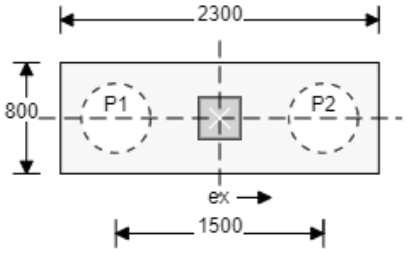
1.0 INPUT

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

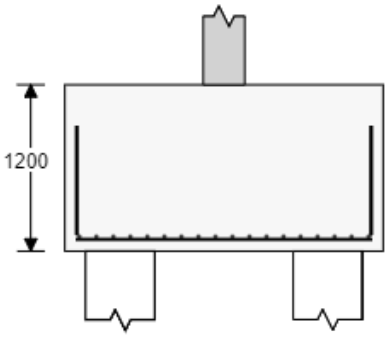
Column Shape		**Rectangle**
Column Dimension - X Direction	x	= **300** mm
Column Dimension - Y Direction	y	= **300** mm
Eccentricity from Centroid of Pile cap	e_x	= **0** mm

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

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



Main Reinforcement 20ϕ - 125 c/c

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

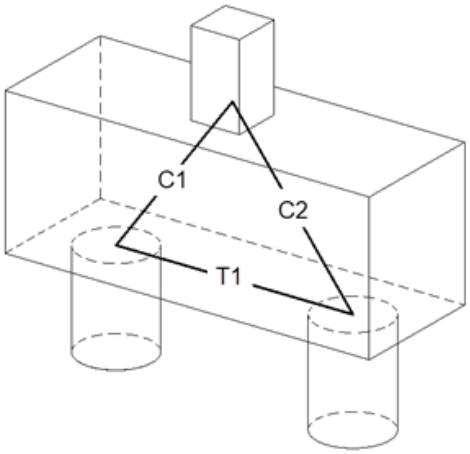
Pile cap Length	L	=s + D + 2 * e = **2300** mm
Pile cap Width	b	=D + 2 * e = **800** mm
Effective Depth	d	=**1115** mm

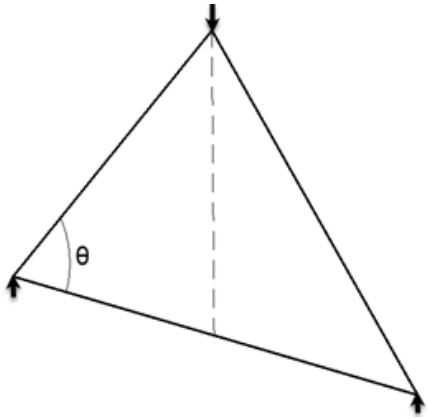
2.2 Pile Loads (Factored)

Load on each Pile	F_{pile}	$=F_{ult} * ((s / 2) - e_x) / s =$ **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	$=\tan^{-1}(d / (s / 2) + e_x) =$ **56.1** deg	

2.3.2 Truss Member Forces

Compressive Force within Pile cap	C	$=F_{pile} / \sin \theta =$ **1205.2** kN	
Tensile Force within Pile cap	T	$=C * \cos \theta =$ **672.6** kN	

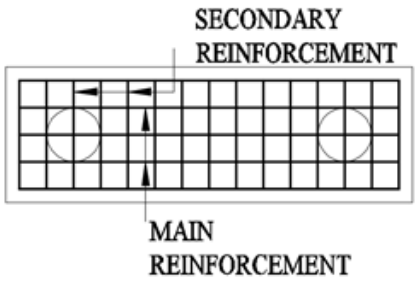
2.4 Pile cap Compression Check

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}	$=L * b * h * \gamma_{con} =$ **53** kN	
Reaction at each Pile	$F_{workpile}$	$=F_{work} * ((s / 2) - e_x) / s + S_{wt} / 2 =$ **1026.5** kN	

2.6 Reinforcement Design



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}	$=T / (f_y / \gamma_{ms}) * 1000 / \min(3 * D , D + 2 * e)$ $=$ **2102** mm^2	
Area of Reinforcement Required /m	A_{sreq}	$=\max(A_{stmin}, A_{sreq1}) =$ **2102** mm^2	

2.7 Shear - One Way

Shear Plane Width	b_v	=max(3 * D, b) = **800** mm	
Shear Stress at Pile	v	=F_{pile} / (b_v * d) = **1.121** N/mm^2	*Cl. 3.4.5.2*
Max. Allowable Shear Stress	v_{max}	=min(0.8 * √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) = **0.3** %	
Design Concrete Shear Stress	v_c	=**0.464** N/mm^2	*Table 3.8*
	a	=(s / 2) + e_x - D / 2 + D / 5 - x / 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) = **2.297** 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) = **1.495** 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) = **0.123** N/mm^2	

3.0 SUMMARY

Description	Required		Actual		Status
Compressive Force (kN)	P_c	<= **3069.6**	C	= **1205.2**	**PASS**
Area of Tension Steel (mm^2/m)	A_{sreq}	>= **2102**	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}	= **1.495**	**PASS**
Punching Shear Stress at 1.5d (N/mm^2)	v_c	<= **0.464**	$v_{1.5d}$	= **0.123**	**PASS**
Shear Stress at Pile (N/mm^2)	v_{cenh}	<= **2.297**	v	= **1.121**	**PASS**