STRUCTURAL DESIGN OF A REINFORCED CONCRETE RESIDENTIAL BUILDING

IDENTIFICATION

PROVINCE**:** WESERTHN PROVINCE

DISTRICT**:** RUBAVU

SECTOR**:** RUGERERO

Plot N^{o}: 577

Owner: **UWAMAHORO Aimable**

Date: February/2017

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0. INTRODUCTION

The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended purpose. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction, use and have adequate durability and resistance to the effects of misuse and fire.

Once the building form and structural arrangement have been finalized the design problem consists of the following:

Idealization of the structure into loadbearing frames and elements for analysis and design
Estimation of loads
Analysis to determine the maximum moments, thrusts and shears for design
Design of sections and reinforcement arrangements for slabs, beams, columns and walls using the results from 3
Production of arrangement and detail drawings and bar schedules

This structural design process has been carried out under use of BS8110 design code of practice. Especially, computations have been made by use of BS 8110 based spreadsheets; publication produced by the Reinforced Concrete Council (RCC) as part of its project 'Spreadsheets for concrete design to BS 8110 and EC2'.

1. NOTATIONS

The symbolic notation used in this project is in accordance with the BS code of practice. Other symbols not defined here, have been defined alongside the particular place where they have been applied.

A: cross section area

A_{smin}: minimum required reinforcement section

B : width of foundation footing, Beam

b: width reinforced concrete section

b_f : width of flange in a beam

b_w : width of web of a flanged a beam

C : cover

d : effective depth of tensile reinforcement

H : depth of foundation

f_{cu}: characteristic yield strength of concrete at 28 days

f_y: characteristic yield strength of steel

G_K: dead load

h: overall depth of a concrete section

h_f: thickness of flange in a T-beam

L : span length

l_x : short-span length

l_y: long-span length

M : bending moment

p: perimeter

q_{adm}: bearing pressure

Q_k: imposed load

S: spacing of shear reinforcement

V: shear force in concrete section

$Ø_t$: shear reinforcement diameter

Ø: reinforcement diameter

B.S: British standard

C.P: Code of Practice

RC: Reinforced concrete

m.f: modification factor

2. ASSUMPTIONS

Design standards used

Design standard used to determine section of steel bars of different structural elements of concerned building are BS 8110

Unities

Volumetric load:	kN/m^3
Surface load:	kN/m^2
Linear load:	kN/m
Point load:	kN

Dead loads

Roof structure:	$1.5kN/m^2$
Reinforced concrete:	$25kN/m^3$
Finishes:	$1.0kN/m^2$
Masonry in burnt bricks:	$18kN/m^3$
Coating in cement mortar:	$20kN/m^3$
Masonry in cement blocks:	$13.5kN/m^3$

Imposed load or live load

Residential building:	$3kN/m^2$

Cover conditions

Slabs, beams and columns [mild condition]:	20mm
Foundation pads [moderate condition]:	40mm

Soil characteristics

Sandy-gravel subsoil of unit weight:	$18kN/m^3$

Allowable bearing pressure: 300 kN/ m^2

Mix proportions [BS 5328-2]

Mix ratio: 350 kg/ m^3

Elasticity limit for construction materials

Strength of reinforcement:

Hot rolled mild steel: 250 N/mm^2
High yield steel (hot rolled or cold worked): 420 N/mm^2

Concrete f_{ck}: 25N/mm^2

Partial safety magnification factors

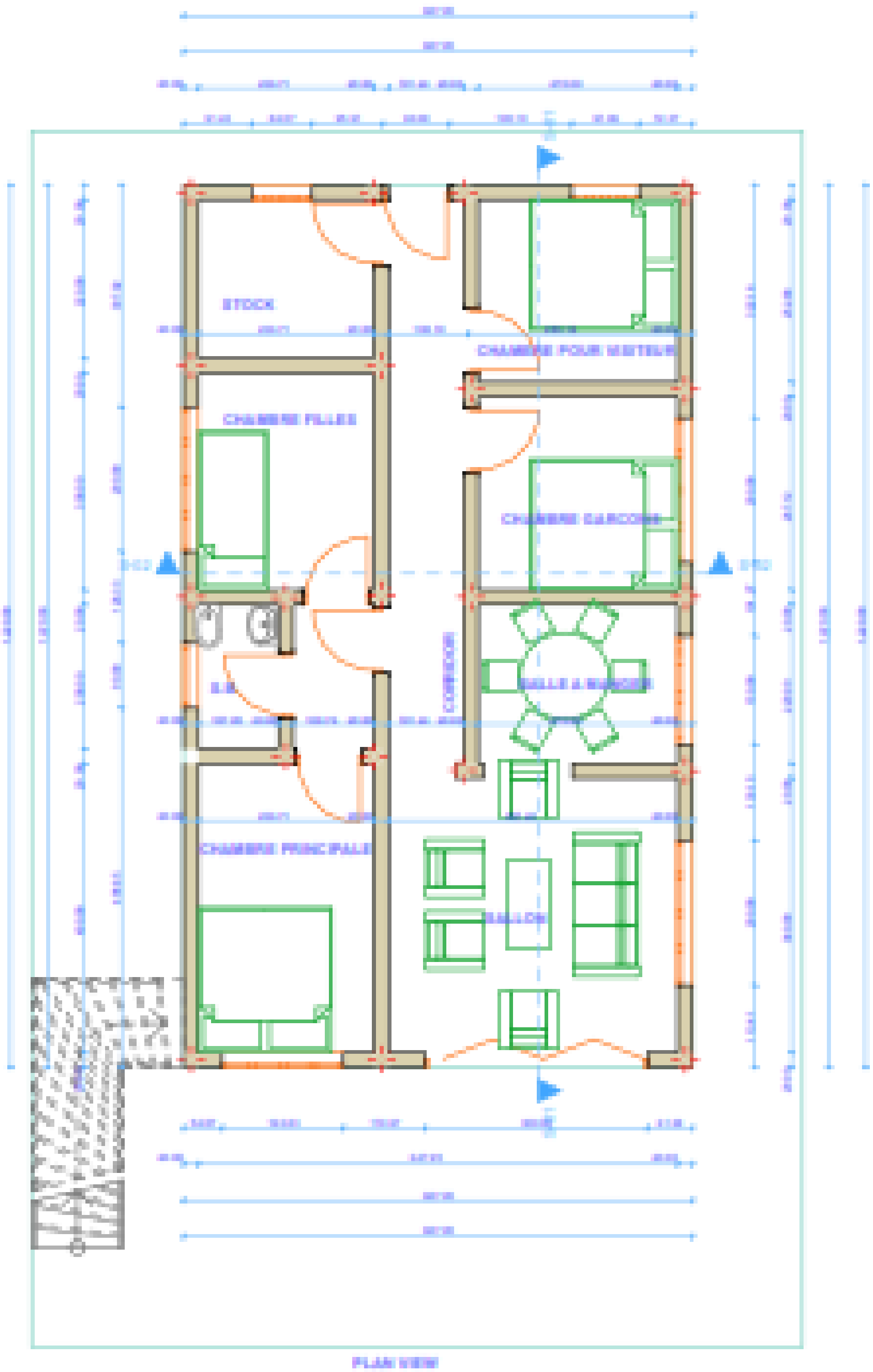
For dead load: 1.4

For live load: 1.6

Basic span-effective depth ration: 26

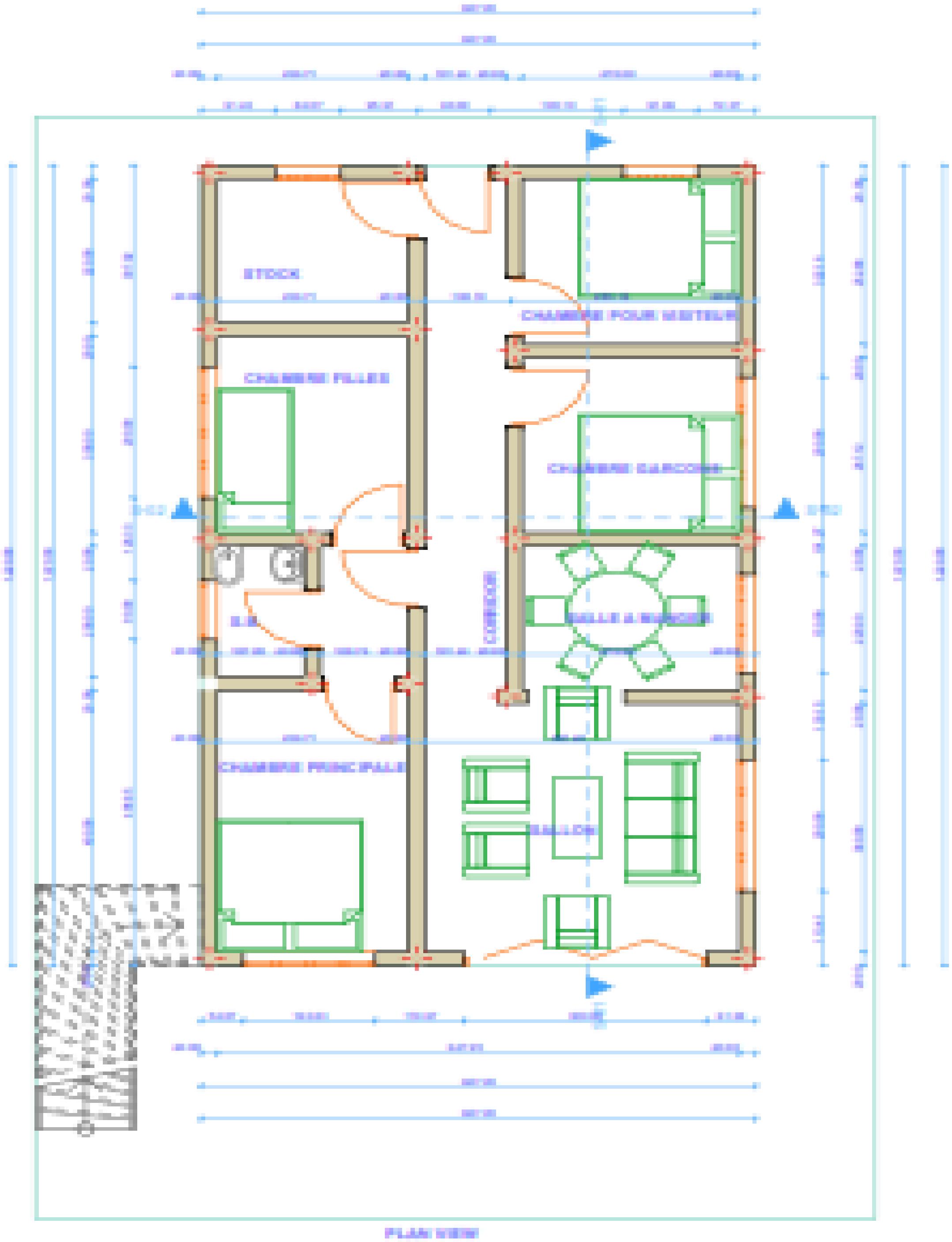
3. LAYOUT OF OVERALL PLAN [STRUCTURAL ARRANGEMENT]

Foundations, columns, beams, slabs Frame with walls



4. CALCULATION AND DESIGN OF SLABS: Critical slabs EG-59 ROOM

FIRST FLOOR Layout



Calculation and design

LOCATION Supports from grid E to grid G

MATERIALS

fcu	25	N/mm²	h agg	20	mm
fy	420	N/mm²	γs	1.05	steel
fyv	420	N/mm²	γc	1.50	concrete

COVERS

Top cover	25	mm
Btm cover	25	mm

SPANS

	L (m)	H (mm)
SPAN 1	4.800	150
SPAN 2		
SPAN 3		
SPAN 4		
SPAN 5		
SPAN 6		

SUPPORTS

Support No	Type
1	E
2	E

K(nife), C(antilever) or E(ncastre)

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED		1.6

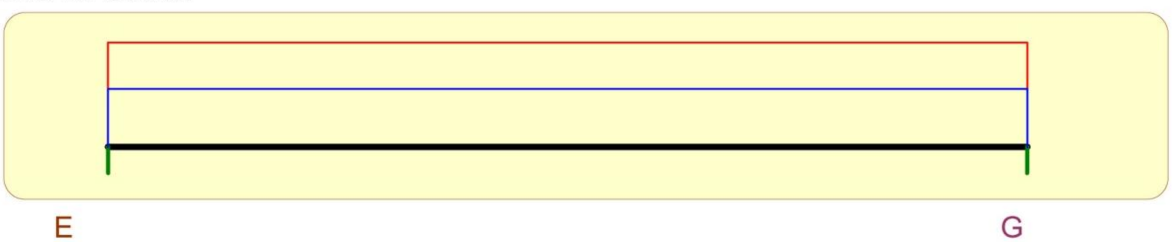
LOADING UDLs (kN/m²) PLs (kN/m) Position (m)

	Dead Load	Imposed Load	Position from left
Span 1			
UDL	3.75	3.00	~~~~
PL 1			
PL 2			
Span 2			
UDL			
PL 1			
PL 2			
Span 3			
UDL			
PL 1			
PL 2			

LOADING

	Dead Load	Imposed Load	Position from left
Span 4			
UDL			
PL 1			
PL 2			
Span 5			
UDL			
PL 1			
PL 2			
Span 6			
UDL			
PL 1			
PL 2			

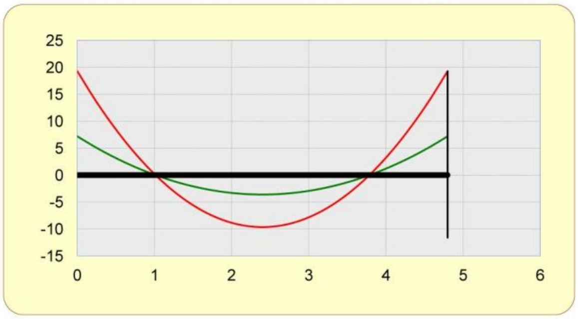
LOADING DIAGRAM

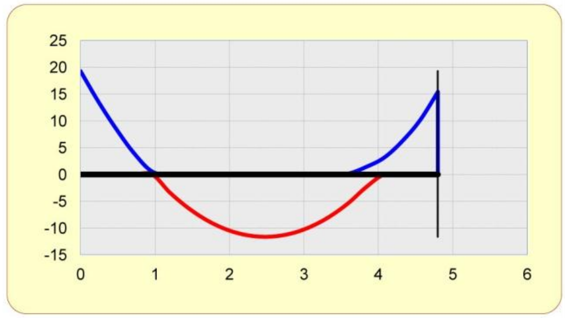


REACTIONS (kN/m)

SUPPORT	1	2
Characteristic Dead	9.00	9.00
Max Imposed	7.70	6.70
Min Imposed	-2.44	-2.06
MAX ULTIMATE	24.92	23.32

BENDING MOMENT DIAGRAMS (kNm/m)





E Elastic Moments G

E Redistributed Envelope G

SUPPORT No	1	2					
Elastic M	19.3	19.3	~	~	~	~	~
Redistributed M	19.3	15.4	~	~	~	~	~
ßb	1.000	0.800	~	~	~	~	~
Redistribution		20.0%	2.0%	10.0%	1.0%		

SPAN No	1					
Elastic M	9.6	~	~	~	~	~
Redistributed M	11.6	~	~	~	~	~
ßb	1.203	~	~	~	~	~

SHEAR FORCE DIAGRAMS (kN/m)

E Elastic Shears G

E Redistributed Shears G

SPAN No	1					
Elastic V	24.1	24.1	~	~	~	~
Redistributed V	24.9	23.3	~	~	~	~

SPAN No						
Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

SPAN 1				LEFT			CENTRE			RIGHT	
	Av	mm		0						4800	
ACTIONS	M	kNm/m		19.3			11.6			15.4	
	ßb			1.00			1.20			0.80	
	V	kN/m		24.92						23.32	
DESIGN	d	mm		111.0			112.0			111.0	
	As	mm²/m		470			360			370	
	As'	mm²/m		0		As top	360		As'	0	
TOP STEEL			R	12	@ 225	R	12	@ 300	R	12	@ 300
	As prov	mm²/m		503		As' prov	377		As prov	377	
BTM STEEL			R	10	@ 200	R	10	@ 200	R	10	@ 200
	As' prov	mm²/m		393		As prov	393		As' prov	393	
SHEAR	v	N/mm2		0.225						0.210	
	vc	N/mm2		0.669						0.608	
					8		Links not required				
DEFLECTION	L/d			42.857		Allowed	56.949	ok			
& CHECKS	% As			ok			ok			ok	
	d'/x			ok			ok			ok	
	max S			ok			ok			ok	

WEIGHT of REINFORCEMENT

		SUPPORT	WIDTH	SUPPORT	WIDTH	Bay width	10000	mm
SUPPORT WIDTHS		1	300		300			
(mm)		2	300		300	DISTRIBUTION STEEL		
			300			ϕ	10	mm

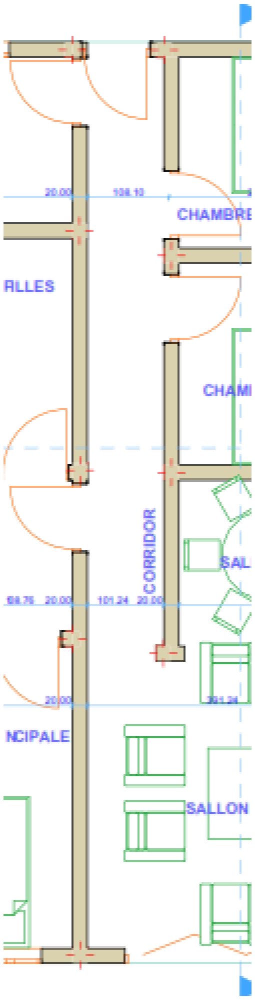
TOP STEEL		Type	Dia		Spacing	No	Length	Unit wt	Weight
	Support 1	R	12	@	225	45	1425	0.888	56.9
	Span 1	R	12	@	300	34	3450	0.888	104.1
	Support 2	R	12	@	300	34	1425	0.888	43.0
BOTTOM STEE	Support 1	R	10	@	200	50	825	0.617	25.4
	Span 1	R	10	@	200	50	4450	0.617	137.2
	Support 2	R	10	@	200	50	850	0.617	26.2
DISTRIBUTION STEEL									
Bottom	Span 1	R	10	@	200	23	10500	0.617	148.9
Top	Span 1	R	10	@	200	23	10500	0.617	148.9

SUMMARY *Links not included. All figures approximate - see User Guide.*

REINFORCEMENT DENSITY (kg/m³) 87.7 TOTAL REINFORCEMENT IN BAY, kg 691

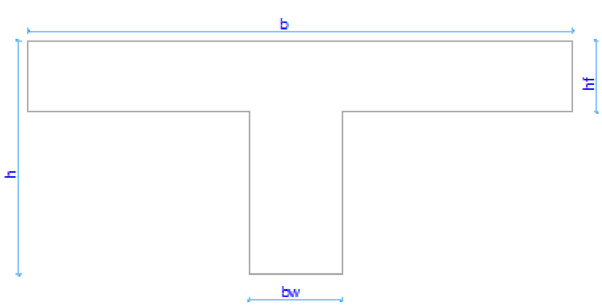
5. CALCULATION AND DESIGN OF A BEAMS: Critical beams

Beam 1 Layout



Calculation and design

Type: T beams



Transverse Section of beam

Breadth of the web, b_w = 200 mm

L_1=1.90m

L_2=1.80m

L_3=4.60m

Nominal diameter 8 mm links and 16 mm for main bars

Basic span-effective depth ration=26 (simple supported beam)

Preliminary analysis

The overall depth of the beam is given by:

The effective depth of the beam:

$$\frac{l}{d} \leq 26 \rightarrow d \geq \frac{l}{26}$$

Breadth of the web b_w=20, $t = \frac{\emptyset_t}{2} + \emptyset_l$=8+8=16

For a long span $\frac{l}{d} \leq 26 \rightarrow d \geq \frac{l}{26}$=$\frac{4600mm}{26}$ =176mm

Try d=176mm

d_t=h_f+d=150+176 =326mm h=d_t+cover+t=326+20+16≈362mm   h=450mm

The effective breadth b_f of flanged beams is given in BS8110:

1. T-beams-web width b_w+l_z/5 or the actual flange width if less

2. L-beams-web width B_W+l_z/10 or the actual flange width if less

Where l_z is the distance between points of zero moment in the beam. In continuous beams l_z may be taken as 0.7 times the effective span.

A general b_f for this continuous beam has been taken as:

$$b_f = bw + \left(0.7 \times \frac{l}{5}\right) = 200 + \left(0.7 \times \frac{4800}{5}\right) = 872mm$$

The area of the T-beam is given by:

Load Surface of the span E-G of the beam FS=6.53m^2

Load Surface of the span G-H of the beam FS=5.12m^2

Load Surface of the span H-K of the beam FS=7.13m^2

DEAD LOAD ESTIMATION ON BEAMS

Wall	N_w [KN/m3]	S_w [m2]	G_w[KN/m]	Finishes	N_w [KN/m^3]	S_w [m2]	G_f[KN/m]	G_w+G_f[KN/m]			
1	18	0.7	12.6	1	20	0.14	2.8	15.4			
SLAB	N_s [KN/m3]	S [m2]	l[m]	Q_p[KN/m]	BEAM	H-Hf	bw [m]	N [KN/m^3]	G_f[KNm]	Wall+ finishing	Dead load G_k [KNm]
EG	6.75	6.53	1.9	**1.96**	EG	0.3	0.2	25	**1.5**	**15.4**	18.86
G-H	6.75	5.12	1.8	**2.37**	G-H	0.3	0.2	25	**1.5**	**15.4**	19.27
H-K	6.75	7.13	4.6	**4.35**	H-K	0.3	0.2	25	**1.5**	**15.4**	21.25

LIVE LOAD ESTIMATION ON BEAMS

BEAM	l[m]	N [KN/m^2]	S [m2]	G_k[KN/m]
EG	1.9	3	6.53	0.87
G-H	1.8	3	5.12	1. 05
H-K	4.6	3	7.13	1.93

Computation

LOCATION Supports from grid E1 to grid E6

MATERIALS

fcu	25	N/mm²	h agg	20	mm	Top cover	20	mm
fyl	420	N/mm²	γs	1.05		Btm cover	20	mm
fyv	250	N/mm²	γc	1.50		Side cover	20	mm

COVERS (to all steel)

SPANS	L (m)	H (mm)	bw (mm)	hf (mm)	Type	bf (mm)
SPAN 1	1.90	300	200	150	T	350
SPAN 2	1.80	300	200	150	T	350
SPAN 3	4.60	300	200	150	T	350
SPAN 4						
SPAN 5						
SPAN 6						

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED	0	1.6

REBAR LAYERING
Support steel in alt layer ? Y

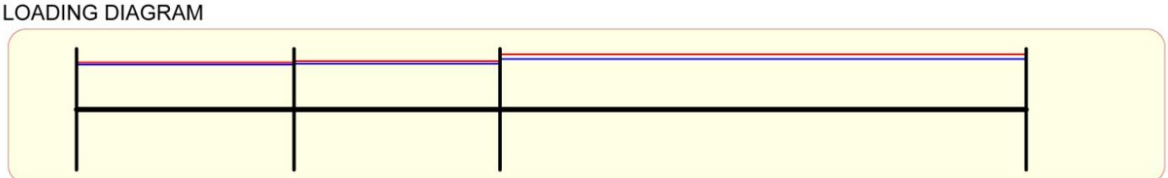
SUPPORTS	ABOVE (m)	H (mm)	B (mm)	End Cond	BELOW (m)	H (mm)	B (mm)	End Cond
Support 1	3.00	200	200	F	3.00	200	200	F
Support 2	3.00	200	200	F	3.00	200	200	F
Support 3	3.00	200	200	F	3.00	200	200	F
Support 4	3.00	200	200	F	3.00	200	200	F
Support 5								
Support 6								
Support 7								

LOADING UDLs (kN/m) PLs (kN) Position (m)

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 1				
UDL	18.9	0.9	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 2				
UDL	19.3	1.1	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 3				
UDL	21.3	1.9	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 4				
UDL				
PL 1				
PL 2				
Part UDL				
Span 5				
UDL				
PL 1				
PL 2				
Part UDL				
Span 6				
UDL				
PL 1				
PL 2				
Part UDL				

LOADING DIAGRAM

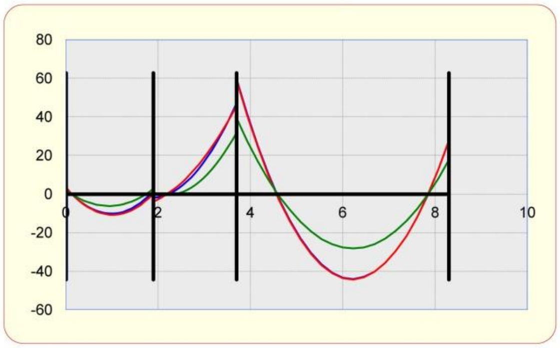


E1 E6

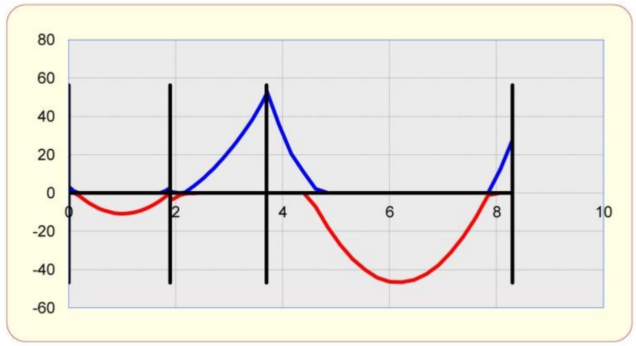
REACTIONS (kN)

SUPPORT	1	2	3	4
ALL SPANS LOADED	27.3	21.4	136.9	69.8
ODD SPANS LOADED	28.1	11.9	128.6	69.9
EVEN SPANS LOADED	17.6	25.1	99.2	43.3
Characteristic Dead	18.4	17.3	88.3	44.4
Characteristic Imposed	1.5	4.9	11.9	4.9

BENDING MOMENT DIAGRAMS (kNm)



E1 Elastic Moments E6



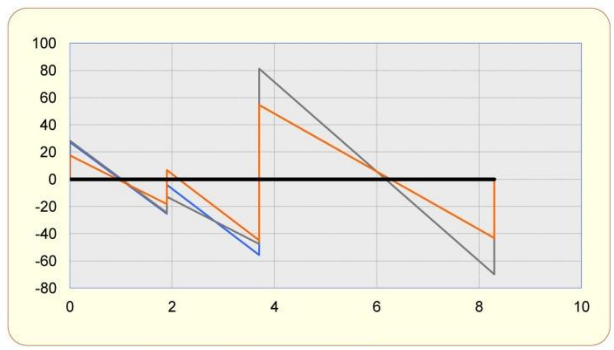
E1 Redistributed Envelope E6

SUPPORT No	1	2	3	4			
Elastic M	3.4	2.7	59.6	27.7	~	~	kNm/m
Redistributed M	3.4	2.7	53.7	27.7	~	~	kNm/m
ßb	1.000	1.000	0.900	1.000	~	~	~
Redistribution			10.0%				

SPAN No	1	2	3			
Elastic M	10.77	3.87	44.25	~	~	~
Redistributed M	10.77	3.87	46.76	~	~	~
ßb	1.000	1.000	1.057	~	~	~

SHEARS (kN)

E1 Elastic Shears E6



E1 Redistributed Shears E6

SPAN No	1		2		3	
Elastic V	28.1	25.5	8.6	53.1	82.5	68.7
Redistributed V	28.1	25.5	6.8	55.7	81.2	69.9

Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

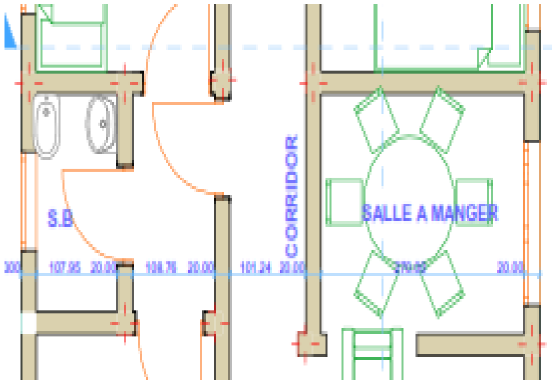
COLUMN MOMENTS (kNm)		1	2	3	4
ALL SPANS	Above	1.6	-1.8	6.3	-13.8
LOADED	Below	1.6	-1.8	6.3	-13.8
ODD SPANS	Above	1.7	-2.0	6.6	-13.8
LOADED	Below	1.7	-2.0	6.6	-13.8
EVEN SPANS	Above	1.0	-0.9	3.8	-8.8
LOADED	Below	1.0	-0.9	3.8	-8.8

SPAN 1				LEFT			CENTRE			RIGHT	
ACTIONS	M	kNm		0.8			10.8			0.9	
	ßb			1.00			1.00			1.00	
DESIGN	d	mm		254.0			265.0			248.0	
	As	mm^2		8			107			10	
	As'	mm^2									
TOP STEEL	Layer 1		2	R	12	2	R	12	2	R	16
	Layer 2										
	As prov	mm^2		226		As' prov	226		As prov	402	
BTM STEEL	Layer 1		2	R	10	2	R	14	2	R	12
	Layer 2										
	As' prov	mm^2		157		As prov	308		As' prov	226	
DEFLECTION			L/d	7.170		Allowed	51.316				
SHEAR	V	kN		18.3			Link Ø			15.8	
	v	N/mm^2		0.360			8			0.319	
	vc	N/mm^2		0.541			Nominal			0.664	
LINKS				R8 @ 175 for 525			R8 @ 175			R8 @ 175 for 525	
	legs	No		2			2			2	
CHECKS	% As			ok			ok			ok	
	Cover			ok			ok			ok	
	min S			ok			ok			ok	
	max S			ok			ok			ok	
	Links			ok			ok			ok	
	Main bars			ok			ok			ok	
	max V			ok						ok	
	Deflection						ok				

SPAN 2				LEFT			CENTRE			RIGHT	
ACTIONS	M	kNm		0.3			3.9			46.3	
	ßb			1.00			1.00			1.10	
DESIGN	d	mm		246.0			264.0			246.0	
	As	mm^2		3			39			602	
	As'	mm^2									
TOP STEEL	Layer 1		2	R	16	2	R	16	3	R	16
	Layer 2										
	As prov	mm^2		402		As' prov	402		As prov	603	
BTM STEEL	Layer 1		2	R	12	2	R	12	2	R	12
	Layer 2										
	As' prov	mm^2		226		As prov	226		As' prov	226	
DEFLECTION			L/d	6.818		Allowed	54.872				
SHEAR	V	kN		3.1			Link Ø			45.8	
	v	N/mm^2		0.063			10			0.930	
	vc	N/mm^2		0.530			Nominal			0.764	
LINKS				R10 @ 175 for 525			R10 @ 175			R10 @ 175 for 525	
	legs	No		2			2			2	
CHECKS	% As			ok			ok			ok	
	Cover			ok			ok			ok	
	min S			ok			ok			ok	
	max S			ok			ok			ok	
	Links			ok			ok			ok	
	Main bars			ok			ok			ok	
	max V			ok						ok	
	Deflection						ok				

SPAN 3			LEFT			CENTRE			RIGHT		
ACTIONS	M	kNm		45.7			46.8			20.9	
	ßb			0.90			1.06			1.00	
DESIGN	d	mm		246.0			262.0			246.0	
	As	mm^2		590			470			231	
	As'	mm^2									
TOP STEEL	Layer 1		3	R	16	2	R	16	2	R	16
	Layer 2										
	As prov	mm^2		603		As' prov	402		As prov	402	
BTM STEEL	Layer 1		2	R	14	3	R	16	2	R	14
	Layer 2										
	As' prov	mm^2		308		As prov	603		As' prov	308	
DEFLECTION				17.557		Allowed	36.871				
SHEAR	V	kN		69.8			Link Ø		V	58.5	
	v	N/mm^2		1.420			10		v	1.189	
	vc	N/mm^2		0.606			Nominal		vc	0.667	
LINKS				R10 @ 175 for 875			R10 @ 175			R10 @ 175 for 700	
	legs	No		2			2			2	
CHECKS	% As			ok			ok			ok	
	Cover			ok			ok			ok	
	min S			ok			ok			ok	
	max S			ok			ok			ok	
	Links			ok			ok			ok	
	Main bars			ok			ok			ok	
	max V			ok						ok	
	Deflection						ok				

6. CALCULATION AND DESIGN OF COLUMN



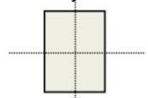
Critical columns

INPUT

Location Edge Column B1 (akin to D&D)

EG

y

Orientation **3--5** x  x **5--9** H

y

GH

concrete density, kN/m^3	25.0
γ_{fgk}	1.40
γ_{fqk}	1.60

				Level	1	0
Dimensions						
Spans	Cl to Cl	3--5	m		2.10	2.10
		5--9	m		4.80	4.80
		EG	m		1.90	1.90
		GH	m		1.80	1.80
Slab	thickness (solid)		mm		150	150
	span direction,(II to) x, y or b				x,y	x,y
Beams	width	3--5	mm		200	200
	depth o/a	3--5	mm		300	300
	width	5--9	mm		200	200
	depth o/a	5--9	mm		300	300
	width	EG	mm		200	200
	depth o/a	EG	mm		300	300
	width	GH	mm		200	200
	depth o/a	GH	mm		300	300
Column below				(col above)		
	H (II to yy)	mm			200	200
	B (II to xx)	mm			200	200
	Height (fl. to floor.)	m			3.00	3.00

				Level	1	0
Loads (characteristic uno)						
Slab	(inc swt.)	gk	kN/m2		3.75	3.75
		qk	kN/m2		3.00	3.00
Beams	(swt.)	gk	kN/m		included	included
	line loads (-extra over slab loads and beam self weight)					
	3--5	gk	kN/m		1.5	1.5
		qk	kN/m		0.0	
	5--9	gk	kN/m		1.5	1.5
		qk	kN/m		0.0	
	EG	gk	kN/m		1.5	1.5
		qk	kN/m		0.0	
	GH	gk	kN/m		1.5	1.5
		qk	kN/m		0.0	
At column position, other applied loads (eg loads from cantilevers)						
		Gk	kN (char)		0.0	
		Qk	kN (char)		0.0	
		Mxx	kNm (ult)		0.0	
		Myy	kNm (ult)		0.0	

Loads per floor				
Floor	Gk	kN	35.9	35.9
Floor	Qk	kN	19.1	19.1
Column below	Gk	kN	3.0	3.0

OUTPUT

			Column level	1 to 0	Below 0
Cumulative loads in column.					
		Gk	kN	38.9	77.7
Redn		Qk	kN	19.1	38.3
factors		Qk redn	factor	1.0	0.9
OK*?	Y	Qk red*	kN	19.1	34.5
		N	kN	**85**	**164**
Moments in column					
about x-x	Mxx	top	kNm	0.3	0.3
about y-y	Myy	top	kNm	3.2	2.9
	Mxx	bottom	kNm	0.3	
	Myy	bottom	kNm	2.9	

Computation

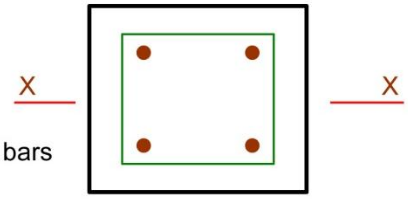
MATERIALS

fcu	25	N/mm²	γm, steel	1.05	Cover to link	20	mm
fy	420	N/mm²	γm, conc	1.5	h agg	20	mm

SECTION

h	200	mm
b	200	mm
with	2	bars per 200 face
and	2	bars per 200 face

ie. 200 x 200 columns with 4 bars



RESTRAINTS

	Lo (mm)	Top Condition	Btm Condition	Braced ?	ß	Le (mm)	Slenderness	Status
X-AXIS	3000	F	F	Y	0.75	2250	Lex/h = 11.25	Column is
Y-AXIS	3000	F	F	Y	0.75	2250	Ley/b = 11.25	SHORT

LOADCASES

	AXIAL N (kN)	TOP MOMENTS (kNm) M ix	TOP MOMENTS (kNm) M iy	BTM MOMENTS (kNm) M ix	BTM MOMENTS (kNm) M iy
B1	164			0.0	0.0
B2	85			0.0	0.0
Loadcase 3				0.0	0.0
Loadcase 4				0.0	0.0
Loadcase 5				0.0	0.0
Loadcase 6				0.0	0.0

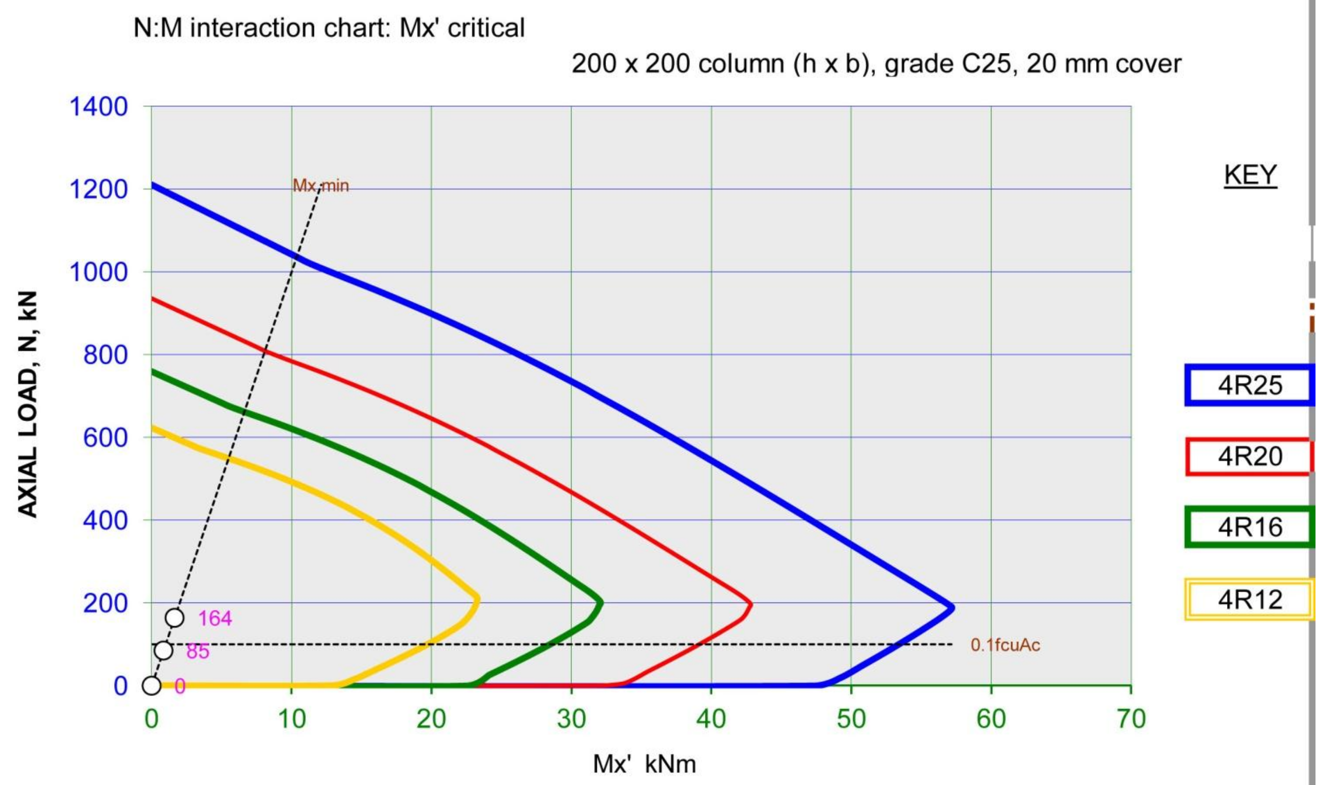
BAR ARRANGEMENTS

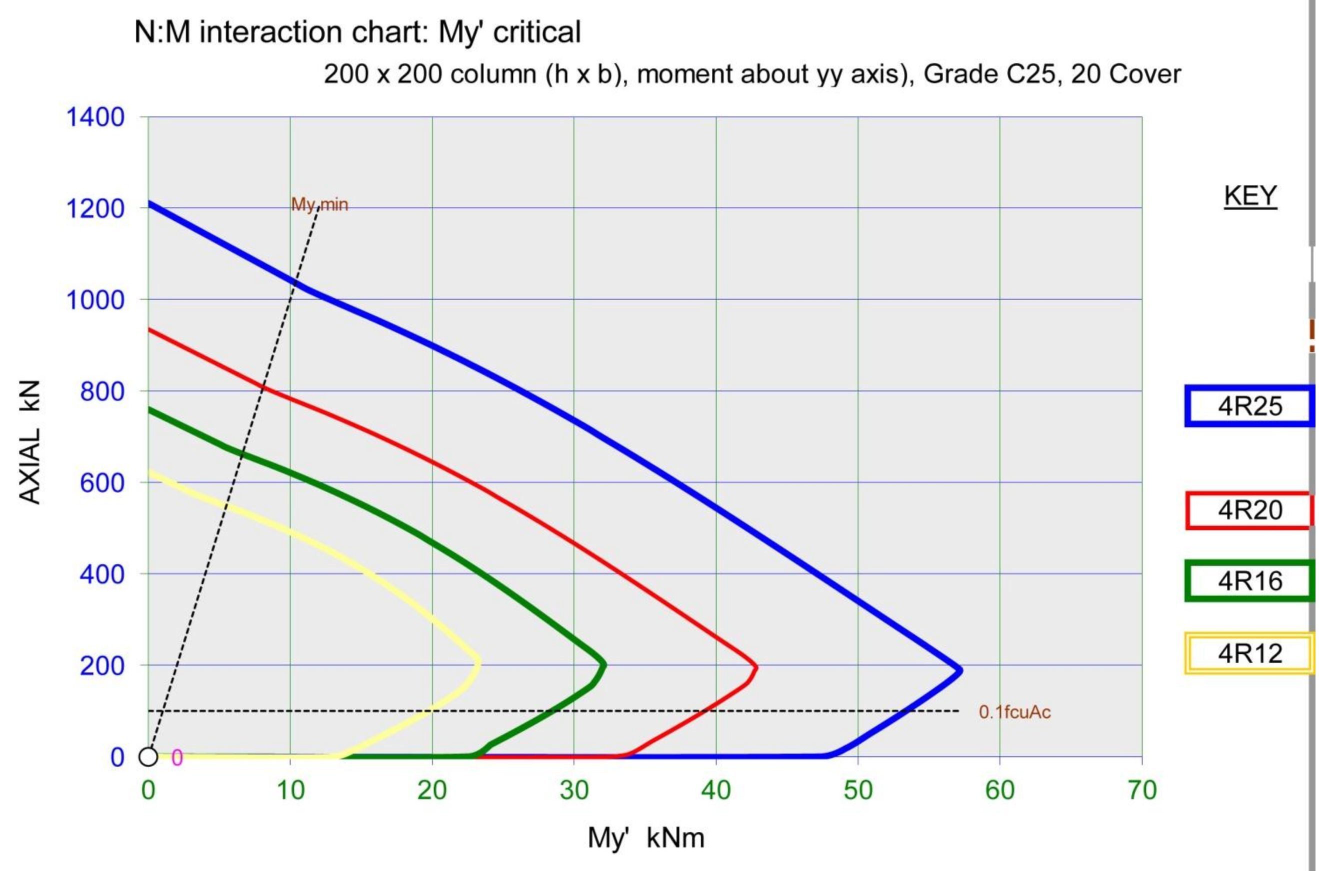
Bar Ø	Asc %	Link Ø	BAR CENTRES (mm) 200 Face	BAR CENTRES (mm) 200 Face	Nuz (kN)	Checks
R 40	12.57	10	100	100	0	Asc > 6 % (3.12.6.2)
R 32	8.04	8	112	112	0	Asc > 6 % (3.12.6.2)
R 25	4.91	8	119	119	1210	ok
R 20	3.14	6	128	128	935	ok
R 16	2.01	6	132	132	759	ok
R 12	1.13	6	136	136	623	ok

DESIGN MOMENTS (kN

	K	X AXIS M add	X AXIS Mx	Y AXIS M add	Y AXIS My	COMBINED Axis	COMBINED M '	REBAR	max V *
B1	0.000	0.0	1.6	0.0	0.0	X	1.6	4 R12	23.3
B2	0.000	0.0	0.9	0.0	0.0	X	0.9	4 R12	23.3
Loadcase 3	0.000	0.0	0.0	0.0	0.0	0.0	0.0	No Fit	
Loadcase 4	0.000	0.0	0.0	0.0	0.0	0.0	0.0	No Fit	
Loadcase 5	0.000	0.0		0.0	0.0	0.0	0.0	No Fit	
Loadcase 6	0.000	0.0	0.0	0.0	0.0	0.0	0.0	No Fit	

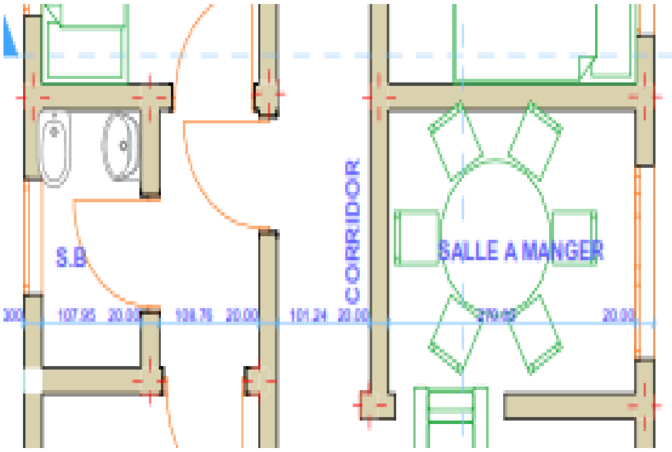
SEE CHARTS ON NEXT SHEET


N:M interaction chart: Mx' critical
200 x 200 column (h x b), grade C25, 20 mm cover
AXIAL LOAD, N, kN
Mx' kNm
Mx,min
164
85
0
0.1fcuAc
KEY
4R25
4R20
4R16
4R12


N:M interaction chart: My' critical
200 x 200 column (h x b), moment about yy axis), Grade C25, 20 Cover
AXIAL kN
My' kNm
My,min
0
0.1fcuAc
KEY
4R25
4R20
4R16
4R12

7. CALCULATION AND DESIGN OF FAUNDATIONS

Critical foundations

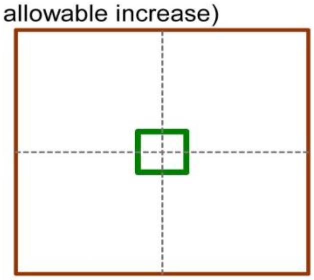


Computation

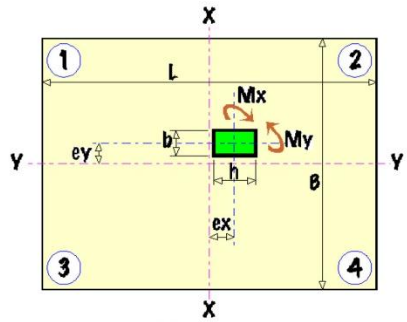
MATERIALS	fcu	25	N/mm²	h agg	20	mm	γc	1.5 concrete
	fy	420	N/mm²	cover	40	mm	γs	1.05 steel
Densities - Concrete		25	kN/m³	Soil	18	kN/m³		
Bearing pressure		200	kN/m² (net allowable increase)					

DIMENSIONS mm

BASE		COLUMN	
L =	1200	h =	200
B =	1200	b =	200
depth H =	200		
ex =	0	ey =	0



Plot (to scale)

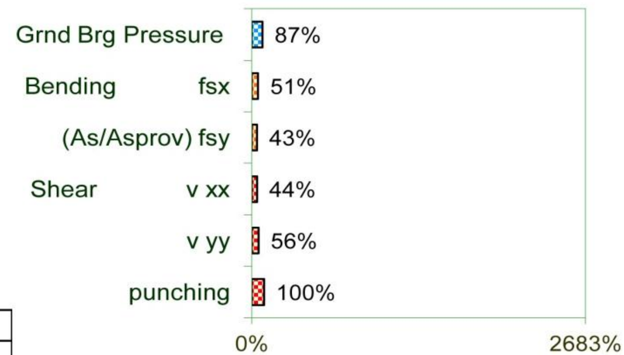


Key

COLUMN REACTIONS kN, kNm *characteristic*

	DEAD	IMPOSED	WIND
Axial (kN)	164.0	85.0	
Mx (kNm)			
My (kNm)			
Hx (kN)			
Hy (kN)			

STATUS VALID DESIGN



BEARING PRESSURES kN/m² *characteristic*

CORNER	1	2	3	4
no wind	174.3	174.3	174.3	174.3
with wind	174.3	174.3	174.3	174.3

REINFORCEMENT

		Detail to 3.11.3.2			Detail to 3.11.3.2
Mxx =	38.1	kNm	Myy =	38.1	kNm
b =	1200	mm	b =	1200	mm
d =	150	mm	d =	130	mm
As =	680	mm²	As =	806	mm²

PROVIDE 5 R20 @ 175 & 325 B1 — PROVIDE 5 R20 @ 175 & 350 B2

As prov =	1571	mm²	As prov =	1571	mm²

Asx increased 124% for shear — Asy increased 94% for shear

BEAM SHEAR

Vxx =	106.6	kN at d from col face	Vyy =	112.7	kN at d from col face
v =	0.592	N/mm²	v =	0.723	N/mm²
or Vxx =	60.9	kN at 2d from col face	or Vyy =	73.1	kN at 2d from col face
v =	0.339	N/mm²	v =	0.469	N/mm²
vc =	0.772	N/mm²	vc =	0.839	N/mm²

PUNCHING SHEAR

d ave =	140	mm	u crit =	2480	mm
As prov =	0.940	%	v max =	3.264	N/mm² at col face
v =	0.801	N/mm²	vc =	0.805	N/mm²

8. CALCULATION AND DESIGN OF STAIRS

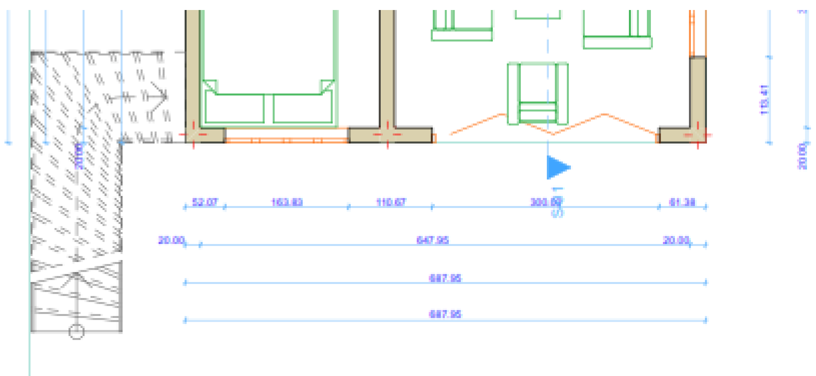
Critical stairs

The of practice C P 110 give the standard using in the design of stairs

Input	Private building	Public building
Rise R	Less than 220mm	Less than 190mm
Riser G	Greater than 220mm	Greater than 230mm
Slope S	Less 42 degree	Less 38 degree
Number of rises/ span	-	Less than 16

General design: 700mm>G+2*R>550mm

Layout



Computation

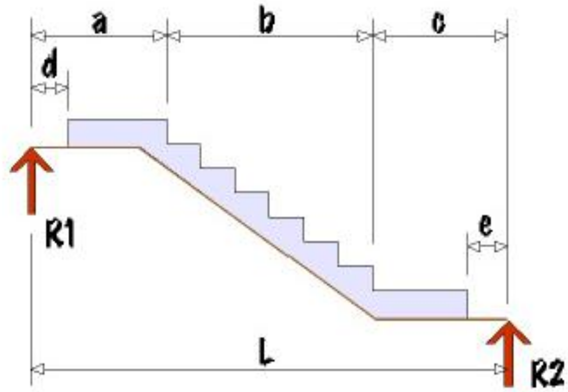
MATERIALS

fcu	25	N/mm²	γm	1.5	concrete	Min bar Ø = 10
fy	420	N/mm²	γm	1.05	steel	Max bar Ø = 16
h agg	20	mm	Density	25	kN/m³	
Cover	25	mm	*(Normal weight concrete)*			Nominal top steel ? Y

DIMENSIONS

a =	1100	mm	landing A h =	150	
b =	2700	mm	flight waist =	200	
c =	1100	mm	landing B h =	150	
d =	-300	mm			
e =	-100	mm			
Going =	300	mm	L =	**4900**	
Rise =	1650	mm total		9 treads	
Rise =	165	mm each step	Rake =	28.81 °	

Sectional Elevation



m ult

(19.76 + 11.03) (18.67 + 10.17)

LOADING

Imposed	4.00	kN/m²
Flight finishes	1.60	kN/m²
Landing finishes	1.30	kN/m²

DESIGN

LANDING A,	gk = 3.75 + 1.30 = 5.05 kN/m²	n = 1.4 x 5.05 + 1.6 x 4.0 = 13.47 kN/m²
FLIGHT,	gk = 7.77 + 1.60 = 9.37 kN/m²	n = 1.4 x 9.37 + 1.6 x 4.0 = 19.52 kN/m²
LANDING C,	gk = 3.75 + 1.30 = 5.05 kN/m²	n = 1.4 x 5.05 + 1.6 x 4.0 = 13.47 kN/m²

Zero shear is at 1.1 + (45.32 - 18.86) / 19.52 = 2.456 m from left

M = 45.32 x 2.456 - 18.86 x 2.056 - 19.52 x 1.356²/2 = 54.58 kNm/m

d = 200 - 25 - 8 = 167 mm K = 0.0783 As = 904 mm²/m

PROVIDE R16 @ 160 B = 1257 mm²/m

Enhanced by 36.8 % for deflection R12 @ 225 T in span

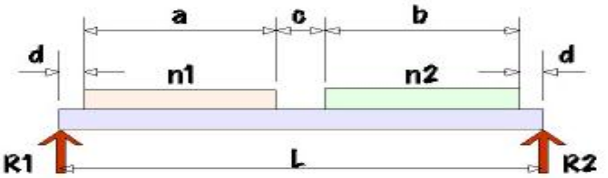
L/d = 4,900 / 167 = 29.341 < 20.0 x 1.354 x 1.091 = 29.544 allowed OK

MATERIALS

fcu 25 N/mm² | γm 1.5 concrete | Min bar Ø = 10
fy 420 N/mm² | γm 1.05 steel | Max bar Ø = 16
h agg 20 mm | Density 25 kN/m³
Cover 25 mm | *(Normal weight concrete)* | Nominal top steel ? Y

DIMENSIONS

a = 1200 mm   depth, h = 175 mm
b = 1200 mm   width, w = 1200 mm
c = 250 mm
d = 175 mm   L = **3000** mm



LOADING

LANDING	Imposed	4.00		kN/m²
	Finishes	1.50		kN/m²
	Slab	4.38		kN/m²
	gk	qk		
Flight a reaction	19.76	11.03		kN/m
Flight b reaction	18.67	10.17		kN/m

79.8 kN ult   78.1 kN ult
66.5 kN/m ult   65.1 kN/m ult
n = 1.4 x 5.88 + 1.6 x 4.0 = 14.63 kN/m²

n1 = (1.4 x 19.76 + 1.6 x 11.03)/1.20 = 37.76 kN/m²
n2 = (1.4 x 18.67 + 1.6 x 10.17)/1.20 = 35.33 kN/m²

DESIGN

Zero shear is at (66.50 - 45.32) / 14.63 = 1.449 m from left
M = 66.50 x 1.449 - 45.32 x 0.674 - 14.63 x 1.449²/2 = 50.46 kNm/m
d = 175 - 25 - 8 = 142 mm   K = 0.1001   As = 1018 mm²/m
PROVIDE R16 @ 190 B = 1058 mm²/m
R12 @ 250 T in span

L/d = 3,000 / 142 = 21.127 < 20.0 x 1.058 = 23.200 allowed   OK

9. SUMMARY OF REINFORCEMENT TO BE USED

Steel bars in the frame of the building

STRUCTURAL ELEMMENT	REINFORCEMENT TO BE USED	COMMENTS
1.Foundation pad		
	B: 5R20@175 T: 5R20@175	Spacing @ expressed in mm
2. Sub column		
	Main bars: 4R12 Link : R8@150	Spacing @ expressed in mm
3.Column		
1st and ground floor	Main bars: 4R12	Spacing @ expressed in mm

	Link : R8@150	
4. Beam		
1st level	Span of 4.6m At the support (2 parts of every support): 3R16 top steel Link: R10@175 Other span At the support (2 parts of every support): 2R14 Link: R10@175	Spacing @ expressed in mm This summary have been derived from the beam design notes P.16, for more information you can read carefully the whole related design
5. Slab		
	Short span B_1: R10@200 Short span B_2: R12@225 Distribution : R12@225	Spacing @ expressed in mm
5. Stairs		
	Flight **B**: R16@160 T: R12@225 **Landing** **B**: R16@190 in span T: R12@250	Spacing @ expressed in mm

END