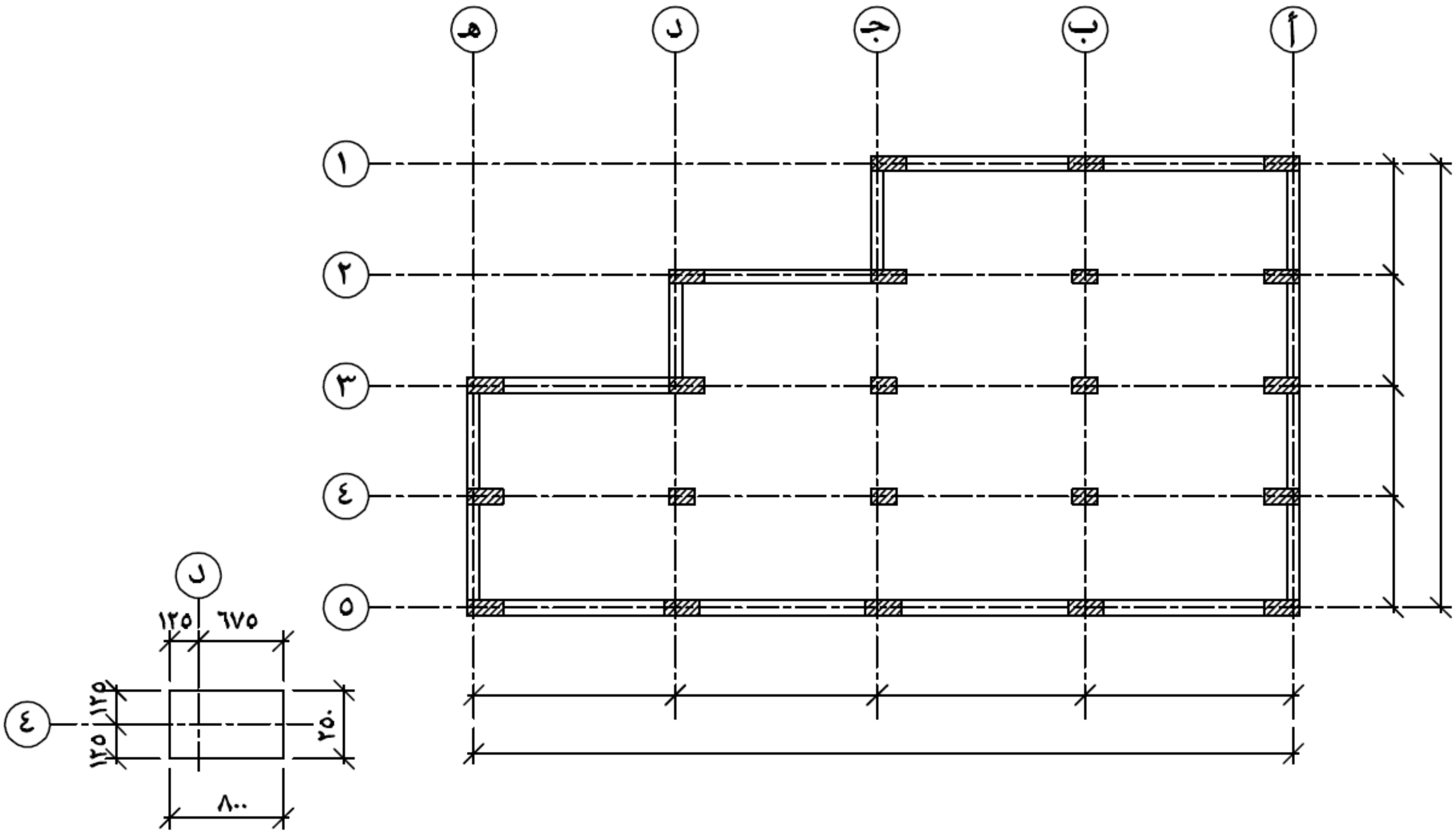
ECP Detailing
Hisham Qasrawi

Notations

ق	=	قاعدة مسلحة أو عادية
ع	=	عمود
ك	=	كمرة
م	=	ميدة
كا	=	كابولى
ب	=	بلاطة
ح	=	حائط خرساني (أو مباني)
خ٠ع	=	خرسانة عادية
خ٠م	=	خرسانة مسلحة
$\varnothing$	=	قطر أو علامة لأسياخ الصلب الطري العادي – رتبة ٢٤٠/٣٥٠
$\varnothing\!\!/$	=	صلب تسليح عالي المقاومة – رتبة ٣٦٠/٥٢٠
	=	صلب تسليح عالي المقاومة – رتبة ٤٠٠/٦٠٠
Φ	=	شبك تسليح ملحوم – رتبه ٤٥٠/٥٢٠
#	=	المسافة بين محاور الأسياخ

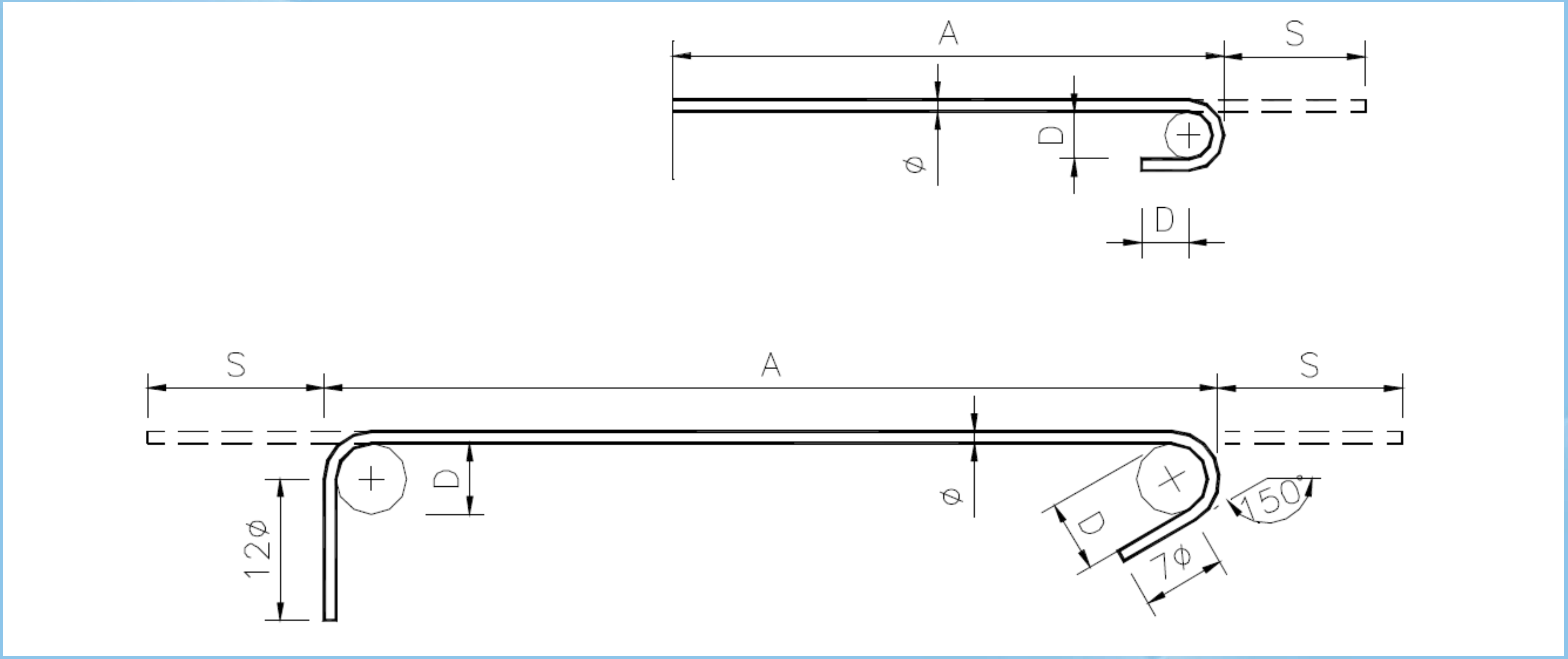
كل أو @

Grids and Centerlines

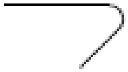


شكل رقم (٢-٤) ترقيم المحاور

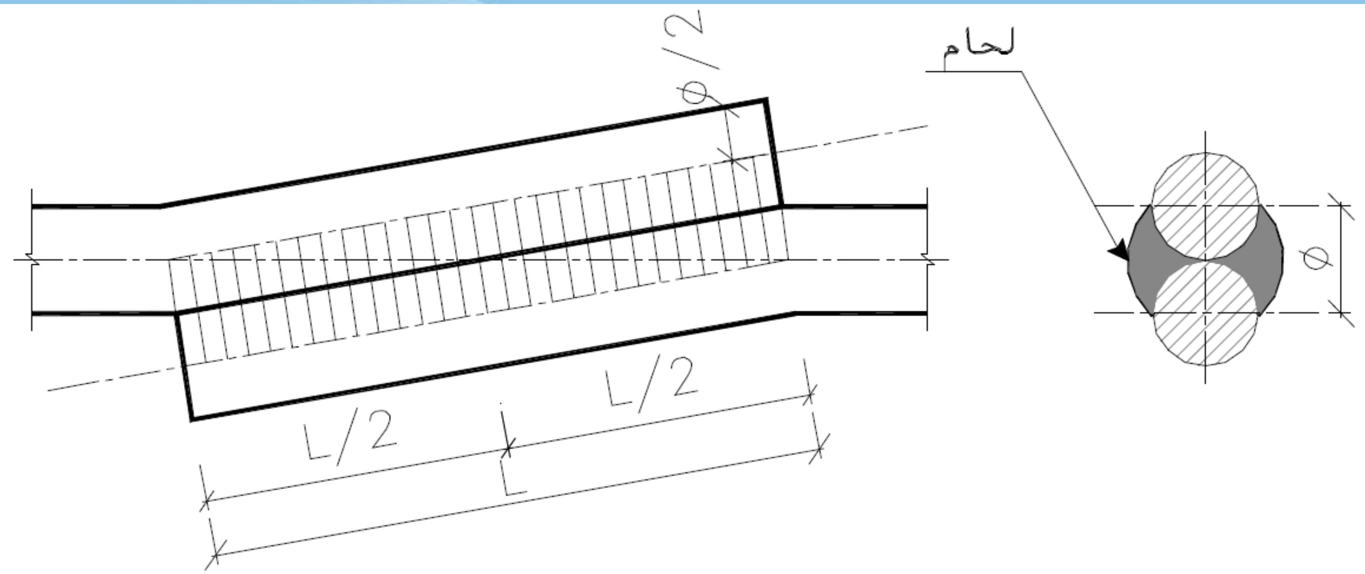
Bends



جدول رقم (٣-٢) : الحد الأدنى للطول المضاف S بالمليمتر

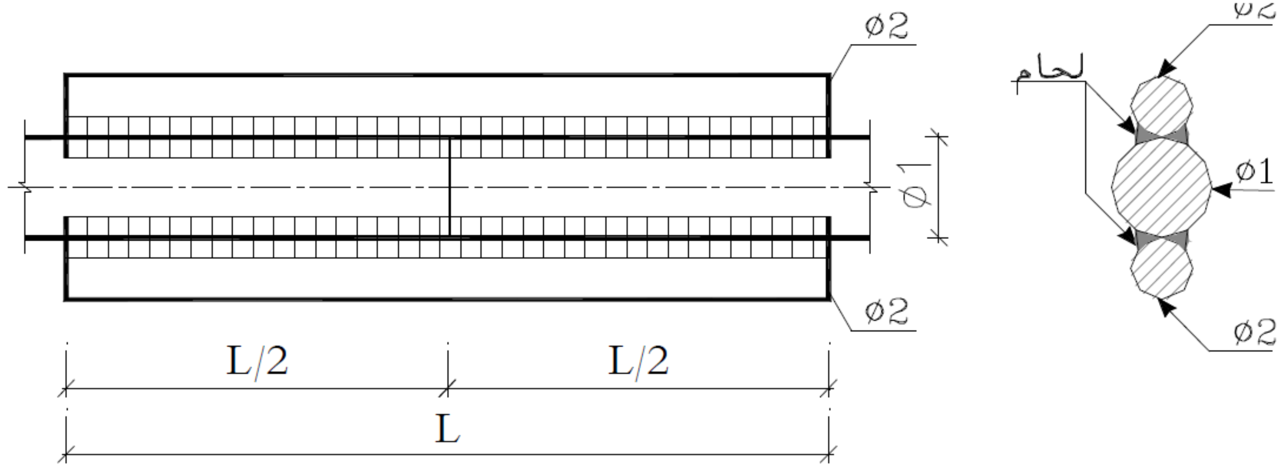
الشكل	القطر / رتبة الصلب	٦	٨	١٠	١٢	١٣	١٤	١٦	١٨	١٩	٢٠	٢٢	٢٥	٢٨	٣٢	٤٠
	ϕ	٦٠	٨٠	١٠٠	١١٠	١٢٠	١٣٠	١٥٠	١٧٠	١٨٠	١٨٠	٢٠٠	٢٣٠	٢٦٠	٢٩٠	٣٦٠
	ϕ	٨٠	١١٠	١٣٠	١٦٠	١٧٠	١٩٠	٢١٠	٢٤٠	٢٥٠	٢٦٠	٢٩٠	٣٣٠	٤٨٠	٥٥٠	٦٨٠
	ϕ	٧٠	٩٠	١٢٠	١٤٠	١٥٠	١٦٠	١٨٠	٢٠٠	٢١٠	٢٢٠	٢٥٠	٢٨٠	٣١٠	٣٦٠	٤٥٠
	ϕ	٨٠	١٠٠	١٢٠	١٥٠	١٦٠	١٧٠	٢٠٠	٢٢٠	٢٣٠	٢٤٠	٢٧٠	٣٠٠	٣٥٠	٤٠٠	٥٠٠
	ϕ	٨٠	١١٠	١٣٠	١٦٠	١٧٠	١٨٠	٢١٠	٢٤٠	٢٥٠	٢٦٠	٢٩٠	٣٣٠	٣٧٠	٤٢٠	٥٤٠
	ϕ	٩٠	١١٠	١٤٠	١٧٠	١٨٠	١٩٠	٢٢٠	٢٥٠	٢٦٠	٢٧٠	٣٠٠	٣٤٠	٣٩٠	٤٦٠	٥٧٠

Welded splices
Direct



شكل (٣-٤) تفاصيل وصلات اللحام بالتراكب

Welded splices
Additional Bars



٢ × مساحة الاسياخ ø2 ≥ مساحة السيخ ø1

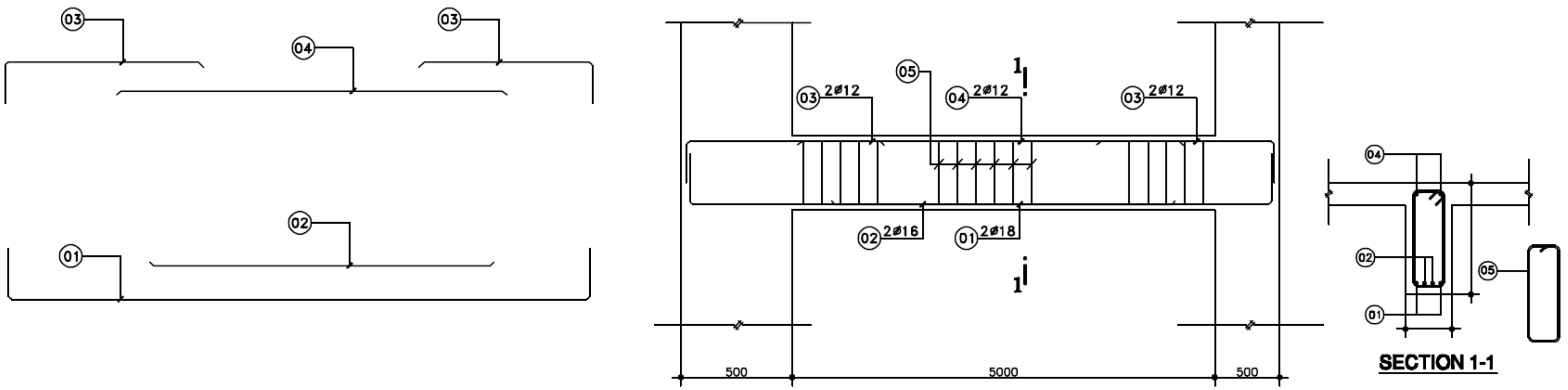
شكل (٣–٥) تفاصيل وصلات اللحام باستخدام أسياخ إضافية

Area of steel bars

جدول رقم (٣-٤) مساحة ومحيط الأعداد المتكررة من الأقطار المختلفة لأسياخ صلب التسليح

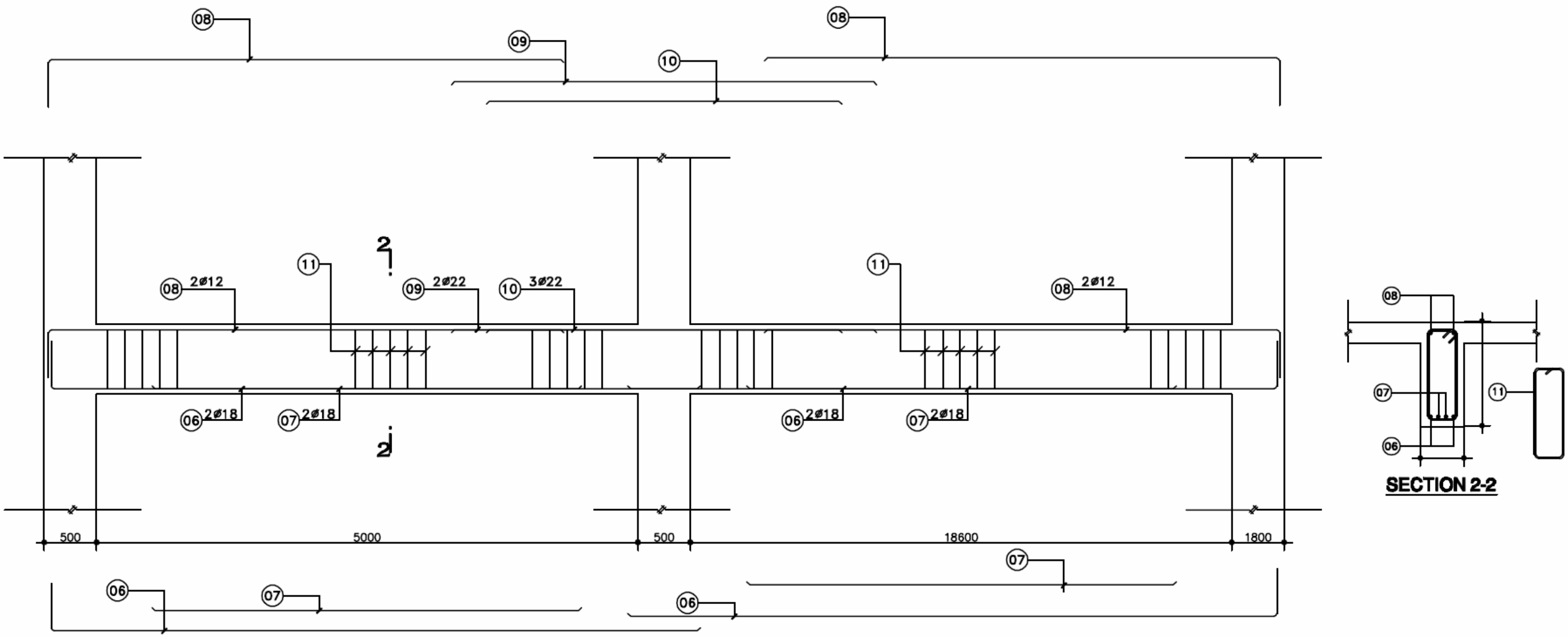
القطر (مم)	العدد	مساحة الأسياخ (مم٢)										المحيط / سيخ مم
		١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	
٦		٢٨	٥٦	٨٥	١١٣	١٤١	١٧٠	١٩٨	٢٢٦	٢٥٥	٢٨٣	١٨,٨
٨		٥٠	١٠٠	١٥١	٢٠١	٢٥١	٣٠٢	٣٥٢	٤٠٢	٤٥٢	٥٠٣	٢٥,١
١٠		٧٨	١٥٧	٢٢٦	٣١٤	٣٩٣	٤٧١	٥٥٠	٦٢٨	٧٠٧	٧٨٥	٣١,٤
١٢		١١٣	٢٢٦	٣٣٩	٤٥٢	٥٦٦	٦٧٩	٧٩٢	٩٠٥	١٠١٨	١١٣١	٣٧,٧
١٣		١٣٣	٢٦٦	٣٩٨	٥٣١	٦٦٤	٧٩٦	٩٢٩	١٠٦٢	١١٩٥	١٣٢٨	٤٠,٩
١٤		١٥٤	٣٠٨	٤٦٢	٦١٦	٧٧٠	٩٢٤	١٠٧٨	١٢٣٢	١٣٨٦	١٥٤٠	٤٤,٠
١٦		٢٠١	٤٠٢	٦٠٣	٨٠٤	١٠٠٥	١٢٠٦	١٤٠٧	١٦٠٨	١٨١٠	٢٠١١	٥٠,٣
١٨		٢٥٥	٥٠٩	٧٦٤	١٠١٨	١٢٧٣	١٥٢٧	١٧٨٢	٢٠٣٧	٢٢٩١	٢٥٤٦	٥٦,٦
١٩		٢٨٤	٥٦٧	٨٥١	١١٣٥	١٤١٨	١٧٠٢	١٩٨٦	٢٢٦٩	٢٥٥٣	٢٨٣٦	٥٩,٧
٢٠		٣١٤	٦٢٨	٩٤٢	١٢٥٧	١٥٧١	١٨٨٥	٢١٩٩	٢٥١٣	٢٨٢٧	٣١٤٢	٦٢,٨
٢٢		٣٨٠	٧٦١	١١٤١	١٥٢١	١٩٠١	٢٢٨٢	٢٦٦٢	٣٠٤٢	٣٤٢٣	٣٨٠٣	٦٩,١
٢٥		٤٩١	٩٨٢	١٤٧٣	١٩٦٣	٢٤٥٤	٢٩٤٥	٣٤٣٦	٣٩٢٧	٤٤١٨	٤٩٠٩	٧٨,٥
٢٨		٦١٦	١٢٣٢	١٨٤٨	٢٤٦٤	٣٠٨٠	٣٦٩٦	٤٣١٢	٤٩٢٨	٥٥٤٤	٦١٦٠	٨٨,٠
٣٢		٨٠٤	١٦٠٨	٢٤١٣	٣٢١٧	٤٠٢١	٤٨٢٥	٥٦٣٠	٦٤٣٤	٧٢٣٨	٨٠٤٢	١٠٠,٥
٤٠		١٢٥٧	٢٥١٣	٣٧٧٠	٥٠٢٦	٦٢٨٣	٧٥٤٠	٨٧٩٠	١٠٠٥٣	١١٣١٠	١٢٥٦٦	١٢٥,٧

Simple beam



SIMPLE BEAM

Continuous beam



CONTINUOUS BEAM

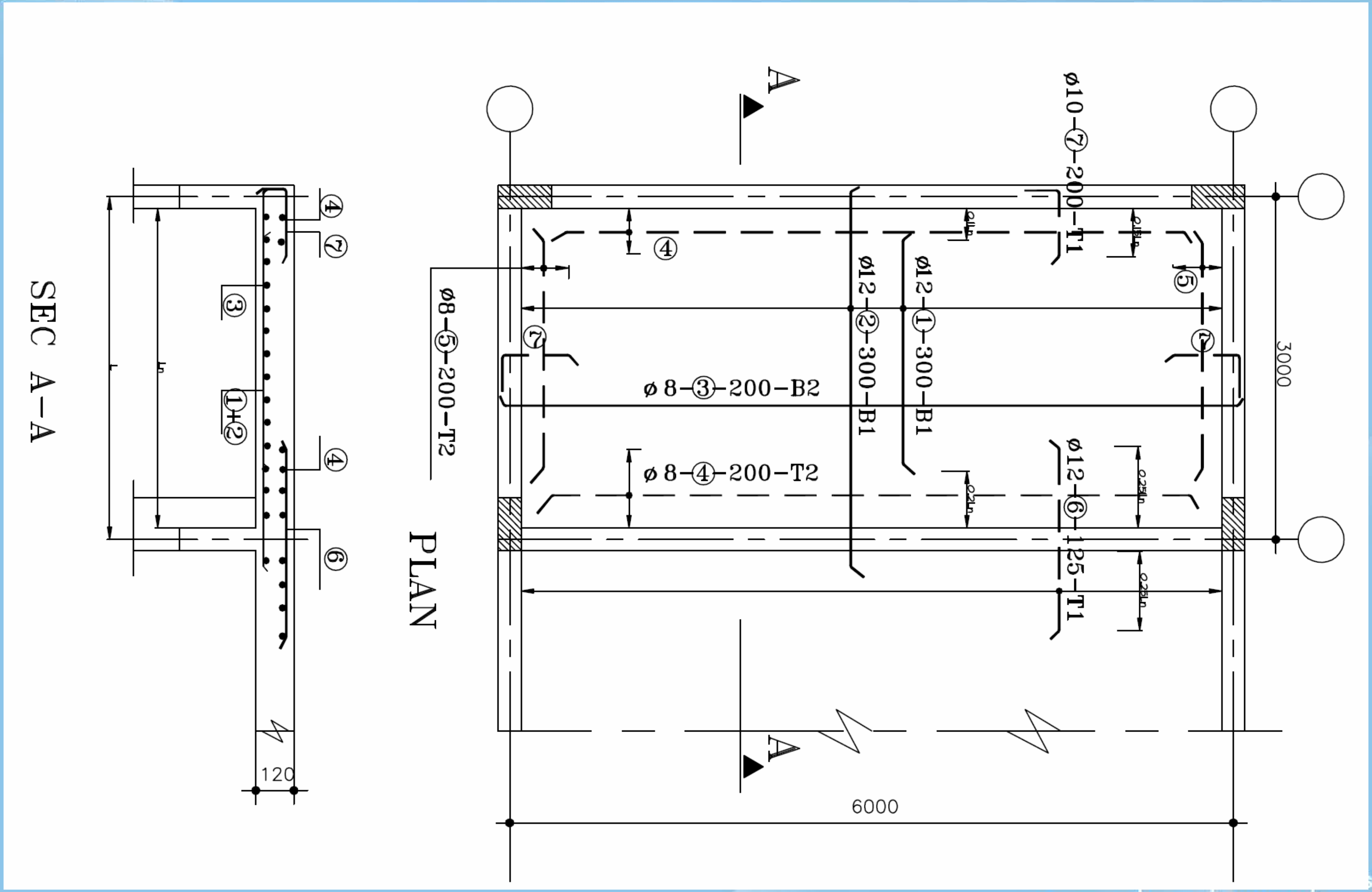
Bar schedule for beams

MEMBER	BAR MARK	TYPE & SIZE	NO. OF MEMBERS	NO. OF BARS IN EACH MEMBER	TOTAL NO. OF BARS	CODE SHAPE	LENGTH A (mm)	LENGTH B (mm)	LENGTH C (mm)	LENGTH D (mm)	LENGTH E (mm)	TOTAL LENGTH (mm)	TOTAL WEIGHT (Kg)
Simple Beam	1	∅18	1	2	2	SH–5	550	6250	550			7205	
	2	∅16	1	2	2	SH–1	4000					4000	
	3	∅12	1	2	2	SH–4	550	1500				2005	
	4	∅12	1	2	2	SH–1	3750					3750	
	5	∅ 8	1	25	25	SH–8	550	200				1600	
Continuous Beam	6	∅18	2	2	4	SH–4	550	5950				6445	
	7	∅18	2	2	4	SH–1	4000					4000	
	8	∅12	2	2	4	SH–4	550	4055				4570	
	9	∅22	2	2	4	SH–1	3840					3840	
	10	∅22	2	3	6	SH–1	2500					2500	
	11	∅8	2	50	50	SH–8	550	200				1600	

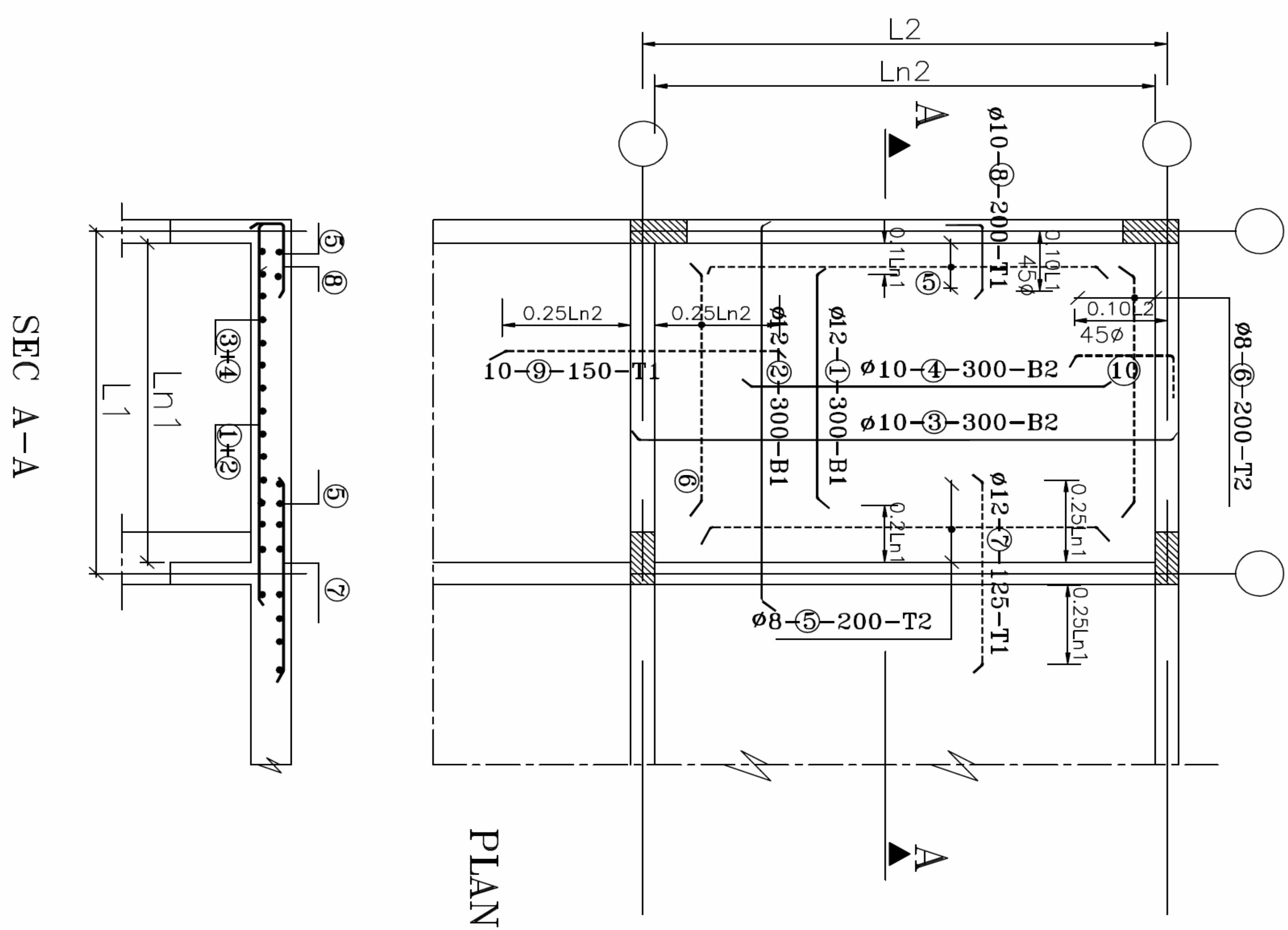
Bar schedule for solid slab

MEMBER	BAR MARK	TYPE & SIZE	NO. OF MEMBERS	NO. OF BARS IN EACH MEMBER	TOTAL NO. OF BARS	CODE SHAPE	LENGTH A (mm)	LENGTH B (mm)	LENGTH C (mm)	LENGTH D (mm)	LENGTH E (mm)	TOTAL LENGTH (mm)	TOTAL WEIGHT (Kg)
Solid Slab Between Axes (,)	1	ϕ12	1	19	19	SH–1	2400					2400	
	2	ϕ12	1	20	20	SH–1	3250					3250	
	3	ϕ8	1	14	14	SH–1	6250					6250	
	4	ϕ8	1	14	14	SH–1	5750					5750	
	5	ϕ 8	1	10	10	SH–1	2750					2750	
	6	ϕ12	2	46	46	SH–1	5750					5750	
	7	ϕ10.	2	57	57	SH–4	80	1050				1100	

Solid one-way-slab

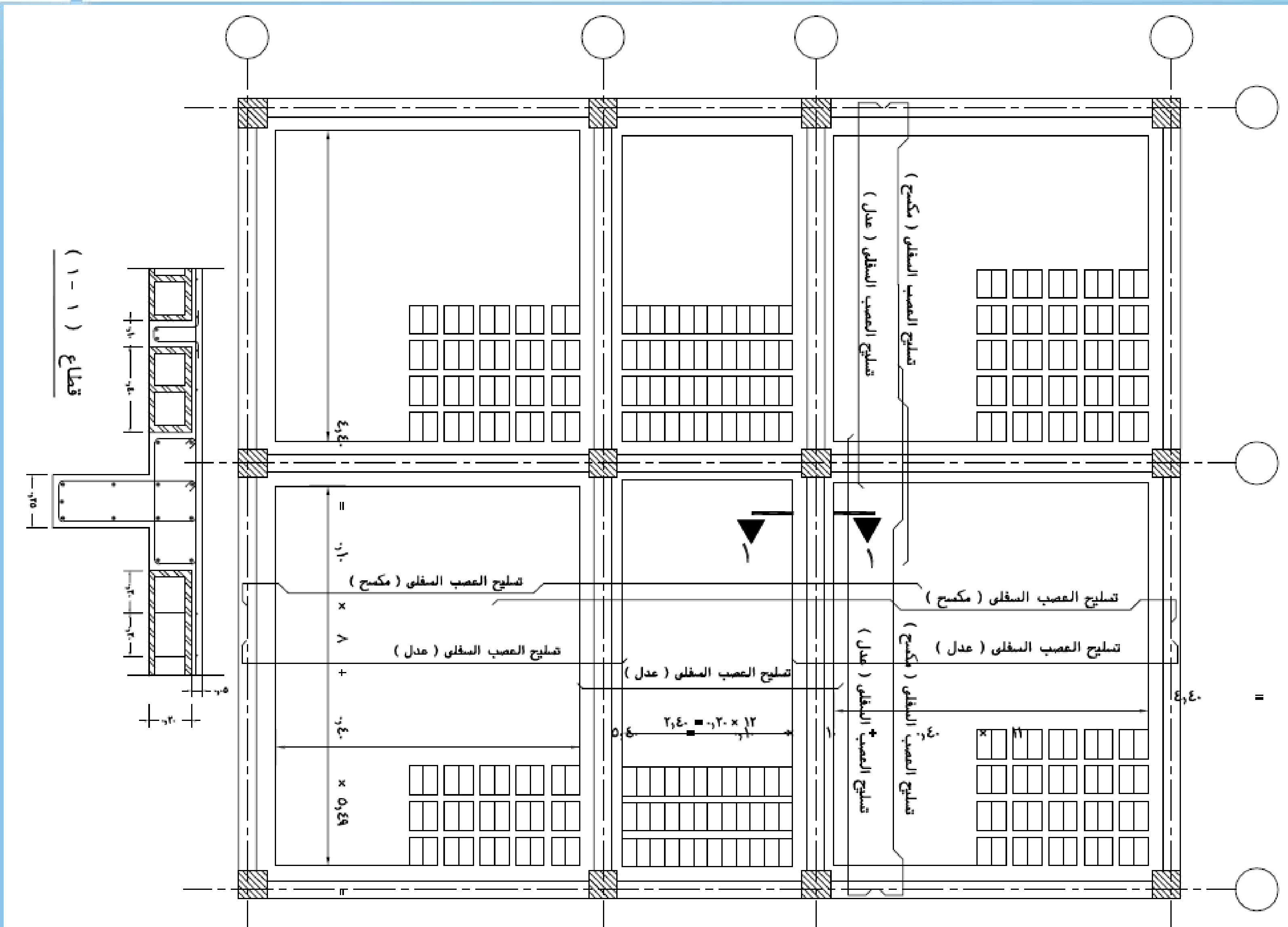


Solid two-way-slab

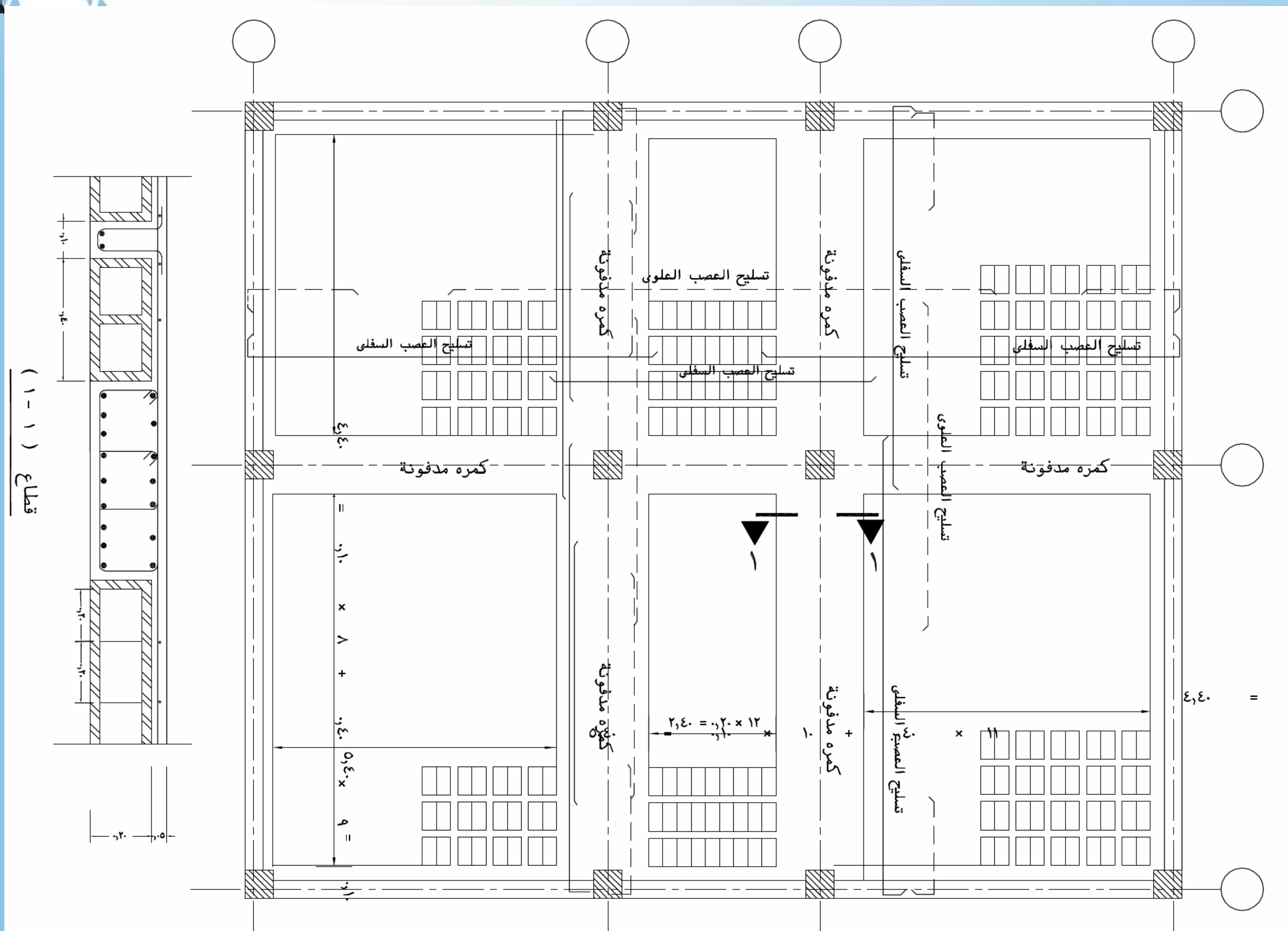


Ribbed slab (one- and two-way)

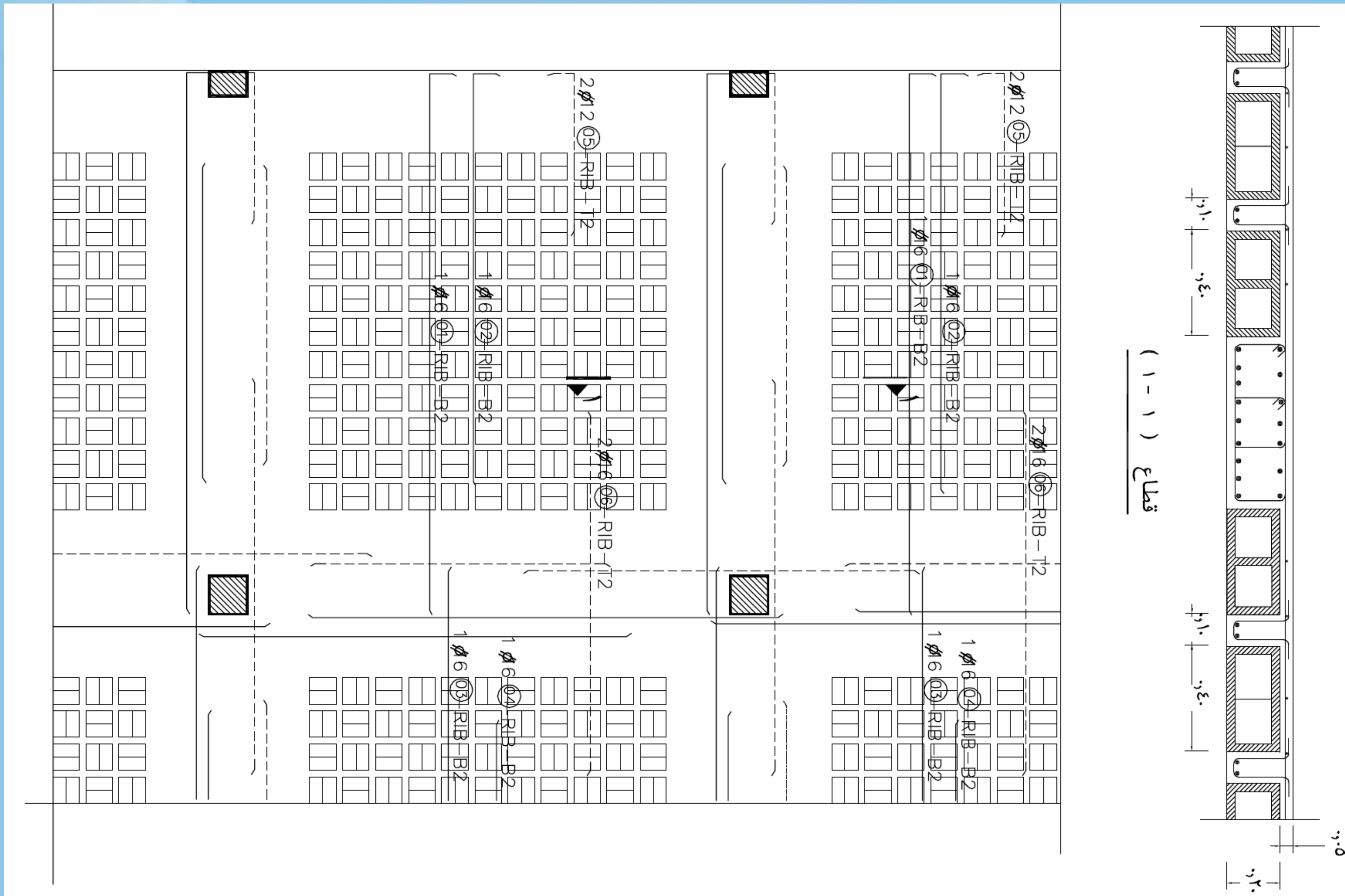
Ribbed slab (one- and two-way)



Ribbed slab (one- and two-way) Hidden beams



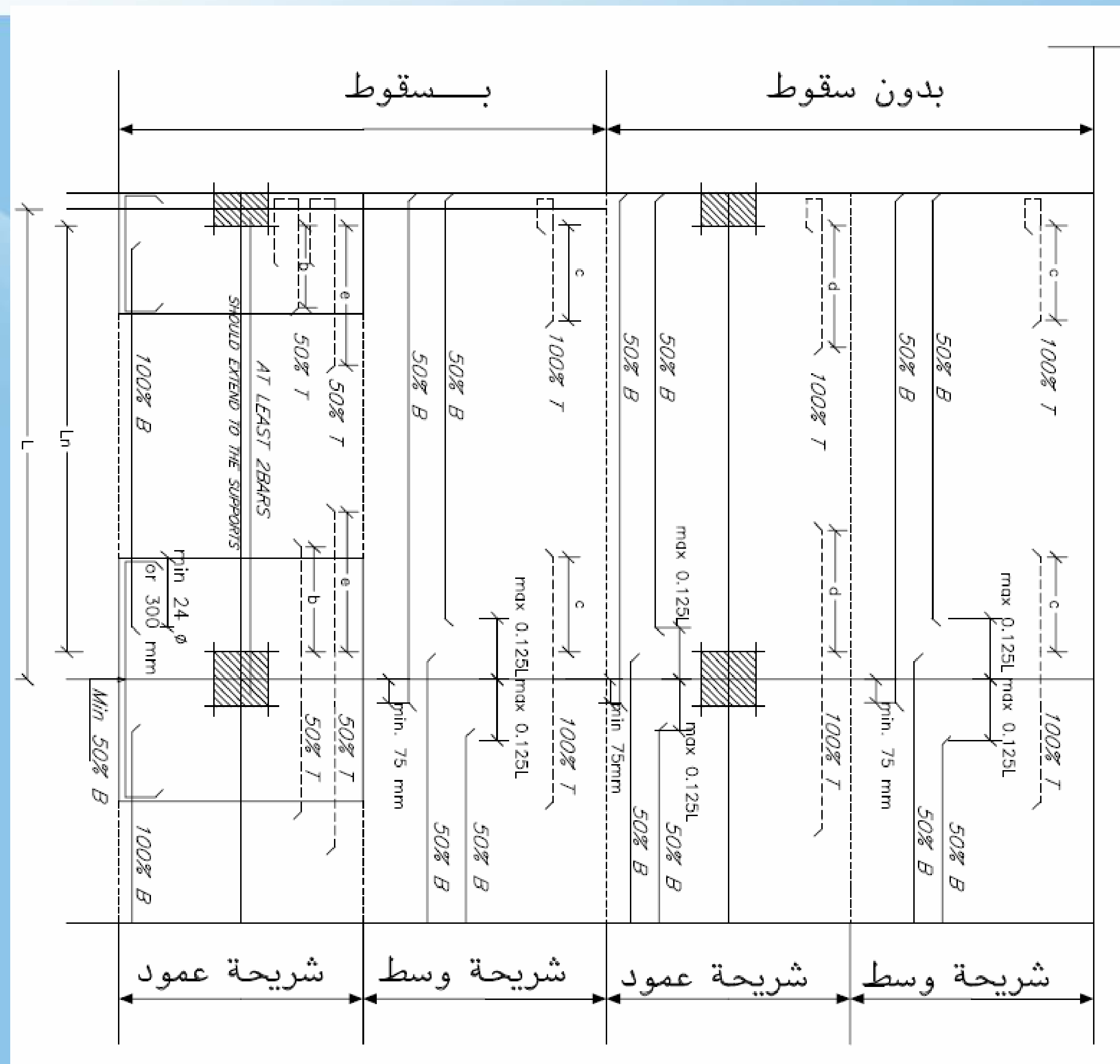
Solid ribbed two-way slab with hidden beams



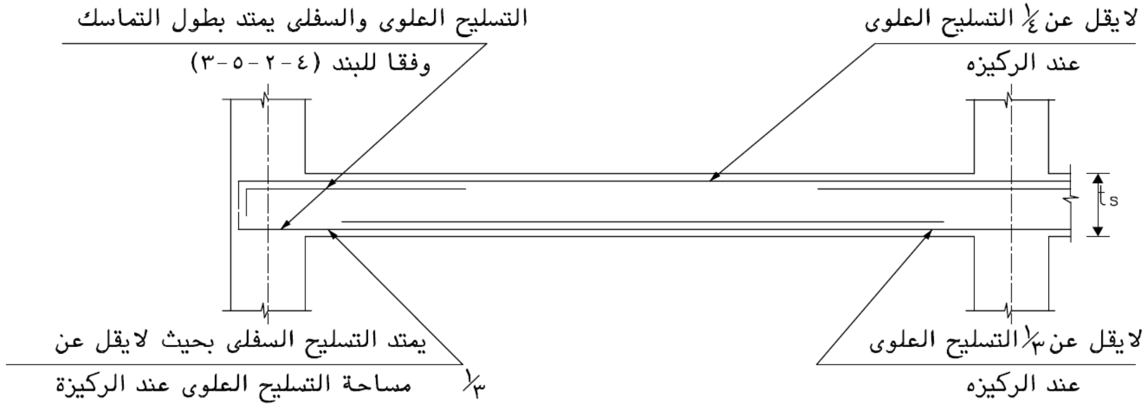
Solid slabs
(with or without drop beams)

ادنى بعد				
b	*c*	*d*	*e*	
0.20	0.22	0.30	0.33	*Ln*

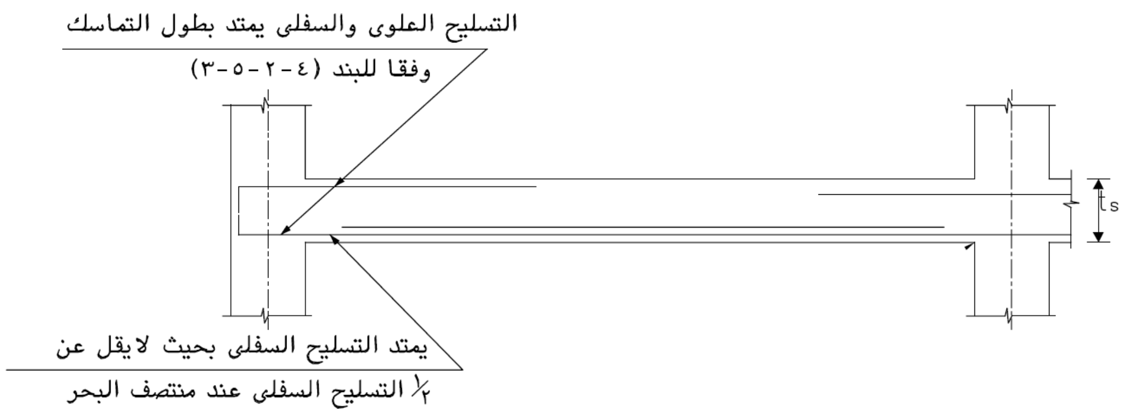
B : تسليح سفلى
T : تسليح علوى
L : المسافة بين محاور الركائز
Ln : البحر الصافى بين وجة الركائز



- To resist earthquakes

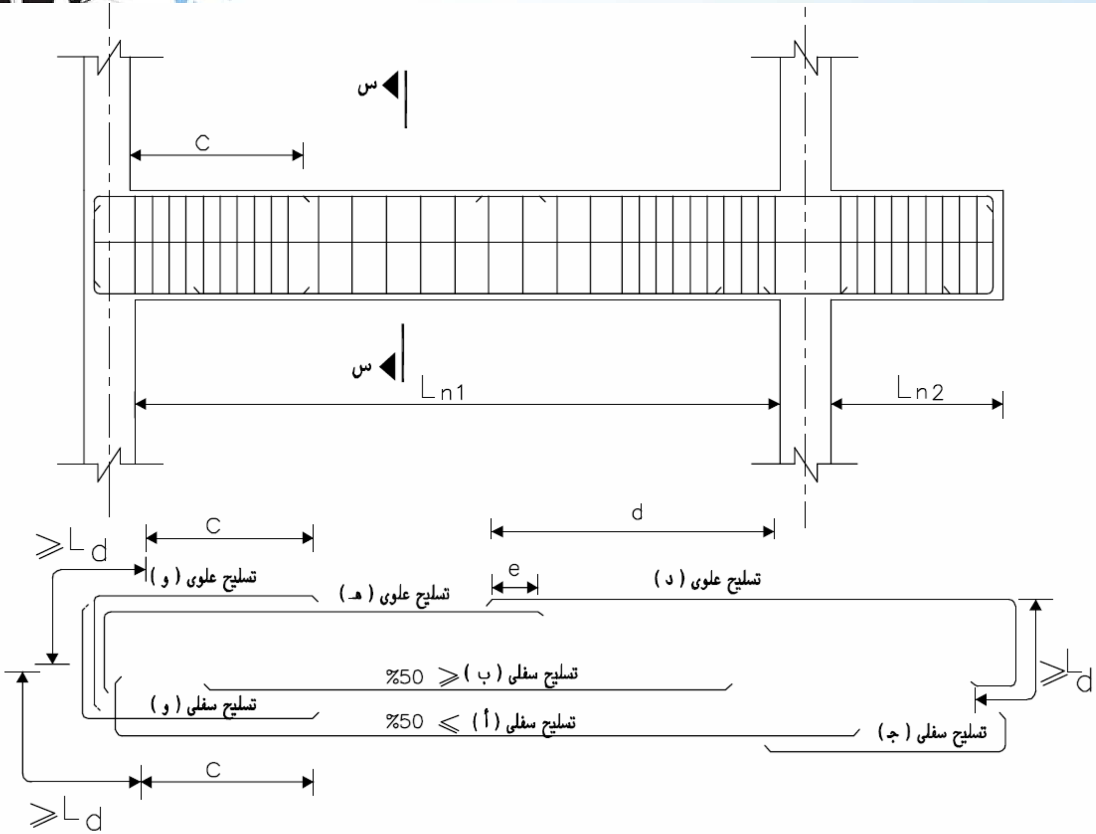


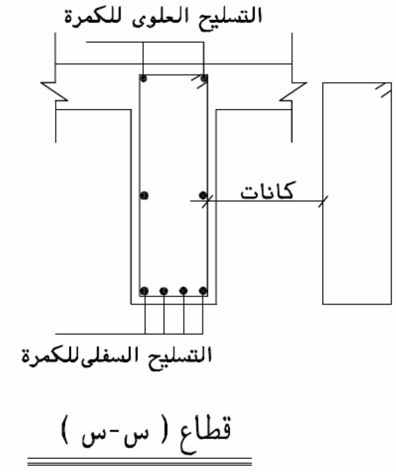
(أ) شريحة العمود



(ب) شريحة الوسط

Beams





Beams' Table :

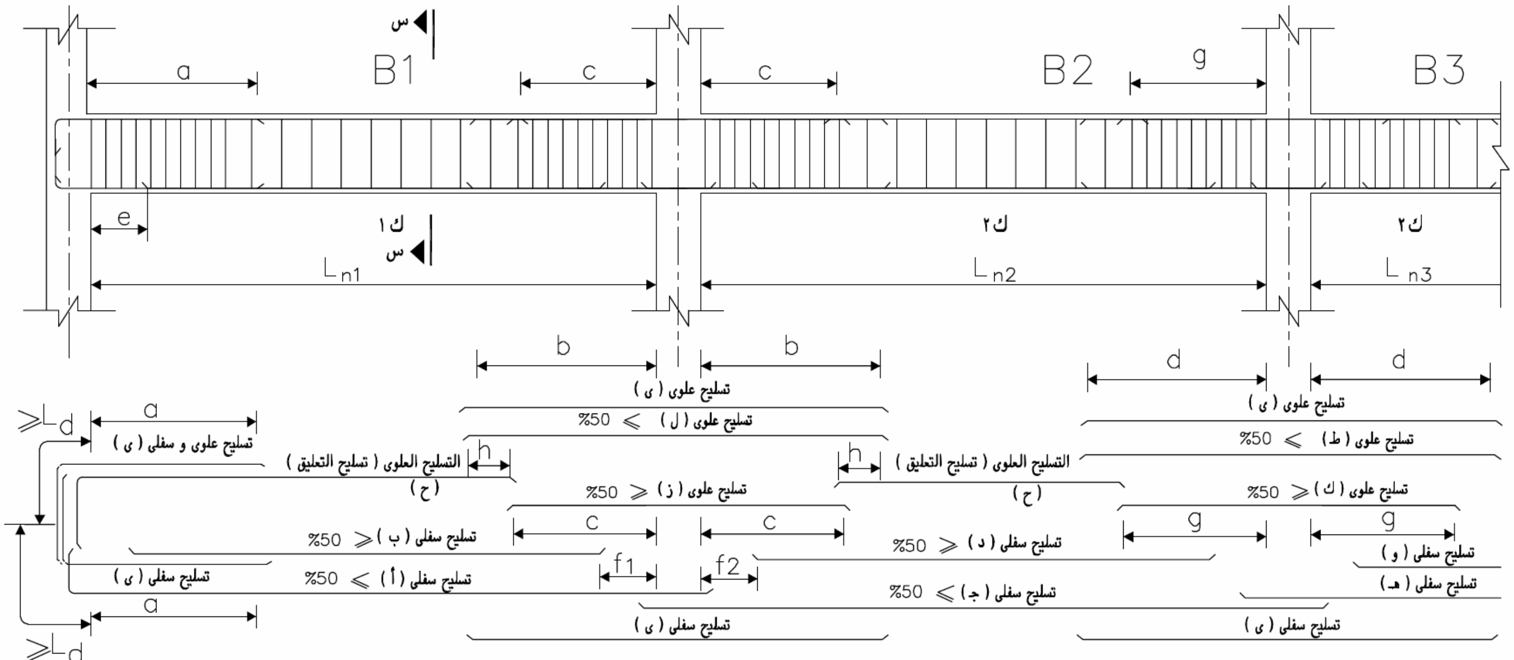
Beam Type	Bot. Rft.			Top. Rft.			Stirrups/m			Remarks
	Long	Short	At Supp.	Right	Mid.	Left	Right	Mid.	Left	
B1	Ø12 2	Ø16 2	Ø12 2	Ø12 4	Ø12 2	Ø12 4	8Ø 6	8Ø 5	8Ø 6	
Beam	أ	ب	و	د	هـ	هـ + و	Stirrups/m			
C1	Ø12 2	—	—	Ø16 4	Ø16 4	Ø16 4	Ø10 7	Ø10 7	Ø10 7	
Cantilever	جـ	—	—	د	د	د	Stirrups/m			

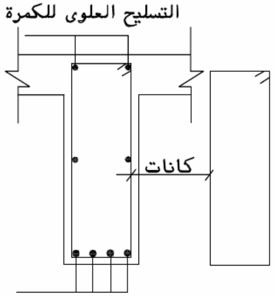
TYPE	Length
a	Max. 0.10 L_{n1}
b	Max. 0.125 L_{n1}
c	Min. 0.15 L_{n1}
d	Min. 1.00 L_{n2}
e	Bigger of 12Ø or 25 cm

ملاحظات :

- التسليح (و) هو التسليح الخاص بحسابات الأحمال الجانبية [يرجع الى بند (٦-٧-٢-٢)
- يراعى دراسة اجهادات القص لتحديد كمية و مسافة توزيع الكانات المقاومة للقص .
- يراعى حساب الكانات الاضافية الخاصة باماكن توقف الاسياخ طبقا للبند (٤-٢-٥-٣)

Continuous beams (span difference <20%)





TYPE	Length
a	Min. 0.15 L_{n1}
b	Min. 0.33 (bigger of L_{n1} or L_{n2})
c	Min. 0.20 (bigger of L_{n1} or L_{n2})
d	Min. 0.33 (bigger of L_{n2} or L_{n3})
e	Max. 0.10 L_{n1}
f1	Max. 0.125 L_{n1}
f2	Max. 0.125 L_{n2}
g	Min. 0.20 (bigger of L_{n2} or L_{n3})
h	Bigger of 12 ∅ or 25 cm

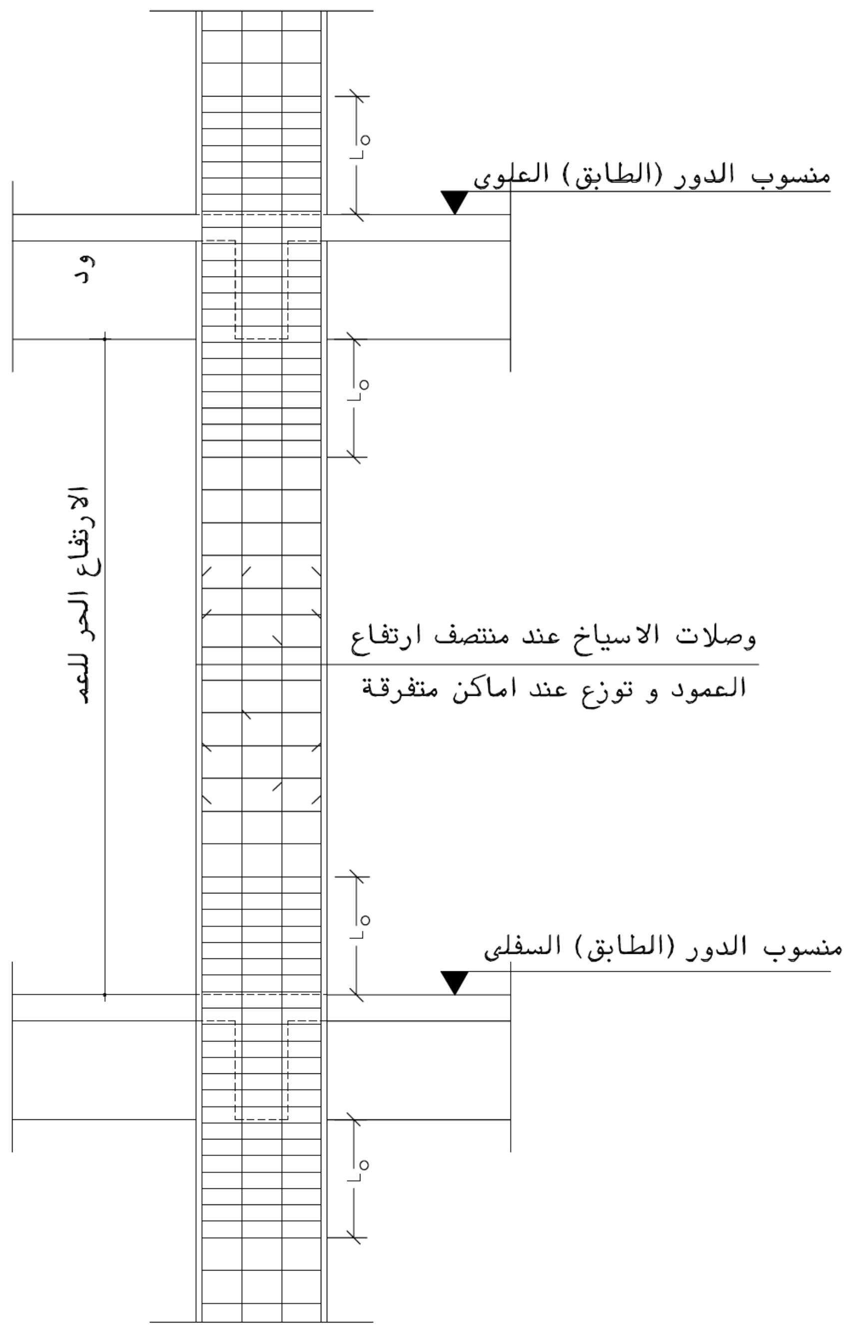
Beams' Table :

Beam Type	Bot. Rft.			Top. Rft.			Stirrups/m			Remarks
	Long	Short	At Supp.	Right	Mid.	Left	Right	Mid.	Left	
B1	أ	ب	ى	ل + ز + ى	ح	ح				
B2	جـ	د	ى	ط + ك + ى	ح	ل + ز + ى	Stirrups/m			
B3	هـ	و	ى	ط + ك + ى	ح	ط + ك + ى				

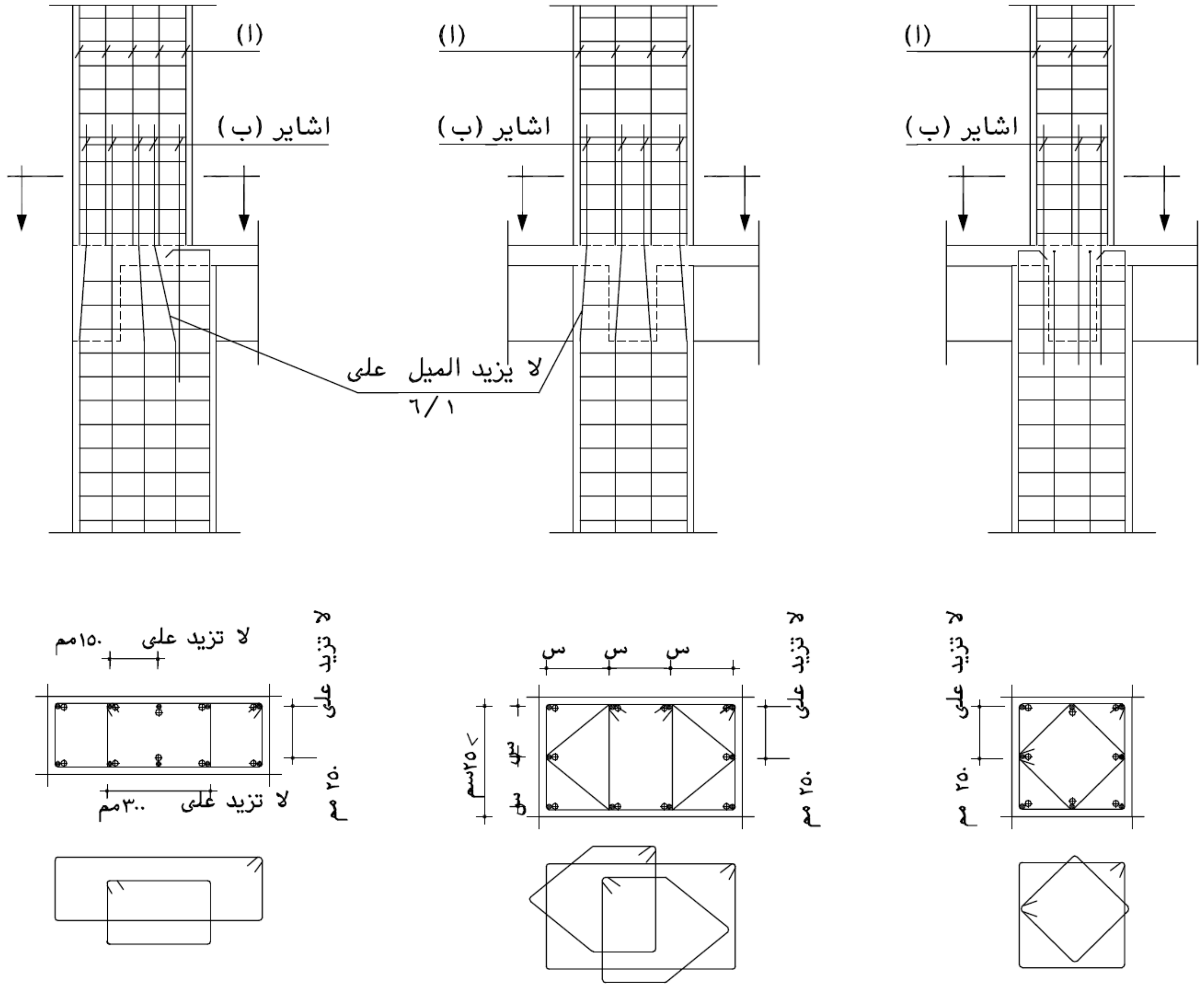
ملاحظات :

- التسليح (ى) هو التسليح الخاص بحسابات الأحمال الجانبية [يرجع الى بند (٦-٧-٢-٢)
- يراعى دراسة اجهادات القص لتحديد كمية و مسافة توزيع الكانات المقاومة للقص .
- يراعى حساب الكانات الاضافية الخاصة باماكن توقف الاسياخ طبقا للبند (٤-٢-٥-٣)
- لا تبعد اول كانة اكثر من ٥٠ مم من وجه الركيزة

Columns



منسوب الدور (الطابق) العلوى
وصلات الاسياخ عند منتصف ارتفاع
العمود و توزع عند اماكن متفرقة
منسوب الدور (الطابق) السفلى
الارتفاع الحر للعمود

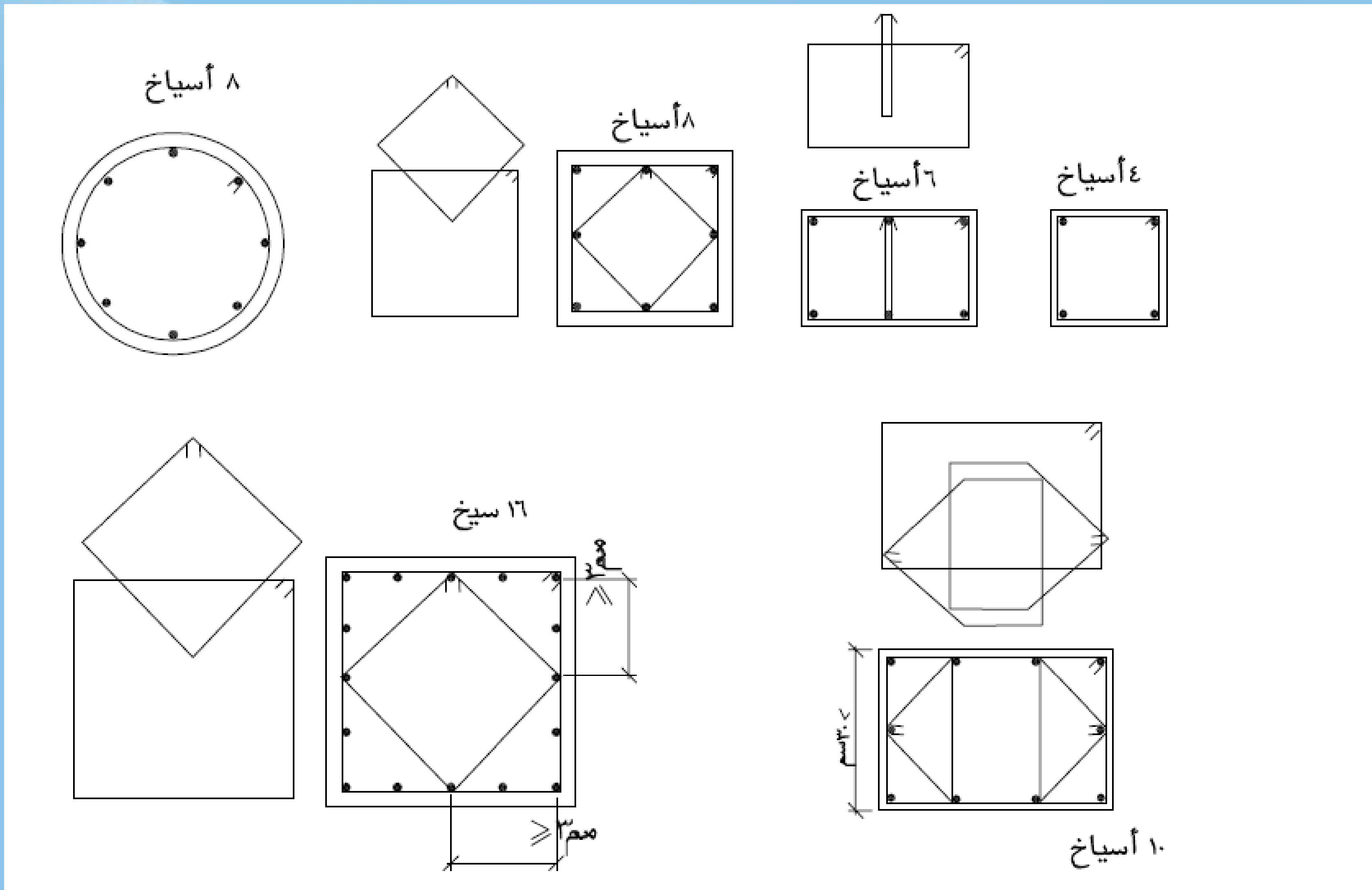


تفاصيل وصلات الاعمدة عند تغير القطاع

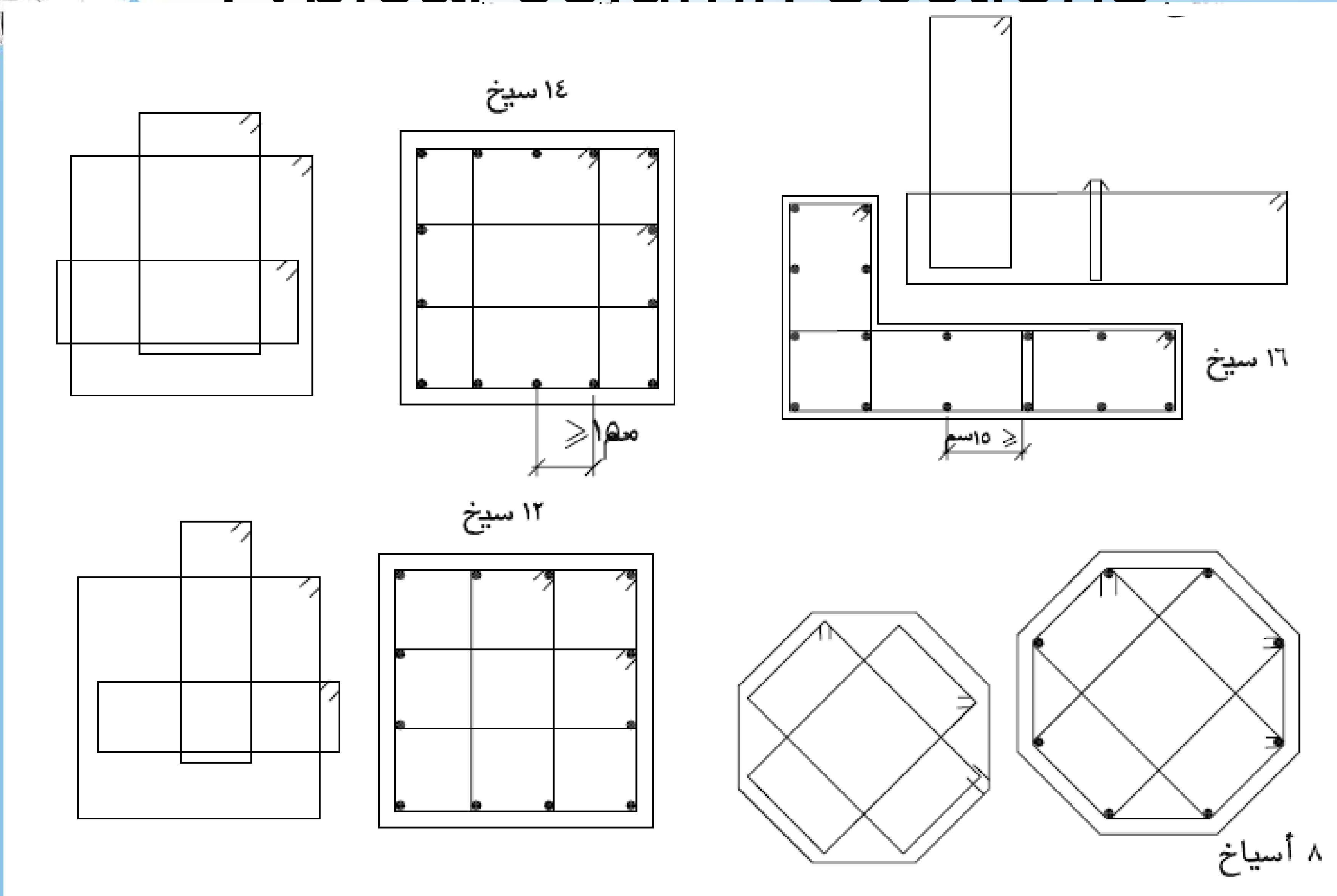
(ا) تسليح العمود

(ب) الاشاير

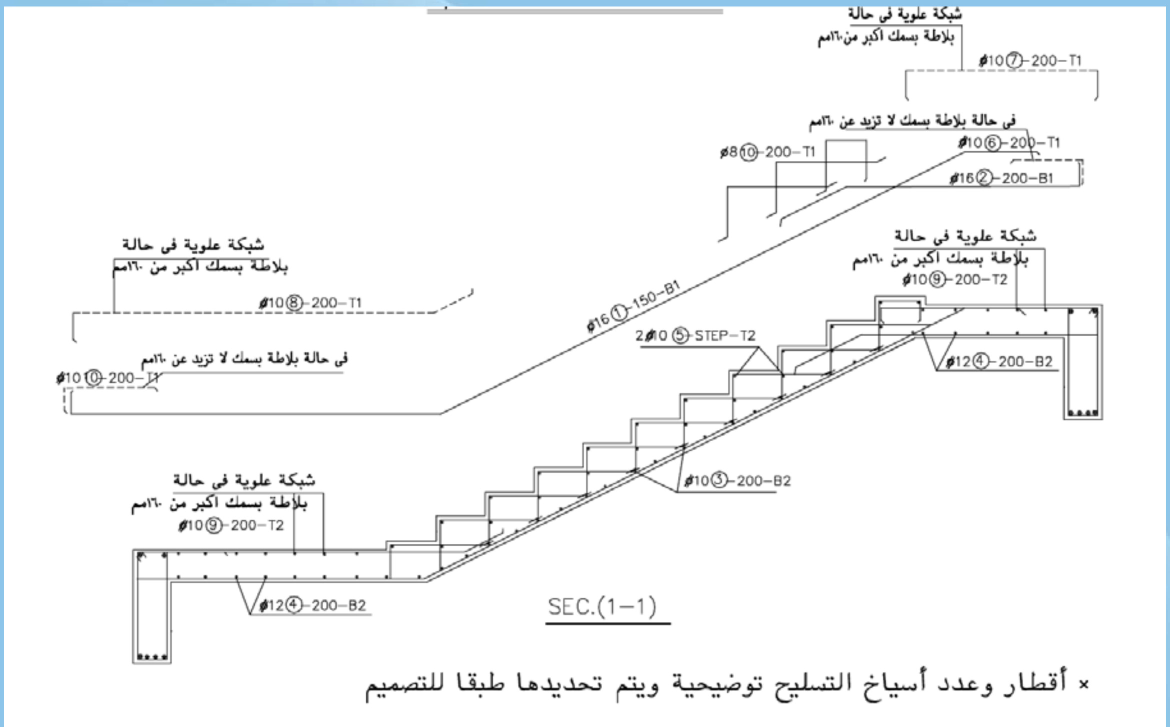
Typical column sections

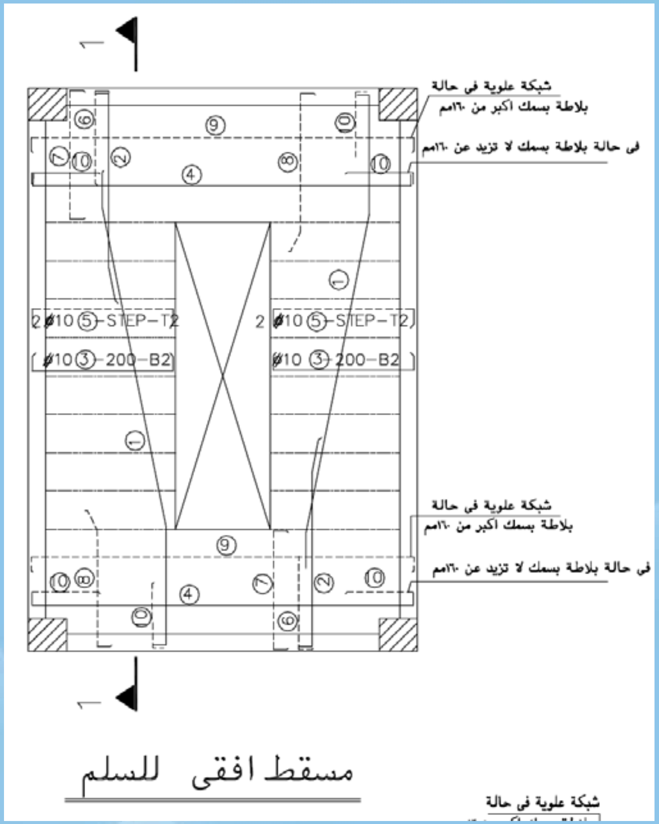


Typical column sections

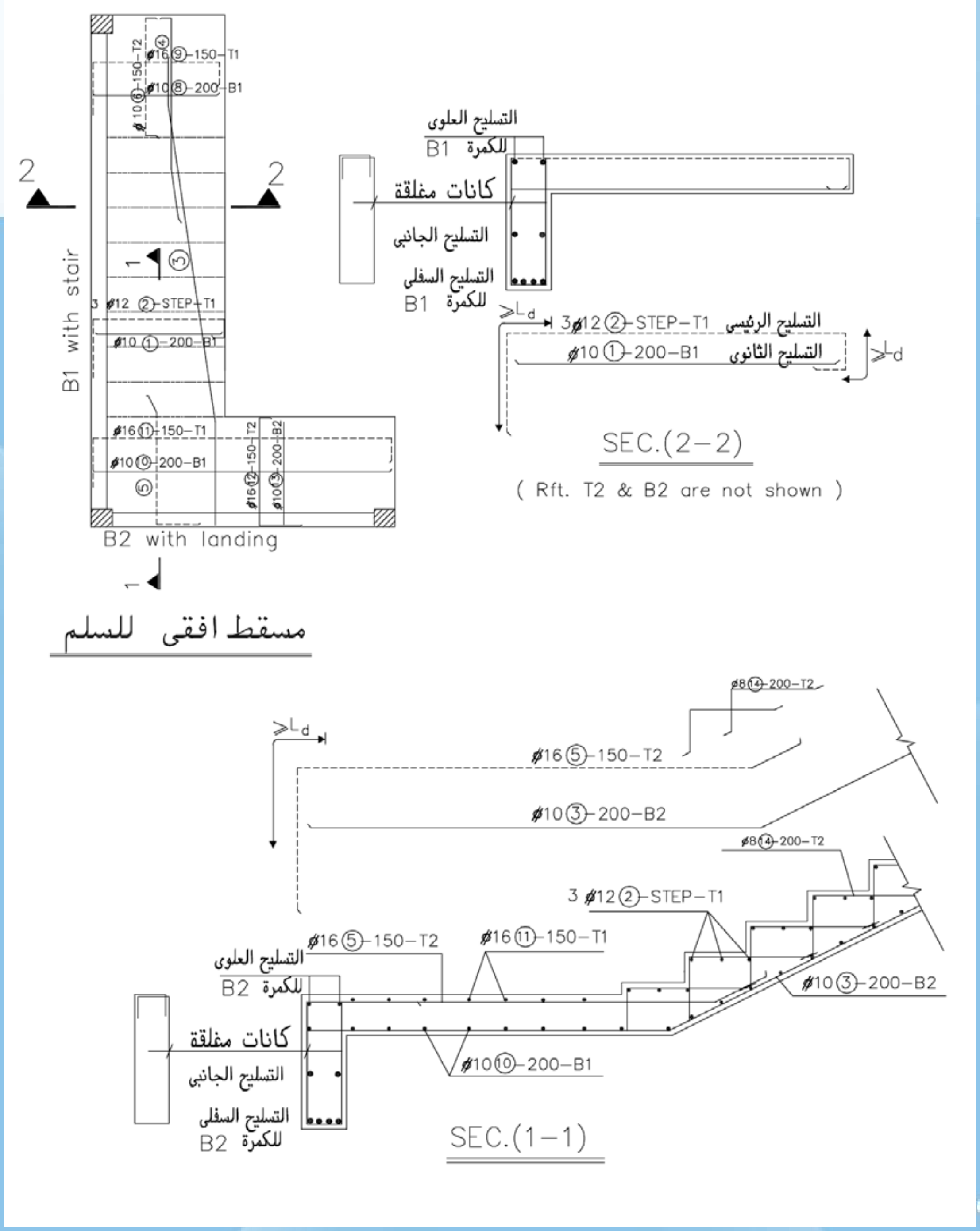


Staircase: slab type

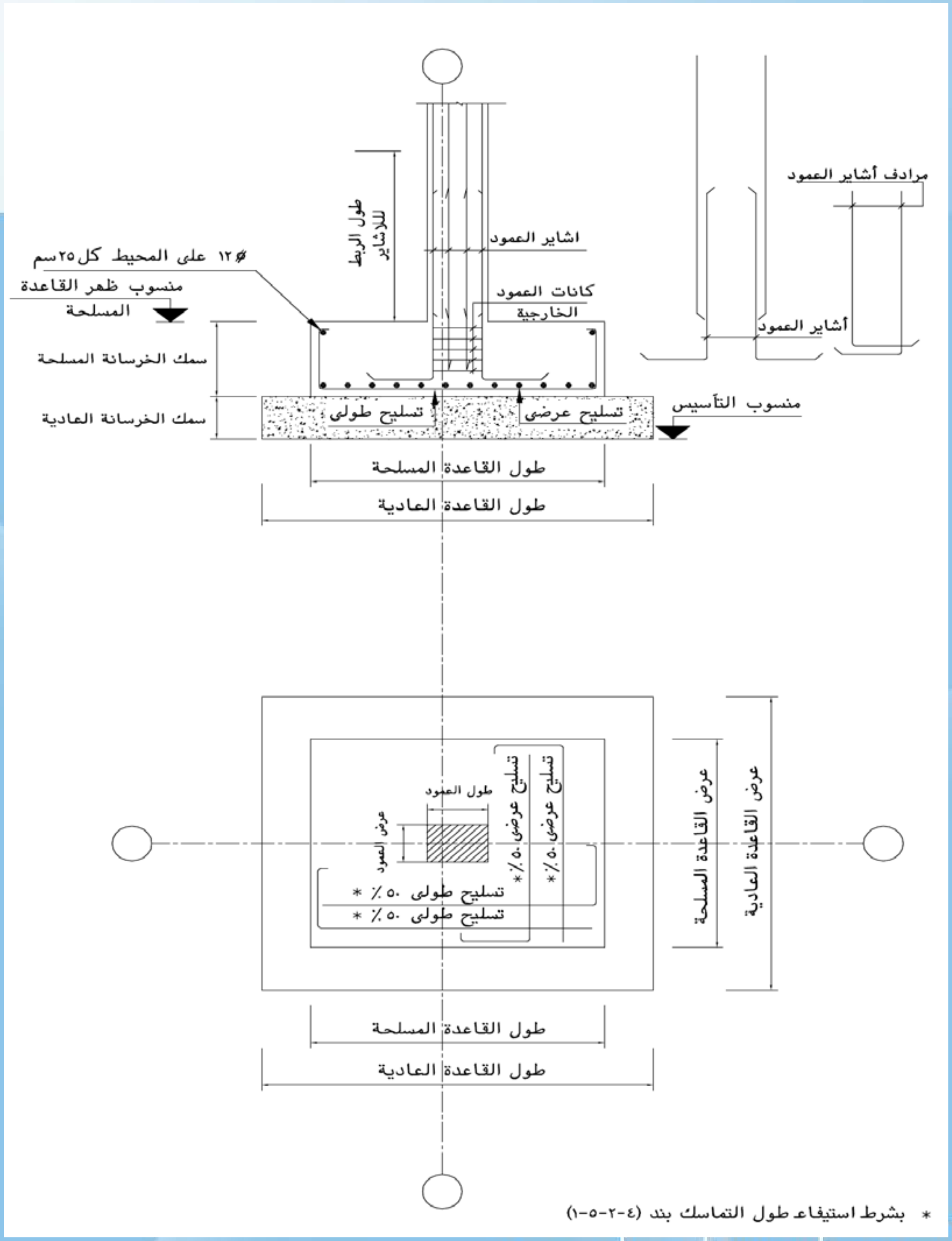




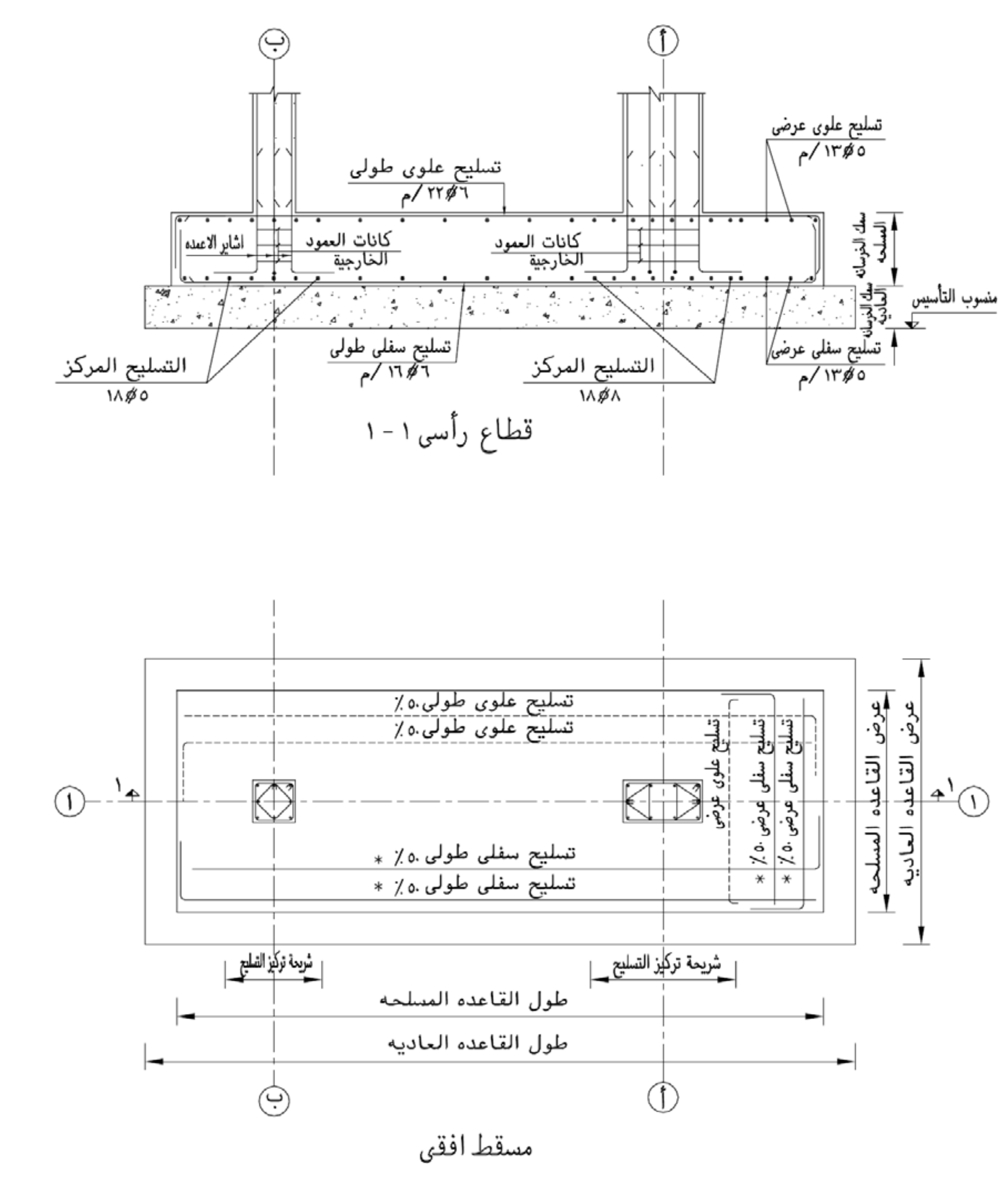
- Staircase:
- cantilever type



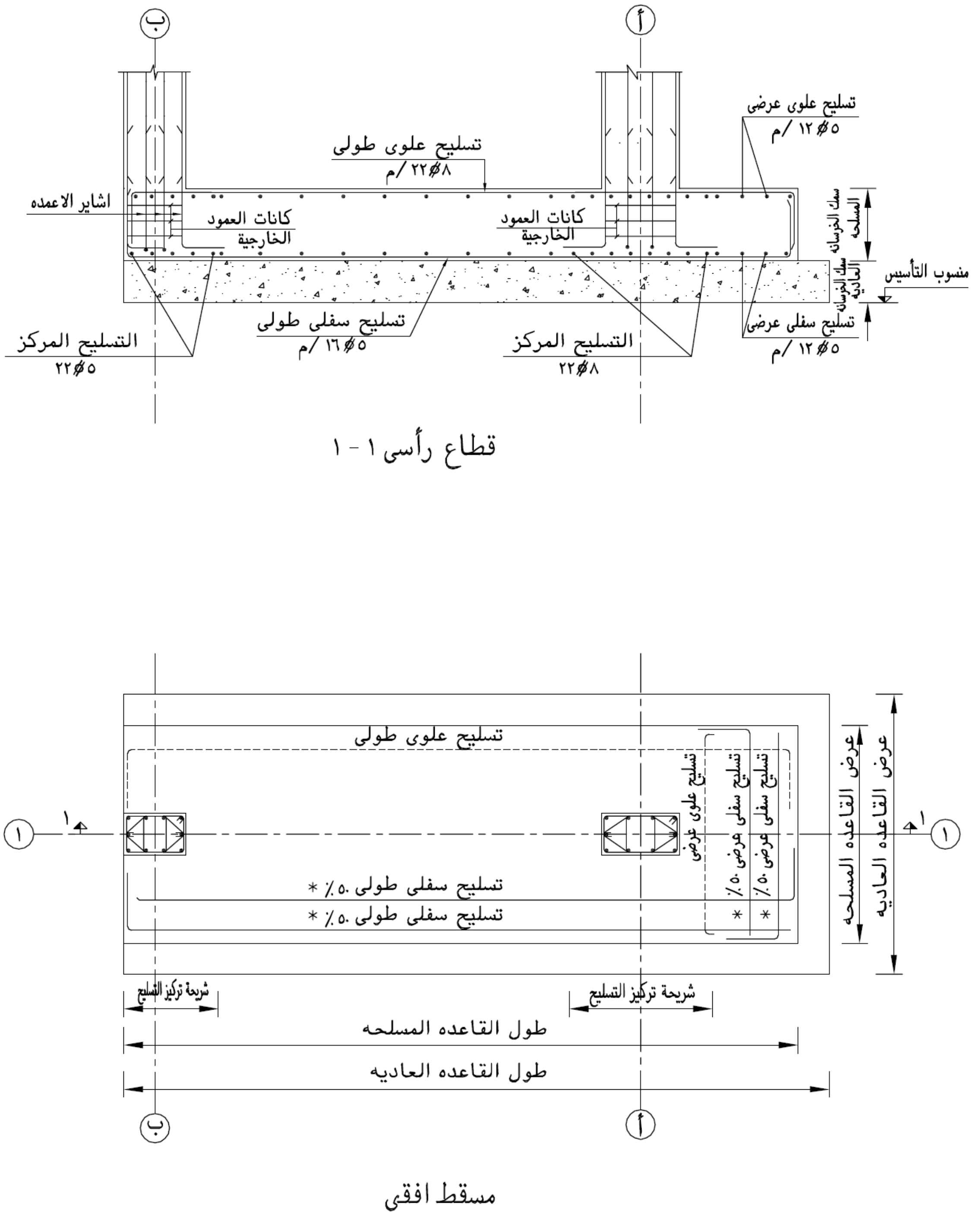
- Single footing



- Combined footing



- Combined footing: Edge column



Formwork design

Hisham Qasrawi

Basic principles of design

H. Qasrawi

- Important factors in design are:
  - safety (the structure doesn’t fall down);
  - serviceability (how well the structure performs in term of appearance and deflection);
  - economy (an efficient use of materials and labor); and
- Several alternative designs should be prepared and their costs compared.

Loads

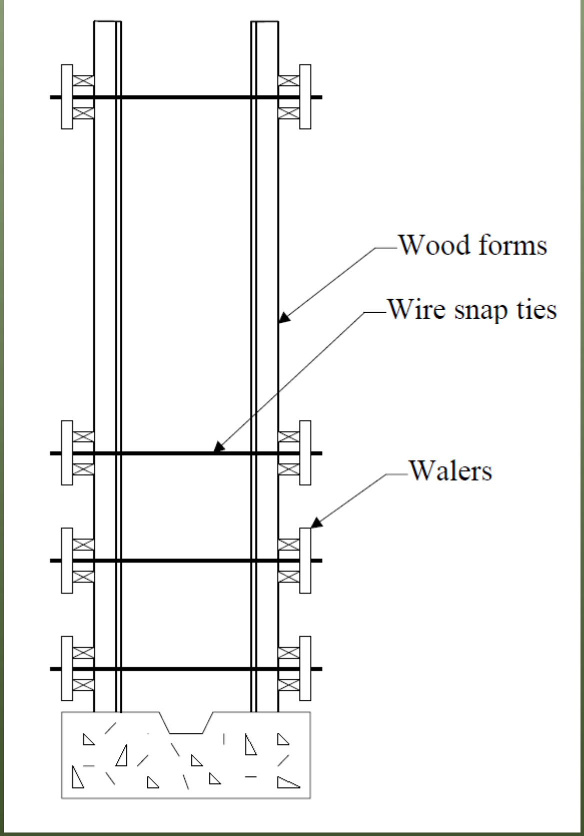
H. Qasrawi

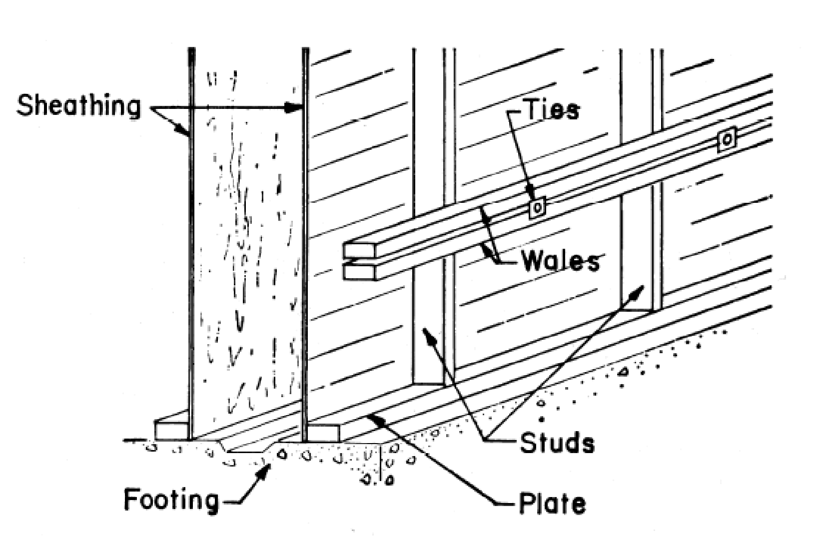
- **Dead loads** – permanent; including self-weight, floor covering, suspended ceiling, partitions, etc.
- **Live loads** – not permanent; the location is not fixed; including furniture, equipment, and occupants of buildings
- **Wind load** (exerts a pressure or suction on the exterior of a building);
- **Earthquake loads** (the effects of ground motion are simulated by a system of horizontal forces);
- **Snow load** (varies with geographical location and drift);
- **Other loads** (hydrostatic pressure, soil pressure)
- If the load is applied suddenly, the effects of **IMPACT** must be accounted for.
- **Vibrations**
- **Any nearby loading that may affect the structure**

Minimum loads

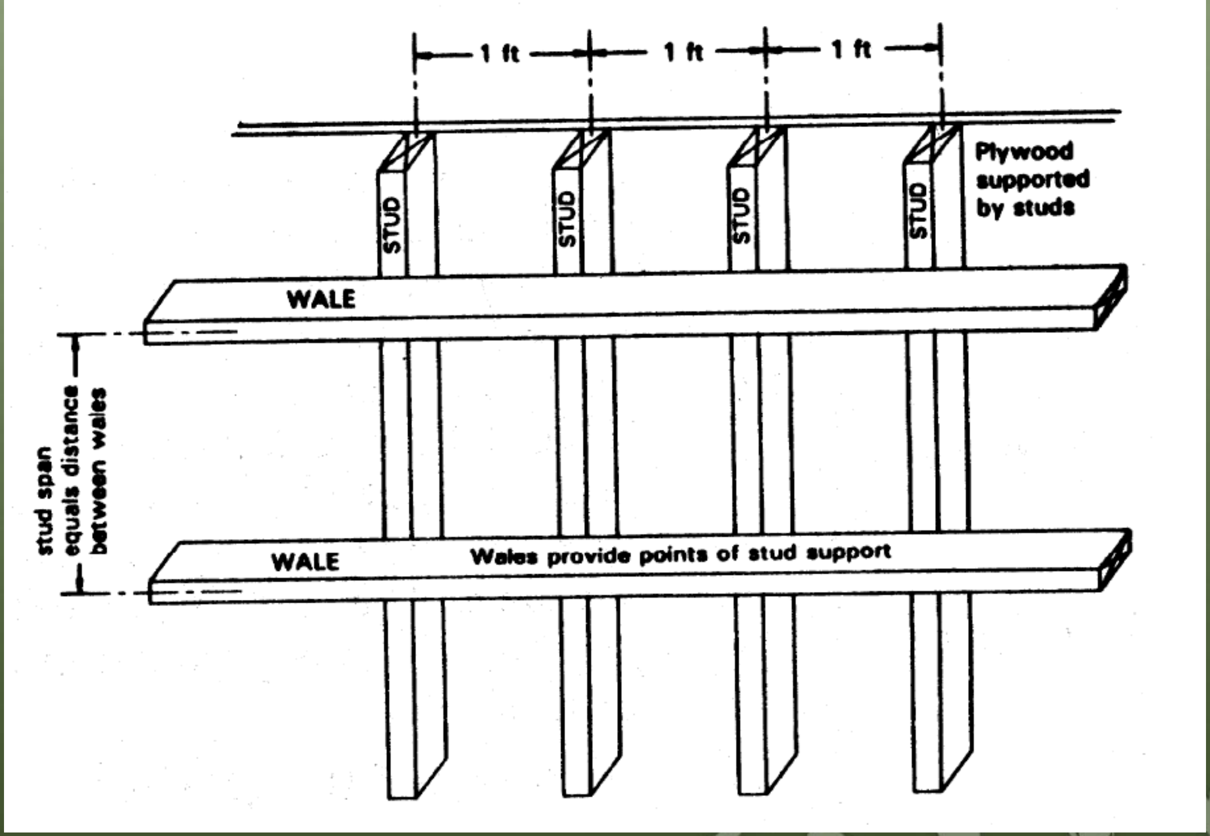
- The formwork should be designed for a live load of not (2.4 kPa) of horizontal projection.
- When motorized carts are used, the live load should not be less than (3.6 kPa).
- The design load for combined dead and live loads should not be less than (4.8 kPa) or (6.0 kPa) if motorized carts are used

Basic elements of wall

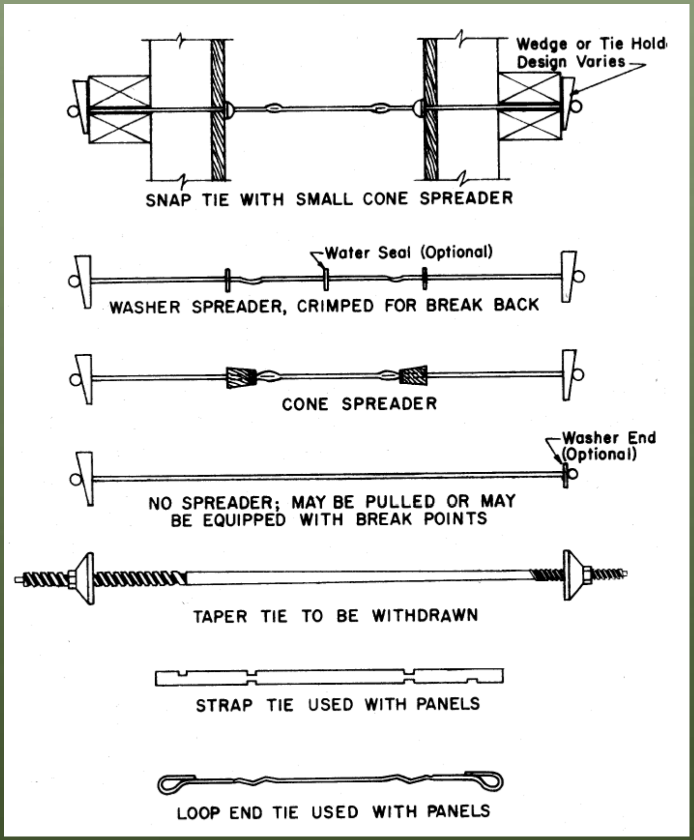


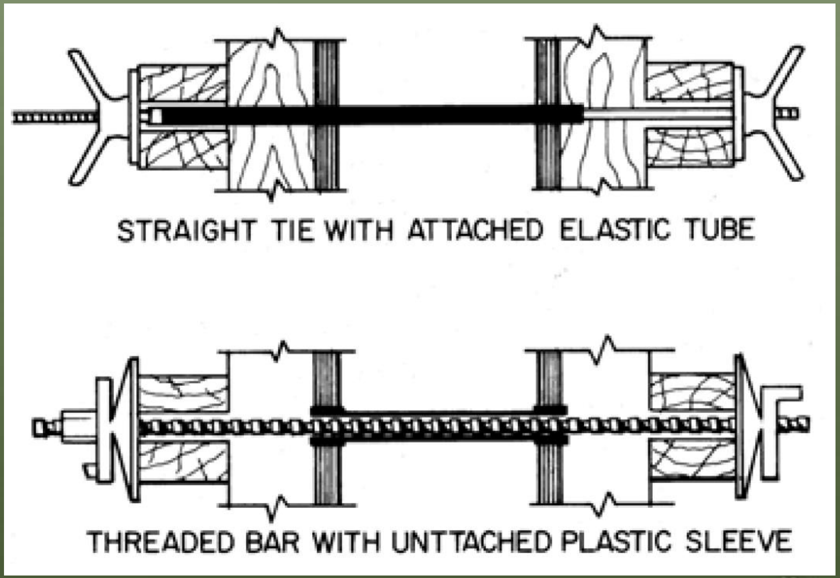


Typical wall form

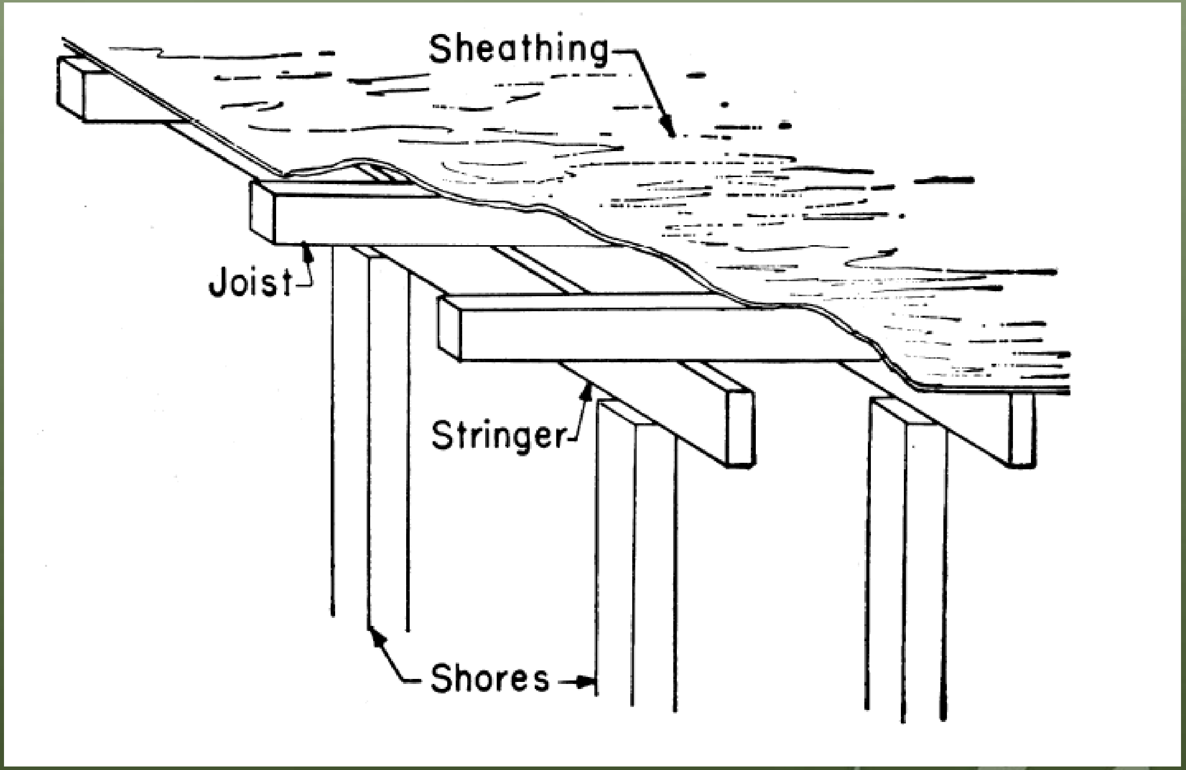


Typical member ties





Typical slab formwork



ACI 347

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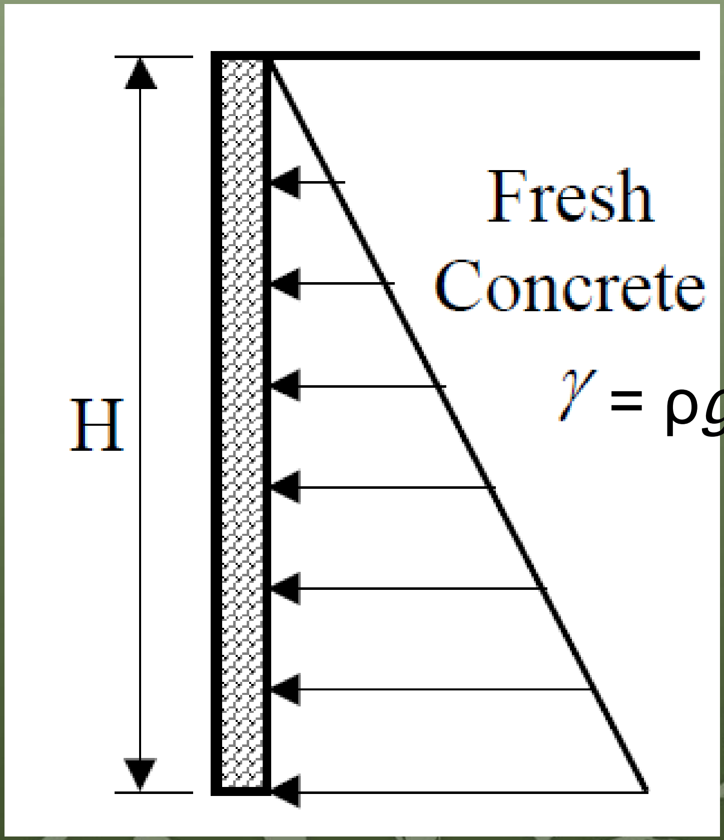
- The variables used in the pressure formulas are defined as follows:
- p = lateral pressure of concrete
- h = depth of fluid or plastic concrete from top of placement to point of consideration,
- w = unit weight of concrete,
- R = rate of placement,
- T = temperature of concrete during placement,
- C_W= unit weight coefficient; and
- Cc = chemistry coefficient.

Lateral pressure of concrete

- $p = \rho g h =$

- p = lateral pressure (kPa);
- w = unit weight of concrete,
- ρ = density of concrete, kg/m3;
- g = gravitational constant, 9.81 N/kg; and
- h = depth of fluid or plastic concrete from top of placement
- to point of consideration in form, (m).



$\gamma = \rho g h$

Condition for application of design equations

- For concrete having a
  - slump of 175 mm or less and
  - placed with normal internal vibration
  - to a depth of 1.2 m or less,
  - formwork can be designed for a lateral pressure as follows

Effect of pumping

H. Qasrawi

- If concrete is pumped from the base of the form, the form should be designed for full hydrostatic head of concrete *wh* plus a minimum allowance of 25% for pump surge pressure.
- In certain instances, pressures can be as high as the face pressure of the pump piston.

Definitions

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- For the purpose of applying the pressure formulas,
  - Columns are defined as vertical elements with no plan dimension exceeding (2 m).
  - Walls are defined as vertical elements with at least one plan dimension greater than (2 m).

Columns

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- For **columns**, the formula used to determine the design pressure is

$$p_{max} = C_w C_c \left[7.2 + \frac{785R}{T + 17.8} \right]$$

- with
  - a maximum required pressure of 3000 $C_W C_C$ and
  - a minimum of 600 C_W
  - but never more than *wh.*

Unit weight coefficient C_W

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Density of concrete	C_w
Less than 2240 kg/m^3	$C_w = 0.5[1 + (w/2320\ \text{kg/m}^3)]$ but not less than 0.80
2240 to 2400 kN/m^3	1.0
More than 2400 kg/m^3	$C_w = w/2320\ \text{kg/m}^3$

Chemistry coefficient C_C

H. Qasrawi

Cement type or blend	C_c
Types I, II, and III without retarders*	1.0
Types I, II, and III with a retarder	1.2
Other types or blends containing less than 70% slag or 40% fly ash without retarders*	1.2
Other types or blends containing less than 70% slag or 40% fly ash with a retarder*	1.4
Blends containing more than 70% slag or 40% fly ash	1.4

*Retarders include any admixture, such as a retarder, retarding water reducer, retarding midrange water-reducing admixture, or high-range water-reducing admixture (superplasticizer), that delays setting of concrete.

Walls

H. Qasrawi

- For walls with a rate of placement of less than 2.1 m/h and a placement height not exceeding 4.2 m

$$p_{max} = C_w C_c \left[7.2 + \frac{785R}{T + 17.8} \right]$$

- with a minimum of $30C_w$ kPa, but in no case greater than ρgh.

Walls

- For walls with a placement rate less than 2.1 m/h where placement height exceeds 4.2 m, and for all walls with a placement rate of 2.1 to 4.5 m/h

$$p_{max} = C_w C_c \left[7.2 + \frac{1156}{T + 17.8} + \frac{244R}{T + 17.8} \right]$$

- with a minimum of 30C_w kPa, but in no case greater than ρgh.

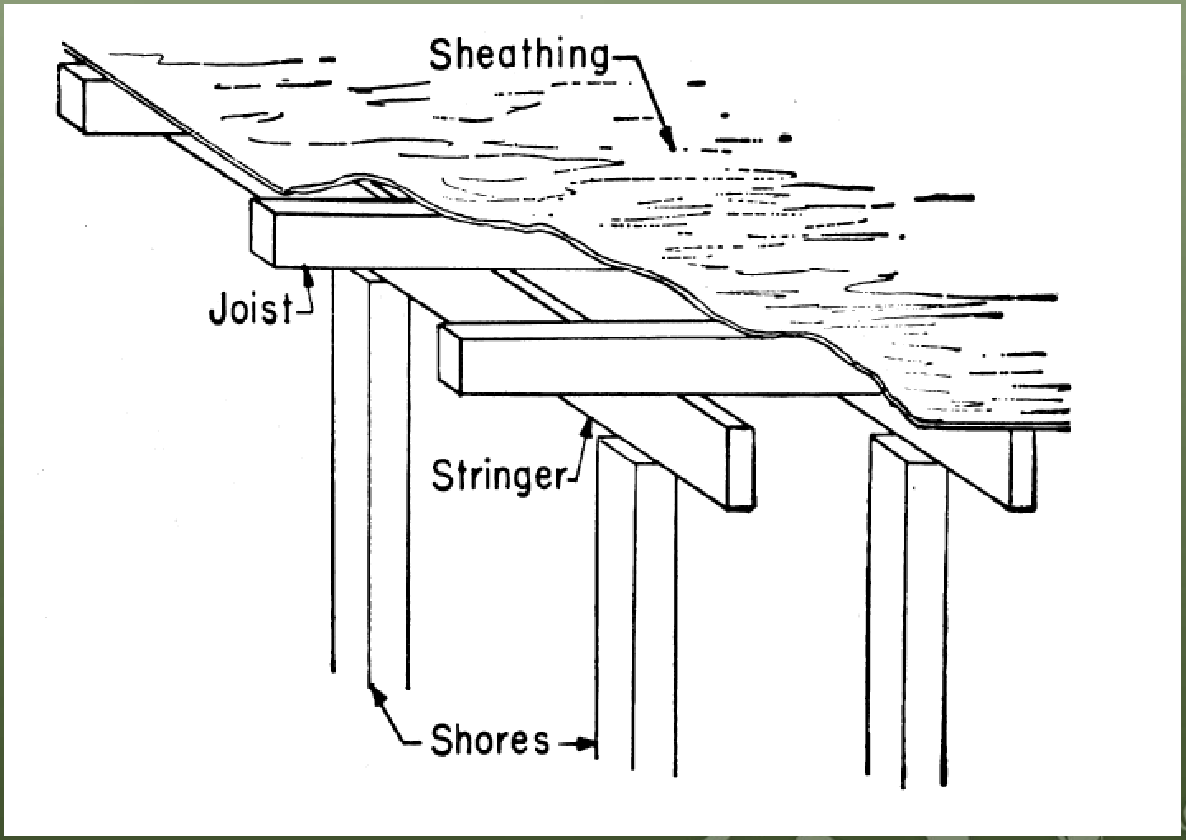
Minimum safety factors of formwork accessories*

H. Qasrawi

Accessory	Safety factor	Type of construction
Form tie	2.0	All applications
Form anchor	2.0	Formwork supporting form weight and concrete pressures only
	3.0	Formwork supporting weight of forms, concrete, construction live loads, and impact
Form hangers	2.0	All applications
Anchoring inserts used as form ties	2.0	Precast-concrete panels when used as formwork

*Safety factors are based on the ultimate strength of the accessory when new.

Horizontal formwork design



Slab from design

H. Qasrawi

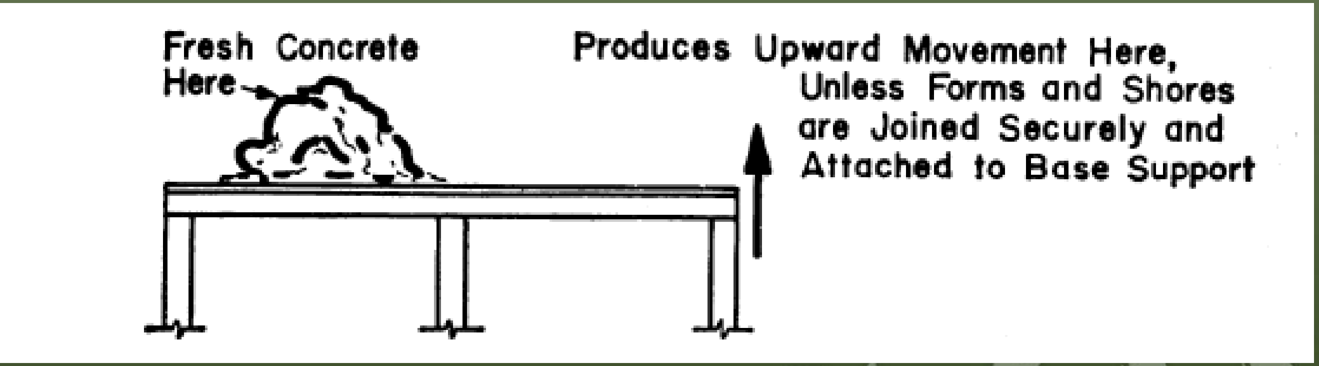
- Design of slab forms can be summarized in the following design steps:
  - Step 1: Estimate design loads
  - Step 2: Determine sheathing thickness and the spacing of its supports (joist spacing)
  - Step 3: Determine joist size and spacing of supports (stringer spacing)
  - Step 4: Determine stringer size and span (shore spacing)
  - Step 5: Perform shore design to support stringers
  - Step 6: Check bearing stresses
  - Step 7: Design lateral bracing

Vertical Loads

- Vertical loads on formwork include:
  - the weight of reinforced concrete;
  - the weight of forms themselves (dead load); and
  - the live loads imposed during the construction process (material storage, personnel and equipment).

Upload

- When slab form members are continuous over several supporting shores, dumping concrete on one span of the form member may cause uplift of the form in other spans.
- Forms must me designed to hold together under such conditions. If form members are not secured to resist this uplift, they should be built as a simple pan.



SLAB FORM EXAMPLE:

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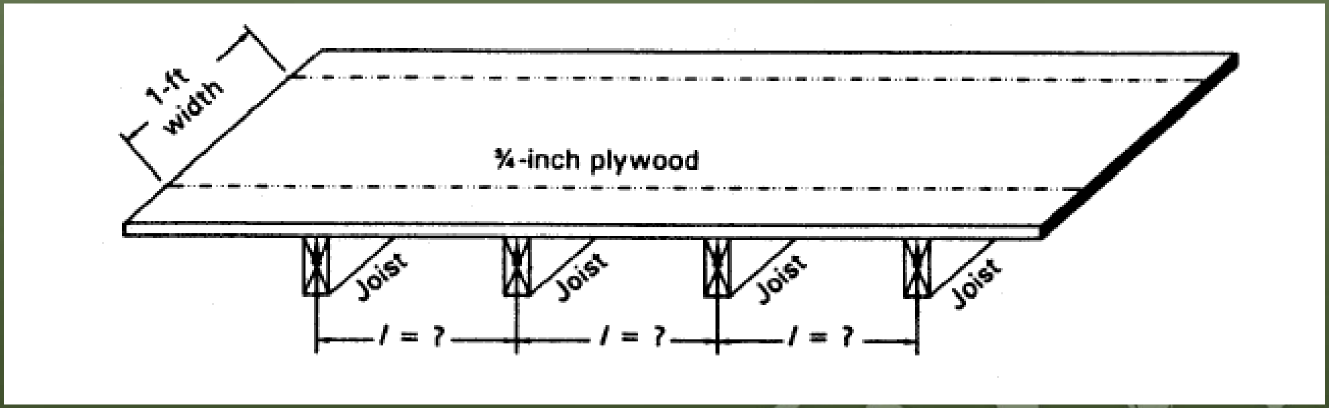
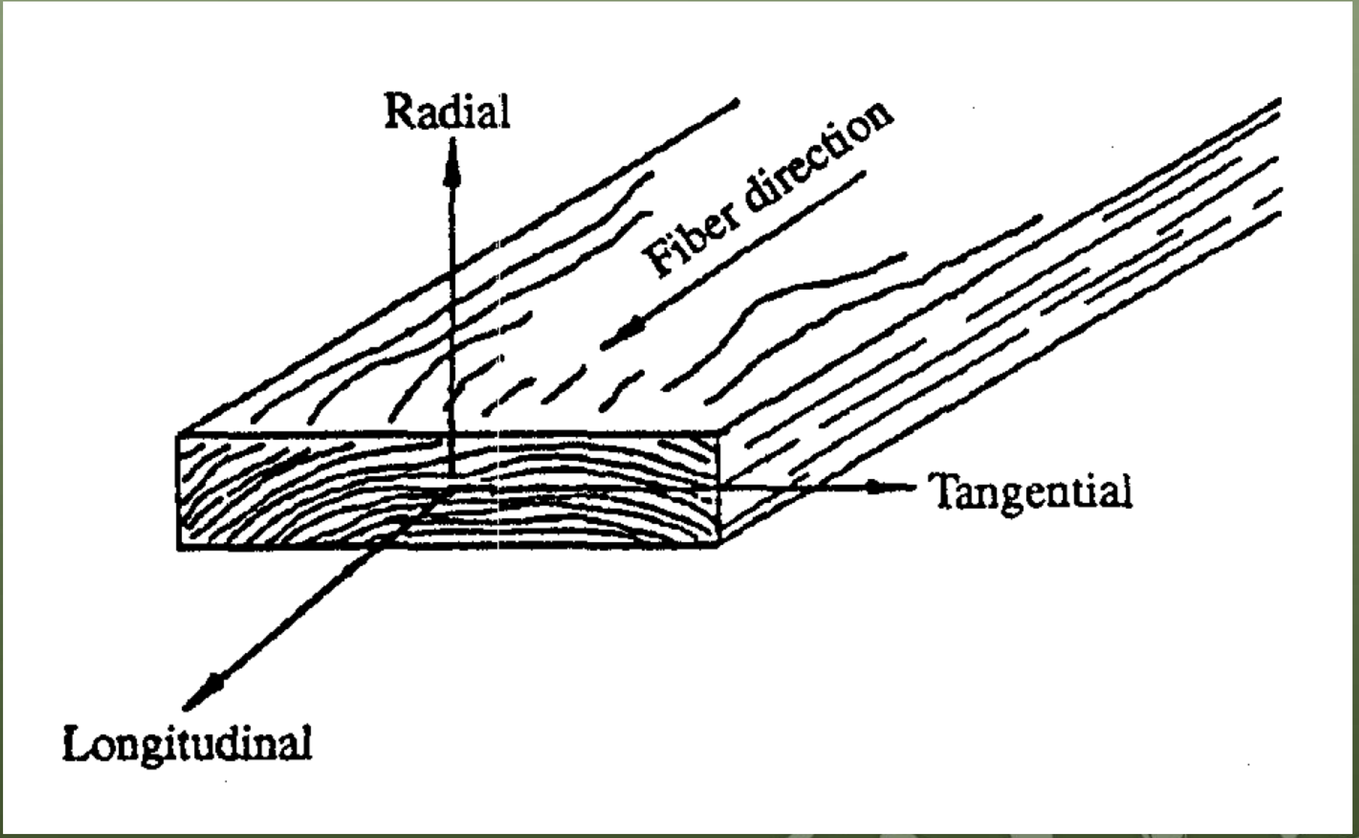
- Design forms to support a flat slab floor 8 inches thick of high-strength concrete with a unit weight of 138 lb/ft3, using construction grade Douglas Fir-Larch form in members and steel shoring. Ceiling height is 8 feet and bays are 15×15 feet.
- Assume forms will have continuing reuse.



Orthotropic Nature of Wood Properties

H. Qasrawi



Wood: Strength and Stiffness

H. Qasrawi

Major elastic constants for five wood species at 12% moisture content.[a]

Property	Loblolly pine	Sitka spruce	Red oak	Yellow poplar	Balsa
E_T/E_L	0.078	0.043	0.082	0.043	0.015
E_R/E_L	0.113	0.078	0.154	0.092	0.046
G_{LR}/E_L	0.082	0.064	0.089	0.075	0.054
G_{LT}/E_L	0.081	0.061	0.081	0.069	0.037
G_{RT}/E_L	0.013	0.003	—	0.011	0.005
μ_{LR}	0.328	0.372	0.350	0.318	0.229
μ_{LT}	0.292	0.467	0.448	0.392	0.488
μ_{RT}	0.382	0.435	0.560	0.703	0.665
μ_{TR}	0.362	0.245	0.292	0.392	0.231

a Values for μ_{RL}, and μ_{TL} are small, seldom used, and often not available. Values of E_L may be estimated by multiplying the modulus of elasticity in static bending given in Table 2 by 1.10.

Mechanical properties for five wood species at 12% moisture content.[a]

	Bending		Compression		Shear	Tension		
Species	Modulus of rupture (MPa)	Modulus of elasticity (GPa)	Parallel to grain (MPa)	Perpendicular to grain (MPa)	Parallel to grain (MPa)	Parallel to grain (MPa)	Perpendicular to grain (MPa)	Side hardness (kN)[a]
Loblolly pine	88.0	12.3	49.2	5.4	9.6	88.0	3.2	3.1
Sitka spruce	70.0	10.8	38.7	4.0	7.9	75.8	2.6	2.4
Red oak	99.0	12.5	46.6	7.0	12.3	101.4	5.5	5.7
Yellow poplar	70.0	10.9	38.2	3.4	8.2	154.4	3.7	2.4
Balsa	21.6	3.4	14.9	—	2.1	—	—	—

a Force at 5.6mm indention.

Design Values

- An important part of wood design is being able to determine design values for the following mechanical properties:
  - Bending stress, F_b
  - Tension stress parallel to grain, F_t
  - Shear stress, F_v
  - Compressive stress parallel to grain, F_c
  - Compressive stress perpendicular. to grain, $F_{c\perp}$
  - Modulus of Elasticity, E

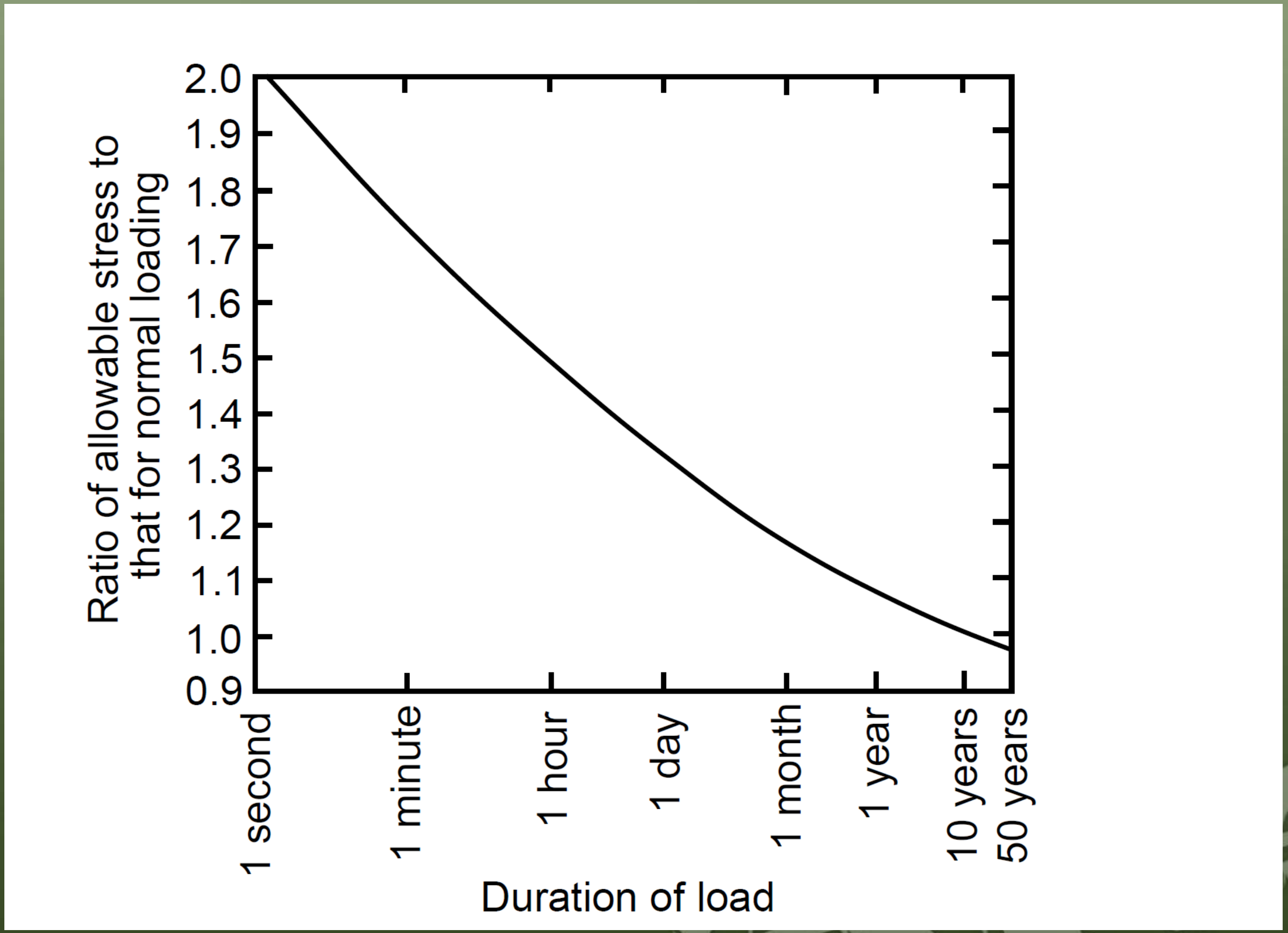
Allowable bending strength for wood

H. Qasrawi

- $F_b' = F_b\, C_D\, C_M\, C_t\, C_L\, C_F\, C_r\, C_{fu}\, C_i$

- C_D : Load duration factor
- C_M : Wet service factor
- C_t : Temperature factor
- C_L : Beam stability factor
- C_F : Size factor
- C_r : Repetitive member factor
- C_{fu} : Flat-use factor
- C_i : Incising Factor

C_D : Load duration factor



Load Duration Factor (C_D)

H. Qasrawi

- Wood can support higher stresses if the loads are applied for a short period of time. The tabulated stresses in the NDS apply to normal load duration (floor live load duration=10 years). For other loads, C_D lies in the range of 0.9 to 2.0.
- Duration of load refers to the accumulated length of time that a load is applied during the life of a structure.
- It is the full design load that is of concern, and not the length of time over which a portion of the load may be applied.
- C_D does not apply to $F_{c\perp}$ and E.

Table for Load Duration Factor

Shortest-Duration Load in Combination	C_D
Dead load	0.9
Floor live load	1.0
Snow load	1.15
Roof live load	1.25
Wind or seismic force	1.6
Impact	2.0

C_M : Wet service factor

H. Qasrawi

	Property (MPa (lb/in^2))		
Coefficients	MOR	UTS	UCS
B_1	16.6 (2,415)	21.7 (3,150)	9.6 (1,400)
B_2	0.276 (40)	0.552 (80)	0.234 (34)

[a]MOR is modulus of rupture; UTS, ultimate tensile stress; and UCS, ultimate compressive stress.

$$P_2 = P_1 + \left(\frac{P_1 - B_1}{B_2 - M_1}\right)(M_1 - M_2)$$

where M_1 is moisture content 1 (%), M_2 is moisture content 2 (%), and B_1, B_2 are constants from Table 6–7.

For E, the following equation applies:

$$E_1 = E_2\left(\frac{1.857 - (0.0237\,M_2)}{1.857 - (0.0237\,M_1)}\right)$$

where E_1 is property (MPa, lb/in^2) at moisture content 1 and E_2 is property (MPa, lb/in^2) at moisture content 2.

For MOR, ultimate tensile stress (UTS), and ultimate compressive stress (UCS), the following ASTM D1990 equations apply:

For MOR $\leq$ 16.7 MPa (2,415 lb/in^2)
UTS $\leq$ 21.7 MPa (3,150 lb/in^2)
UCS $\leq$ 9.7 MPa (1,400 lb/in^2)

$$P_1 = P_2$$

Thus, there is no adjustment for stresses below these levels.

For MOR > 16.6 MPa (2,415 lb/in^2)
UTS > 21.7 MPa (3,150 lb/in^2)
UCS > 9.7 MPa (1,400 lb/in^2)

Also,
C_M = 1.0
In-service moisture content less than 19%

C_t : Temperature factor

H. Qasrawi

Design values	In-service moisture content	Factor: $T \leq 37^{\circ}C$ ($T \leq 100^{\circ}F$)	$37^{\circ}C < T \leq 52^{\circ}C$ ($100^{\circ}F < T \leq 125^{\circ}F$)	$52^{\circ}C < T \leq 65^{\circ}C$ ($125^{\circ}F < T \leq 150^{\circ}F$)
F_t, E	Wet or dry	1.0	0.9	0.9
F_b, F_v, F_c, $F_{c\perp}$	Dry	1.0	0.8	0.7
	Wet	1.0	0.7	0.5

C_F : Size factor

H. Qasrawi

$$P_1 = P_2\left(\frac{W_1}{W_2}\right)^w\left(\frac{L_1}{L_2}\right)^l$$

Exponent	MOR	UTS	UCS
w	0.29	0.29	0.13
l	0.14	0.14	0

[a]MOR is modulus of rupture;
UTS, ultimate tensile stress; and
UCS, ultimate compressive stress.

- where
- P_1 is property value (MPa, lb/in^2) at volume 1,
- P_2 property value (MPa, lb/in^2) at volume 2,
- W_1 width (mm, in.) at P_1,
- $W2$ width (mm, in.) at P_2,
- L_1 length (mm, in.) at P_1, and L_2 length (mm, in.) at P_2.
- Exponents are defined in Table

C_F : Size factor

H. Qasrawi

- Approximate method

- The size of a wood member has an effect on its strength. For dimension lumber, the size affects F_t , F_c , and F_b. The values of C_F are given at the beginning of Table 4A.
- For timbers, C_F applies only to F_b:
  - $C_F=(300/d)^{1/9}$
  - When d, depth of timber, is less than 300 mm., $C_F=1$

C_r : Repetitive member factor

H. Qasrawi

- If all of the following are true:
  - The lumber is (50 – 100 mm) thick.
  - Spaced no more than (600 mm) on center.
  - No less than three parallel members acting in the system.
  - All members must be joined together by some load distributing element (plywood, sheathing, flooring, roofing, etc.) in order to distribute the load amongst the various members.
- Then a 15% increase in the capacity of the members can be used (Cr = 1.15)

C_L : Beam stability factor

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$$C_L = \frac{1 + (F_{bE} / F_b^*)}{1.9} - \sqrt{\left[\frac{1 + F_{bE} / F_b^*}{1.9}\right]^2 - \frac{F_{bE} / F_b^*}{0.95}}$$

where:

- $F_b{}^*$ = reference bending design value multiplied by all applicable adjustment factors except C_{fu}, C_V, and C_L and
- $F_{bE} = 1.20E_{min}' / R_b{}^2$

Modulus of Elasticity for Beam and Column Stability, E_{min}'

H. Qasrawi

$E_{min} = 1.03E\,(1 - 1.645(COV_E))\,/\,1.66$

- where:
- E = reference modulus of elasticity,
- 1.03 = adjustment factor to convert E to a pure bending basis except that the factor is
- 1.05 for glued laminated timber,
- 1.66 = factor of safety, and
- COV_E = coefficient of variation in modulus of elasticity (given in *NDS* Appendix F).

- E_{min}'(represents an approximate 5% lower exclusion value on pure bending modulus of elasticity, divided by a 1.66 factor of safety),

C_i : Incising Factor

H. Qasrawi

- For the modulus of elasticity, C_i 0.95
- For bending, tension, shear, and compression parallel to grain, C_i 0.80.
- For compression perpendicular to grain as well as for non-incised treated lumber, the incising factor is taken as 1.0.

C_{fu} : Flat-use factor

- $C_{fu} = 1.0$
  for member loaded in edge-wise bending.

Allowable bending strength for wood

- $F_v' = F_v\, C_D\, C_M\, C_t\, C_i$

- C_D : Load duration factor
- C_M : Wet service factor
- C_t : Temperature factor
- C_i : Incising Factor

Deflection

H. Qasrawi

$$\text{Max. } \Delta = f\left(\frac{P, w, L}{I, E'}\right)$$

$$\text{Max. } \Delta_{\text{L}} \leq \text{allow. } \Delta_{\text{L}}$$
$$\text{Max. } \Delta_{\text{TL}} \leq \text{allow. } \Delta_{\text{TL}}$$

- $E' = E\, C_M\, C_t\, C_i$

- C_M : Wet service factor
- C_t : Temperature factor
- C_i : Incising Factor

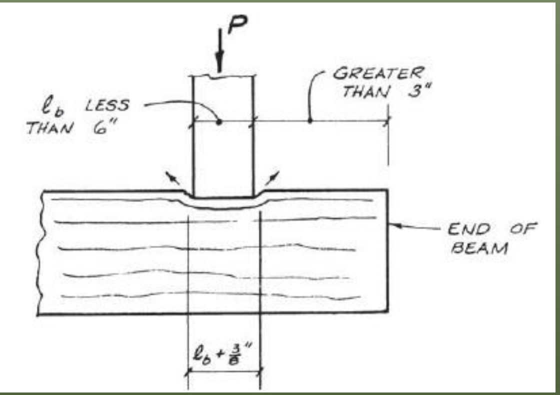
Δ_L : Live load deflection

Δ_{TL} : Live load deflection

Bearing at supports

- $F_{C\perp}' = F_{C\perp}\, C_M\, C_t\, C_i\, C_b$

- C_M : Wet service factor
- C_t : Temperature factor
- C_i : Incising Factor



$$C_b = \frac{l_b + 10\text{ mm}}{l_b}$$

- C_b : bearing area factor = 1.0 is conservative conservatively

Compression parallel to the grains

H. Qasrawi

- $F_c^* = F_c\, C_D\, C_M\, C_t\, C_F\, C_i$

- C_D : Load duration factor
- C_M : Wet service factor
- C_t : Temperature factor
- C_F : Size factor
- C_i : Incising Factor

Axial tension

- $F_t' = F_t \, C_D \, C_M \, C_t \, C_F \, C_i$

- C_D : Load duration factor
- C_M : Wet service factor
- C_t : Temperature factor
- C_L : Beam stability factor
- C_F : Size factor
- C_i : Incising Factor

Axial compression

H. Qasrawi

- $F_c' = F_c\, C_D\, C_M\, C_t\, C_F\, C_P\, C_i$
- C_D : Load duration factor
- C_M : Wet service factor
- C_t : Temperature factor
- C_L : Beam stability factor
- C_F : Size factor
- C_P : Column stability factor
- C_i : Incising Factor

Column Stability Factor

H. Qasrawi

- C_P = 1.0 for fully supported column

$$C_P = \frac{1 + F_{cE}/F_c^*}{2c} - \sqrt{\left(\frac{1 + F_{cE}/F_c^*}{2c}\right)^2 - \frac{F_{cE}/F_c^*}{c}}$$

$$F_{cE} = \frac{0.822E'_{\min}}{(l_e/d)^2}$$

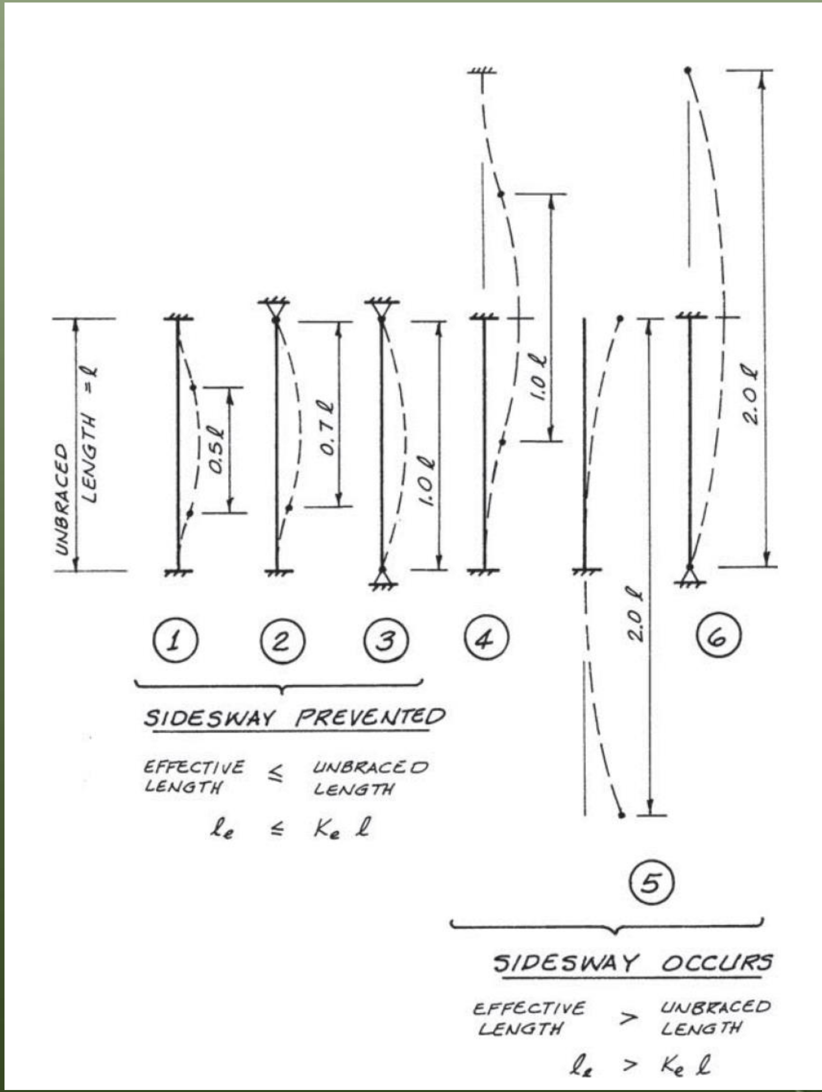
- *c =* buckling and crushing interaction factor for columns

  = 0.80 for sawn lumber columns

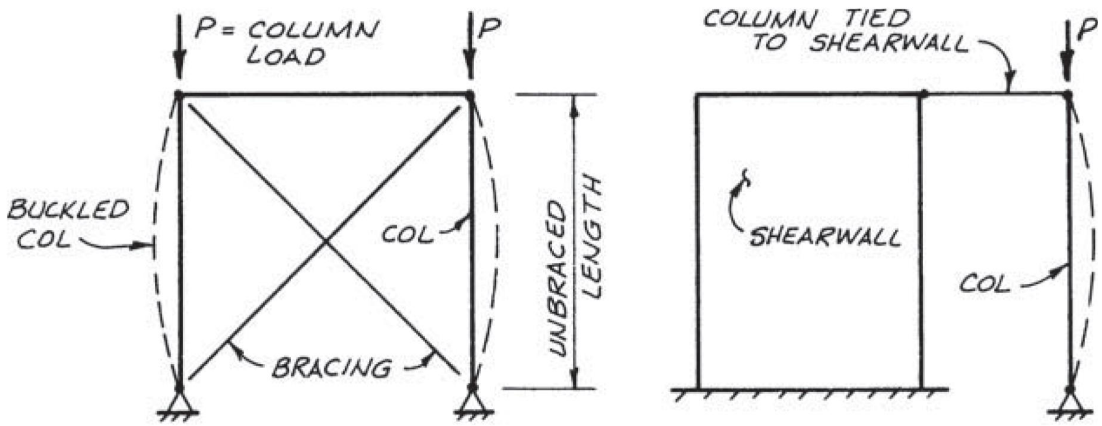
  = 0.85 for round timber poles and piles

  = 0.90 for glulam or structural composite lumber columns

Effective length l_e

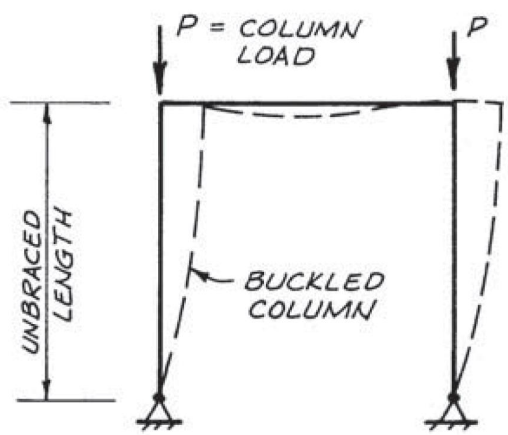


Column No.	1	2	3	4	5	6
Theoretical effective length factors	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design K_e	0.65	0.8	1.0	1.2	2.1	2.4



a. SIDESWAY PREVENTED

EFFECTIVE LENGTH $\leq$ UNBRACED LENGTH



b. SIDESWAY

EFFECTIVE LENGTH > UNBRACED LENGTH

H. Qasrawi

Applicability of Adjustment Factors for Sawn Lumber

		ASD only	ASD and LRFD										
		Load duration factor	Wet service factor	Temperature factor	Beam stability factor	Size factor	Flat use factor	Incising factor	Repetitive member factor	Column stability factor	Buckling stiffness factor	Bearing area factor
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	–	–	–
$F_t' = F_t$	x	C_D	C_M	C_t	–	C_F	–	C_i	–	–	–	–
$F_v' = F_v$	x	C_D	C_M	C_t	–	–	–	C_i	–	–	–	–
$F_{c\perp}' = F_{c\perp}$	x	–	C_M	C_t	–	–	–	C_i	–	–	–	C_b
$F_c' = F_c$	x	C_D	C_M	C_t	–	C_F	–	C_i	–	C_P	–	–
$E' = E$	x	–	C_M	C_t	–	–	–	C_i	–	–	–	–
$E_{min}' = E_{min}$	x	–	C_M	C_t	–	–	–	C_i	–	–	C_T	–

Personal Protective Equipment PPE

Hisham Qasrawi

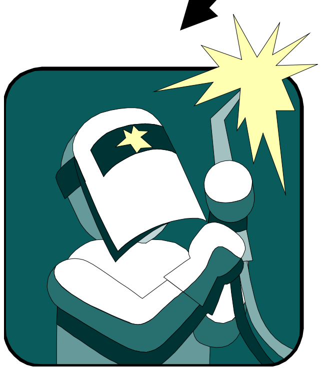
Personal Protective Equipment
PPE

What is PPE?

- PPE is defined in the Regulations as 'all equipment (including clothing affording protection against the weather) which is intended to be worn or held by a person at work and which protects him against one or more risks to his health or safety', e.g. safety helmets, gloves, eye protection, high visibility clothing, safety footwear and safety harnesses.

Eyes & Face

- **Hazards**: chemical or metal splash, dust, projectiles, gas and vapour, radiation.
- **Options**: safety spectacles, goggles نظارات واقية, face shields, visors أقنعة.

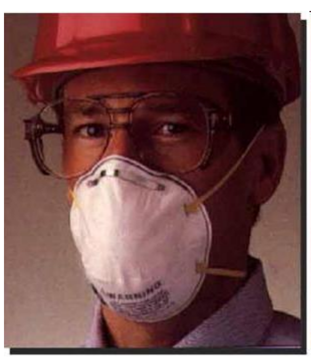


Head

- **Hazards**: impact from falling or flying objects, risk of head bumping, hair entanglement.
- **Options**: a range of helmets and bump caps.

Breathing

- Hazards: dust, vapour, gas, oxygen deficient atmospheres.
- Options: disposable filtering face piece or respirator, half-or full-face respirators, air-fed helmets, breathing apparatus.



Protecting the body

- **Hazards**: temperature extremes, adverse weather, chemical or metal splash, spray from pressure leaks or spray guns, impact or penetration, contaminated dust, excessive wear or entanglement of own clothing.
- **Options**: conventional or disposable overalls, boiler suits, specialist protective clothing, e.g. chain mail aprons, high visibility clothing.

Hands and arms

- **Hazards**: abrasion, temperature extremes, cuts and punctures, impact, chemicals, electric shock, skin infection, disease or contamination.
- **Options**: gloves, gauntlets, mitts, wrist cuffs, armlets أساور.



Feet and legs

- Hazards: wet, electrostatic buildup, slipping, cuts and punctures, falling objects, metal and chemical splash, abrasion.
- Options: safety boots and shoes with protective toe caps and penetration resistant mid-sole, gaiters, spats.





Special equipment

- Protect body from falling
- Safety harnesses

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Aya kotkot
2011-2012

Key points to remember

- PPE is provided;
- it offers adequate protection for its intended use;
- those using it are adequately trained in its safe use;
- it is properly maintained and any defects are reported;
- it is returned to its proper storage after use.

مشروع العبدلي