University of East London

FOUNDATIONS

Construction Week

By Gennady Vasilchenko-Malishev at Malishev Wilson Engineers
www.malishevwilson.com
gennady@malishevwilson.com

Foundation types

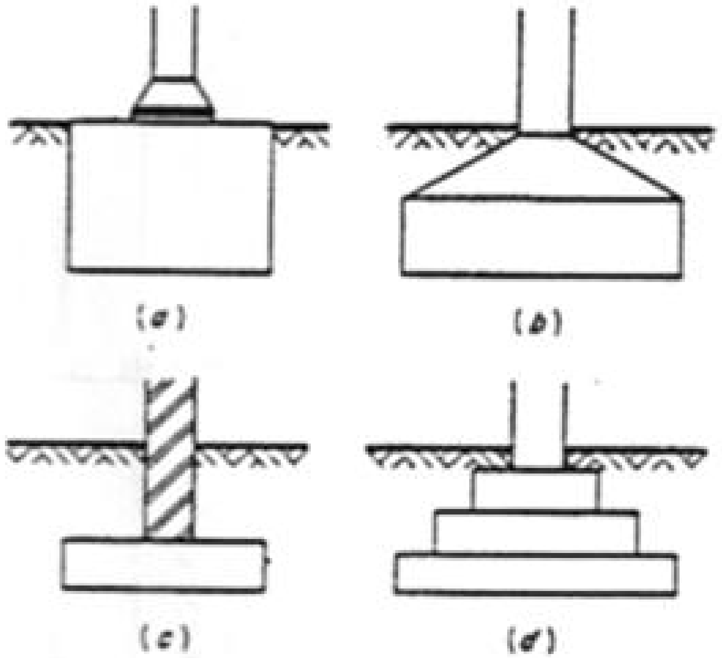


Fig. 2.1 Types of pad foundation. (*a*) Mass concrete for steel column. (*b*) Reinforced concrete with sloping upper face. (*c*) Plain reinforced concrete. (*d*) Stepped reinforced concrete.

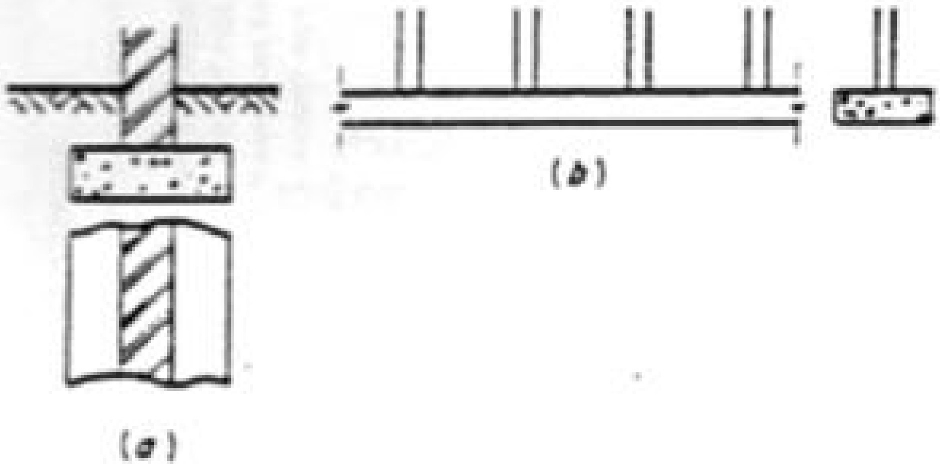
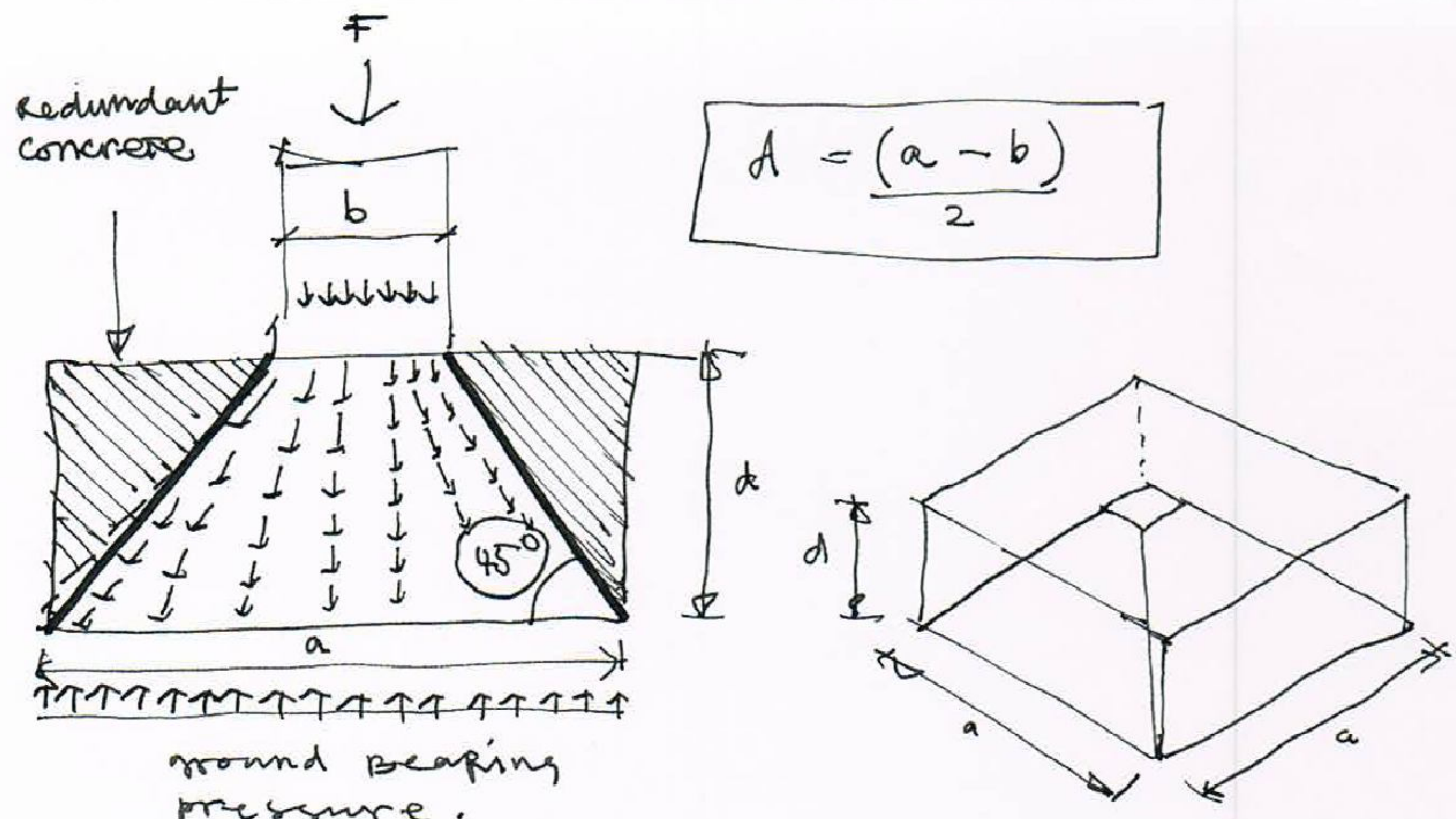


Fig. 2.2 Types of strip foundation. (*a*) Strip foundation to load-bearing wall. (*b*) Strip foundation to a row of close-spaced columns.



F
Redundant concrete
b
d = (a − b) / 2
d
45°
a
d
a
a
ground bearing pressure.

Building near trees (NHBC, chapter 4.2)

TYPE OF SOIL	Type of trees (mature height of about 20m)	Foundation depth At distance 1m	Foundation depth At distance 5m	Foundation depth At distance 10m	Foundation depth At distance 15m	Foundation depth At distance 20m
High shrinkage (clay)	Water demanding (Elm, oak, poplar, willow)	3.5	3	2.5	2.0	1.5
High shrinkage (clay)	Moderate demanding (Ash)	2.5	2	1.5	1.0	1.0
medium shrinkage (sandy clay)	Water demanding (Elm, oak, poplar, willow)	3.0	2.5	2.0	1.5	1.0
medium shrinkage (sandy clay)	Moderate demanding (Ash)	2.0	1.6	1.25	1.0	1.0
Low shrinkage (sand)	Water demanding (Elm, oak, poplar, willow)	2.5	2.2	1.8	1.5	1.2
Low shrinkage (sand)	Moderate demanding (Ash)	1.5	1.3	1.05	1.5	0.75

Foundation types

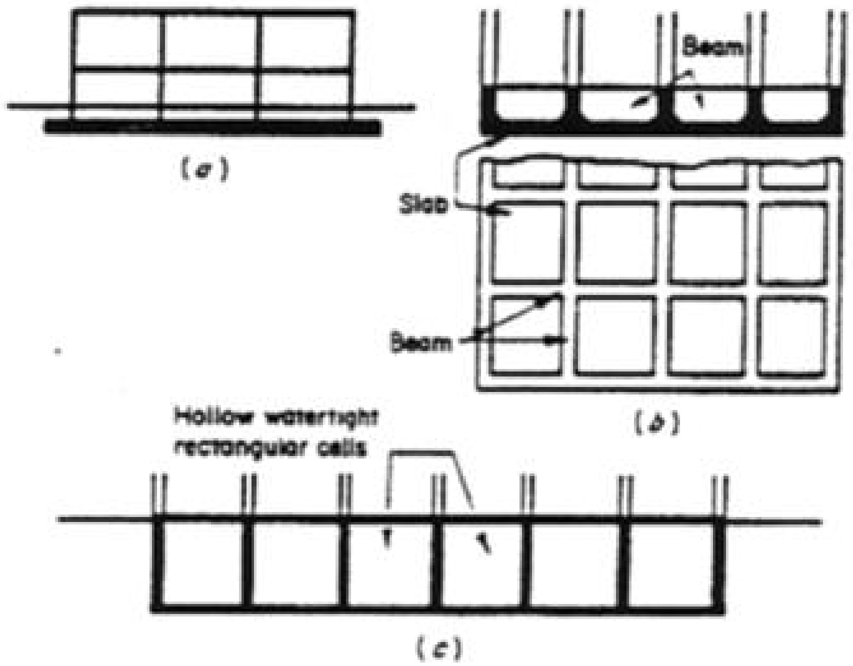
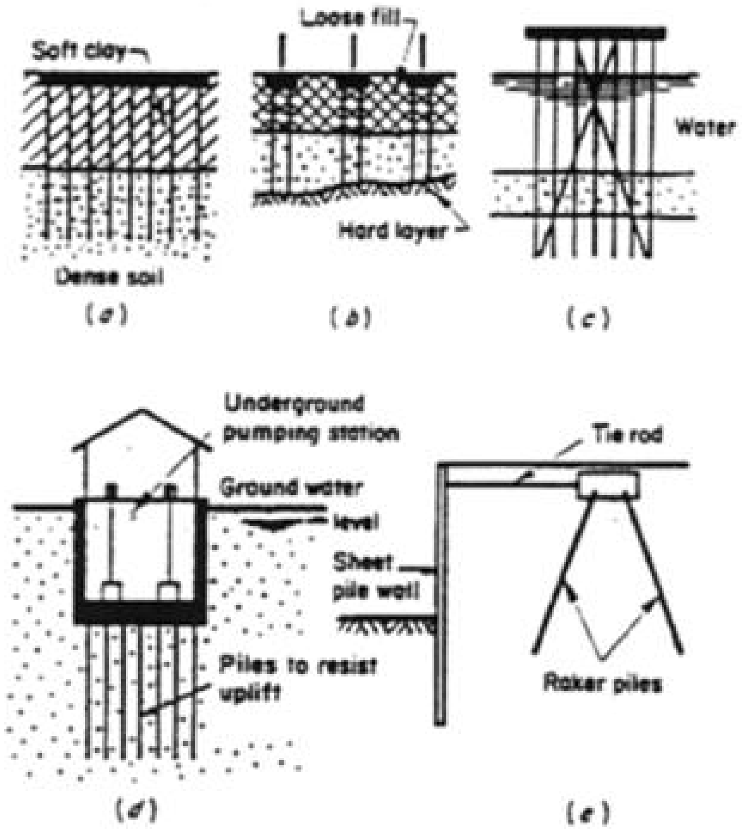
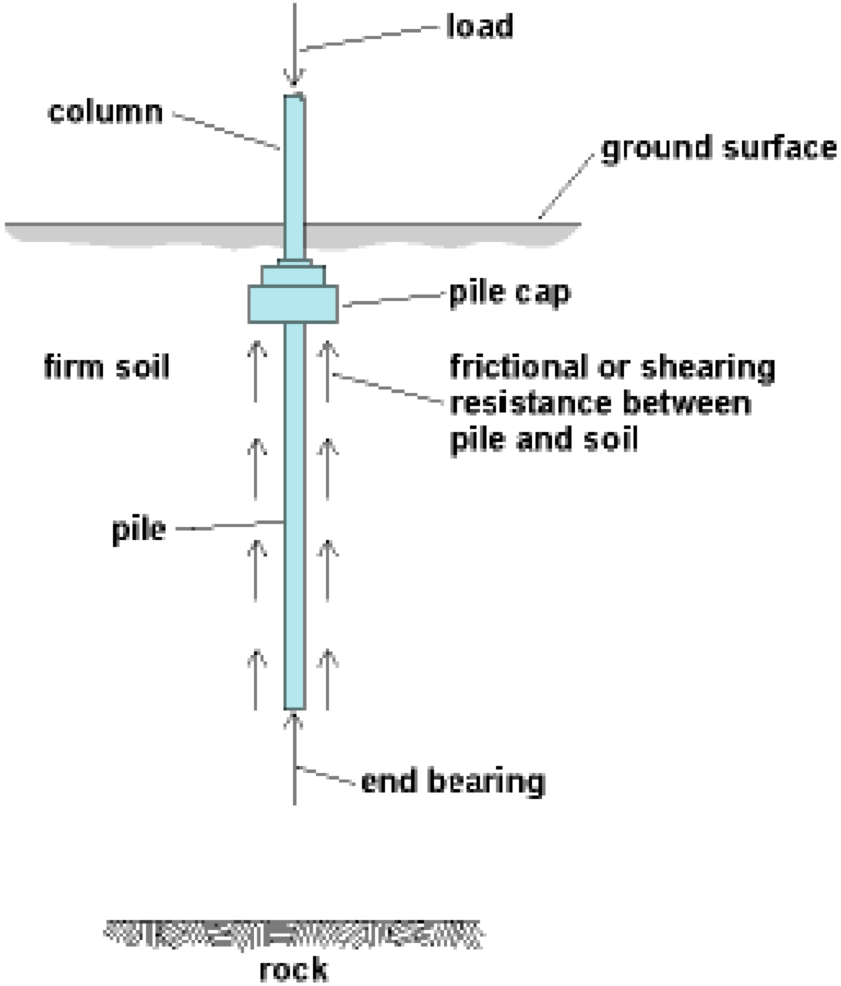


Fig. 2.4 Types of raft foundation. (a) Plain slab. (b) Slab and beam. (c) Cellular (or buoyancy) raft.





load
column
ground surface
pile cap
firm soil
frictional or shearing
resistance between
pile and soil
pile
end bearing
rock

Tanking details

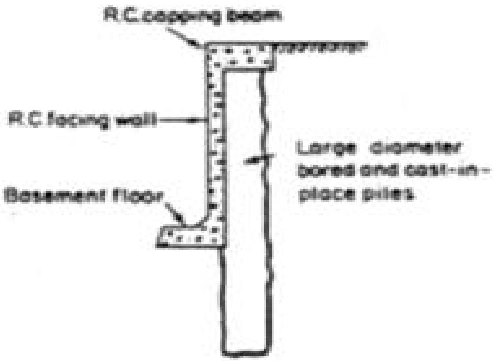


Fig. 5.18 Facing wall for contiguous or secant pile retaining wall.

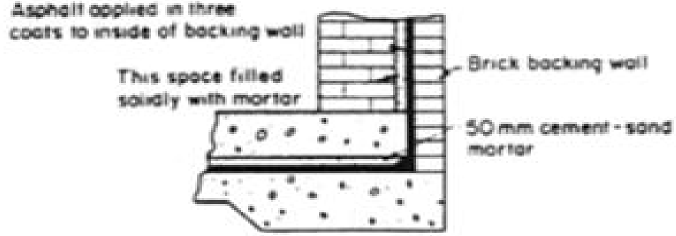


Fig. 5.46 Asphalt tanking to brick basement wall where asphalt is applied to brick backing wall (internally applied).

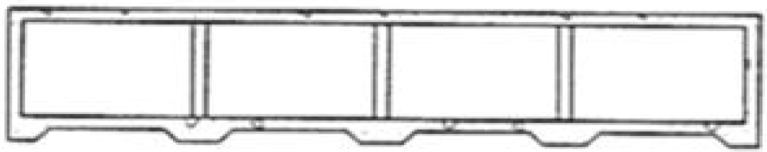
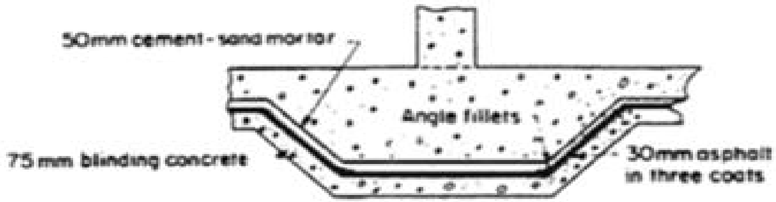


Fig. 5.32 Basement floor slab with thickened bases to columns.



neath column bases.

Working loads for piles (kN) bored/driven

Length	Pile diameter (mm)					
	200	250	300	400	450	500
10	90	115	145	210	245	280
12	120	155	195	275	315	360
15	170	215	265	370	430	485
18	220	280	345	475	545	615
21	275	350	425	585	665	755

Piling for the building began in March 2009 following the demolition of the 26-storey Southwark Towers. A view of the Sharda building construction site in June 2009

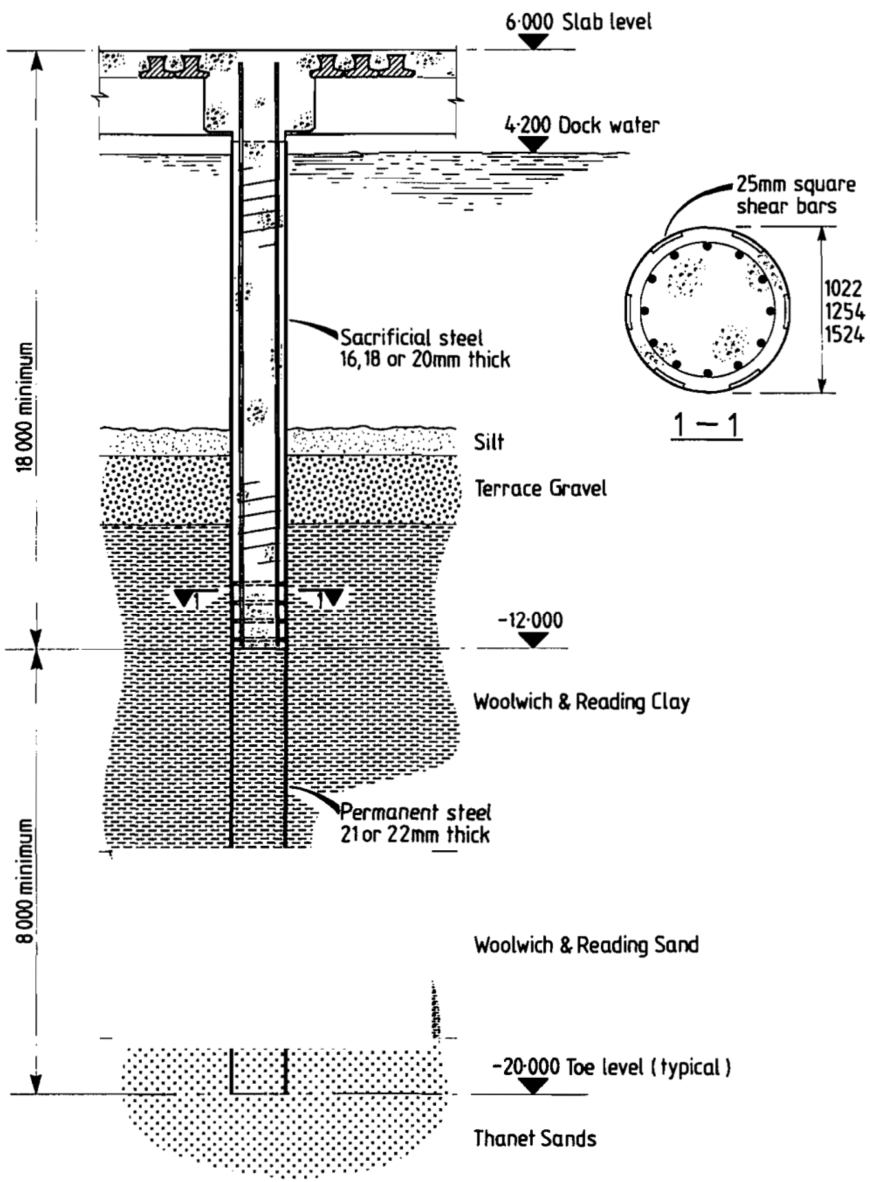
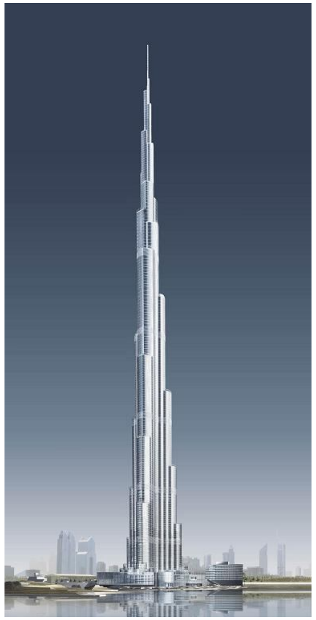


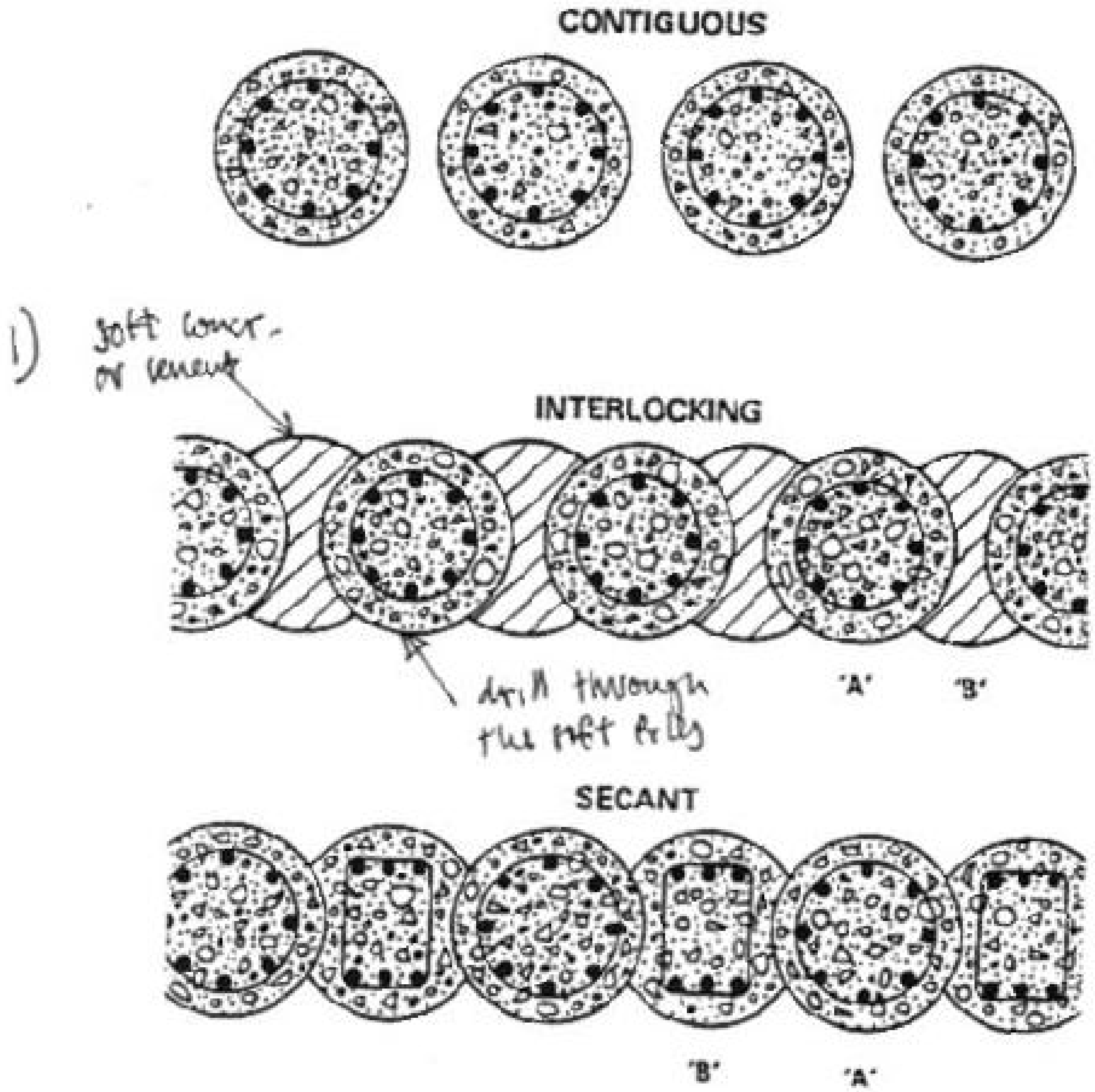
Fig 4. Detailed section through driven piles

Comparison of some tall buildings foundations

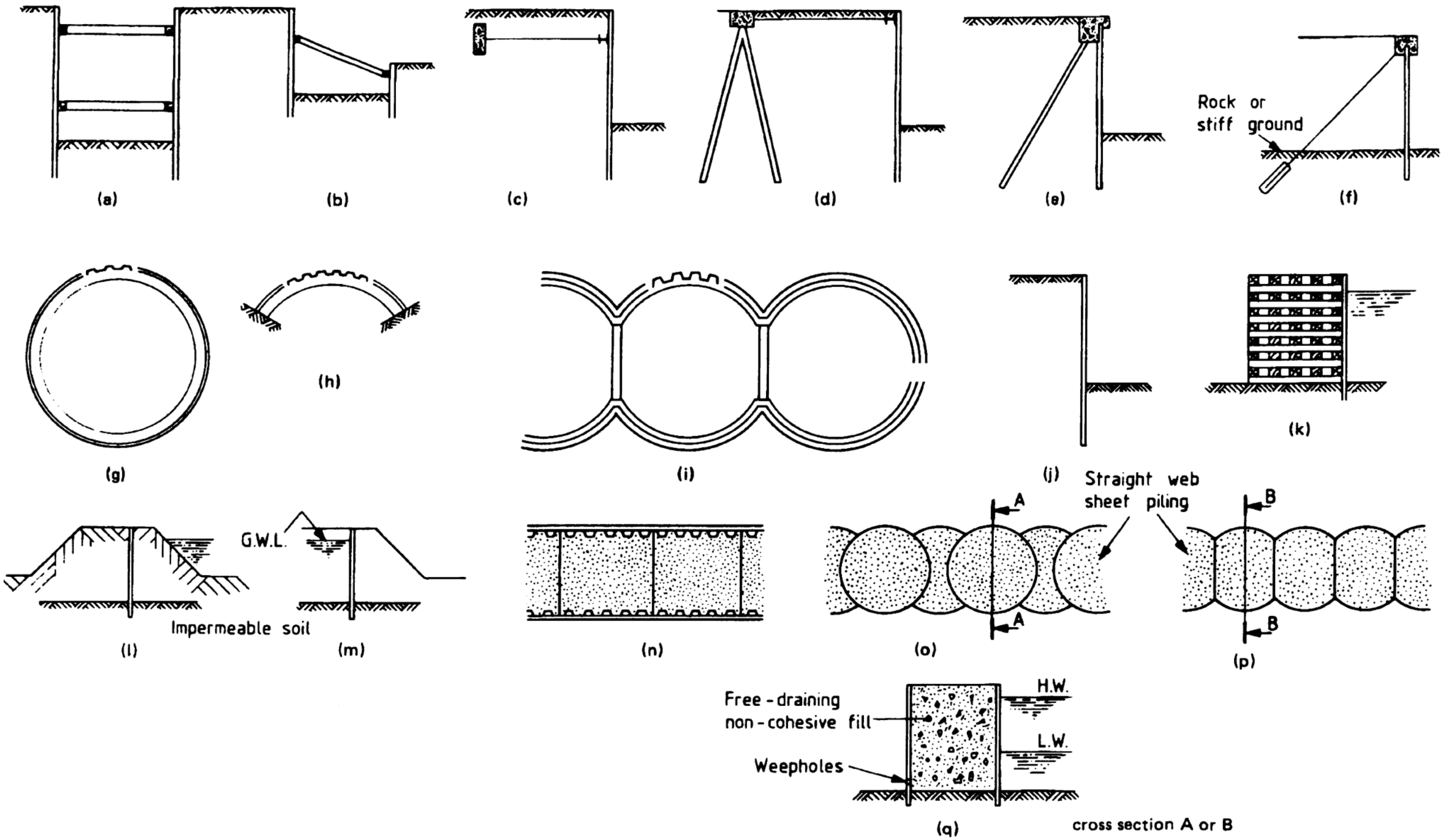
bldg	height	N of floor	floor area	Self weight,t	Live load,t	N piles	Load/ pile, t	Pile, dia	Length	load/m, t	Shear,kPa
Burj	818	160	334000	792000	67000	200	4295	1.5	50	86	182
Petronas	452	88	790000	600000	60000	1000	660	1	29	23	72
shard	310	87	120000	120000	12000	55	2400	1.8	50	48	85
canary w	236	50	115000	250000	12000	222	1180	1.5	25	47	100



Piled retaining wall

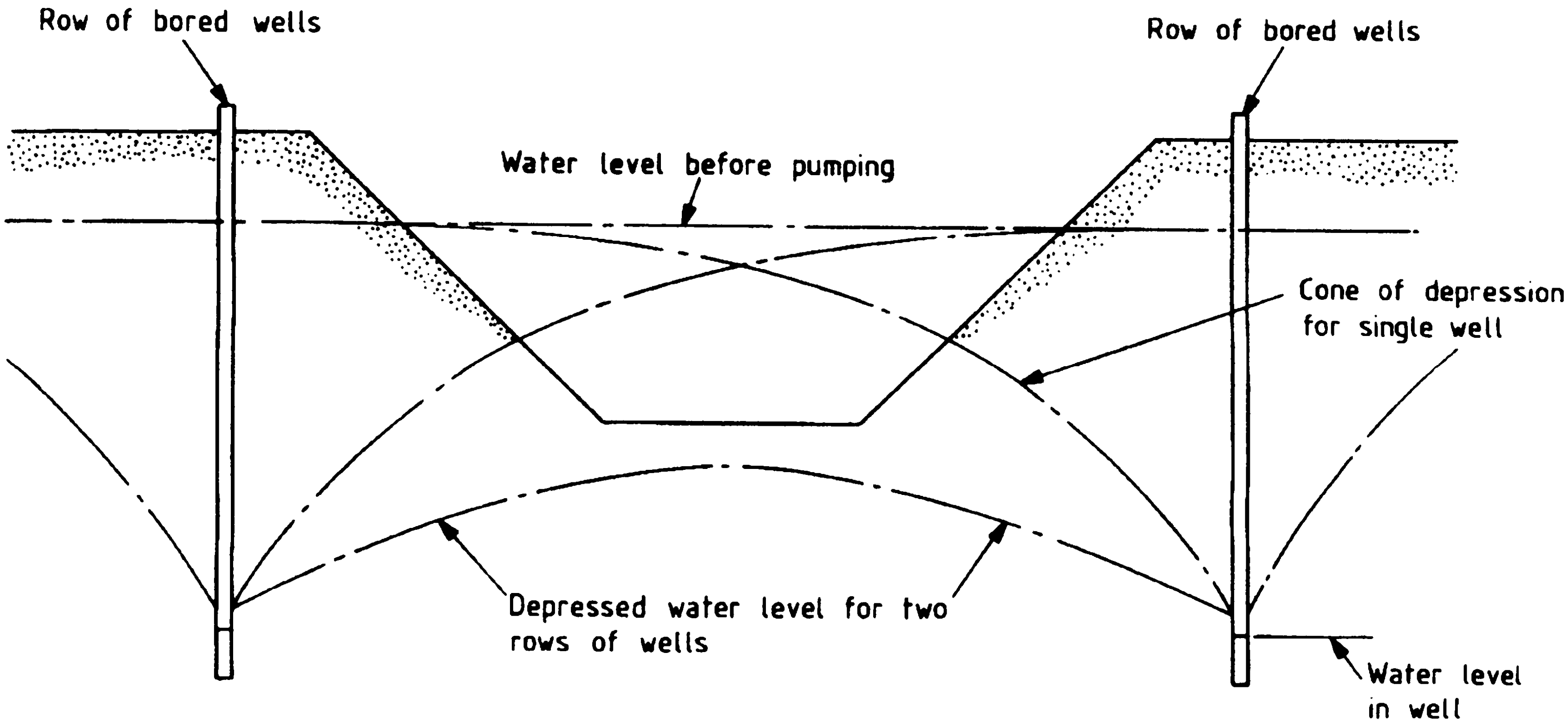


Sheet piling



(b) Cofferdams using sheet piling

Water levels



Reduction of water levels below an excavation by bored well groundwater lowering system, from BS8004

Steel Sheet Piling

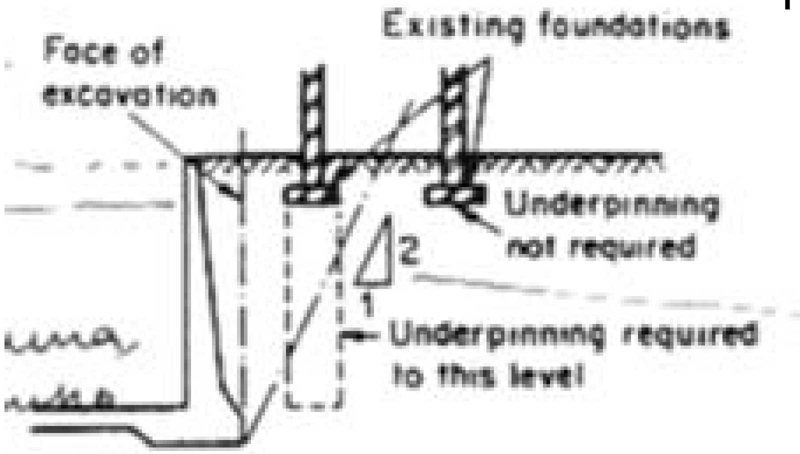
Steel sheet piling is a manufactured construction product with a mechanical connection "interlock" at both ends of the section. These mechanical connections interlock with one another to form a continuous wall of sheet piling. Steel sheet pile applications are typically designed to create a rigid barrier for earth and water, while resisting the lateral pressures of those bending forces. The shape or geometry of a section lends to the structural strength. In addition, the soil in which the section is driven has numerous mechanical properties that can affect the performance.

Steel sheet piling is classified in two construction applications, permanent and temporary. A permanent application is "stay-in-place" where the sheet piling wall is driven and remains in the ground. A temporary application provides access and safety for construction in a confined area. Once the work is completed, the sheet piling is removed.

Z Sheet Pile

Z sections are considered one of the most efficient piles available today. Having the interlocks located at the outer fibers of the wall, assures the designer of their published section modulus.
Z-Piles are commonly used for Cantilevered, Tied-Back, King Pile and Combi-Wall retaining systems. Additional applications also include load bearing bridge abutments

Underpinning



10 Underpinning adjacent to basement excavations

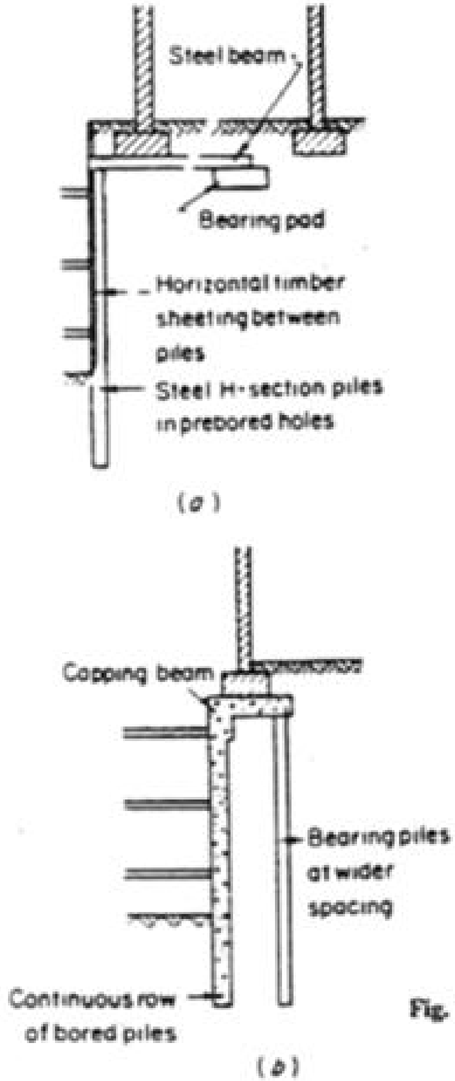


Fig. 12.11 M

. 12.8 Methods of underpinning by piling adjacent to deep avations.

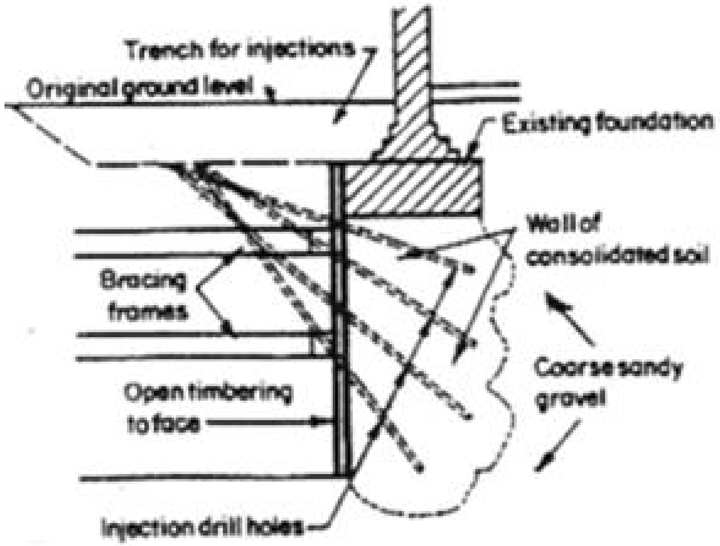
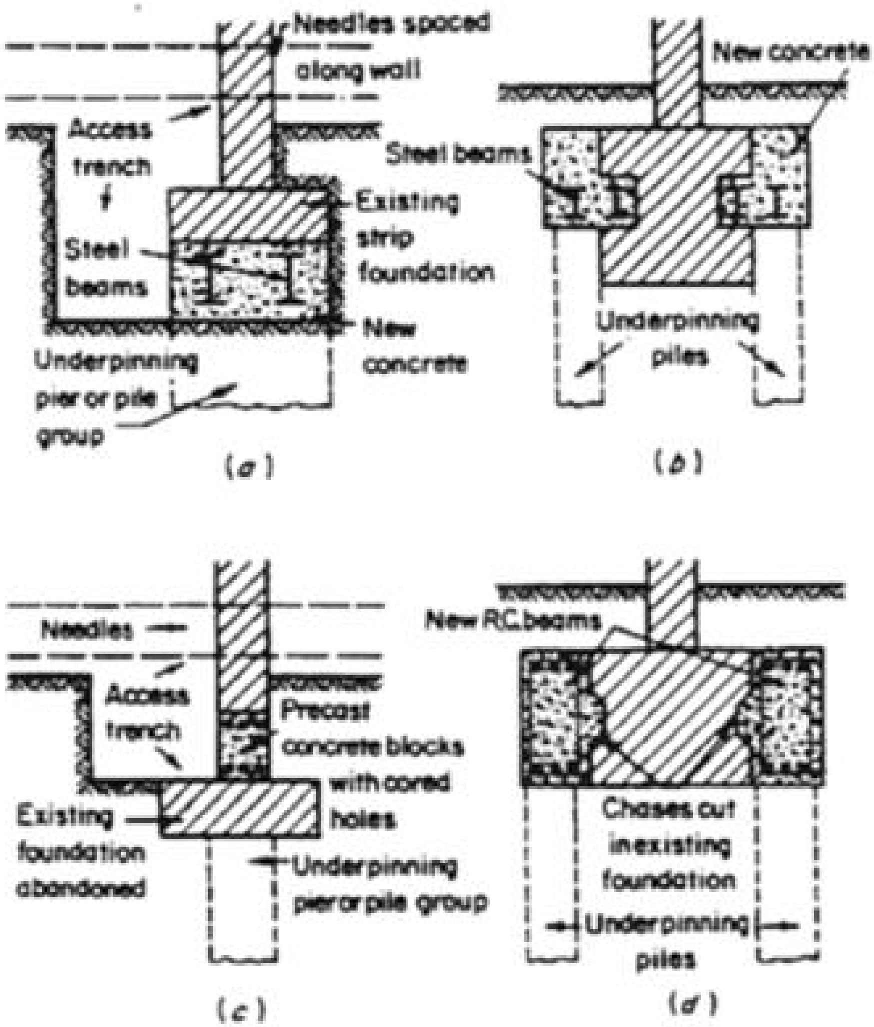


Fig. 12.19 Underpinning by chemical injections.

Underpinning



inning wall foundations using beams spanning between piers or piles.

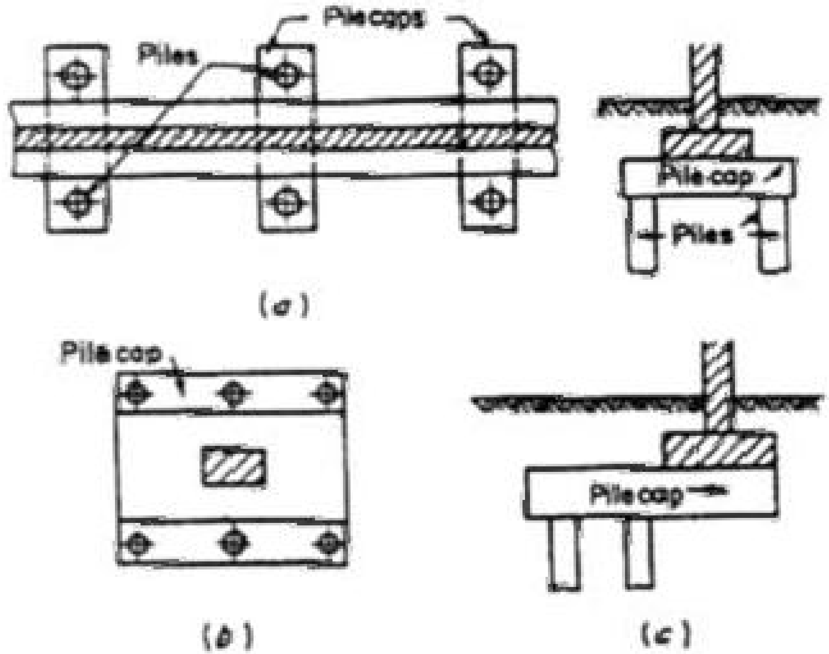
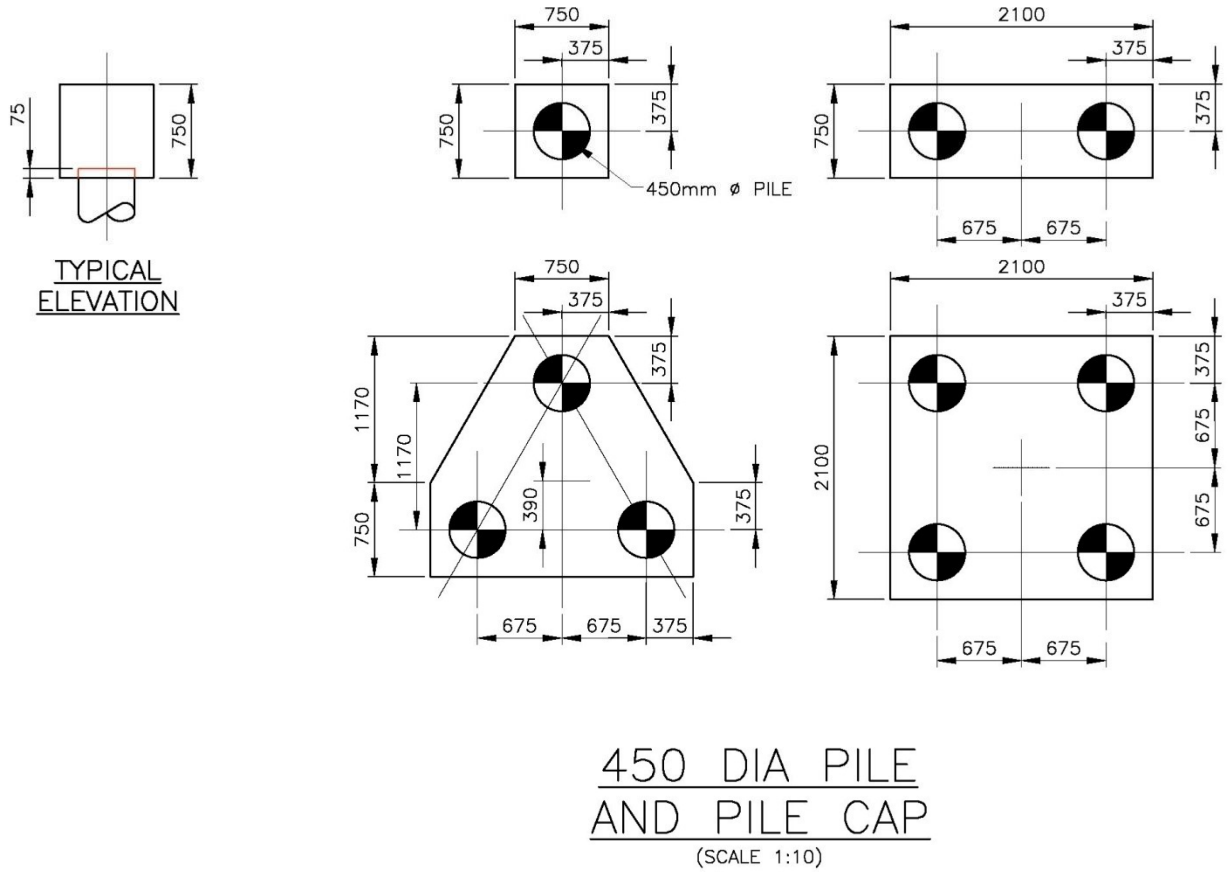


Fig. 12.13 Underpinning with piles. (a) Strip foundations. (b) Column base. (c) Cantilevered pile cap.

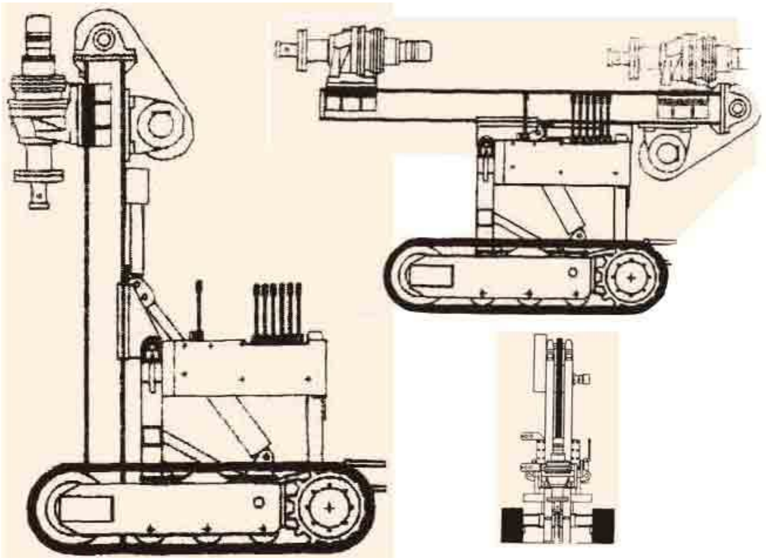
Rough guide to foundations

Type	Typical depth, m	Typical size, B, m	Length, m	Remarks
Concrete Strip footing	½ b	b~0.3 x n With minimum width ~0.6m	Full length of the wall	N- number of storeys Used under walls
Concrete pad (square)	½ b	B~0.9 x n	-	n- number of storeys Used under columns
Raft foundation	span/10	-	-	Span is distance between the walls or columns
Pile foundations	-	0.2-1m (diameter)	3-20m	Minimum spacing 3 x d d- diameter

Pile caps

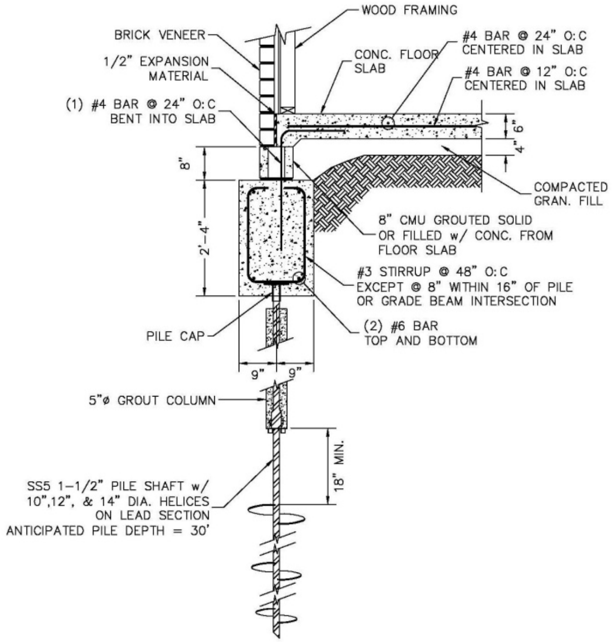


75
750
TYPICAL
ELEVATION
750
375
375
750
450mm ø PILE
2100
375
375
750
675
675
750
375
375
1170
1170
390
375
750
675
675
375
2100
375
375
675
675
2100
675
675
450 DIA PILE
AND PILE CAP
(SCALE 1:10)



The Stealth T3000 consists of a 1.0 tonne robust drill rig mounted on extendible rubber tracks with the added feature of a hydraulic mast 'jack down' for added stability when piling. The T3000 is capable of working within a confined width of 720mm and can easily be maneuvered through a standard household doorway. When operating in unrestricted working areas the T3000 opens up to 1020mm in width. The minimum working height required is 2250mm with the capabilities of installing up to a 320mm diameter pile to a maximum depth of 12.0 metres. The Stealth T3000 has a torque capability of up to 0.3 tonnes. The T3000 also has the capability to tilt its mast angle from -5 to +90 degrees which gives the advantage of enabling the machine to carry out horizontal drilling. With the aid of a bolt-on air flush assembly the rig can also be easily transformed into a DTH System. The T3000 Piling Rig comes complete with a super silenced 30kW power pack which can be detached and used up to a distance of 25.0 metres away. This feature is particularly useful when working within restricted or limited access areas where operating space is an issue.

Minipile rig



TYPICAL FOUNDATION SECTION

Helical piling or Screw Piling is long-standing and established foundation method, and has been used on projects for over 150 years. The first recorded use of helical piles was in 1836 for moorings, and then in 1838 for Maplin Sands Lighthouse in the Thames estuary. The system consisted of 30 piles to a depth of 23 metres.

The helical pile was invented in 1833 by Thomas Mitchell, a blind civil engineer from Ireland. He won the Telford Medal for his creation. Later, in 1863, Brighton Pier was built upon helical piles and stood on the same foundations for 138 years.

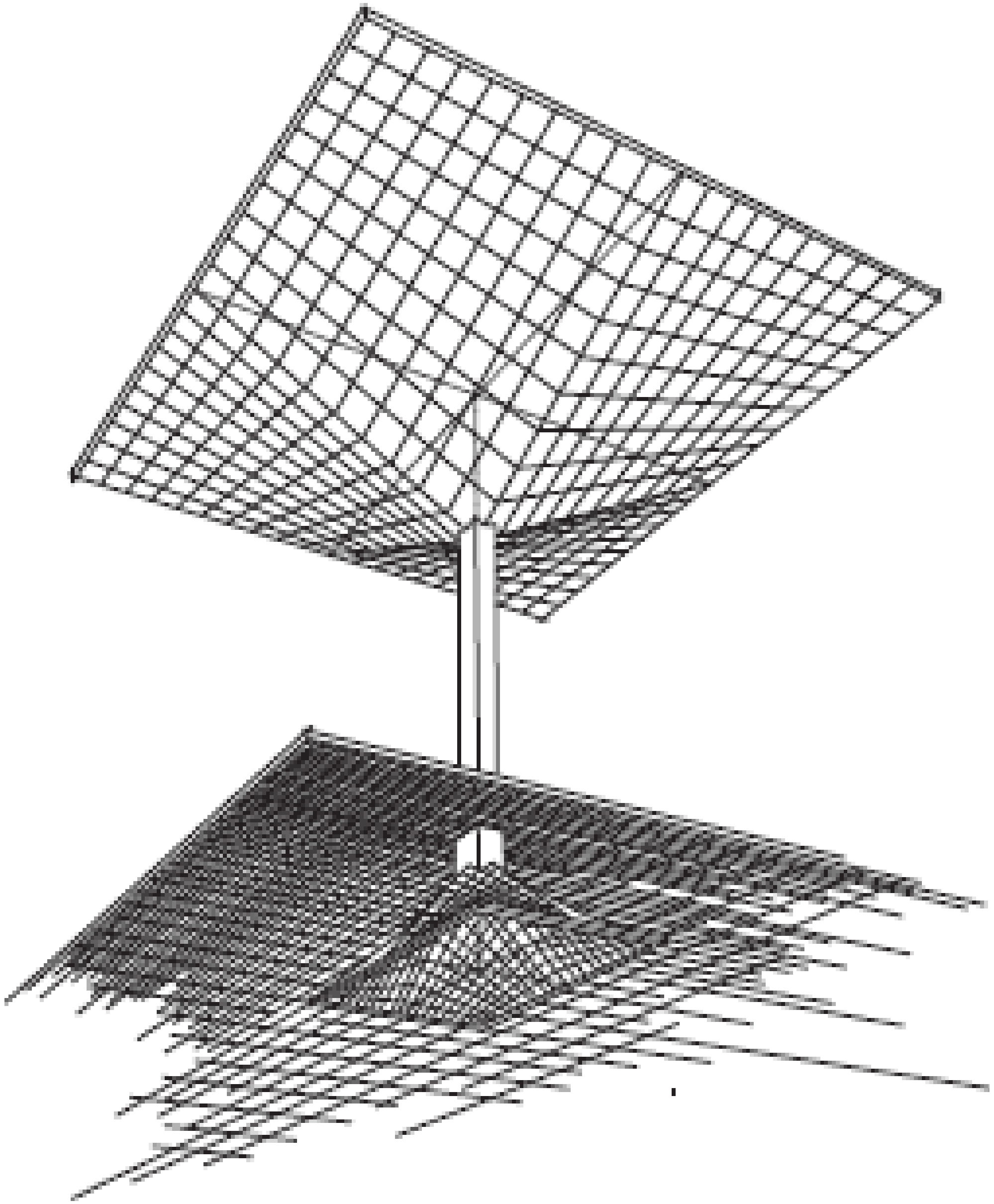
The technique was then used intermittently for projects in the UK, the majority of which were marine-based. Then in 2000 ScrewFast Foundations began to reintroduce the technique for telecommunication towers as a fast solution in locations where concrete foundations were not viable. The speed, ease of install and other benefits were soon recognised by the Highways Agency and Network Rail, and has now become the preferred choice for most projects in the the transportation sector.

Helical Piles are suited to waterlogged and marshland where the use of concrete is not viable because of the saturated ground conditions. The piles penetrate beyond the waterlogged soil to a depth where the soil strength is capable of generating sufficient bearing capacity.

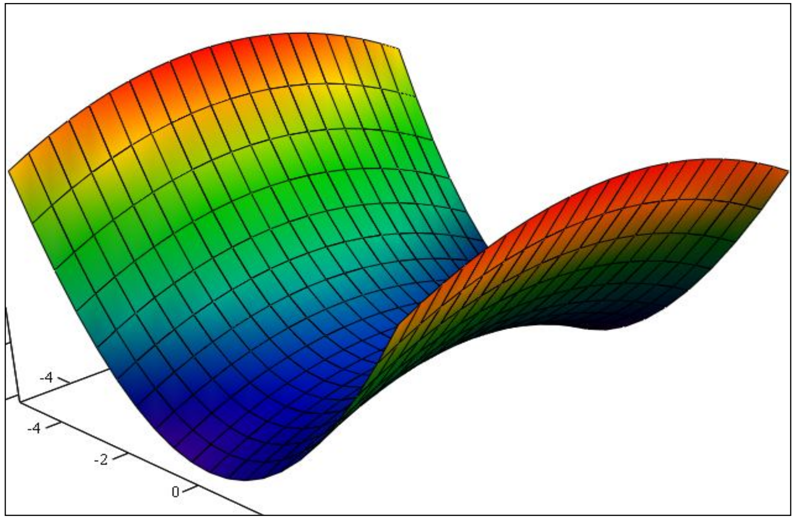
The other benefits which can be realised include avoiding the difficult process of soil excavation, and potential contamination of the surrounding environment leading to a negative environmental legacy. A small excavator can be used to install the piles, which allows remote locations can be reached comfortably. Urgent projects can be completed quickly and modular bridges are possible, as the foundations are ready for immediate loading once installed.

Corrosion

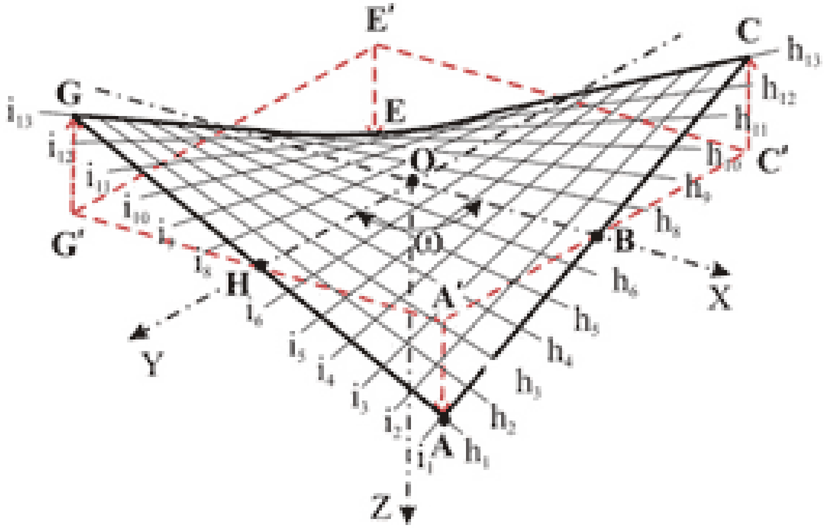
Helical pile material is typically hot-dipped galvanized to extend the life of the pile in aggressive environments. Non galvanized pile material may be used in temporary shoring/tieback locations. Corrosion protection can be increased further by using the pulldown micropile with grout column.



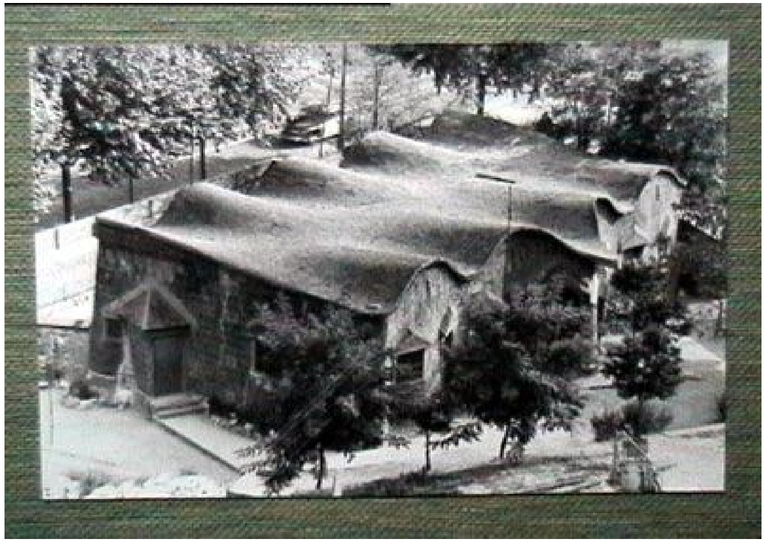
$h2(x, y) := (4x)^2 - (2y)^2$



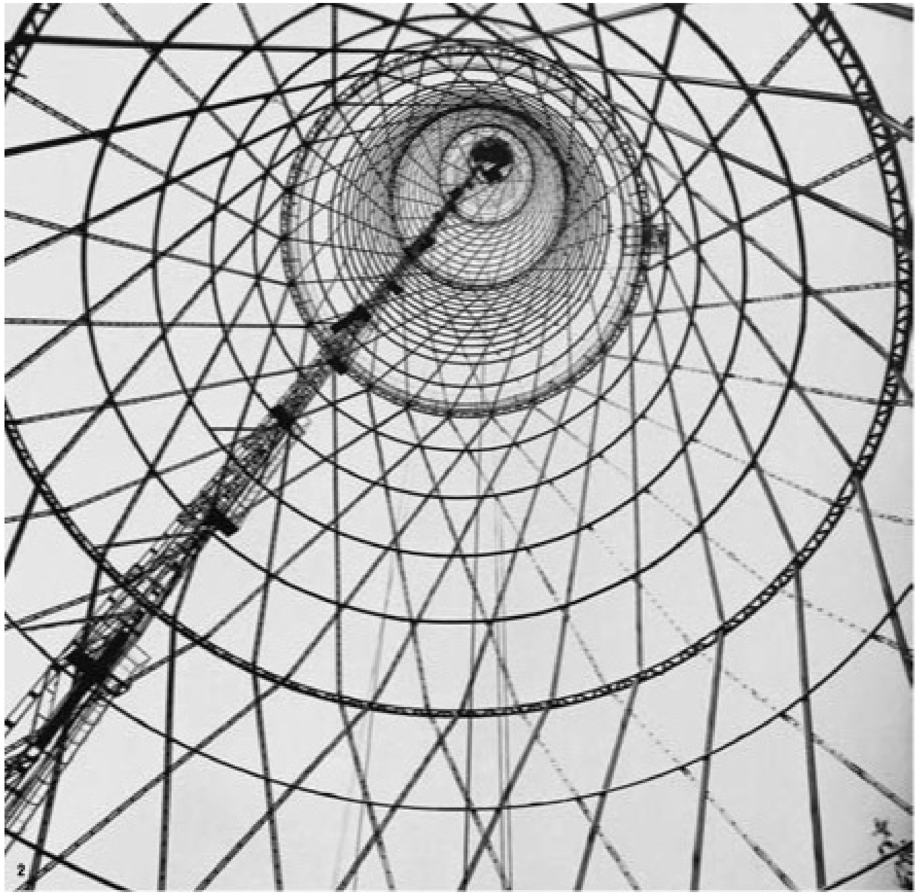
h2



Antoni Plàcid Guillem Gaudí i Cornet (1852 –1926)



Vladimir Grigorievich Shukhov, 1853-1939



Hyperbolische Wassertürme in verschiedenen Ausführungen. Suchov variierte bei allen Standardisierungsbestrebungen stets Form und Proportionen der Bauwerke. Abgebildete Türme gebaut zwischen 1902 und 1915, Höhen (ohne Behälter) von 10 bis 36m, Fassungsvermögen zwischen 60000 und 600000 l (Bilder: Archiv Akademie der Wissenschaften, Moskau, aus Anm. 1)

hyperboloid roofs of the exhibition pavilions of the 1896 All-Russian Industrial and Handicrafts Exposition in Nizhny Novgorod

Hyperboloid structures

- **Hyperboloid structures** are architectural structures designed with hyperboloid geometry. Often these are tall structures such as towers where the hyperboloid geometry's structural strength is used to support an object high off the ground, however hyperboloid geometry is also often used for decorative effect as well as structural economy. The first hyperboloid structures were built by Russian engineer Vladimir Shukhov (1853-1939).

The hyperboloid roofs of the exhibition pavilions of the 1896 All-Russian Industridal and Handicrafts Esposition in Nizhny Novgorod were the first publicly prominent examples of Shukhov's new system. The roofs of these pavilions were doubly-curved surfaces formed entirely of a lattice of straight angle-iron and flat iron bars. Shukhov himself called them "metal lace." The patent of this system, for which Shukhov applied in 1895, was awarded in 1899.
For more info see http://www.shukhov.org

Hyperbolic paraboloids

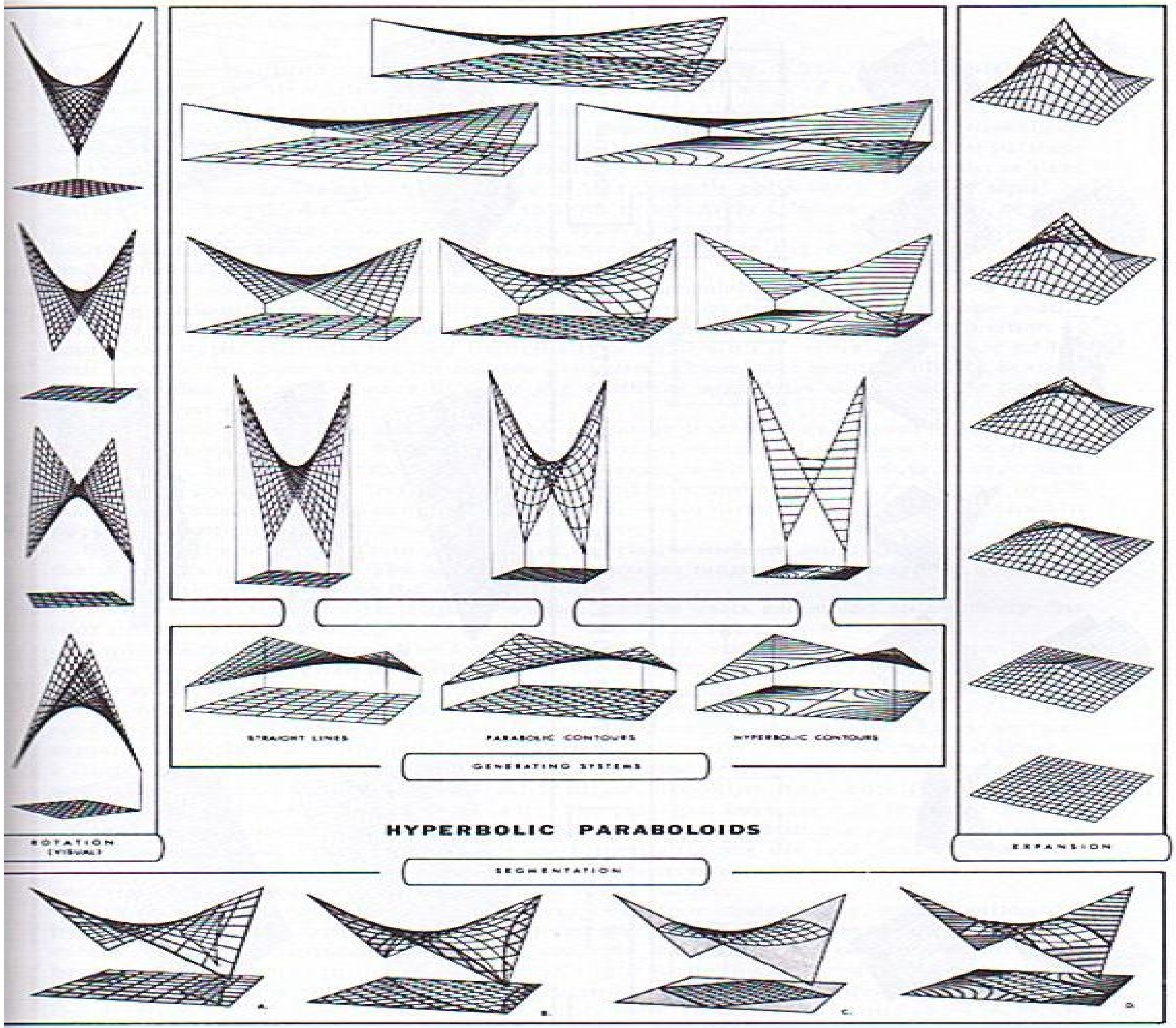
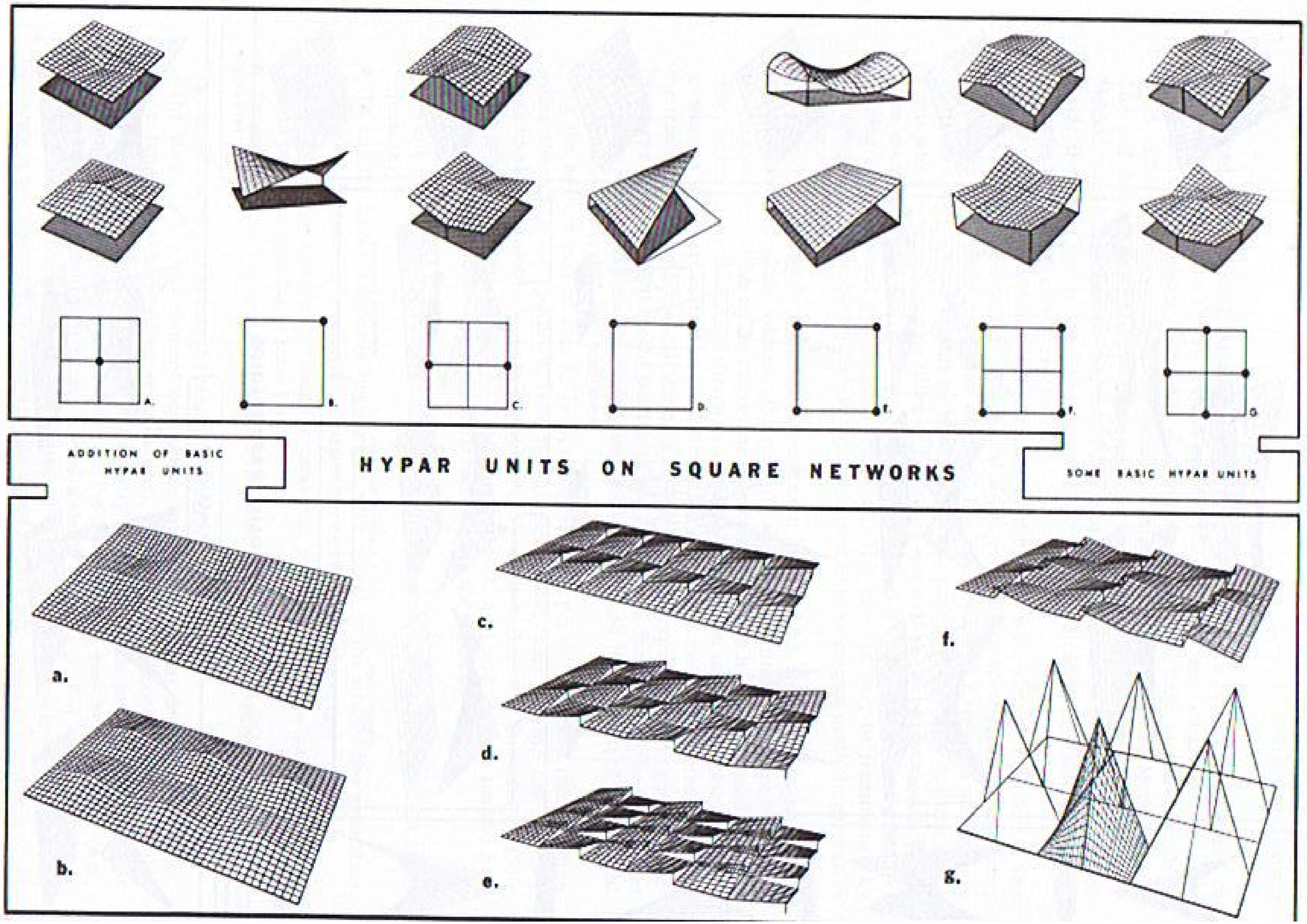


Fig. 8.27 Hyperbolic paraboloids.

Hypers on square plan



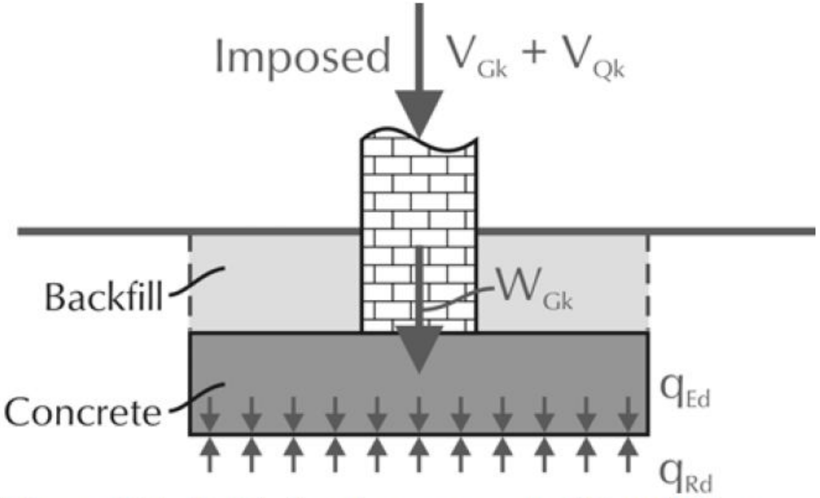


Figure 136. *Vertical actions on a spread foundation*

Figure 136 shows a
footing carrying characteristic vertical a c t i o n s V G k (permanent) and VQk (variable) imposed on it by the super-structure. The characteristic self weights of the footing and of the backfill upon it are both permanent actions (WGk). The following sub-sections explain how qEd and qRd are obtained from VGk, VQk, WGk, and ground properties.

The characteristic bearing pressure q_{Ek} shown in **Figure 136** is given by:

$$q_{Ek} = \frac{\sum V_{rep}}{A'} = \frac{(V_{Gk} + \sum_i \psi_i V_{Qk,i}) + W_{Gk}}{A'}$$

The design bearing pressure q_{Ed} beneath the footing is then:

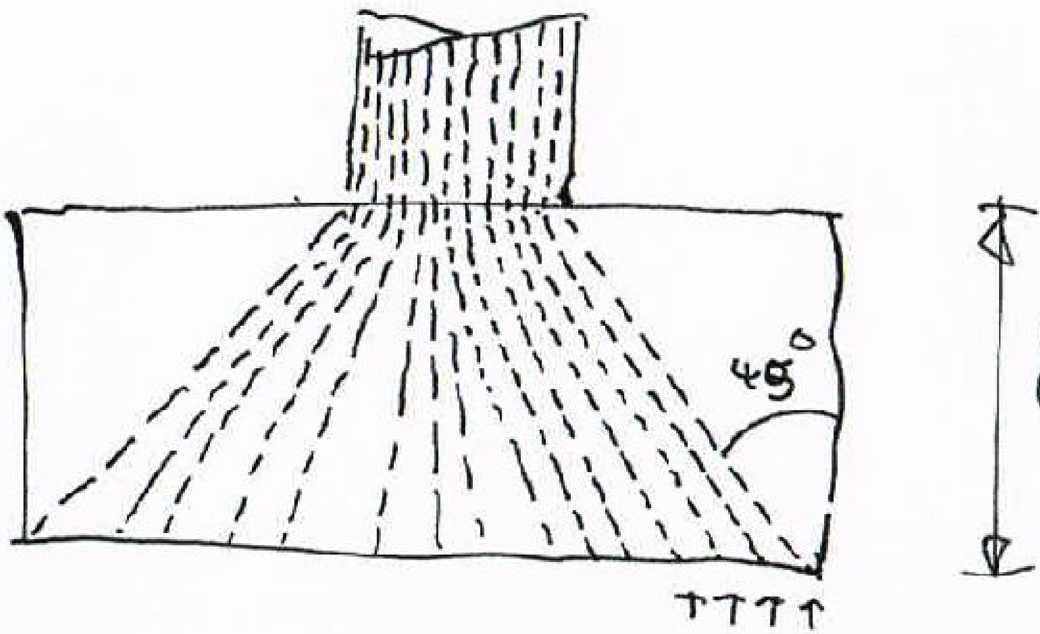
$$q_{Ed} = \frac{\sum V_d}{A'} = \frac{\gamma_G (V_{Gk} + W_{Gk}) + \gamma_Q V_{Qk,1}}{A'}$$

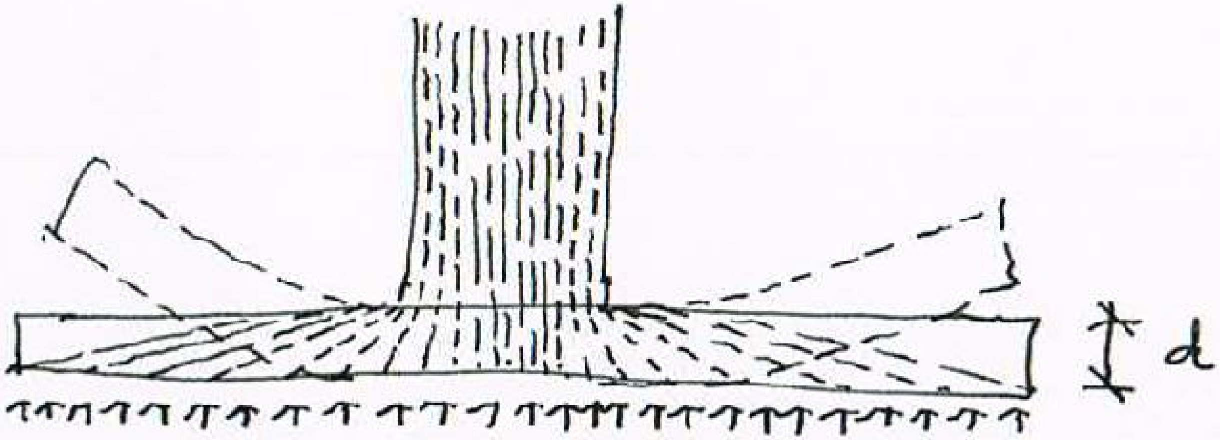
where γ_G and γ_Q are partial factors on permanent and variable actions, respectively.

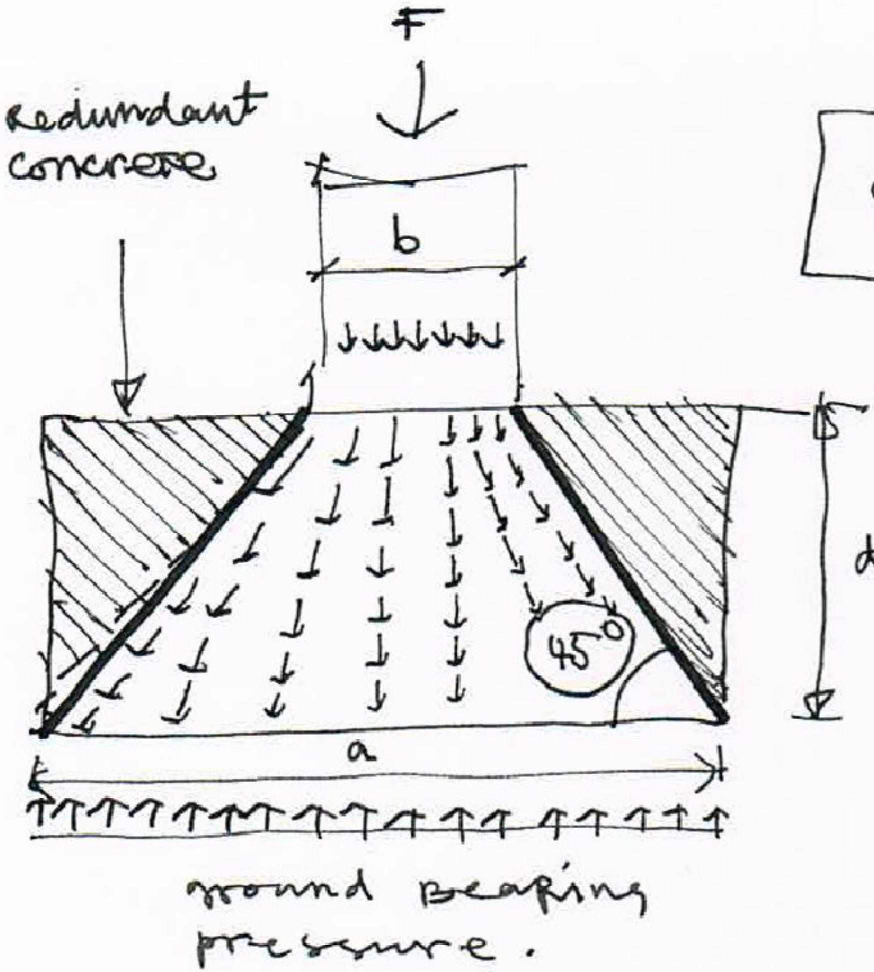
NOTE These values are for preliminary design purposes only, and may need alteration upwards or downwards. No addition has been made for the depth of embedment of the foundation (see **2.1.2.3.2** and **2.1.2.3.3**).

Category	Types of rocks and soils	Presumed allowable bearing value		Remarks
		kN/m^2 [a]	kgf/cm^2 [a] tontf/ft^2	
Rocks	Strong igneous and gneissic rocks in sound condition	10 000	100	These values are based on the assumption that the foundations are taken down to unweathered rock. For weak, weathered and broken rock, see **2.2.2.3.1.12**
		4 000	40	
	Strong limestones and strong sandstones	3 000	30	
	Schists and slates	2 000	20	
	Strong shales, strong mudstones and strong siltstones			
Non-cohesive soils	Dense gravel, or dense sand and gravel	> 600	> 6	Width of foundation not less than 1 m. Groundwater level assumed to be a depth not less than below the base of the foundation. For effect of relative density and groundwater level, see **2.2.2.3.2**
	Medium dense gravel, or medium dense sand and gravel	< 200 to 600	< 2 to 6	
	Loose gravel, or loose sand and gravel	< 200	< 2	
	Compact sand	> 300	> 3	
	Medium dense sand	100 to 300	1 to 3	
	Loose sand	< 100 Value depending on degree of looseness	< 1	
Cohesive soils	Very stiff boulder clays and hard clays	300 to 600	3 to 6	Group 3 is susceptible to long-term consolidation settlement (see **2.1.2.3.3**). For consistencies of clays, see Table 5
	Stiff clays	150 to 300	1.5 to 3	
	Firm clays	75 to 150	0.75 to 1.5	
	Soft clays and silts	<75	<0.75	
	Very soft clays and silts	Not applicable		
Peat and organic soils		Not applicable		See **2.2.2.3.4**
Made ground or fill		Not applicable		See **2.2.2.3.5**

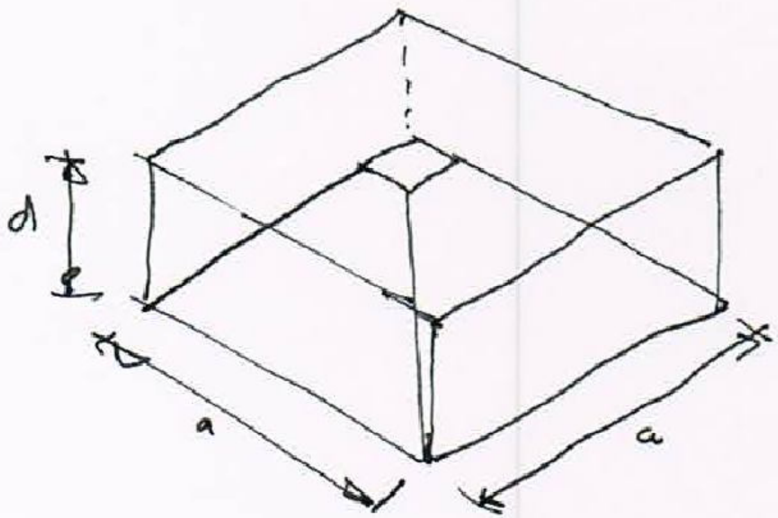
[a] 107.25 kN/m^2 = 1.094 kgf/cm^2 = 1 tonf/ft^2.


45°
d


d

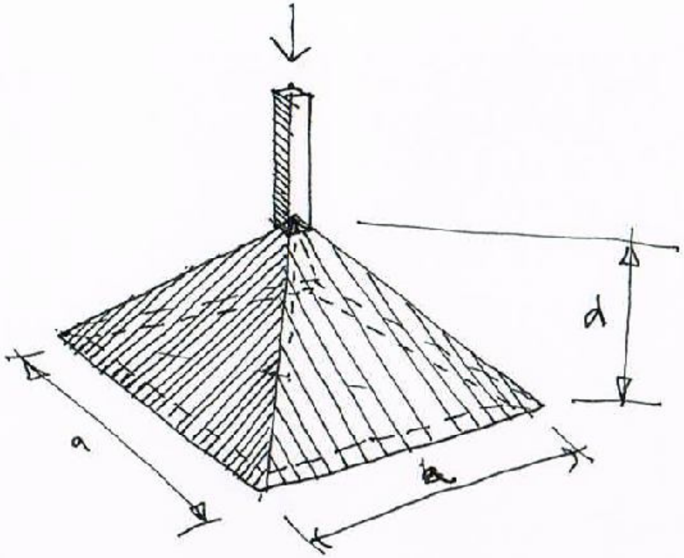


$$d = \frac{(a - b)}{2}$$



PYRAMID VOLUME : $V = \frac{1}{3} \cdot a^2 \cdot d$

67% ECONOMY OF CONCRETE



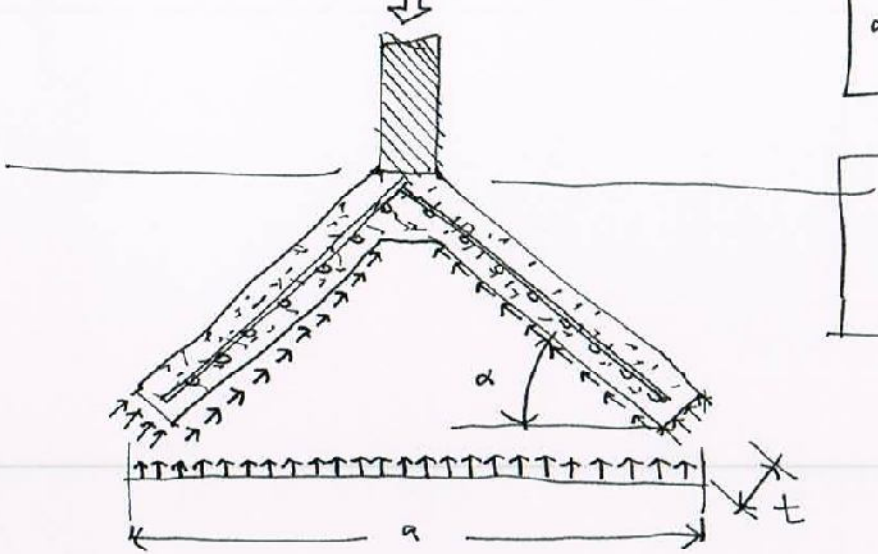
Slab thickness approx:

$t = a/10$

MINIMUM COVER TO REINFORCEMENT

$c = 50$ mm

$\alpha = 30 \div 45°$ → CONCRETE IS IN COMRESSION



$\alpha < 30°$ → SOME BENDING IN CONCRETE MAY OCCUR HENCE NEED REINFORCEMENT

Rough guide to foundation design

1. Work out load acting on the footing (Wgk;Vgk;Vqk) in kN (kilo Newton).
2. Based on soil conditions choose allowable bearing pressure (see BS table)
3. Find require area of a pad:

$$A_{req.} = F/\sigma_{\text{allowable}} \text{ (m}^2\text{)}$$

$$a = \sqrt{A_{req}}, \text{ (m)}$$

CONCRETE MIX

Class	Class description	Informative example applicable to the United Kingdom
No risk of corrosion or attack (XO class)		
X0	For concrete without reinforcement or embedded metal where there is no significant freeze/thaw, abrasion or chemical attack.	Unreinforced concrete surfaces inside structures. Unreinforced concrete completely buried in soil classed as AC-1 and with hydraulic gradient not greater than 5.Unreinforced concrete permanently submerged in non-aggressive water. Unreinforced concrete in cyclic wet and dry conditions not subject to abrasion, freezing or chemical attack. NOTE: For reinforced concrete, use at least XC1.
Corrosion induced by carbonation (XC classes)(a)(Where concrete containing reinforcement or other embedded metal is exposed to air and moisture.)		
XC1	Dry or permanently wet.	Reinforced and prestressed concrete surfaces inside enclosed structures except areas of structures with high humidity. Reinforced and prestressed concrete surfaces permanently submerged in non-aggressive water.
XC2	Wet, rarely dry.	Reinforced and prestressed concrete completely buried in soil classed as AC-1 and with a hydraulic gradient not greater than 5.For other situations see 'chemical attack' section below.
XC3 &XC4	Moderate humidity or cyclic wet and dry.	External reinforced and prestressed concrete surfaces sheltered from, or exposed to, direct rain. Reinforced and prestressed concrete surfaces inside structures with high humidity (e.g.poorly ventilated, bathrooms, kitchens).Reinforced and prestressed concrete surfaces exposed to alternate wetting and drying.
Corrosion induced by chlorides other than from sea water (XD classes)(a)(Where concrete containing reinforcement or other embedded metal is subject to contact with water containing chlorides, including de-icing salts, from sources other than from sea water.)		
XD1	Moderate humidity.	Concrete surfaces exposed to airborne chlorides. Parts of structures exposed to occasional or slight chloride conditions.
XD2	Wet, rarely dry.	Reinforced and prestressed concrete surfaces totally immersed in water containing chlorides (b).
XD3	Cyclic wet and dry.	Reinforced and prestressed concrete surfaces directly affected by de-icing salts or spray containing de-icing salts (e.g. walls; abutments and columns within 10 m of the carriageway; parapet edge beams and buried structures less than 1 m below carriageway level, pavements and car park slabs).
Corrosion induced by chlorides from sea water (XS classes)(a)(Where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water.)		
XS1	Exposed to airborne salt but not in direct contact with sea water.	External reinforced and prestressed concrete surfaces in coastal areas.
XS2	Permanently submerged.	Reinforced and prestressed concrete completely submerged and remaining saturated, e.g. concrete below mid-tide level (b).
XS3	Tidal, splash and spray zones.	Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones (C).
Freeze/thaw attack (XF classes) (Where concrete is exposed to significant attack from freeze/thaw cycles whilst wet.)		
XF1	Moderate water saturation without de-icing agent.	Vertical concrete surfaces such as facades and columns exposed to rain and freezing. Non-vertical concrete surfaces not highly saturated, but exposed to freezing and to rain or water.
XF2	Moderate water saturation with de-icing agent.	Elements such as parts of bridges, which would otherwise be classified as XF1 but which are exposed to de-icing salts either directly or as spray or run-off.
XF3	High water saturation without de-icing agent.	Horizontal concrete surfaces, such as parts of buildings, where water accumulates and which are exposed to freezing. Elements subjected to frequent splashing with water and exposed to freezing.
XF4	High water saturation with de-icing agent or sea water (d).	Horizontal concrete surfaces, such as roads and pavements, exposed to freezing and to de-icing salts either directly or as spray or run-off. Elements subjected to frequent splashing with water containing de-icing agents and exposed to freezing.
Chemical attack (ACEC classes) (Where concrete is exposed to chemical attack.) Note:BS 8500-1 refers to ACEC classes rather than XA classes used in BS EN 206-1		
a)The moisture condition relates to that in the concrete cover to reinforcement or other embedded metal but, in many cases, conditions in the concrete cover can be taken as being that of the surrounding environment. This might not be the case if there is a barrier between the concrete and its environment. b)Reinforced and prestressed concrete elements, where one surface is immersed in water containing chlorides and another is exposed to air, are potentially a more severe condition, especially where the dry side is at a high ambient temperature. Specialist advice should be sought where necessary, to develop a specification that is appropriate to the actual conditions likely to be encountered. c) Exposure XS3 covers a range of conditions. The most extreme conditions are in the spray zone. The least extreme is in the tidal zone where conditions can be similar to those in XS2.Therecommendations given take into account the most extreme UK conditions within this class. d) It is not normally necessary to classify in the XF4 exposure class those parts of structures located in the United Kingdom which are in frequent contact with the sea.		

Selected [a] recommendations for normal-weight reinforced concrete quality for combined exposure classes and cover to reinforcement for at least a50-year intended working life and 20 mm maximum aggregate size, based on BS 8500											
Exposure conditions			Cement/ combination designations [b]	Strength class [c],maximum w/c ratio,minimum cement or combination content (kg/m3),and equivalent designated concrete (where applicable)							
				Nominal cover to reinforcement [d]							
Typical example	Primary	Secondary		15+Δcd	20+Δcd	25+Δcd	30+Δcd	35+Δcd	40+Δcd	45+Δcd	50+Δcd
Internal massconcrete	X0	-	All	Recommended that this exposure is not applied to reinforced concrete							
Internal elements(except humidlocations)	XC1		All	C20/25, 0.70,240	<<<	<<<	<<<	<<<	<<<	<<<	<<<
Buried concrete in AC-1 ground conditions [e]	XC2	AC-1	all	-	-	C25/30, 0.65,260	<<<	<<<	<<<	<<<	<<<
Vertical surface protected from direct rainfall	XC3 &XC4	-	All except IVB-V	-	C40/50, 0.45,340	C30/37,0.55 ,300	C28/35, 0.60,280	C25/30, 0.65,260	<<<	<<<	<<<
Exposed verticalsurfaces		XF1	All except IVB-V	-	C40/50, 0.45,340	C40/50, 0.45,340	C28/35, 0.60,280	<<<	<<<	<<<	<<<
Exposed horizontal surfaces		XF3	All except IVB-V	-	C40/50, 0.45,340 [g]	<<<	<<<	<<<	<<<	<<<	<<<
		XF3 (air entrained)	All except IVB-V	-	-	C30/37, 0.55,300plus air [g,h]	C28/35, 0.60,280 plus air [g,h]	C25/30, 0.60,280plus air [g,h,j]	<<<	<<<	<<<
Elements subject to airborne chlorides	XD1 [f]	-	All	-	-	C40/50, 0.45,360	C32/40, 0.55,320	C28/35, 0.60,300	<<<	<<<	<<<
Car park decks and areas subject to de-icing spray	XD3 [f]	-	IIB-V,IIIA	-	-	-	-	-	C35/45, 0.40,380	C32/40, 0.45,360	C28/35, 0.50,340
			CEM I,IIA, IIB-S,SRPC	-	-	-	-	-	See BS 8500	C40/50, 0.40,380	C35/45, 0.45,360
			IIIB,IVB-V	-	-	-	-	-	C32/40, 0.40,380	C28/35, 0.45,360	C25/30, 0.50,340
Vertical elements subject to de-icing spray and freezing		XF2	IIB-V,IIIA	-	-	-	-	-	C35/45, 0.40,380	C32/40, 0.45,360	C32/40, 0.50,360
			CEM I,IIA, IIB-S,SRPC	-	-	-	-	-	See BS 8500	C40/50, 0.40,380	C35/45, 0.45,360
			IIIB,IVB-V	-	-	-	-	-	C32/40, 0.40,380	C32/40, 0.45,360	C32/40, 0.50,340
Car park decks, ramps and external areas subject tofreezing and de-icing salts		XF4	CEM I,IIA, IIB-S,SRPC	-	-	-	-	-	See BS 8500	C40/50, 0.40,380	<<<
		XF4 (air entrained)	IIB-V,IIIA,IIIB	-	-	-	-	-	C28/35, 0.40,380 [g,h]	C28/35, 0.45,360 [g,h]	C28/35, 0.50,340 [g,h]
Exposed verticalsurfaces near coast	XS1 [f]	XF1	CEM I,IIA, IIB-S,SRPC	-	-	-	See BS 8500	C35/45, 0.45,360	C32/40, 0.50,340	<<<	<<<
			IIB-V,IIIA	-	-	-	See BS 8500	C32/40, 0.45,360	C28/35, 0.50,340	C28/35, 0.55,320	<<<
		-	IIIB	-	-	-	C32/40, 0.40,380	C25/30, 0.50,340	C25/30, 0.50,340	C25/30, 0.55,320	<<<
Exposed horizontalsurfaces near coast		XF3 orXF4	CEM I,IIA, IIB-S,SRPC	-	-	-	See BS 8500	C40/50, 0.45,360g	<<<	<<<	<<<

Key
a)This table comprises a selection of common exposure class combinations.
Requirements for other sets of exposure classes,e.g.XD2,XS2 and XS3
shouldbe derived from BS 8500-1:2006,Annex A.
b)See BS 8500-2,Table 1.(CEM I is Portland cement,IIA to IVB are cement combinations.)
c)For prestressed concrete the minimum strength class should be C28/35.

d) Δcd an allowance for deviations.
e) For sections less than 140 mm thick refer to BS 8500.
f) Also adequate for exposure class XC3/4.
g) Freeze/thaw resisting aggregates should be specified.
h) Air entrained concrete is required.
j) This option may not be suitable for areas subject to severe abrasion.

- Not recommended
<<< Indicates that concrete quality in cell to the left should not be reduced

Using Table 1, select concrete exposure type which is appropriate for your project location (in land, close to the sea, external, internal) and type or structure (normal, exposed to the chemicals etc) and proceed to Table 2
Using Table 2, find required exposure type which was defined in Table 1 and sliding across find recommended concrete strength class with recommended water to cement ratio (W/C) and minimum cement content (C)
Example:
Take normal exposure XC1 (concrete containing reinforcement or other embedded metal is exposed to air and moisture)
Using Table 2, find recommended minimum concrete strength class and it's mix as **C20/25, 0.70,240** , where C stands for "Concrete", **20/25** is it's compressive cylinder/cube strength in MPa (N/mm^2) respectively. (The testing cylinder is measured 150 mm diameter by 300 mm height, and cube is measured $100mm^3$)
Figure **0.70** represents W/C ratio. And **240** is amount of cement in kg/m^3(cubic meter!).
C=240 kg/m³

$$W/C = 0.7 \qquad W = 0.7 * C = 0.7 * 240 = 168\ kg/m^3$$

Therefore required amount of aggregate (or ballast) would be:

$$A = 2400 - (C) = 2400 - (240) = 2160 kg$$