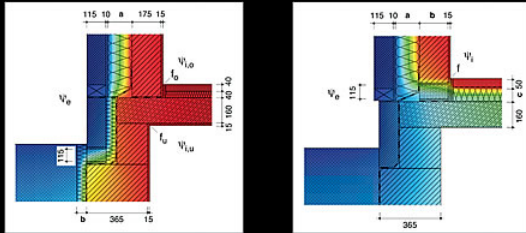


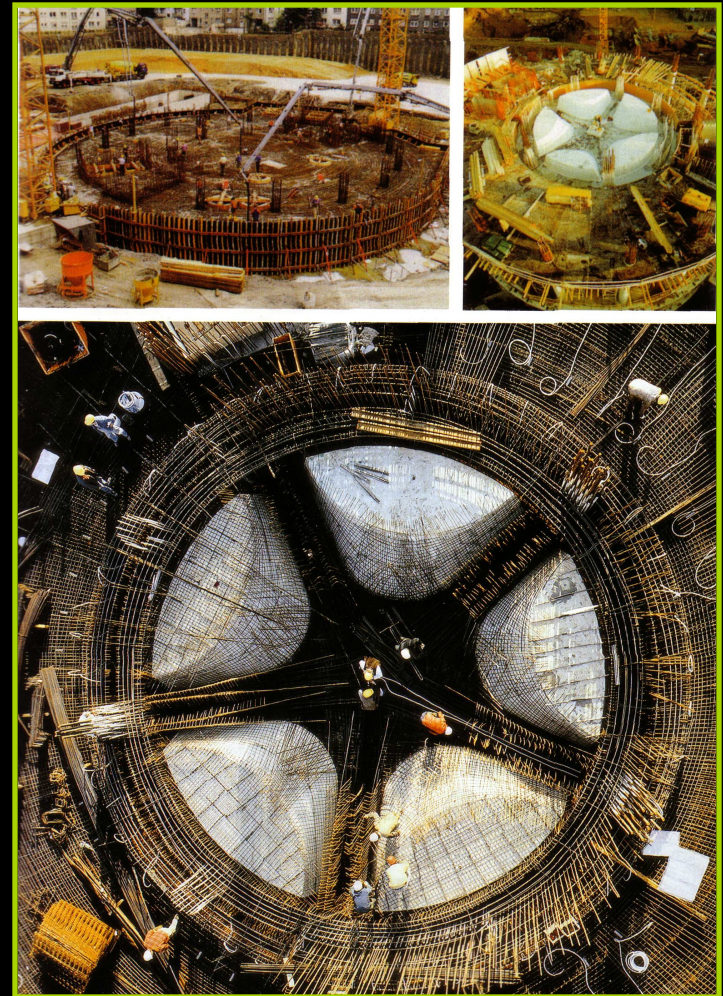
Construction Technology 1

(ARCH 35301)

Intro to Basic Materials:



FOUNDATIONS

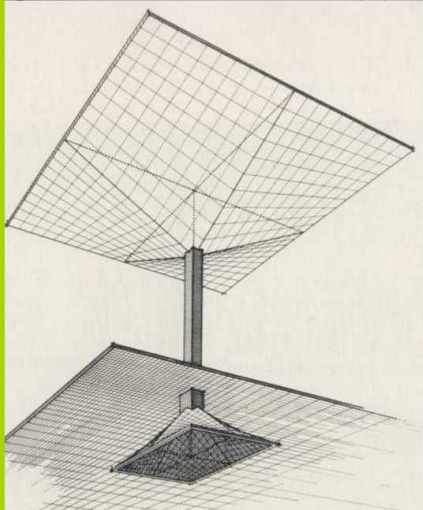
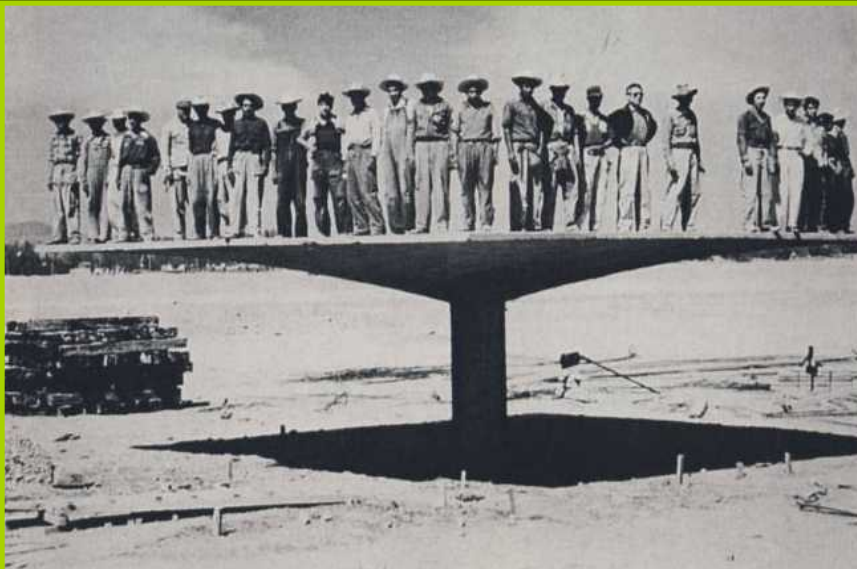


→ *FOUNDATIONS: “THE INVISIBLE”,... “THE BIG TICKET” ITEM*

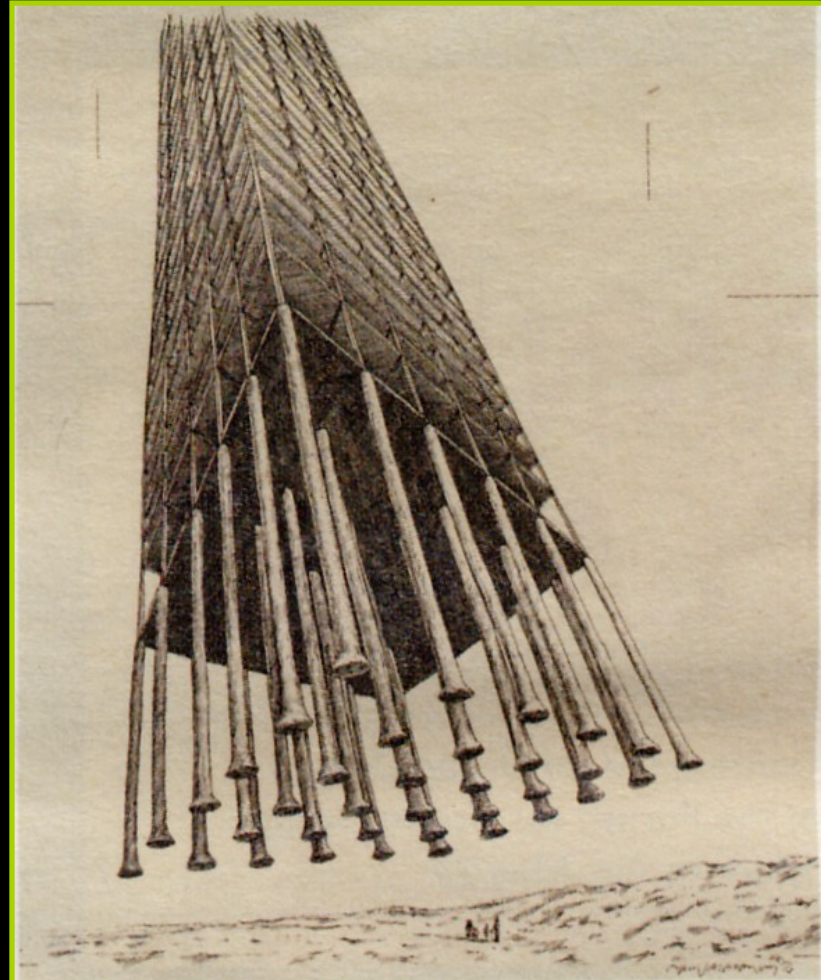


F.L.WRIGHT: 'FALLINGWATER', 1936-1939

→ *FOUNDATIONS: “THE INVISIBLE”,... “THE BIG TICKET” ITEM*



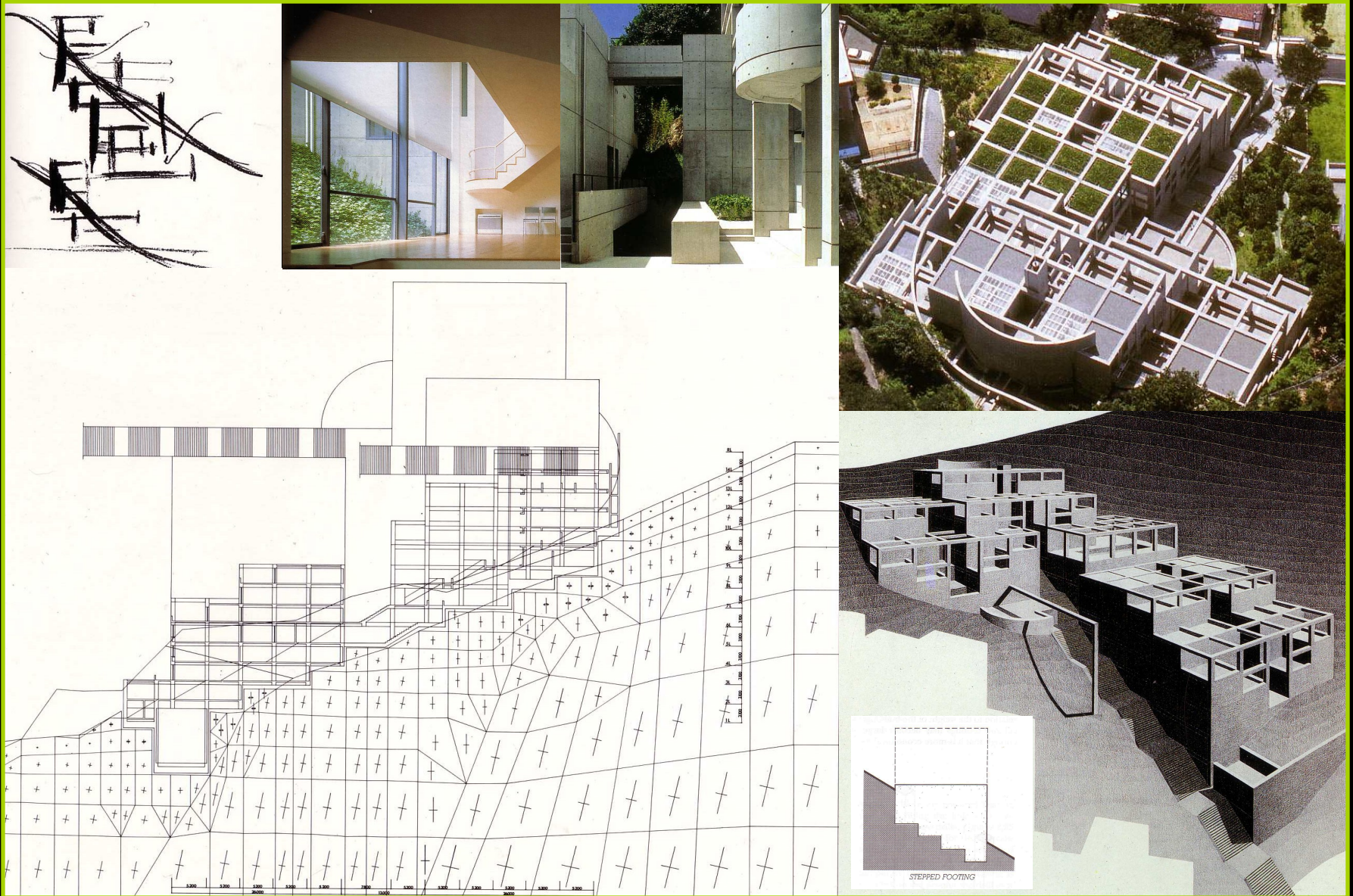
FELIX CANDELA: STRUCTURAL CANOPY STUDIES



DAVID MACAULAY / COURTESY NATIONAL BUILDING MUSEUM

DAVID MACAULAY:
THE ART OF DRAWING ARCHITECTURE

SOIL CONDITIONS ↔ BUILDING CONSEQUENCES:



→ SUBSTRUCTURE/SUPERSTRUCTURE: RELATIONSHIPS

The substructure in the superstructure

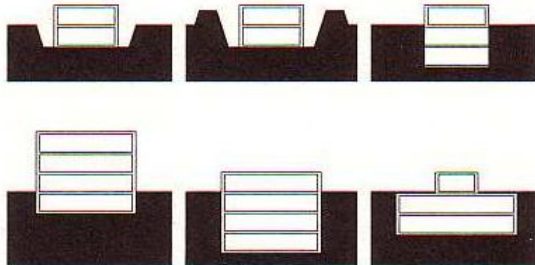


Fig. 4: Underground building in superstructure style

Top (from left to right): the excavation that remains open – with the spoil used to form an enclosing wall – excavation backfilled

Bottom: possible relationships between substructure and superstructure

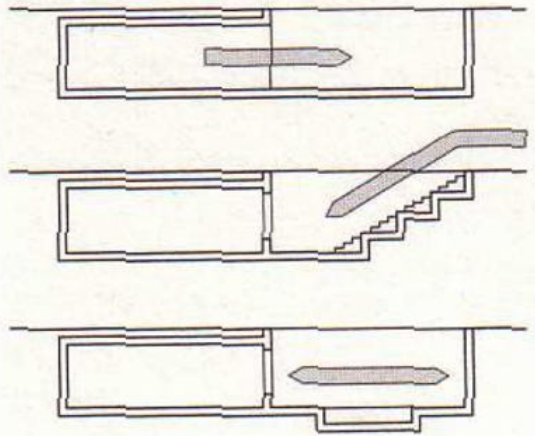


Fig. 6: Horizontal extensions

Relationships (from top to bottom): inside–outside
– outside–inside – centred

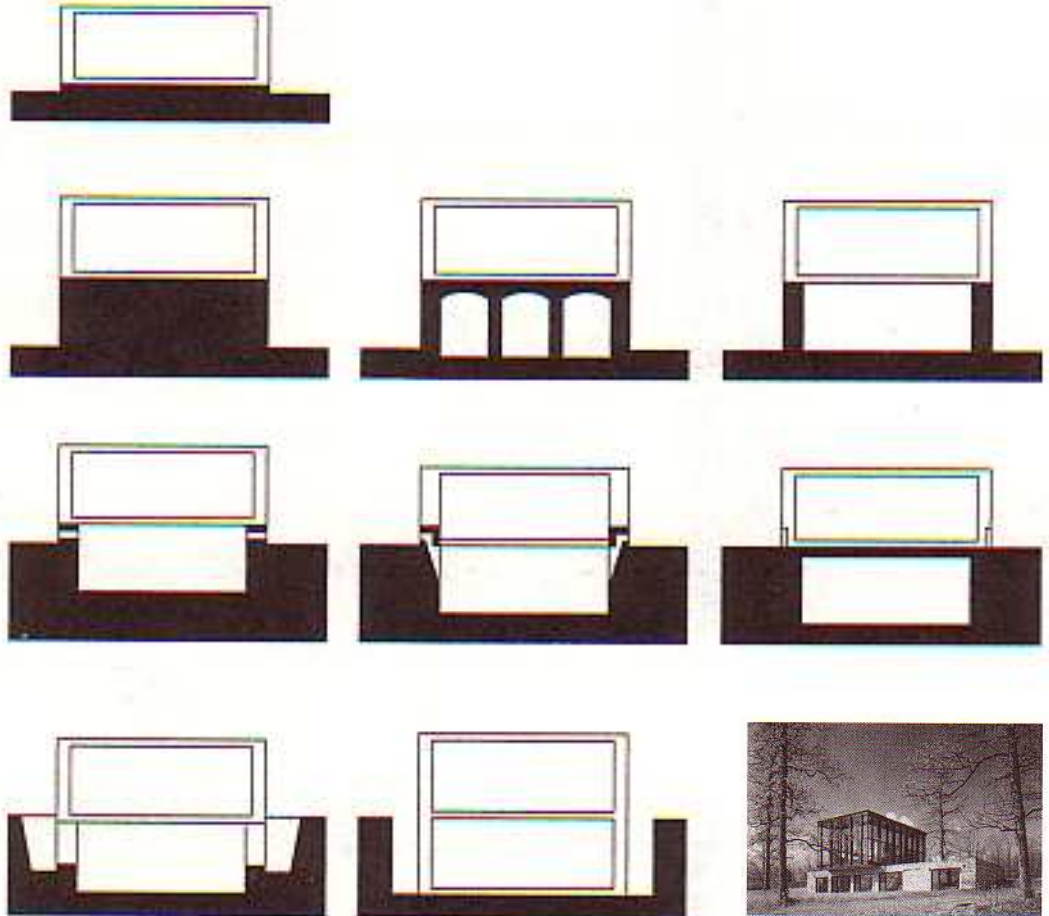


Fig. 56: Types of plinth

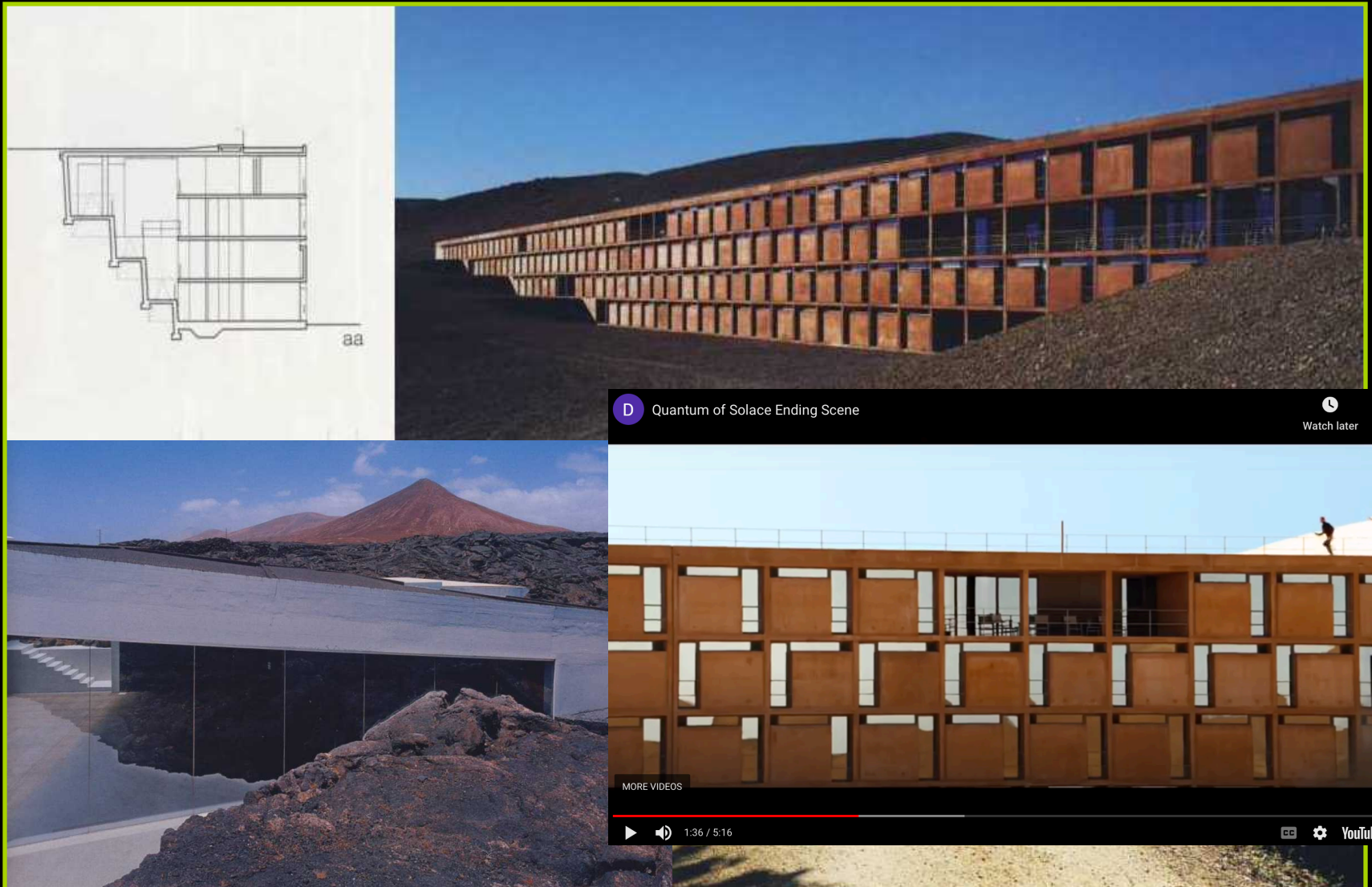
From top to bottom: platform, "earth pile", basement, box



Fig. 57: Substructure and superstructure as structurally independent constructions with the same use (residential)

Philip Johnson: Wiley House, New Canaan (USA), 1953

→ EXAMPLES: SPACIAL CONNECTION BETWEEN SOIL AND BUILDING



→ *START OF CONSTRUCTION:*



CONDITION: '**SOLID**'



ROCK

REQ.: DRILLING,
BLASTING,
PNEUM. HAMMERING



DATE: 6/20/07 ^



DATE: 8/20/07 >

- EXCAVATION TIME
- DRILL EQUIPMENT
- SHEETING METHOD



→ SOIL CONDITIONS:

CONDITION: 'PARTICULATE'

SOIL (PARTICULATE)

REQ.: EXCAVATION

TYPES OF SOIL:

BOULDER, COBBLE

GRAVEL, SAND (COARSE-GRAINED SOIL)

SILT (EQUIDIMENSIONAL GRANULES; 0.002 - 0.00008")

CLAY (PLATELIKE GRANULES; < 0.00008")

PEAT, TOPSOIL (ORGANIC, NOT SUITABLE)

→ WATER CONTENT, PORE VOLUME

COHESIVE (+) ↔ FRICTIONAL (-)
(SHEAR RESISTANCE OF SOIL)

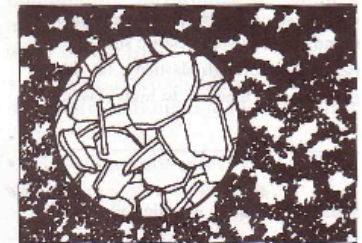
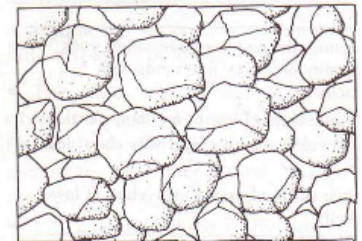
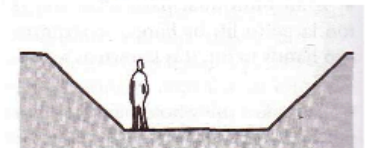


FIGURE 2.3
Silt particles (top) are approximately equidimensional granules, while clay particles (bottom) are platelike and generally much smaller than silt. Notice that the clay particles here are much smaller than the silt particles; a circular area of clay particles has been magnified to make their structure easier to see.



EXCAVATION IN FRICTIONAL SOIL



EXCAVATION IN HIGHLY COHESIVE SOIL

→ SOIL CONDITIONS:

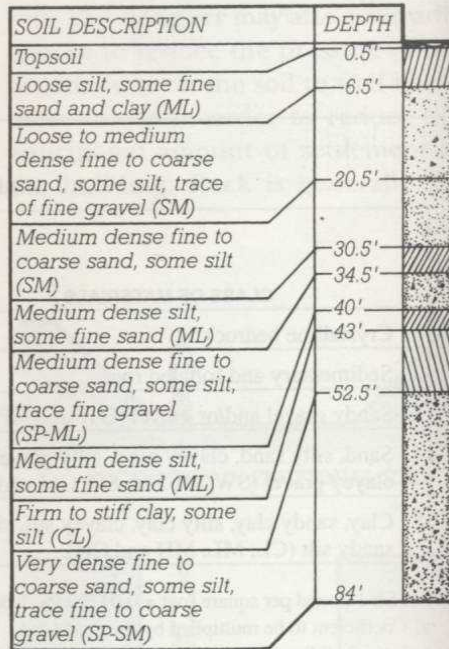


FIGURE 2.7

A typical log from a soil test boring, indicating the type of soil in each stratum and the depth in feet at which it was found. The abbreviations in parentheses refer to the Unified Soil Classification System, and are explained in Figure 2.2.

TABLE 1804.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf) ^d	LATERAL BEARING (psf/f below natural grade) ^d	LATERAL SLIDING
			Coefficient of friction ^a
1. Crystalline bedrock	12,000	1,200	0.70
2. Sedimentary and foliated rock	4,000	400	0.35
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500 ^c	100	—

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.

a. Coefficient to be multiplied by the dead load.

b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.

c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

d. An increase of one-third is permitted when considering load combinations, including wind or earthquake loads.

FIGURE 2.5

Presumptive surface bearing values of various soils, as given in the 2000 International Building Code. Classes 3, 4, and 5 are keyed to the group symbols in Figure 2.2.

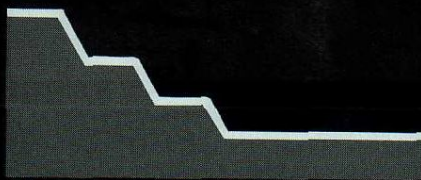
NOTE: SHEAR RESISTANCE BETWEEN GRANULES WILL INCREASE WHERE SURROUNDING SUPPORTIVE STRATA CONFINES IT.

→ SOIL CONDITIONS / EXCAVATION:

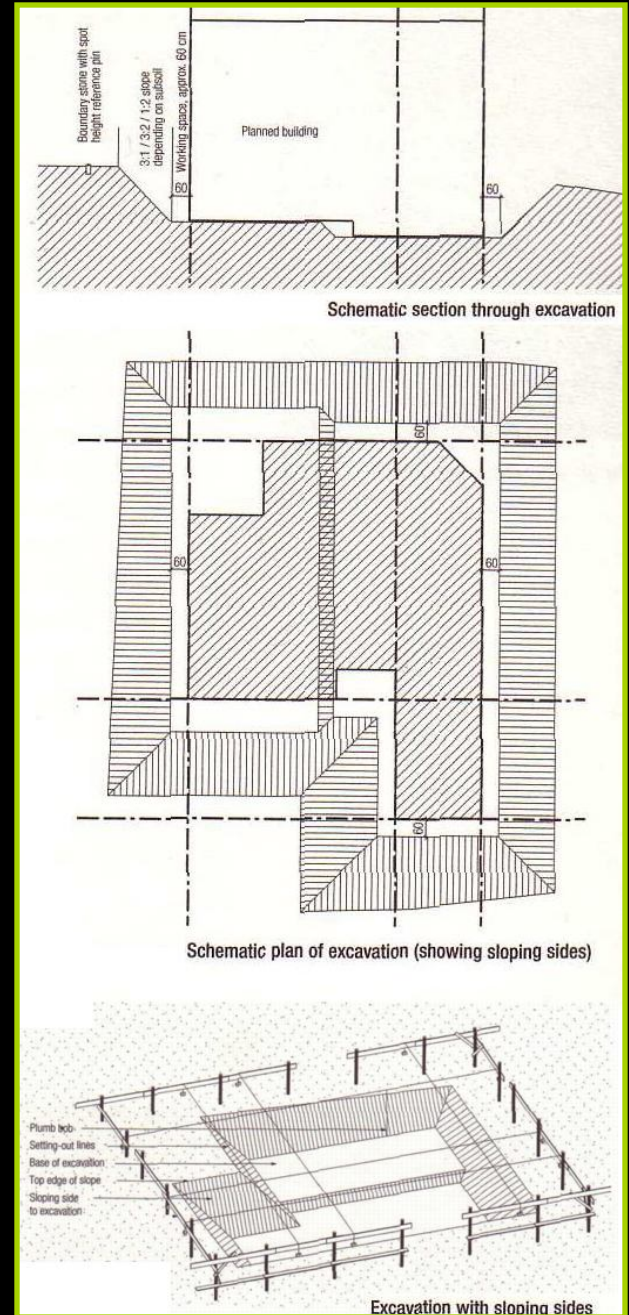
SIMPLE EXCAVATION PROCESS:

→ 'BENCHED EXCAVATION'

- REMOVAL OF UPPERMOST LAYER OF TOPSOIL; STORAGE ON SITE (CA. 1 FT.)
 - PROFILE BOARDS, MAIN GRID LINE SURVEYING
 - FURTHER REMOVAL → TOOLS → DEPENDENT ON GROUND CONDITIONS; PART STORAGE ON SITE FOR BACKFILL
 - AT ARRIVAL OF REQ. DEPTH: FOOTING w/ 'MUD SLAB' w/ CRUSHED STONE UNDERLAYMENT
- INSPECTION FOUNDATION ENGINEER



SECTION THROUGH BENCHED EXCAVATION



→ EXCAVATION PROCESS:

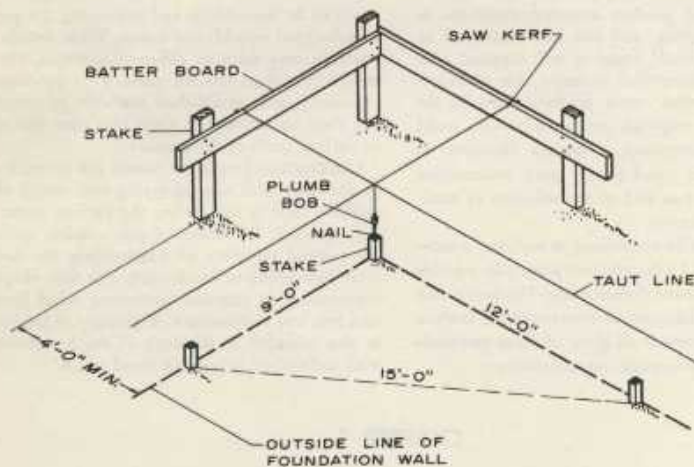
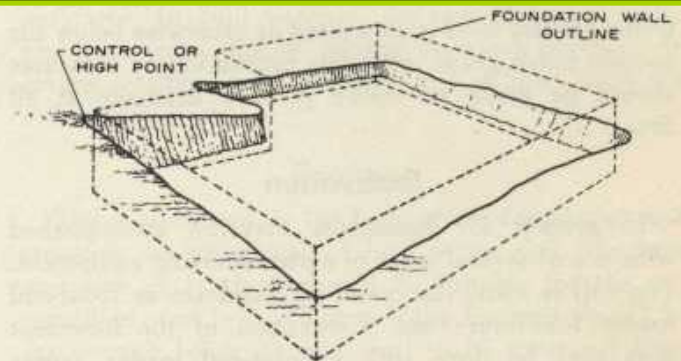
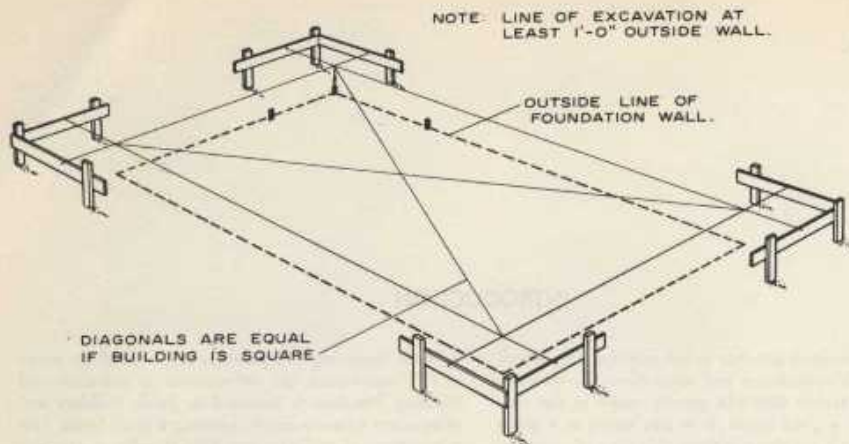


Figure 1.—Staking and laying out the house.

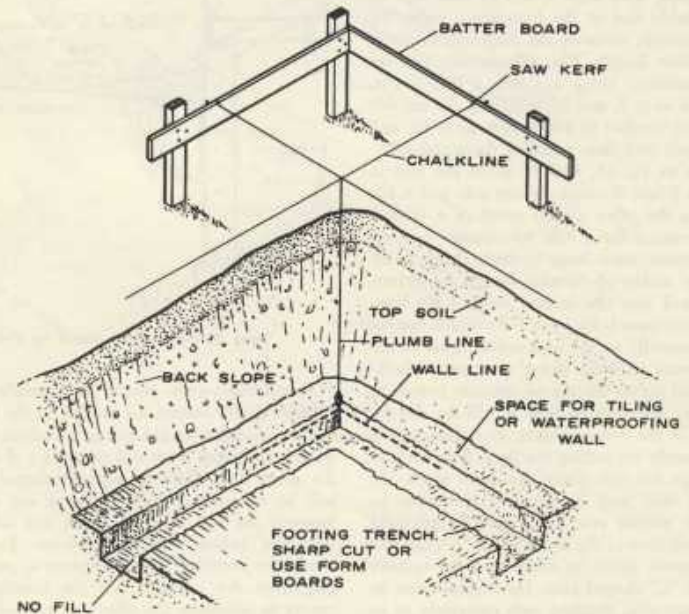


Figure 4.—Establishing corners for excavation and footings.

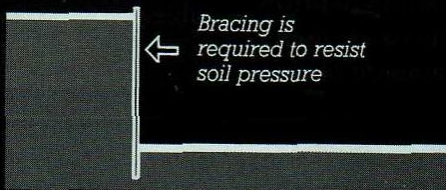
**RULES: SET-BACKS + SIDE YARD (FOLLOW LOCAL CODES! > PLOT PLAN),
HEIGHTS: FROST LINE, BASEMENT HEIGHT, PROTECTION WOOD FRAME.**

→ SOIL CONDITIONS / EXCAVATION:

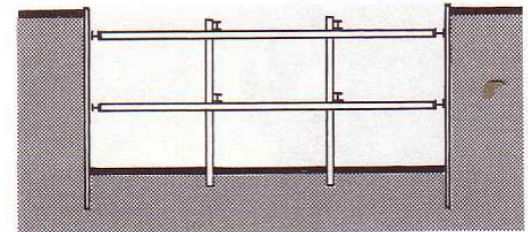
ADVANCED EXCAVATION PROCESS:

→ 'SHEETED EXCAVATION'

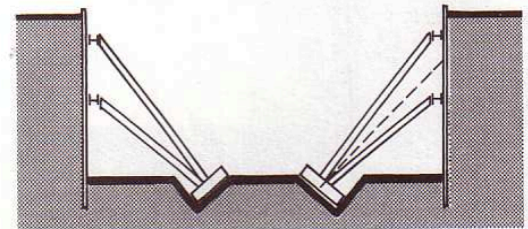
- REMOVAL OF UPPERMOST LAYER OF TOPSOIL; STORAGE ON SITE (CA. 1 FT.)
 - 1 STORY EXCAVATION/STABLE SOIL: DRILLING OF SHEETING MATERIAL
 - TALLER WALLS → BRACING NECESSARY
 - SUBSEQUENT PROGRESS ACCORDING TO: SOIL QUALITY, EQUIPMENT, PROXIMITY OF SURR. BUILDINGS, WATER TABLE, PERMANENT SUBSTRUCTURE OF THE BUILDING
- INSPECTIONS FOUNDATION ENGINEER



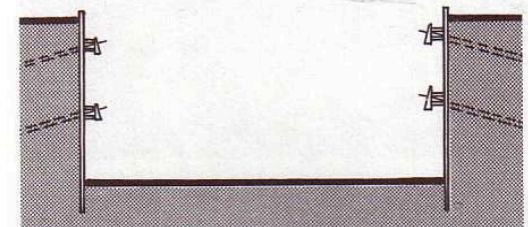
SECTION THROUGH SHEETED EXCAVATION



CROSSLOT BRACING



RAKERS



TIEBACKS

→ TIEBACK-SUPPORTS:

- UNDISTURBED EXCAVATION PROCESS
- EFFORT+COST SAVINGS
- DEPENDENT ON SUBSOIL CONDITIONS
- MANY SHEETING APPLICATIONS

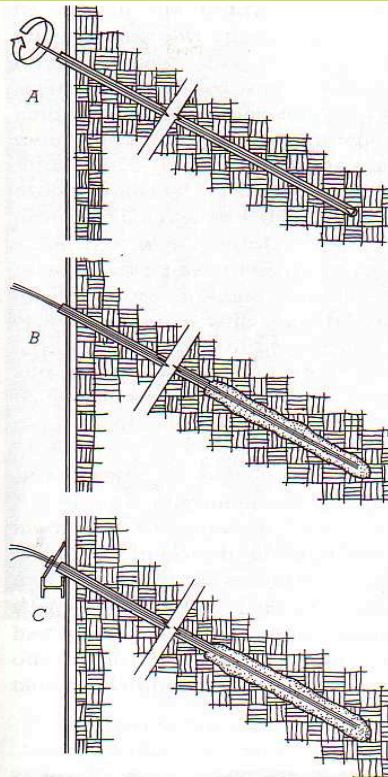
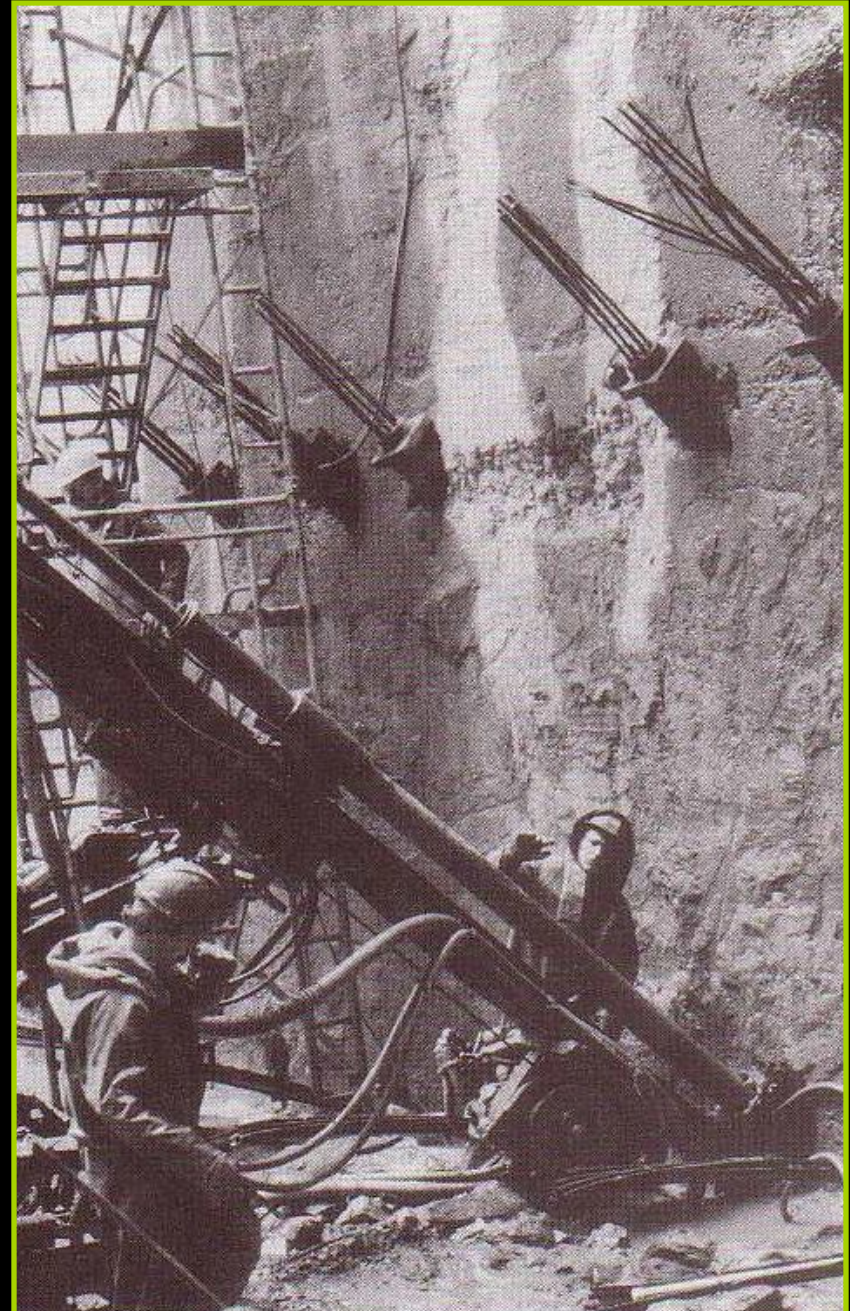


FIGURE 2.19

Three steps in the installation of a tieback to a soil anchor. (a) A rotary drill bores a hole through the sheeting and into stable soil or rock. A steel pipe casing keeps the hole from caving in where it passes through noncohesive soils. (b) Steel prestressing tendons are inserted into the hole and grouted under pressure to anchor them to the soil. (c) After the grout has hardened, the tendons are tensioned with a hydraulic jack and anchored to a waler.



→ SHEETING METHODS:

'SOLDIER BEAMS + LAGGING':

- STEEL WIDE-FLANGE SECTIONS DRIVEN INTO EARTH BEFORE DIGGING BEGINS.
- AS EARTH IS REMOVED, 'LAGGING' IS PLACED AGAINST THE FLANGES.

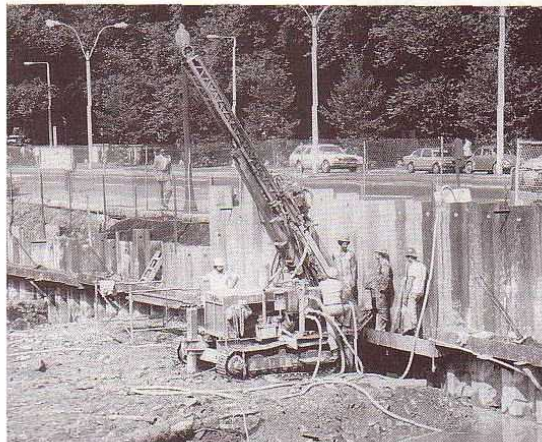
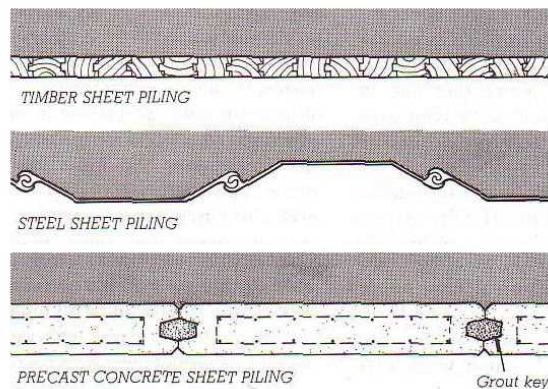
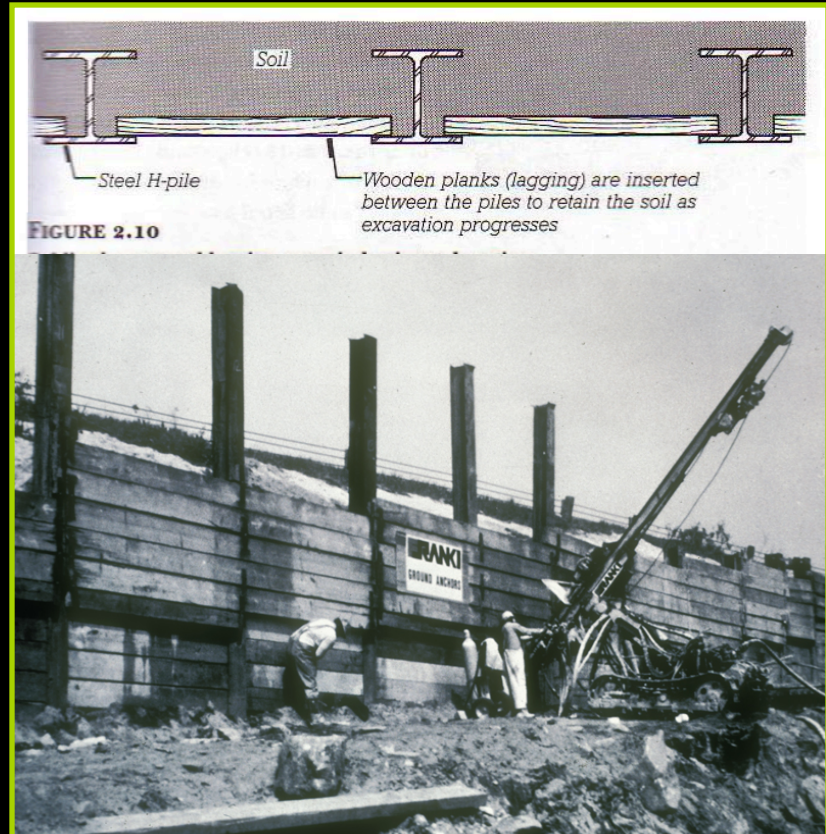
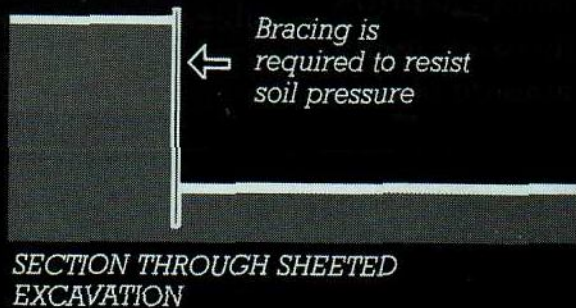


FIGURE 2.13
Drilling tieback holes for a wall of steel sheet piling. Notice the completed tieback connections to the waler in the foreground and background. The hole in the top of each piece of sheet piling allows it to be lifted by a crane.

'SHEET PILING':

- IDENTICAL VERTICAL PLANKS W/ END CONNECTOR (I.E. TUNG+GROOVE).
- DRIVEN INTO EARTH BEFORE DIGGING.
- REMOVAL OR 'LOST PILING' AFTER SUBSTRUCTURE IS COMPLETED.

→ SHEETING METHODS:
*DRIVING SOLDIER BEAMS
WITH PILE DRIVER*



→ SHEETING METHODS:

'SLURRY WALLS':

- CONCRETE CONSTRUCTION
- ‘SHEETING’ BECOMES SUBSEQUENTLY PERMANENT FOUNDATION WALL
- LAY-OUT W/ PRECISION → GUIDE WALLS
- CRANE/CLAMSHELL BUCKET EXCAVATION
- SLURRY-FILL: BENTONITE/CLAY/WATER-MIXTURE, TO AVOID TRENCH COLLAPSE
- TREMIE: BOTTOM-UP CONCRETE FILL
- SITECAST REINFORCED CONCRETE

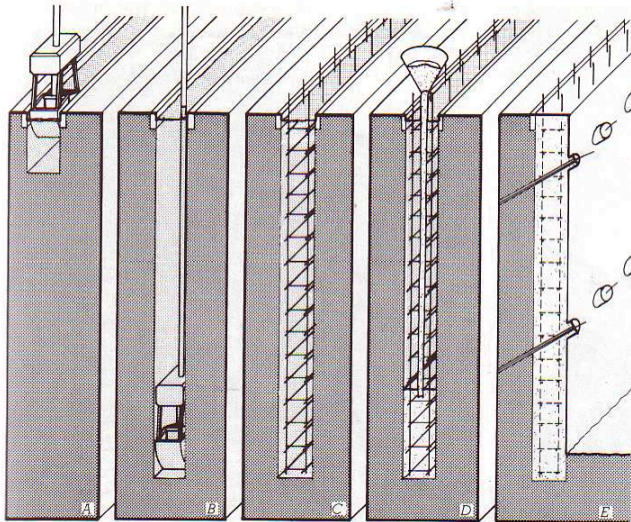


FIGURE 2.14

Steps in constructing a slurry wall.

(a) The concrete guide walls have been installed, and the clamshell bucket begins excavating the trench through a bentonite clay slurry.

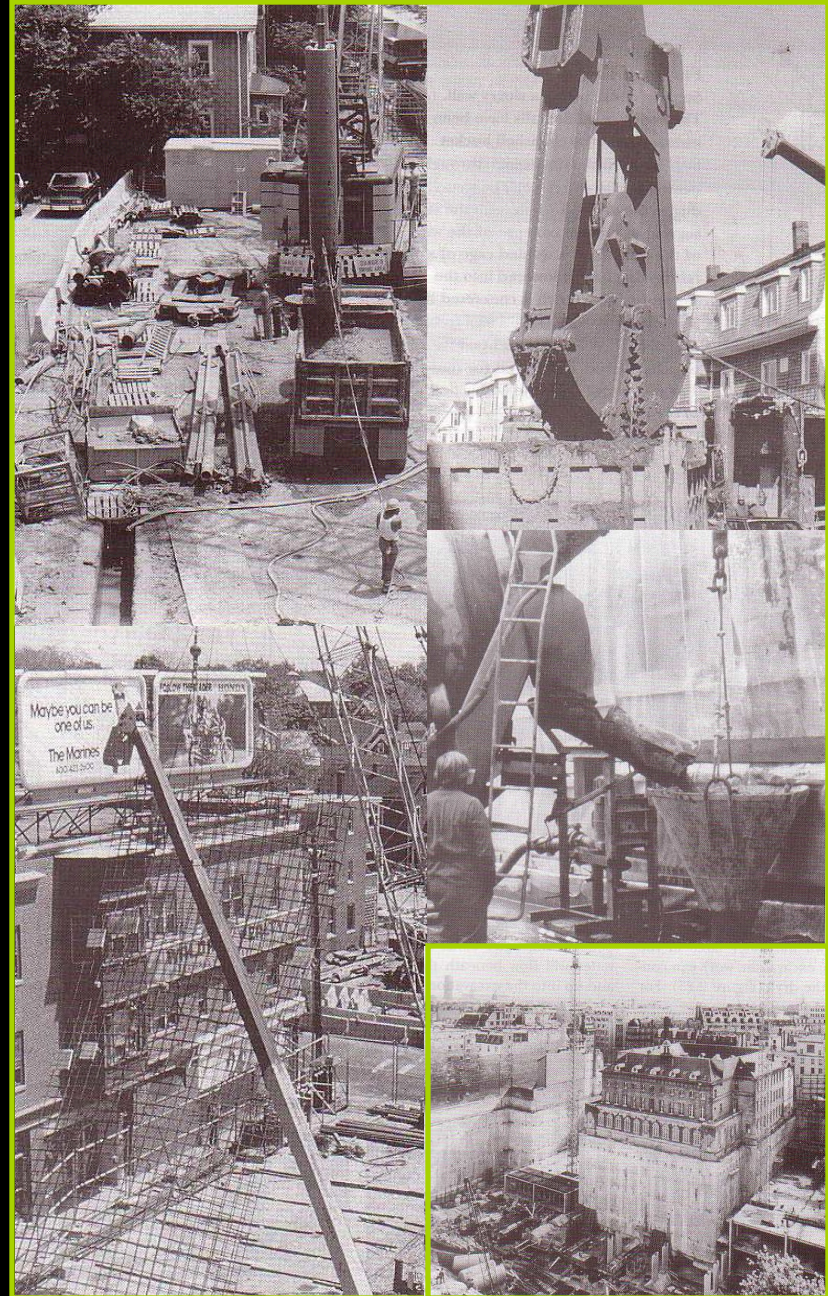
(b) The trench is dug to the desired depth, with the slurry serving to prevent collapse of the walls of the trench.

(c) A welded cage of steel reinforcing bars is lowered into the slurry.

(d) The trench is concreted from the bottom up with the aid of a tremie.

The displaced slurry is pumped from trench, filtered, and stored for reuse.

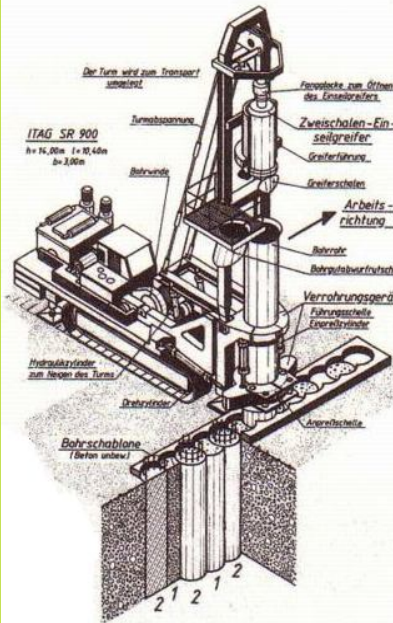
(e) The reinforced concrete wall is tied back as excavation progresses.



‘SLURRY WALLS’ :



→ SOIL CONDITIONS: 'CONTIGUOUS PILES' 'SOIL MIXING'



Wall of contiguous bored piles
Every second pile is installed first and the intermediate spaces filled with concrete afterwards; the soil provides the formwork.



Credits and Data
Project title: Gymnastic Hall and Media Center, Freudenberg
Location: Zurich, Switzerland
Client: Kanton Zurich
Design date: 2002, competition
Architect: Christian Kerez
Floor area: 2,560 m²
Total floor area: 3,900 m²
Structural system: Concrete piles

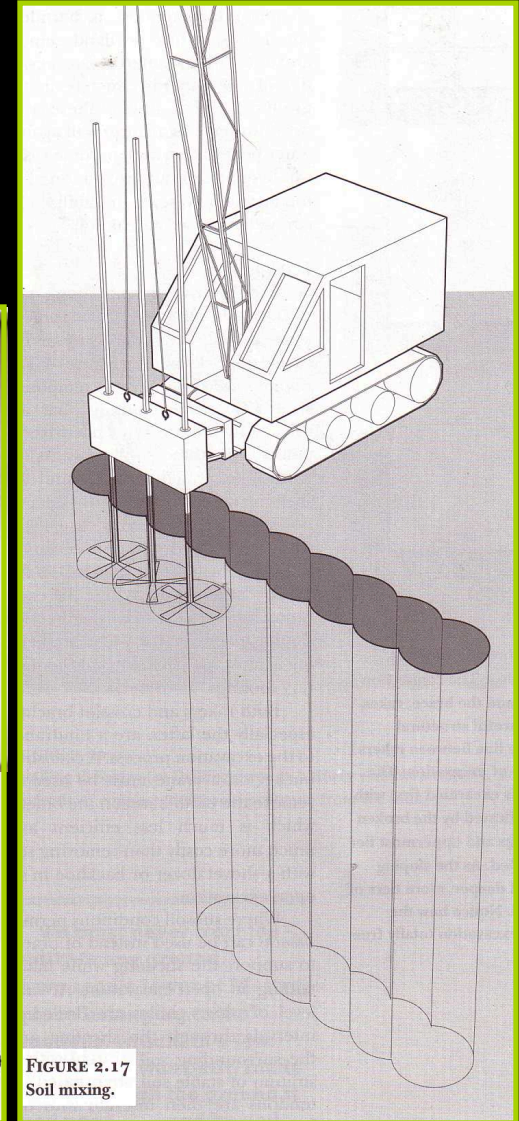
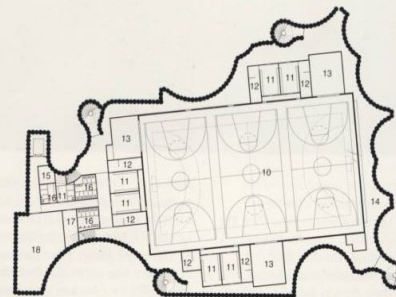
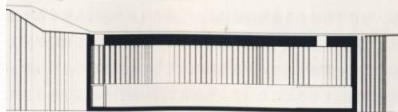


FIGURE 2.17
Soil mixing.

NOTE PURPOSE: SUPPORT STRUCTURE ↔ SUPPORT EXCAVATION

→ SOIL CONDITIONS: 'WATER TABLE' ; 'DEWATERING'

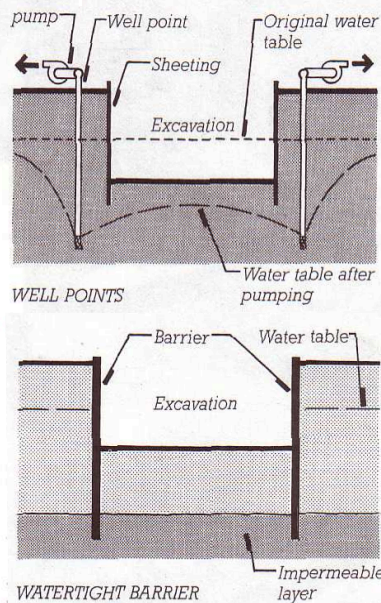
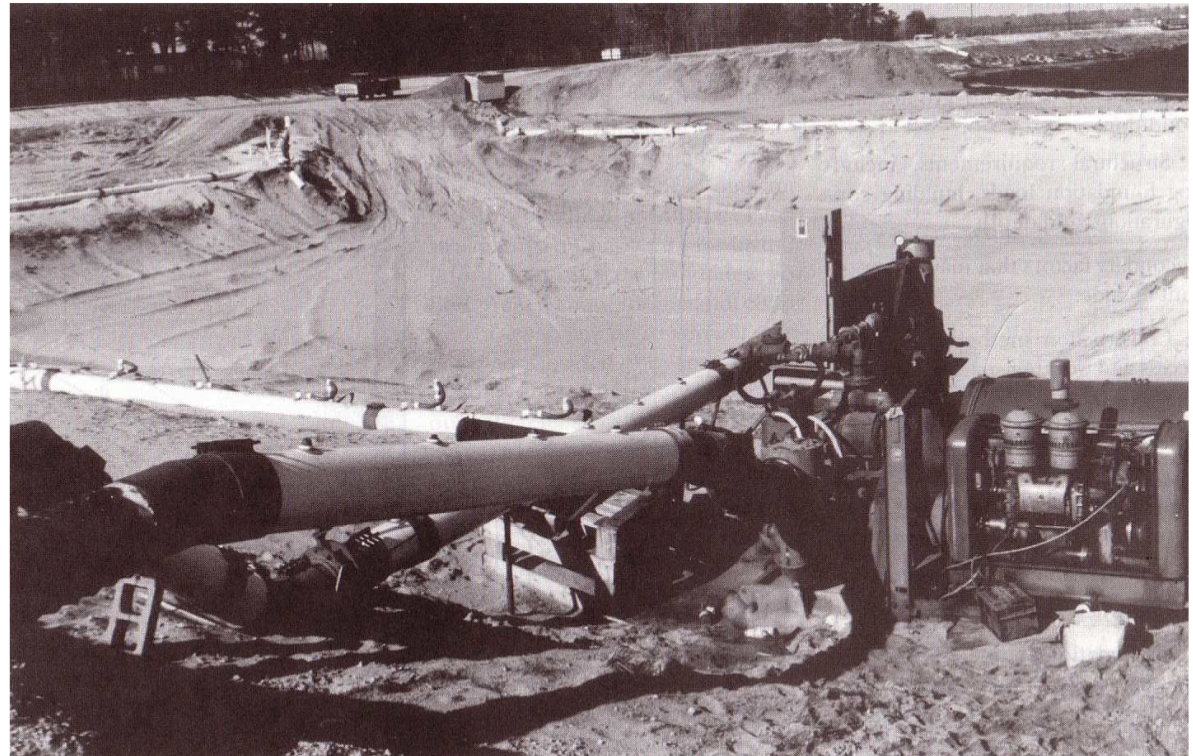


FIGURE 2.22

Two methods of keeping an excavation dry, viewed in cross section. The water sucked from well points depresses the water table in the immediate vicinity to a level below the bottom of the excavation. Watertight barrier walls work only if their bottom edges are inserted into an impermeable stratum that prevents water from working its way under the walls.



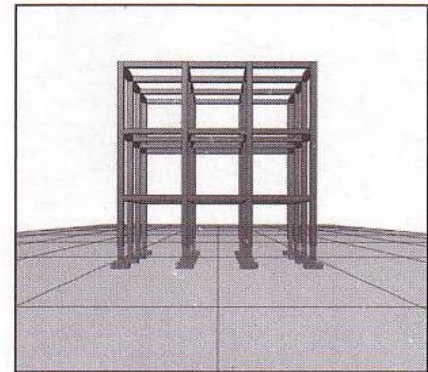
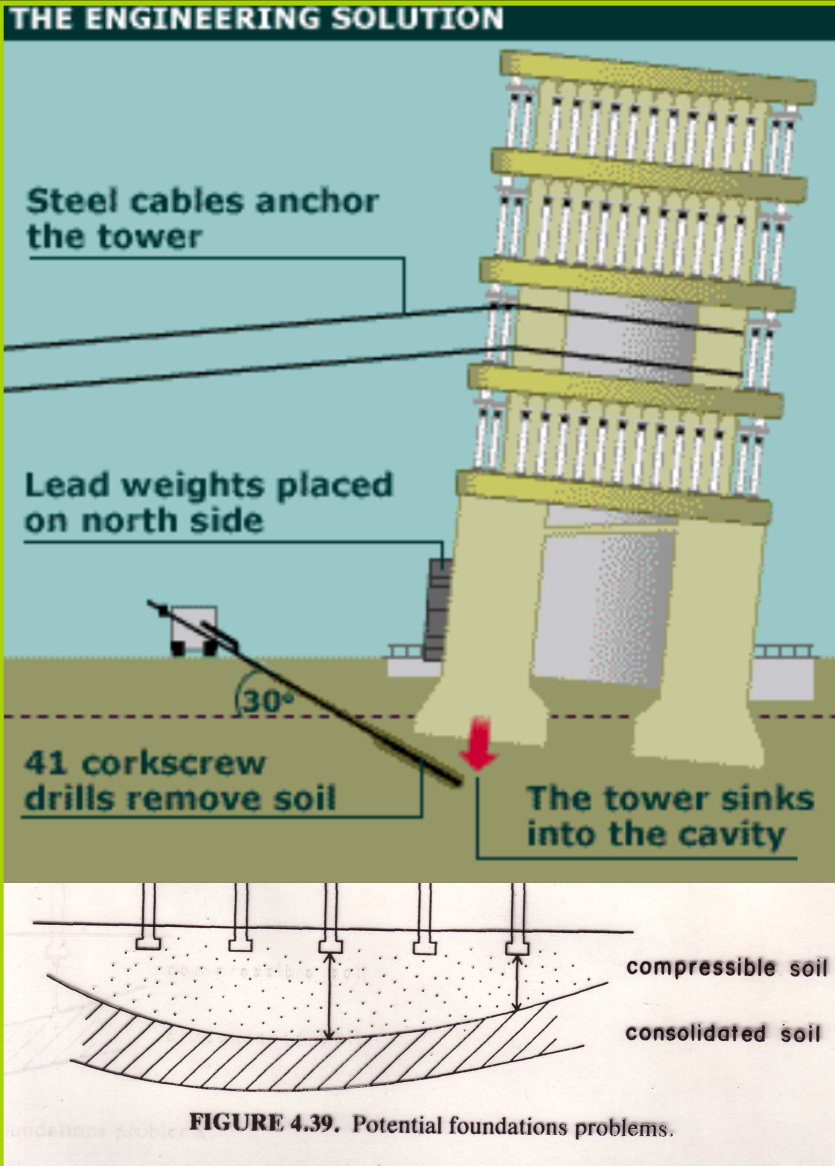
The pump in the foreground draws water through a header pipe that connects to well points spaced every meter or so around the perimeter of the excavation. This allows work to continue in the dry despite a high water table maintained by the lake just visible at the upper right. (Courtesy of Griffin Dewatering Corporation)

→ SOIL CONDITIONS / SETTLEMENT:

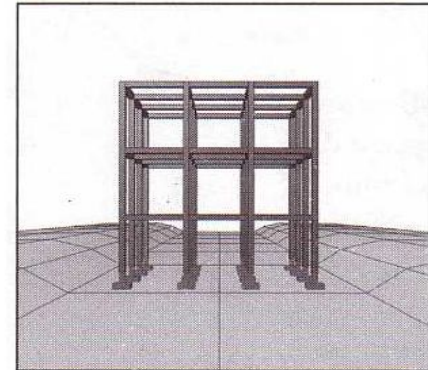


SOIL DESCRIPTION	DEPTH
Topsoil	0.5'
Loose silt, some fine sand and clay (ML)	6.5'
Loose to medium dense fine to coarse sand, some silt, trace of fine gravel (SM)	20.5'
Medium dense fine to coarse sand, some silt (SM)	30.5'
	34.5'
Medium dense silt, some fine sand (ML)	40'
	43'
Medium dense fine to coarse sand, some silt, trace fine gravel (SP-ML)	53.5'
Medium dense silt, some fine sand (ML)	
Firm to stiff clay, some silt (CL)	
Very dense fine to coarse sand, some silt, trace fine to coarse gravel (SP-SM)	84'

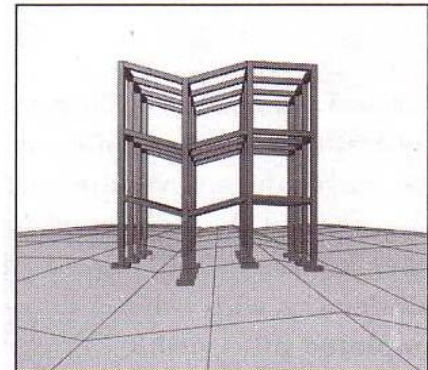
FIGURE 2.7
A typical log from a soil test boring, indicating the type of soil in each stratum and the depth in feet at which it was found. The abbreviations in parentheses refer to the Unified Soil Classification System, and are explained in Figure 2.2.



(a) Before settlement occurs



(b) Uniform settlement



(c) Differential settlement

→ SOIL CONDITIONS / SETTLEMENT:



→ **LOAD CONDITIONS / FOUNDATION LOADS:**

DEAD LOAD: SUM OF WEIGHTS: FRAME/STRUCTURE

(FOUNDATIONS, FLOORS, WALLS, ROOFS, HVAC, ...)

LIVE LOAD: SUM OF WEIGHTS: PEOPLE/USAGE (IMPOSED)

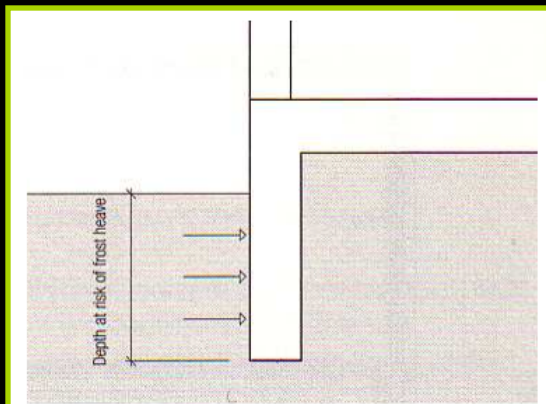
(OCCUPANCY, EQUIPMENT/FURNITURE, SNOW/ICE/WATER @ ROOF)

LATERAL LOADS: POSSIBLE WIND FORCES; CANTILEVERS
(LATERAL, DOWNWARD, UPLIFT)

EARTHQUAKES: HORIZONTAL+VERTICAL FORCES
(GROUND MOTION ↔ BUILDING MOTION)

EARTH/WATER: HORIZONTAL PRESSURE
(AGAINST BASEMENT WALLS)

'FROST PRESSURE': HORIZONTAL+VERTICAL FORCES



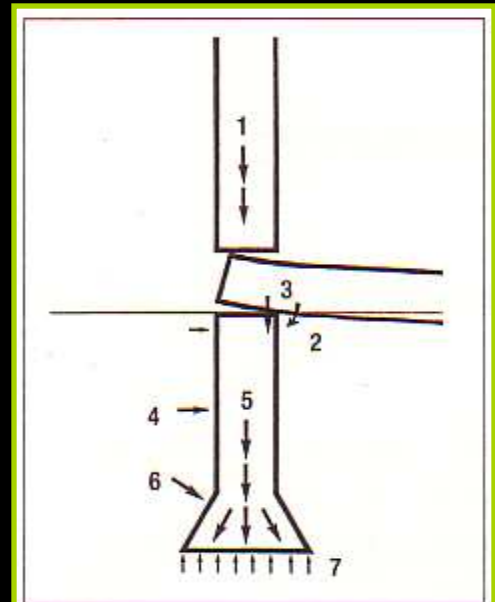
Stem wall to provide frost protection

No direct structural function; prevents water seeping below the ground slab within the depth subject to frost heave; up to 800 m above sea level frost line = 80 cm below surface; at higher altitudes 1/10 (i.e. 120 cm at 1200 m above sea level)

Influences

Mechanical, biological and chemical effects:

Loads	dead and imposed
Settlement	compression of the subsoil during and after the construction process
Earth pressure	forces acting (primarily horizontally) on the underground walls
Moisture	in the atmosphere (precipitation) on the ground (splashing) in the ground (moisture, frost, ground-water) in the building (vapour diffusion)

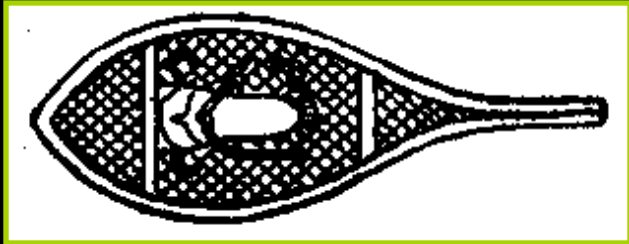


Load transfer

- 1 Dead and imposed loads
- 2 Bending moment at floor support
- 3 Bearing pressure at support
- 4 Earth pressure, hydrostatic pressure
- 5 Foundation load
- 6 Spread of load
- 7 Ground pressure (underside of foundation)

→ *SPREAD OF LOAD:*

‘SNOWSHOE’



→ *LOAD+SOIL CONDITIONS / FOUNDATION DIMENSIONS:*

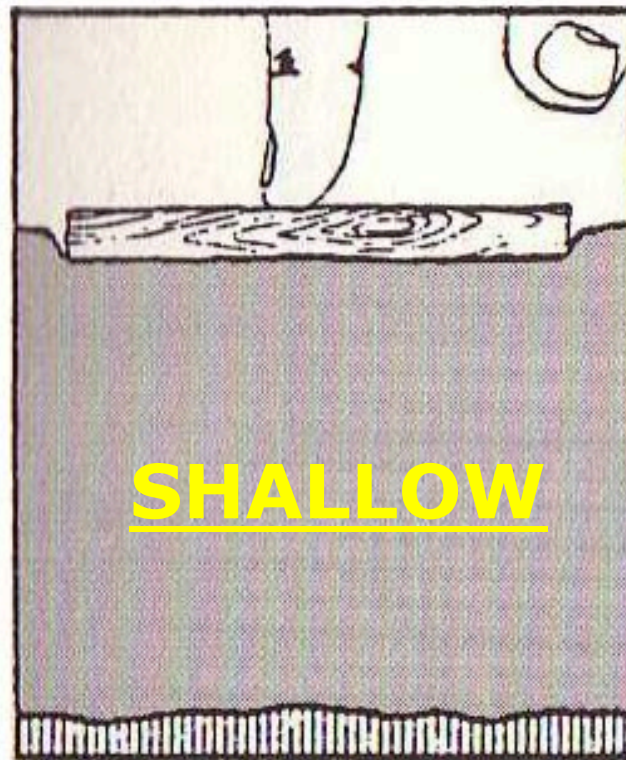
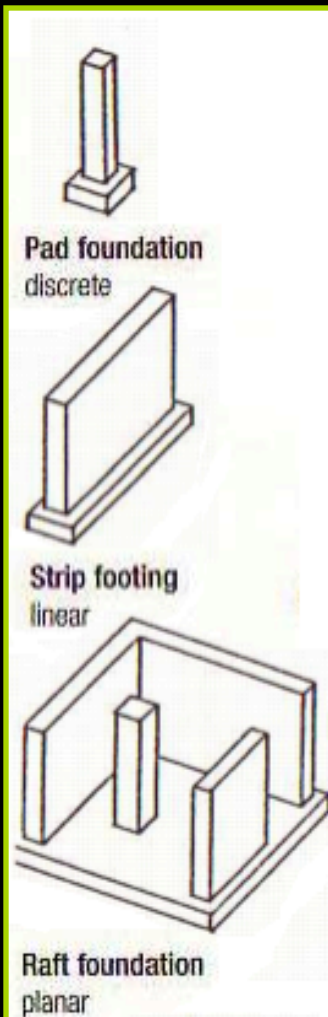


Fig. 46: Shallow foundation

Used when the load-carrying capacity of the subsoil is consistent; depth of foundation = "depth at risk of frost heave" (alternative: provide stem wall)

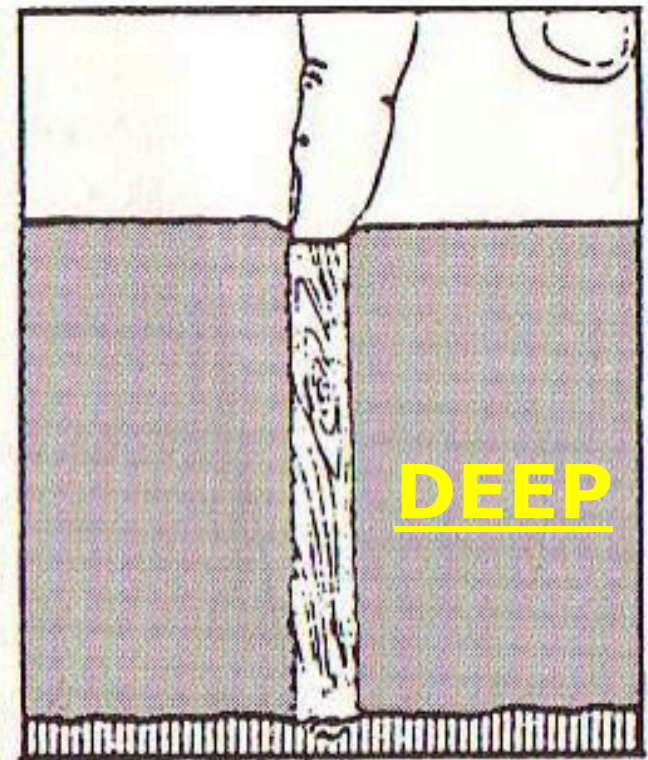


Fig. 47: Deep foundation

Used when the load-carrying capacity of the subsoil is inconsistent or inadequate near the surface; depth of foundation = depth of loadbearing stratum

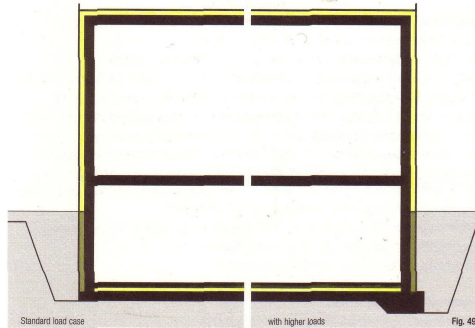
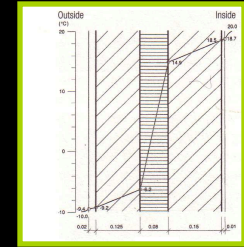
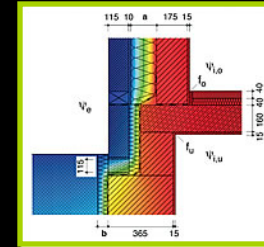
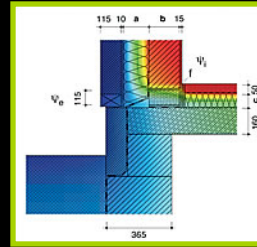
→ *FOUNDATION CHOICE: FACTORS:*

The primary factors that affect the choice of a foundation type :

- Subsurface soil and groundwater conditions
- Structural requirements, including foundation loads, building configurations, and depth

- Construction methods, including access and working space
- Environmental factors, including noise, traffic, and disposal of earth and water
- Building codes and regulations
- Impact on adjacent property
- Time available for construction
- Construction risks

→ FOUNDATIONS: INSULATION CONCEPTS



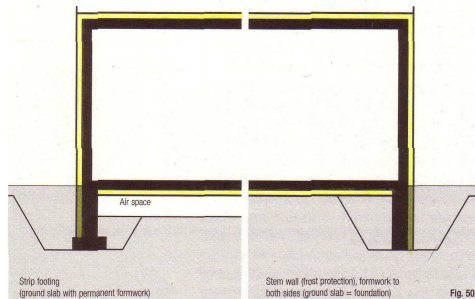
Foundation schemes Loadbearing layer inside

Insulation on cold side, inner skin loadbearing (normal case)
As a rule, all "underground components" for foundations are constructed these days in reinforced concrete.

Raft

Building below ground level

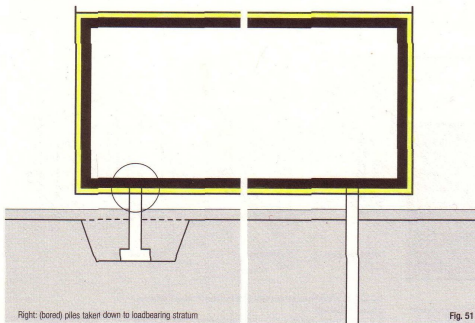
Building supported on raft foundation
Thickening below walls with higher loads
Change of material from building to perimeter insulation
Problem at base of wall: thermal insulation interrupted (heated basement)



Strip footing, stem wall (frost protection)

Building at ground level (= no basement)

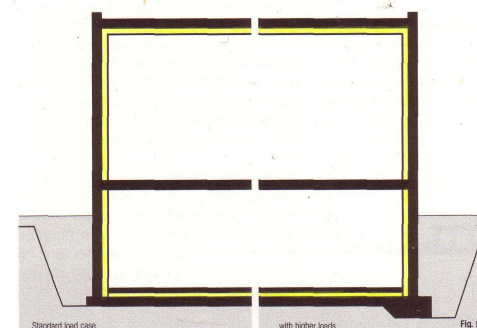
Building supported on strip foundations in the case of:
a) loadbearing strata at lower level
b) air space (enables floor construction without damp-proof membrane)
Underside of strip footing down to frost line
Stem wall necessary when building supported on ground slab
Change of material from building to perimeter insulation
Problem at base of wall: thermal insulation interrupted



Individual foundations

Building above ground level

Lightweight, pragmatic architecture: e.g. protection against floods
(cf. Farnsworth House, Mies van der Rohe)
Underside of foundation down to frost line or loadbearing strata (piles)
Problem at column head: insulation penetrated
Lateral stability provided by fixity and/or wind bracing, depending on height of column



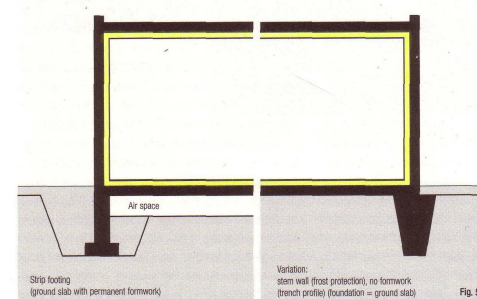
Foundation schemes Loadbearing layer outside

Insulation on warm side, inner skin non-loadbearing (special case in concrete or timber)

Raft

Building below ground level

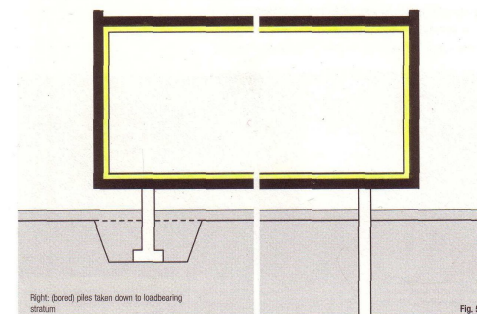
Building supported on raft foundation
Thickening below walls with higher loads
In concrete change of material not necessary at ground level
Problem at floors: thermal insulation interrupted



Strip footing

Building at ground level (= no basement)

Building supported on strip foundations in the case of:
a) loadbearing strata at lower level
b) air space (enables floor construction without damp-proof membrane)
Underside of strip footing down to frost line
Stem wall (frost protection) necessary when building supported on ground slab
Advantage: thermal insulation not interrupted/penetrated

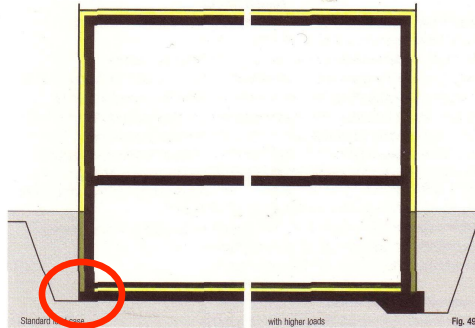
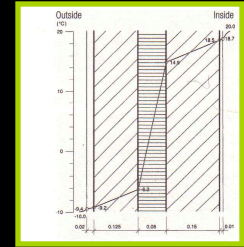
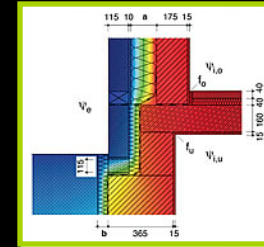
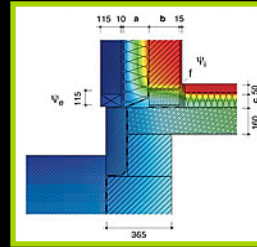


Individual foundations

Building above ground level

Building supported on columns, pilots, piers, etc.
Lightweight, pragmatic architecture: e.g. protection against floods
(cf. Farnsworth House, Mies van der Rohe)
Underside of foundation down to frost line
Advantage: thermal insulation not interrupted/penetrated
Lateral stability provided by fixity and/or wind bracing, depending on height of column

→ FOUNDATIONS: INSULATION CONCEPTS



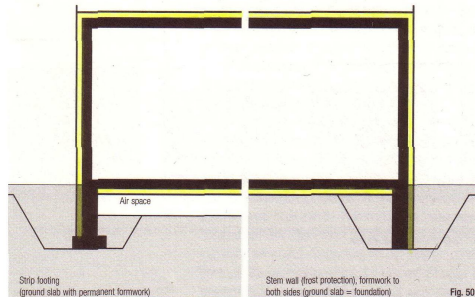
Foundation schemes Loadbearing layer inside

Insulation on cold side, inner skin loadbearing (normal case)
As a rule, all "underground components" for foundations are constructed these days in reinforced concrete.

Raft

Building below ground level

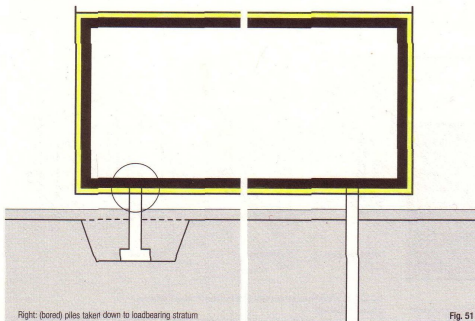
Building supported on raft foundation
Thickening below walls with higher loads
Change of material from building to perimeter insulation
Problem at base of wall: thermal insulation interrupted (heated basement)



Strip footing, stem wall (frost protection)

Building at ground level (= no basement)

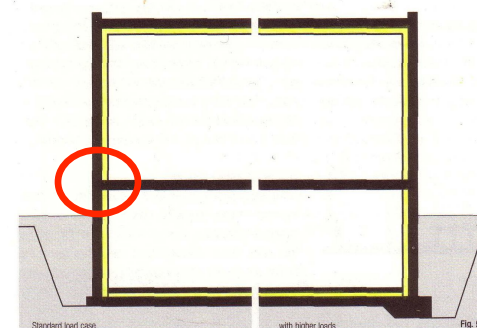
Building supported on strip foundations in the case of:
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Underside of strip footing down to frost line
Stem wall necessary when building supported on ground slab
Change of material from building to perimeter insulation
Problem at base of wall: thermal insulation interrupted



Individual foundations

Building above ground level

Lightweight, pragmatic architecture: e.g. protection against floods
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Underside of foundation down to frost line or loadbearing strata (piles)
Problem at column head: insulation penetrated
Lateral stability provided by fixity and/or wind bracing, depending on height of column



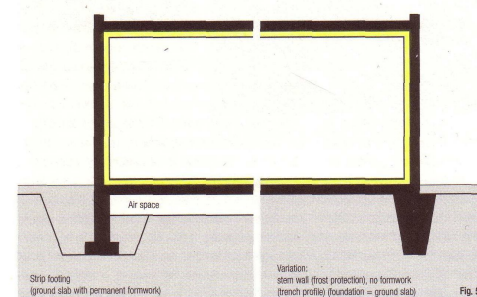
Foundation schemes Loadbearing layer outside

Insulation on warm side, inner skin non-loadbearing (special case in concrete or timber)

Raft

Building below ground level

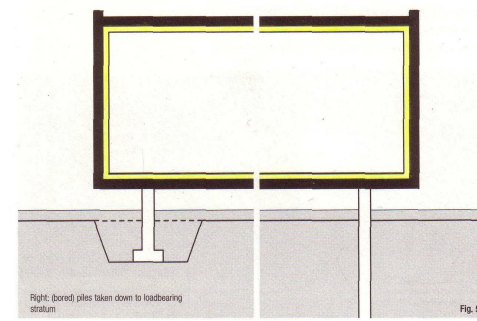
Building supported on raft foundation
Thickening below walls with higher loads
In concrete change of material not necessary at ground level
Problem at floors: thermal insulation interrupted



Strip footing

Building at ground level (= no basement)

Building supported on strip foundations in the case of:
a) loadbearing strata at lower level
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Underside of strip footing down to frost line
Stem wall (frost protection) necessary when building supported on ground slab
Advantage: thermal insulation not interrupted/penetrated



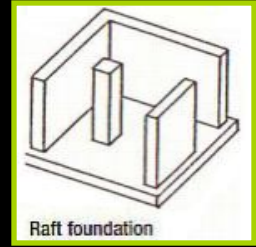
Individual foundations

Building above ground level

Building supported on columns, pilots, piers, etc.
Lightweight, pragmatic architecture: e.g. protection against floods
(cf. Farnsworth House, Mies van der Rohe)
Underside of foundation down to frost line
Advantage: thermal insulation not interrupted/penetrated
Lateral stability provided by fixity and/or wind bracing, depending on height of column

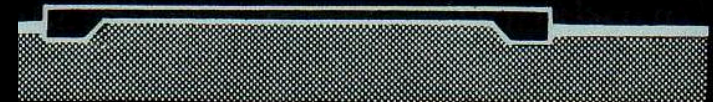
→ FOUNDATIONS: SHALLOW FOUNDATIONS

• 'RAFT' or 'MAT' FOUNDATION

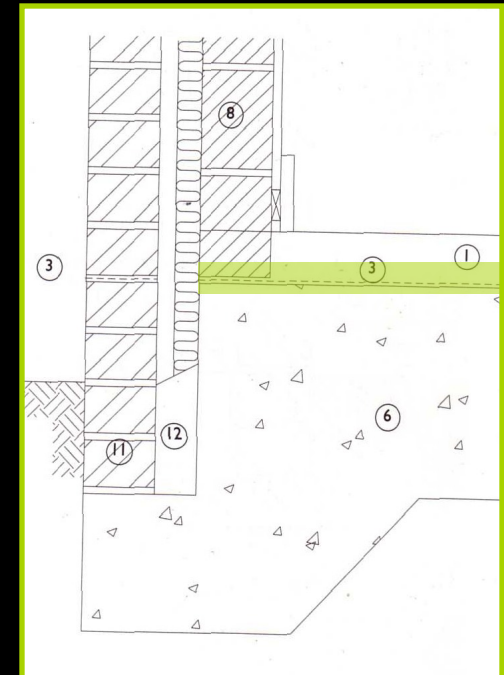
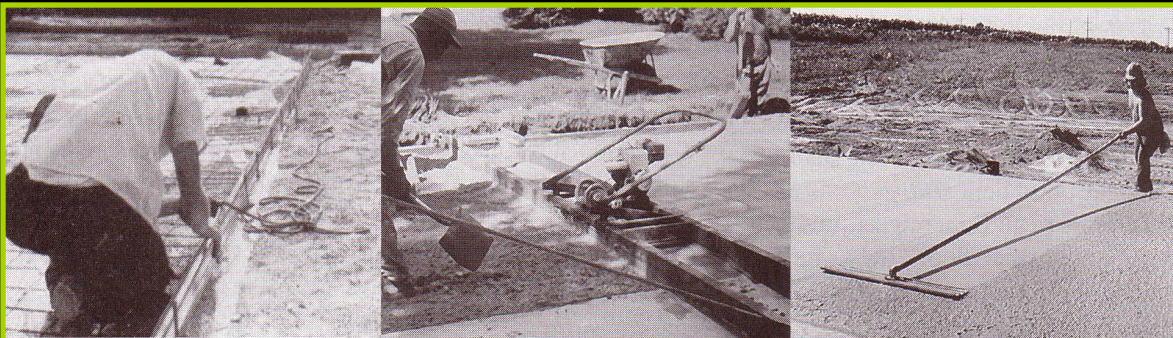


SLAB ON GRADE

- USUALLY POOR SOIL BEARING CAPACITY; OR DANGER OF CRACKING STRIP FOUNDATION
- PROVIDES LOWEST FLOOR SLAB
→ BELOW TIMBER CONSTRUCTION
- BIG LOADS, I.E. WAREHOUSES
- WEAKENED BY UTILITY LINES
- STEEL BAR REINFORCEMENT
- BAD MATERIAL ECONOMY

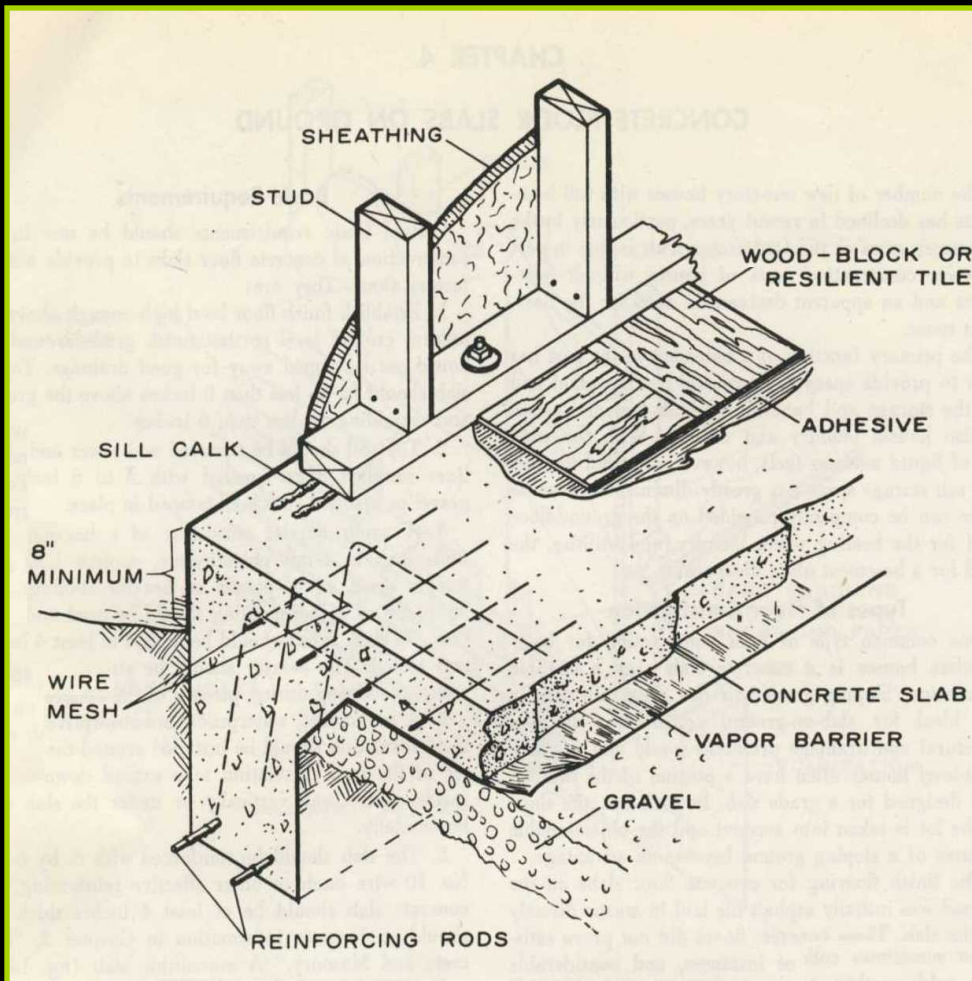
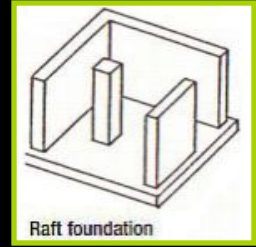


SLAB ON GRADE



→ FOUNDATIONS: SHALLOW FOUNDATIONS

• 'RAFT' or 'MAT' FOUNDATION



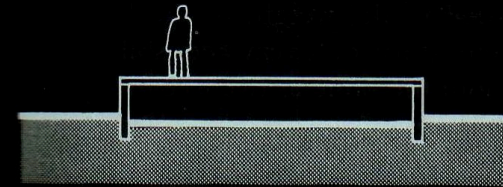
SLAB ON GRADE

- WHERE IS THE INSULATION?
- POTENTIAL DAMAGES?
- SOLUTIONS?

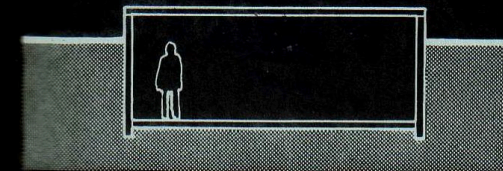
→ FOUNDATIONS: SHALLOW FOUNDATIONS

STRIP FOUNDATION

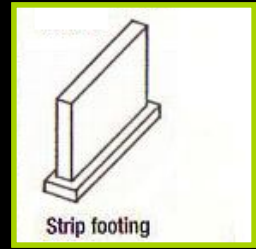
- SUPPORT LOADBEARING WALLS
- CONTINUOUS SUPPORT → EVENLY TRANSMITTED LOADS
- EVEN-OUT GROUNDBEARING CONDITIONS (SHORT BORE PILES)
- O.K. MATERIAL ECONOMY
- PROPORTION OF STRIP FOUNDATION DEPENDING ON GROUND CONDITION
- UTILITY LINE PENETRATION
- STEEL BAR REINFORCEMENT



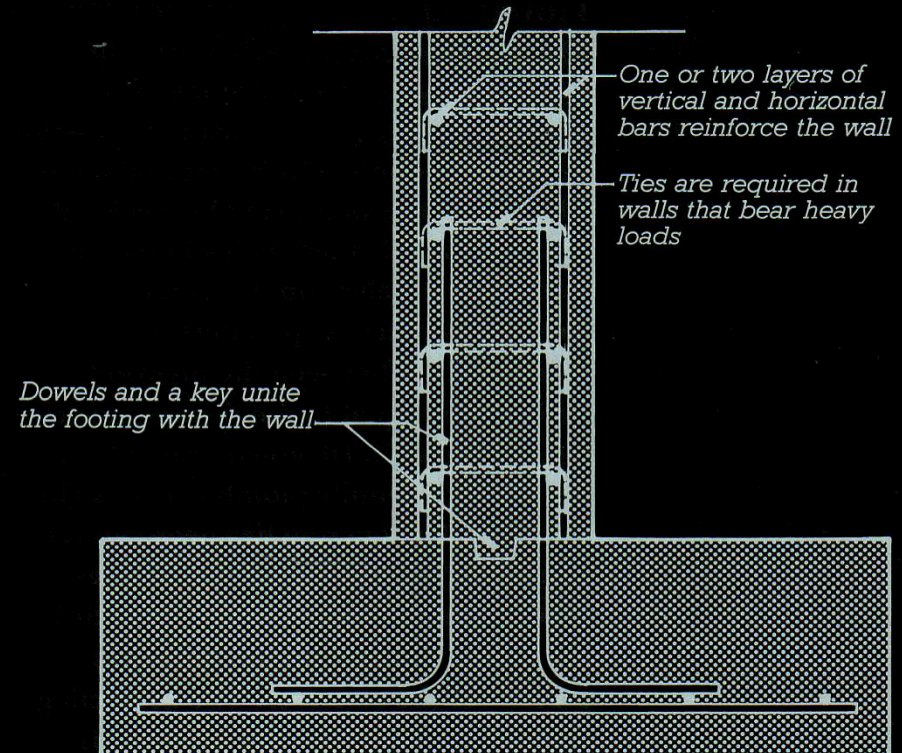
CRAWLSPACE



BASEMENT

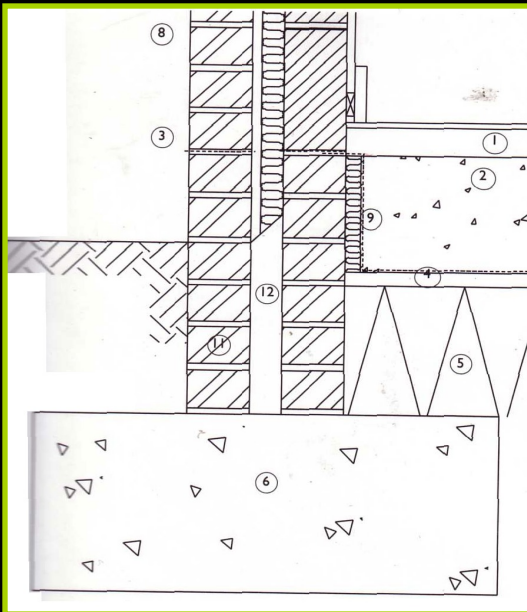
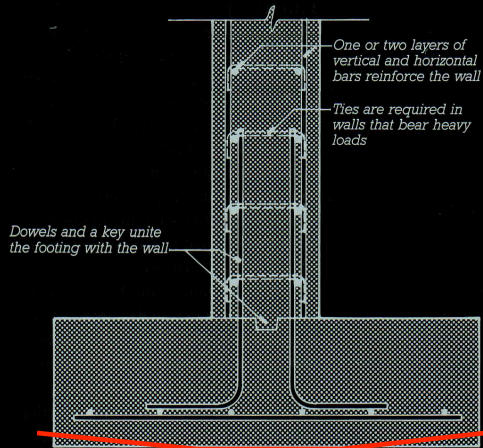
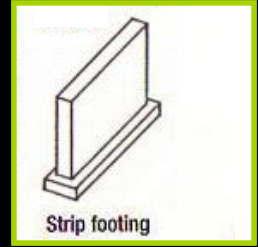


Strip footing



→ FOUNDATIONS: SHALLOW FOUNDATIONS

STRIP FOUNDATION



→ 'SHALLOW FOUNDATIONS': FOOTINGS

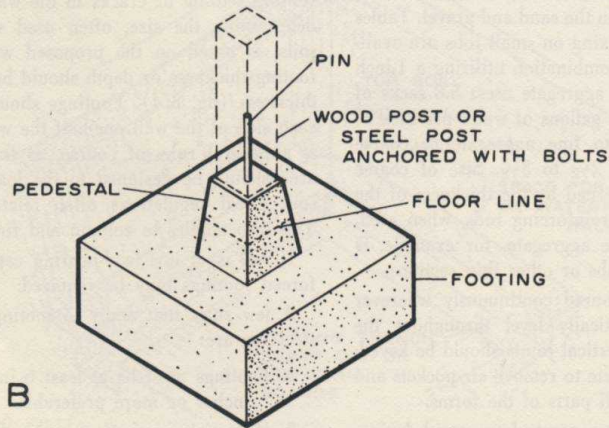
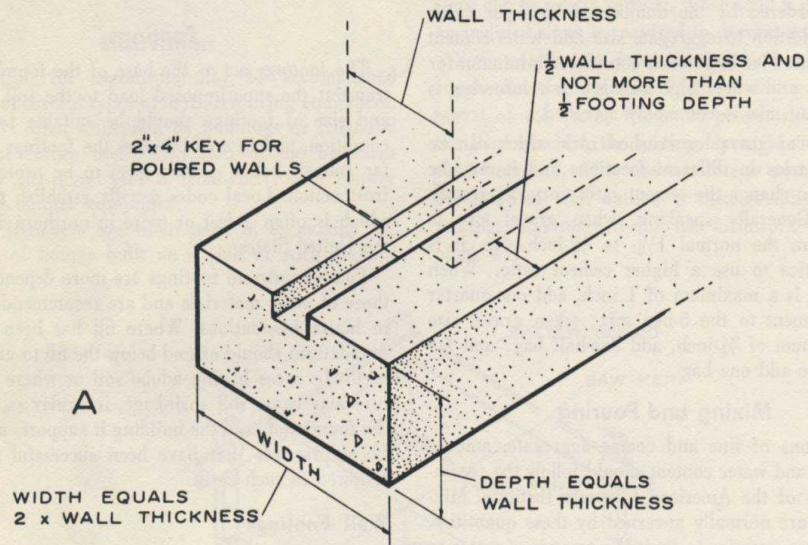
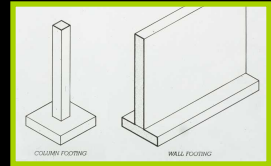
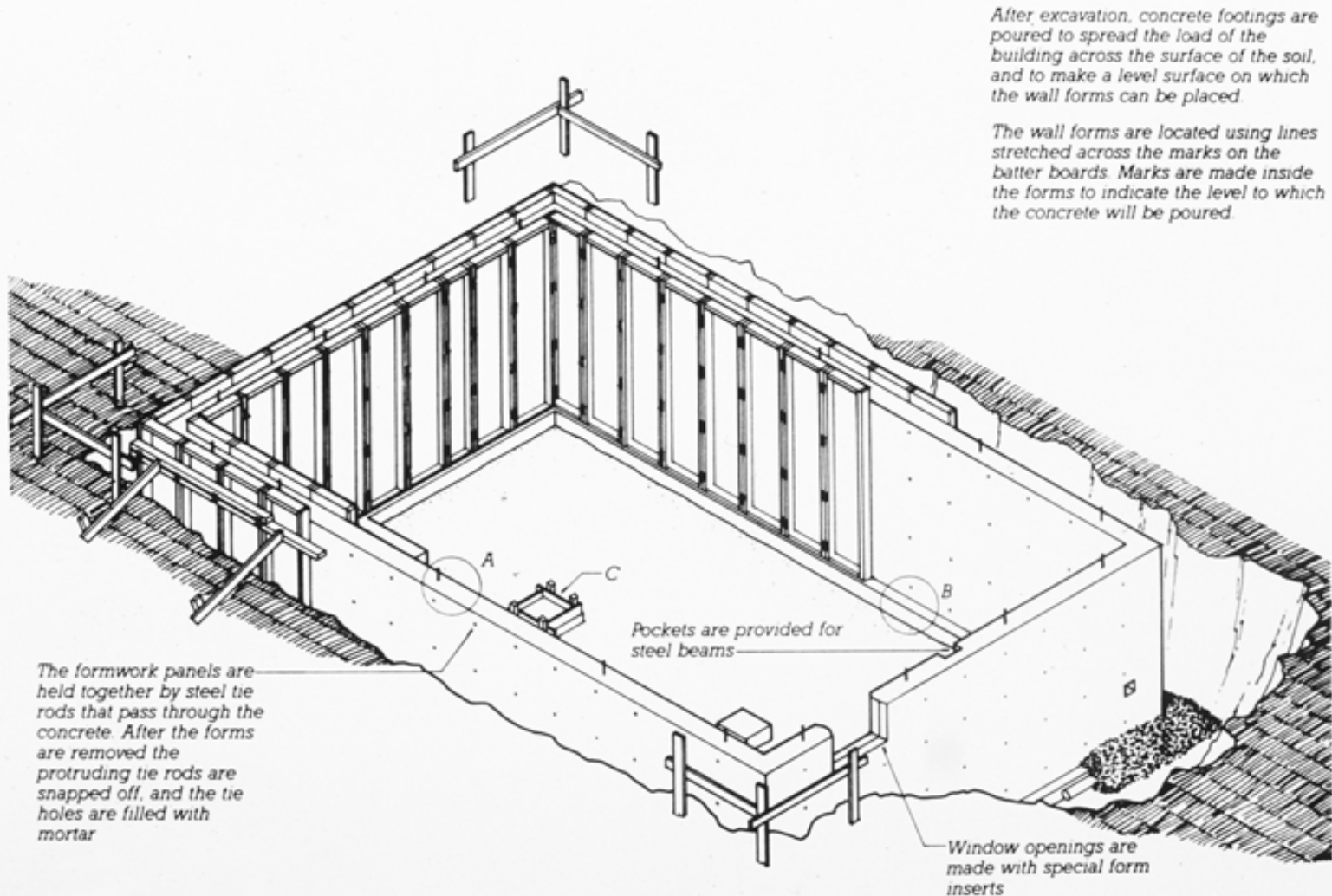


Figure 5.—Concrete footing: A, Wall footing; B, post footing.



→ FOUNDATIONS: SHALLOW FOUNDATIONS

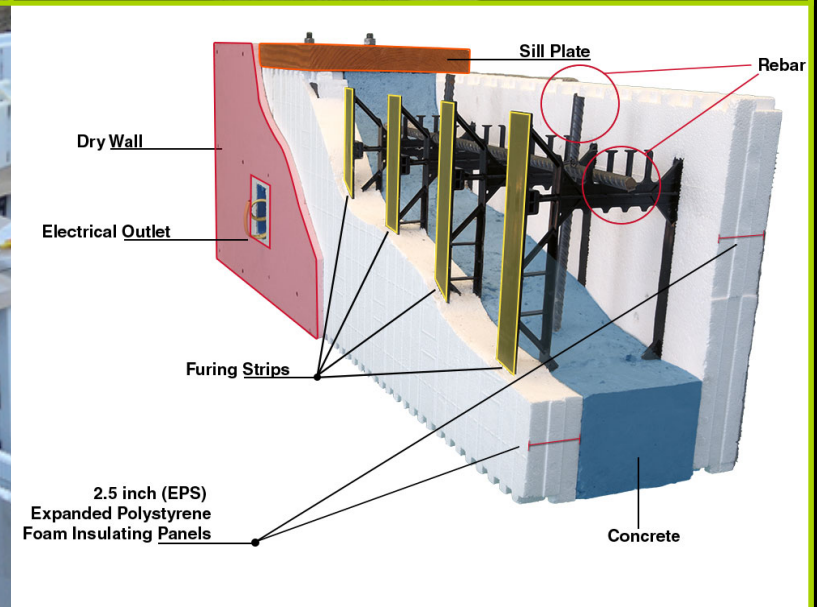
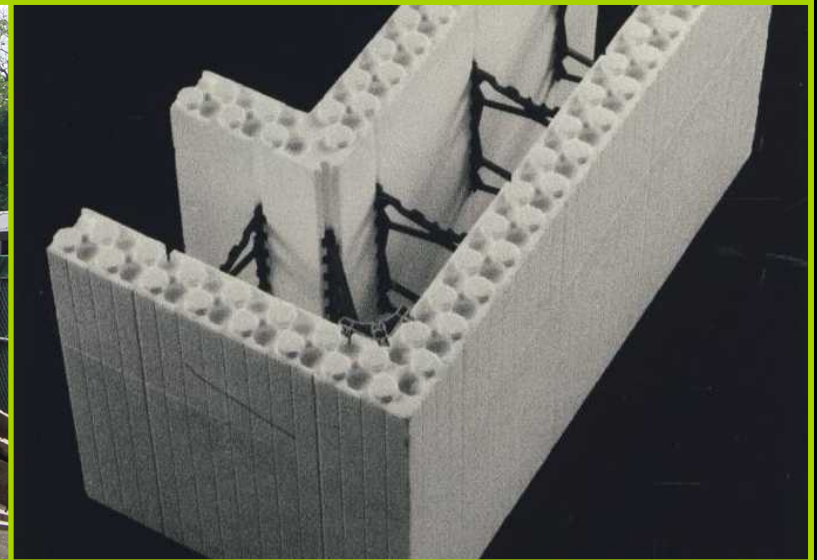


→ FOUNDATIONS: SHALLOW FOUNDATIONS

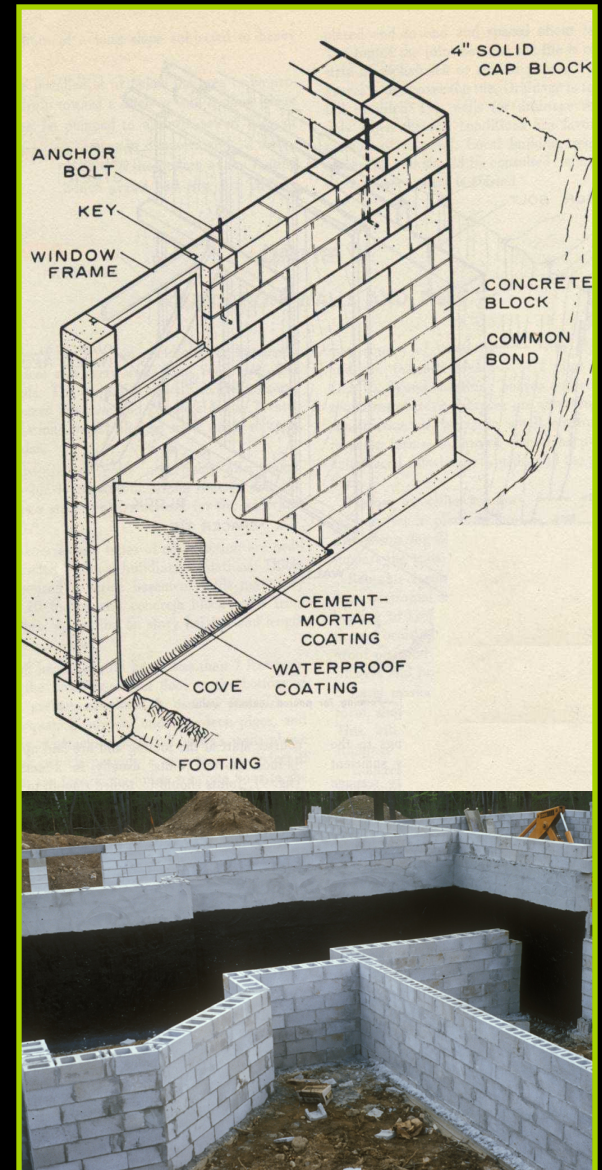
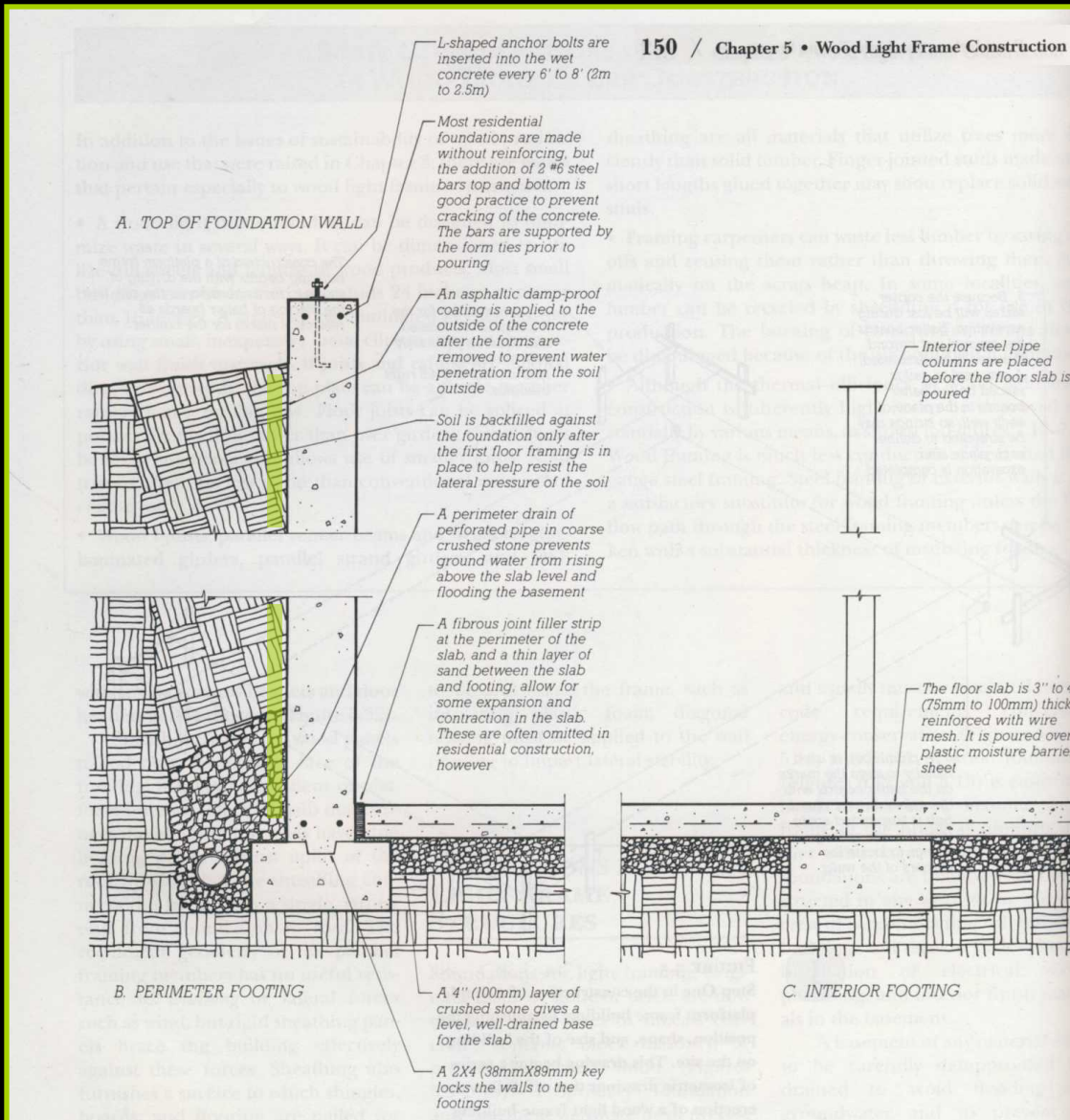


→ SHALLOW FOUNDATIONS

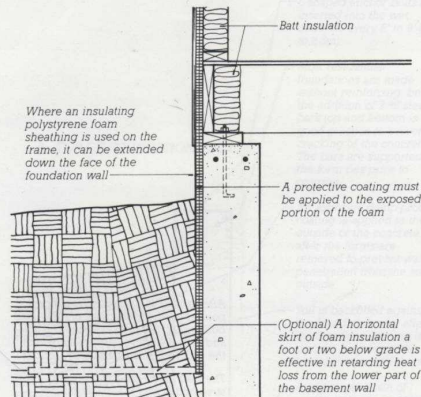
→ ICF: INSULATED CONCRETE FORM



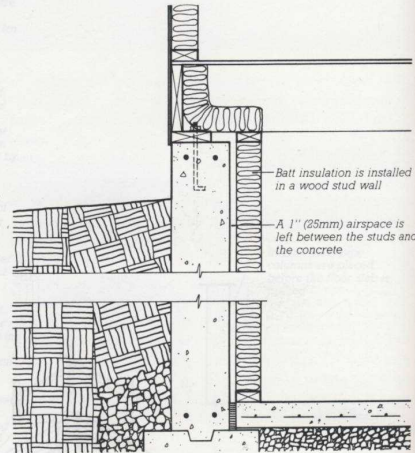
→ FOUNDATIONS: SHALLOW FOUNDATIONS: DETAILS



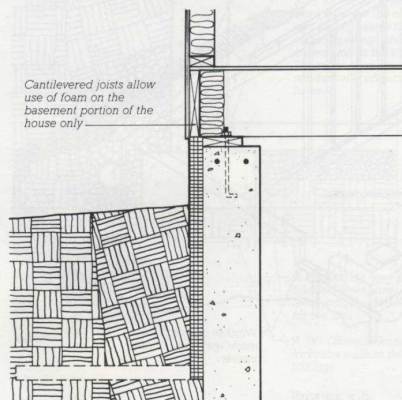
→ STRIP FOUNDATIONS:



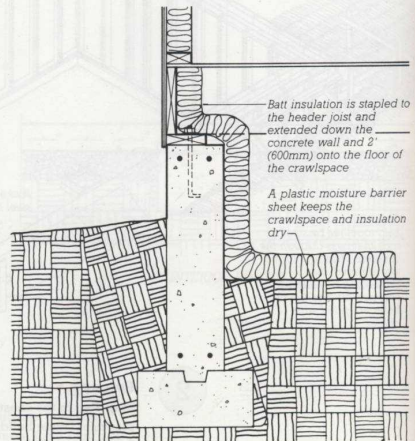
A. BASEMENT WITH EXTERIOR FOAM INSULATION



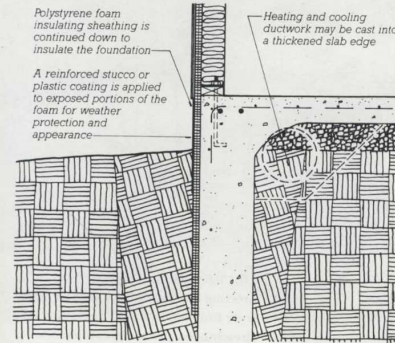
B. BASEMENT WITH INTERIOR BATT INSULATION



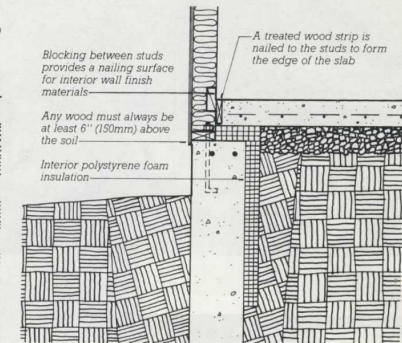
C. BASEMENT WITH EXTERIOR FOAM INSULATION



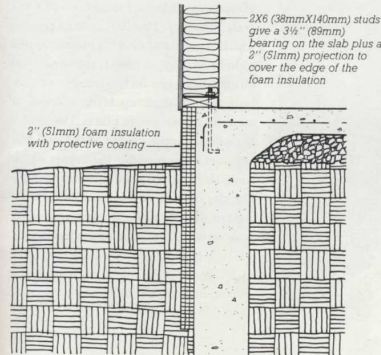
D. CRAWLSPACE WITH INTERIOR BATT INSULATION



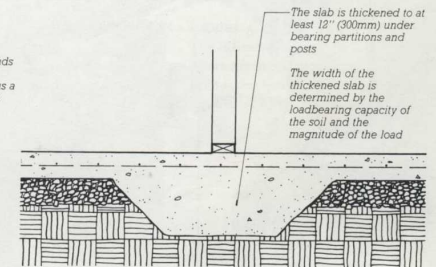
A. SLAB ON GRADE WITH EXTERIOR INSULATION



B. SLAB ON GRADE WITH INTERIOR INSULATION



C. SLAB ON GRADE WITH EXTERIOR INSULATION

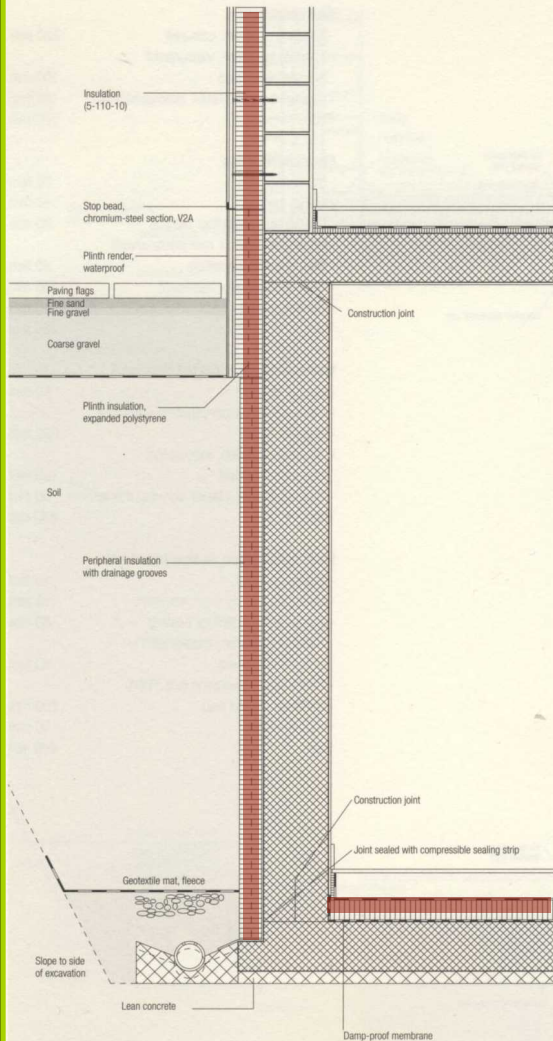


D. INTERIOR FOOTING FOR SLAB ON GRADE

→ STRIP FOUNDATIONS: INSULATION CONCEPTS

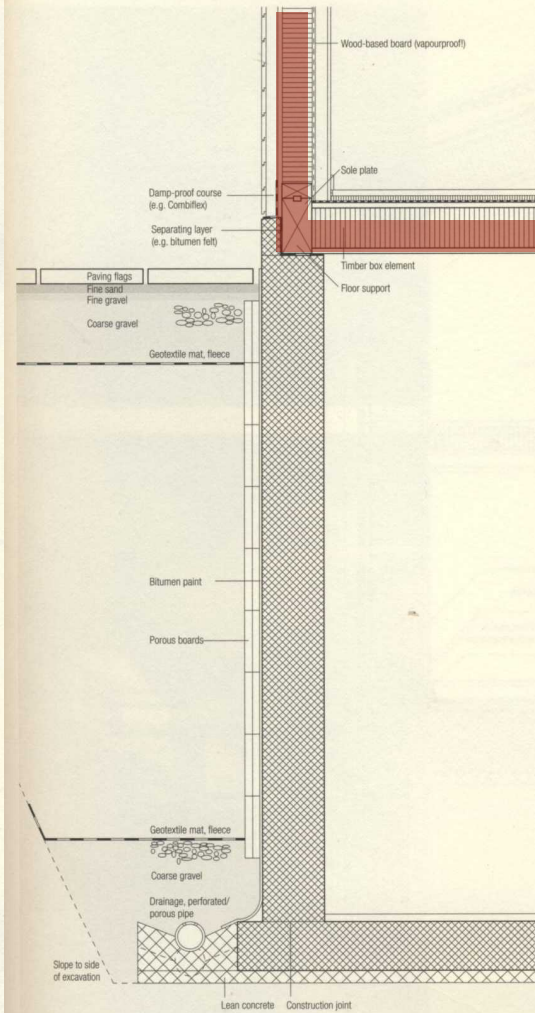
Plinth, external insulation, rendered

1:20



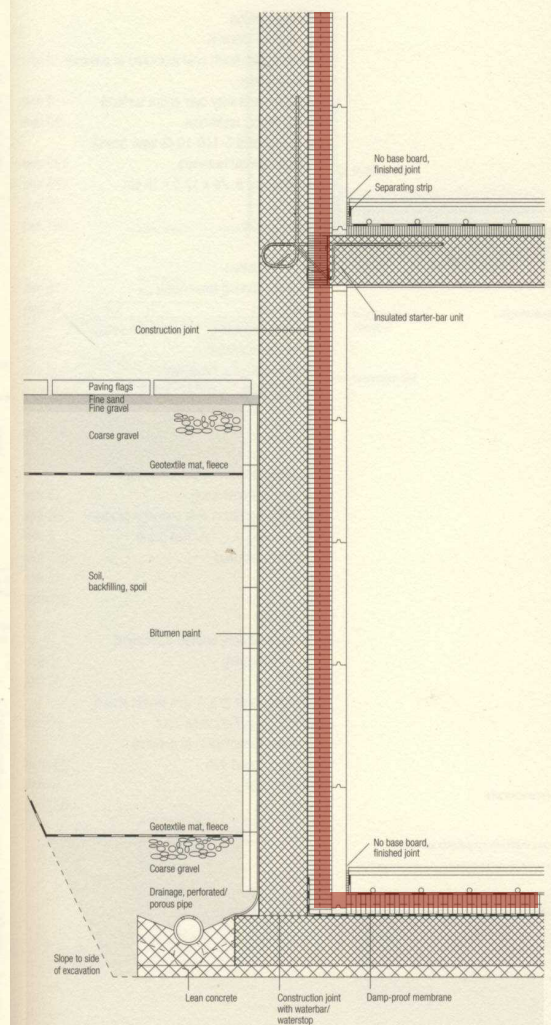
Plinth, timber platform frame construction

1:20



Plinth, fair-face concrete with internal insulation

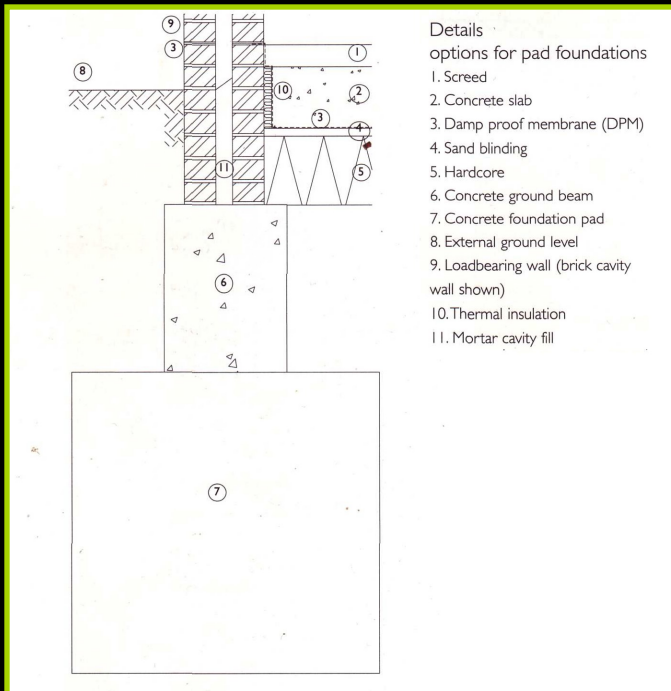
1:20



→ FOUNDATIONS: SHALLOW FOUNDATIONS

• ‘PAD’ FOUNDATION

- STRONG SOIL CONDITION
- COLUMN FOOTING →
USUALLY COLUMN STRUCTURE
- CONNECTED BY GROUND/TIE BEAMS
(REINFORCED CONCRETE STRIPS)
- EFFICIENT MATERIAL ECONOMY !



→ FOUNDATIONS: SHALLOW FOUNDATIONS

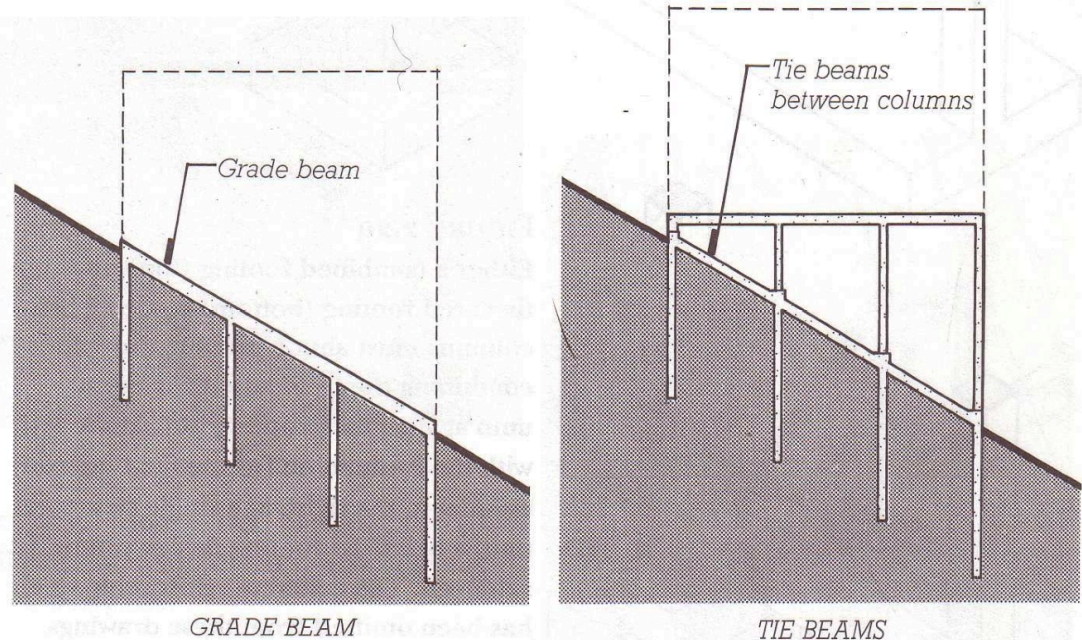
• 'PAD' FOUNDATION: 'TIE BEAMS'



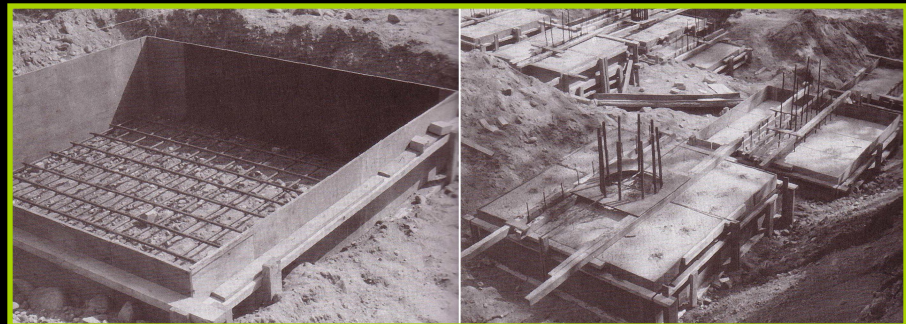
Foundations on sloping sites, viewed in a cross section through the building. The broken line indicates the outline of the superstructure.

Separate column foundations, whether caissons, as shown here, or column footings, are often connected with reinforced concrete tie beams to reduce differential movement between the columns.

A grade beam differs from a tie beam by being reinforced to distribute the continuous load from a bearing wall to separate foundations.

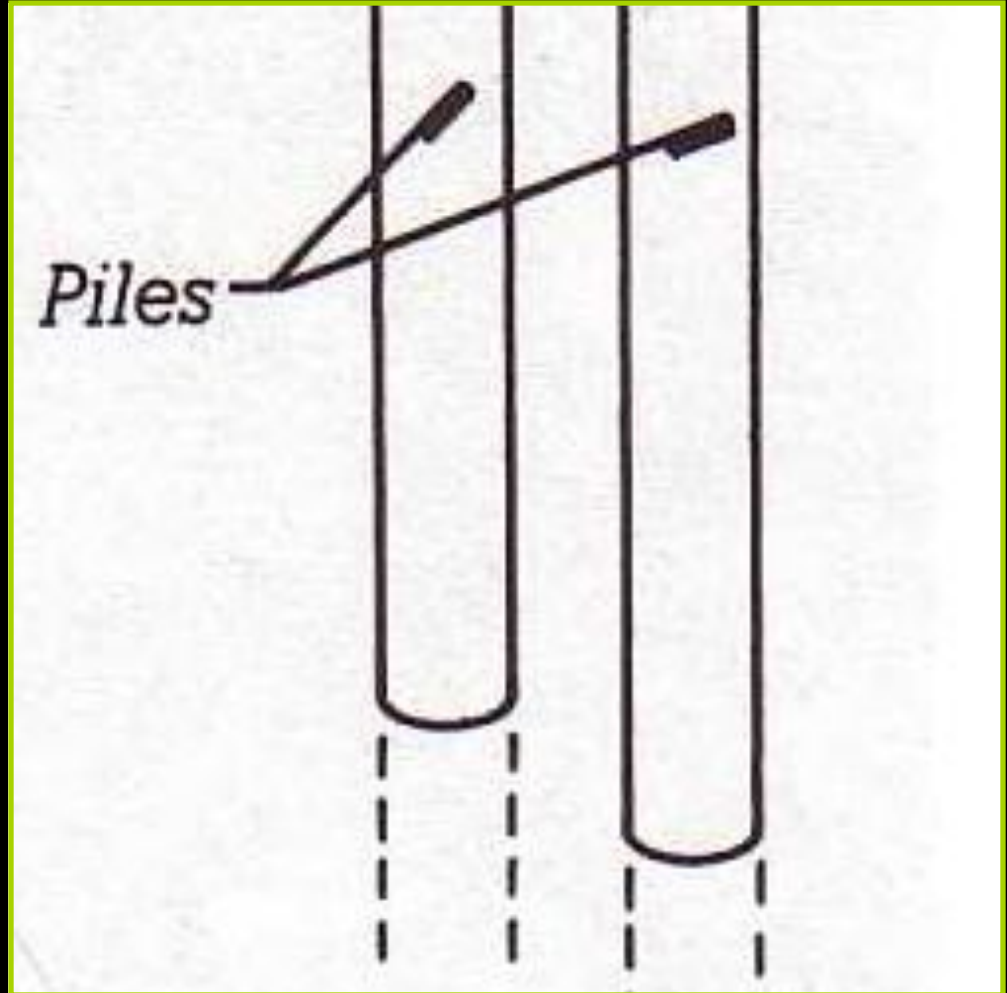
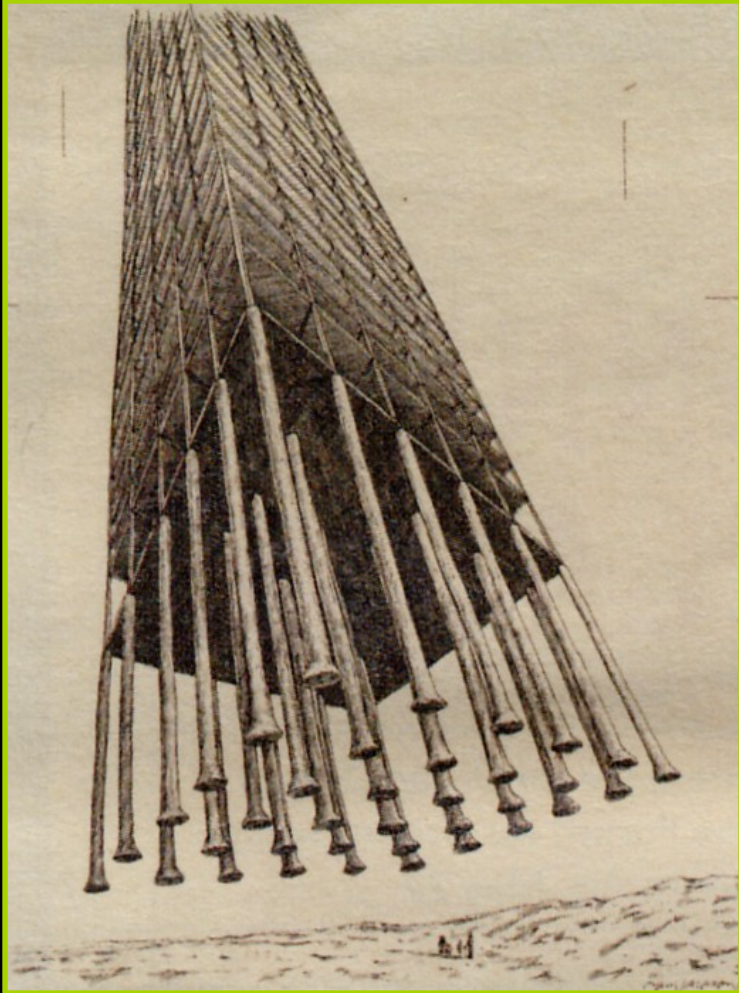


NOTE: TIE BEAMS APPLY TO 'POINT LOAD FOUNDATIONS': 'PAD' AS WELL AS 'PILE' TYPE



→ FOUNDATIONS: DEEP FOUNDATIONS

"DEEP FOUNDATIONS"



→ FOUNDATIONS: DEEP FOUNDATIONS

- 'PILE' FOUNDATION:
 - CAISSON (POURED)
 - PILE (DRIVEN)

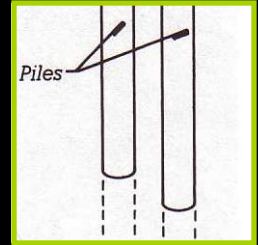
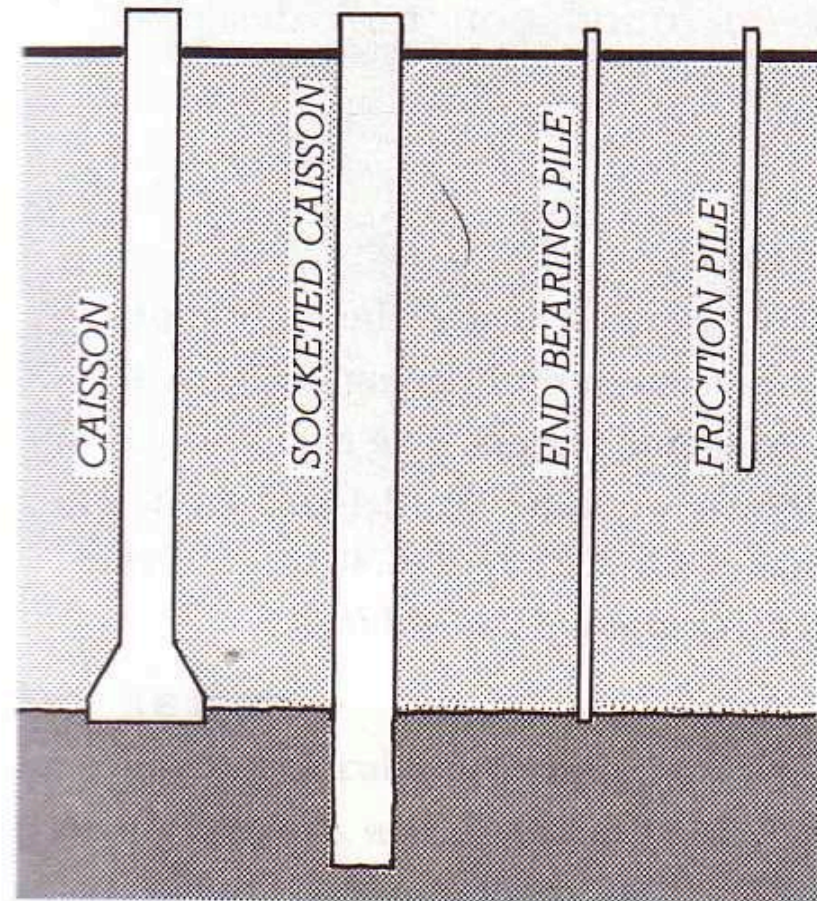


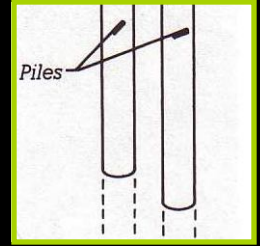
FIGURE 2.32

Deep foundations. The caissons are concrete cylinders poured into drilled holes. They reach through weaker soil (light shading) to bear on competent soil beneath. The end bearing caisson at the left is belled as shown when additional bearing capacity is required. The socketed caisson is drilled into a hard stratum and transfers its load primarily by friction between the soil or rock and the sides of the caisson. Piles are driven into the earth. End bearing piles act in the same way as caissons. The friction pile derives its load-carrying capacity from friction between the soil and the sides of the pile.



→ FOUNDATIONS: DEEP FOUNDATIONS

- 'PILE' FOUNDATION: 'CAISSON'

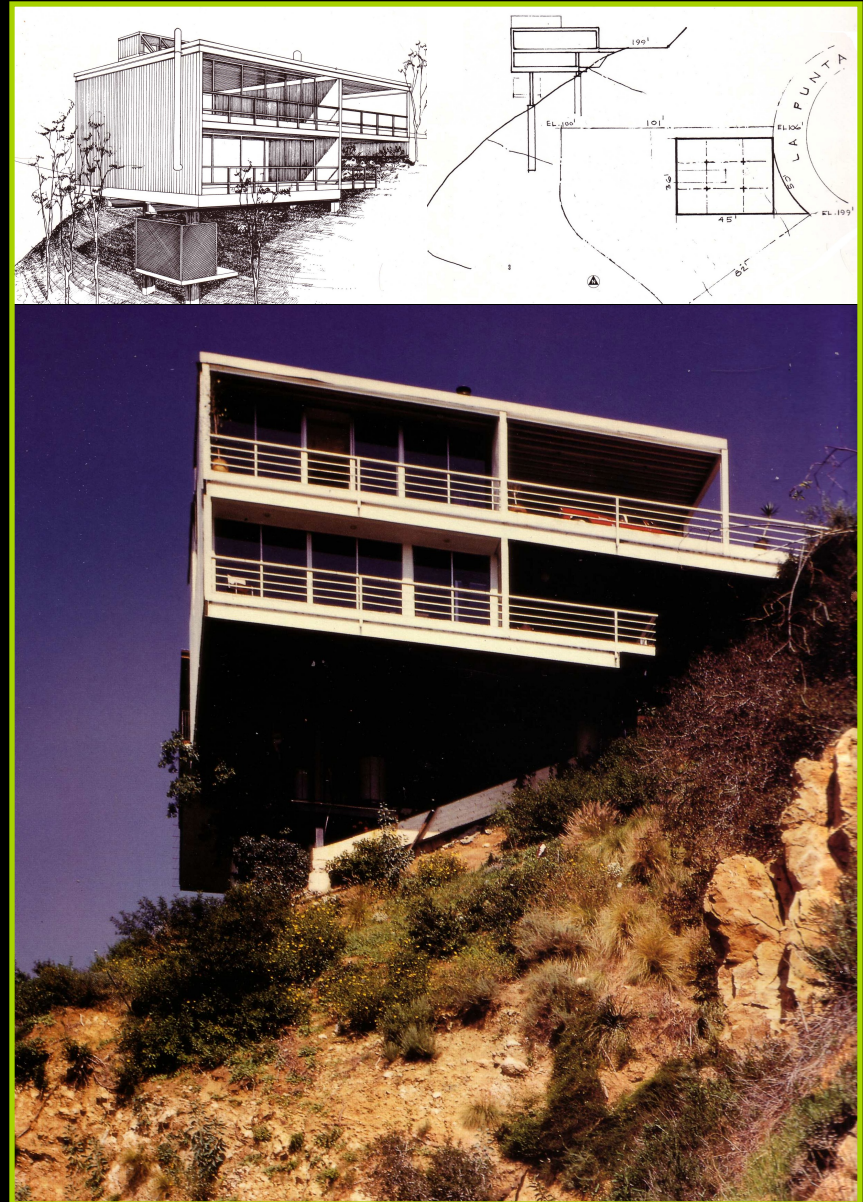


→ FOUNDATIONS: DEEP FOUNDATIONS

● ‘PILE’ FOUNDATION

→ DRIVEN PILES / CAISSONS

- EITHER GROUND CONDITIONS EXTREMELY POOR (WATER, SAND,...), OR:
- COMPLEX TOPOGRAPHY ADJUSTMENT, OR:
- HIGH LOADS OF BUILDING STRUCTURE
→ TALL BUILDINGS
- CONCRETE (USUALLY REINFORCED, ALSO STEEL/ WOOD HISTORICALLY)
- COMBINATION: -INCREASE OF FRICTION
-SOIL/END BEARING
- PILE CAPS: SUPPORTED BY SEVERAL PILES
(→ EVEN TRANSMISSION DOWN TO THE LOAD BEARING STRATA !)



→ FOUNDATIONS: DEEP FOUNDATIONS

• 'PILE' FOUNDATION

- PRESSURE BULBS
w/ PILE CAP

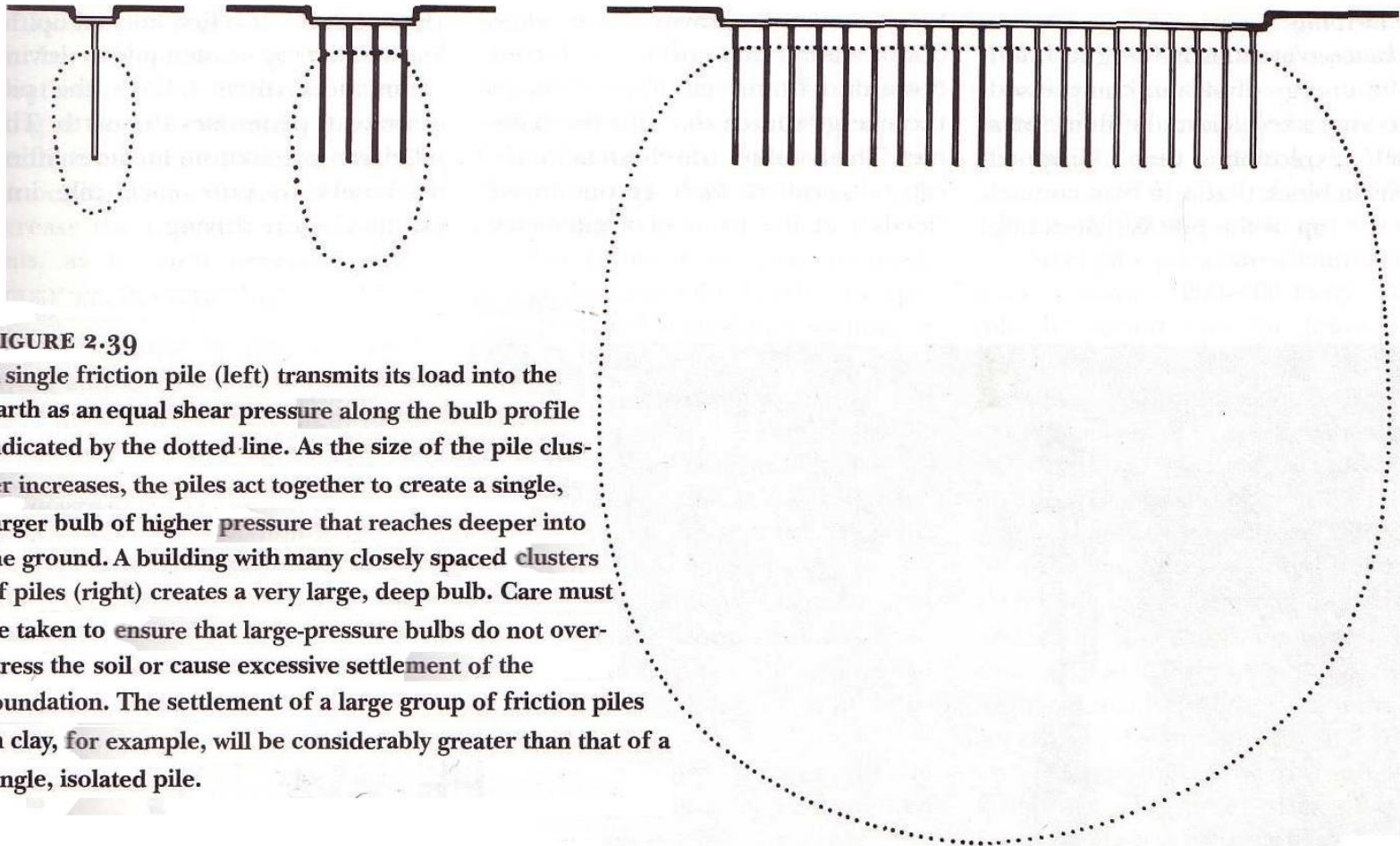
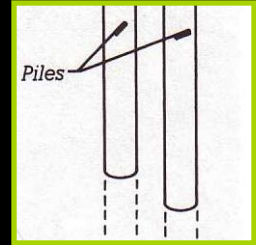
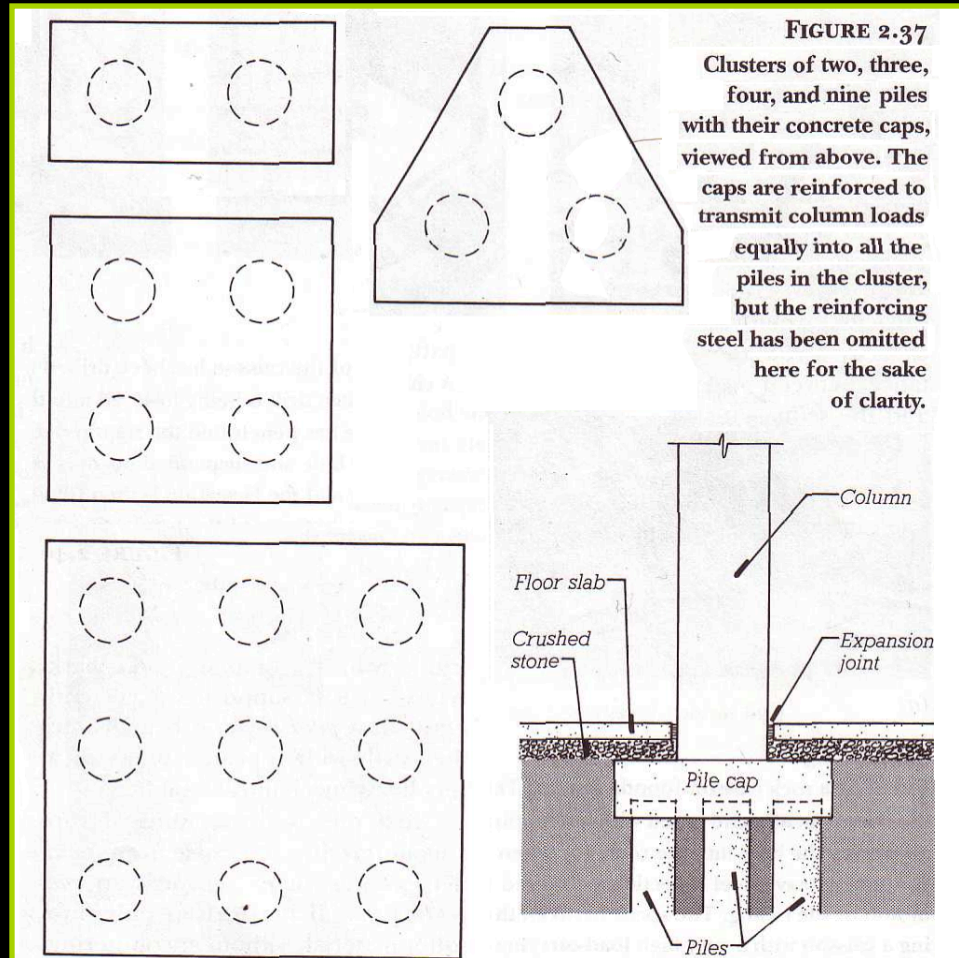
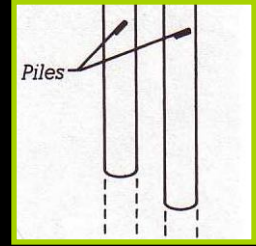


FIGURE 2.39

A single friction pile (left) transmits its load into the earth as an equal shear pressure along the bulb profile indicated by the dotted line. As the size of the pile cluster increases, the piles act together to create a single, larger bulb of higher pressure that reaches deeper into the ground. A building with many closely spaced clusters of piles (right) creates a very large, deep bulb. Care must be taken to ensure that large-pressure bulbs do not overstress the soil or cause excessive settlement of the foundation. The settlement of a large group of friction piles in clay, for example, will be considerably greater than that of a single, isolated pile.

→ FOUNDATIONS: DEEP FOUNDATIONS

• 'PILE' FOUNDATION: 'PILE CAPS'



NOTE: CONNECTED/CONTINUOUS PILE CAPS ACT AS 'GRADE BEAM' PLANE

→ FOUNDATIONS: DEEP FOUNDATIONS

• 'PILE' FOUNDATION: MATERIAL

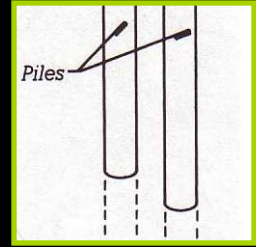


FIGURE 2.43
Precast, prestressed concrete piles. Lifting loops are cast into the sides of the piles as crane attachments for hoisting them into a vertical position.

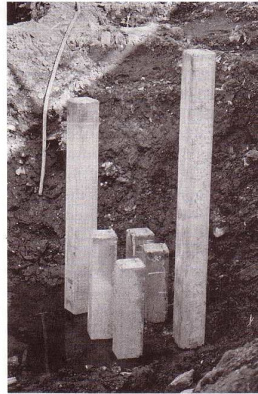


FIGURE 2.44
A driven cluster of six precast concrete piles, ready for cutting off and capping.

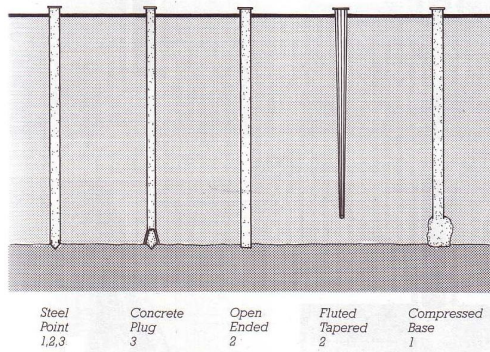
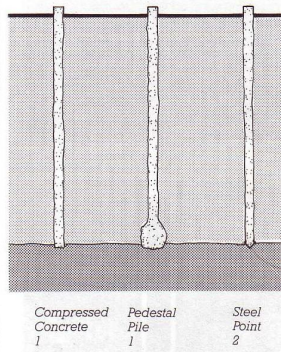


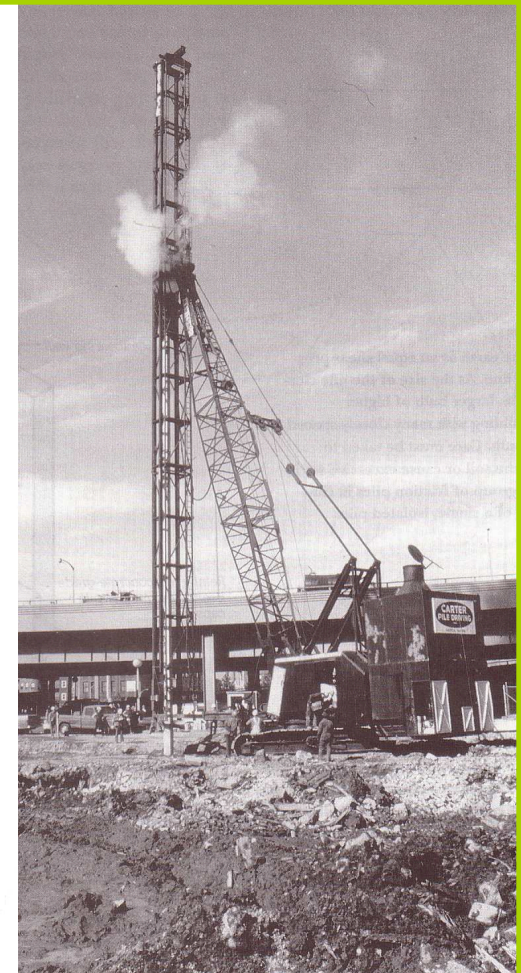
FIGURE 2.45
Some proprietary types of sitecast concrete piles. All are cast into steel casings have been driven into the ground; the uncased piles are made by withdrawing the casing as the concrete is poured and saving it for subsequent reuse. The numbers refer to the methods of driving that may be used with each: 1. Mandrel driven. 2. Driven from the top of the tube. 3. Driven from the bottom of the tube.



UNCASED PILES

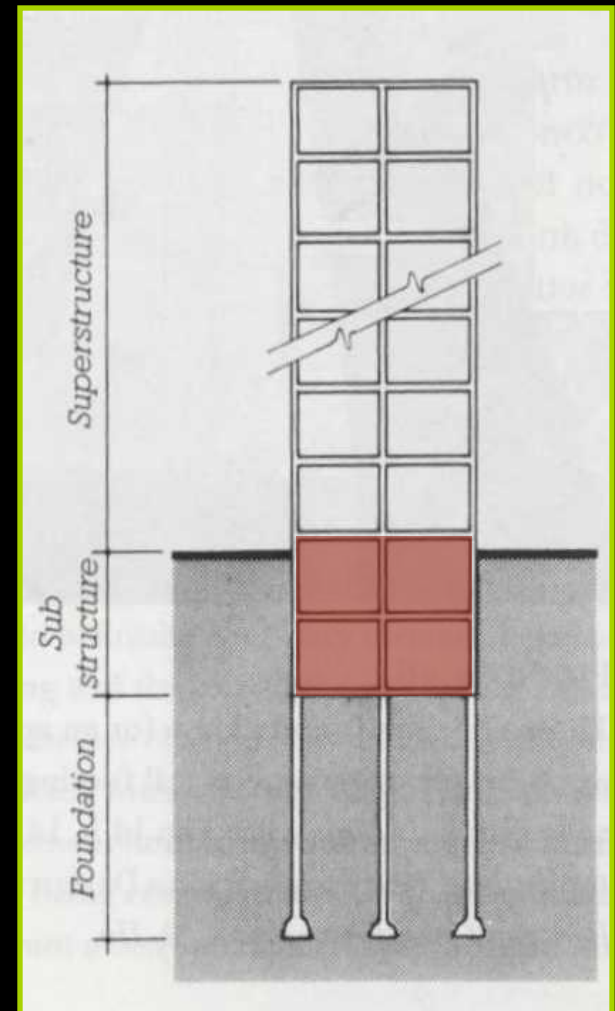
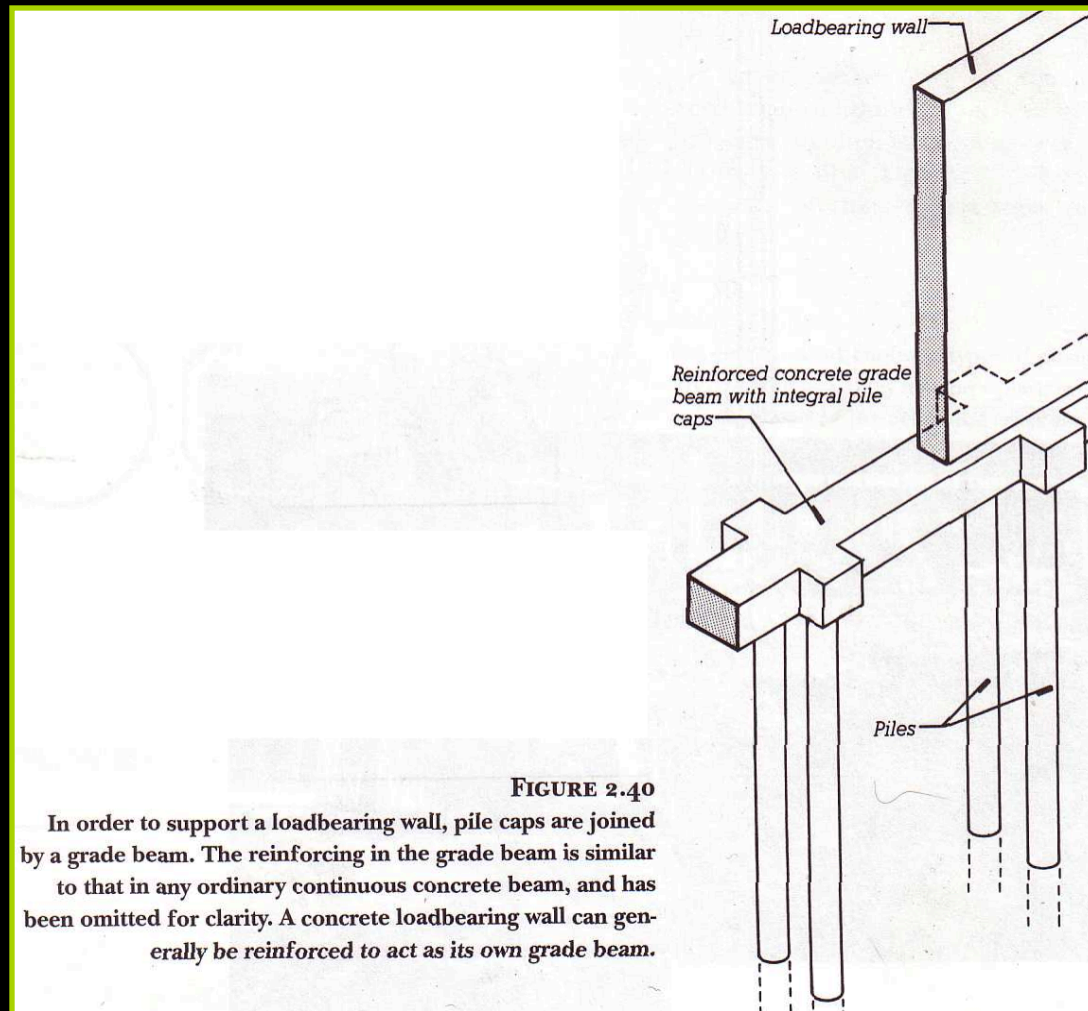


FIGURE 2.42
Cross sections of types of piles. Precast concrete piles may be square or round instead of the octagonal cross section shown, and may be hollow in the larger sizes.



→ FOUNDATIONS: DEEP FOUNDATIONS

- 'PILE' FOUNDATION: "HYBRIDS"



→ FOUNDATIONS ↔ PROPERTY LINES

'UNDERPINNING'

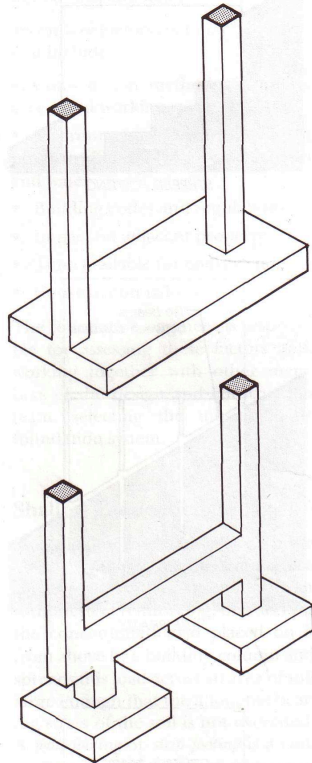
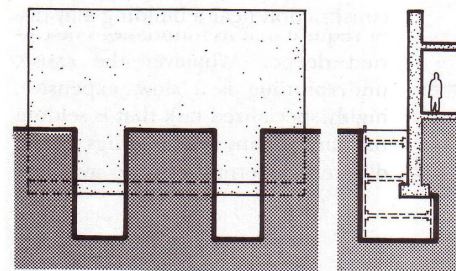
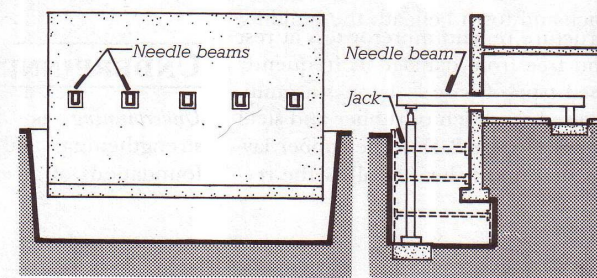


FIGURE 2.29
Either a combined footing (top) or a cantilevered footing (bottom) is used when columns must abut a property line. By combining the foundation for the column against the property line, at the left, with the foundation for the next interior column to the right, in a single structural unit, a balanced footing design can be achieved. The concrete reinforcing steel has been omitted from these drawings for the sake of clarity.

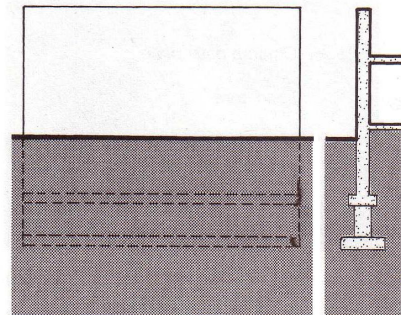


A. ELEVATION SECTION

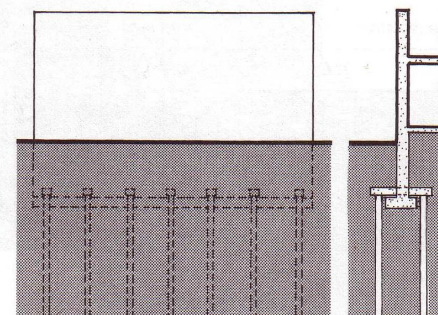


B. ELEVATION SECTION

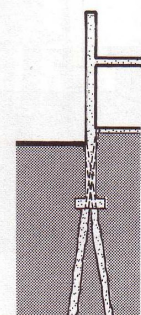
FIGURE 2.48 Two methods of supporting a building while carrying out underpinning work beneath its foundation, each shown in both elevation and section. (a) Trenches are dug beneath the existing foundation at intervals, leaving the majority of the foundation supported by the soil. When portions of the new foundations have been completed in the trenches, using one of the types shown in Figure 2.49, another set of trenches is dug between them and the remainder of the foundations is completed. (b) The foundations of an entire wall can be exposed at once by needling, in which the wall is supported temporarily on *needle beams* threaded through holes cut in the wall. After underpinning has been accomplished, the jacks and needle beams are removed and the trench is backfilled.



A. ELEVATION SECTION



B. ELEVATION SECTION



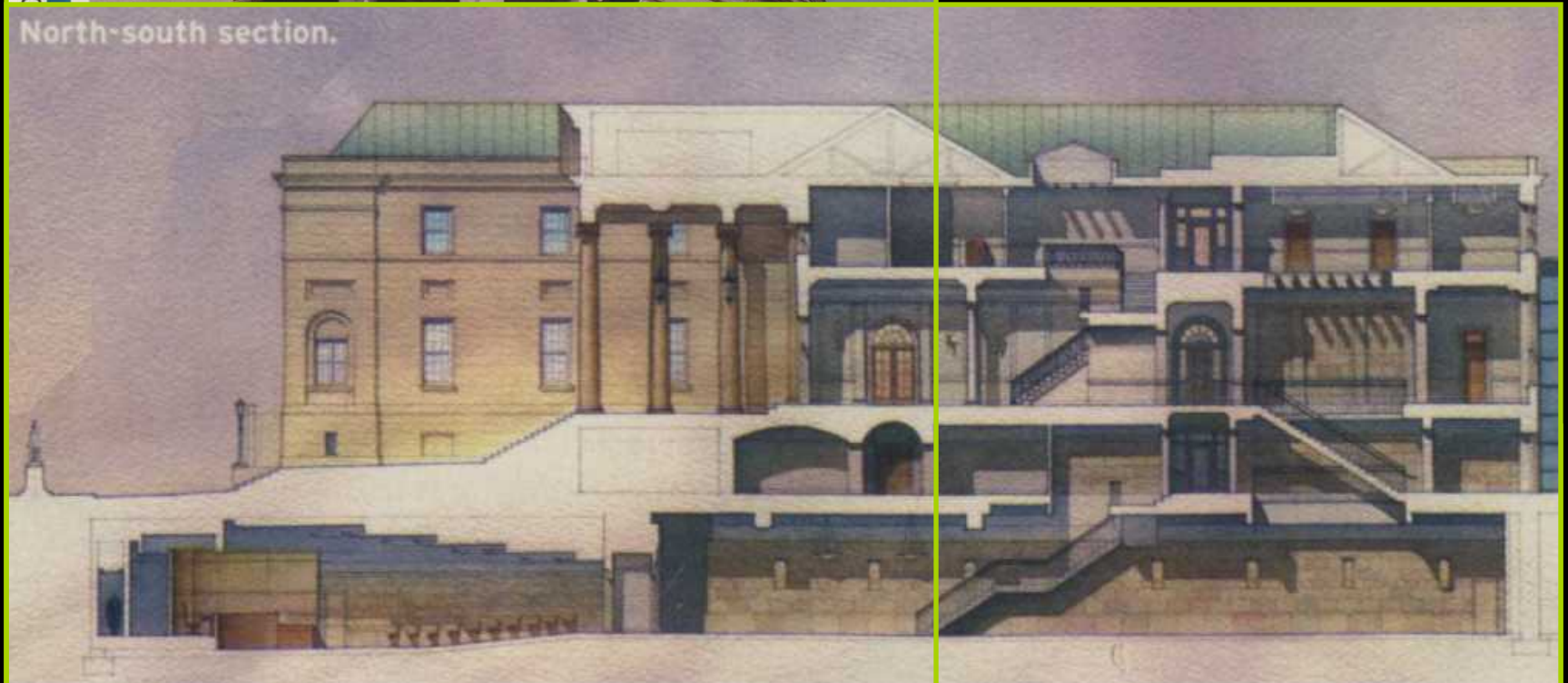
C. SECTION

FIGURE 2.49 Three types of underpinning. (a) A new foundation wall and footing are constructed beneath the existing foundation. (b) New piles or caissons are constructed on either side of the existing foundation. (c) Concrete mini-piles are cast into holes drilled diagonally through the existing foundation. Mini-piles do not generally require excavation or temporary support of the building.

→ UNDERPINNING / 'NEEDLING' ↔ HOUSE MOVE



→ *UNDERPINNING:*



→ *MOISTURE + WATER PRESSURE*



→ FOUNDATIONS: RETAINING WALLS

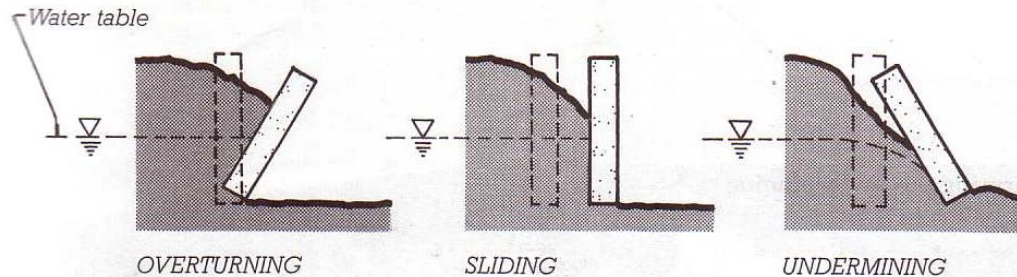
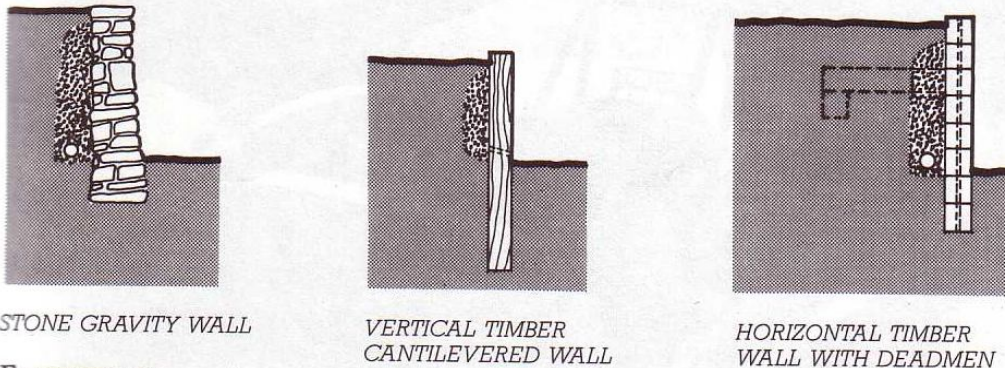


FIGURE 2.50

Three failure mechanisms in retaining walls. The high water table shown in these illustrations creates pressure against the walls that contributes to their failures. The undermining failure is directly attributable to groundwater running beneath the base of the wall, carrying soil with it.



STONE GRAVITY WALL

VERTICAL TIMBER
CANTILEVERED WALL

HORIZONTAL TIMBER
WALL WITH DEADMEN

FIGURE 2.51

Three types of simple retaining walls, usually used for heights not exceeding 3 feet (900 mm). The *deadmen* in the horizontal timber wall are timbers embedded in the soil behind the wall and connected to it with timbers inserted into the wall at right angles. The timbers, which should be pressure treated with a wood preservative, are held together with very large spikes or with steel reinforcing bars driven into drilled holes. The crushed-stone drainage trench behind each wall is important as a means of relieving water pressure against the wall to prevent wall failure. With proper engineering design, any of these types of construction can also be used for taller retaining walls.



→ RETAINING WALL FOUNDATIONS

KEY / HEEL

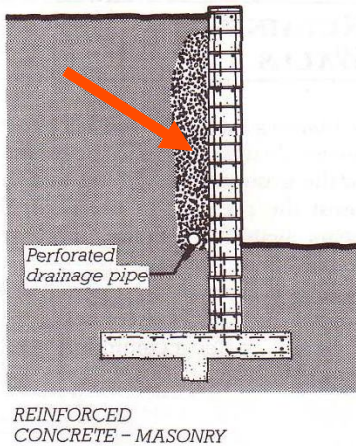
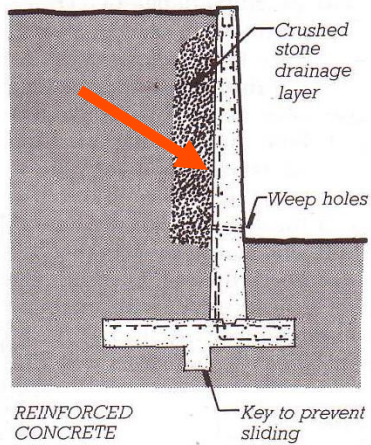
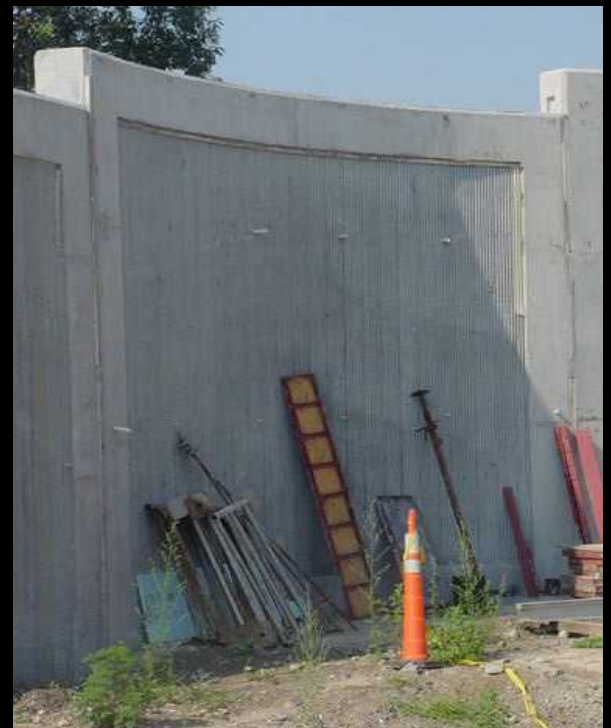
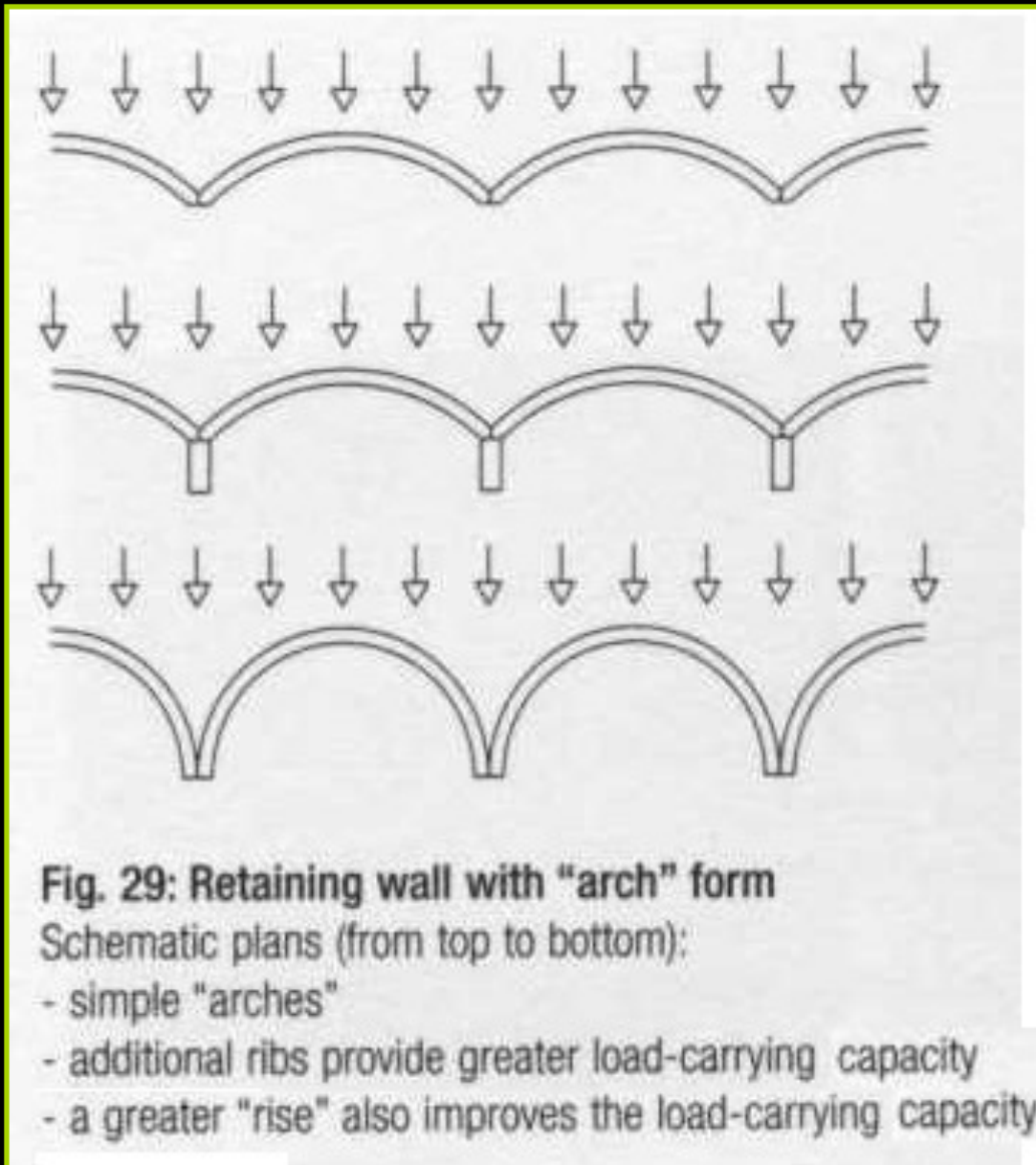


FIGURE 2.52

Cantilevered retaining walls of concrete and concrete masonry. The footing is shaped to resist sliding and overturning, and drainage behind the wall reduces the likelihood of undermining. The pattern of steel reinforcing (broken lines) is designed to resist the tensile forces in the wall.



→ FOUNDATIONS: RETAINING WALLS



→ RETAINING WALL: ALTERNATIVE: EARTH REINFORCING

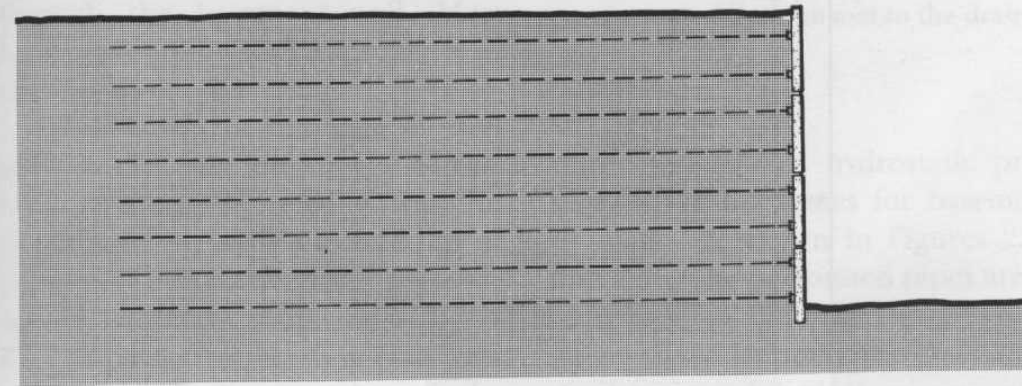
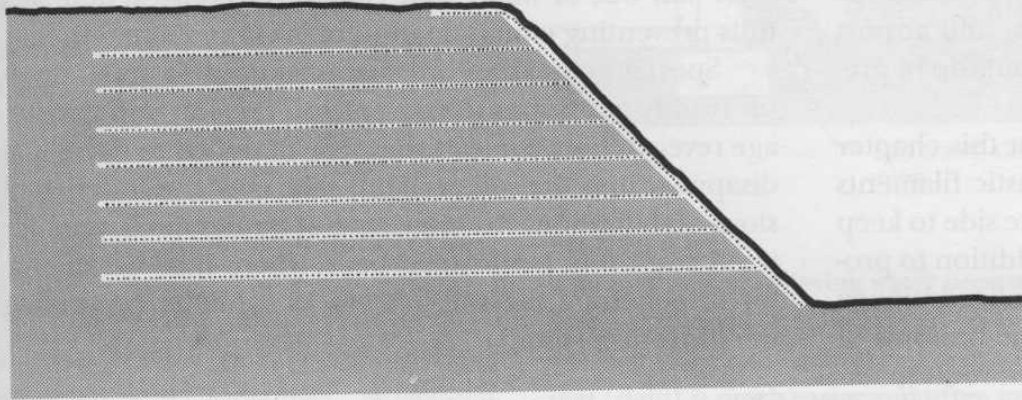
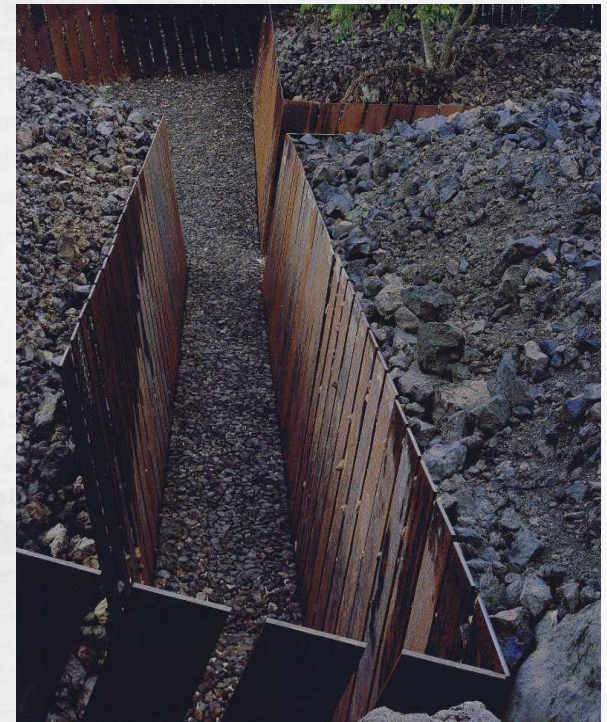


FIGURE 2.54

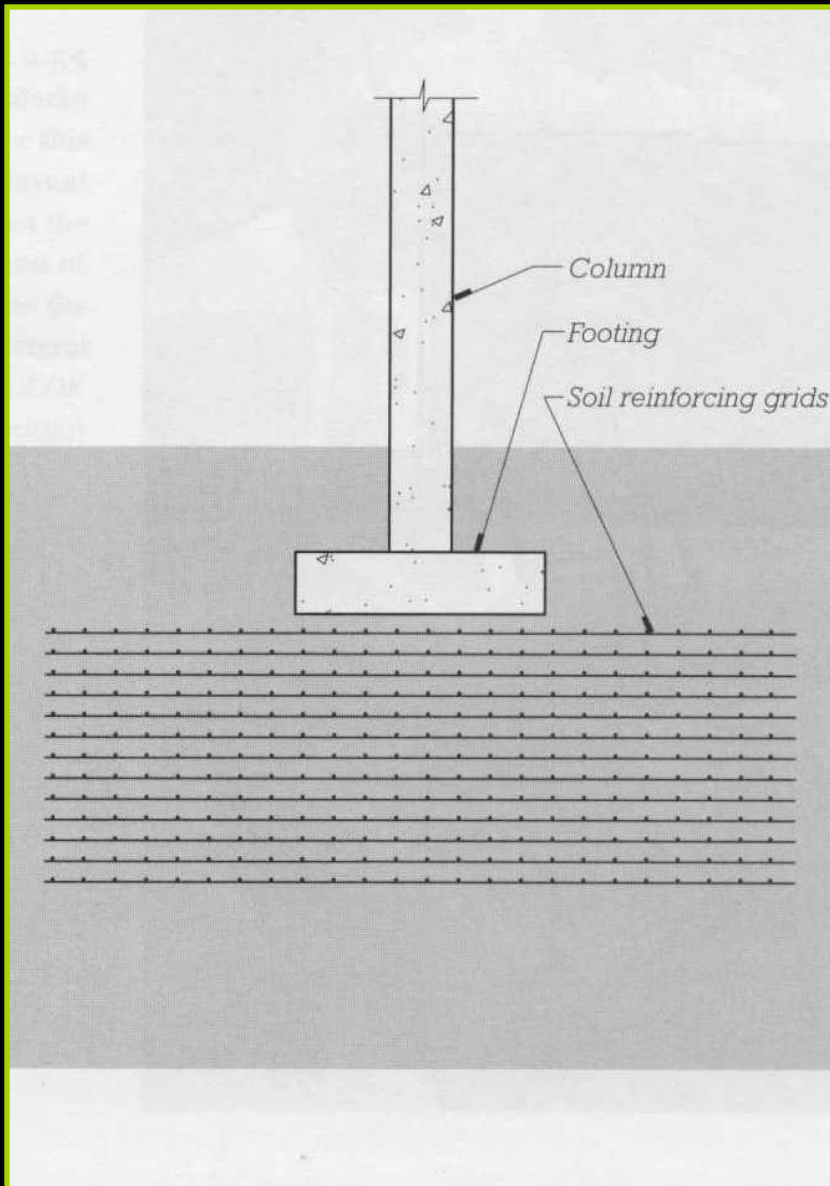
Two examples of earth reinforcing.

The embankment in the top section was placed by alternating thin layers of earth with layers of synthetic mesh fabric.

The retaining wall in the lower section is made of precast concrete panels fastened to long galvanized steel straps that run back into the soil.



→ FOUNDATIONS: GEOTEXTILES



- PREVENTION OF SETTLEMENT
- MATERIAL: CHEMICALLY INERT PLASTIC
- HIGHLY RESISTANT TO DETERIORATION
- REINFORCEMENT STRATEGY
 - SOIL MUST BE COMPACTED
- HINDRANCE MOVEMENT OF SOIL PARTICLES
 - LIKE ROOTS OF PLANTS
- PREVENT SOIL EROSION

→ FOUNDATIONS: DRAINAGE

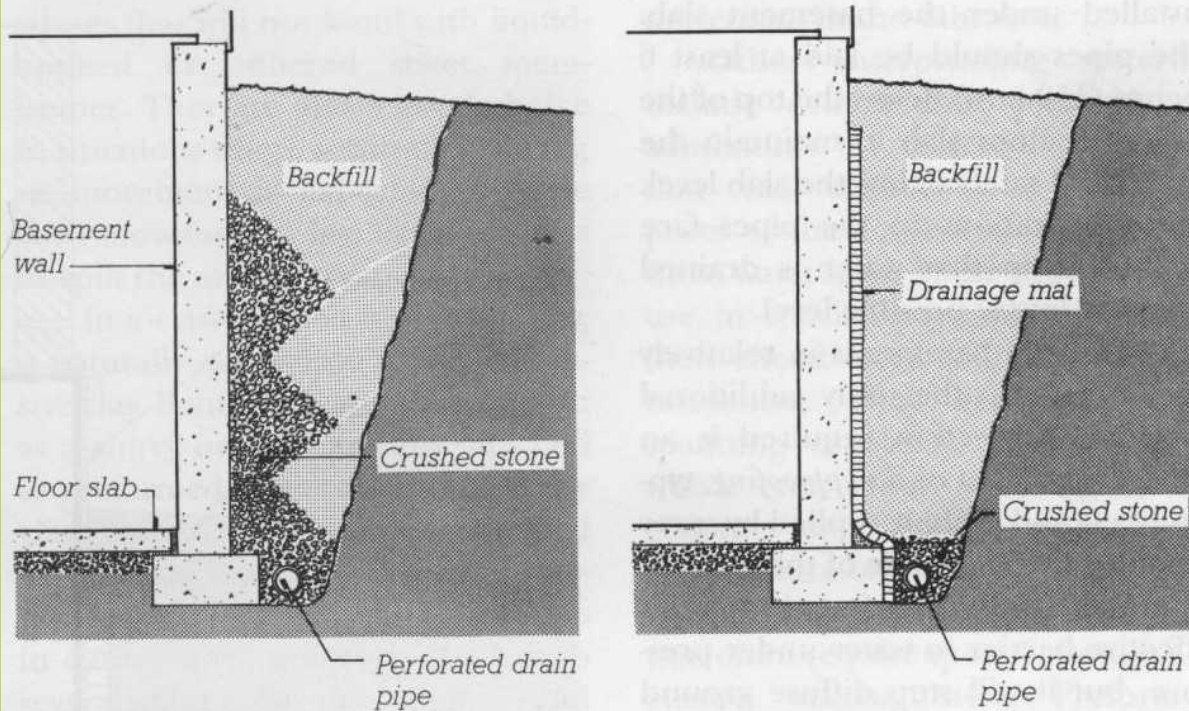


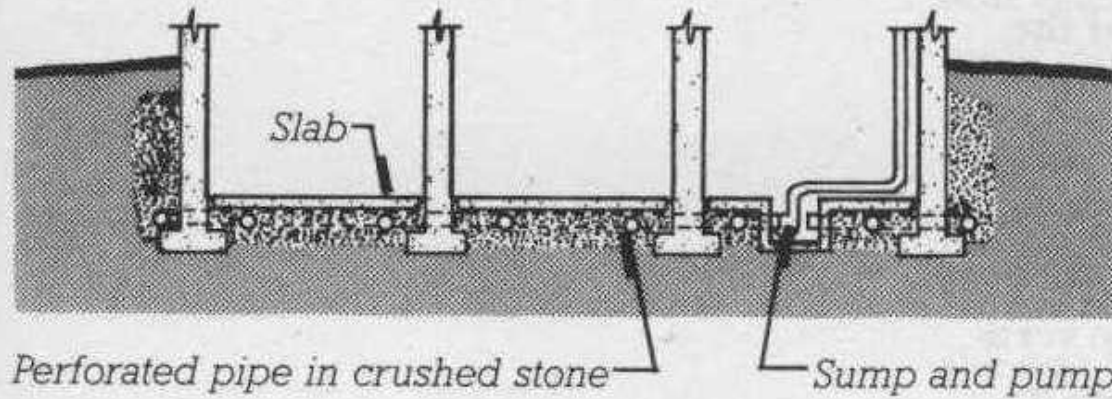
FIGURE 2.55

Two methods of relieving water pressure around a building substructure by drainage. The gravel drain (left) is hard to do well because of the difficulty of depositing the crushed stone and backfill soil in neatly separated, alternating layers. The drainage mat (right) is much easier and often more economical to install. It is a manufactured component that may be made of a loose mat of stiff, inert fibers, a plastic egg-crate structure, or some other very open, porous material. It is faced on the outside with a filter fabric that prevents fine soil particles from entering and clogging the drainage passages in the mat. Any subterranean water that approaches the wall falls through the porous material of the mat to the drain pipe at the footing.

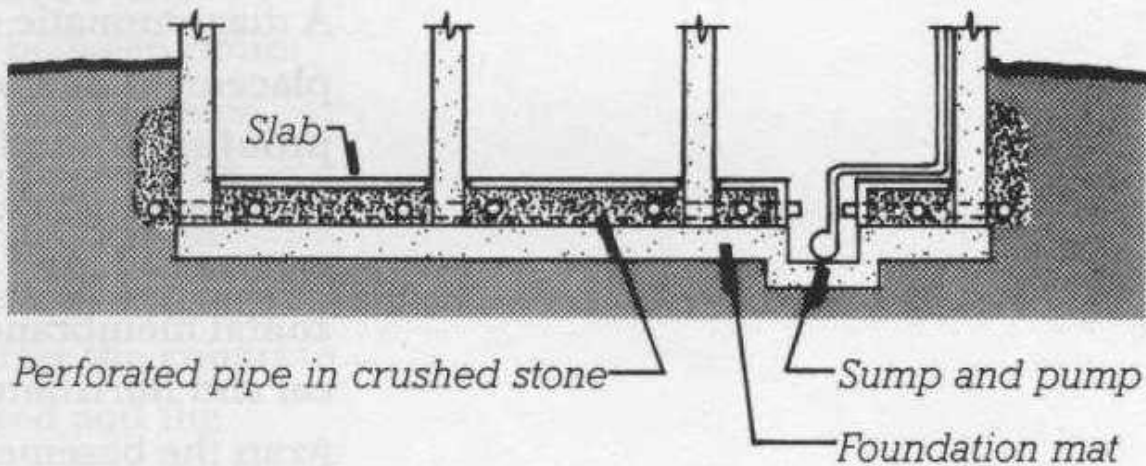


→ FOUNDATIONS: DRAINAGE

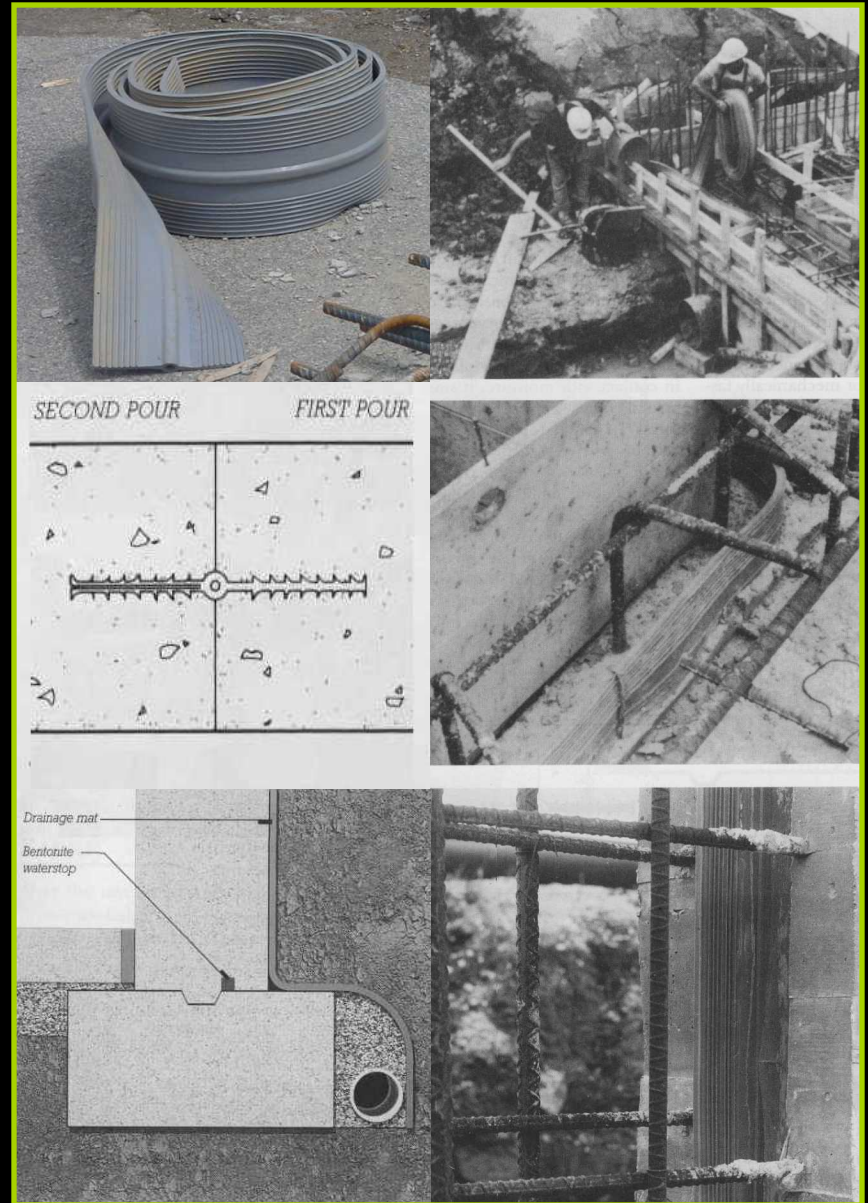
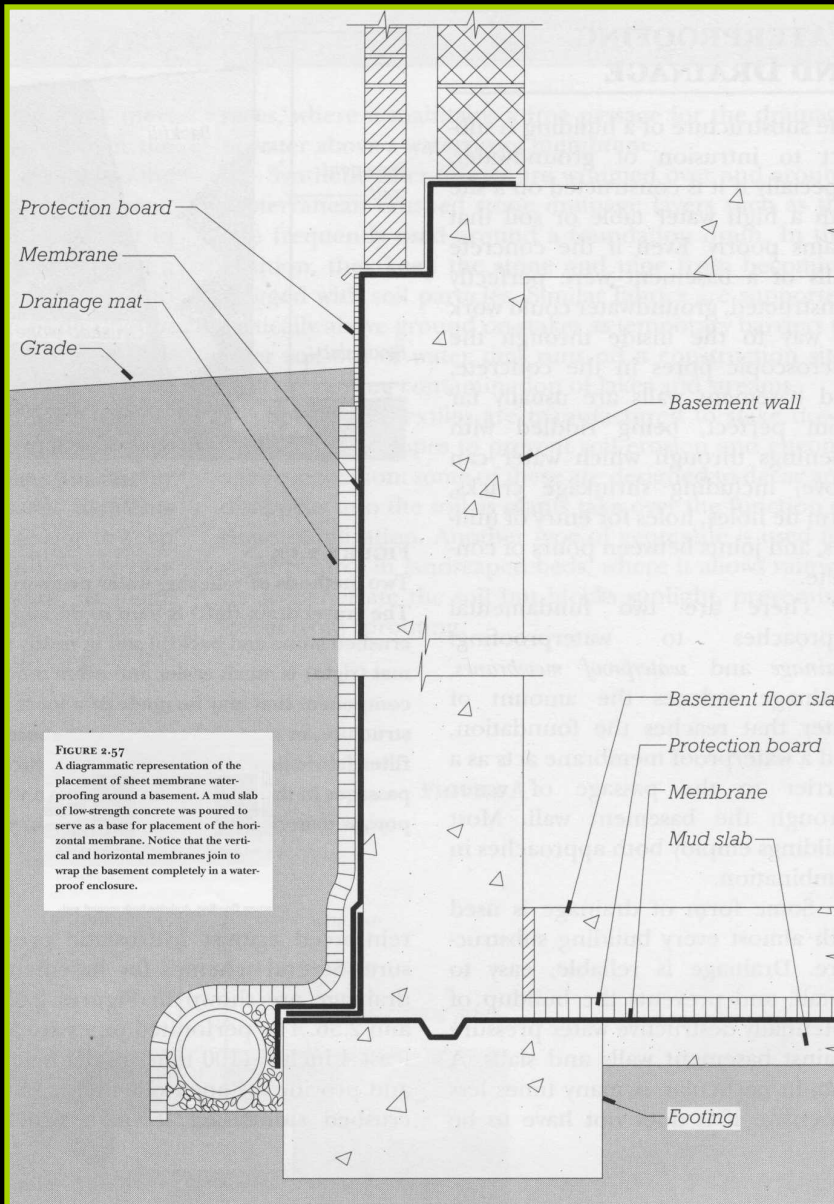
BELOW-SLAB DRAINAGE



ABOVE-SLAB DRAINAGE



→ FOUNDATIONS: DRAINAGE + WATER STOPS



→ FOUNDATIONS: BLIND-SIDE WATERPROOFING

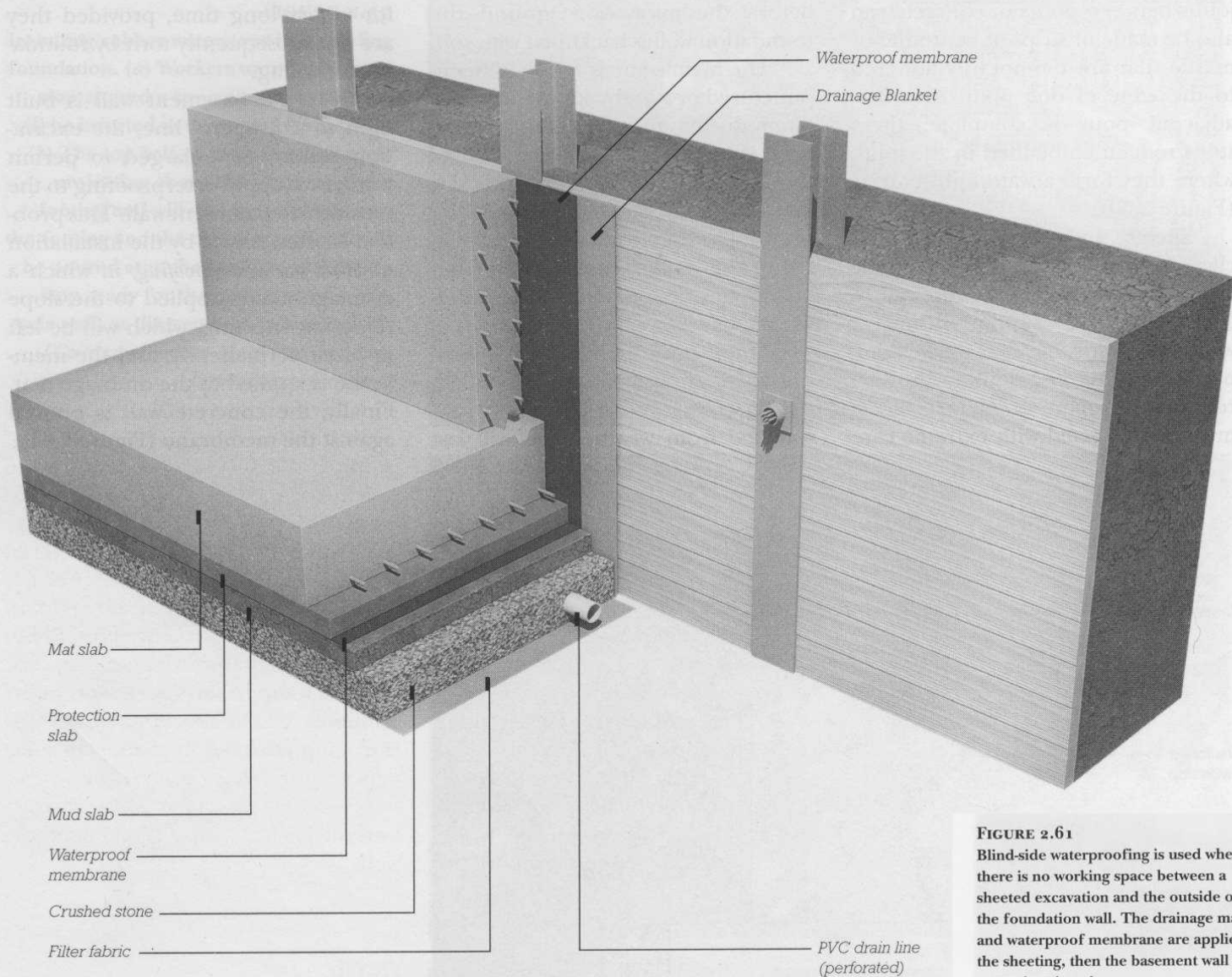
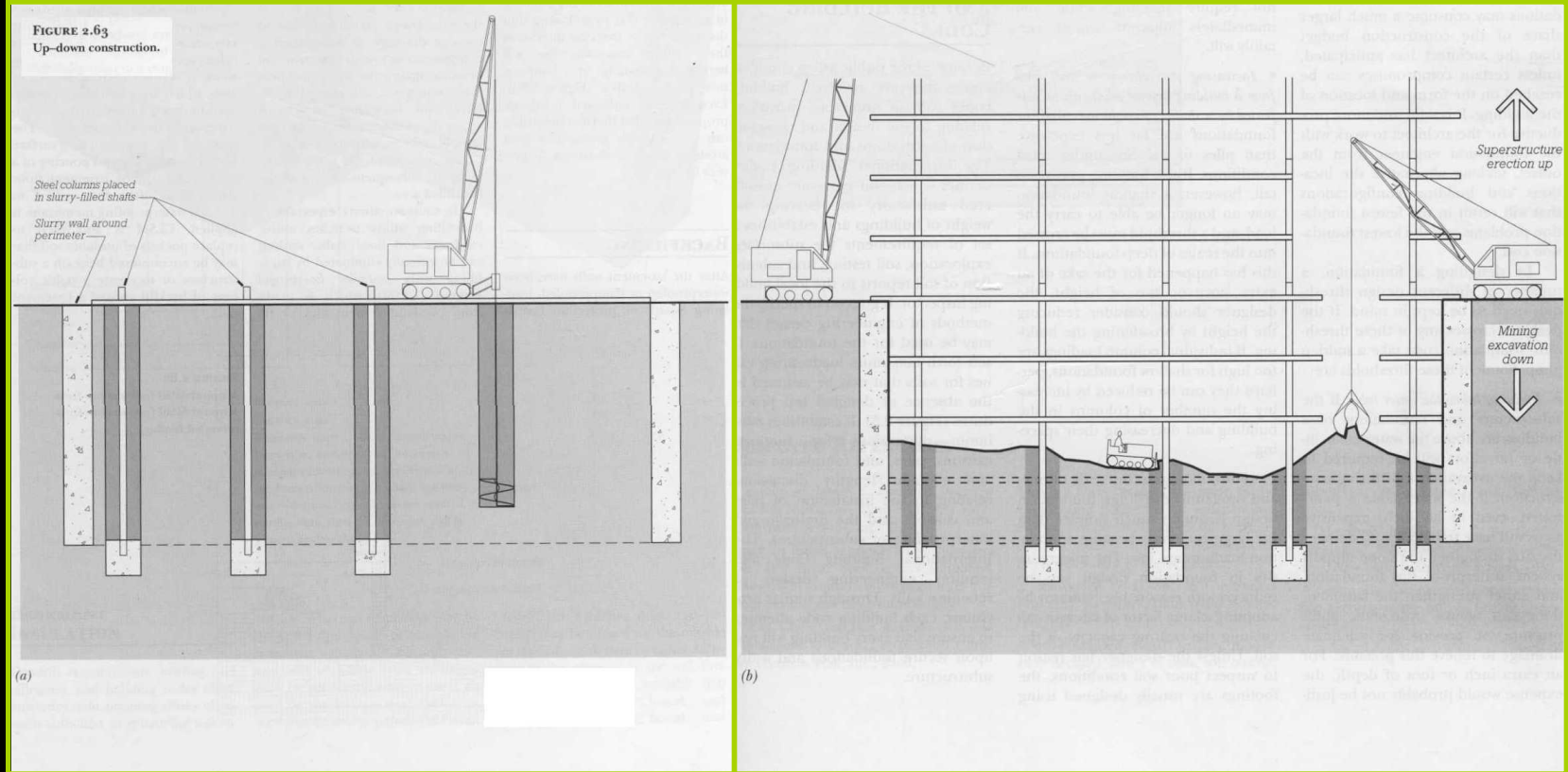


FIGURE 2.61

Blind-side waterproofing is used where there is no working space between a sheeted excavation and the outside of the foundation wall. The drainage mat and waterproof membrane are applied to the sheeting, then the basement wall is poured against them.

→ FOUNDATIONS: UP-DOWN CONSTRUCTION

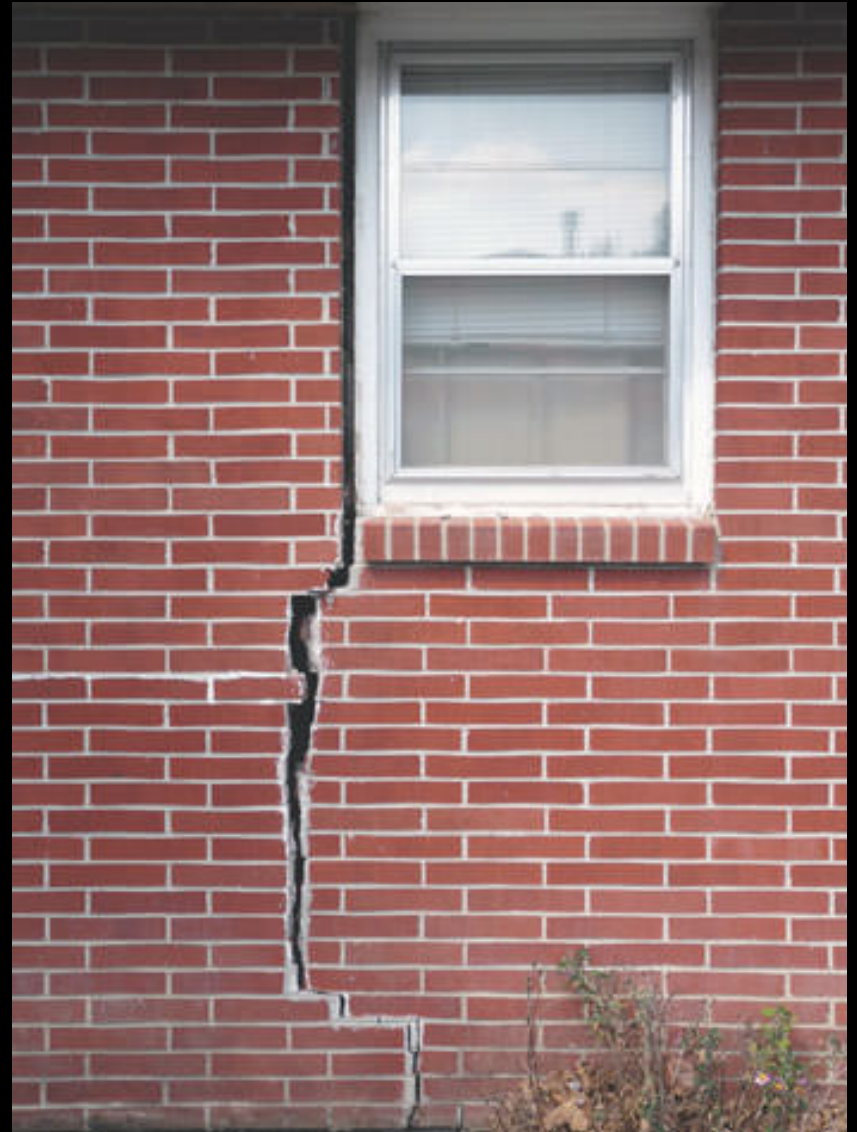
FIGURE 2.63
Up-down construction.



→ *FOUNDATIONS: ECONOMY RULES*
'DESIGN THRESHOLDS'

- BUILDING LOAD COMPATIBILITY ↔ SOIL QUALITY
(FOUNDATION COSTS: SHALLOW OR DEEP)
- BUILDING BELOW/ABOVE WATERTABLE
(DEWATERING PROCESS, RISK OF LEAKS,...)
- BUILDING VICINITY TO EXISTING STRUCTURE
(EXCAVATION METHOD, UNDERPINNING, RISKS OF DAMAGES)
- BUILDING DEPTH ↔ NEIGHBOR BASEMENT DEPTH
(EXCAVATION METHOD, UNDERPINNING, RISKS OF DAMAGES)

→ *FOUNDATIONS: RESPONSIBLE FOR LONG LIFE CYCLE*



→ *FOUNDATIONS: RESPONSIBLE FOR LONG LIFE CYCLE*



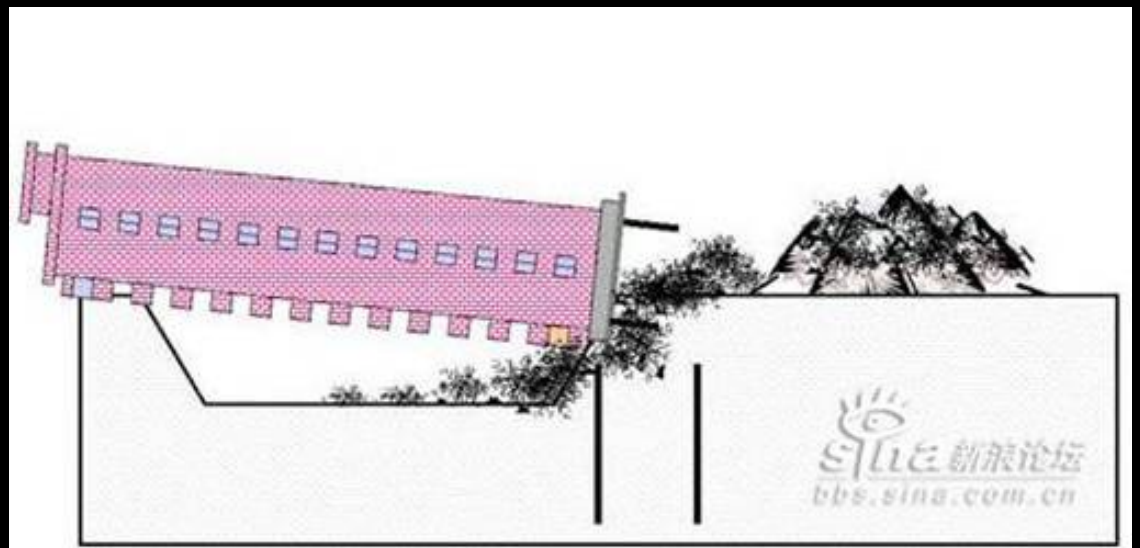
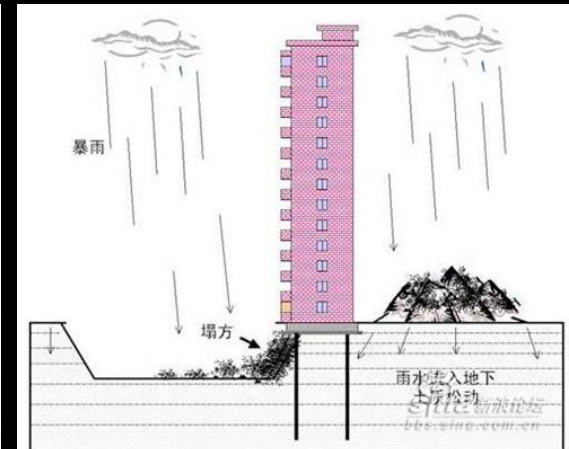
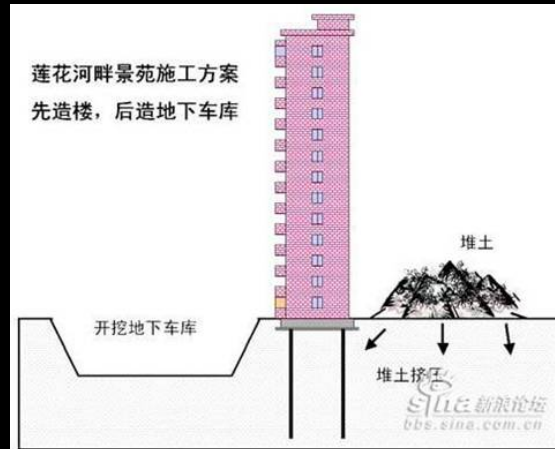
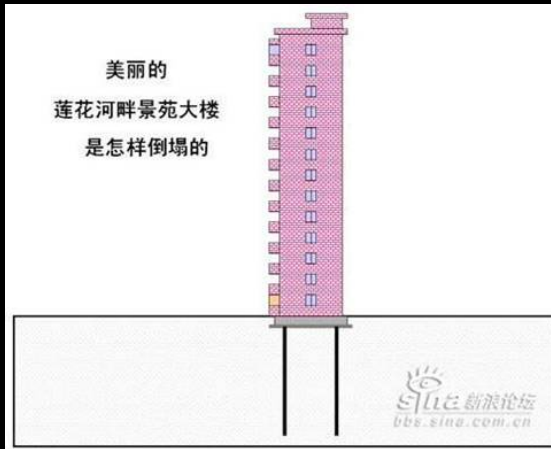
→ *FOUNDATIONS: RESPONSIBLE FOR LONG LIFE CYCLE*



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→ FOUNDATIONS: RESPONSIBLE FOR LONG LIFE CYCLE

