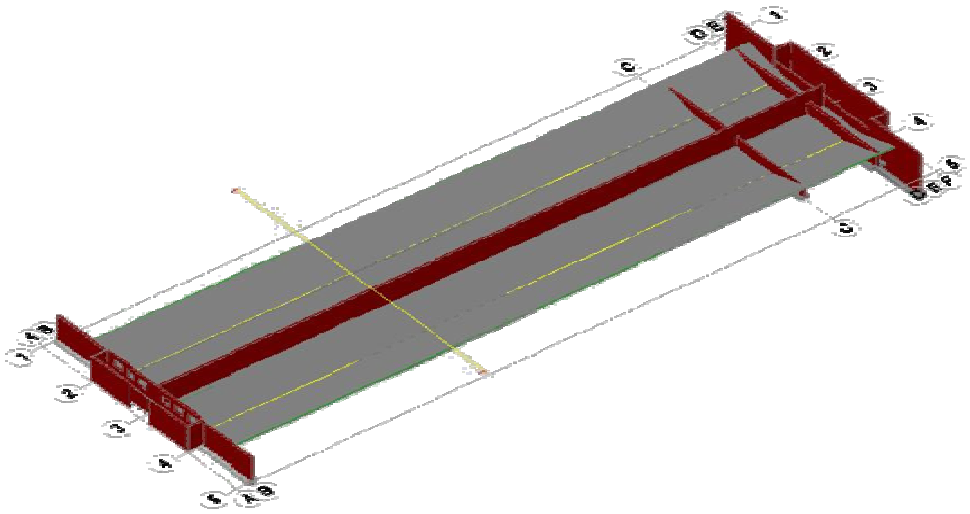
9.1 Appendix A – Calculations
9.2 Appendix B – Autodesk Robot Structural Analysis 2010 verification report

APPENDIX A

CALCULATIONS

7.1.1 SDD SETTLING TANK WALL DESIGN

STRUCTURE VIEW



CALCULATION NOTE

Code preferences:

- **BS 8110** and **PN-B-03264(2002) –** Reinforced concrete design
- **PN-83/B-03010 –** Soil Code

1. Calculation parameters for retaining wall on gridline 3:

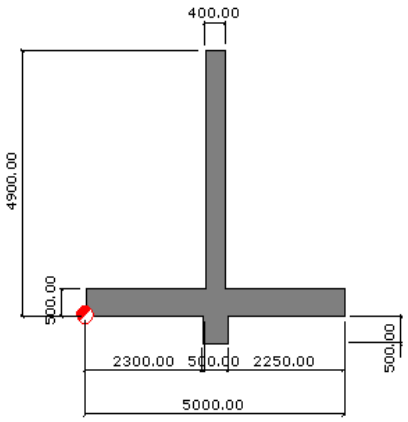
MATERIAL:

- **CONCRETE: class B 30, fck = 30.00 (MN/m2), Unit weight = 24.00 (kN/m3)**
- **STEEL: class A - IIIN, fyk = 450.00 (MN/m2)**

OPTIONS:

- Calculations according to: concrete code: **PN-B-03264(2002)**
  soil code: **PN-83/B-03010**
- Cover: c1 = 50.0 (mm), c2 = 50.0 (mm)
- Exposure: X0
- Retainig wall design according to:
  - Capacity m = 0.810 g = 2.000
  - Sliding m = 1.000 g = 2.000
  - Overturning m = 0.720 g = 2.000
- Retainig wall verification according to:
  - Average settlement:
    S_{dop} = 100.00 (mm)
  - Settlement differences:
    DS_{dop} = 50.00 (mm)
  - Wall top displacements:
    f_0 = 0.015
    f_1 = 0.010
    f_2 = 0.006
    f_3 = 0.004
- Wall/soil friction angle:
  - Passive pressure for cohesive soils -1/3×ϕ
  - Cohesive soil pressure 1/2×ϕ
  - Passive pressure for non-cohesive soils -1/3×ϕ
  - Pressure for non-cohesive soils 1/2×ϕ

2. Geometry:



3. Soil:

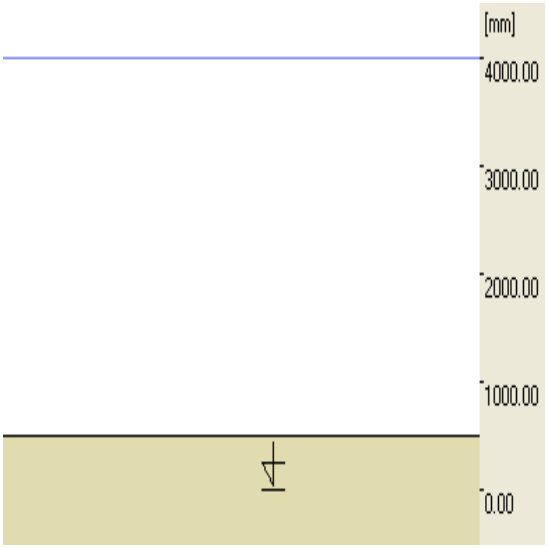
- **Soil parameter selection - method: A**
- **Backfill** Soil depth (behind the wall) Ho = 3000.00 (mm)
- **Original layers:**

Description:

No.	Soil name	Level *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1.	silty fine sands	500.00	-	-	-	0.000

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1.	67.03	18.00	21.99	29.65	29.65



- **Soils (behind the wall):**

Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	silty fine sands	500.00	500.00	-	-	0.000

* With respect to the lower right footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	67.03	18.00	21.99	29.65	29.65

- **Soils (before the wall):**

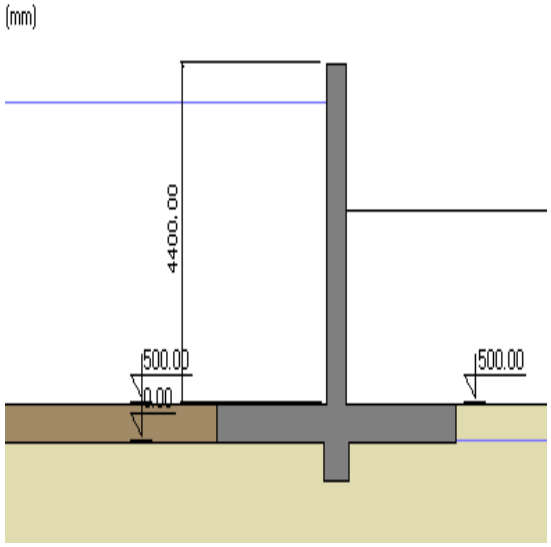
Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	poorly graded sands	500.00	500.00	-	-	0.000

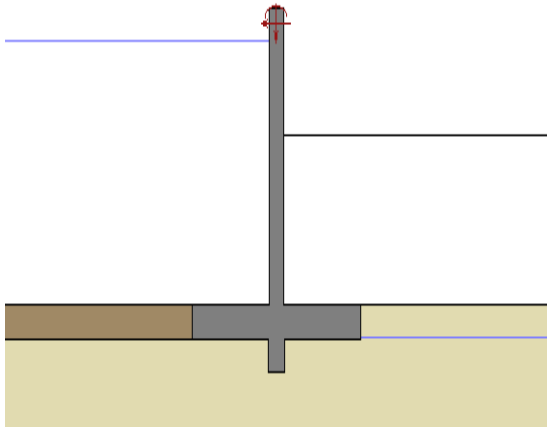
* With respect to the lower left footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	37.00	19.64	121.82	121.82



4. Loads



- **Load report**

1 concentrated on wall

a1 live z = 250.00 (mm) V = 0.00 (kN) H = -1.00 (kN) M = 0.00 (kN*m)

5. Results (soils)

PRESSURES

Factors for pressures and passive pressures for soils:

Average backfill slope angle ε = 0.00 (Deg)
Wall inclination angle β = 0.00 (Deg)

$$K_a = \frac{\cos^2 \cdot (\beta - \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta_2) \cdot \sin(\phi - \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_p = \frac{\cos^2 \cdot (\beta + \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 - \sqrt{\frac{\sin(\phi - \delta_2) \cdot \sin(\phi + \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_o = \frac{\sigma_x}{\sigma_z} = \frac{\nu}{1 - \nu}$$

$$K_a \le K_o \le K_p$$

Soils (behind the wall):

No.	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	silty fine sands	500.00	18.00	0.483	0.691	2.190

- Generalized limit displacements
  - passive pressure 0.134
  - pressure 0.013

Soils (before the wall):

	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	poorly graded sands	0.00	37.00	0.528	0.691	1.894
2.	poorly graded sands	500.00	37.00	0.249	0.398	4.023
3.	poorly graded sands	4400.00	37.00	1.000	1.000	1.000

- Generalized limit displacements
  - passive pressure 0.131
  - pressure 0.013

CAPACITY

- Soil type under footing: not layered
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*C + 1.000*W + 1.300*a1
- Reduced design load:
  N=-88.33 (kN/m) My=-6.91 (kN*m) Fx=178.20 (kN/m)
- Equivalent footing dimension: A = 2826.15 (mm)
- Coefficient of load capacity and influence of load inclination:

  N_B = 0.745 i_B = 0.059
  N_C = 11.768 i_C = 0.266
  N_D = 4.419 i_D = 0.442

- Soil limit pressure: Qf = 615.99 (kN/m)
- Safety factor: Qf * m / Nr = 5.649 > 2.000

SETTLEMENT

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*C + 1.000*W + 1.000*a1
- Reduced design load:
  N=-88.33 (kN/m) My=-5.23 (kN*m) Fx=178.50 (kN/m)
- Unit load of total loads: q = 0.02 (MN/m2)
- Thickness of the actively settling soil: z = 1000.00 (mm)
- Stress on the level z:
  - additional: szd = 0.01 (MN/m2)
  - caused by soil weight: szg = 0.03 (MN/m2)
- Settlement: S = 0.22 (mm) < Sdop = 100.00 (mm)

OVERTURNING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*C + 1.000*W
- Reduced design load:
  N=-88.33 (kN/m) My=-1.51 (kN*m) Fx=176.90 (kN/m)
- Overturning moment: Mo= 200.39 (kN*m)
- Moment preventing foundation overturning: M_{uf} = 511.16 (kN*m)
- Safety factor: $M_{uf} * m / M_0 = 1.837 < 2.000$

SLIDING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*C + 1.000*W
- Reduced design load:
  N=-88.33 (kN/m) My=-1.51 (kN*m) Fx=176.90 (kN/m)
- Equivalent footing dimension: A = 5000.00 (mm)
- Friction coefficient:
  - of soil (on the settlement level): $\mu = 0.039$
- Soil cohesion reduction factor = 100.000 %
- Cohesion: C = 60.33 (kN/m2)
- Sliding force value: Q_{tr} = 176.90 (kN/m)
- Value of force preventing wall sliding:
- $Q_{tf} = N * \mu + C * A$
- - on the foundation level: Q_{tf} = 305.06 (kN/m)
- Safety factor: $Q_{tf} * m / Q_{tr} = 1.725 < 2.000$

SLIDING

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*C + 1.000*W + 1.000*a1
- Thickness of soil cooperating with foundation: z = 2282.84 (mm)
- Wedge length: la = 707.11 (mm)
- Sliding:
  f_0 = -21.04 (mm)
  f_1 = -5.59 (mm)
  f_2 = -1.57 (mm)
  f_3 = -13.88 (mm)

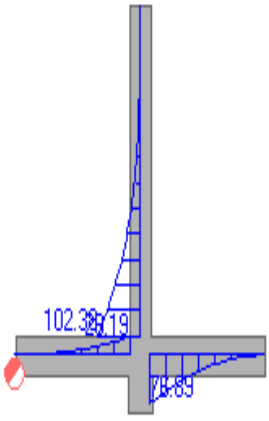
- Safety factor:
  3.493 > 1.000

OVERTURNING ANGLES

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*C + 1.000*W + 1.000*a1
- Reduced design load:
  N=-88.33 (kN/m) My=-5.23 (kN*m) Fx=178.50 (kN/m)
- Maximum unit stresses from total loads:
  qmax = 0.04 (MN/m2)
- Minimum unit stresses from total loads:
  qmin = 0.00 (MN/m2)
- Overturning angle: ro = -0.02 (Deg)
- Coordinates of wall rotation point:
  X = 709.12 (mm)
  Z = 0.00 (mm)
- Safety factor: 36.280 > 2.000

6. Results of RC design

- Moments



(kN*m)

Element	Moments	Value *[kN*m]*	Position *[mm]*	Combination
Wall	maximum	0.00	4650.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.100*C + 1.000*W + 1.300*a1
Wall	minimum	-102.38	500.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.100*C + 1.000*W + 1.300*a1
Footing	maximum	78.43	2700.00	1.100*PM + 0.765*P'a + 0.900*Pa + 0.900*C + 1.000*W + 1.300*a1
Footing	minimum	-31.08	2300.00	0.900*PM + 0.765*P'a + 0.900*Pa + 0.900*C + 1.000*W + 1.300*a1

1. Calculation parameters for retaining walls on gridlines C & D:

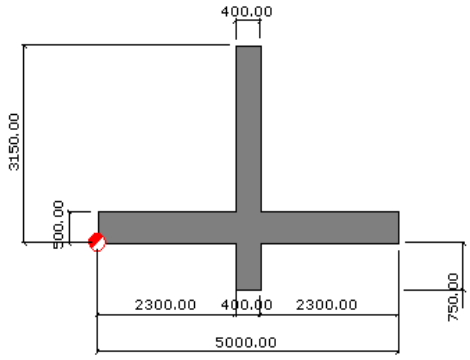
MATERIAL:

- **CONCRETE: class B 30, fck = 30.00 (MN/m2), unit weight = 24.00 (kN/m3)**
- **STEEL: class A - III, fyk = 450.00 (MN/m2)**

OPTIONS:

- Calculations according to: concrete code: **PN-B-03264(2002)**
  soil code: **PN-83/B-03010**
- Cover: c1 = 50.0 (mm), c2 = 50.0 (mm)
- Exposure: X0
- Retainig wall design according to:
  - Capacity m = 0.810 g = 2.000
  - Sliding m = 0.720 g = 2.000
  - Overturning m = 0.720 g = 2.000
- Retainig wall verification according to:
  - Average settlement:
    S_{dop} = 100.00 (mm)
  - Settlement differences:
    DS_{dop} = 50.00 (mm)
- Reduction factors for:
  - Soil cohesion 100.000 %
  - Soil frictions 0.000 %
  - Wall passive pressure 50.000 %
  - Key passive pressure 100.000 %
- Wall/soil friction angle:
  - Passive pressure for cohesive soils $-1/3\times\phi$
  - Cohesive soil pressure $1/2\times\phi$
  - Passive pressure for non-cohesive soils $-1/3\times\phi$
  - Pressure for non-cohesive soils $1/2\times\phi$

2. Geometry:



3. Soil:

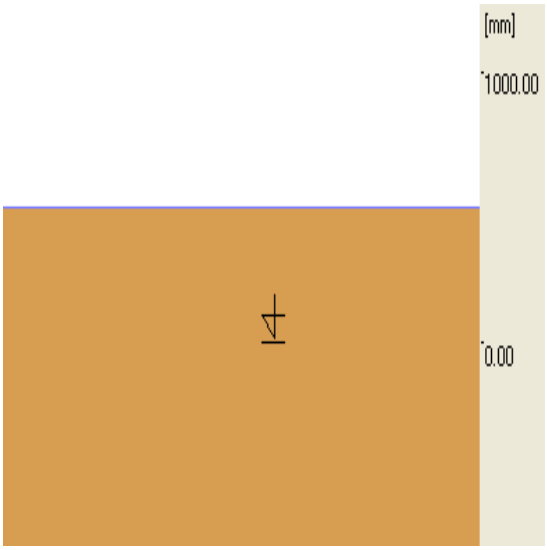
- **Soil parameter selection - method: B**
- **Backfill** Soil depth (behind the wall) Ho = 3000.00 (mm)
- **Original layers:**

Description:

No.	Soil name	Level *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1.	clayey fine sands	500.00	-	-	-	0.000

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1.	67.03	18.00	21.21	29.65	29.65



- **Soils (behind the wall):**

Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	500.00	500.00	-	-	0.000

* With respect to the lower right footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50

- **Soils (before the wall):**

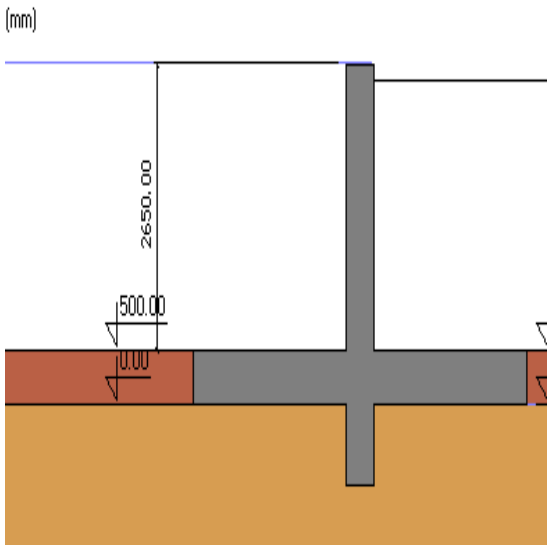
Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravels	500.00	500.00	-	-	0.000

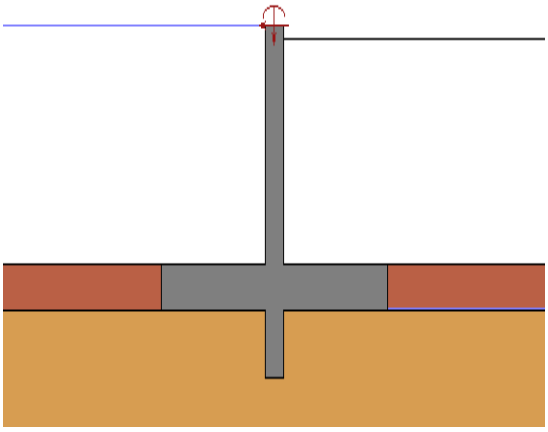
* With respect to the lower left footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	42.00	21.99	199.50	199.50



4. Loads



- **Load report**

1 concentrated on wall

a1 live z = 0.00 (mm) V = 0.00 (kN)
H = 1.00 (kN) M = 0.00 (kN*m)

5. Results (soils)

PRESSURES

Soil pressure and passive pressure : according to wall displacements
Factors for pressures and passive pressures for soils:

Average backfill slope angle ε = 0.00 (Deg)
Wall inclination angle β = 0.00 (Deg)

$$K_a = \frac{\cos^2 \cdot (\beta - \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta_2) \cdot \sin(\phi - \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_p = \frac{\cos^2 \cdot (\beta + \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 - \sqrt{\frac{\sin(\phi - \delta_2) \cdot \sin(\phi + \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_o = \frac{\sigma_x}{\sigma_z} = \frac{\nu}{1 - \nu}$$

$$K_a \le K_o \le K_p$$

Soils (behind the wall):

No.	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1	well graded gravels	500.00	42.00	0.183	0.331	9.569

- Generalized limit displacements
  - passive pressure 0.132
  - pressure 0.013

Soils (before the wall):

	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravels	0.00	42.00	0.528	0.691	1.894
2.	well graded gravels	500.00	42.00	0.198	0.331	5.045
3.	well graded gravels	3150.00	42.00	1.000	1.000	1.000

- Generalized limit displacements
  - passive pressure 0.131
  - pressure 0.013

CAPACITY

- Soil type under footing: not layered
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-77.45 (kN/m) My=5.05 (kN*m) Fx=68.94 (kN/m)
- Equivalent footing dimension: A = 4240.24 (mm)
- Coefficient of load capacity and influence of load inclination:

$N_B = 0.745$ $i_B = 0.059$
$N_C = 11.768$ $i_C = 0.266$
$N_D = 4.419$ $i_D = 0.442$

- Soil limit pressure: Qf = 953.64 (kN/m)
- Safety factor: Qf * m / Nr = 9.974 > 2.000

SETTLEMENT

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W + 1.000*a1
- Reduced design load:
  N=-77.06 (kN/m) My=9.03 (kN*m) Fx=69.00 (kN/m)
- Unit load of total loads: q = 0.02 (MN/m2)
- Thickness of the actively settling soil: z = 1000.00 (mm)
- Stress on the level z:
  - additional: szd = -0.00 (MN/m2)
  - caused by soil weight: szg = 0.04 (MN/m2)
- Settlement: S = 0.00 (mm) < Sdop = 100.00 (mm)

OVERTURNING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-77.45 (kN/m) My=5.05 (kN*m) Fx=68.94 (kN/m)
- Overturning moment: Mo= 139.81 (kN*m)
- Moment preventing foundation overturning: M_{uf} = 362.85 (kN*m)
- Safety factor: M_{uf} * m / M_0 = 1.869 < 2.000

SLIDING

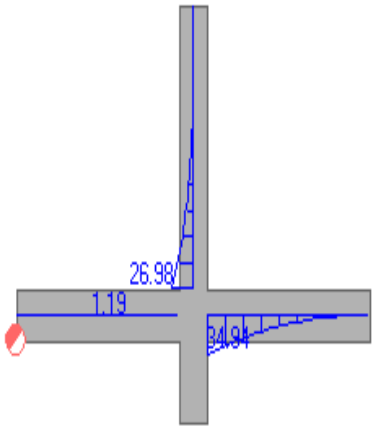
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W
- Reduced design load:
  N=-77.45 (kN/m) My=5.05 (kN*m) Fx=68.94 (kN/m)
- Equivalent footing dimension: A = 5000.00 (mm)
- Friction coefficient:
  - of soil (on the settlement level): $\mu = 0.058$
- Soil cohesion reduction factor = 100.000 %
- Cohesion: C = 12.05 (kN/m2)
- Sliding force value: Q_{tr} = 68.94 (kN/m)
- Value of force preventing wall sliding:
- $Q_{tf} = N * \mu + C * A$
- - on the foundation level: Q_{tf} = 64.76 (kN/m)
- Safety factor: $Q_{tf} * m / Q_{tr} = 0.676 < 2.000$

OVERTURNING ANGLES

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W
- Reduced design load:
  N=-77.07 (kN/m) My=6.33 (kN*m) Fx=69.96 (kN/m)
- Maximum unit stresses from total loads:
  qmax = 0.02 (MN/m2)
- Minimum unit stresses from total loads:
  qmin = 0.01 (MN/m2)
- Overturning angle: ro = -0.01 (Deg)
- Coordinates of wall rotation point:
  X = -3104.26 (mm)
  Z = 0.00 (mm)
- Safety factor: 109.823 > 2.000

6. Results of RC design

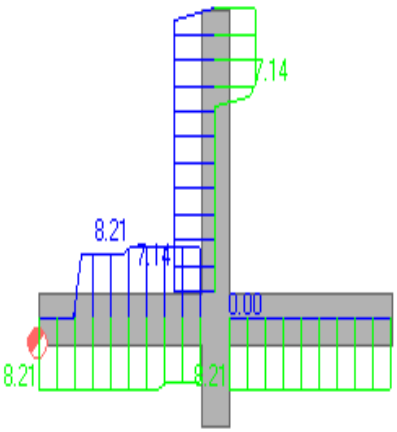
- Moments



(kN*m)

Element	Moments	Value *[kN*m]*	Position *[mm]*	Combination
Wall	maximum	0.45	2635.18	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W + 1.300*a1
Wall	minimum	-30.43	500.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	maximum	36.77	2700.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W
Footing	minimum	-5.09	2300.00	0.900*PM + 1.100*P'a + 1.320*Pa + 1.000*W

- Reinforcement



(cm2/m)

Position	Required reinf. area *[cm2/m]*	Bars		Spacing *[mm]*	Provided reinf. area *[cm2/m]*
wall from the left	7.14	12.0	every	150.00	7.54
wall from the left (h/3)	7.14	12.0	every	150.00	7.54
wall from the left (h/2)	7.14	12.0	every	150.00	7.54
wall from the right	7.14	12.0	every	150.00	7.54
left footing (+)	8.21	16.0	every	200.00	10.05
left footing (-)	8.21	16.0	every	200.00	10.05
right footing (-)	8.21	16.0	every	200.00	10.05
right footing (+)	0.00	16.0	every	200.00	10.05

APPENDIX B

AUTODESK ROBOT STRUCTURES 2010 VERIFICATION

CONCRETE

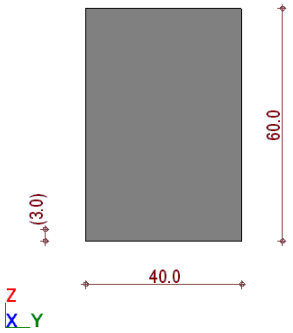
1. BS 9/1/96 – RC columns

VERIFICATION EXAMPLE 1
- Column subjected to axial load and biaxial bending

DESCRIPTION OF THE EXAMPLE:

Following example illustrates the procedure of dimensioning of biaxial bending of column, which is non-sway in one direction, whereas sway in the other. The results of the program are accompanied by the „manual" calculations.

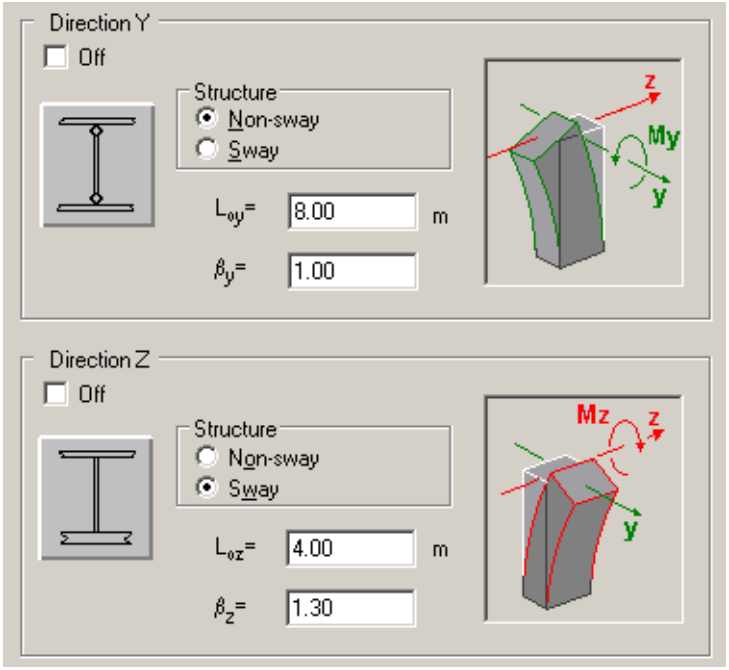
1. SECTION DIMENSIONS



2. MATERIALS

Concrete	: C20	f_{cu} = 20.00 (MPa)
Longitudinal reinforcement	: T	f_y = 460.00 (MPa)
Transversal reinforcement	: R	f_y = 250.00 (MPa)

3. BUCKLING MODEL



As can be seen the sway column is assumed for Z direction, and the non-sway column for Y direction.

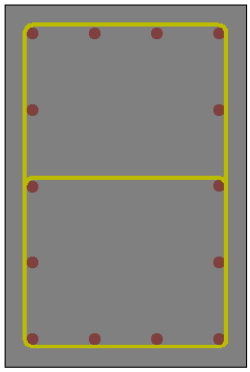
4. LOADS

No.	Case	Nature	Group	N (kN)	MyA (kN'm)	MyB (kN'm)	MyC (kN'm)	MzA (kN'm)	MzB (kN'm)	MzC (kN'm)	γ
1	DL1	dead load	1	400.00	150.00	30.00	102.00	20.00	30.00	50.00	1.40
2	LL1	Live	1	150.00	120.00	30.00	84.00	10.00	20.00	40.00	1.60
*											

NOTE: Let us assume, the moments in Y direction are linearly distributed along the height of the column. Thus, we define only the ends' moments for Y direction. In Z direction however, we assume the mid-height moment is not a result of the linear distribution. For such a case, Robot let the user define the moments in the mid-section explicitly.

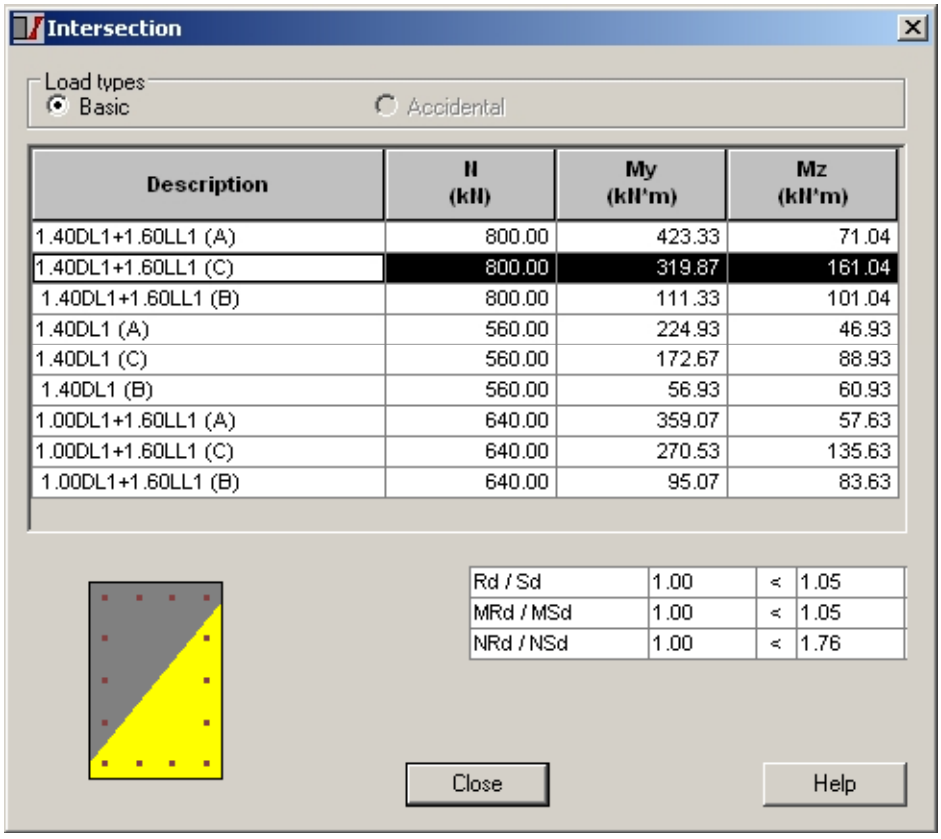
5. CALCULATED REINFORCEMENT:

Program generates the reinforcement 14 ϕ 20.



6. RESULTS OF THE SECTION CALCULATIONS:

The dimensioning combination is 1.4DL1+1.6LL1
The dimensioning section (where the most unfavorable set of forces is found) is for that combination the section in the mid-height of the column (marked as (C)).



Since the column is found as slender, in both direction the second-order effects are taken into account.

In parallel the other sections (at the ends of the column) are checked for all combinations of loads.
All the results of total forces for each combination and each section of the column may be seen in the table “Intersection” at the Column-results layout.

7. CALCULATIONS OF TOTAL MOMENT:

7.1. LOADS

For the dimensioning combination, the loads are:

	Case	N (kN)	MyA (kN*m)	MyB (kN*m)	MyC (kN*m)	MzA (kN*m)	MzB (kN*m)	MzC (kN*m)
1	DL1	400	150	30	102	20	30	50*
2	LL1	150	120	30	84	10	20	40*
Dimensioning combination	1.4DL1+1.6LL1	800	402	90	277.2	44	74	134

,where A, B and C denote upper, lower and mid-height sections of the column respectively.
* - the values are written “by hand” by the user (see point 4 – Loads)

7.2. THE INFLUENCE OF SLENDERNESS

Two independent calculations of the total moment for both directions are carried out.

Slenderness analysis acc. to 3.8.1.3:

l_{ey} / h = 13.33 < 15 (non-sway for Y direction)

l_{ez} / b = 13.0 > 10 (sway for Z direction)

Since the ratio l_{ez} / b exceeds the limit, the column is found as **slender**.

Y DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot h; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have:

$M_i = 0.4 \cdot M_1 + 0.6 \cdot M_2$ = 277.2 (kNm) > $0.4 \cdot M_2$ = 160.8 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.053 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{h}\right)$ = 0.088

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c} A_c + \frac{f_y}{\gamma_s} A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 42.67 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**
- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment My :

$M_y = M_i + M_{add}$ = 319.87 (kNm) > 16.00 (kNm) = $M_{\min}$

Z DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot b; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have the moment fixed directly by the user:

M_i = 134 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.034 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{b}\right)$ = 0.0845

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c}A_c + \frac{f_y}{\gamma_s}A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 27.04 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**

- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment Mz :

$M_z = M_i + M_{add}$ = 161.04 (kNm) > 16.00 (kNm) = $M_{\min}$

7.3. FINAL RESULT

M_y = 320 (kNm)

M_z = 161 (kNm)

8. CONCLUSIONS

The algorithm of calculations of the total moments (i.e. slenderness effects) in non-sway/sway column has been presented. The results obtained with the program (see point 6 – Results of the Section Calculations) are in agreement with the manual calculations (see point 7.3 – Final Result)

LITERATURE

[1] British Standard BS 8110: 1985. Structural use of concrete. British Standard Institution, 1985.

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 18

Project Name: Kusile Power Station **Job No:** K5452-038

Calculation Title: SDD Inlet Baffle Wall

Calculation No./File No.: K5452-038 R1b (REPORT 3 OF 3)

Calculation is: ☐ Preliminary ☒ Final

Objective: Determine required reinforcement areas for ULS & SLS

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
1	Fluid density – 10kN/m^3	KG	16/07/2009
2	Soil pressure (see "Annexure A")	KG	16/07/2009
3	Founding on non-yielding material	KG	16/07/2009

See page ____ of this calculation for additional assumptions.

This section applies to computer generated calculations			
Program Name/Number:	Autodesk Robot Structural Analysis 2010	**Version:**	V23.0.1.3128
Program Name/Number:	Autodesk Revit Structure 2010	**Version:**	V2010
Evidence of or reference to computer program verification, if applicable: See "Annexure B"			
Bases or reference thereto supporting application of the computer program to the physical problem: Autodesk Expert Retaining Wall 2010 – ver 23.0			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
1	C Vorster	17/07/09	AR Gorman PrEng	20/07/09	K Georgala PrEng	20/07/2009

1. PURPOSE:

Determination of structure dimensions and required reinforcement under specified load.

2. REFERENCES:

	1. Concrete layout drawing	K5406-038	Rev	P1
	2.		Rev	

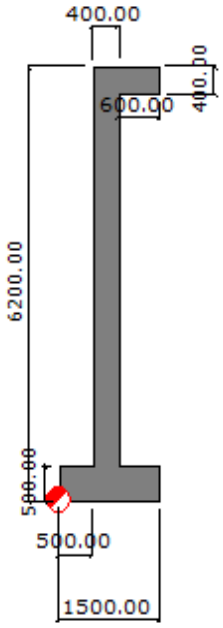
3. LOAD CASES AND COMBINATIONS

Load Cases:

1. **Own Weight**
2. **Live load**
3. **Water load**

4. APPLICATIONS:

STRUCTURE



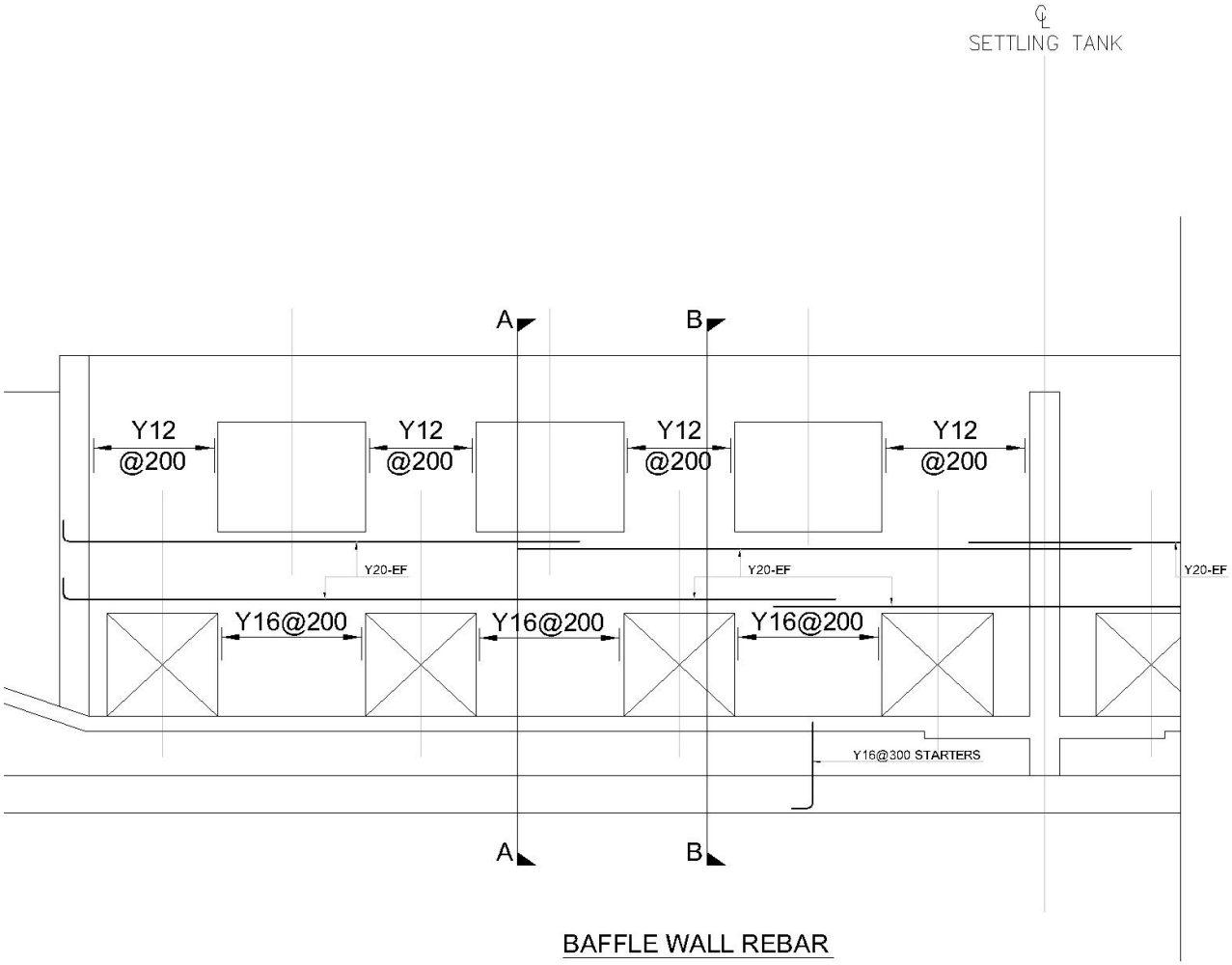
Required reinforcement:

Position	**Required reinf. area** *[cm2/m]*	**Bars**		**Spacing** *[mm]*	**Provided reinf. area** *[cm2/m]*
wall from the left	7.14	10.0	every	100.00	7.85
wall from the left (h/3)	7.14	12.0	every	150.00	7.54
wall from the left (h/2)	7.14	12.0	every	150.00	7.54
wall from the right	7.14	10.0	every	100.00	7.85
shelf 1 (+)	7.14	10.0	every	100.00	7.85
left footing (-)	8.21	12.0	every	130.00	8.70
right footing (+)	8.21	12.0	every	130.00	8.70
left footing (+)	0.00	12.0	every	130.00	8.70

Note:

Due to openings in the wall, reinforcement is suggested as displayed in figures 1 to 5 as indicated below, with the addition of ground beams for stability of wall.

Figure 1 – Front elevation of baffle wall:



Note:
Y20 bars to lap 1200mm MIN

Figure 2 – Typical section of baffle wall:

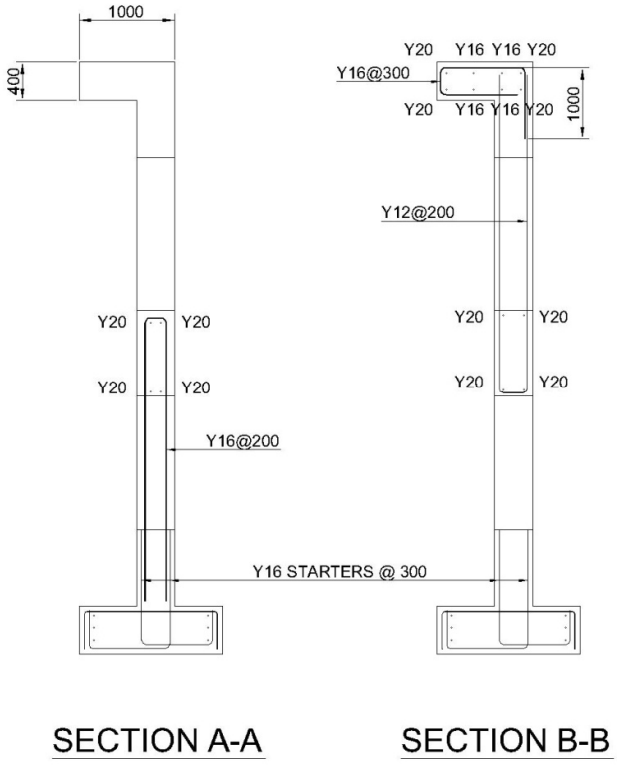


Figure 3 – Positions of ground beams:

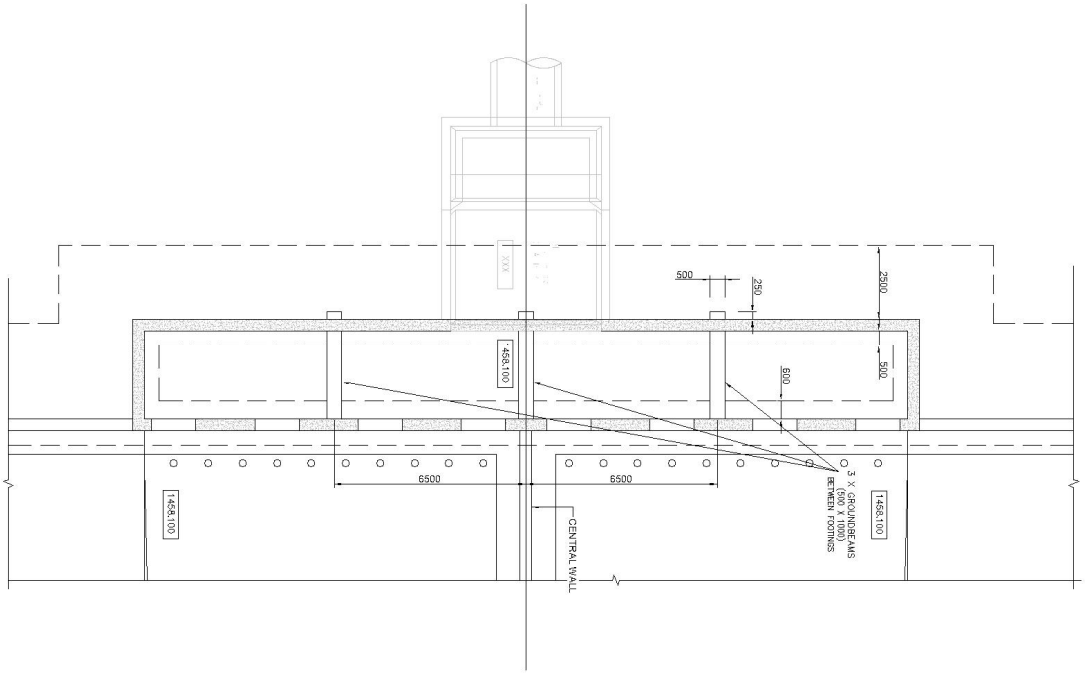

500
250
2500
1458.100
600
500
6500
6500
1458.100
1458.100
CENTRAL WALL
3 X GROUNDBEAMS (600 X 1000) BETWEEN FOOTINGS

Figure 4 – Typical sections of ground beams (sizes):

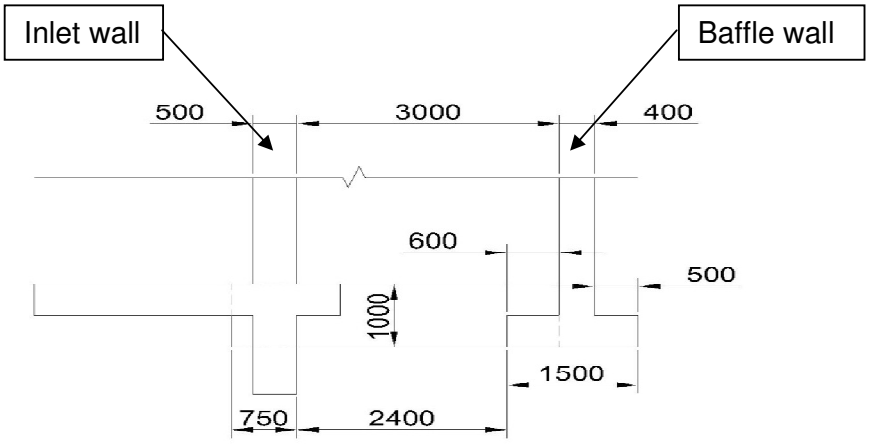
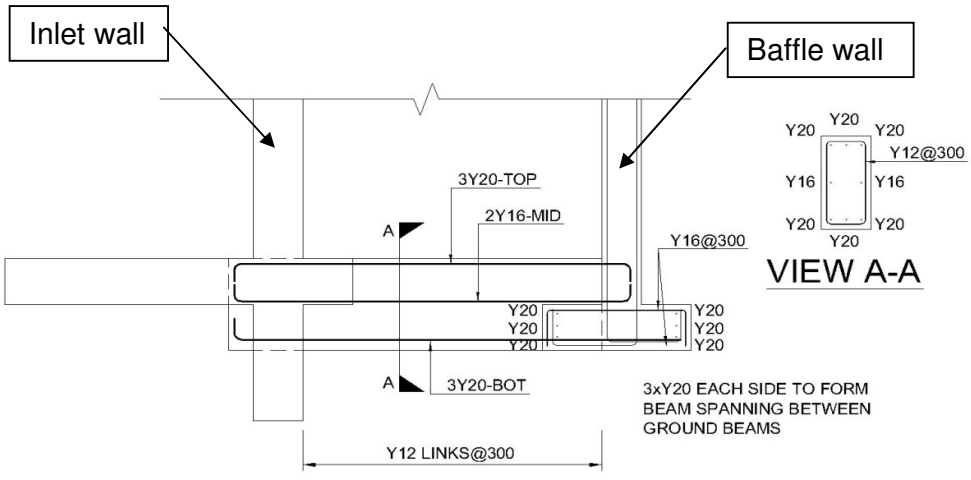


Figure 5 – Typical sections of ground beams (reinforcement layout):



SECTION SHOWING GROUND BEAMS

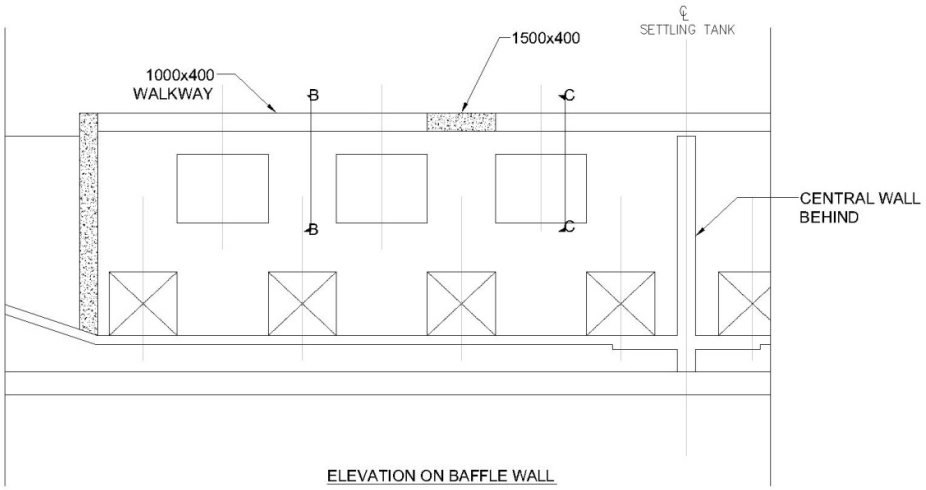
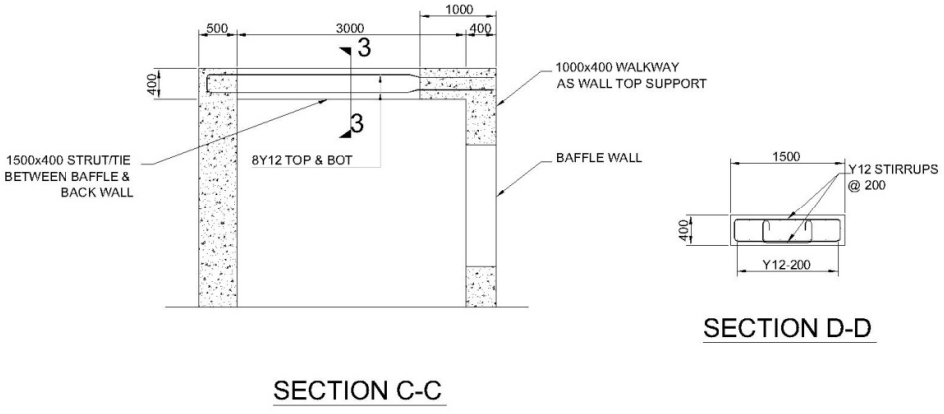


Figure 8 – Sections on walkway slab:



5. PROCEDURE/METHODOLOGY OF DESIGN:

5.1 The finite element design method has been applied for this analysis
5.2 3 Load cases and 2 Load combinations have been analyzed, as indicated in “Annexure A”

6. ASSUMPTIONS:

6.1 Assumptions requiring verification will be listed on the cover sheet

7. DEFINITION OF UNITS AND CONSTANTS:

Refer to “Annexure A”

8. ANALYSIS/SOLUTION: (see body of calculation for analysis and solutions)

Note: Detailed calculations output data to be provided on request.

9. METHOD OF RESULTS GENERATION:

All loads and load combinations are defined as load cases within Robot Structural Analysis, combinations have the addition of factors applied as explained on page 9-16 of this document, and are governed by ULS or SLS criteria.
The results displayed in this document, represents the worst cases of all possible cases, where each case has been analyzed individually as well as specified in combination cases.

10. APPENDICES TO CALCULATIONS:

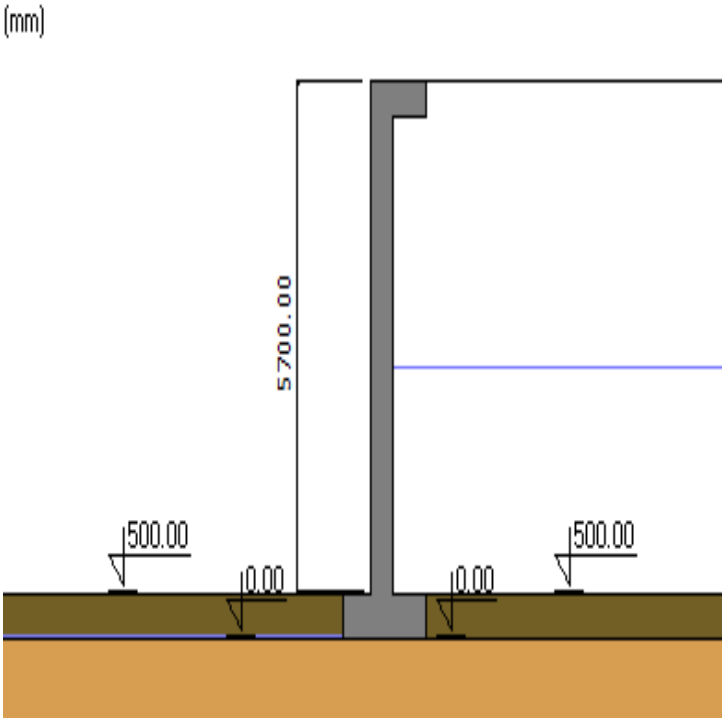
10.1 Appendix A – Calculations
10.2 Appendix B – Autodesk Robot Structural Analysis 2010 verification report

APPENDIX A

CALCULATIONS

8.1.1 SDD Baffle Wall Design

STRUCTURE VIEW



1. Calculation parameters:

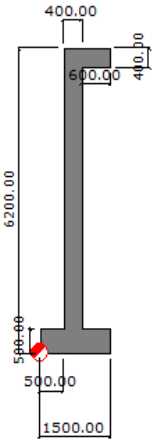
MATERIAL:

- **CONCRETE: class B 30, fck = 30.00 (MN/m2), unit weight = 24.00 (kN/m3)**
- **STEEL: class A - III, fyk = 450.00 (MN/m2)**

OPTIONS:

- Calculations according to: concrete code: **PN-B-03264(2002)**
  soil code: **PN-83/B-03010**
- Cover: c1 = 50.0 (mm), c2 = 50.0 (mm)
- Exposure: X0
- Retainig wall design according to:
  - Capacity m = 0.810
  - Sliding m = 0.720
  - Overturning m = 0.720
- Retainig wall verification according to:
  - Average settlement:
    S_{dop} = 100.00 (mm)
  - Settlement differences:
    DS_{dop} = 50.00 (mm)
- Wall/soil friction angle:
  - Passive pressure for cohesive soils -1/3×ϕ
  - Cohesive soil pressure 1/2×ϕ
  - Passive pressure for non-cohesive soils -1/3×ϕ
  - Pressure for non-cohesive soils 1/2×ϕ

2. Geometry:



3. Soil:

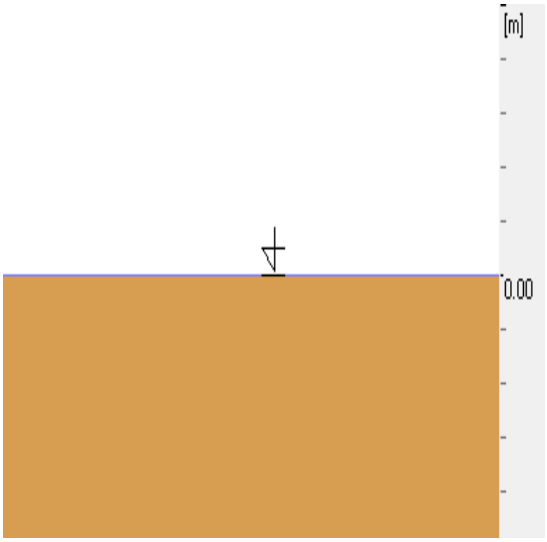
- **Soil parameter selection - method: B**
- **Backfill** Soil depth (behind the wall) Ho = 6200.00 (mm)
- **Original layers:**

Description:

No.	Soil name	Level *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1.	clayey fine sands	0.00	-	-	-	0.000

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1.	67.03	18.00	21.21	29.65	29.65



Soils (behind the wall):

Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravel - sand mixtures	500.00	500.00	-	-	0.000

* With respect to the lower right footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	38.00	21.99	199.50	199.50

- **Soils (before the wall):**

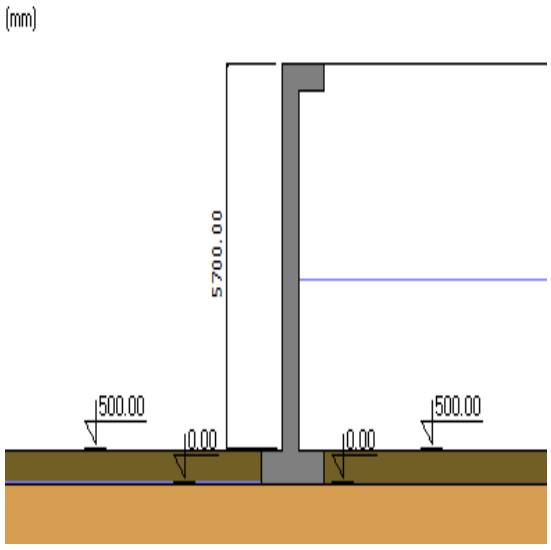
Description:

No.	Soil name	Level* *[mm]*	Thickness *[mm]*	Consolidation type	Moisture type	I_D/I_L
1	well graded gravel - sand mixtures	500.00	500.00	-	-	0.000

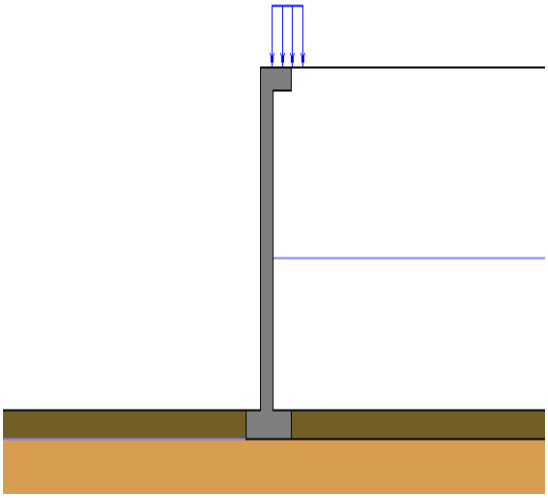
* With respect to the lower left footing point

Parameters:

No.	Cohesion *[kN/m2]*	Friction angle *[Deg]*	Unit weight *[kN/m3]*	M *[MN/m2]*	Mo *[MN/m2]*
1	0.00	38.00	21.99	199.50	199.50



4. Loads



- **Load report**

·

· *1 distributed*

· a1 live x1 = 0.00 (m) x2 = 1.00 (m) P = -3.00 (kN/m2)

·

· 5. Results (soils)

·

PRESSURES

·

Soil pressure and passive pressure : static
Factors for pressures and passive pressures for soils:

Average backfill slope angle ε = 0.00 (Deg)
Wall inclination angle β = 0.00 (Deg)

$$K_a = \frac{\cos^2 \cdot (\beta - \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta_2) \cdot \sin(\phi - \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_p = \frac{\cos^2 \cdot (\beta + \phi)}{\cos^2 \beta \cdot \cos(\beta + \delta_2) \cdot \left(1 - \sqrt{\frac{\sin(\phi - \delta_2) \cdot \sin(\phi + \varepsilon)}{\cos(\beta + \delta_2) \cdot \cos(\beta - \varepsilon)}}\right)^2}$$

$$K_o = \frac{\sigma_x}{\sigma_z} = \frac{\nu}{1 - \nu}$$

$$K_a \le K_o \le K_p$$

Soils (behind the wall):

No.	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravel - sand mixtures	500.00	38.00	0.238	0.384	4.204
2.		3000.00		1.000	1.000	1.000

- Generalized limit displacements
  - passive pressure 0.132
  - pressure 0.013

Soils (before the wall):

	Soil name	Level *[mm]*	Friction angle *[Deg]*	Ka	Ko	Kp
1.	well graded gravel - sand mixtures	500.00	38.00	0.217	0.384	7.007

- Generalized limit displacements
  - passive pressure 0.132
  - pressure 0.013

Simple cases

No.	Case	x (m)	y (m)	Px (kN/m)	Py (kN/m)	Description
1.	PM	0.75	1.66	0.00	-78.48	Self-weight of a retaining wall
2.	P'a	0.00	0.17	1.03	0.23	Soil pressure (before the wall)
3.	Pa	0.46	0.17	-0.67	0.00	Soil pressure (behind the wall)
4.	W	0.60	1.00	-44.15	7.36	Hydrostatic pressure
5.	a1	0.46	1.61	0.00	0.00	Live load

CAPACITY

- Soil type under footing: not layered
- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W + 1.200*a1
- Reduced design load:
  N=-70.93 (kN/m) My=17.44 (kN*m) Fx=-44.07 (kN/m)
- Equivalent footing dimension: A = 286.76 (mm)
- Coefficient of load capacity and influence of load inclination:

N_B = 0.745 i_B = 0.059
N_C = 11.768 i_C = 0.266
N_D = 4.419 i_D = 0.442

- Soil limit pressure: Qf = 59.67 (kN/m)
- Safety factor: Qf * m / Nr = Qf * m / Nr = 0.682 < 1.000

SETTLEMENT

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W + 1.000*a1
- Reduced design load:
  N=-70.89 (kN/m) My=17.52 (kN*m) Fx=-43.78 (kN/m)
- Unit load of total loads: q = 0.16 (MN/m2)
- Thickness of the actively settling soil: z = 3000.00 (mm)
- Stress on the level z:
  - additional: szd = 0.01 (MN/m2)
  - caused by soil weight: szg = 0.06 (MN/m2)

- Settlement: S = 5.04 (mm) < Sdop = 100.00 (mm)

OVERTURNING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W + 1.200*a1
- Reduced design load:
  N=-70.93 (kN/m) My=17.44 (kN*m) Fx=-44.07 (kN/m)
- Overturning moment: Mo= 66.35 (kN*m)
- Moment preventing foundation overturning: M_{uf} = 76.52 (kN*m)
- Safety factor: $M_{uf} * m / M_0 = 0.830 < 1.000$

SLIDING

- Design combination: 1.000*PM + 0.850*P'a + 1.200*Pa + 1.000*W + 1.200*a1
- Reduced design load:
  N=-70.93 (kN/m) My=17.44 (kN*m) Fx=-44.07 (kN/m)
- Equivalent footing dimension: A = 1500.00 (mm)
- Friction coefficient:
  - of soil (on the settlement level): $\mu = 0.000$
- Soil cohesion reduction factor = 100.000 %
- Cohesion: C = 60.33 (kN/m2)
- Sliding force value: Q_{tr} = 44.07 (kN/m)
- Value of force preventing wall sliding:
- $Q_{tf} = N * \mu + C * A$
- - on the foundation level: Q_{tf} = 90.49 (kN/m)
- Safety factor: $Q_{tf} * m / Q_{tr} = 1.479 > 1.000$

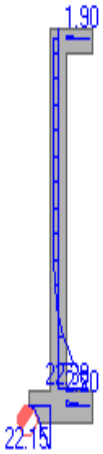
OVERTURNING ANGLES

- Soil type under foundation: not layered
- Design combination: 1.000*PM + 1.000*P'a + 1.000*Pa + 1.000*W + 1.000*a1
- Reduced design load:
  N=-70.89 (kN/m) My=17.52 (kN*m) Fx=-43.78 (kN/m)
- Maximum unit stresses from total loads:
  qmax = 0.33 (MN/m2)
- Minimum unit stresses from total loads:
  qmin = 0.00 (MN/m2)
- Overturning angle: ro = 1.44 (Deg)
- Coordinates of wall rotation point:
  X = 432.39 (mm)
  Z = 0.00 (mm)
- Safety factor: 4.600 > 1.000

6. Results of RC design

.

- Moments



. (kN*m)

.

Element	Moments	Value *[kN*m]*	Position *[mm]*	Combination
Wall	maximum	22.95	500.00	0.900*PM + 0.765*P'a + 0.900*Pa + 1.000*W + 1.320*a1
Wall	minimum	-3.17	3000.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W + 1.320*a1
Footing	maximum	26.34	500.00	0.900*PM + 0.765*P'a + 1.320*Pa + 1.000*W + 1.320*a1
Footing	minimum	-2.20	900.00	1.100*PM + 1.100*P'a + 1.320*Pa + 1.000*W + 1.320*a1

APPENDIX B

AUTODESK ROBOT STRUCTURES 2010 VERIFICATION

CONCRETE

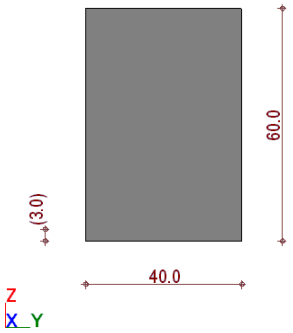
1. BS 9/1/96 – RC columns

VERIFICATION EXAMPLE 1
- Column subjected to axial load and biaxial bending

DESCRIPTION OF THE EXAMPLE:

Following example illustrates the procedure of dimensioning of biaxial bending of column, which is non-sway in one direction, whereas sway in the other. The results of the program are accompanied by the „manual" calculations.

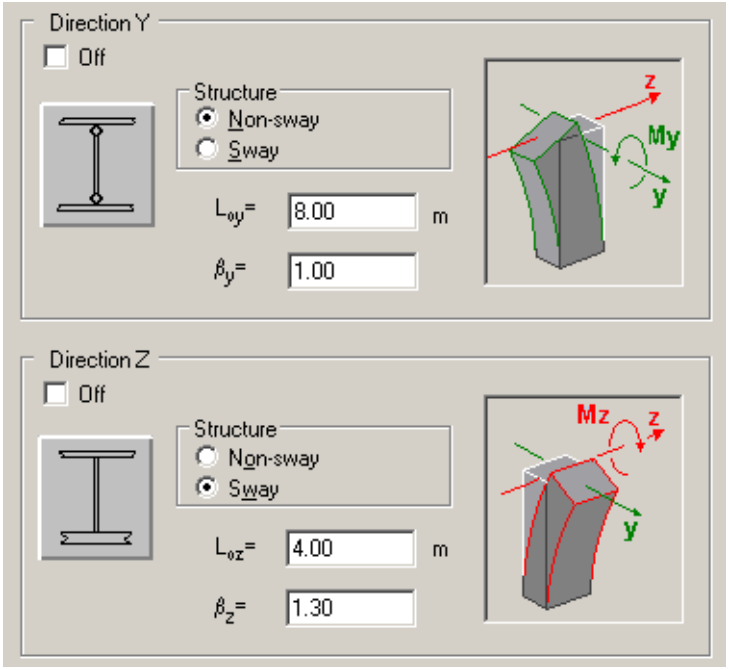
1. SECTION DIMENSIONS



2. MATERIALS

Concrete	: C20	f_{cu} = 20.00 (MPa)
Longitudinal reinforcement	: T	f_y = 460.00 (MPa)
Transversal reinforcement	: R	f_y = 250.00 (MPa)

3. BUCKLING MODEL



As can be seen the sway column is assumed for Z direction, and the non-sway column for Y direction.

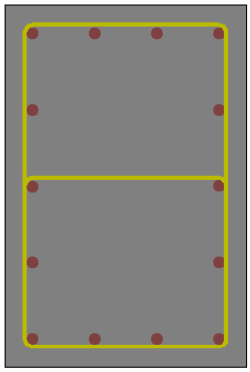
4. LOADS

No.	Case	Nature	Group	N (kN)	MyA (kN'm)	MyB (kN'm)	MyC (kN'm)	MzA (kN'm)	MzB (kN'm)	MzC (kN'm)	γ
1	DL1	dead load	1	400.00	150.00	30.00	102.00	20.00	30.00	50.00	1.40
2	LL1	Live	1	150.00	120.00	30.00	84.00	10.00	20.00	40.00	1.60
*											

NOTE: Let us assume, the moments in Y direction are linearly distributed along the height of the column. Thus, we define only the ends' moments for Y direction. In Z direction however, we assume the mid-height moment is not a result of the linear distribution. For such a case, Robot let the user define the moments in the mid-section explicitly.

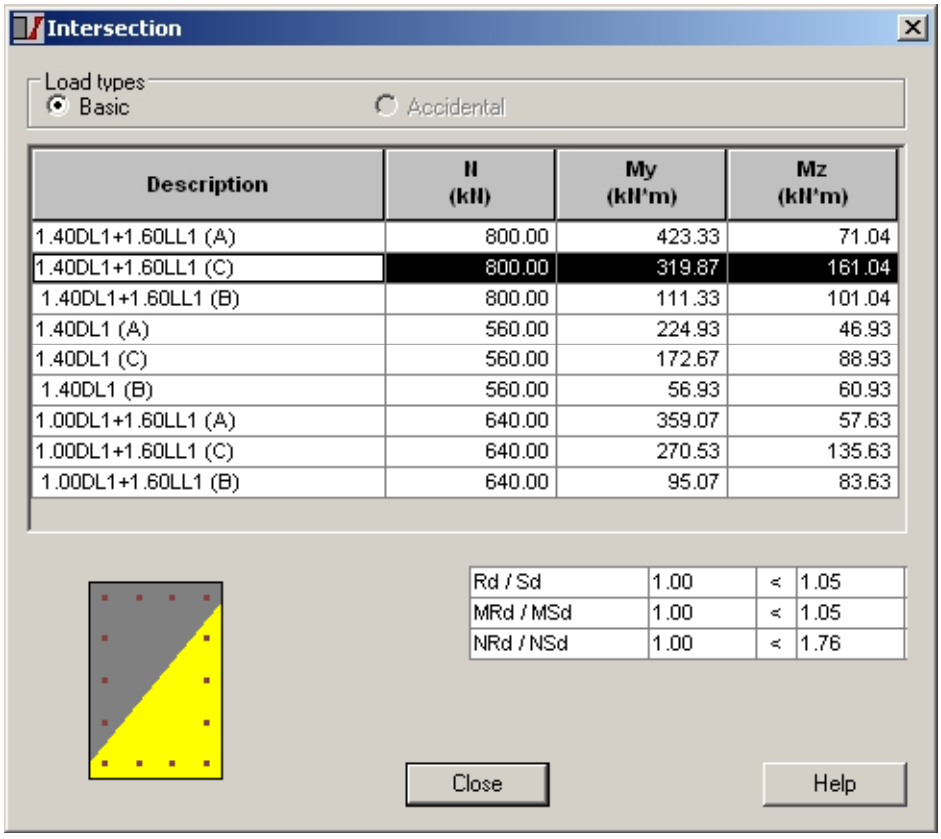
5. CALCULATED REINFORCEMENT:

Program generates the reinforcement 14 ϕ 20.



6. RESULTS OF THE SECTION CALCULATIONS:

The dimensioning combination is 1.4DL1+1.6LL1
The dimensioning section (where the most unfavorable set of forces is found) is for that combination the section in the mid-height of the column (marked as (C)).



Since the column is found as slender, in both direction the second-order effects are taken into account.

In parallel the other sections (at the ends of the column) are checked for all combinations of loads.
All the results of total forces for each combination and each section of the column may be seen in the table “Intersection” at the Column-results layout.

7. CALCULATIONS OF TOTAL MOMENT:

7.1. LOADS

For the dimensioning combination, the loads are:

	Case	N (kN)	MyA (kN*m)	MyB (kN*m)	MyC (kN*m)	MzA (kN*m)	MzB (kN*m)	MzC (kN*m)
1	DL1	400	150	30	102	20	30	50*
2	LL1	150	120	30	84	10	20	40*
Dimensioning combination	1.4DL1+1.6LL1	800	402	90	277.2	44	74	134

,where A, B and C denote upper, lower and mid-height sections of the column respectively.
* - the values are written “by hand” by the user (see point 4 – Loads)

7.2. THE INFLUENCE OF SLENDERNESS

Two independent calculations of the total moment for both directions are carried out.

Slenderness analysis acc. to 3.8.1.3:

l_{ey} / h = 13.33 < 15 (non-sway for Y direction)

l_{ez} / b = 13.0 > 10 (sway for Z direction)

Since the ratio l_{ez} / b exceeds the limit, the column is found as **slender**.

Y DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot h; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have:

$M_i = 0.4 \cdot M_1 + 0.6 \cdot M_2$ = 277.2 (kNm) > $0.4 \cdot M_2$ = 160.8 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.053 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{h}\right)$ = 0.088

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c} A_c + \frac{f_y}{\gamma_s} A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 42.67 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**
- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment My :

$M_y = M_i + M_{add}$ = 319.87 (kNm) > 16.00 (kNm) = $M_{\min}$

Z DIRECTION

Calculation of minimum eccentricity e_{min} and minimum moment M_{min}– 3.8.2.4

$e_{\min} = \min(0.05 \cdot b; 0.02m)$ = 0.02 (m)

$M_{\min} = N \cdot e_{\min}$ = 16.0 (kNm)

Calculation of initial moment M_i – eq. 36

For the mid-height section, we have the moment fixed directly by the user:

M_i = 134 (kNm)

Calculation of second-order eccentricity a_u – eq. 32

$a_u = \beta_a K h$ = 0.034 (m)

$\beta_a = \frac{1}{2000}\left(\frac{l_e}{b}\right)$ = 0.0845

$K = \min\left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}; 1\right)$

$N_{uz} = \frac{2}{3}\frac{f_{cu}}{\gamma_c}A_c + \frac{f_y}{\gamma_s}A_{sc}$ = 4060.18 (kN)

A_c = 0.24 (m^2)

A_{sc} = 43.98 (cm^2)

N_{bal} = 1222.64 (kN) – note that this value is calculated in detail for the state equilibrium in a section. Using the approximated code formula one would obtain

N_{bal} = 1173.33 (kN)

$K = \left(\frac{N_{uz} - N}{N_{uz} - N_{bal}}\right)$ = - thus, K = 1 was assumed

Calculation of second-order moment M_{add}

$M_{add} = N \cdot a_u$ = 27.04 (kNm)

NOTE: The second-order effects in Robot are taken into account dependent upon the section and upon the parameter sway/non sway in a following way:

- **in non-sway structures, M_{add} is added for the mid-height section, while 0.5 M_{add} is added for the end sections. Such addition is carried out disregarding the distribution of the first-order moment.**

- **in sway structures, M_{add} is added to each of three sections of column. Such addition is carried out disregarding the distribution of the first-order moment.**

The total moment Mz :

$M_z = M_i + M_{add}$ = 161.04 (kNm) > 16.00 (kNm) = $M_{\min}$

7.3. FINAL RESULT

M_y = 320 (kNm)

M_z = 161 (kNm)

8. CONCLUSIONS

The algorithm of calculations of the total moments (i.e. slenderness effects) in non-sway/sway column has been presented. The results obtained with the program (see point 6 – Results of the Section Calculations) are in agreement with the manual calculations (see point 7.3 – Final Result)

LITERATURE

[1] British Standard BS 8110: 1985. Structural use of concrete. British Standard Institution, 1985.

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 31

Project Name: SDD SETTLING TANKS **Job No:** K5452-80-071

Calculation Title: Junction Boxes - Typical

Calculation No./File No.: K5452-80-071 R1

Calculation is: ☐Preliminary ☐ Final

Objective: Determine required reinforcement areas for ULS & SLS

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
1	Fluid density – 10kN/m^3	K. Georgala	05/04/2010
2	Soil pressure (see "Annexure A")	K. Georgala	05/04/2010
3	Founding on non-yielding material	K. Georgala	05/04/2010

This section applies to computer generated calculations			
Program Name/Number:	Autodesk Robot Structural Analysis 2010	**Version:**	V23.0.1.3128
Program Name/Number:	Autodesk Revit Structure 2010	**Version:**	V2010
Evidence of or reference to computer program verification, if applicable: See "Annexure B"			
Bases or reference thereto supporting application of the computer program to the physical problem: Finite element analysis (FEA) method can be implemented with acceptable standards to South Africa			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
1	S. Wilding	03/05/2010	T. Tjia	03/05/2010	K Georgala PrEng	04/05/2010

1. PURPOSE:

Determination of structure dimensions and required reinforcement under specified load

2. REFERENCES:

	1. Concrete layout drawing	K5452-80-103 to 109 & 111 to 117
	2. Reinforcement detail	K5452-80-103 to 109 & 111 to 117

3. LOAD CASES AND COMBINATIONS:

Load Cases:

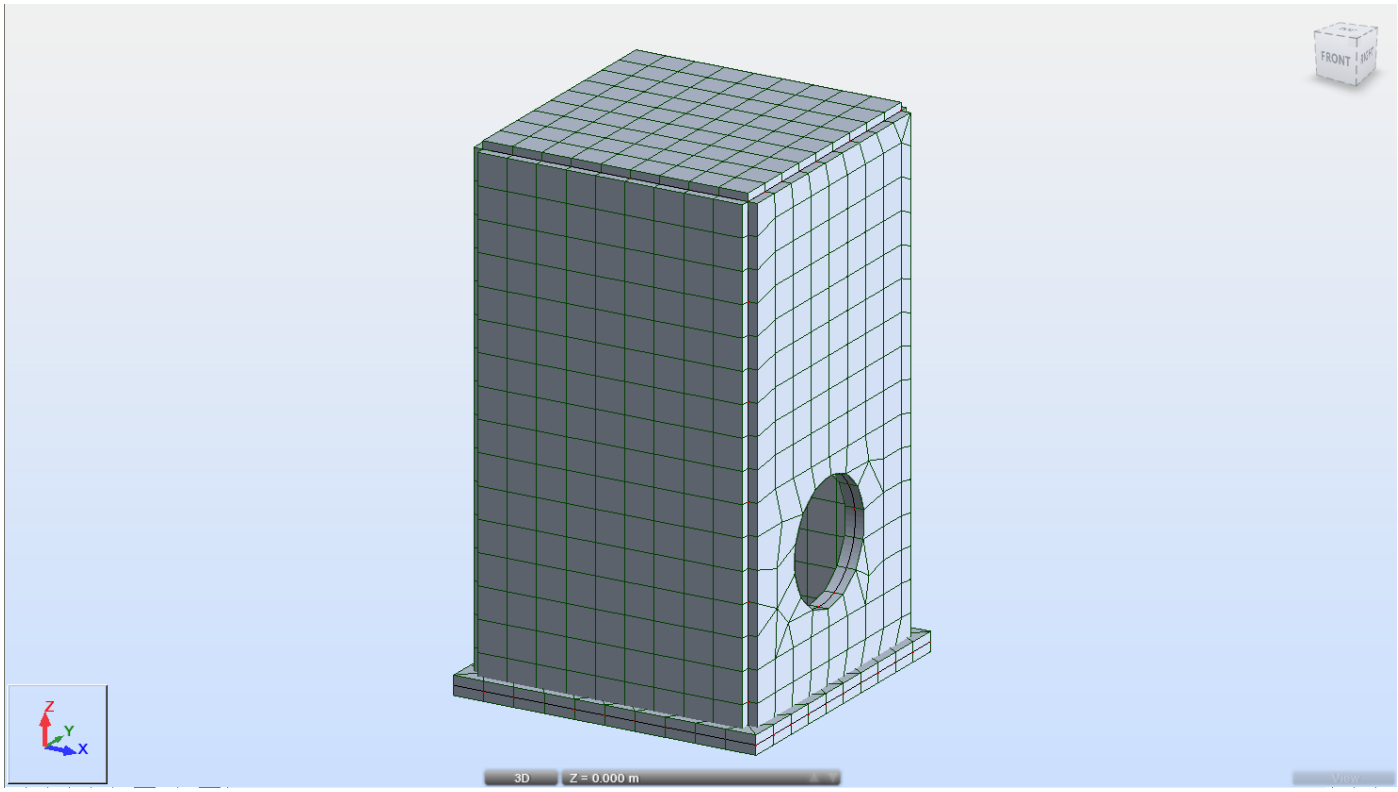
1. **Self Weight**
2. **Soil Pressure**
3. **Soil Water Pressure**
4. **Water Pressure**

Load Combinations:

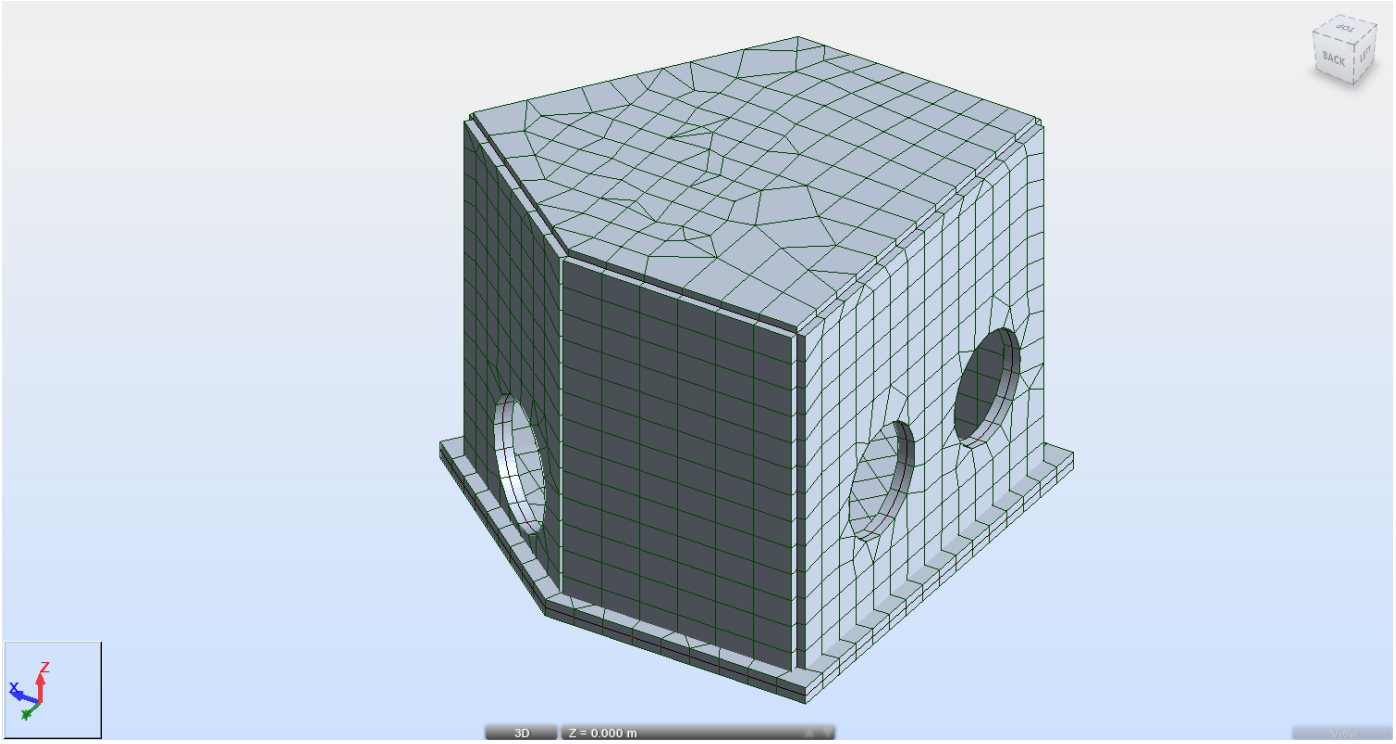
10. **Own Weight + Soil Pressure + Soil Water Pressure (ULS)**
20. **Own Weight + Soil Pressure + Soil Water Pressure (SLS)**

4. APPLICATIONS:

STRUCTURE VIEW (SQUARE & RECTANGULAR SHAPED JUNCTION BOXES)

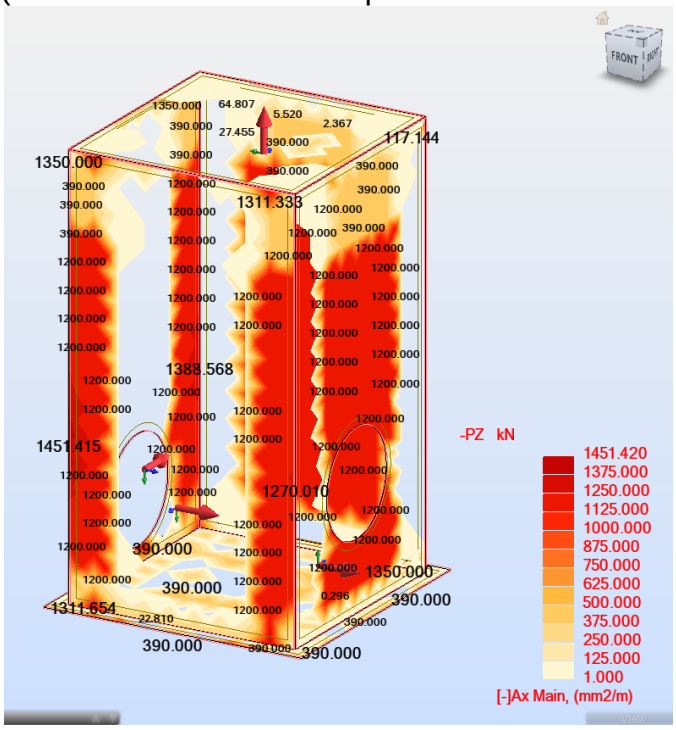


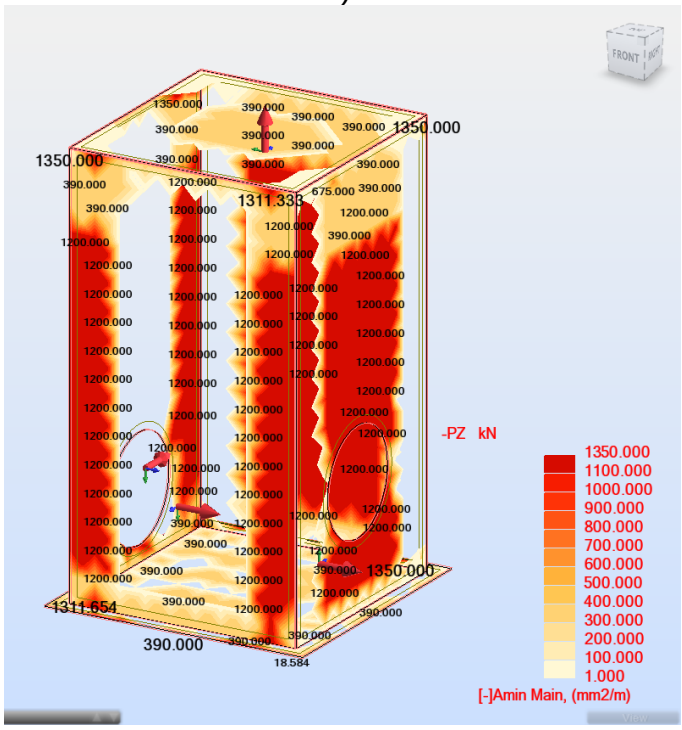
STRUCTURE VIEW (PENTAGON SHAPED JUNCTION BOXES)



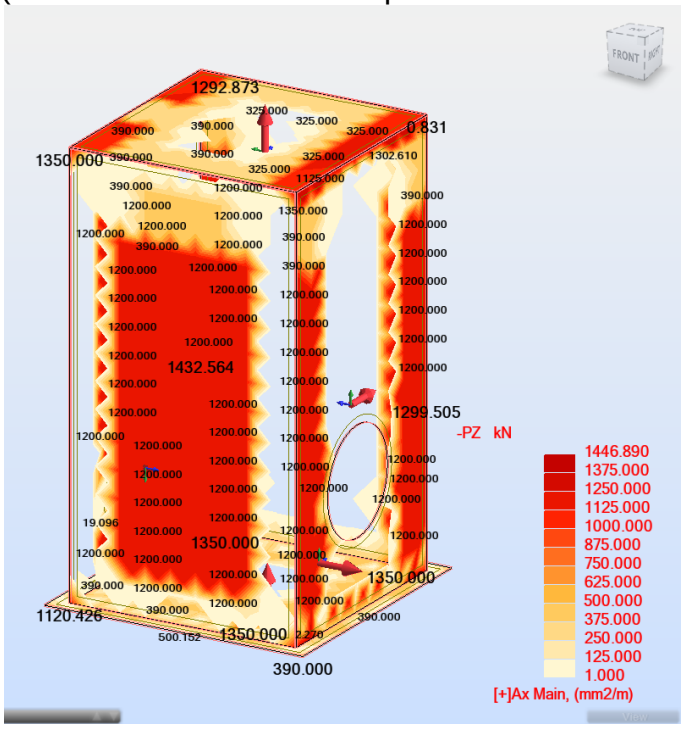
REINFORCING (SQUARE AND RECTANGULAR SHAPED JUNCTION BOXES):

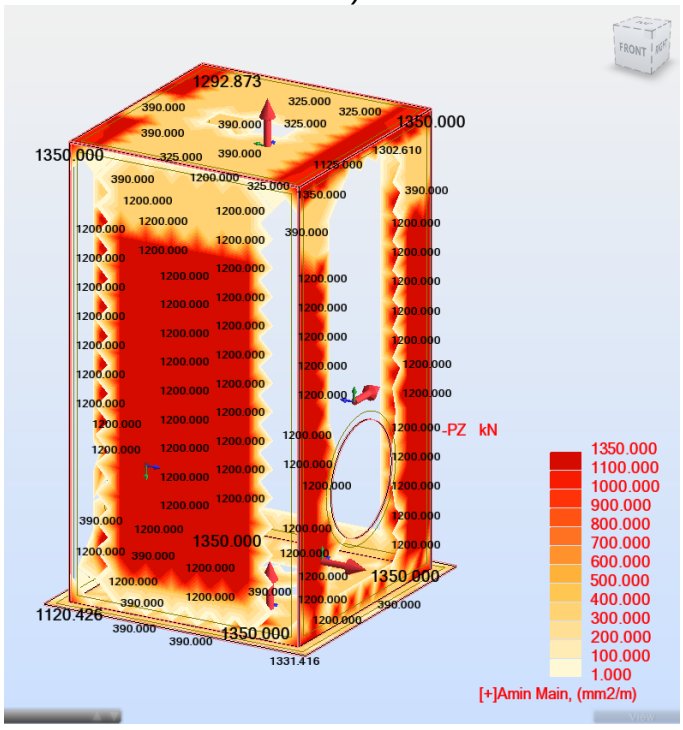
(Horizontal inside face required reinforcement & minimum reinforcement)



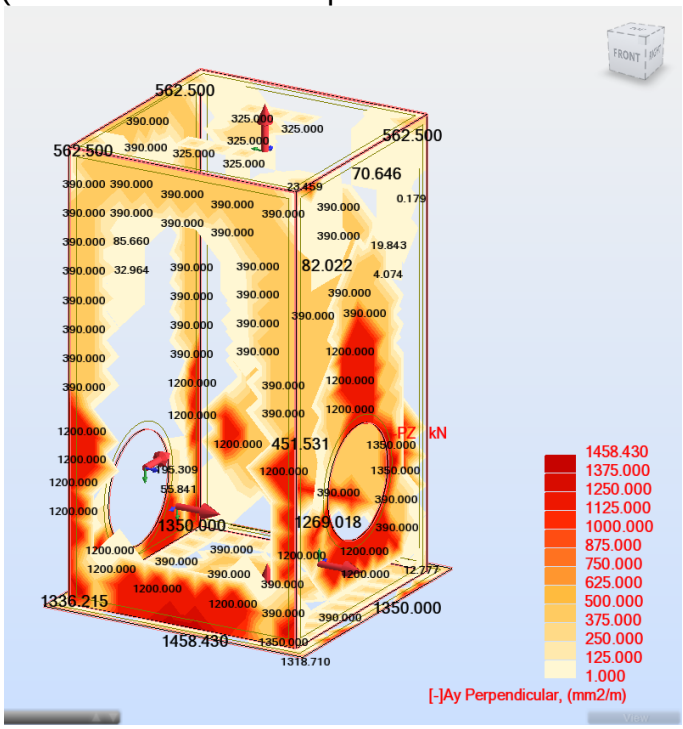


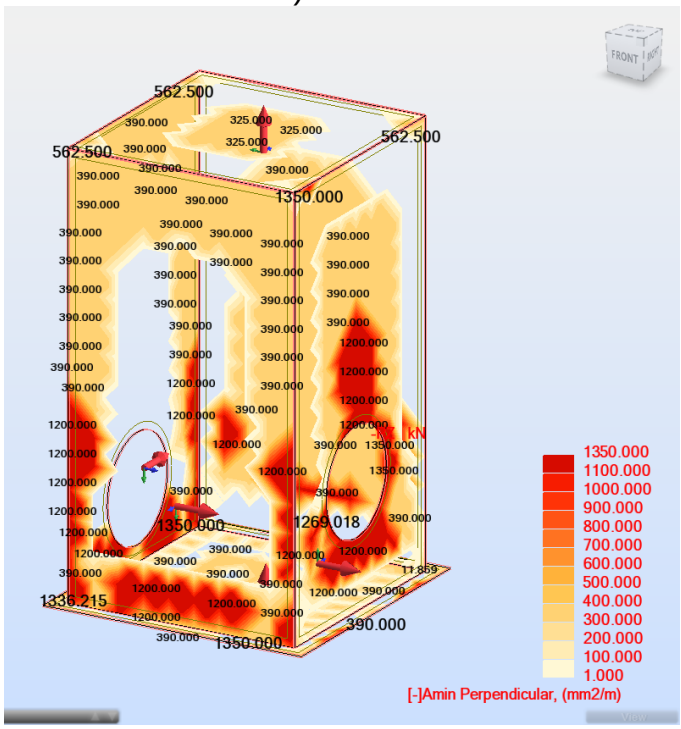
(Horizontal outside face required reinforcement & minimum reinforcement)



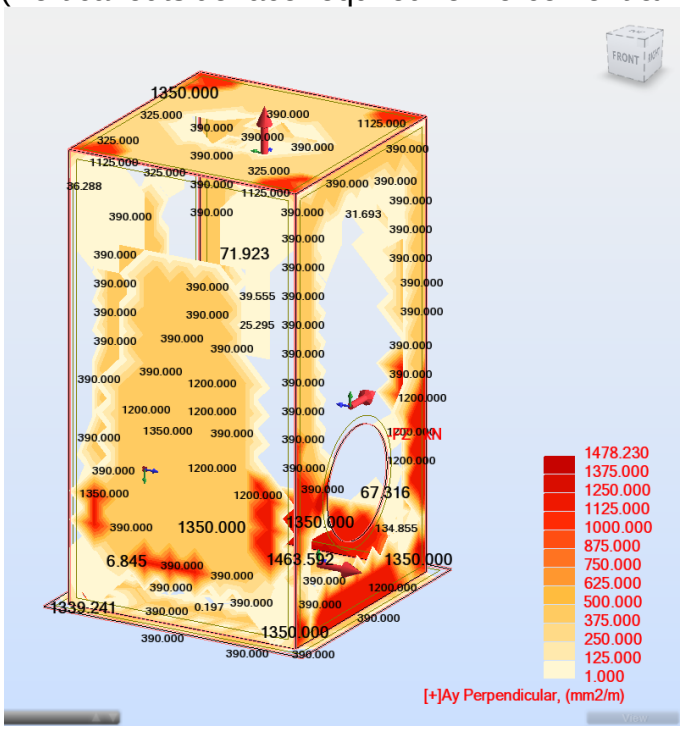


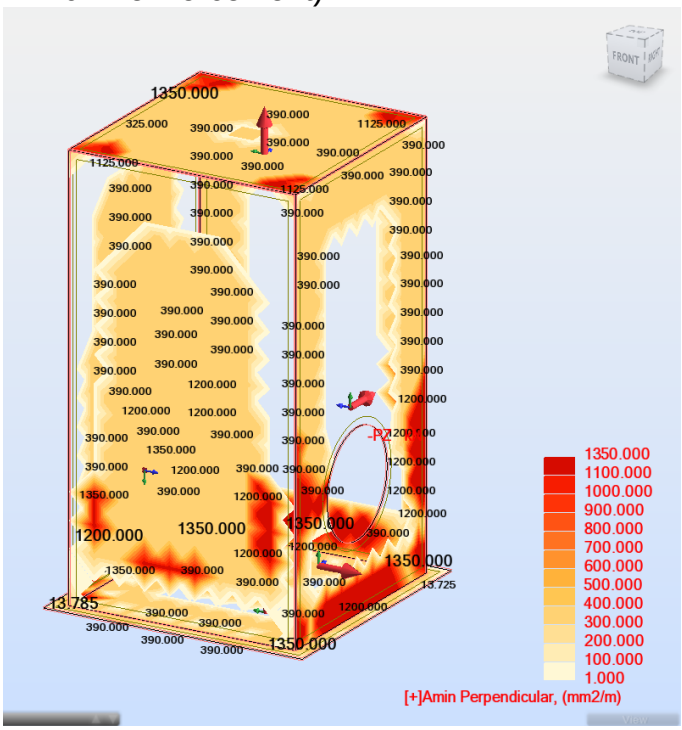
(Vertical inside face required reinforcement & minimum reinforcement)





(Vertical outside face required reinforcement & minimum reinforcement)





INTERPRETATION:

A reinforcement area of 1340mm²/m will be sufficient to withstand the worst load combination scenario, Self Weight + Soil Pressure in the side walls.

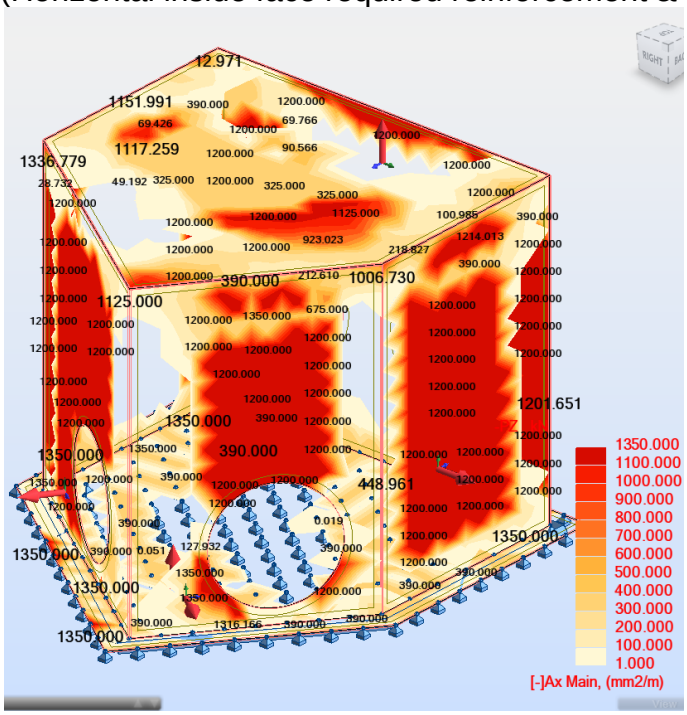
Y16@150mm centre-to-centre = 1340mm²/m.

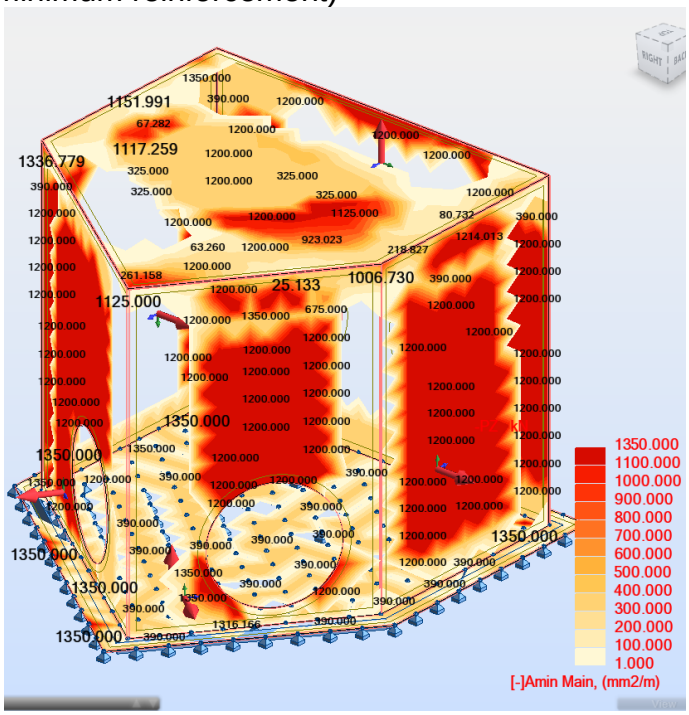
A reinforcement area of 754mm²/m will be sufficient to withstand the worst load combination scenario, Self Weight + Soil pressure in the top slab. The vertical reinforcement, Y15 @150mm, must act as starter bars of the top face slab reinforcement.

Y12@150mm centre-to-centre = 754mm²/m.

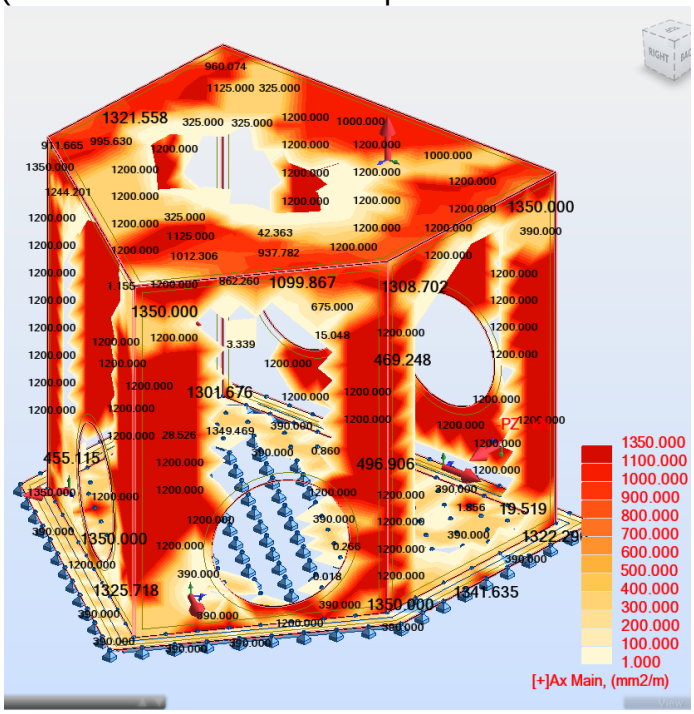
REINFORCING (PENTAGON SHAPED JUNCTION BOXES):

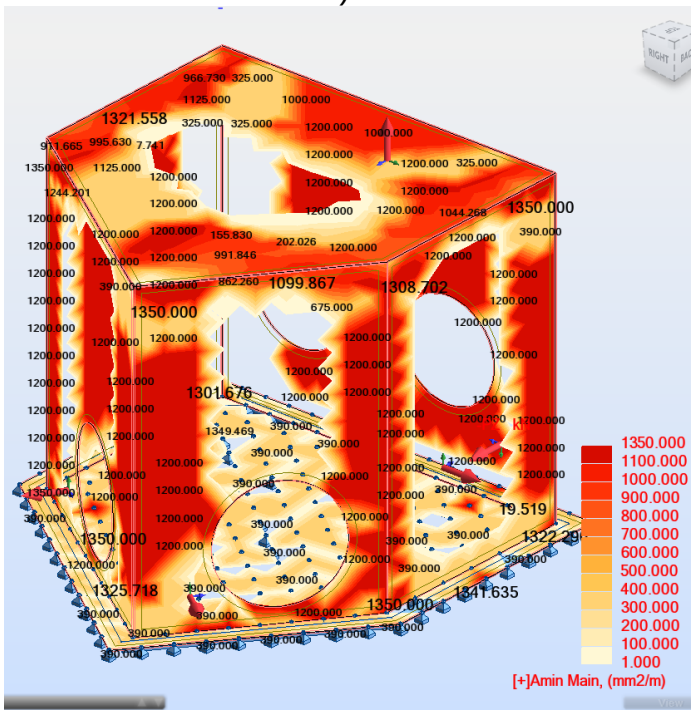
(Horizontal inside face required reinforcement & minimum reinforcement)



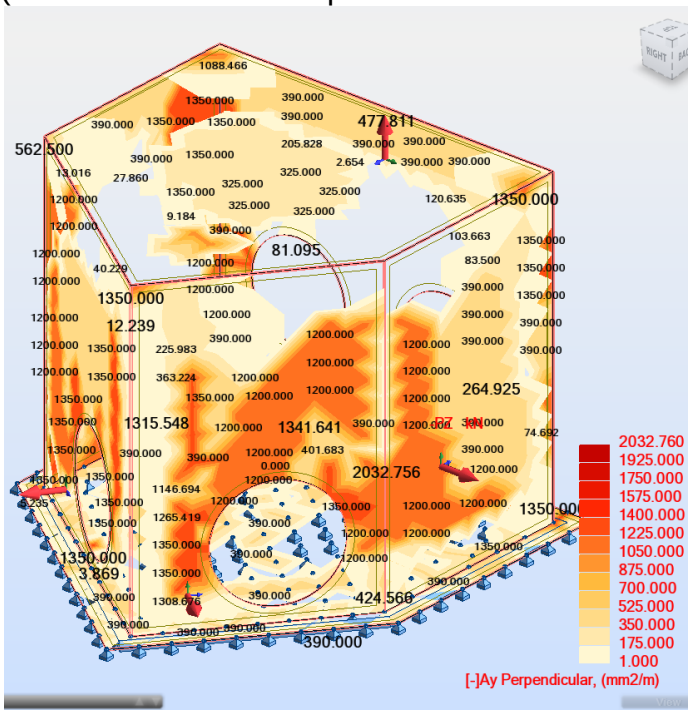


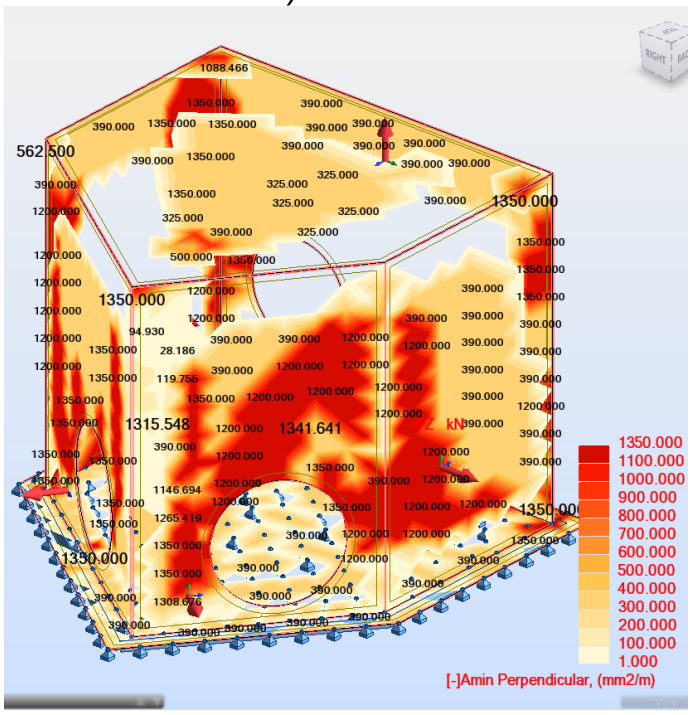
(Horizontal outside face required reinforcement & minimum reinforcement)



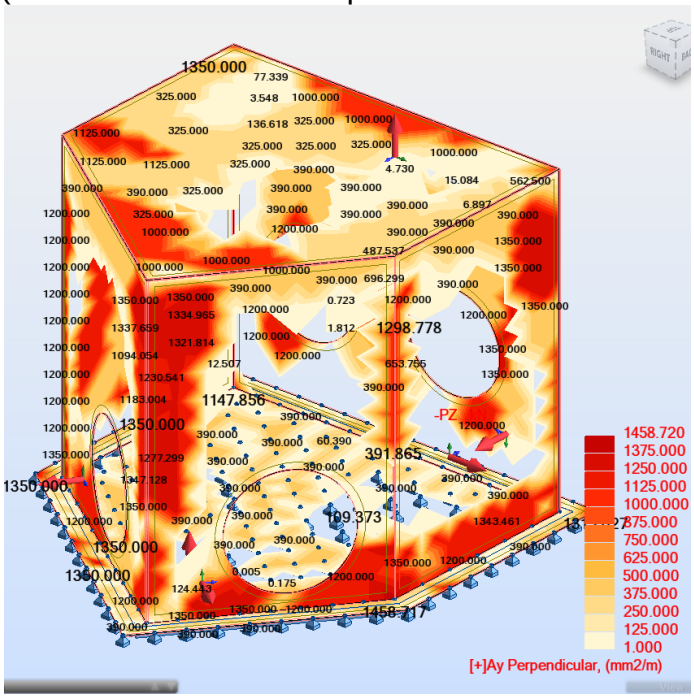


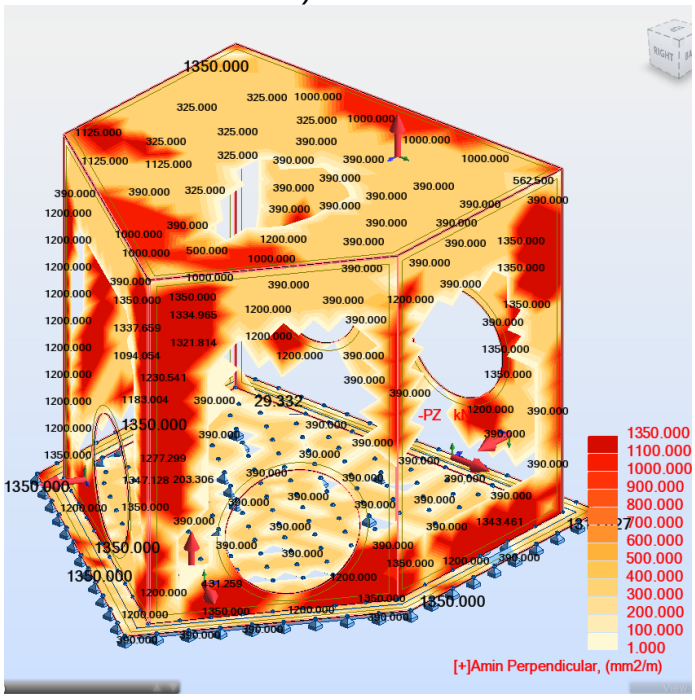
(Vertical inside face required reinforcement & minimum reinforcement)





(Vertical outside face required reinforcement & minimum reinforcement)





INTERPRETATION:

A reinforcement area of 1340mm²/m will be sufficient to withstand the worst load combination scenario, Self Weight + Soil Pressure, in the side walls

Y16@150mm centre-to-centre = 1340mm²/m.

A reinforcement area of 2094mm²/m will be sufficient to withstand the worst load combination scenario, Self Weight + Soil Pressure as the vertical reinforcement on the outside face of the longer wall.

Y20@150mm centre-to-centre = 2094mm²/m.

5. PROCEDURE/METHODOLOGY OF DESIGN:

5.1. The finite element design method has been applied for this analysis, as well as mathematical design procedures to SABS 0100, BS 8110 and ACI 318

5.2. Four load cases and two load combinations have been analyzed, as indicated in “Annexure A”

6. ASSUMPTIONS:

Assumptions requiring verification will be listed on the cover sheet

7. DEFINITION OF UNITS AND CONSTANTS:

Refer to “Annexure A”

8. ANALYSIS/SOLUTION: (see body of calculation for analysis and solutions)

Note: Detailed calculations output data to be provided on request.

9. METHOD OF RESULTS GENERATION:

All loads and load combinations are defined as load cases within Robot Structural Analysis, combinations have the addition of factors applied as explained on page 11 to 21 of this document, and are governed by ULS or SLS criteria.

The results displayed in this document, represents the worst cases of all possible cases, where each case has been analyzed individually as well as specified in combination cases.

10. APPENDICES TO CALCULATIONS:

10.1 Appendix A – Calculations.

10.2 Appendix B – Prokon Structural Analysis verification report – Side walls

10.3 Appendix C – Prokon Structural Analysis verification report – Top slab

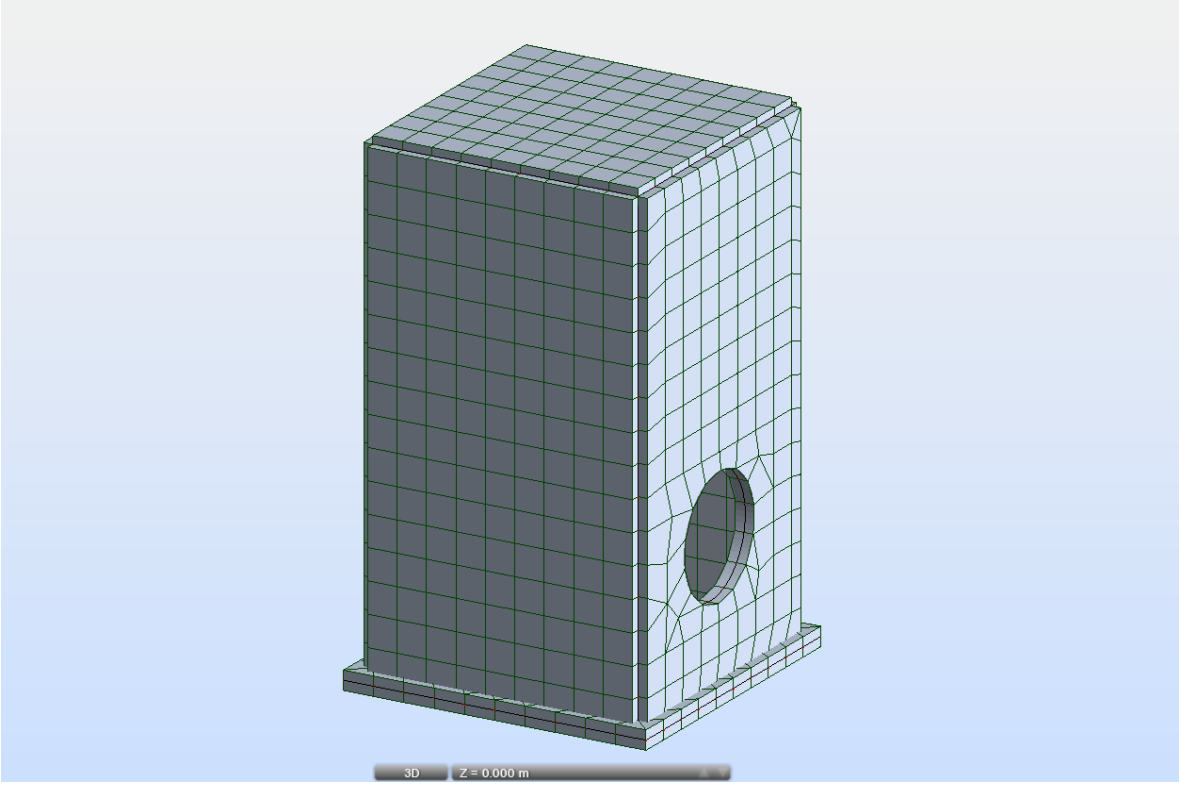
APPENDIX A

CALCULATIONS

SDD Junction Box Design

SQUARE & RECTANGULAR SHAPED JUNCTION BOXES

STRUCTURE VIEW



CALCULATION NOTE

Code preferences:

- BS 8004 – Soil Code
- SABS 1060 – Code Combinations
- BS 8110 – Concrete Design

Structure centre of gravity coordinates:
X = 2.425 (m)
Y = 2.425 (m)
Z = 3.808 (m)

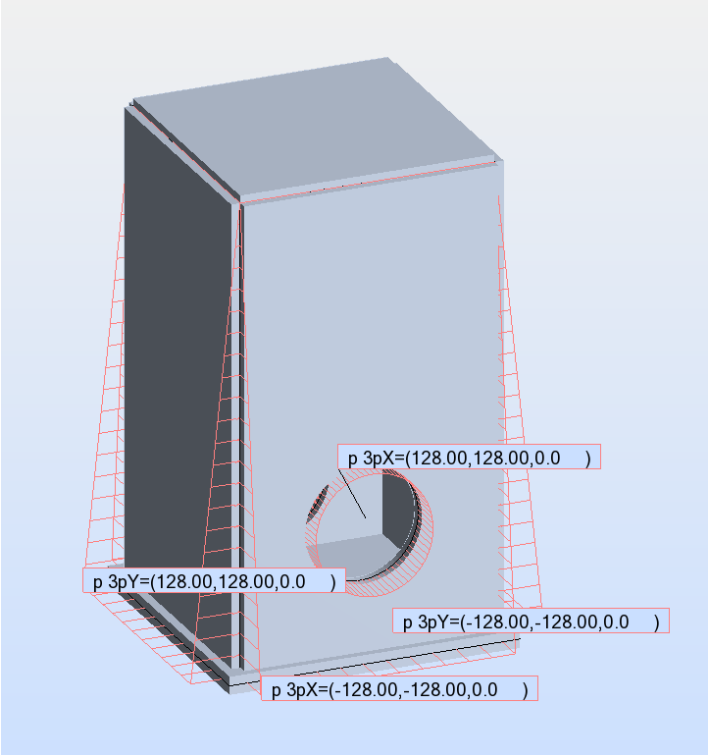
Structure central moments of inertia:
Lx = 1244524.873 (kg.m²)
Ly = 1226735.499 (kg.m²)
Lz = 660942.734 (kg.m²)
Mass = 120248.968 (kg)

LOADS & LOAD COMBINATIONS:

Table of load cases / analysis types

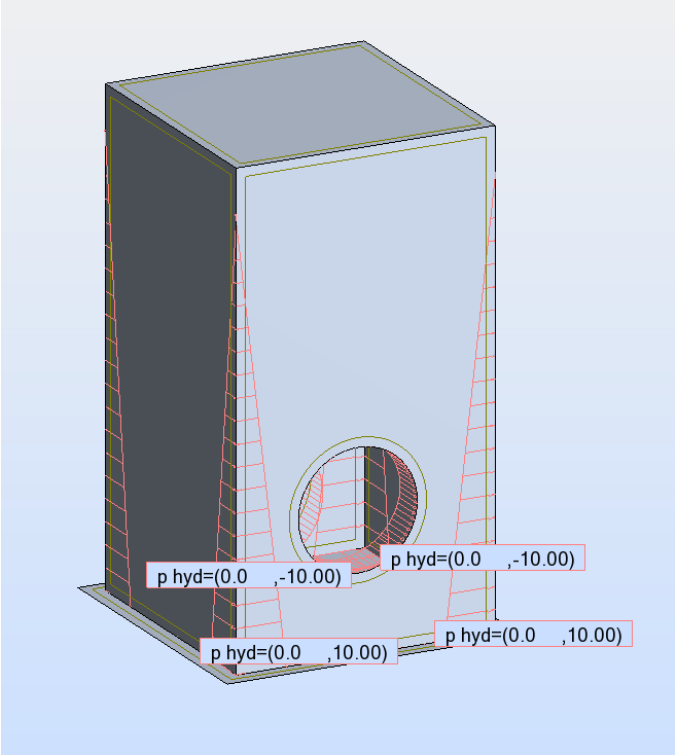
Case 1 : OWN WEIGHT
Analysis type: Static – Linear

Case 2 : SOIL PRESSURE
Analysis type: Static – Linear



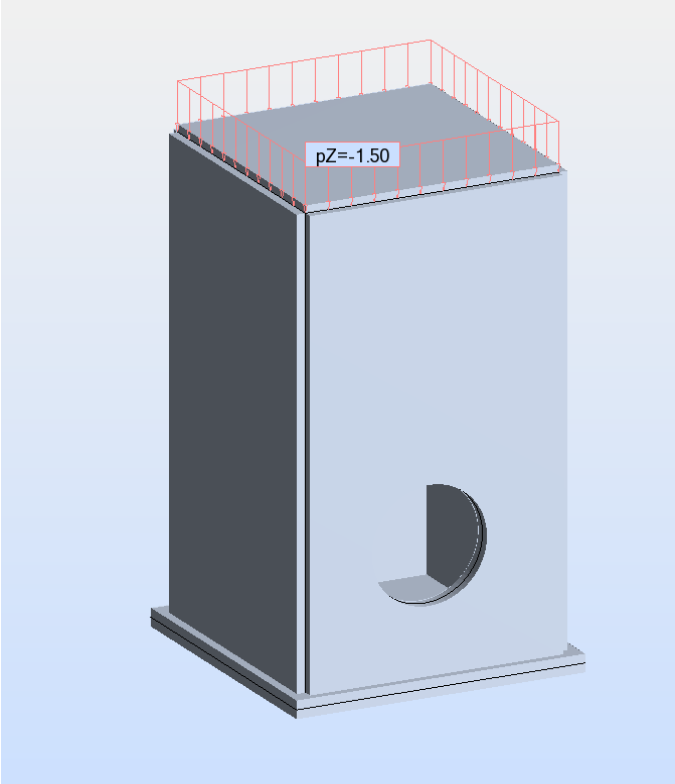
Case 3 : WATER PRESSURE

Analysis type: Static - Linear



Case 4 : LIVE LOAD

Analysis type: Static – Linear



Case 10 : SELF WEIGHT + SOIL PRESSURE (ULS)
Analysis type: Linear combination

Case 20 : SELF WEIGHT + SOIL PRESSURE (SLS)
Analysis type: Linear combination

SOIL PRESSURE

Geometrical data

Soil level (Z) = 7.1 (m)
Soil inclination (alpha) = 0.0 (Deg)
Wall inclination (beta) = 0.0 (Deg)

Soil

Underground water level = 7.10 (m)

Soil layers:

No.	Soil name	Level (m)	Unit weight (kg/m3)	Unit weight of solid (kg/m3)
1	Well graded gravel - sand mixtures	7.10	2242.58	2702.31

Limit and static pressure factors for soil layers taken into account during calculations:

No.	Soil name	Level (m)	Friction angle (Deg)	Ka	Ko	Kp
1	well graded gravel - sand mixtures	6.20	38.0	0.238	0.384	4.204

Soil pressure and passive pressure:

Limit displacement factor: = 0.00

LOADS

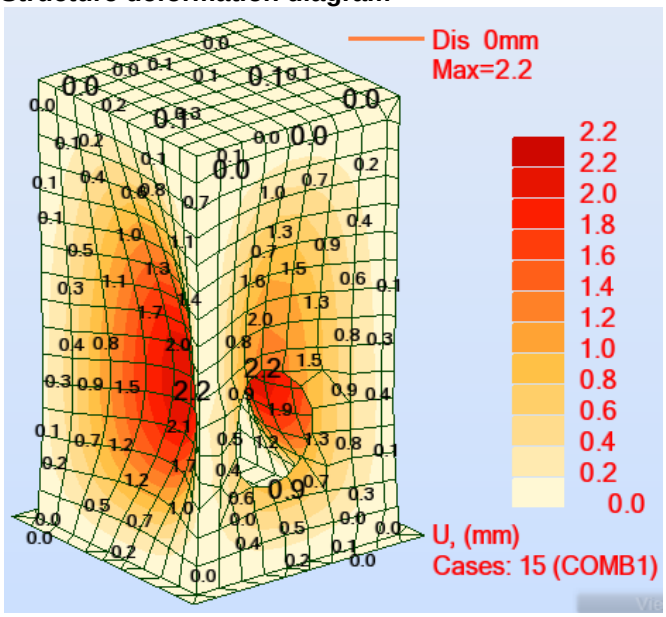
Case	Load type	List	Load values
1:DL1	self-weight	1to6	' PZ Negative Factor=1.00
2:Soil load	(FE) planar		' PX2=0.00(kN/m2) PX3=118.00(kN/m2) N1X=0.300(m) N1Y=4.550(m) N1Z=7.300(m) N2X=0.300(m) N2Y=0.300(m) N2Z=7.300(m) N3X=0.300(m) N3Y=0.300(m) N3Z=0.0(m)
2:Soil load	(FE) planar		' PY2=118.00(kN/m2) PY3=118.00(kN/m2) N1X=0.300(m) N1Y=0.300(m) N1Z=7.300(m) N2X=0.300(m) N2Y=0.300(m) N2Z=0.0(m) N3X=4.550(m) N3Y=0.300(m) N3Z=0.0(m)
2:Soil load	(FE) planar		' PX2=0.00(kN/m2) PX3=-118.00(kN/m2) N1X=0.300(m) N1Y=4.550(m) N1Z=7.300(m) N2X=0.300(m) N2Y=0.300(m) N2Z=7.300(m) N3X=0.300(m) N3Y=0.300(m) N3Z=0.0(m)
2:Soil load	(FE) planar		' PX2=0.00(kN/m2) PY3=-118.00(kN/m2) N1X=0.300(m) N1Y=4.550(m) N1Z=7.300(m) N2X=0.300(m) N2Y=0.300(m) N2Z=7.300(m) N3X=0.300(m) N3Y=0.300(m) N3Z=0.0(m)
3:Live Load	(FE) uniform		' PZ=-1.50(kN/m2)
3:Live Load	(FE) uniform	6	' PZ=-1.50(kN/m2)
2:Soil load	(FE) planar	5	' PX1=-128.00(kN/m2) PX2=-128.00(kN/m2) N1X=4.550(m) N1Y=0.300(m) N1Z=0.0(m) N2X=4.550(m) N2Y=4.550(m) N2Z=0.0(m) N3X=4.550(m) N3Y=2.425(m) N3Z=7.865(m)
2:Soil load	(FE) planar	4	' PY1=128.00(kN/m2) PY2=128.00(kN/m2) N1X=0.300(m) N1Y=0.300(m) N1Z=0.0(m) N2X=4.550(m) N2Y=0.300(m) N2Z=0.0(m) N3X=2.425(m) N3Y=0.300(m) N3Z=7.865(m)
2:Soil load	(FE) planar	3	' PX1=128.00(kN/m2) PX2=128.00(kN/m2) N1X=0.300(m) N1Y=4.550(m) N1Z=0.0(m) N2X=0.300(m) N2Y=0.300(m) N2Z=0.0(m) N3X=0.300(m) N3Y=2.425(m) N3Z=7.865(m)
2:Soil load	(FE) planar	2	' PY1=-128.00(kN/m2) PY2=-128.00(kN/m2) N1X=4.550(m) N1Y=4.550(m) N1Z=0.0(m) N2X=0.300(m) N2Y=4.550(m) N2Z=0.0(m) N3X=2.425(m) N3Y=4.550(m) N3Z=7.865(m)
4:Water Pressure	(FE) hydrostatic pressure	2 5	' GAMMA=10.00(kN/m3) H=7.050(m) NDIR=-Z
4:Water Pressure	(FE) hydrostatic pressure	3 4	' GAMMA=-10.00(kN/m3) H=7.050(m) NDIR=-Z

COMBINATIONS

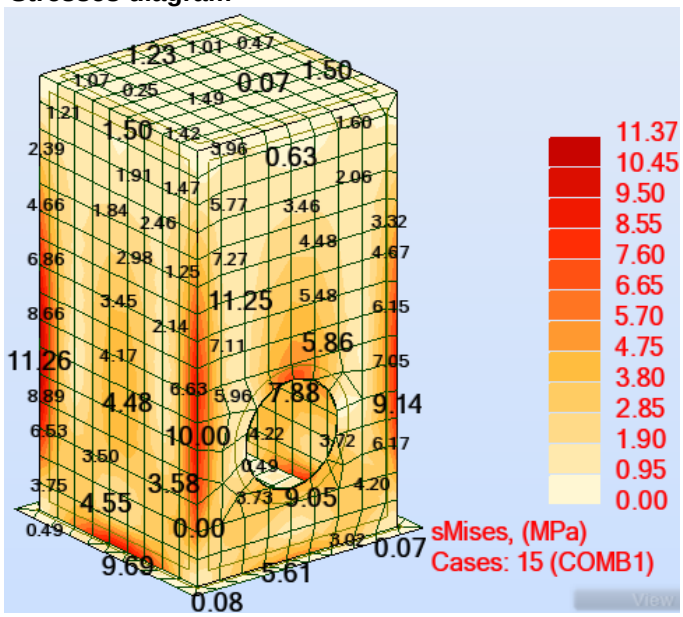
Combinations	Name	Analysis type	Combination nature	Case nature	Definition
10 (C)	COMB1	Linear Combination	ULS	dead	1*1.20+(2+3)*1.60
20 (C)	COMB2	Linear Combination	SLS	dead	1*1.10+(2+3)*1.00

STRUCTURAL DIAGRAMS (SQAURE & RECTANGULAR SHAPED JUNCTION BOXES):

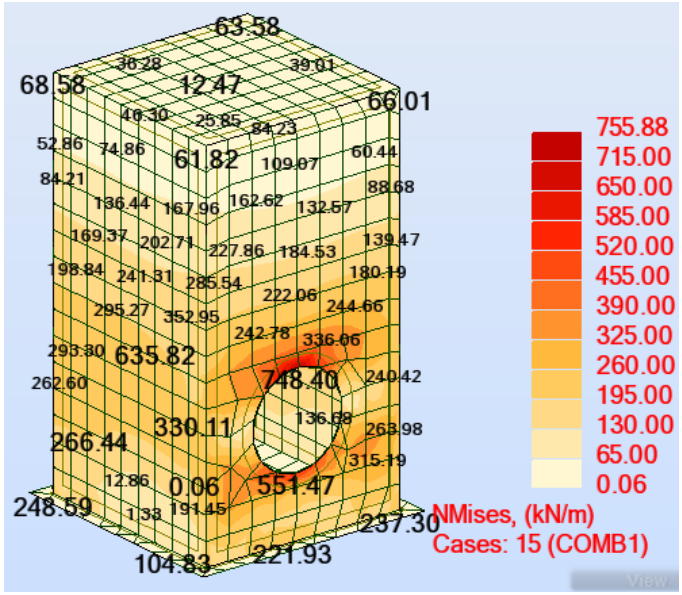
Structure deformation diagram



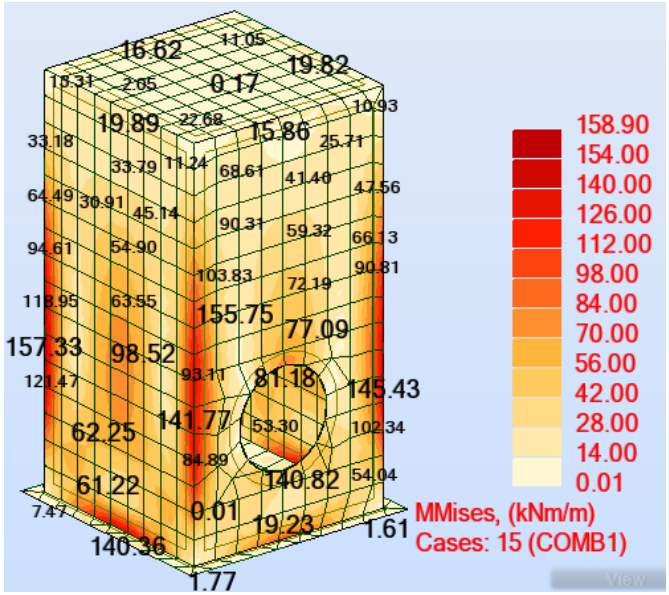
Stresses diagram



Forces diagram



Moments diagram



REINFORCEMENT PARAMETERS

GENERAL

Concrete as in the structure model

Lightweight concrete:	NO

ADDITIONAL INFO

Reinforcement check (cracking):	YES
Maximum cracking value:	0.3 mm
Exposure:	mild

LONGITUDINAL REINFORCEMENT

Steel characteristic strength:	450.00 MPa
The same bar diameter in both directions:	YES
Diameters of reinforcing bars	
- Top/along b:	12 mm to 20 mm
- Bottom/along h:	12 mm to 32 mm
Cover	
- Clear cover:	50 mm to 70 mm
- To axis:	58 mm

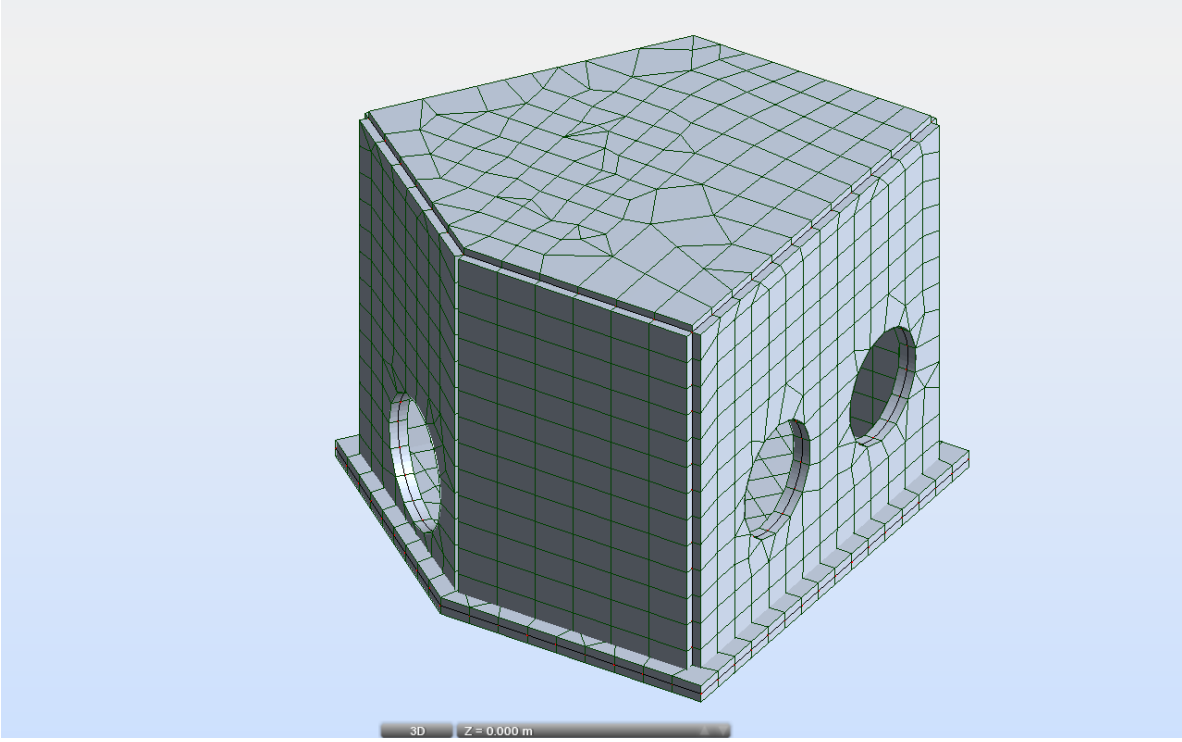
TRANSVERSAL REINFORCEMENT

Steel characteristic strength:	450.00 MPa
Stirrups	
- Bar diameter:	12 mm to 20 mm
- Number of legs:	2
- Number of reinforced. sections:	3
Modularity of spacing:	20 mm

For final reinforcement refer to reinforcement detail drawings.

PENTAGON SHAPED JUNCTION BOXES

STRUCTURE VIEW



CALCULATION NOTE

Code preferences:

- BS 8004 – Soil Code
- SABS 1060 – Code Combinations
- BS 8110 – Concrete Design

Structure centre of gravity coordinates:
X = 3.372 (m)
Y = 3.981 (m)
Z = 2.967 (m)

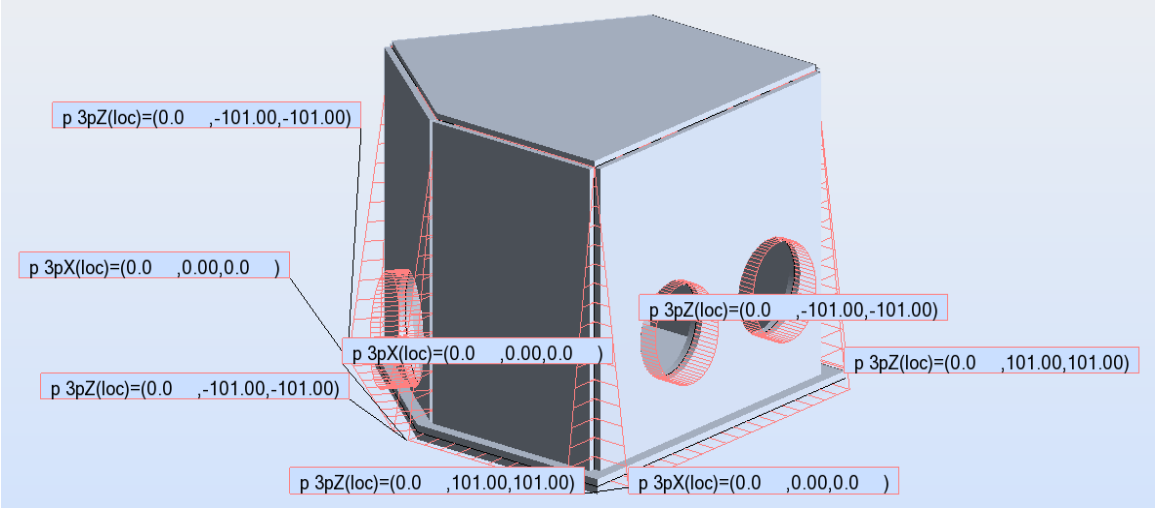
Structure central moments of inertia:
Lx = 1964416.926 (kg.m²)
Ly = 1877775.884 (kg.m²)
Lz = 1923736.791 (kg.m²)
Mass = 166093.661 (kg)

LOADS & LOAD COMBINATIONS:

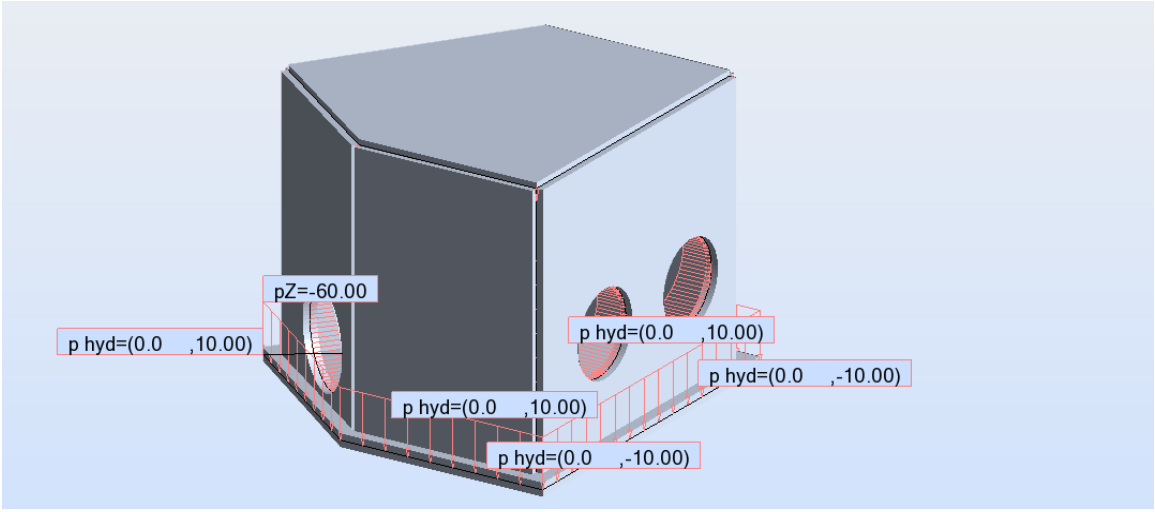
Table of load cases / analysis types

Case 1 : OWN WEIGHT
Analysis type: Static – Linear

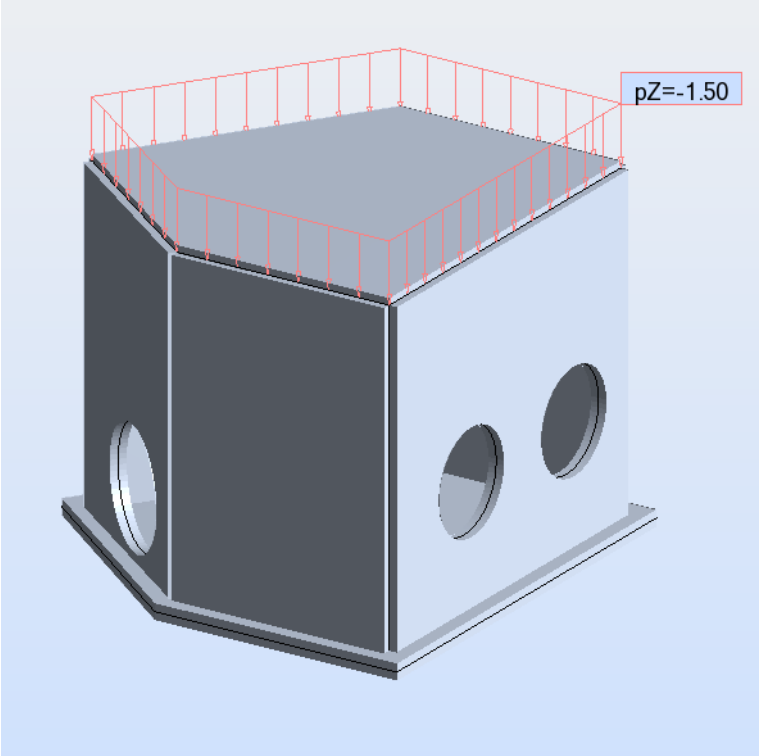
Case 2 : SOIL PRESSURE
Analysis type: Static – Linear



Case 3 : WATER PRESSURE
Analysis type: Static - Linear



Case 4 : LIVE LOAD
Analysis type: Static – Linear



Case 10 : SELF WEIGHT + SOIL PRESSURE (ULS)
Analysis type: Linear combination

Case 20 : SELF WEIGHT + SOIL PRESSURE (SLS)
Analysis type: Linear combination

SOIL PRESSURE

Geometrical data

Soil level (Z) = 7.1 (m)
Soil inclination (alpha) = 0.0 (Deg)
Wall inclination (beta) = 0.0 (Deg)

Soil

Underground water level = 7.10 (m)

Soil layers:

No.	Soil name	Level (m)	Unit weight (kg/m3)	Unit weight of solid (kg/m3)
1	Well graded gravel - sand mixtures	7.10	2242.58	2702.31

Limit and static pressure factors for soil layers taken into account during calculations:

No.	Soil name	Level	Friction angle	Ka	Ko	Kp
			(m)	(Deg)		
1	well graded gravel - sand mixtures	6.20	38.0	0.238	0.384	4.204

Soil pressure and passive pressure:

Limit displacement factor: = 0.00

LOADS

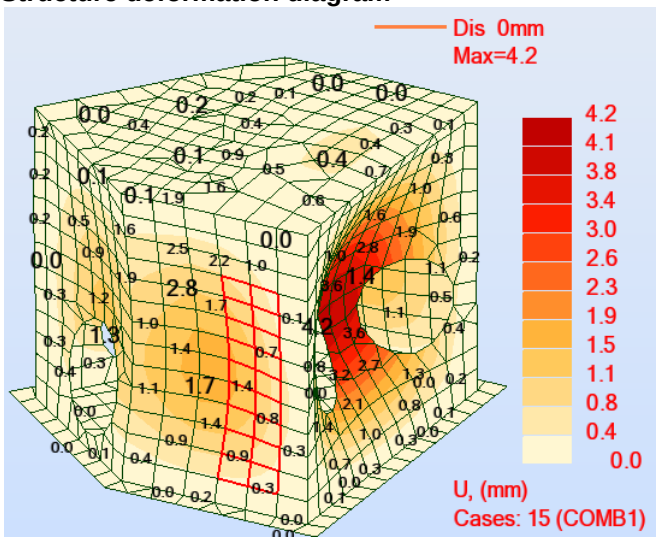
Case	Load type	List	Load values
1:DL1	self-weight	2 4to9	' PZ Negative Factor=1.00
2:Soil load	(FE) planar		' PX2=0.00(kN/m2) PX3=-118.00(kN/m2) N1X=0.300(m) N1Y=4.550(m) N1Z=7.300(m) N2X=0.300(m) N2Y=0.300(m) N2Z=7.300(m) N3X=0.300(m) N3Y=0.300(m) N3Z=0.0(m)
3:Live Load	(FE) uniform		' PZ=-1.50(kN/m2)
3:Live Load	(FE) uniform	9	' PZ=-1.50(kN/m2)
2:Soil load	(FE) planar	5	' PX2=0.00(kN/m2) PZ2=101.00(kN/m2) PZ3=101.00(kN/m2) local N1X=0.425(m) N1Y=3.920(m) N1Z=6.275(m) N2X=0.425(m) N2Y=7.414(m) N2Z=0.0(m) N3X=0.425(m) N3Y=0.425(m) N3Z=0.0(m)
2:Soil load	(FE) planar	2	' PZ2=101.00(kN/m2) PZ3=101.00(kN/m2) local N1X=2.582(m) N1Y=0.425(m) N1Z=6.275(m) N2X=0.425(m) N2Y=0.425(m) N2Z=0.0(m) N3X=4.738(m) N3Y=0.425(m) N3Z=0.0(m)
2:Soil load	(FE) planar	7	' PX2=0.00(kN/m2) PZ2=-101.00(kN/m2) PZ3=-101.00(kN/m2) local N1X=6.224(m) N1Y=6.159(m) N1Z=6.275(m) N2X=7.869(m) N2Y=4.903(m) N2Z=0.0(m) N3X=4.579(m) N3Y=7.414(m) N3Z=0.0(m)
2:Soil load	(FE) planar	4	' PX2=0.00(kN/m2) PZ2=-101.00(kN/m2) PZ3=-101.00(kN/m2) local N1X=2.502(m) N1Y=7.414(m) N1Z=6.275(m) N2X=4.579(m) N2Y=7.414(m) N2Z=0.0(m) N3X=0.425(m) N3Y=7.414(m) N3Z=0.0(m)
2:Soil load	(FE) planar	6	' PZ2=-101.00(kN/m2) PZ3=-101.00(kN/m2) local N1X=6.303(m) N1Y=2.664(m) N1Z=6.275(m) N2X=4.738(m) N2Y=0.425(m) N2Z=0.0(m) N3X=7.869(m) N3Y=4.903(m) N3Z=0.0(m)
4:Water Pressure	(FE) hydrostatic pressure	9	' GAMMA=10.00(kN/m3) H=6.000(m) NDIR=-Z
4:Water Pressure	(FE) hydrostatic pressure	5	' GAMMA=-10.00(kN/m3) H=6.000(m) NDIR=-Z
4:Water Pressure	(FE) hydrostatic pressure	2	' GAMMA=-10.00(kN/m3) H=6.000(m) NDIR=-Z
4:Water Pressure	(FE) hydrostatic pressure	4 6 7	' GAMMA=10.00(kN/m3) H=6.000(m) NDIR=-Z
4:Water Pressure	(FE) uniform	8	' PZ=-60.00(kN/m2)

COMBINATIONS

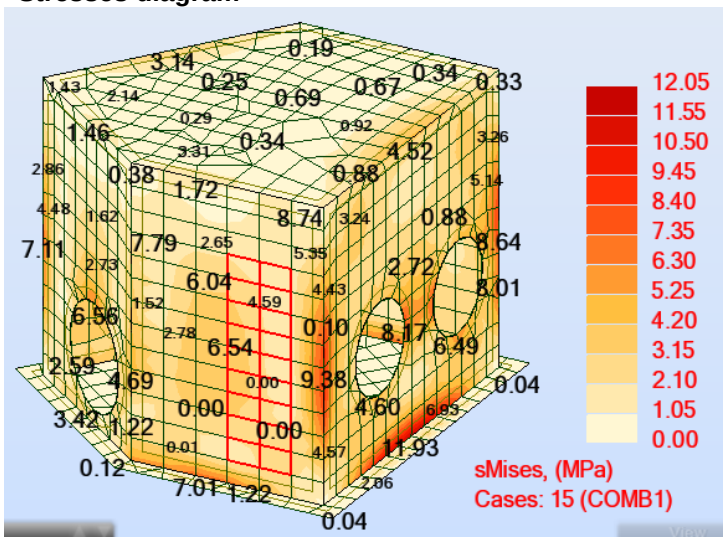
Combinations	Name	Analysis type	Combination nature	Case nature	Definition
10 (C)	COMB1	Linear Combination	ULS	dead	1*1.20+(2+3)*1.60
20 (C)	COMB2	Linear Combination	SLS	dead	1*1.10+(2+3)*1.00

STRUCTURAL DIAGRAMS (SQAURE & RECTANGULAR SHAPED JUNCTION BOXES):

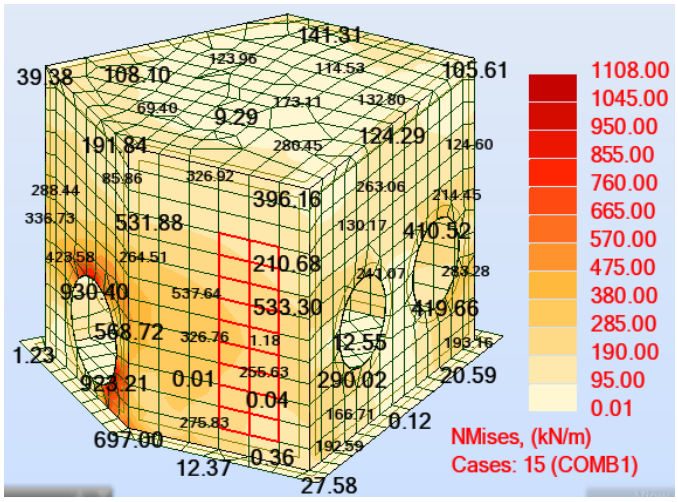
Structure deformation diagram



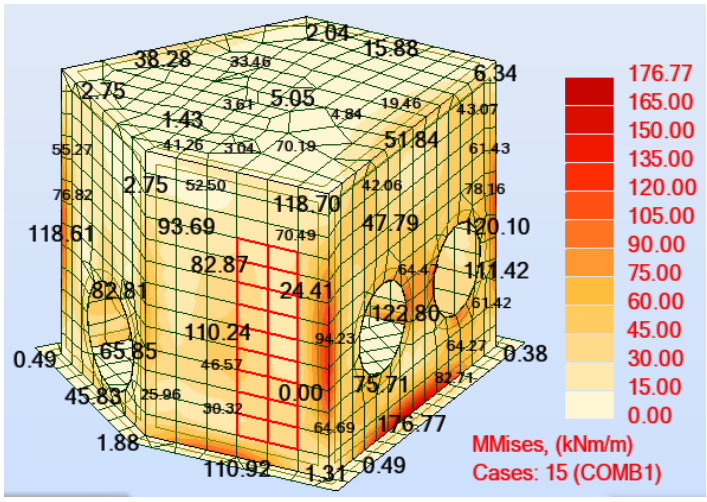
Stresses diagram



Forces diagram



Moments diagram



REINFORCEMENT PARAMETERS

GENERAL

Concrete as in the structure model

Lightweight concrete:	NO

ADDITIONAL INFO

Reinforcement check (cracking):	YES
Maximum cracking value:	0.3 mm
Exposure:	mild

LONGITUDINAL REINFORCEMENT

Steel characteristic strength:	450.00 MPa
The same bar diameter in both directions:	YES
Diameters of reinforcing bars	
- Top/along b:	12 mm to 20 mm
- Bottom/along h:	12 mm to 32 mm
Cover	
- Clear cover:	50 mm to 70 mm
- To axis:	58 mm

TRANSVERSAL REINFORCEMENT

Steel characteristic strength:	450.00 MPa
Stirrups	
- Bar diameter:	12 mm to 20 mm
- Number of legs:	2
- Number of reinforced. sections:	3
Modularity of spacing:	20 mm

For final reinforcement refer to reinforcement detail drawings.

APPENDIX B

PROKON STRUCTURAL ANALYSIS VERIFICTION REPORT – SIDE WALLS

Knight Piesold CONSULTING
Knight Piesold Consulting (Pty) Ltd
Internet: http://www.knightpiesold.org
E-Mail : enquiries@knightpiesold.com

Job Number	3030009806		Sheet 1
Job Title	Kusile Power Station - Junction Box		
Client	Eskom		
Calcs by TT	Checked by SW	Date 03-05-2010	

1000x300 Wall (Code of Practice : SABS 0100 - 2000)

2010/05/10 11:22:37 AM

C01

Input Tables

Fcu (MPa)	30
Fy (MPa)	450
Fyv (MPa)	250
% Redistribution	0
Downward/Optimized redistr.	D
Cover to centre top steel(mm)	70
Cover to centre bot.steel(mm)	70
Dead Load Factor	1.2
Live Load Factor	1.6
Density of concrete (kN/m3)	24
% Live load permanent	25
Ø (Creep coefficient)	2
Ecs (Free shrinkage strain)	300E-6

Sec No.	Bw (mm)	D (mm)	Bf-top (mm)	Hf-top (mm)	Bf-bot (mm)	Hf-bot (mm)	Y-offset (mm)	Web offset	Flange offset
1	1000	300							

Span No	Section Length(m)	Sec No Left	Sec No Right
1	6.55	1	1

Sup No.	Code C,F	Column Below			Code F,P	Column above			Code F,P
		D(mm)	B(mm)	H(m)		D(mm)	B(mm)	H(m)	
1	F								
2	F								

Case D,L	Span	Wleft (kN/m)	Wright (kN/m)	a (m)	b (m)	P (kN)	a (m)	M (kNm)	a (m)
D	1	16.9	0		4				
L	1	3	0		4				

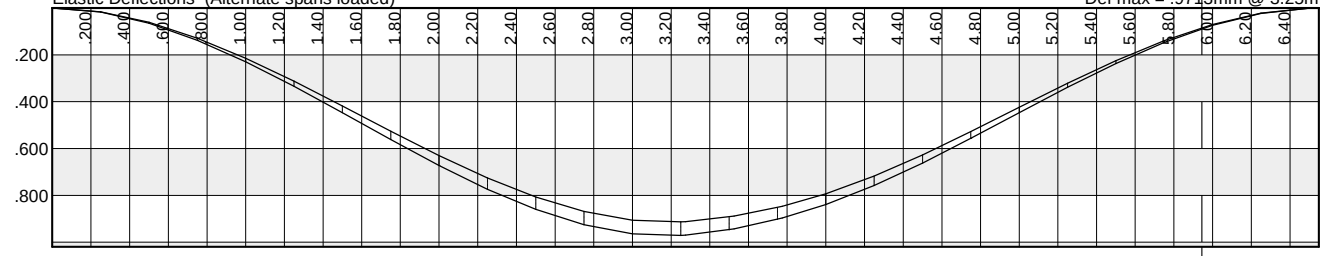
Span	M left (kNm)	M right (kNm)

Knight Piésold CONSULTING
Knight Piesold Consulting (Pty) Ltd
Internet: http://www.knightpiesold.org
E-Mail : enquiries@knightpiesold.com

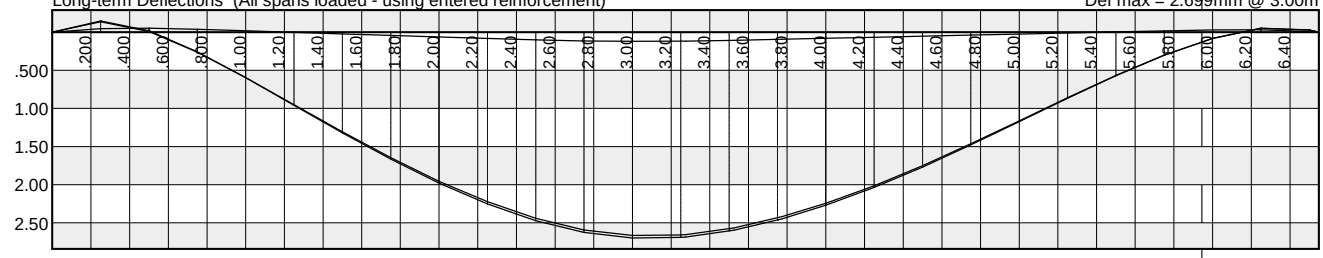
Job Number	3030009806		Sheet 2
Job Title	Kusile Power Station - Junction Box		
Client	Eskom		
Calcs by	TT	Checked by SW	Date 03-05-2010

Deflection, Shear, Moment and Steel diagrams. Span 1

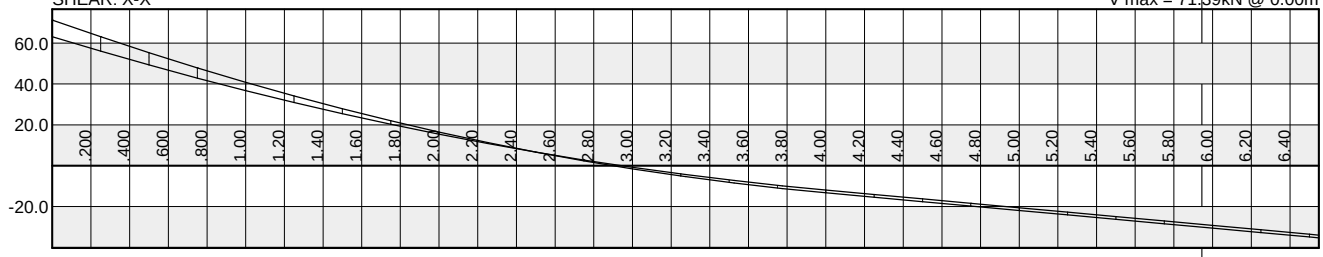
Elastic Deflections (Alternate spans loaded) — Def max = .9713mm @ 3.25m



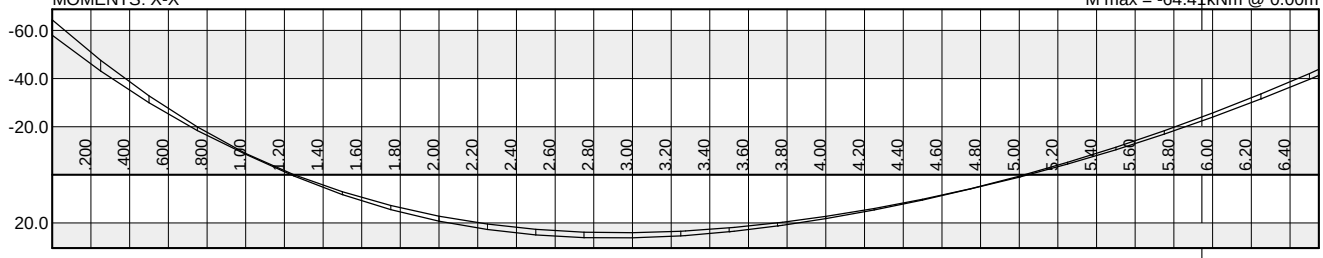
Long-term Deflections (All spans loaded - using entered reinforcement) — Def max = 2.699mm @ 3.00m



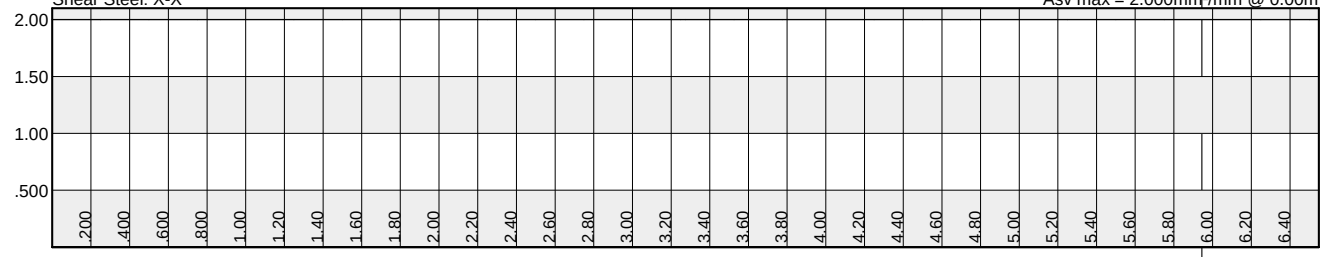
SHEAR: X-X — V max = 71.39kN @ 0.00m



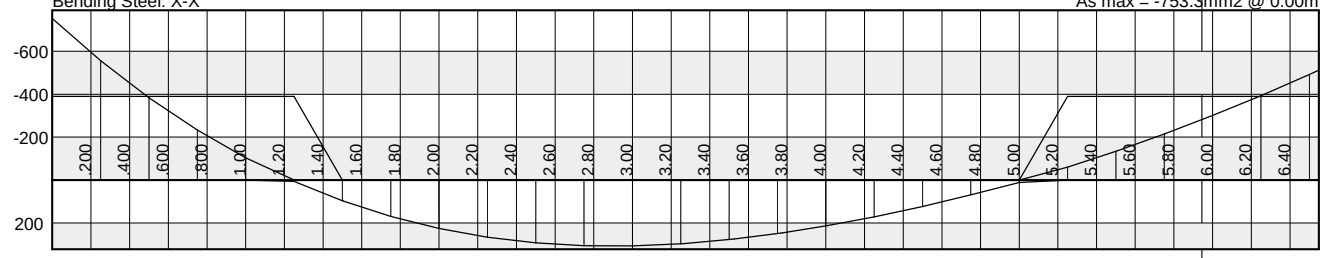
MOMENTS: X-X — M max = -64.41kNm @ 0.00m

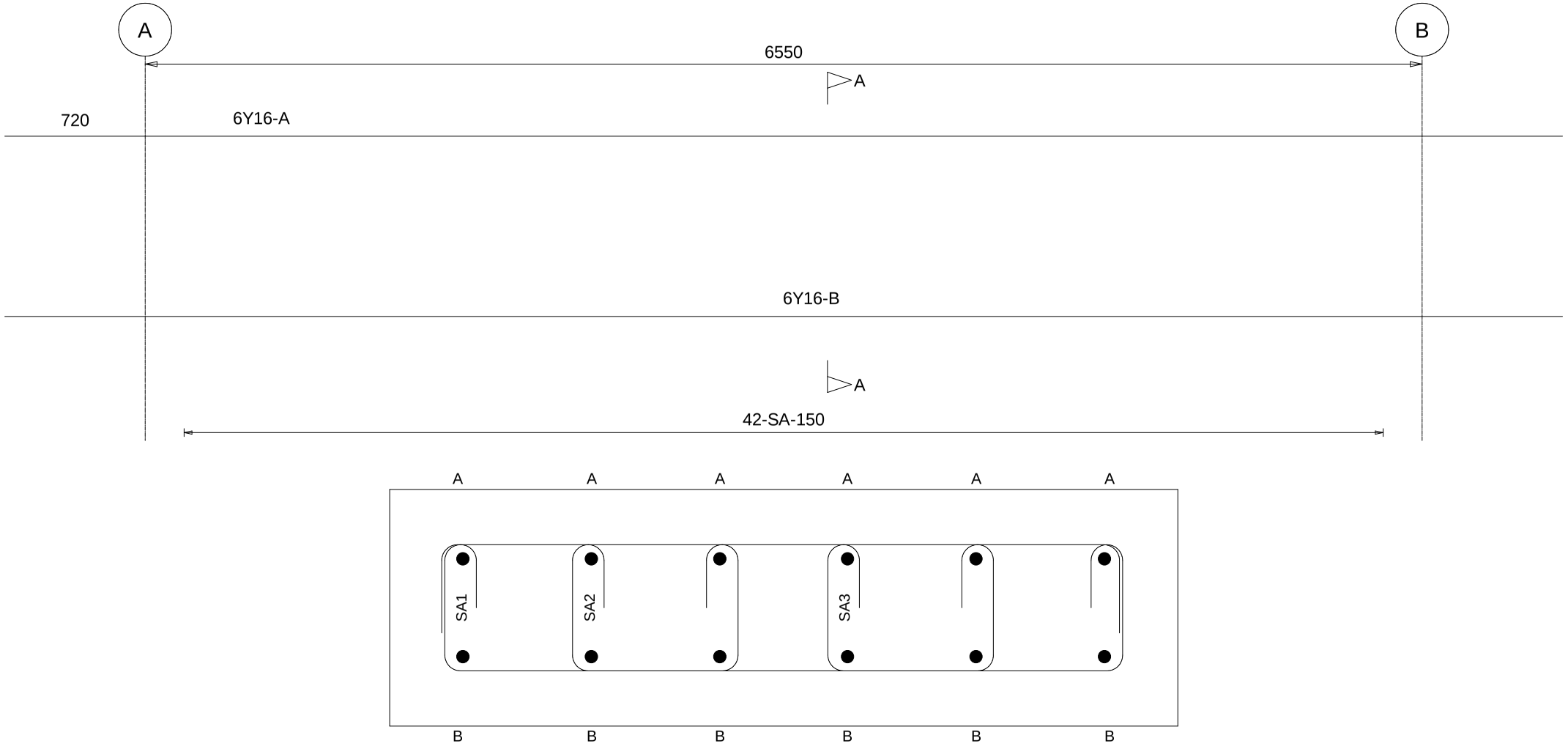


Shear Steel: X-X — Asv max = 2.000mm²/mm @ 0.00m



Bending Steel: X-X — As max = -753.3mm2 @ 0.00m





SECTION A-A

APPENDIX C

PROKON STRUCTURAL ANALYSIS VERIFICTION REPORT – TOP SLAB

Knight Piesold CONSULTING
Knight Piesold Consulting (Pty) Ltd
Internet: http://www.knightpiesold.org
E-Mail : enquiries@knightpiesold.com

Job Number	3030009806		Sheet 1
Job Title	Kusile Power Station - Junction Box		
Client	Eskom		
Calcs by	TT	Checked by SW	Date 03-05-2010

1000x250 Slab (Code of Practice : SABS 0100 - 2000)

2010/05/10 11:18:06 AM

C01

Input Tables

Fcu (MPa)	30
Fy (MPa)	450
Fyv (MPa)	250
% Redistribution	0
Downward/Optimized redistr.	D
Cover to centre top steel(mm)	50
Cover to centre bot.steel(mm)	50
Dead Load Factor	1.2
Live Load Factor	1.6
Density of concrete (kN/m3)	24
% Live load permanent	25
Ø (Creep coefficient)	2
Ecs (Free shrinkage strain)	300E-6

Sec No.	Bw (mm)	D (mm)	Bf-top (mm)	Hf-top (mm)	Bf-bot (mm)	Hf-bot (mm)	Y-offset (mm)	Web offset	Flange offset
1	1000	250							

Span No	Section Length(m)	Sec No Left	Sec No Right
1	8.72	1	1

Sup No.	Code C,F	Column Below			Code F,P	Column above			Code F,P
		D(mm)	B(mm)	H(m)		D(mm)	B(mm)	H(m)	
1	F								
2	F								

Case D,L	Span	Wleft (kN/m)	Wright (kN/m)	a (m)	b (m)	P (kN)	a (m)	M (kNm)	a (m)
D	1								
L	1	3							

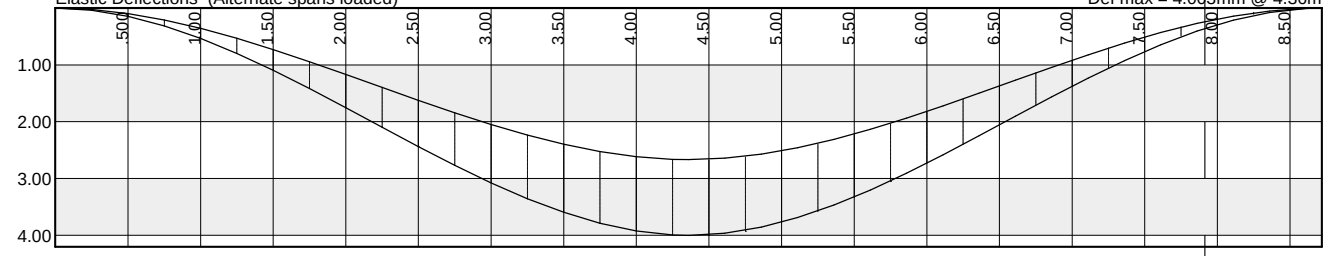
Span	M left (kNm)	M right (kNm)

Knight Piesold CONSULTING
Knight Piesold Consulting (Pty) Ltd
Internet: http://www.knightpiesold.org
E-Mail : enquiries@knightpiesold.com

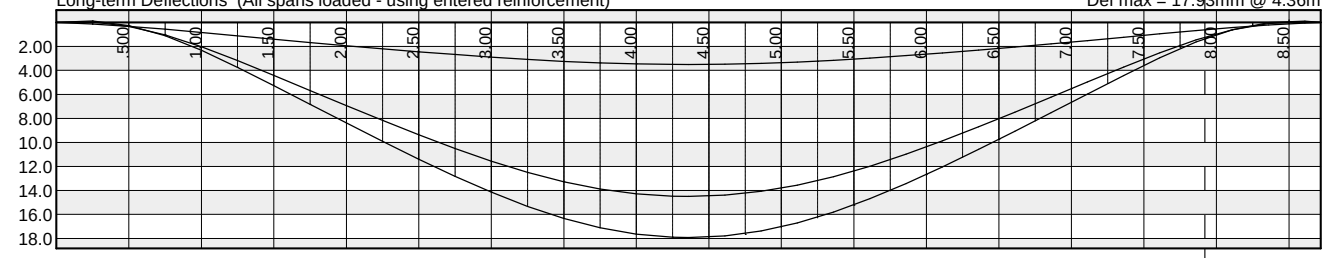
Job Number	3030009806		Sheet 2
Job Title	Kusile Power Station - Junction Box		
Client	Eskom		
Calcs by	TT	Checked by SW	Date 03-05-2010

Deflection, Shear, Moment and Steel diagrams. Span 1

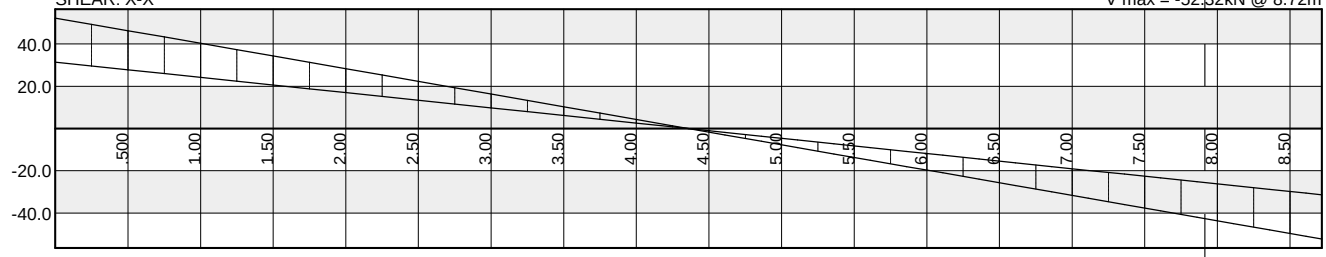
Elastic Deflections (Alternate spans loaded) — Def max = 4.003mm @ 4.36m



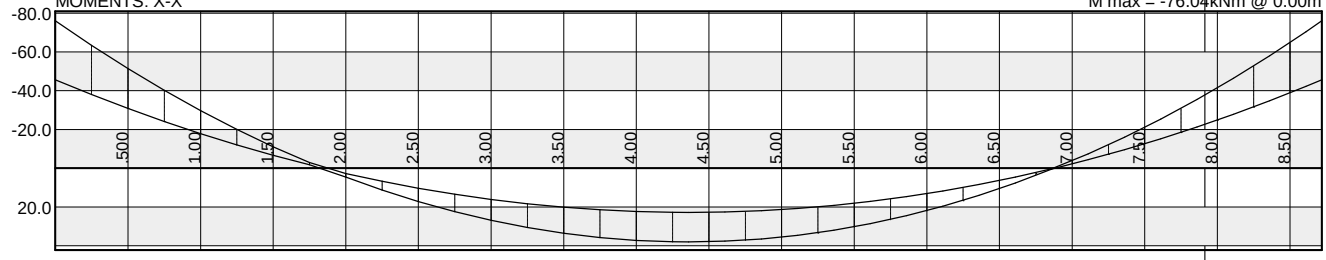
Long-term Deflections (All spans loaded - using entered reinforcement) — Def max = 17.93mm @ 4.36m



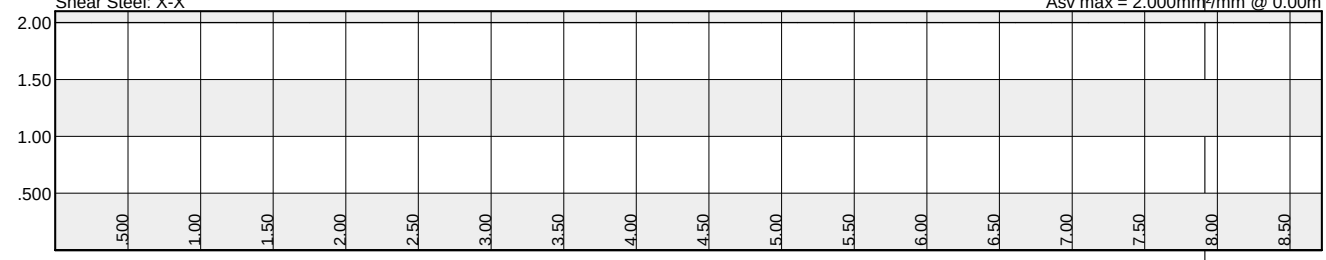
SHEAR: X-X — V max = -52.32kN @ 8.72m



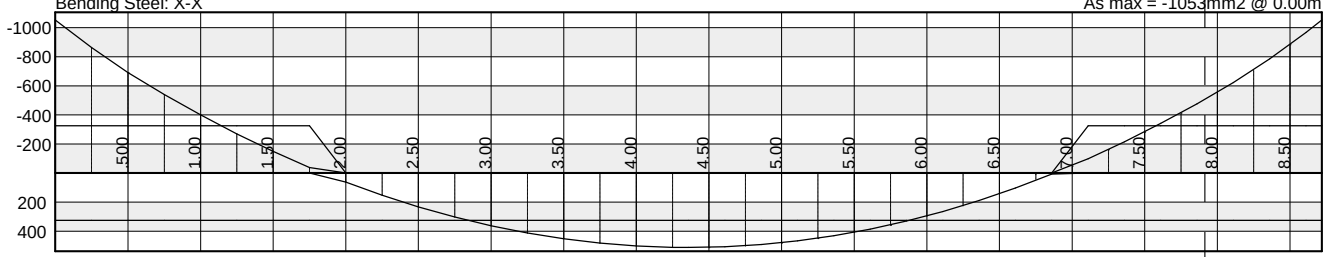
MOMENTS: X-X — M max = -76.04kNm @ 0.00m

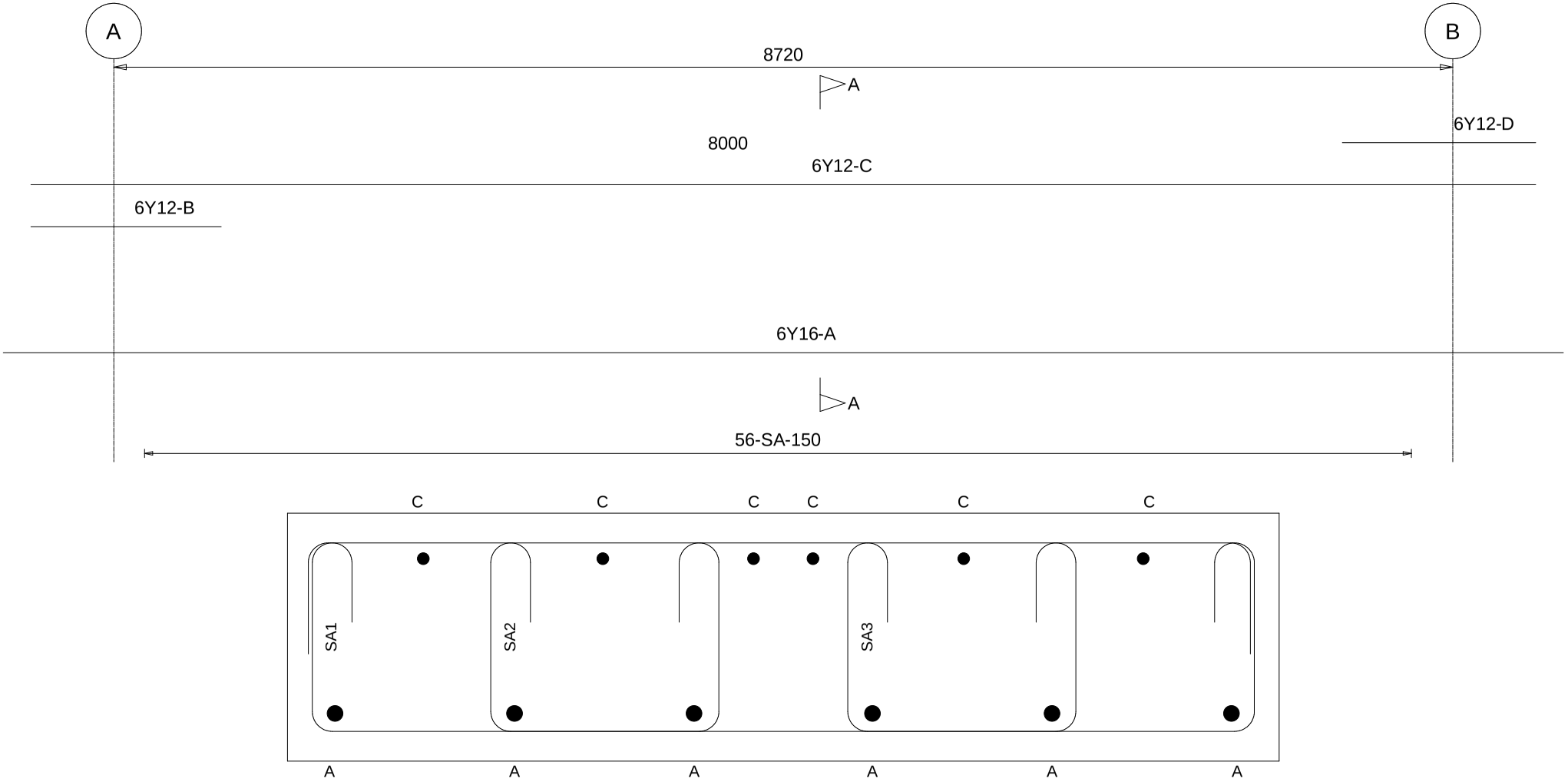


Shear Steel: X-X — Asv max = 2.000mm²/mm @ 0.00m



Bending Steel: X-X — As max = -1053mm2 @ 0.00m




A
B
8720
A
8000
6Y12-D
6Y12-C
6Y12-B
6Y16-A
A
56-SA-150
C
C
C
C
C
C
SA1
SA2
SA3
A
A
A
A
A
A

SECTION A-A

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 6

Project Name: Kusile Power Station **Job No:** 303-00098/06

Calculation Title: Pipe Hydraulic Calculations : SDD Settling Tanks

Calculation No./File No.:

Calculation is: ☐ Preliminary ☒ Final

Objective: Hydraulic design of the SDD and SDD Settling Tanks inlet and outlet pipes.

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
	None		

This section applies to computer generated calculations			
Program Name/Number: N/A		**Version:**	
Program Name/Number: N/A		**Version:**	
Evidence of or reference to computer program verification, if applicable:			
Bases or reference thereto supporting application of the computer program to the physical problem:			

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
0	Scott Rees	Oct 09				

1. PURPOSE:

To calculate the size/capacity of the SDD and SDD ST inlet and outlet pipes.

2. REFERENCES:

1.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS GENERAL ARRANGEMENT	5452/80/071	Rev	
2.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS SECTIONS & DETAILS	5452/50/072	Rev	
3.	SDD SETTLING TANKS INLET & OUTLET PIPEWORKS SECTIONS	5452/80/100	Rev	

3. ASSUMPTIONS

Density of water = $1000kg/m^3$
Acceleration due to gravity = $9.81m/s^2$

Additional assumptions are listed in the detailed hydraulic calculations, where applicable.

4. HYDRAULIC CALCULATIONS

APPENDICES

None

Calculations

Knight Piésold CONSULTING

PHALABORWA OFFICE
First Floor, Park Building
Tambotie Street,
P O Box 830, Phalaborwa 1390
Tel: (015) 781-0839/0882 Fax: (015) 781-3788
Email: kppha@mweb.co.za

JOB KUSILE POWER STATION | SHEET No.

JOB No. 303-00098/06

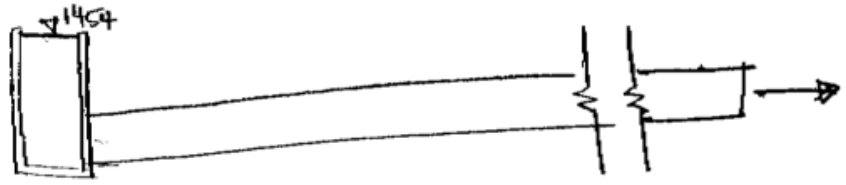
REF.DRGS

DESIGNED Scott Rees | DATE Oct. 20/09

CHECKED | DATE

HYDRAULIC DESIGN - SDD & SDDST PIPES

★ assume SDD is operated empty, check JBK13 to SDD compartment 2 first.



- length = 250m
- headwater level = 1454m
- tailwater level = 1445.2m (assume pipe ℄ @ outlet

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + \sum h_L$$

$$\Delta Z - \sum h_L = V_2^2/2g$$

$$\sum h_L = \sum K \cdot \frac{V^2}{2g} + f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}, \quad \sum K = 3 \times 1.0 + 2 \times 0.5 = 4$$

- substitute in $V = Q/A$, and solve Swamee-Jain formula with excel program

$$\boxed{Q = 24.8 m^3/s}$$

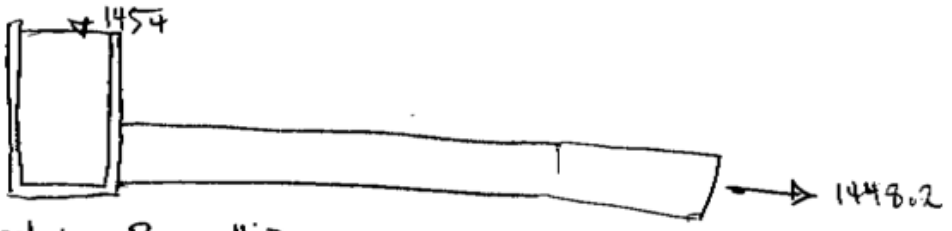
★ this is sufficient to handle all of the dirty water flow to the SDD

Knight Piésold CONSULTING

PHALABORWA OFFICE
First Floor, Park Building
Tambotie Street,
P O Box 830, Phalaborwa 1390
Tel: (015) 781-0839/0882 Fax: (015) 781-3788
Email: kppha@mweb.co.za

JOB KUSILE POWER STATION		SHEET No.
		JOB No.
REF.DRGS		
DESIGNED Scott Rees		DATE Oct 20/09
CHECKED		DATE

JBK13 → Compartment 1



• applying Bernoulli's,

$$\Delta z - \Sigma h_L = V_2^2/2g$$

$$\Sigma h_L = \Sigma K . V^2/2g + f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}, \quad \Sigma K = 1 + 0.5 = 1.5$$

$L = 60m$

• substitute in $V = Q/A$, and solve using the Swamee-Jain approximation.

$$\boxed{Q = 4.63 m^3/s}$$

Knight Piésold CONSULTING

PHALABORWA OFFICE
First Floor, Park Building
Tambotie Street,
P O Box 830, Phalaborwa 1390
Tel: (015) 781-0839/0882 Fax: (015) 781-3788
Email: kppha@mweb.co.za

JOB KUSILE POWER STATION | SHEET No. | JOB No. 303-00098/06

REF.DRGS

DESIGNED Scott Rees | DATE Oct 2009

CHECKED | DATE

JB504 - JBK12

- 1950 ND Class 100D Concrete Pipe - 1.8m Inside Diameter
- length = 440m
- minor losses, $K = 4.5$
- headwater ~ 1463m, Tailwater ~ 1455m

$Q = 12.24\ m^3/s$

JBK12 → JBK13

- 2x1950 ND Class 100D Concrete Pipe
- length = 245m
- headwater = 1455m, tailwater = 1454m

$Q = 7.4\ m^3/s$

$2Q = 14.8\ m^3/s$

→ this is under-capacity, however in the event that the SDD is full, the water will be backed up through the entire pipeline

- try with JBK13 at 1452m TWL (more realistic)

$Q = 12.8\ m^3/s$

$2Q = 25.6\ m^3/s$ * this is sufficient to pass the total flow (1:50yr) of $23.9\ m^3/s$

Knight Piésold CONSULTING

PHALABORWA OFFICE
First Floor, Park Building
Tambotie Street,
P O Box 830, Phalaborwa 1390
Tel: (015) 781-0838/0882 Fax: (015) 781-3788
Email: kppha@mweb.co.za

JOB KUSILE POWER STATION | SHEET No.

JOB No. 303-00098/6

REF.DRGS

DESIGNED Scott Rees | DATE Oct 30/09

CHECKED | DATE

SDD ST → JBK12

- 1950 ND Class 100D Concrete Pipe
- length = 130m
- $\sum K = 2(1.0) + 2(0.5) = 3$
- Top Water Level = 1459m, Tail Water Level = 1455m

$Q = 13.1 m^3/s$

JB509 → SDDST

- 1950 ND Class 100D Concrete Pipe
- length = 185m
- $\sum K = 2(1.0) + 2(0.5) = 3.0$

Top Water Level = 1467m, Tail Water Level = 1460.4m

$Q = 15.8 m^3/s$

→ more conservatively, try Headwater Level = 1466m

$Q = 14.5 m^3/s$