Construction of

220 kV Loop in Loop out Paliastomi- into Ozurgeti Substation and

110 kV Double Circuit (D/C) Overhead Line from Ozurgeti Substation to Zoti HPP

Foundation Design Calculations of Tower Type "12B-MA"

(for all soil types)

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Document Title	Scale	Sheet of Sheets
Foundation Design Calculations of Tower Type "12B-MA" (for all soil types)	**n.a.**	Page **1** of 52

Soils and Foundations Specifications

Soil Type & Designation	Ground Water Presence	Foundation Type	Density (kN/m3)	Angle of Frustum [°]	Bearing Capacity (kN/m2)
Type 1-Sound Rock	No	Rock Anchor	25	25	1000
Type 2-Deleterious Rock	No	Rock Anchor	20	25	500
Type 2-Deleterious Rock	No	Semi-Auger	20	25	500
Type 3-Good Soil	No	Semi-Auger	17	22	300
Type 3-Good Soil	No	Pad & Chimney	17	22	300
Type 4-Normal Soil-Dry	No	Pad & Chimney	18	15	200
Type 4-Normal Soil-Submerge	Yes	Pad & Chimney	10	15	200
Type 5-Poor Soil-Dry	No	Pad & Chimney	16	0	150
Type 5-Poor Soil-Submerge	Yes	Pad & Chimney	8	0	80

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Soil Type: Type 1-Sound Rock
Foundation Type: Rock Anchor
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 Tech. Spec. Clause 2.5.3.4

Foundation Dimensions	Width of Pad	bp =	1.4	m	
	Height of Pad	hp =	0.65	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney under ground level	hc2 =	0.6	m	
	Total Height of Chimney	hc =	0.9	m	
	Depth of Pad	H =	1.25	m	
	Inplane Slope	β =	9.43	Degree	
	Eccentricity (Bottom of Pad)	e =	0.26	m	
Soil Specifications	Soil Type	Type 1-Sound Rock			
	Density	γ_s =	2.55	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	10.19	kg/cm2	Tech. Spec. Section C1 4.1
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.33	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebar	Fy =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2
Bond Stress	Grout and Steel Bond Stress	τ_{gs} =	2	Mpa	Ref. Pile Design in Construction Practice by Tomlinson Page 217
	Grout and Rock Bond Stress	τ_{gr} =	0.9	Mpa	Ref. Pile Design in Construction Practice by Tomlinson Table 6.1
	Concrete and Rebar Bond Stress	τ_{cr} =	2.3	Mpa	EN 50341 2012 Table K.2

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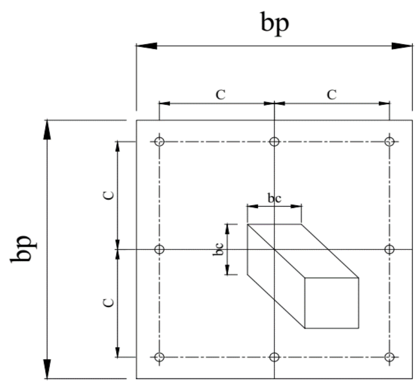

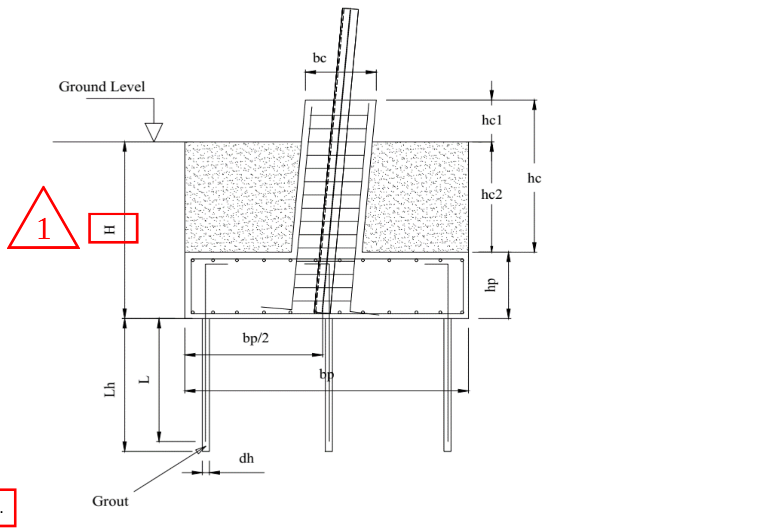

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* The foundation is in direct contact with undisturbed soil.

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Tension	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Tension	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Design of Anchors:

Volume of chimney above ground level V1 = 0.15 m3
Volume of chimney under ground level V2 = 0.29 m3
Volume of pad, V3 = 1.27 m3
Total volume of foundation , Vf = 1.72 m3

Total weight of foundation, Wf = Vf * γc = 4.29 ton

Uplift Force, U = 107.18 ton

Design force for anchors, U net = U - Wf = 102.89 ton

Required anchor area for uplift, Asu = U net / (φs * Fy) = 24.22 cm2

Anchor arrangement:

No. of anchor rows, n = 3 Distance from hole center to pad edge = 0.2 m

Central Holes to be Ommited = Yes

Total No. of anchors holes, i = 8

Distance between anchor rows C = 50.0 cm

Distance of the last row to center, c = 50 cm

Σ di ^{2} = 10000

Anchor diameter, da = 1.6 cm

No. of Anchor in one hole m = 2 The effect of rebars boundle on embedded lenghts would be considered!

Total anchor area in one hole = 4.02 cm

Total area of anchors, As =	32.17	cm2	>	24.22	OK

Uplift Force, T = 107.58 ton
Bending Moment about x axis, Mx = -2.68 ton.m
Bending Moment about y axis, My = 1.19 ton.m

Required Modulus of Section at x direction Wx = Mx / (φs * Fy) = -63.10 cm3
Required Modulus of Section at y direction Wy = My / (φs * Fy) = 27.99 cm3

Required anchor area for bending moment about x axis, Asmx = n * m * Wx * c / (Σ di ^{2}) = 1.89 cm2

Required anchor area for bending moment about y axis, Asmy = n* m * Wy * c / (Σ di ^{2}) = 0.84 cm2

Total Required Area for Anchors, Astot = Asu + Asmx + Asmy =	26.96	cm2	<	32.17	OK

Bearing Capacity:

Compression Force, C = 118.86 ton
Bending Moment about x axis, Mx = -2.45 ton.m
Bending Moment about y axis, My = 0.87 ton.m

Over Load of Concrete, Wf = 4.29 ton

Volume of the Soil directly above foundation Vsl = (H * bp ^{2}) - V2 - V3 = 0.88 m3

Over Load of Soil directly above foundation Wsl= Vsl * γs = 2.25 ton

Overall Bearing Pressure = σp = ((C + Wf + Wsl)/A) =	6.40	kg/cm2	<	10.19	kg/cm2	OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) + (6*My)/(bp3) =$ 6.05 kg/cm2

Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) - (6*My)/(bp3) =$ 5.67 kg/cm2

Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) + (6*My)/(bp3) =$ 7.12 kg/cm2

Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) - (6*My)/(bp3) =$ 6.74 kg/cm2

Max. Toe Pressure =	7.12	<	q_{all} =	12.74	OK
Min. Toe Pressure =	5.67	>	0		OK

Bond of Anchor and Grout Check :

Max. force of one anchor hole Pa = 14312 kg

Required embedded length of anchor in Rock, Lmin= Pa / (m * τ_{gs} * π * da) = 71.2 cm

Design embedded length of anchor in Rock, L= 160 cm

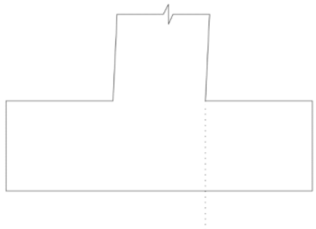
Bond of Grout and Rock Check :

Anchor Hole Diameter, Dh = 7.5 cm

Resisting bond force of the Grout and Rock, $F\tau_{gr} = \tau_{gr}$ * L* Dh * π =	33929	kg	>	14312	OK

Structural Design of Pad:

Longitudinal Rebar:



Moment Control Section For Pad

Compression Stress at section of Max. bending moment, σm = 6.67 kg/cm2

Mu = 573760 kg.cm = 57376 N.m

Effective Depth, dp = hp - cp = 0.575 m

$K = Mu / f'c * bp * dp^2 =$ 0.00930 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 570.24 > 546.25 ==>>> Zmax=0.95 dp = 546.25 mm

As = Mu / φs * fyr * z = 252

ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>> 0.0013 EN 1992-1-1:2004 9.1N

ρmax = 0.040 EN 1992-1-1:2004 9.2.1.1

As min = 1183 mm2

As max = 36400 mm2

As = 1183

Rebar Diameter = 16 mm =====> QTY = 6 =====> 6 =====> 6 Ø 16

Rebar Quantity = 6

Rebar Spacing = 25.0

===> As= 1206 mm2

One Way Shear:

Compression Stress at critical section of shear , σv = 7.11 kg/cm2

Vu = -21629 kg = -216291 N Not defined since Theorical shear check distance is more than pad width!

k = 1 +(200/dp)^0.5 < 2.0 >>> k = 1.59 EN 1992-1-1:2004 6.2

ρ_1 = 0.0015

$\sigma_{cp} = N_{ED}/A_C$ = 0 No Axial Force!

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.256 Mpa EN 1992-1-1:2004 6.3N

Vr = 206221 N

Vr	>	Vu	OK

F.S= Not Defined!

MİTAŞ ENERGY

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 6.40 kg/cm2

Vpunch = -368744 kg = -3687438 N

Resisting Shear of Concrete,

Vr = 1476791 N

Vr	>	Vu	OK

F.S. = Not Defined!
Theorical shear check section distance is more than pad width!

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis

Mx max = -1.58 ton.m = -15775 N.m

Rebar arrangement:

No. of Rebar rows, n = 3

Total No. of Rebars = 8

Distance of the last row to center, c = 27.5 cm

Σ Ai * di^2 = 4537.5

φs * fy = M * c /I >>>>> Σ Ai * di^2= M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σ di^2)

As1= 1.8 cm2

B) Moment at the bottom of chimney about y axis

My max = 0.70 ton.m = 6997 N.m

>>>>> A = M * c / (φs * fyr *Σdi2)

As2= 0.8 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fys) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Longitudinal rebar area Ast =As1+As2+As3 = 15.6 cm2

As min = max (0.1*Cs/Fy , 0.002*Ac) = 9.8 cm2 9.12 N

As max = 0.04 *Ac = 196.0 cm2 9.5.2.3

As = 15.6

Rebar Diameter = 16 mm =====> QTY = 8 =====> 8 =====> 8 Ø 16

===>> As final= 16.1 cm2

Rebar Quantity of One Row = 3

Rebar Spacing = 27.5

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a \le 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$ 4.5 mm

$N_{Ed} =$ 122.09 ton

$M_{0Ed,x} =$ 1.44 ton.m

$e_0 = h /30 > 20$ mm ==> $e_0 =$ 23 mm

$M_{Ed,x}$ =	2.85	ton.m					
$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$							
$M_{0Ed,y}$=	0.51	ton.m					
$M_{Ed,y}$ =	2.85	ton.m					
As * F yr / bc^2 * f'c =	0.082						
N_{ED}/ f'c * bc^2 =	0.122						
d2 =	144	mm					
d2 / bc =	0.21						
Interaction Chart Gives ===> MRd / f'c * bc3 =			0.08	===> $M_{Rd,x} = M_{Rd,y}$ =		55.94	ton.m
N_{Rd} = Ac * f'c + As * Fyr =			734.31	ton			
N_{Ed} / N_{Rd} =	0.17		===>	a =	1.06		
$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a$ =			0.086	<	1	OK	

Stirrup Rebar : EN 1992-1-1:2004 9.5.3.3

Max Spacing of links =	320	mm	
Rebar Space =	150	mm	==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm	

Soil Type: Type 2-Deleterious Rock
Foundation Type: Rock Anchor
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 Tech. Spec. Clause 2.5.3.4

Foundation Dimensions	Width of Pad	bp =	1.6	m	
	Height of Pad	hp =	0.65	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney under ground level	hc2 =	0.6	m	
	Total Height of Chimney	hc =	0.9	m	
	Depth of Pad	H =	1.25	m	
	Inplane Slope	β =	9.43	Degree	
	Eccentricity (Bottom of Pad)	e =	0.26	m	
Soil Specifications	Soil Type	Type 2-Deleterious Rock			
	Density	γ_s =	2.04	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	5.10	kg/cm2	Tech. Spec. Section C1 4.1
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.33	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebar	Fy =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2
Bond Stress	Grout and Steel Bond Stress	τ_{gs} =	2	Mpa	Ref. Pile Design in Construction Practice by Tomlinson Page 217
	Grout and Rock Bond Stress	τ_{gr} =	0.6	Mpa	Ref. Pile Design in Construction Practice by Tomlinson Table 6.1
	Concrete and Rebar Bond Stress	τ_{cr} =	2.3	Mpa	EN 50341 2012 Table K.2

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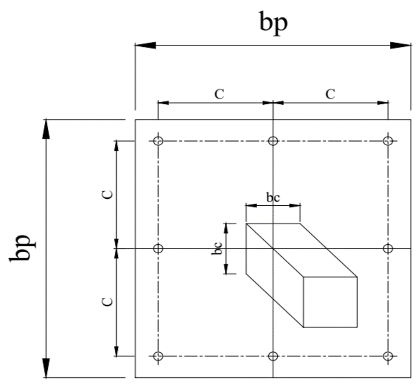

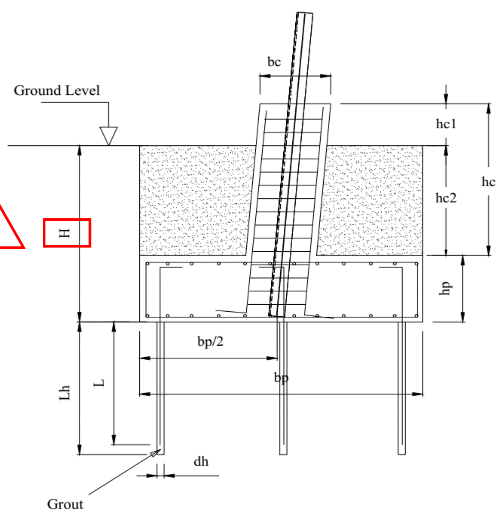

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1 * The foundation is in direct contact with undisturbed soil.

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Tension	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Tension	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Design of Anchors:

Volume of chimney above ground level V1 = 0.15 m3
Volume of chimney under ground level V2 = 0.29 m3
Volume of pad, V3 = 1.66 m3
Total volume of foundation , Vf = 2.11 m3

Total weight of foundation, Wf = Vf * γc = 5.26 ton

Uplift Force, U = 107.18 ton

Design force for anchors, U net = U - Wf = 101.92 ton

Required anchor area for uplift, Asu = U net / (φs * Fy) = 24.00 cm2

Anchor arrangement:

No. of anchor rows, n = 3 Distance from hole center to pad edge = 0.2 m

Central Holes to be Ommited = No

Total No. of anchors holes, i = 9

Distance between anchor rows C = 60.0 cm

Distance of the last row to center, c = 60 cm

Σ di ^{2} = 14400

Anchor diameter, da = 1.6 cm

No. of Anchor in one hole m = 2 The effect of rebars boundle on embedded lenghts would be considered!

Total anchor area in one hole = 4.02 cm

Total area of anchors, As =	36.19	cm2	>	24.00	OK

Uplift Force, T = 107.58 ton
Bending Moment about x axis, Mx = -2.68 ton.m
Bending Moment about y axis, My = 1.19 ton.m

Required Modulus of Section at x direction Wx = Mx / (φs * Fy) = -63.10 cm3
Required Modulus of Section at y direction Wy = My / (φs * Fy) = 27.99 cm3

Required anchor area for bending moment about x axis, Asmx = n * m * Wx * c / (Σ di ^{2}) = 1.58 cm2

Required anchor area for bending moment about y axis, Asmy = n* m * Wy * c / (Σ di ^{2}) = 0.70 cm2

Total Required Area for Anchors, Astot = Asu + Asmx + Asmy =	26.27	cm2	<	36.19	OK

Bearing Capacity:

Compression Force, C = 118.86 ton
Bending Moment about x axis, Mx = -2.45 ton.m
Bending Moment about y axis, My = 0.87 ton.m

Over Load of Concrete, Wf = 5.26 ton

Volume of the Soil directly above foundation Vsl = (H * bp ^{2}) - V2 - V3 = 1.24 m3

Over Load of Soil directly above foundation Wsl= Vsl * γs = 2.53 ton

Overall Bearing Pressure = σp = ((C + Wf + Wsl)/A) =	4.95	kg/cm2	<	5.10	kg/cm2	OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) + (6*My)/(bp3) =$ 4.72 kg/cm2

Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) - (6*My)/(bp3) =$ 4.46 kg/cm2

Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) + (6*My)/(bp3) =$ 5.43 kg/cm2

Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) - (6*My)/(bp3) =$ 5.18 kg/cm2

Max. Toe Pressure =	5.43	<	q_{all} =	6.37	OK
Min. Toe Pressure =	4.46	>		0	OK

Bond of Anchor and Grout Check :

Max. force of one anchor hole Pa = 12399 kg

Required embedded length of anchor in Rock, Lmin= Pa / (m * τ_{gs} * π * da) = 61.7 cm

Design embedded length of anchor in Rock, L= 220 cm

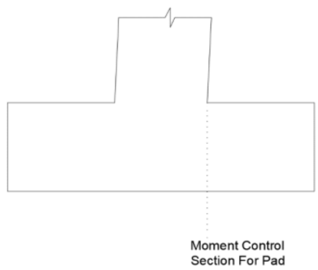
Bond of Grout and Rock Check :

Anchor Hole Diameter, Dh = 7.5 cm

Resisting bond force of the Grout and Rock, $F\tau_{gr} = \tau_{gr}$ * L* Dh * π =	31102	kg	>	12399	OK

Structural Design of Pad:

Longitudinal Rebar:



Compression Stress at section of Max. bending moment, σm = 5.10 kg/cm2

Mu = 828893 kg.cm = 82889 N.m

Effective Depth, dp = hp - cp = 0.575 m

$K = Mu / f'c * bp * dp^2 =$ 0.01175 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 568.98 > 546.25 ==>>> Zmax=0.95 dp = 546.25 mm

As = Mu / φs * fyr * z = 364

ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>> 0.0013 EN 1992-1-1:2004 9.1N

ρmax = 0.040 EN 1992-1-1:2004 9.2.1.1

As min = 1352 mm2

As max = 41600 mm2

As = 1352

Rebar Diameter = 16 mm =====> QTY = 7 =====> 7 =====> 7 Ø 16

Rebar Quantity = 7

Rebar Spacing = 24.2

===> As= 1407 mm2

One Way Shear:

Compression Stress at critical section of shear , σv = 5.36 kg/cm2

Vu = -10424 kg = -104238 N Not defined since Theorical shear check distance is more than pad width!

k = 1 +(200/dp)^0.5 < 2.0 >>> k = 1.59 EN 1992-1-1:2004 6.2

ρ_1 = 0.0015

$\sigma_{cp} = N_{ED}/A_C$ = 0 No Axial Force!

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.256 Mpa EN 1992-1-1:2004 6.3N

Vr = 235682 N

Vr	>	Vu	OK

F.S= Not Defined!

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 4.95 kg/cm2

Vpunch = -255963 kg = -2559630 N

Resisting Shear of Concrete,

Vr = 1476791 N

Vr	>	Vu	OK

F.S. = Not Defined!
Theorical shear check section distance is more than pad width!

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis

Mx max = -1.58 ton.m = -15775 N.m

Rebar arrangement:

No. of Rebar rows, n = 3

Total No. of Rebars = 8

Distance of the last row to center, c = 27.5 cm

Σ Ai * di^2 = 4537.5

φs * fy = M * c /I >>>>> Σ Ai * di^2 = M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σ di^2)

As1= 1.8 cm2

B) Moment at the bottom of chimney about y axis

My max = 0.70 ton.m = 6997 N.m

>>>>> A = M * c / (φs * fyr *Σ di2)

As2= 0.8 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fys) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Longitudinal rebar area Ast =As1+As2+As3 = 15.6 cm2

As min = max (0.1*Cs/Fy , 0.002*Ac) = 9.8 cm2 9.12 N

As max = 0.04 *Ac = 196.0 cm2 9.5.2.3

As = 15.6

Rebar Diameter = 16 mm =====> QTY = 8 =====> 8 =====> 8 Ø 16

===>> As final= 16.1 cm2

Rebar Quantity of One Row = 3

Rebar Spacing = 27.5

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a <= 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$ 4.5 mm

$N_{Ed} =$ 122.09 ton

$M_{0Ed,x} =$ 1.44 ton.m

$e_0 = h /30 > 20$ mm ==> $e_0 =$ 23 mm

$M_{Ed,x}$ = 2.85 ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y}$= 0.51 ton.m

$M_{Ed,y}$ = 2.85 ton.m

$As * F yr / bc^2 * f'c$ = 0.082

$N_{ED} / f'c * bc^2$ = 0.122

d2 = 144 mm

d2 / bc = 0.21

Interaction Chart Gives ===> MRd / f'c * bc3 = 0.08 ===> $M_{Rd,x} = M_{Rd,y}$ = 55.94 ton.m

$N_{Rd} = Ac * f'c + As * Fyr$ = 734.31 ton

N_{Ed} / N_{Rd} = 0.17 ===> a = 1.06

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a$ = 0.086 < 1 OK

Stirrup Rebar : EN 1992-1-1:2004 9.5.3.3

Max Spacing of links =	320	mm
Rebar Space =	150	mm
Link Rebar Diameter =	8	mm

==>> Ø8 @ 150 mm

Soil Type: Type 2-Deleterious Rock
Foundation Type: Semi-Auger
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

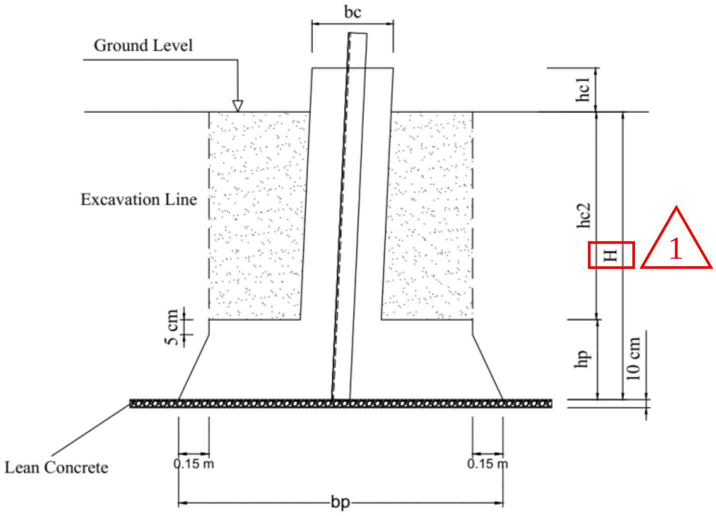
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

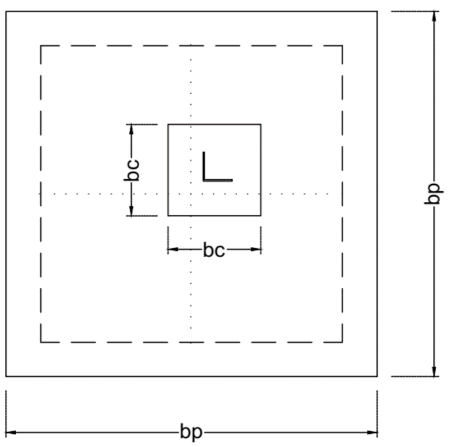
Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

	Width of Pad	bp =	2	m	
	Height of Pad	hp =	0.45	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.25	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 2-Deleterious Rock			
	Natural Soil Density	γ_s =	2.04	ton/m3	
	Backfill Density	γ_b =	2.04	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	5.10	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	25	Degree	
	Internal Friction Angle	ϕ =	35	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2





* The foundation is in direct contact with undisturbed soil. 1

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient   Kp = tan 2 (45+φ/2) =   3.69
Passive Force on chimney,   Fp1 =   27.81   ton
Passive Force on pad,   Fp2 =   23.53   ton

Uplift:

Volume of chimney above ground level   V1 =   0.15   m3
Volume of chimney under ground level   V2 =   1.59   m3
Volume of pad,   V3 =   1.54   m3
Total volume of foundation ,   Vf =   3.28   m3

Total weight of foundation,   Wf = Vf * γc =   8.20   ton

Cone volume, $V_{cone} = (H/3)*(\pi*H^2*\tan^2\Theta + 3*bp^2 + 6*bp*H*\tan\theta) =$ 51.87   m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 =   48.74   m3
Soil weight above foundation,   Ws = Vsoil * γb =   99.36   ton

Total resistance force against uplift,   Ru= Ws + Wf =   107.56   ton
Uplift Force,   U=   107.18   ton

107.56	>	107.18	OK

S.F.= 1.00

Bearing Capacity:

Compression Force,   C =   118.86   ton
Bending Moment about x axis,   Mx =   6.41   ton.m
Bending Moment about y axis,   My =   2.27   ton.m

Over Load of Concrete Wf=   8.20   ton

Volume of the Soil directly above foundation $V_{sl} = (H * bp^2) - V2 - V3 =$ 11.67   m3

Over Load of Soil directly above foundation   Wsl= Vsl * γb =   23.79   ton

Average Bearing Pressure = σp = ((C + Wf + Wsl)/A) =	3.77	kg/cm2	<	5.10	kg/cm2	OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 4.42   kg/cm2
Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 4.08   kg/cm2
Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 3.46   kg/cm2
Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 3.12   kg/cm2

Max. Toe Pressure =	4.42	<	q_{all} =	6.37	OK
Min. Toe Pressure =	3.12	>	0		OK

S.F.= 1.44

Top Surface Pressure due to Uplift:

Uplift Force,   T =   107.58   ton
Bending Moment about x axis,   Mx =   6.22   ton.m
Bending Moment about y axis,   My =   2.76   ton.m

Pressure due to Uplift at top surface at corner 1, $\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 3.16   kg/cm2
Pressure due to Uplift at top surface at corner 2, $\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 2.74   kg/cm2
Pressure due to Uplift at top surface at corner 3, $\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 2.22   kg/cm2
Pressure due to Uplift at top surface at corner 4, $\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 1.81   kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp/3)+((hp) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp)/cos β)- (((bp/3)+(hp) * tan β)* sin β))

Mo = 83.84 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp/6)+Wf*(bp/3)

Mr = 88.27 ton.m

Mr	>	Mo	OK

S.F.= 1.05

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 0.38 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 =

Fr = 51.49

Fr	>	Fo	OK

S.F.= 2.64

Structural Design of Pad:

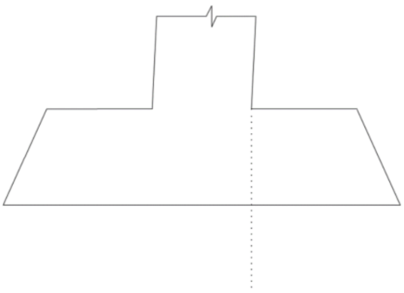
Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad , σmc = 3.94 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad , σmu = 2.65 kg/cm2



Max. bending moment at Pad, **(Compression)**

Muc = 1472390 kg.cm = 144441 N.m

Max. bending moment at Pad, **(Uplift)**

Muu = 1204155 kg.cm = 118128 N.m

Effective Depth of pad , dp = hp - cp = 0.375 m

Compression :

$K = Mu / f'c * bp * dp^2 =$ 0.039 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 361.8 > 356.25 ==>>> Zmax=0.95 dp = 356.25

As = Mu / φs * fyr * z = 973.1 mm2

Uplift :

$K = Mu / f'c * bp * dp^2 =$ 0.032

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 364.3 > 356.25 ==>>> Zmax=0.95 dp = 356.25

As = Mu / φs * fyr * z = 795.8 mm2

Top of Pad :

As2t= 795.8 mm2

Rebar Diameter= 12 mm =====> QTY = 8 ==>> 8 =====> 8 Ø 12 =====> 905 mm2

Rebar Quantity = 8

Rebar Spacing = 221.4 mm

Bottom of Pad :

As2b= 973.1 mm2

Rebar Diameter= 12 mm =====> QTY = 9 ==>> 9 =====> 9 Ø 12 =====> 1018 mm2

Rebar Quantity = 9

Rebar Spacing = 231.3 mm

Min. Rebar Check:

Ast =	1922.7	mm2			
ρst =	0.0026		>		
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>>			0.0013		EN 1992-1-1:2004 9.1N
ρmax =			0.040		EN 1992-1-1:2004 9.2.1.1
	ρst		>	ρmin	OK
	ρst		<	ρmax	OK

One Way Shear:

Compression Stress at critical section of shear at Pad , σv = 4.12 kg/cm2

Vu = 19376 kg = 193764 N

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.73 EN 1992-1-1:2004 6.2

ρ_1 = 0.0026

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.356 Mpa EN 1992-1-1:2004 6.3N

Vr = 268526 N

Vr	>	Vu	OK

F.S= 1.39

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 3.77 kg/cm2

To check if punch shear section is defined in Pad ==> bp1 - (bc + 4dp2) = -0.2 < 0 ==> Not Defined

Vpunch = No Defined kg = Not Defined N

Resisting Shear of Concrete,

Vr = Not Defined N

Vr	<	Vpunch	Not Defined

F.S.= Not Defined

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.22 ton.m = 62222 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

φs * fyr = M * c /I >>>>> $\Sigma Ai*di^2$ = M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σdi^2)

As1= 7.7 cm2

B) Moment at the bottom of chimney about y axis My max = 2.76 ton.m = 27601 N.m

φs * fyr = M * c /I As2= 3.4 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area	Ast =As1+As2+As3 =		24.2	cm2				
As min =	max (0.1*Cs/Fy , 0.002*Ac) =	9.8	cm2	9.12 N				
As max =	0.04 *Ac =	196.0	cm2	9.5.2.3				
As =	24.2							
Rebar Diameter =	16	mm	=====>	QTY =	13	=====>	16	=====> 16 Ø 16
===>> As final=	32.2	cm2						
Rebar Quantity of One Row =	5							
Rebar Spacing =	13.8							

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a <= 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.75	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed, x} =$	5.69	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.85	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed, y} =$	2.02	ton.m
$M_{Ed,y} =$	4.18	ton.m
$As * F yr / bc^2 * f'c =$	0.164	
$N_{ED}/ f'c * bc^2 =$	0.122	
d2 =	144	mm
d2 / bc =	0.21	

Interaction Chart Gives ===>	$M_{Rd} / f'c * bc^3 =$	0.1	===> $M_{Rd,x} = M_{Rd,y} =$	46.62	ton.m	
$N_{Rd} =$	$Ac * f'c + As * Fyr =$	802.62	ton			
$N_{Ed} / N_{Rd} =$	0.15	===>	a =	1.04		
$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$		0.237	<	1	OK	

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3	
Rebar Space =	150	mm		==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm		

MİTAŞ ENERGY

Soil Type: Type 3-Good Soil
Foundation Type: Semi-Auger
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

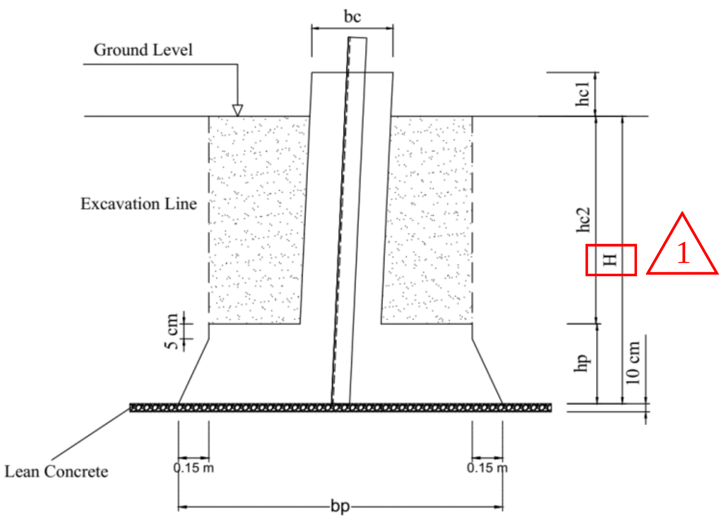
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

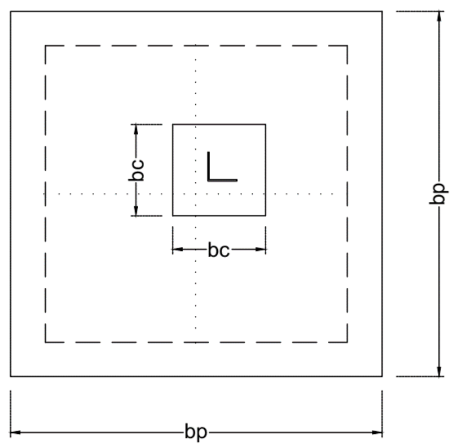
Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

	Width of Pad	bp =	2.55	m	
	Height of Pad	hp =	0.45	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.25	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 3-Good Soil			
	Natural Soil Density	γ_s =	1.73	ton/m3	
	Backfill Density	γ_b =	1.73	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	3.06	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	22	Degree	
	Internal Friction Angle	ϕ =	35	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2





* The foundation is in direct contact with undisturbed soil.

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Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient $Kp = \tan 2 (45+\varphi/2) =$ 3.69
Passive Force on chimney, Fp1 = 23.64 ton
Passive Force on pad, Fp2 = 25.50 ton

Uplift:

Volume of chimney above ground level V1 = 0.15 m3
Volume of chimney under ground level V2 = 1.59 m3
Volume of pad, V3 = 2.59 m3
Total volume of foundation , Vf = 4.33 m3

Total weight of foundation, $Wf = Vf * \gamma c =$ 10.83 ton

Cone volume, $Vcone = (H/3)*(\pi*H^2*\tan^2\Theta + 3*bp^2 + 6*bp*H*\tan\theta) =$ 60.93 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 56.74 m3
Soil weight above foundation, $Ws = Vsoil * \gamma b =$ 98.33 ton

Total resistance force against uplift, Ru= Ws + Wf = 109.16 ton
Uplift Force, U= 107.18 ton

109.16	>	107.18	OK

S.F.= 1.02

Bearing Capacity:

Compression Force, C = 118.86 ton
Bending Moment about x axis, Mx = 6.41 ton.m
Bending Moment about y axis, My = 2.27 ton.m

Over Load of Concrete Wf= 10.83 ton

Volume of the Soil directly above foundation $Vsl = (H * bp^2) - V2 - V3 =$ 19.87 m3

Over Load of Soil directly above foundation $Wsl= Vsl * \gamma b =$ 34.44 ton

Average Bearing Pressure = $\sigma p = ((C + Wf + Wsl)/A) =$	2.52	kg/cm2	<	3.06	kg/cm2	OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 2.84 kg/cm2
Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 2.67 kg/cm2
Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 2.37 kg/cm2
Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 2.21 kg/cm2

Max. Toe Pressure =	2.84	<	q_{all} =	3.82	OK
Min. Toe Pressure =	2.21	>	0		OK

S.F.= 1.35

Top Surface Pressure due to Uplift:

Uplift Force, T = 107.58 ton
Bending Moment about x axis, Mx = 6.22 ton.m
Bending Moment about y axis, My = 2.76 ton.m

Pressure due to Uplift at top surface at corner 1, $\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 1.81 kg/cm2
Pressure due to Uplift at top surface at corner 2, $\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 1.61 kg/cm2
Pressure due to Uplift at top surface at corner 3, $\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp^3) + (6*My)/(bp^3) =$ 1.36 kg/cm2
Pressure due to Uplift at top surface at corner 4, $\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp^3) - (6*My)/(bp^3) =$ 1.16 kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp/3)+((hp) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp)/cos β)- (((bp/3)+(hp) * tan β)* sin β))

Mo = 103.80 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp/6)+Wf*(bp/3)

Mr = 113.68 ton.m

Mr	>	Mo	OK

S.F.= 1.10

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 1.98 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 =

Fr = 49.93

Fr	>	Fo	OK

S.F.= 2.56

Structural Design of Pad:

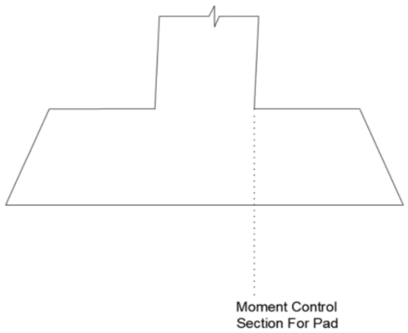
Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad , σmc = 2.59 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad , σmu = 1.55 kg/cm2



Max. bending moment at Pad, **(Compression)**

Muc = 2330947 kg.cm = 228666 N.m

Max. bending moment at Pad, **(Uplift)**

Muu = 1809411 kg.cm = 177503 N.m

Effective Depth of pad , dp = hp - cp = 0.375 m

Compression :

$K = Mu / f'c * bp * dp^2 =$ 0.048 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 358.4 > 356.25 ==>>> Zmax=0.95 dp = 356.25

As = Mu / φs * fyr * z = 1540.5 mm2

Uplift :

$K = Mu / f'c * bp * dp^2 =$ 0.037

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 362.3 > 356.25 ==>>> Zmax=0.95 dp = 356.25

As = Mu / φs * fyr * z = 1195.8 mm2

Top of Pad :

As2t= 1195.8 mm2

Rebar Diameter= 12 mm =====> QTY = 11 ==>> 11 =====> 11 Ø 12 =====> 1244 mm2

Rebar Quantity = 11

Rebar Spacing = 210.0 mm

Bottom of Pad :

As2b= 1540.5 mm2

Rebar Diameter= 12 mm =====> QTY = 14 ==>> 14 =====> 14 Ø 12 =====> 1583 mm2

Rebar Quantity = 14

Rebar Spacing = 184.6 mm

Min. Rebar Check:

Ast =	2827.4	mm2			
ρst =	0.0030		>		
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013	>>>		0.0013		EN 1992-1-1:2004 9.1N
ρmax =			0.040		EN 1992-1-1:2004 9.2.1.1
		ρst	>	ρmin	OK
		ρst	<	ρmax	OK

One Way Shear:

Compression Stress at critical section of shear at Pad , σv = 2.66 kg/cm2

Vu = 30052 kg = 300519 N

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.73 EN 1992-1-1:2004 6.2

ρ_1 = 0.0030

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.356 Mpa EN 1992-1-1:2004 6.3N

Vr = 359052 N

Vr	>	Vu	OK

F.S= 1.19

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 2.52 kg/cm2

To check if punch shear section is defined in Pad ==> bp1 - (bc + 4dp2) = 0.35 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch = 42069 kg = 420688 N

Resisting Shear of Concrete,

Vr = 1057779 N

Vr	>	Vpunch	OK

F.S.= 2.51

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.22 ton.m = 62222 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma A_i * d_i^2$ = 8318

φs * fyr = M * c /I >>>>> $\Sigma A_i * d_i^2$ = M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σd_i^2)

As1= 7.7 cm2

B) Moment at the bottom of chimney about y axis My max = 2.76 ton.m = 27601 N.m

φs * fyr = M * c /I As2= 3.4 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area	Ast =As1+As2+As3 =			24.2	cm2				
As min =	max (0.1*Cs/Fy , 0.002*Ac) =		9.8	cm2		9.12 N			
As max =	0.04 *Ac =		196.0	cm2		9.5.2.3			
As =	24.2								
Rebar Diameter =	16	mm	=====>	QTY =	13	=====>	16	=====>	16 Ø 16
===>> As final=	32.2	cm2							
Rebar Quantity of One Row =	5								
Rebar Spacing =	13.8								

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a <= 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.75	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed,x} =$	5.69	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.85	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y} =$	2.02	ton.m
$M_{Ed,y} =$	4.18	ton.m
$As * F yr / bc^2 * f'c =$	0.164	
$N_{ED}/ f'c * bc^2 =$	0.122	
d2 =	144	mm
d2 / bc =	0.21	

Interaction Chart Gives ===>	$M_{Rd} / f'c * bc^3 =$	0.1	===> $M_{Rd,x} = M_{Rd,y} =$		46.62	ton.m
$N_{Rd} =$	$Ac * f'c + As * Fyr =$	802.62	ton			
$N_{Ed} / N_{Rd} =$	0.15	===>	a =	1.04		
$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$		0.237	<	1	OK	

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3	
Rebar Space =	150	mm		==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm		

Soil Type: Type 3-Good Soil
Foundation Type: Pad & Chimney
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

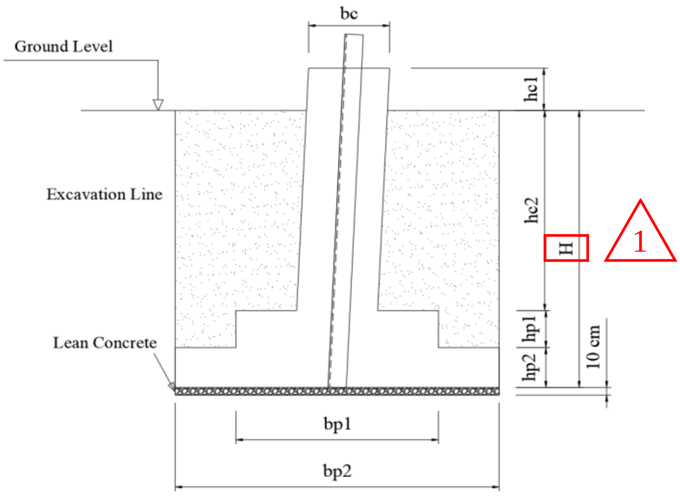
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

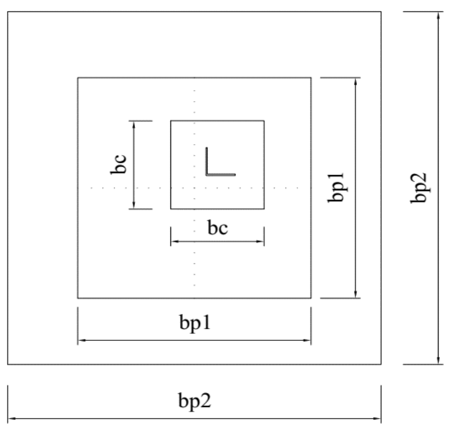
Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

Foundation Dimensions	Width of Pad 1	bp1 =	1.45	m	
	Width of Pad 2	bp2 =	2.95	m	
	Height of Pad 1	hp1 =	0.25	m	
	Height of Pad 2	hp2 =	0.3	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.15	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 3-Good Soil			
	Natural Soil Density	γ_s =	1.73	ton/m3	
	Backfill Density	γ_b =	1.73	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	3.06	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	22	Degree	
	Internal Friction Angle	ϕ =	35	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f'c =	13.3	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2





Pad 1 ==> Top Pad
Pad 2 ==> Bottom Pad

1 * The foundation is in direct contact with undisturbed soil.

MİTAŞ ENERGY

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient Kp = tan 2 (45+φ/2) = 3.69
Passive Force on chimney, Fp1 = 22.21 ton
Passive Force on pad1, Fp2 = 7.59 ton
Passive Force on pad2, Fp3 = 20.09 ton

Uplift:

Volume of chimney above ground level V1 = 0.15 m3
Volume of chimney under ground level V2 = 1.54 m3
Volume of pad1, V3 = 0.53 m3
Volume of pad2, V4 = 2.61 m3
Total volume of foundation , Vf = 4.83 m3

Total weight of foundation, Wf = Vf * γc = 12.07 ton

Cone volume, $Vcone = (h/3)*(\pi*h^2*\tan^2\Theta + 3*bp2^2 + 6*bp2*h*\tan\theta) =$ 68.58 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 66.51 m3
Soil weight above foundation, Ws = Vsoil * γb = 115.26 ton

Total resistance force against uplift, Ru= Ws + Wf = 127.33 ton
Uplift Force, U= 107.18 ton

127.33 > 107.18 OK S.F.= 1.19

Additional condition: G/Z > 0.67 EN 50341 M.3.1.6
G: weight of foundation and soil vertical to the base = 59.76 ton
Z: uplift force on fondation = 97.44 ton

Z/G = 0.61 >>> Ratio = 0.92 OK

1

Bearing Capacity:

Compression Force, C = 118.86 ton
Bending Moment about x axis, Mx = 6.41 ton.m
Bending Moment about y axis, My = 2.27 ton.m

Over Load of Concrete Wf= 12.07 ton

Volume of the Soil directly above foundation $Vsl = (H * bp2^2) - V2 - V3 - V4 =$ 27.52 m3

Over Load of Soil directly above foundation Wsl= Vsl * γb = 47.69 ton

Average Bearing Pressure = σp = ((C + Wf + Wsl)/A) = 2.05 kg/cm2 < 3.06 kg/cm2 OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 2.26 kg/cm2
Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 2.15 kg/cm2
Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 1.96 kg/cm2
Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 1.85 kg/cm2

Max. Toe Pressure =	2.26	<	q_{all} =	3.82	OK
Min. Toe Pressure =	1.85	>		0	OK

S.F.= 1.69

Top Surface Pressure due to Uplift:

Uplift Force, T = 107.58 ton
Bending Moment about x axis, Mx = 6.05 ton.m
Bending Moment about y axis, My = 2.68 ton.m

Pressure due to Uplift at top surface at corner 1, $\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 1.30 kg/cm2
Pressure due to Uplift at top surface at corner 2, $\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 1.18 kg/cm2
Pressure due to Uplift at top surface at corner 3, $\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 1.02 kg/cm2
Pressure due to Uplift at top surface at corner 4, $\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 0.89 kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp2/3)+((hp1+hp2) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp1+hp2)/cos β)- (((bp2/3)+(hp1+hp2) * tan β)* sin β))

Mo = 120.12 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp2/6)+Wf*(bp2/3)

Mr = 153.54 ton.m

Mr	>	Mo	OK

S.F.= 1.28

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 20.15 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 + Fp3 =

Fr = 57.95

Fr	>	Fo	OK

S.F.= 2.97

Structural Design of Pad:

Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad 1, σmc1 = 2.09 kg/cm2

Compression Stress at section of Max. bending moment at Pad 2, σmc2 = 2.13 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad 1, σmu1 = 1.13 kg/cm2

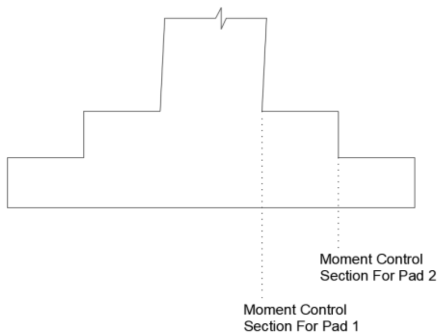
Compression Stress at section of Max. bending moment at Pad 2, σmu2 = 1.17 kg/cm2

Max. bending moment at Pad1, **(Compression)**

Muc 1= 3020978 kg.cm = 296358 N.m

Max. bending moment at Pad2, **(Compression)**

Muc 2= 1317239 kg.cm = 129221 N.m



Max. bending moment at Pad1, **(Uplift)**

Muu 1= 2245616 kg.cm = 220295 N.m

Max. bending moment at Pad2, **(Uplift)**

Muu 2= 1007989 kg.cm = 98884 N.m

Effective Depth of pad 1, dp1 = hp1+hp2 - cp = 0.475 m

Effective Depth of pad 2, dp2 = hp2 - cp = 0.225 m

Compression :

Pad 1:

K = Mu /f 'c * bp *dp^2 = 0.068 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 445 < 451.25 ==>>> OK

As = Mu / φs * fyr * z = 1600 mm2

Pad 2:

K = Mu /f 'c * bp *dp^2 = 0.065 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 211.3 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 1467.9 mm2

Uplift :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$	0.025	<	0.167	OK			

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max =	464.4	>	451.25	==>>>	Zmax=0.95 dp =	451.25
As = Mu / φs * fyr * z =	1171.7	mm2				

Pad 2:

$K = Mu / f'c * bp * dp^2 =$	0.050

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max =	214.7	>	213.75	==>>>	Zmax=0.95 dp =	213.75
As = Mu / φs * fyr * z =	1110.3	mm2				

Top of Pad 1 :											
As1t=	1171.7		mm2								
Rebar Diameter=	16	mm	=====>	QTY =	6 ==>>	6	=====>	6 Ø 16	=====>	1206	mm2
Rebar Quantity =	6										
Rebar Spacing =	260.0	mm									
Top of Pad 2 :											
As2t=	1110.3	mm2									
Rebar Diameter=	12	mm	=====>	QTY =	10 ==>>	13	=====>	13 Ø 12	=====>	1470	mm2
Rebar Quantity =	13										
Rebar Spacing =	233.3	mm									
Bottom of Pad 2 :											
As2b=	1599.8	mm2									
Rebar Diameter=	12	mm	=====>	QTY =	15 ==>>	15	=====>	15 Ø 12	=====>	1696	mm2
Rebar Quantity =	15										
Rebar Spacing =	200.0	mm									

Min. Rebar Check:

Ast =	4373.1	mm2			
ρst =	0.0043		>		
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013	>>>		0.0013		EN 1992-1-1:2004 9.1N
ρmax =			0.040		EN 1992-1-1:2004 9.2.1.1
		ρst	>	ρmin	OK
		ρst	<	ρmax	OK

One Way Shear:

Compression Stress at critical section of shear at Pad1 ,		σv1 =	2.14	kg/cm2	
Vu1 =	31128	kg	=	311276	N
Compression Stress at critical section of shear at Pad2 ,		σv2 =	2.15	kg/cm2	
Vu2 =	24569	kg	=	245688	N

Pad 1

k = 1 +(200/dp1)^0.5 < 2.0	>>>	k =	1.65	EN 1992-1-1:2004	6.2
$\rho_1 =$	0.0043				
$\sigma_{cp} = N_{ED}/A_C =$	0	No Axial Force!			
$C_{Rd,c} = 0.18/\gamma_c =$	0.12				
k1 =	0.15				
$v_{min} = 0.035 * k^{3/2} * f'c^{1/2} =$	0.331	Mpa		EN 1992-1-1:2004	6.3N

Vr1 = 414776 N

Vr1	>	Vu1	OK

F.S= 1.33

Pad 2

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.94 EN 1992-1-1:2004 6.2

ρ_1 = 0.0048

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.424 Mpa EN 1992-1-1:2004 6.3N

Vr2 = 328217 N

Vr2	>	Vu2	OK

F.S= 1.34

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 2.05 kg/cm2

Pad 1

Vpunch1 = 40938 kg = 409378 N

Resisting Shear of Concrete,

Vr1 = 1683470 N

Vr1	>	Vpunch1	OK

F.S.= 4.11

Pad 2

To check if punch shear section is defined in Pad 2 ==> bp1 - (bp2 + 4dp2) = 0.6 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch2 = 49076 kg = 490761 N

Resisting Shear of Concrete,

Vr2 = 959888 N

Vr2	>	Vpunch2	OK

F.S.= 1.96

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.05 ton.m = 60469 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

$\varphi s * fyr = M * c / I$ >>>>> $\Sigma Ai*di^2 = M * c / \varphi s * fyr$

>>>>> $A = M * c / (\varphi s * fyr * \Sigma di^2)$

As1= 7.5 cm2

B) Moment at the bottom of chimney about y axis My max = 2.68 ton.m = 26823 N.m

$\varphi s * fyr = M * c / I$ As2= 3.3 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area Ast =As1+As2+As3 = 23.9 cm2

As min =	max (0.1*Cs/Fy , 0.002*Ac) =			9.8	cm2		9.12 N	
As max =	0.04 *Ac =			196.0	cm2		9.5.2.3	
As =	23.9							
Rebar Diameter =	16	mm	=====> QTY =	12	=====>	16	=====>	16 Ø 16
===>> As final=	32.2	cm2						
Rebar Quantity of One Row =	5							
Rebar Spacing =	13.8							

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a$ <= 1 EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.25	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed,x} =$	5.53	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.63	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y} =$	1.96	ton.m						
$M_{Ed,y} =$	4.07	ton.m						
$As * F yr / bc^2 * f'c =$	0.164							
$N_{ED}/ f'c * bc^2 =$	0.122							
d2 =	144	mm						
d2 / bc =	0.21							
Interaction Chart Gives ===>	$M_{Rd} / f'c * bc^3 =$		0.1	===> $M_{Rd,x} = M_{Rd,y} =$		46.62	ton.m	
$N_{Rd} =$	$Ac * f'c + As * Fyr =$		802.62	ton				
$N_{Ed} / N_{Rd} =$	0.15		===>	a =	1.04			
$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$			0.230	<	1	OK		

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3	
Rebar Space =	150	mm		==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm		

Soil Type: Type 4-Normal Soil-Dry
Foundation Type: Pad & Chimney
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

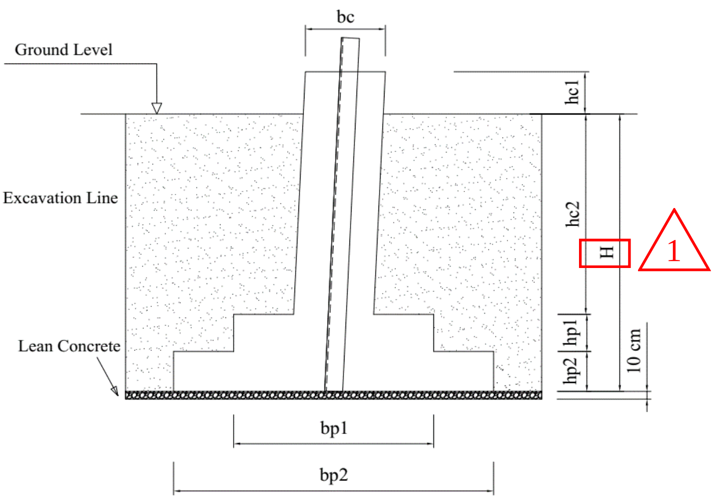
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

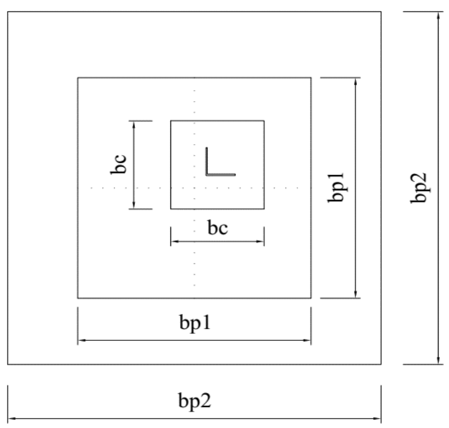
Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

Foundation Dimensions	Width of Pad 1	bp1 =	1.45	m	
	Width of Pad 2	bp2 =	3.15	m	
	Height of Pad 1	hp1 =	0.25	m	
	Height of Pad 2	hp2 =	0.3	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.15	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 4-Normal Soil-Dry			
	Natural Soil Density	γ_s =	1.83	ton/m3	
	Backfill Density	γ_b =	1.83	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	2.04	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	ϴ =	15	Degree	
	Internal Friction Angle	ϕ =	25	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2





Pad 1 ==> Top Pad
Pad 2 ==> Bottom Pad

* The foundation is cast inside formwork. 1

MİTAŞ ENERGY

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient	Kp = tan 2 (45+φ/2) =	2.46	
Passive Force on chimney,	Fp1 =	15.70	ton
Passive Force on pad1,	Fp2 =	5.37	ton
Passive Force on pad2,	Fp3 =	15.17	ton

Uplift:

Volume of chimney above ground level	V1 =	0.15	m3
Volume of chimney under ground level	V2 =	1.54	m3
Volume of pad1,	V3 =	0.53	m3
Volume of pad2,	V4 =	2.98	m3
Total volume of foundation ,	Vf =	5.19	m3

Total weight of foundation, Wf = Vf * γc = 12.98 ton

Cone volume, $V_{cone} = (h/3)*(\pi*h^2*\tan^2\Theta + 3*bp2^2 + 6*bp2*h*\tan\theta) =$ 59.86 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 57.79 m3

Soil weight above foundation, Ws = Vsoil * γb = 106.04 ton

Total resistance force against uplift, Ru= Ws + Wf = 119.03 ton

Uplift Force, U= 107.18 ton

119.03	>	107.18	OK

S.F.= 1.11

Additional condition: G/Z > 0.8 EN 50341 M.3.1.6

G: weight of foundation and soil vertical to the base = 71.09 ton

Z: uplift force on fondation = 97.44 ton

Z/G = 0.73 >>> Ratio = 0.91 OK

1

Bearing Capacity:

Compression Force,	C =	118.86	ton
Bending Moment about x axis,	Mx =	6.41	ton.m
Bending Moment about y axis,	My =	2.27	ton.m

Over Load of Concrete Wf= 12.98 ton

Volume of the Soil directly above foundation $V_{sl} = (H * bp2^2) - V2 - V3 - V4 =$ 31.67 m3

Over Load of Soil directly above foundation Wsl= Vsl * γb = 58.11 ton

Average Bearing Pressure = $\sigma_p = ((C + W_f + W_{sl})/A) =$	1.91	kg/cm2	<	2.04	kg/cm2	OK

Compression Stress at corner 1,	$\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	2.08	kg/cm2
Compression Stress at corner 2,	$\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	1.99	kg/cm2
Compression Stress at corner 3,	$\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	1.83	kg/cm2
Compression Stress at corner 4,	$\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	1.75	kg/cm2

Max. Toe Pressure =	2.08	<	q_{all} =	2.55	OK
Min. Toe Pressure =	1.75	>	0		OK

S.F.= 1.22

Top Surface Pressure due to Uplift:

Uplift Force,	T =	107.58	ton
Bending Moment about x axis,	Mx =	6.05	ton.m
Bending Moment about y axis,	My =	2.68	ton.m

Pressure due to Uplift at top surface at corner 1,	$\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	1.12	kg/cm2
Pressure due to Uplift at top surface at corner 2,	$\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	1.02	kg/cm2
Pressure due to Uplift at top surface at corner 3,	$\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	0.89	kg/cm2
Pressure due to Uplift at top surface at corner 4,	$\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	0.79	kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp2/3)+((hp1+hp2) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp1+hp2)/cos β)- (((bp2/3)+(hp1+hp2) * tan β)* sin β))

Mo = 127.38 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp2/6)+Wf*(bp2/3)

Mr = 152.81 ton.m

Mr	>	Mo	OK

S.F.= 1.20

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 11.85 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 + Fp3 =

Fr = 40.97

Fr	>	Fo	OK

S.F.= 2.10

Structural Design of Pad:

Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad 1, σmc1 = 1.94 kg/cm2

Compression Stress at section of Max. bending moment at Pad 2, σmc2 = 1.97 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad 1, σmu1 = 0.98 kg/cm2

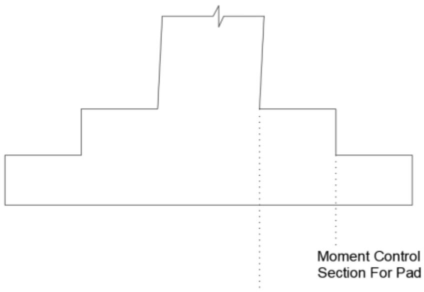
Compression Stress at section of Max. bending moment at Pad 2, σmu2 = 1.01 kg/cm2

Max. bending moment at Pad1, **(Compression)**

Muc 1= 3373715 kg.cm = 330961 N.m

Max. bending moment at Pad2, **(Compression)**

Muc 2= 1583237 kg.cm = 155316 N.m



Max. bending moment at Pad1, **(Uplift)**

Muu 1= 2456484 kg.cm = 240981 N.m

Max. bending moment at Pad2, **(Uplift)**

Muu 2= 1193197 kg.cm = 117053 N.m

Effective Depth of pad 1, dp1 = hp1+hp2 - cp = 0.475 m

Effective Depth of pad 2, dp2 = hp2 - cp = 0.225 m

Compression :

Pad 1:

K = Mu /f 'c * bp *dp^2 = 0.076 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 441 < 451.25 ==>>> OK

As = Mu / φs * fyr * z = 1802 mm2

Pad 2:

K = Mu /f 'c * bp *dp^2 = 0.073 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 209.4 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 1779.9 mm2

Uplift :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$	0.025	<	0.167	OK			
Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp							
Z max =	464.1	>	451.25	==>>>	Zmax=0.95 dp =	451.25	
As = Mu / φs * fyr * z =	1281.7	mm2					

Pad 2:

$K = Mu / f'c * bp * dp^2 =$	0.055				
Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp					
Z max =	213.5	<	213.75	==>>>	OK
As = Mu / φs * fyr * z =	1315.9	mm2			

Top of Pad 1 :

As1t=	1281.7		mm2							
Rebar Diameter=	16	mm	=====>	QTY =	7 ==>>	7	=====>	7 Ø 16	=====>	1407 mm2
Rebar Quantity =	7									
Rebar Spacing =	216.7	mm								

Top of Pad 2 :

As2t=	1315.9	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	12 ==>>	13	=====>	13 Ø 12	=====>	1470 mm2
Rebar Quantity =	13									
Rebar Spacing =	250.0	mm								

Bottom of Pad 2 :

As2b=	1802.2	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	16 ==>>	16	=====>	16 Ø 12	=====>	1810 mm2
Rebar Quantity =	16									
Rebar Spacing =	200.0	mm								

Min. Rebar Check:

Ast =	4687.3	mm2		
ρst =	0.0044	>		
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>>		0.0013		EN 1992-1-1:2004 9.1N
ρmax =		0.040		EN 1992-1-1:2004 9.2.1.1
	ρst	>	ρmin	OK
	ρst	<	ρmax	OK

One Way Shear:

Compression Stress at critical section of shear at Pad1 ,		σv1 =	1.98	kg/cm2	
Vu1 =	33785	kg	=	337846	N
Compression Stress at critical section of shear at Pad2 ,		σv2 =	1.99	kg/cm2	
Vu2 =	27347	kg	=	273468	N

Pad 1

k = 1 +(200/dp1)^0.5 < 2.0	>>>	k =	1.65	EN 1992-1-1:2004 6.2
$\rho_1 =$	0.0044			
$\sigma_{cp} = N_{ED}/A_C =$	0	No Axial Force!		
$C_{Rd,c} = 0.18/\gamma_c =$	0.12			
k1 =	0.15			
$v_{min} = 0.035 * k^{3/2} * f'c^{1/2} =$	0.331	Mpa		EN 1992-1-1:2004 6.3N

Vr1 = 436799 N

Vr1	>	Vu1	OK

F.S= 1.29

Pad 2

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.94 EN 1992-1-1:2004 6.2

ρ_1 = 0.0046

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.424 Mpa EN 1992-1-1:2004 6.3N

Vr2 = 346923 N

Vr2	>	Vu2	OK

F.S= 1.27

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 1.91 kg/cm2

Pad 1

Vpunch1 = 52615 kg = 526145 N

Resisting Shear of Concrete,

Vr1 = 1698385 N

Vr1	>	Vpunch1	OK

F.S.= 3.23

Pad 2

To check if punch shear section is defined in Pad 2 ==> bp1 - (bp2 + 4dp2) = 0.8 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch2 = 59024 kg = 590238 N

Resisting Shear of Concrete,

Vr2 = 950177 N

Vr2	>	Vpunch2	OK

F.S.= 1.61

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.05 ton.m = 60469 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

$\varphi s * fyr = M * c / I$ >>>>> $\Sigma Ai*di^2 = M * c / \varphi s * fyr$

>>>>> $A = M * c / (\varphi s * fyr * \Sigma di^2)$

As1= 7.5 cm2

B) Moment at the bottom of chimney about y axis My max = 2.68 ton.m = 26823 N.m

$\varphi s * fyr = M * c / I$ As2= 3.3 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area Ast =As1+As2+As3 = 23.9 cm2

As min =	max (0.1*Cs/Fy , 0.002*Ac) =			9.8	cm2		9.12 N	
As max =	0.04 *Ac =			196.0	cm2		9.5.2.3	
As =	23.9							
Rebar Diameter =	16	mm	=====> QTY =	12	=====>	16	=====>	16 Ø 16
===>> As final=	32.2	cm2						
Rebar Quantity of One Row =	5							
Rebar Spacing =	13.8							

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a$ <= 1 EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.25	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed,x} =$	5.53	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.63	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y} =$	1.96	ton.m
$M_{Ed,y} =$	4.07	ton.m
$As * F yr / bc^2 * f'c =$	0.164	
$N_{ED}/ f'c * bc^2 =$	0.122	
d2 =	144	mm
d2 / bc =	0.21	

Interaction Chart Gives ===>	$M_{Rd} / f'c * bc^3 =$	0.1	===> $M_{Rd,x} = M_{Rd,y} =$		46.62	ton.m	
$N_{Rd} =$	Ac * f'c + As * Fyr =	802.62	ton				
$N_{Ed} / N_{Rd} =$	0.15	===>	a =	1.04			
$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$		0.230	<	1	OK		

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3	
Rebar Space =	150	mm		==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm		

Soil Type: Type 4-Normal Soil-Submerge
Foundation Type: Pad & Chimney
Tower Type: 12B-MA

Maximum Loads on Stub				
		Stub Force Components		
Description	*Load Combination*	*Shear Force Transversal component*	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

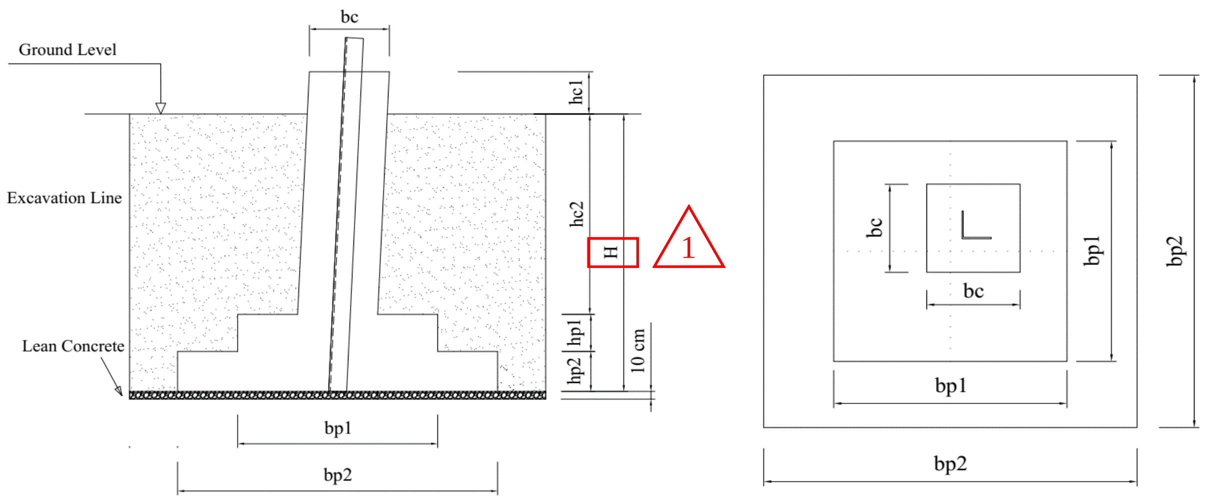
Maximum Loads on Foundation				
		Foundation Components		
Description	*Load Combination*	*Transversal*	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

Foundation Dimensions	Width of Pad 1	bp1 =	1.8	m	
	Width of Pad 2	bp2 =	4.3	m	
	Height of Pad 1	hp1 =	0.25	m	
	Height of Pad 2	hp2 =	0.3	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.15	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 4-Normal Soil-Submerge			
	Natural Soil Density	γ_s =	1.02	ton/m3	
	Backfill Density	γ_b =	1.02	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	2.04	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	15	Degree	
	Internal Friction Angle	ϕ =	25	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	1.4	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2



Pad 1 ==> Top Pad
Pad 2 ==> Bottom Pad

* The foundation is cast inside formwork. 1

MİTAŞ ENERGY

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient	Kp = tan 2 (45+φ/2) =	2.46	
Passive Force on chimney,	Fp1 =	8.72	ton
Passive Force on pad1,	Fp2 =	3.70	ton
Passive Force on pad2,	Fp3 =	11.50	ton

Uplift:

Volume of chimney above ground level	V1 =	0.15	m3
Volume of chimney under ground level	V2 =	1.54	m3
Volume of pad1,	V3 =	0.81	m3
Volume of pad2,	V4 =	5.55	m3
Total volume of foundation ,	Vf =	8.05	m3

Total weight of foundation, Wf = Vf * γc = 11.27 ton

Cone volume, $V_{cone} = (h/3)*(\pi*h^2*\tan^2\Theta + 3*bp2^2 + 6*bp2*h*\tan\theta) =$ 98.04 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 95.69 m3
Soil weight above foundation, Ws = Vsoil * γb = 97.54 ton

Total resistance force against uplift, Ru= Ws + Wf = 108.81 ton
Uplift Force, U= 107.18 ton

108.81	>	107.18	OK

S.F.= 1.02

Additional condition: G/Z > 0.8 EN 50341 M.3.1.6
G: weight of foundation and soil vertical to the base = 72.95 ton
Z: uplift force on fondation = 97.44 ton

Z/G = 0.75 >>> Ratio = 0.94 OK

1

Bearing Capacity:

Compression Force,	C =	118.86	ton
Bending Moment about x axis,	Mx =	6.41	ton.m
Bending Moment about y axis,	My =	2.27	ton.m

Over Load of Concrete Wf= 11.27 ton

Volume of the Soil directly above foundation $V_{sl} = (H * bp2^2) - V2 - V3 - V4 =$ 60.51 m3

Over Load of Soil directly above foundation Wsl= Vsl * γb = 61.68 ton

Average Bearing Pressure = σp = ((C + Wf + Wsl)/A) =	1.04	kg/cm2	<	2.04	kg/cm2	OK

Compression Stress at corner 1,	$\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	1.10	kg/cm2
Compression Stress at corner 2,	$\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	1.07	kg/cm2
Compression Stress at corner 3,	$\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	1.01	kg/cm2
Compression Stress at corner 4,	$\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	0.97	kg/cm2

Max. Toe Pressure =	1.10	<	q_{all} =	2.55	OK
Min. Toe Pressure =	0.97	>	0		OK

S.F.= 2.31

Top Surface Pressure due to Uplift:

Uplift Force,	T =	107.58	ton
Bending Moment about x axis,	Mx =	6.05	ton.m
Bending Moment about y axis,	My =	2.68	ton.m

Pressure due to Uplift at top surface at corner 1,	$\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	0.59	kg/cm2
Pressure due to Uplift at top surface at corner 2,	$\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	0.55	kg/cm2
Pressure due to Uplift at top surface at corner 3,	$\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$	0.50	kg/cm2
Pressure due to Uplift at top surface at corner 4,	$\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$	0.46	kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp2/3)+((hp1+hp2) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp1+hp2)/cos β)- (((bp2/3)+(hp1+hp2) * tan β)* sin β))

Mo = 169.12 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp2/6)+Wf*(bp2/3)

Mr = 190.91 ton.m

Mr	>	Mo	OK	S.F.= 1.13

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 1.63 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 + Fp3 =

Fr = 24.58

Fr	>	Fo	OK	S.F.= 1.26

Structural Design of Pad:

Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad 1,	σmc1 =	1.05	kg/cm2
Compression Stress at section of Max. bending moment at Pad 2,	σmc2 =	1.06	kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad 1,	σmu1 =	0.53	kg/cm2
Compression Stress at section of Max. bending moment at Pad 2,	σmu2 =	0.54	kg/cm2

Max. bending moment at Pad1, **(Compression)**

Muc 1= 5232404 kg.cm = 513299 N.m

Max. bending moment at Pad2, **(Compression)**

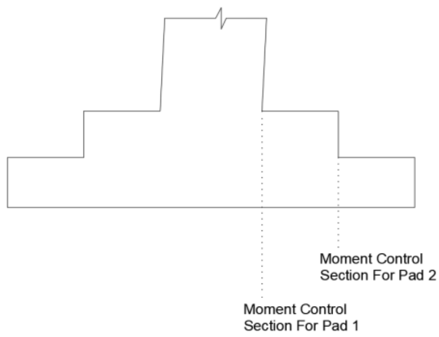
Muc 2= 2451581 kg.cm = 240500 N.m

Max. bending moment at Pad1, **(Uplift)**

Muu 1= 3857714 kg.cm = 378442 N.m

Max. bending moment at Pad2, **(Uplift)**

Muu 2= 1873466 kg.cm = 183787 N.m



Effective Depth of pad 1, dp1 = hp1+hp2 - cp = 0.475 m

Effective Depth of pad 2, dp2 = hp2 - cp = 0.225 m

Compression :

Pad 1:

K = Mu /f 'c * bp *dp^2 = 0.095 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 431 < 451.25 ==>>> OK

As = Mu / φs * fyr * z = 2857 mm2

Pad 2:

K = Mu /f 'c * bp *dp^2 = 0.083 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 207.1 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 2786.6 mm2

Uplift :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$	0.029	<	0.167	OK			

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max =	462.4	>	451.25	==>>>	Zmax=0.95 dp =	451.25	
As = Mu / φs * fyr * z =	2012.8	mm2					

Pad 2:

$K = Mu / f'c * bp * dp^2 =$	0.063				

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max =	211.6	<	213.75	==>>>	OK
As = Mu / φs * fyr * z =	2084.2	mm2			

Top of Pad 1 :										
As1t=	2012.8	mm2								
Rebar Diameter=	16	mm	=====>	QTY =	11 ==>>	11	=====>	11 Ø 16	=====>	2212 mm2
Rebar Quantity =	11									
Rebar Spacing =	165.0	mm								
Top of Pad 2 :										
As2t=	2084.2	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	19 ==>>	19	=====>	19 Ø 12	=====>	2149 mm2
Rebar Quantity =	19									
Rebar Spacing =	230.6	mm								
Bottom of Pad 2 :										
As2b=	2856.7	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	26 ==>>	26	=====>	26 Ø 12	=====>	2941 mm2
Rebar Quantity =	26									
Rebar Spacing =	166.0	mm								

Min. Rebar Check:

Ast =	7301.1	mm2			
ρst =	0.0052	>			
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>>		0.0013		EN 1992-1-1:2004 9.1N	
ρmax =		0.040		EN 1992-1-1:2004 9.2.1.1	
	ρst	>	ρmin	OK	
	ρst	<	ρmax	OK	

One Way Shear:

Compression Stress at critical section of shear at Pad1 ,	σv1 =	1.06	kg/cm2	
Vu1 = 42716	kg	=	427158	N
Compression Stress at critical section of shear at Pad2 ,	σv2 =	1.06	kg/cm2	
Vu2 = 32070	kg	=	320698	N

Pad 1

k = 1 +(200/dp1)^0.5 < 2.0	>>>	k =	1.65	EN 1992-1-1:2004	6.2
$\rho_1 =$	0.0052				
$\sigma_{cp} = N_{ED}/A_C =$	0	No Axial Force!			
$C_{Rd,c} = 0.18/\gamma_c =$	0.12				
k1 =	0.15				
$v_{min} = 0.035 * k^{3/2} * f'c^{1/2} =$	0.331	Mpa		EN 1992-1-1:2004	6.3N

Vr1 = 610275 N

Vr1	>	Vu1	OK

F.S= 1.43

Pad 2

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.94 EN 1992-1-1:2004 6.2

ρ_1 = 0.0053

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.424 Mpa EN 1992-1-1:2004 6.3N

Vr2 = 494247 N

Vr2	>	Vu2	OK

F.S= 1.54

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 1.04 kg/cm2

Pad 1

Vpunch1 = 89569 kg = 895689 N

Resisting Shear of Concrete,

Vr1 = 1793278 N

Vr1	>	Vpunch1	OK

F.S.= 2.00

Pad 2

To check if punch shear section is defined in Pad 2 ==> bp1 - (bp2 + 4dp2) = 1.6 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch2 = 78570 kg = 785701 N

Resisting Shear of Concrete,

Vr2 = 1152564 N

Vr2	>	Vpunch2	OK

F.S.= 1.47

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.05 ton.m = 60469 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

$\varphi s * fyr = M * c / I$ >>>>> $\Sigma Ai*di^2 = M * c / \varphi s * fyr$

>>>>> $A = M * c / (\varphi s * fyr * \Sigma di^2)$

As1= 7.5 cm2

B) Moment at the bottom of chimney about y axis My max = 2.68 ton.m = 26823 N.m

$\varphi s * fyr = M * c / I$ As2= 3.3 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area Ast =As1+As2+As3 = 23.9 cm2

As min =	max (0.1*Cs/Fy , 0.002*Ac) =			9.8	cm2		9.12 N		
As max =	0.04 *Ac =			196.0	cm2		9.5.2.3		
As =	23.9								
Rebar Diameter =	16	mm	=====> QTY =	12	=====>	16	=====>	16 Ø 16	
===>> As final=	32.2	cm2							
Rebar Quantity of One Row =	5								
Rebar Spacing =	13.8								

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a <= 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.25	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed, x} =$	5.53	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.63	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed, y} =$	1.96	ton.m
$M_{Ed,y} =$	4.07	ton.m
$As * F yr / bc^2 * f'c =$	0.164	
$N_{ED}/ f'c * bc^2 =$	0.122	
d2 =	144	mm
d2 / bc =	0.21	

Interaction Chart Gives ===> $M_{Rd} / f'c * bc^3 =$ 0.1 ===> $M_{Rd,x} = M_{Rd,y} =$ 46.62 ton.m

$N_{Rd} =$ Ac * f'c + As * Fyr = 802.62 ton

$N_{Ed} / N_{Rd} =$ 0.15 ===> a = 1.04

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$ 0.230 < 1 OK

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3
Rebar Space =	150	mm	==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm	

Soil Type: Type 5-Poor Soil-Dry
Foundation Type: Pad & Chimney
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

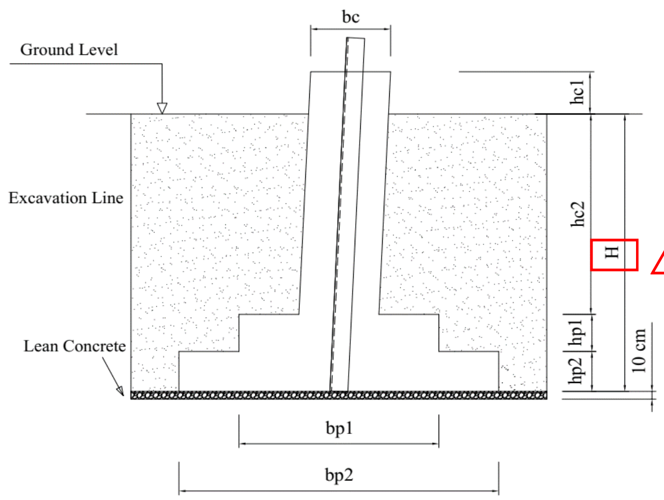
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

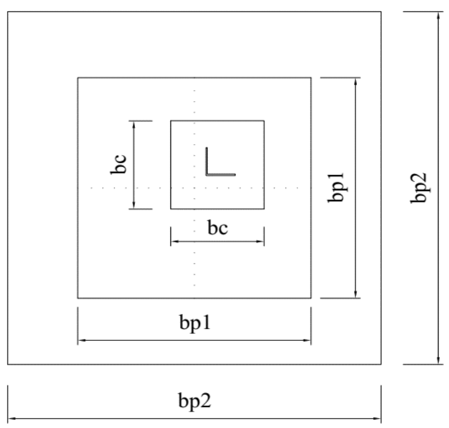
Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

Foundation Dimensions	Width of Pad 1	bp1 =	1.7	m	
	Width of Pad 2	bp2 =	4.1	m	
	Height of Pad 1	hp1 =	0.25	m	
	Height of Pad 2	hp2 =	0.3	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.15	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 5-Poor Soil-Dry			
	Natural Soil Density	γ_s =	1.63	ton/m3	
	Backfill Density	γ_b =	1.63	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	1.53	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	0	Degree	
	Internal Friction Angle	ϕ =	15	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	2.5	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2





Pad 1 ==> Top Pad
Pad 2 ==> Bottom Pad

* The foundation is cast inside formwork. 1

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient $Kp = \tan 2\,(45+\varphi/2) =$ 1.70
Passive Force on chimney, Fp1 = 9.62 ton
Passive Force on pad1, Fp2 = 3.86 ton
Passive Force on pad2, Fp3 = 12.10 ton

Uplift:

Volume of chimney above ground level V1 = 0.15 m3
Volume of chimney under ground level V2 = 1.54 m3
Volume of pad1, V3 = 0.72 m3
Volume of pad2, V4 = 5.04 m3
Total volume of foundation , Vf = 7.46 m3

Total weight of foundation, $Wf = Vf * \gamma c =$ 18.64 ton

Cone volume, $Vcone = (h/3)*(\pi*h^2*\tan^2\Theta + 3*bp2^2 + 6*bp2*h*\tan\theta) =$ 59.68 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 57.41 m3
Soil weight above foundation, $Ws = Vsoil * \gamma b =$ 93.63 ton

Total resistance force against uplift, Ru= Ws + Wf = 112.27 ton
Uplift Force, U= 107.18 ton

112.27	>	107.18	OK

S.F.= 1.05

Additional condition: G/Z > 0.8 EN 50341 M.3.1.6
G: weight of foundation and soil vertical to the base = 108.16 ton
Z: uplift force on fondation = 97.44 ton

Z/G = 1.11 >>> Ratio = 1.39 OK

1

Bearing Capacity:

Compression Force, C = 118.86 ton
Bending Moment about x axis, Mx = 6.41 ton.m
Bending Moment about y axis, My = 2.27 ton.m

Over Load of Concrete Wf= 18.64 ton

Volume of the Soil directly above foundation $Vsl = (H * bp2^2) - V2 - V3 - V4 =$ 54.89 m3

Over Load of Soil directly above foundation $Wsl = Vsl * \gamma b =$ 89.52 ton

Average Bearing Pressure = $\sigma p = ((C + Wf + Wsl)/A) =$	1.35	kg/cm2	<	1.53	kg/cm2	OK

Compression Stress at corner 1, $\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 1.43 kg/cm2
Compression Stress at corner 2, $\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 1.39 kg/cm2
Compression Stress at corner 3, $\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 1.31 kg/cm2
Compression Stress at corner 4, $\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 1.27 kg/cm2

Max. Toe Pressure =	1.43	<	q_{all} =	1.91	OK
Min. Toe Pressure =	1.27	>	0		OK

S.F.= 1.34

Top Surface Pressure due to Uplift:

Uplift Force, T = 107.58 ton
Bending Moment about x axis, Mx = 6.05 ton.m
Bending Moment about y axis, My = 2.68 ton.m

Pressure due to Uplift at top surface at corner 1, $\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 0.61 kg/cm2
Pressure due to Uplift at top surface at corner 2, $\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 0.56 kg/cm2
Pressure due to Uplift at top surface at corner 3, $\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3) =$ 0.50 kg/cm2
Pressure due to Uplift at top surface at corner 4, $\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3) =$ 0.45 kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp2/3)+((hp1+hp2) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp1+hp2)/cos β)- (((bp2/3)+(hp1+hp2) * tan β)* sin β))

Mo = 161.86 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp2/6)+Wf*(bp2/3)

Mr = 185.43 ton.m

Mr	>	Mo	OK

S.F.= 1.15

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 5.10 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 + Fp3 =

Fr = 27.61

Fr	>	Fo	OK

S.F.= 1.41

Structural Design of Pad:

Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad 1, σmc1 = 1.36 kg/cm2

Compression Stress at section of Max. bending moment at Pad 2, σmc2 = 1.37 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad 1, σmu1 = 0.54 kg/cm2

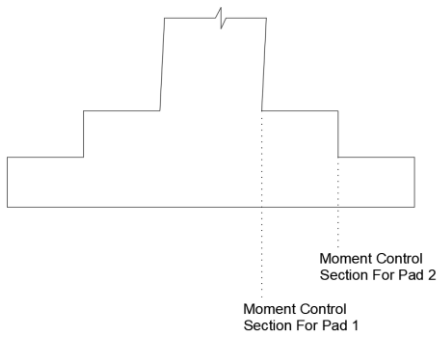
Compression Stress at section of Max. bending moment at Pad 2, σmu2 = 0.55 kg/cm2

Max. bending moment at Pad1, **(Compression)**

Muc 1= 5196465 kg.cm = 509773 N.m

Max. bending moment at Pad2, **(Compression)**

Muc 2= 2482260 kg.cm = 243510 N.m



Max. bending moment at Pad1, **(Uplift)**

Muu 1= 3360251 kg.cm = 329641 N.m

Max. bending moment at Pad2, **(Uplift)**

Muu 2= 1686946 kg.cm = 165489 N.m

Effective Depth of pad 1, dp1 = hp1+hp2 - cp = 0.475 m

Effective Depth of pad 2, dp2 = hp2 - cp = 0.225 m

Compression :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$ 0.100 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 429 < 451.25 ==>>> OK

As = Mu / φs * fyr * z = 2854 mm2

Pad 2:

$K = Mu / f'c * bp * dp^2 =$ 0.088 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 205.9 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 2838.2 mm2

Uplift :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$	0.027	<	0.167	OK			
Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp							
Z max =	463.5	>	451.25	==>>>	Zmax=0.95 dp =	451.25	
As = Mu / φs * fyr * z =	1753.2	mm2					

Pad 2:

$K = Mu / f'c * bp * dp^2 =$	0.060				
Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp					
Z max =	212.4	<	213.75	==>>>	OK
As = Mu / φs * fyr * z =	1869.7	mm2			

Top of Pad 1 :										
As1t=	1753.2	mm2								
Rebar Diameter=	16	mm	=====>	QTY =	9 ==>>	9	=====>	9 Ø 16	=====>	1810 mm2
Rebar Quantity =	9									
Rebar Spacing =	193.8	mm								
Top of Pad 2 :										
As2t=	1869.7	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	17 ==>>	17	=====>	17 Ø 12	=====>	1923 mm2
Rebar Quantity =	17									
Rebar Spacing =	246.9	mm								
Bottom of Pad 2 :										
As2b=	2853.8	mm2								
Rebar Diameter=	12	mm	=====>	QTY =	26 ==>>	26	=====>	26 Ø 12	=====>	2941 mm2
Rebar Quantity =	26									
Rebar Spacing =	158.0	mm								

Min. Rebar Check:

Ast =	6672.7	mm2		
ρst =	0.0050	>		
ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>>		0.0013		EN 1992-1-1:2004 9.1N
ρmax =		0.040		EN 1992-1-1:2004 9.2.1.1
	ρst	>	ρmin	OK
	ρst	<	ρmax	OK

One Way Shear:

Compression Stress at critical section of shear at Pad1 ,		σv1 =	1.37	kg/cm2
Vu1 =	43990	kg =	439904	N
Compression Stress at critical section of shear at Pad2 ,		σv2 =	1.38	kg/cm2
Vu2 =	33519	kg =	335188	N

Pad 1

k = 1 +(200/dp1)^0.5 < 2.0	>>>	k =	1.65	EN 1992-1-1:2004 6.2
$\rho_1 =$	0.0050			
$\sigma_{cp} = N_{ED}/A_C =$	0	No Axial Force!		
$C_{Rd,c} = 0.18/\gamma_c =$	0.12			
k1 =	0.15			
$v_{min} = 0.035 * k^{3/2} * f'c^{1/2} =$	0.331	Mpa		EN 1992-1-1:2004 6.3N

Vr1 = 572579 N

Vr1	>	Vu1	OK	F.S= 1.30

Pad 2

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.94 EN 1992-1-1:2004 6.2

ρ_1 = 0.0053

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.424 Mpa EN 1992-1-1:2004 6.3N

Vr2 = 471599 N

Vr2	>	Vu2	OK	F.S= 1.41

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 1.35 kg/cm2

Pad 1

Vpunch1 = 90577 kg = 905769 N

Resisting Shear of Concrete,

Vr1 = 1769913 N

Vr1	>	Vpunch1	OK	F.S.= 1.95

Pad 2

To check if punch shear section is defined in Pad 2 ==> bp1 - (bp2 + 4dp2) = 1.5 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch2 = 81380 kg = 813802 N

Resisting Shear of Concrete,

Vr2 = 1107386 N

Vr2	>	Vpunch2	OK	F.S.= 1.36

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.05 ton.m = 60469 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

φs * fyr = M * c /I >>>>> $\Sigma Ai*di^2$ = M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σdi^2)

As1= 7.5 cm2

B) Moment at the bottom of chimney about y axis My max = 2.68 ton.m = 26823 N.m

φs * fyr = M * c /I As2= 3.3 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area Ast =As1+As2+As3 = 23.9 cm2

As min =	max (0.1*Cs/Fy , 0.002*Ac) =			9.8	cm2		9.12 N		
As max =	0.04 *Ac =			196.0	cm2		9.5.2.3		
As =	23.9								
Rebar Diameter =	16	mm	=====> QTY =	12	=====>	16	=====>	16 Ø 16	
===>> As final=	32.2	cm2							
Rebar Quantity of One Row =	5								
Rebar Spacing =	13.8								

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a \le 1$ EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$	17.25	mm
$N_{Ed} =$	122.09	ton
$M_{0Ed,x} =$	5.53	ton.m
$e_0 = h /30 > 20$ mm ==> $e_0 =$	23	mm
$M_{Ed,x} =$	7.63	ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y} =$	1.96	ton.m
$M_{Ed,y} =$	4.07	ton.m
$As * F yr / bc^2 * f'c =$	0.164	
$N_{ED}/ f'c * bc^2 =$	0.122	
d2 =	144	mm
d2 / bc =	0.21	

Interaction Chart Gives ===> $M_{Rd} / f'c * bc^3 =$ 0.1 ===> $M_{Rd,x} = M_{Rd,y} =$ 46.62 ton.m

$N_{Rd} =$ Ac * f'c + As * Fyr = 802.62 ton

$N_{Ed} / N_{Rd} =$ 0.15 ===> a = 1.04

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$ 0.230 < 1 OK

Stirrup Rebar :

Max Spacing of links =	320	mm	EN 1992-1-1:2004 9.5.3.3
Rebar Space =	150	mm	==>> Ø8 @ 150 mm
Link Rebar Diameter =	8	mm	

Soil Type: Type 5-Poor Soil-Submerge
Foundation Type: Pad & Chimney
Tower Type: 12B-MA

Maximum Loads on Stub				
Description	*Load Combination*	*Stub Force Components*		
		Shear Force Transversal component	*Shear Force Longitudinal component*	*Axial force*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	510	-1,436	-110,989
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	697	-1,572	100,455

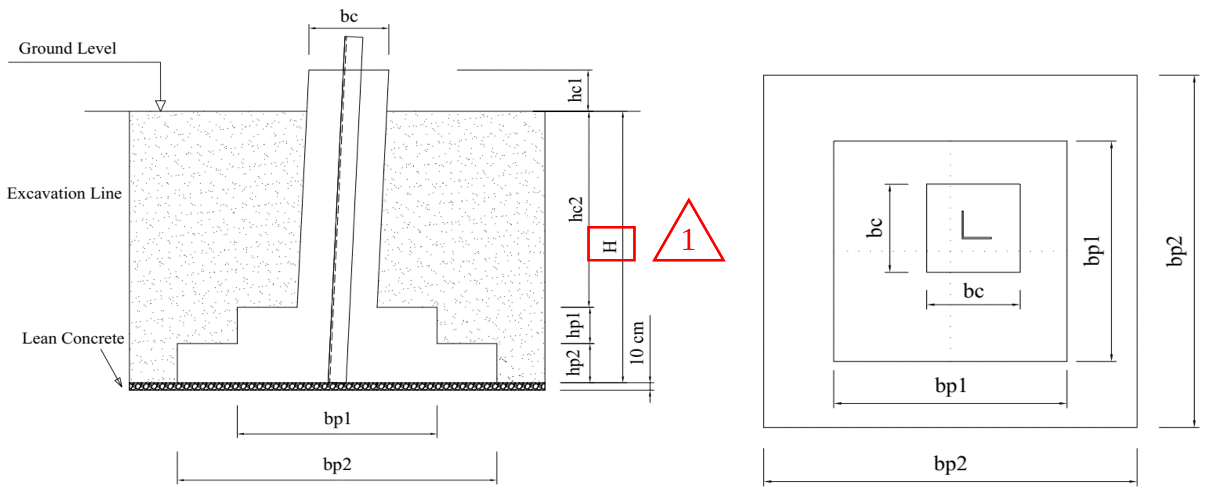
Maximum Loads on Foundation				
Description	*Load Combination*	*Foundation Components*		
		Transversal	*Longitudinal*	*Vertical*
		kg	kg	kg
Maximum Axial Force, Compression	60°C3,C NA+	18,407	19,333	-107,741
Maximum Axial Force, Uplift	60°C5, Min. WS,C NA+	16,882	-17,757	97,435

Design Standard: EN 1992:2004

Inputs:

Factor of Safety for Loads F.S.= 1.1 (As per Technical Specifications)

Foundation Dimensions	Width of Pad 1	bp1 =	2.2	m	
	Width of Pad 2	bp2 =	5.9	m	
	Height of Pad 1	hp1 =	0.25	m	
	Height of Pad 2	hp2 =	0.3	m	
	Width of Chimney	bc =	0.7	m	
	Height of Chimney above ground level	hc1 =	0.3	m	
	Height of Chimney unedr ground level	hc2 =	3.15	m	
	Depth of Pad	H =	3.7	m	
	Inplane Slope	β =	9.43	Degree	
	Diagonal Slope	γ =	13.20	Degree	
Soil Specifications	Soil Type	Type 5-Poor Soil-Submerge			
	Natural Soil Density	γ_s =	0.82	ton/m3	
	Backfill Density	γ_b =	0.82	ton/m3	Tech. Spec. Section C1 4.1
	Bearing Capacity	q_{all} =	0.82	kg/cm2	Tech. Spec. Section C1 4.1
	Frustum Angle	Θ =	0	Degree	
	Internal Friction Angle	ϕ =	15	Degree	EN 50341 Table M.4
	Friction Coefficient Between Soil and Concrete	μ =	0.4		
Concrete	Compressive Strength(28 days of Cylindrical Sample)	f 'c =	20	Mpa	
	Strength Reduction Factor	φc =	0.67		Tech. Spec. Section C1 3.2.2
	Allowable Compressive Strength	f 'c =	13.3	Mpa	
	Density	γ_c =	1.4	ton/m3	
	Pad Cover Thickness	cp=	0.075	m	
	Chimney Cover Thickness	cc=	0.075	m	
Steel	Yield Strength of Rebars	Fyr =	500	Mpa	
	Strength Reduction Factor	φs =	0.83		Tech. Spec. Section C1 3.2.2



Pad 1 ==> Top Pad
Pad 2 ==> Bottom Pad

* The foundation is cast inside formwork. 1

MİTAŞ ENERGY

Ultimate Loads:

On Foundation	Compression	C =	118.52	ton
		Vcx =	20.25	ton
		Vcy =	21.27	ton
	Uplift	T =	107.18	ton
		Vtx =	18.57	ton
		Vty =	-19.53	ton

On Stub	Compression	Cs =	122.09	ton
		Vscx =	0.56	ton
		Vscy =	-1.58	ton
	Uplift	Ts =	110.50	ton
		Vstx =	0.77	ton
		Vsty =	-1.73	ton

Soil Passive Pressure Coefficient	Kp = tan 2 (45+φ/2) =	1.70	
Passive Force on chimney,	Fp1 =	4.81	ton
Passive Force on pad1,	Fp2 =	2.49	ton
Passive Force on pad2,	Fp3 =	8.70	ton

Uplift:

Volume of chimney above ground level	V1 =	0.15	m3
Volume of chimney under ground level	V2 =	1.54	m3
Volume of pad1,	V3 =	1.21	m3
Volume of pad2,	V4 =	10.44	m3
Total volume of foundation ,	Vf =	13.34	m3

Total weight of foundation, Wf = Vf * γc = 18.68 ton

Cone volume, Vcone = $(h/3)*(\pi*h^2*\tan^2\Theta + 3*bp2^2 + 6*bp2*h*\tan\theta)$ = 123.58 m3

Soil volume above foundation, Vsoil =Vcone -V2 -V3 = 120.82 m3

Soil weight above foundation, Ws = Vsoil * γb = 98.53 ton

Total resistance force against uplift, Ru= Ws + Wf = 117.21 ton

Uplift Force, U= 107.18 ton

117.21	>	107.18	OK

S.F.= 1.09

Additional condition: G/Z > 0.8 EN 50341 M.3.1.6

G: weight of foundation and soil vertical to the base = 112.95 ton

Z: uplift force on fondation = 97.44 ton

Z/G = 1.16 >>> Ratio = 1.45 OK

1

Bearing Capacity:

Compression Force,	C =	118.86	ton
Bending Moment about x axis,	Mx =	6.41	ton.m
Bending Moment about y axis,	My =	2.27	ton.m

Over Load of Concrete Wf= 18.68 ton

Volume of the Soil directly above foundation Vsl = $(H * bp2^2)$ - V2 - V3 - V4 = 115.60 m3

Over Load of Soil directly above foundation Wsl= Vsl * γb = 94.27 ton

Average Bearing Pressure = σp = ((C + Wf + Wsl)/A) =	0.67	kg/cm2	<	0.82	kg/cm2	OK

Compression Stress at corner 1,	$\sigma p1 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3)$ =	0.69	kg/cm2
Compression Stress at corner 2,	$\sigma p2 = ((C + Wf + Wsl)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3)$ =	0.68	kg/cm2
Compression Stress at corner 3,	$\sigma p3 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3)$ =	0.65	kg/cm2
Compression Stress at corner 4,	$\sigma p4 = ((C + Wf + Wsl)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3)$ =	0.64	kg/cm2

Max. Toe Pressure =	0.69	<	q_{all} =	1.02	OK
Min. Toe Pressure =	0.64	>	0		OK

S.F.= 1.47

Top Surface Pressure due to Uplift:

Uplift Force,	T =	107.58	ton
Bending Moment about x axis,	Mx =	6.05	ton.m
Bending Moment about y axis,	My =	2.68	ton.m

Pressure due to Uplift at top surface at corner 1,	$\sigma u1 = ((T-Wf)/A) + (6*Mx)/(bp2^3) + (6*My)/(bp2^3)$ =	0.28	kg/cm2
Pressure due to Uplift at top surface at corner 2,	$\sigma u2 = ((T-Wf)/A) + (6*Mx)/(bp2^3) - (6*My)/(bp2^3)$ =	0.27	kg/cm2
Pressure due to Uplift at top surface at corner 3,	$\sigma u3 = ((T-Wf)/A) - (6*Mx)/(bp2^3) + (6*My)/(bp2^3)$ =	0.25	kg/cm2
Pressure due to Uplift at top surface at corner 4,	$\sigma u4 = ((T-Wf)/A) - (6*Mx)/(bp2^3) - (6*My)/(bp2^3)$ =	0.23	kg/cm2

Overturning:

Overturning Moment, Mo= Ts * ((((bp2/3)+((hp1+hp2) * tan β)*cos β) + (Vstmax * (((hc1+hc2+hp1+hp2)/cos β)- (((bp2/3)+(hp1+hp2) * tan β)* sin β))

Mo = 227.19 ton.m

Resisting Moment, Mr = (Ws/2)*(5*bp2/6)+Wf*(bp2/3)

Mr = 278.96 ton.m

Mr	>	Mo	OK

S.F.= 1.23

Sliding:

Sliding force, Fo = Vmax

Sliding force, Fo = 19.53 ton

Effective weight of foundation and soil at uplift case, Weff = 10.03 ton

Resisting force, Fr = Weff * μ + Fp1 + Fp2 + Fp3 =

Fr = 20.02

Fr	>	Fo	OK

S.F.= 1.02

Structural Design of Pad:

Longitudinal Rebar:

Compression :

Compression Stress at section of Max. bending moment at Pad 1, σmc1 = 0.67 kg/cm2

Compression Stress at section of Max. bending moment at Pad 2, σmc2 = 0.67 kg/cm2

Uplift :

Compression Stress at section of Max. bending moment at Pad 1, σmu1 = 0.26 kg/cm2

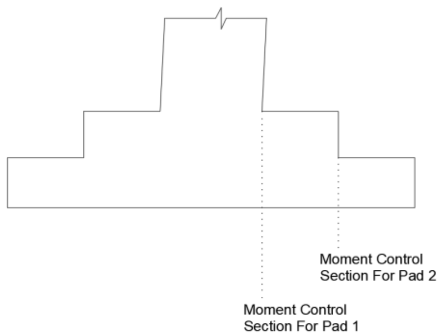
Compression Stress at section of Max. bending moment at Pad 2, σmu2 = 0.26 kg/cm2

Max. bending moment at Pad1, **(Compression)**

Muc 1= 8421020 kg.cm = 826102 N.m

Max. bending moment at Pad2, **(Compression)**

Muc 2= 4073628 kg.cm = 399623 N.m



Max. bending moment at Pad1, **(Uplift)**

Muu 1= 5341638 kg.cm = 524015 N.m

Max. bending moment at Pad2, **(Uplift)**

Muu 2= 2719517 kg.cm = 266785 N.m

Effective Depth of pad 1, dp1 = hp1+hp2 - cp = 0.475 m

Effective Depth of pad 2, dp2 = hp2 - cp = 0.225 m

Compression :

Pad 1:

K = Mu /f 'c * bp *dp^2 = 0.125 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 415 < 451.25 ==>>> OK

As = Mu / φs * fyr * z = 4776 mm2

Pad 2:

K = Mu /f 'c * bp *dp^2 = 0.100 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 202.9 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 4726.6 mm2

Uplift :

Pad 1:

$K = Mu / f'c * bp * dp^2 =$ 0.030 < 0.167 OK

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 462.3 > 451.25 ==>>> Zmax=0.95 dp = 451.25

As = Mu / φs * fyr * z = 2787.0 mm2

Pad 2:

$K = Mu / f'c * bp * dp^2 =$ 0.067

Z max = dp * (1 + (1-3.529K)^0.5)/2 <= 0.95 *dp

Z max = 210.8 < 213.75 ==>>> OK

As = Mu / φs * fyr * z = 3037.3 mm2

Top of Pad 1 :									
As1t=	2787.0		mm2						
Rebar Diameter=	16	mm	=====>	QTY =	14 ==>>	14	=====>	14 Ø 16	=====> 2815 mm2
Rebar Quantity =	14								
Rebar Spacing =	157.7	mm							
Top of Pad 2 :									
As2t=	3037.3	mm2							
Rebar Diameter=	12	mm	=====>	QTY =	27 ==>>	27	=====>	27 Ø 12	=====> 3054 mm2
Rebar Quantity =	27								
Rebar Spacing =	221.2	mm							
Bottom of Pad 2 :									
As2b=	4775.7	mm2							
Rebar Diameter=	16	mm	=====>	QTY =	24 ==>>	24	=====>	24 Ø 16	=====> 4825 mm2
Rebar Quantity =	24								
Rebar Spacing =	250.0	mm							

Min. Rebar Check:

Ast = 10694.0 mm2

ρst = 0.0057 >

ρmin = 0.26*(0.3*(f'c^(2/3))/Fyr > 0.0013 >>> 0.0013 EN 1992-1-1:2004 9.1N

ρmax = 0.040 EN 1992-1-1:2004 9.2.1.1

ρst > ρmin OK

ρst < ρmax OK

One Way Shear:

Compression Stress at critical section of shear at Pad1 , σv1 = 0.67 kg/cm2

Vu1 = 52787 kg = 527870 N

Compression Stress at critical section of shear at Pad2 , σv2 = 0.67 kg/cm2

Vu2 = 38564 kg = 385640 N

Pad 1

k = 1 +(200/dp1)^0.5 < 2.0 >>> k = 1.65 EN 1992-1-1:2004 6.2

$\rho_1 =$ 0.0057

$\sigma_{cp} = N_{ED}/A_C =$ 0 No Axial Force!

$C_{Rd,c} = 0.18/\gamma_c =$ 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2} =$ 0.331 Mpa EN 1992-1-1:2004 6.3N

Vr1 = 835888 N

Vr1	>	Vu1	OK

F.S= 1.58

Pad 2

k = 1 +(200/dp2)^0.5 < 2.0 >>> k = 1.94 EN 1992-1-1:2004 6.2

ρ_1 = 0.0059

$\sigma_{cp} = N_{ED}/A_C$ = 0

$C_{Rd,c} = 0.18/\gamma_c$ = 0.12

k1 = 0.15

$v_{min} = 0.035 * k^{3/2} * f'c^{1/2}$ = 0.424 Mpa EN 1992-1-1:2004 6.3N

Vr2 = 705998 N

Vr2	>	Vu2	OK

F.S= 1.83

Two Way Shear:

Average Compression Stress at the Middle of Pad , σ ave = 0.67 kg/cm2

Pad 1

Vpunch1 = 117910 kg = 1179099 N

Resisting Shear of Concrete,

Vr1 = 1854442 N

Vr1	>	Vpunch1	OK

F.S.= 1.57

Pad 2

To check if punch shear section is defined in Pad 2 ==> bp1 - (bp2 + 4dp2) = 2.8 > 0 ==> Punch Shear to be Checked in Pad 2

Vpunch2 = 98621 kg = 986208 N

Resisting Shear of Concrete,

Vr2 = 1391347 N

Vr2	>	Vpunch2	OK

F.S.= 1.41

Structural Design of Chimney:

Design of Longitudinal Reinforcement for Uplift :

A) Moment at the bottom of chimney about x axis Mx max = 6.05 ton.m = 60469 N.m

Rebar arrangement:

No. of rebars rows, n = 5

Total No. of rebars = 16

Distance of the last row to center, c = 27.5 cm

$\Sigma Ai*di^2$ = 8318

φs * fyr = M * c /I >>>>> $\Sigma Ai*di^2$ = M * c / φs * fyr

>>>>> A = M * c / (φs * fyr *Σdi^2)

As1= 7.5 cm2

B) Moment at the bottom of chimney about y axis My max = 2.68 ton.m = 26823 N.m

φs * fyr = M * c /I As2= 3.3 cm2

C) Axial required rebar area, As3 = Ts / (φs*Fyr) = 13.0 cm2

How Much of Uplift Force to be considered = 50 % of Uplift force is considered because Long Stub transfers 50 % of the force itself!

Total Required Longitudinal rebar area Ast =As1+As2+As3 = 23.9 cm2

As min = max (0.1*Cs/Fy , 0.002*Ac) = 9.8 cm2 9.12 N

As max = 0.04 *Ac = 196.0 cm2 9.5.2.3

As = 23.9

Rebar Diameter = 16 mm =====> QTY = 12 =====> 16 =====> 16 Ø 16

===>> As final= 32.2 cm2

Rebar Quantity of One Row = 5

Rebar Spacing = 13.8

Check for Compression :

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a$ <= 1 EN 1992-1-1:2004 5.39

$M_{Ed,x} = M_{0Ed,x} + e * N_{Ed} > e_0 * N_{Ed}$

$e = l_0 /400 = 2*(hc)/400 =$ 17.25 mm

$N_{Ed} =$ 122.09 ton

$M_{0Ed,x} =$ 5.53 ton.m

$e_0 = h /30 > 20$ mm ==> $e_0 =$ 23 mm

$M_{Ed,x} =$ 7.63 ton.m

$M_{Ed,y} = M_{0Ed,y} + e * N_{Ed} > e_0 * N_{Ed}$

$M_{0Ed,y} =$ 1.96 ton.m

$M_{Ed,y} =$ 4.07 ton.m

$As * F yr / bc^2 * f'c =$ 0.164

$N_{ED}/ f'c * bc^2 =$ 0.122

d2 = 144 mm

d2 / bc = 0.21

Interaction Chart Gives ===> $M_{Rd} / f'c * bc^3 =$ 0.1 ===> $M_{Rd,x} = M_{Rd,y} =$ 46.62 ton.m

$N_{Rd} =$ Ac * f'c + As * Fyr = 802.62 ton

$N_{Ed} / N_{Rd} =$ 0.15 ===> a = 1.04

$(M_{Ed,x}/M_{Rd,x})^a+(M_{Ed,y}/M_{Rd,y})^a =$ 0.230 < 1 OK

Stirrup Rebar :

Max Spacing of links = 320 mm EN 1992-1-1:2004 9.5.3.3
Rebar Space = 150 mm ==>> Ø8 @ 150 mm
Link Rebar Diameter = 8 mm