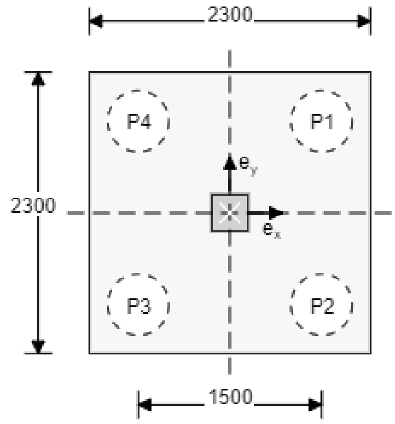
1.0 INPUT

1.1 Pile cap



Pile Shape			**Circle**
Pile Diameter	D	=	**500** mm
Spacing of Piles	s	=	**1500** mm
Pile cap Overhang	e	=	**150** mm
Thickness of Pile cap	h	=	**1200** mm

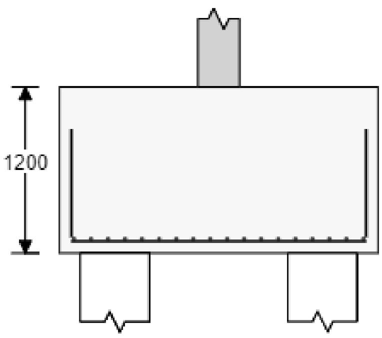
1.2 Column

Column Shape			**Rectangle**
Column Dimension - X Direction	x	=	**300** mm
Column Dimension - Y Direction	y	=	**300** mm
Eccentricity - X Direction	e_x	=	**0** mm
Eccentricity - Y Direction	e_y	=	**0** mm

1.3 Reinforcement

Reinforcement Provided			**20** @ **125** mm C/C
	A_{st}	=	**2513.3** mm^2/m
Clear Cover	C_{ot}	=	**75** mm

1.4 Design Loads



Main Reinforcement 20ϕ - 125 c/c bothways

Factored Axial Load	F_{ult}	=	**4000** kN
Un-factored Axial Load	F_{work}	=	**2000** kN

1.5 Materials

Concrete Grade	f_{cu}	=	**35** N/mm^2
Main Reinforcement Grade	f_y	=	**460** N/mm^2
Density of Concrete	γ_{con}	=	**24** kN/m^3

1.6 Material Safety Factors

Concrete in Compression	γ_{mc}	=	**1.5**
Concrete in Shear	γ_{mcs}	=	**1.25**
Reinforcement	γ_{ms}	=	**1.15**

2.0 OUTPUT

Ref: BS 8110 - Part 1

2.1 Dimensions

Pile cap Length	L	=s + D + 2 * e = **2300** mm
Pile cap Width	b	=s + D + 2 * e = **2300** mm

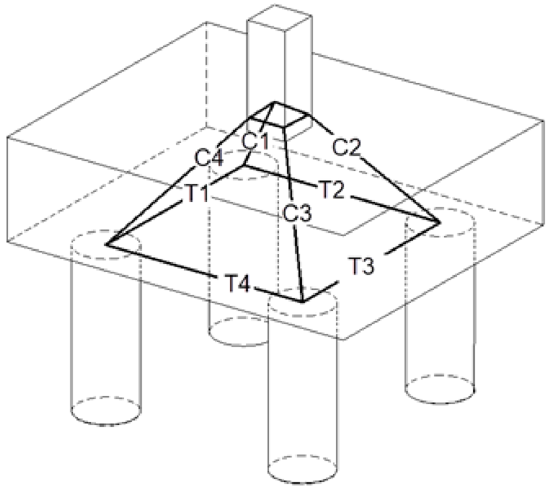
Effective Depth d = **1115** mm

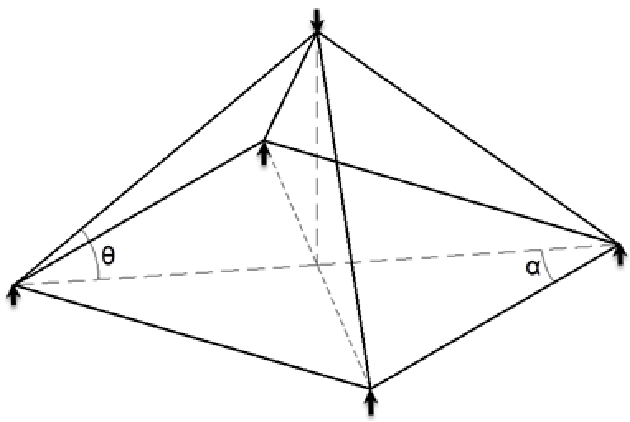
2.2 Pile Loads (Factored)

Load on each Pile F_{pile} $= F_{ult} * (s / 2 + e_x) * (s / 2 + e_y) / s =$ **1000** kN

2.3 Strut and Tie Analogy

The pile cap forces are computed on the basis of strut and tie analogy wherby the force from the column is assumed to be transmitted by a triangular truss action with concrete providing the compressive members of the truss and steel reinforcement providing the tensile member.





2.3.1 Angle Computations

Vertical Angle θ $= \tan^{-1}(d / \sqrt{(s / 2 - e_x)^2 + (s / 2 - e_y)^2}) =$ **46.4** deg

Horizontal Angle α $= \tan^{-1}((s / 2 - e_x) / (s / 2 - e_y)) =$ **45** deg

2.3.2 Truss Member Forces

Compressive Force within Pile cap C $= F_{pile} / \sin \theta =$ **1380.2** kN

Tensile Force within Pile cap T $= C * \cos \theta * \cos \alpha =$ **672.6** kN

2.4 Pile cap Compression Check

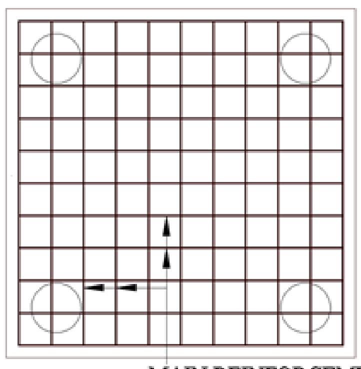
Compression Capacity for Pile c/s P_c $= 0.67 / \gamma_{mc} * f_{cu} * \pi * (D^2 / 4) =$ **3069.6** kN *Cl. 3.8.4.3*

2.5 Pile Loads (Un-factored Loads)

Selfweight of Pile cap S_{wt} $= L * b * h * \gamma_{con} =$ **152.4** kN

Reaction at each Pile $F_{workpile}$ $= F_{work} * (s / 2 + e_x) * (s / 2 + e_y) / s + S_{wt} / 4 =$ **538.1** kN

2.6 Reinforcement Design



MAIN REINFORCEMENT

Minimum Area of Reinforcement /m A_{stmin} $= 0.0013 * 1000 * h =$ **1560** mm^2 *Table 3.25*

Maximum Area of Reinforcement /m	A_{stmax}	$= 0.04 * 1000 * h =$ **48000** mm^2	*Cl 3.12.6*
Reinforcement Required for Tension /m	A_{sreq1}	$= 2 * T / (f_y / \gamma_{ms}) * 1000 / \min(3 * D , D + s + 2 * e)$ $=$ **2242.2** mm^2	
Area of Reinforcement Required /m	A_{sreq}	$= \max(A_{stmin}, A_{sreq1}) =$ **2242.2** mm^2	

2.7 Shear - One Way

Shear Plane Width at Pile	b_v	$= s + D + 2 * e =$ **2300** mm	
Shear Stress at Pile	v	$= (F_{pile} + F_{pile}) / (b_v * d) =$ **0.78** N/mm^2	*Cl. 3.5.5.2*
Max. Allowable Shear Stress	v_{max}	$= \min(0.8 * \sqrt{f_{cu}}, 5) =$ **4.733** N/mm^2	*Cl. 3.4.5.12*
Percentage of Provided Reinforcement	P_t	$= 100 * A_{st} / (b_v * d) =$ **0.1** %	
Design Concrete Shear Stress at Pile	v_c	$=$ **0.326** N/mm^2	*Table 3.8*
	a	$= (s / 2 - e_y - D / 2 + D / 5 - y / 2) =$ **450** mm	
Critical Section Distance for Pile	a_v	$= \min(2 * d, a) =$ **450** mm	*Cl. 3.11.4.3*
Enhanced Shear Strength at Pile	v_{cenh}	$= \min(v_{max}, (2 * d * v_c) / a_v) =$ **1.615** N/mm^2	*Cl. 3.11.4.4*

2.8 Punching Shear Check

Punching Shear Stress at Column Face	v_{punch}	$= F_{ult} / (2 * (x + y) * d) =$ **2.99** N/mm^2	*Cl. 3.11.4.5*
Punching Shear Stress at 1.5d	$v_{1.5d}$	$= F_{ult} / ((2 * (x + y) + 12 * d) * d) =$ **0.246** N/mm^2	

3.0 SUMMARY

Description	Required		Actual		Status
Compressive Force (kN)	P_c	<= **3069.6**	C	= **1380.2**	**PASS**
Area of Tension Steel (mm^2/m)	A_{sreq}	>= **2242.2**	A_{st}	= **2513.3**	**PASS**
Maximum Area of Reinforcement (mm^2/m)	A_{stmax}	<= **48000**	A_{st}	= **2513.3**	**PASS**
Punching Shear at Column Face (N/mm^2)	V_{max}	<= **4.733**	v_{punch}	= **2.99**	**PASS**
Punching Shear Stress at 1.5d (N/mm^2)	v_c	<= **0.326**	$v_{1.5d}$	= **0.246**	**PASS**
Shear Stress at Pile (N/mm^2)	v_{cenh}	<= **1.615**	v	= **0.78**	**PASS**