Foundations... & DIRT!

But before we begin to dig...

> Review: Worksheet #2

> **Allen:** *Chapter 2 -- Foundations*

> Assignment: Worksheet #3:

> In-class Media (Time Permitting)

The Socialist, The Architect,
and the Twisted Tower...

or *The Big Dig*

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Some Observations***

For many of us the first exposure to building code analysis is a bit traumatic, like being asked to do brain surgery when given only a pair of chopsticks.

Don’t worry, it feels that way for everybody.

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: *Some Observations*

Don't be too intent right now about *memorizing* the code or its requirements.

In fact, there are only two ways to put these things in one's head: rote memorization and repeated exposure.

(But folks who can simply memorize pages of numerical data like this usually become rocket scientists, not architects.)

Only through repeated experience with the code will you get the hang of it -- slowly, like everyone else.

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Some Observations***

In lieu of remembering ***everything*** right away, try to familiarize yourself with The Process.

In fact, the code is a guide to itself.

If you are aware that -- for every project -- you have to go through the **same** motions *systematically*, you are already more than half-way to “understanding” the code.

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Some Observations***

We'll get to an encore review of last session's exercise in a moment. But I want to review the major concepts of what one should keep in mind with respect to Building Code:

OCCUPANCY GROUPS

CONSTRUCTION TYPES

FIRE RESISTANCE RATINGS

AREA / HEIGHT LIMITATIONS

REQUIRED EGRESS

ACCESS STANDARDS

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: *Some Observations*

If you understand that...

All buildings must be conceived by these categories...

+

Each building's code review needs to touch upon the interrelationships of each of these categories...

... You will understand how to work systematically through the code to identify and satisfy project requirements, defined by each building's unique constraints.

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Review***

… 1. **Existing, Unsprinklered, Heavy Timber Warehouse;**
Two (2) Stories High, 40'x70' Building Footprint;
Type IV Construction, Group A-1 Occupancy

1a Will the conversion be permitted? YES (Table 503)

1b Rating for new exterior wall construction? 2 hr (Table 601)

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Review***

… 2. **Clothing Store, Protected Wood Frame** (Type 5A construction)

Unsprinklered

Allowable Height/Area:		**3 Stories, 14,000 sf/floor** (Table 503)
2a	Max. Total Area (All Floors):	**42,000 sf** over all 3 Stories
2b	Maximum Height of building:	**50 feet** (Max. 3 Stories)
2c	Required Fire Resistance for Floor Construction:	**1 hr** (Table 601)

Sprinklered

Allowable Height/Area:		**4 Stories, 3x14,000 sf/floor** (Per hand-out)
2a	Max. Total Area (All Floors):	**126,000 sf** over 4 Stories (Per hand-out)
2b	Maximum Height of building:	**70 feet** (Max. 4 Stories, per hand-out)
2c	Required Fire Resistance for Floor Construction:	**0 hr w/o adj.** (Table 601, footnote "d") **1 hr w/ adj.** (Table 601, footnote "d")

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: *Review*

… 3. **Office Building, Reinforced Concrete** (Type IA construction)

Occupancy Group: B

Maximum Height? Unlimited height / stories (Table 601)

3a Required Rating for Column? 3 hr (Table 601)

3b Required Rating for Floor Beams? 2 hr (Table 601)

Why? Floor beams are not critical to the stability of the over-all structure. A 2hr rating gives sufficient protection to assure egress from any particular floor area.

3c Required Fire Separation with Large Concert Hall Abutting?

Occupancy Group: B/A

Required Fire Separation based on Fire Separation Distance, <5': 1 hr (Table 602)

But see footnote "c" which leads to discussion of "Party Walls."

Required Fire Separation based on Shared Fire Walls: 3 hr (Table 705.4)

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: *Review*

… 4. **New, Sprinklered, Steel-Framed Hotel;**
Five (5) Stories High, 41,500sf Building Footprint;
Type I or II Construction, Group R-1 Occupancy

4a Least Expensive Construction Type? IIB (Table 503 & Hand-Out)

4b How Tall? 5 Stories, 75 feet (Table 503 & Hand-Out)

4c Building Element Fire Protection? (Table 601)

Columns: 0
Floor: 0
Roof: 0

4d 15' Pedestrian Passage? Yes (Table 602)

Last Week: *Welcome to Hell: Zoning and Building Codes*

Worksheet #2: ***Review***

... 5. **New, Unprinklered, Single-Family House;**
Wood Frame, Exposed and Unprotected Construction;
Type 5B Construction, Group R-3 Occupancy

How tall? 3 Stories, 40’ (Table 503)

Last Week: *Welcome to Hell: Zoning and Building Codes*

So what's the moral of this story?

Work systematically, carefully, and ***Check Your Work!***

This Week: Now let's talk about something really exciting...

Foundations and Dirt!

This Week: ***Foundations*** (Allen, Chapter 2)

FOUNDATION LOADS

As you know from statics, all buildings are subject to forces from different directions and sources. ALL such loads (both static and dynamic) must ultimately be resolved and supported at the building base -- by the **foundations**.

> Dead Load
> Live Load
> Wind Load
> Seismic Loads

In addition, foundations are subject to additional forces due to its contact with the earth: Lateral soil / hydrostatic (water) pressure

This Week: ***Foundations*** (Allen, Chapter 2)

FOUNDATION DESIGN REQUIREMENTS

> *A Foundation must not fail;*

> *A Foundation must remain in place (no or controlled settlement);*

> AND ...

A Foundation must be technically and economically feasible; a foundation must be practical to build and must not affect surrounding areas.

This Week: ***Foundations*** (Allen, Chapter 2)

FOUNDATION SETTLEMENT

All foundations "settle" ... to a degree, since the supporting soil inevitably deforms with the introduction of new loads. In most cases, design engineers seek to keep settlement to a minimum, and -- equally important -- seek to control the extent of settlement throughout the building.

> Uniform Settlement (Acceptable if controlled)
> Differential Settlement (Bad, bad, bad)

This Week: ***Foundations*** (Allen, Chapter 2)

FOUNDATION SETTLEMENT

Differential Settlement is the most typical structural failure associated with building foundations.

This Week: ***Foundations*** (Allen, Chapter 2)

SOILS

The most significant external factor in foundation design is the type of soil upon which the foundation is expected to bear. The "expert" in assessing the character and capacity of soils for architectural projects is the "geotechnical" engineer, who often is responsible for recommending, to the building structural engineer, the type of foundation most suitable for construction upon the soil type found on a site.

This Week: ***Foundations*** (Allen, Chapter 2)

SOILS

Soil types include the following general categories:

> ROCK
> SOIL (Particulate Matter, graded from coarse to fine)

- Boulders
- Cobble
- Gravel
- Sand
- Silt
- Clay
- Peat/Organic Matter

This Week: ***Foundations*** (Allen, Chapter 2)

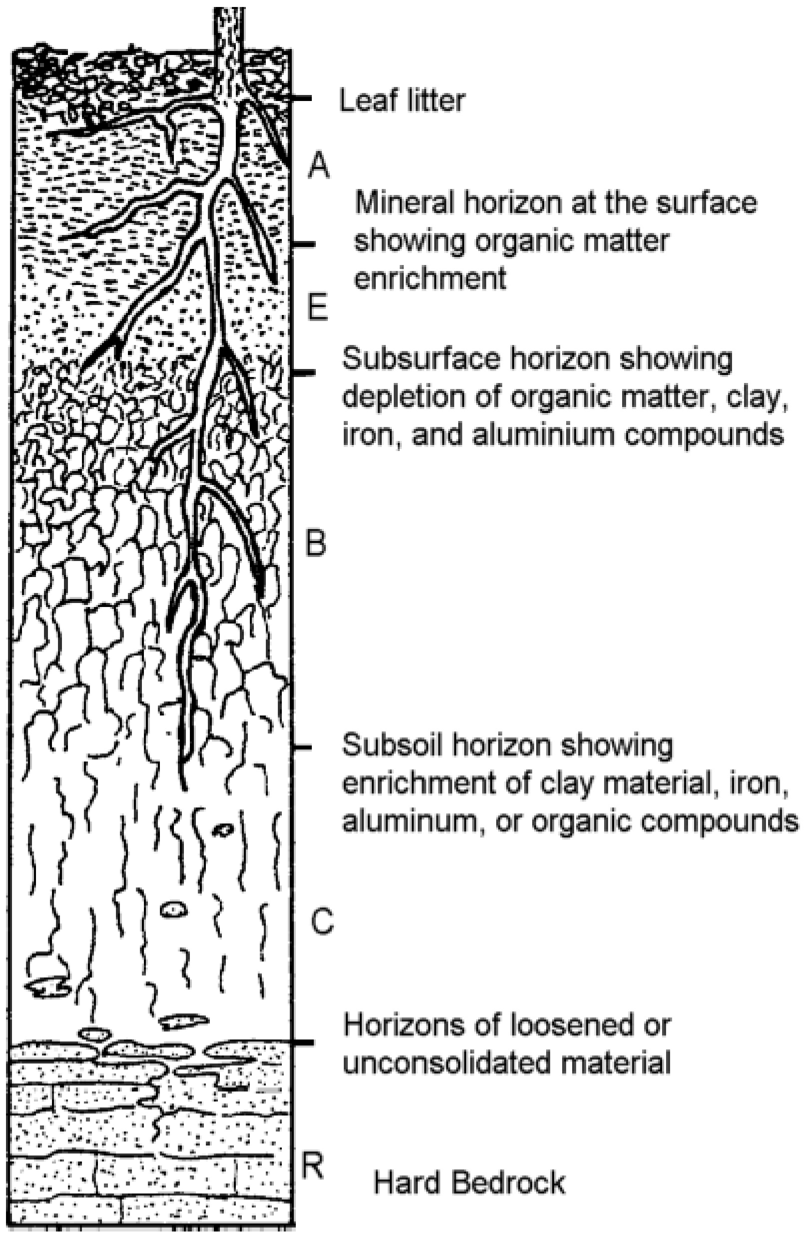
SOILS

Soils can be cohesive or cohesionless (frictional); excavation geometry will differ accordingly.

Most sites have ground conditions which are arranged into Strata, in which different soils occur at various depths, usually statified vertically.

But sometimes ground conditions vary horizontally.

Soil Profile



Soil Strata

Soil Types

			Group Symbols	Typical Names
Coarse-Grained Soils	Gravels	Clean Gravels	GW	Well-graded gravels, gravel–sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel–sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, poorly graded gravel–sand–silt mixtures
			GC	Clayey gravels, poorly graded gravel–sand–clay mixtures
	Sands	Clean Sands	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, poorly graded sand–silt mixtures
			SC	Clayey sands, poorly graded sand–clay mixtures
Fine-Grained Soils	Silts and Clays	(Liquid limit greater than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silt–clays of low plasticity
		(Liquid limit less than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			Pt	Peat and other highly organic soils

This Week: ***Foundations*** (Allen, Chapter 2)

SUBSURFACE EXPLORATION AND TESTING

Before the structural engineer can begin to design foundations, he or she must turn first to the geotechnical engineer for guidance concerning capacity of the bearing soil. To acquire this information, the geotechnical engineer must typically test the ground conditions on site by digging "test pits" or otherwise excavating soil at all depths to be able to characterize accurately the conditions in structurally-critical areas.

Important Concepts:

Root Mat
Heterogeneous Fill
Bedrock
Water Table

This Week: ***Foundations*** (Allen, Chapter 2)

CONSIDERATIONS ABOUT SUSTAINABILITY

> Site Selection

Re-use of existing construction; site remediation; resist use of agricultural sites; avoid construction on wetlands &c.; choose sites which encourage density, with connection to transit.

> Site Design

Respect each site's unique features, including rock formations, mature foliage, grading, and existing structures.

> Construction Process

Control top-soil loss; minimize soil removal or fill;
Minimize soil disturbance; construction waste recycled.


Excavation

This Week: ***Foundations*** (Allen, Chapter 2)

EXCAVATION

Why do we excavate for our Foundations?

> *To place footings at the appropriate depth*
(Frost Line, Soil Conditions, Grading Requirements)

> *To Introduce Programmed Space*
(Basements, Parking, Mechanical Installations)

> *To Prepare the Ground Plane*
(Slabs-on-Grade, Spread Footings...)

This Week: ***Foundations*** (Allen, Chapter 2)

EXCAVATION

Different soil conditions require different technical approaches to excavation: blasting, ripping, drilling, hammering, digging, bull-dozing...



This Week: ***Foundations*** (Allen, Chapter 2)

EXCAVATION SUPPORT

Often, soil conditions determine that temporary measures should be taken at the perimeter of the area to be excavated to assure reliable edge conditions during the time of construction. In certain cases, excavation support may be left in place for use as structure.

Slope Support *(Benched excavation)*

Sheeted Excavation

> Sheeting may be constructed of Wood, Metal, or Concrete
> Sheeting typically needs to be braced or otherwise laterally-supported:

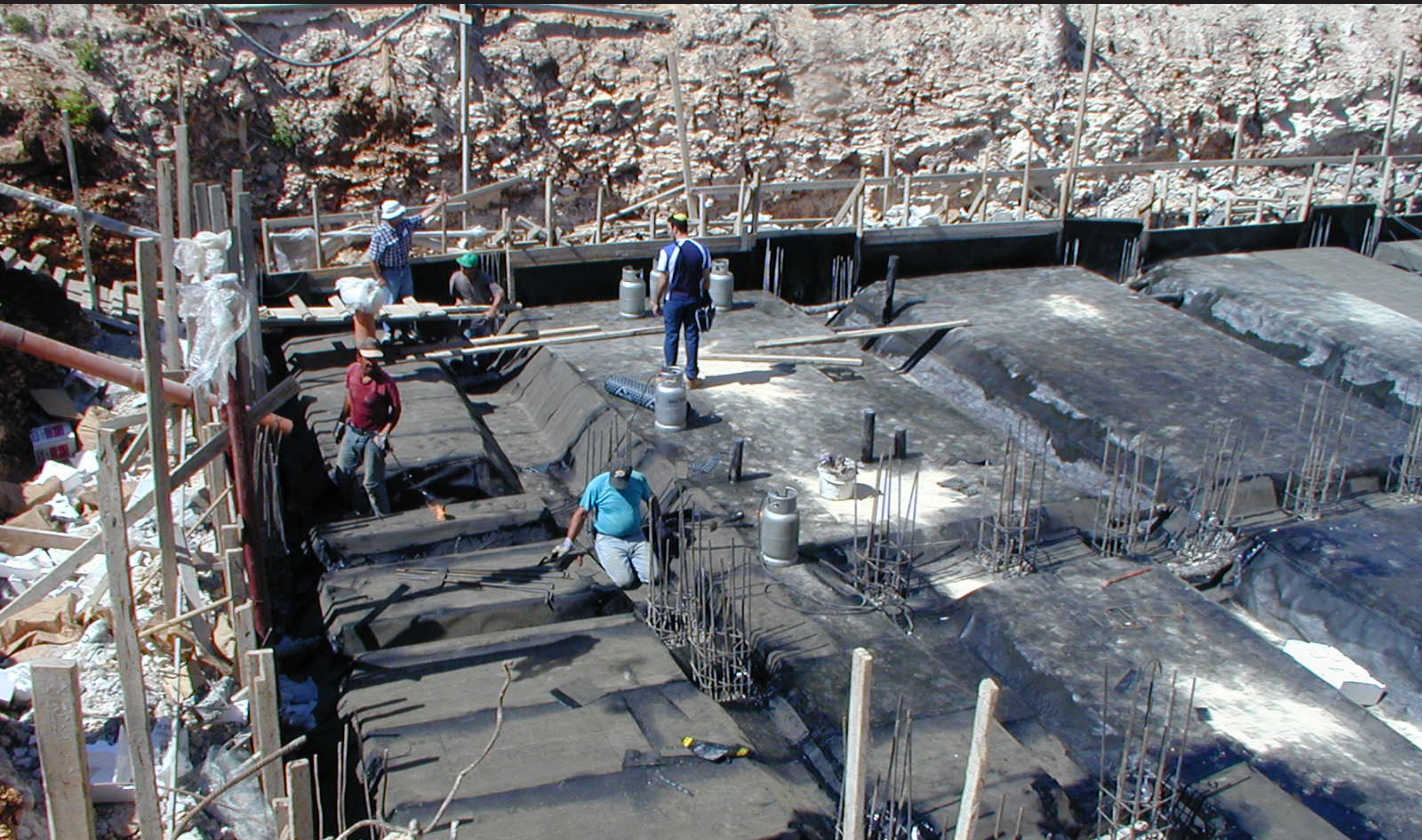
Cross-lot Bracing, Rakers (diagonal bracing), Soil Anchor Tie-back

Soil Mixing

EXCAVATION SUPPORT -- Sheeted Excavation

Once you've dug out a big hole in the ground, you've effectively created a big, reverse bathtub!

Architectural Technology V



Much of what we do as architects is to try keep the water out, but you'll find that it comes as much from below as from above.

This Week: ***Foundations*** (Allen, Chapter 2)

DEWATERING

Sumps

Well points (to affect water table)

Barrier (A real bathtub)

Barriers can extend down to water-impermeable soil, much like a caisson, or they can extend both down and under the foundation structure, like a real bathtub.

This Week: ***Foundations*** (Allen, Chapter 2)

FOUNDATIONS

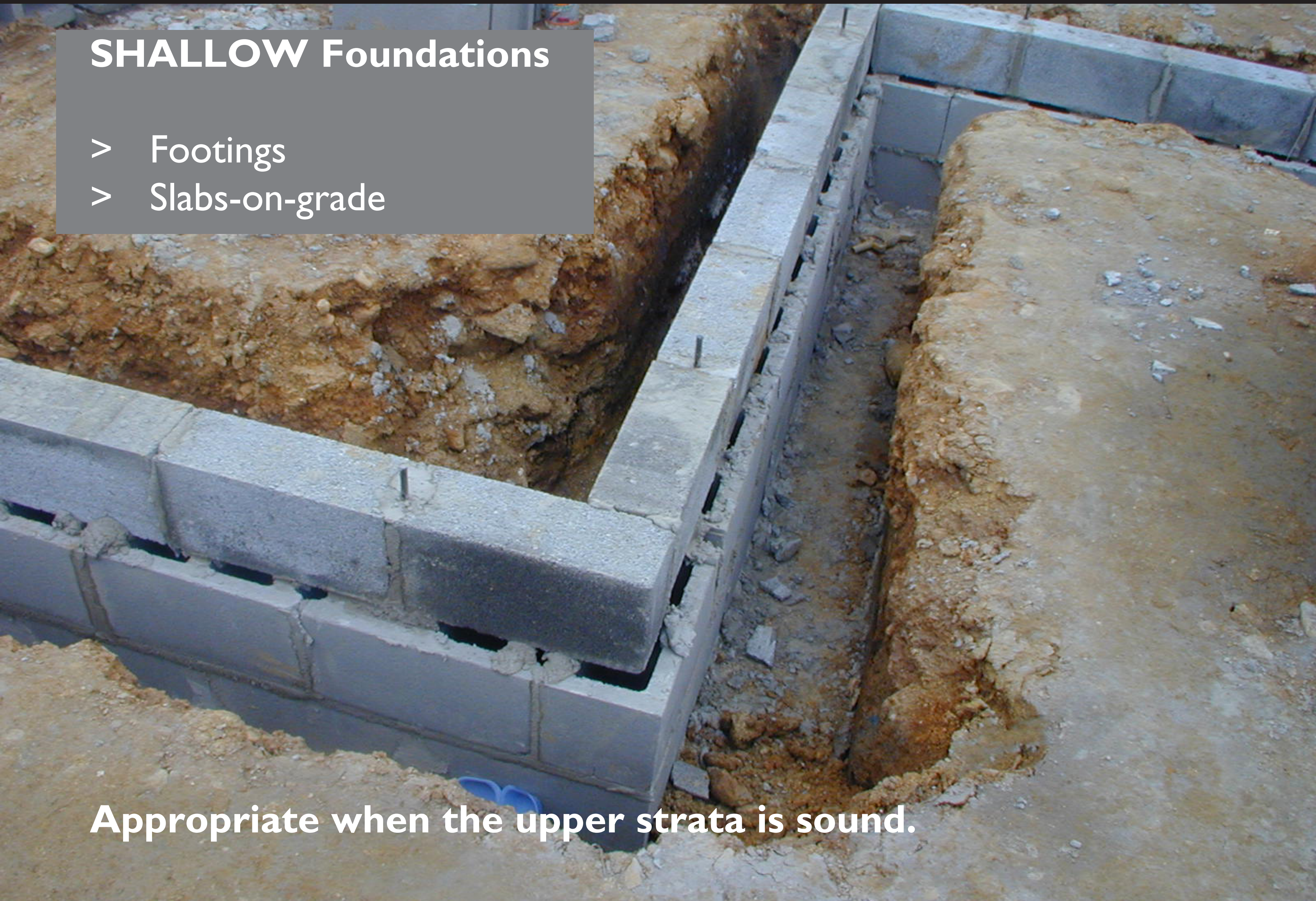
Structurally, a building has three components:

Superstructure

Substructure

Foundation

A foundation is the physical element which transfers a building's loads to the soil.



SHALLOW Foundations

> Footings
> Slabs-on-grade

Appropriate when the upper strata is sound.

This Week: ***Foundations*** (Allen, Chapter 2)

DEEP FOUNDATIONS

> Piles
> Caissons

Appropriate when the upper strata is undependable

This Week: ***Foundations*** (Allen, Chapter 2)

SHALLOW FOUNDATIONS

... include "Spread Footings": Column Footings, Wall Footings: and also include Floating Foundations.

DEEP FOUNDATIONS

... include Caissons, socketed caissons, end-bearing piles, and friction piles.

Who can tell me a bit about each one?

This Week: ***Foundations*** (Allen, Chapter 2)

Piles and Pile Caps

Related Terms: *Grade Beams*
Pile Driving

Pile Materials: *Concrete (CIP or Precast)*
Steel
Wood

Reinforcing for a typical pile cap...

This Week: ***Foundations*** (Allen, Chapter 2)

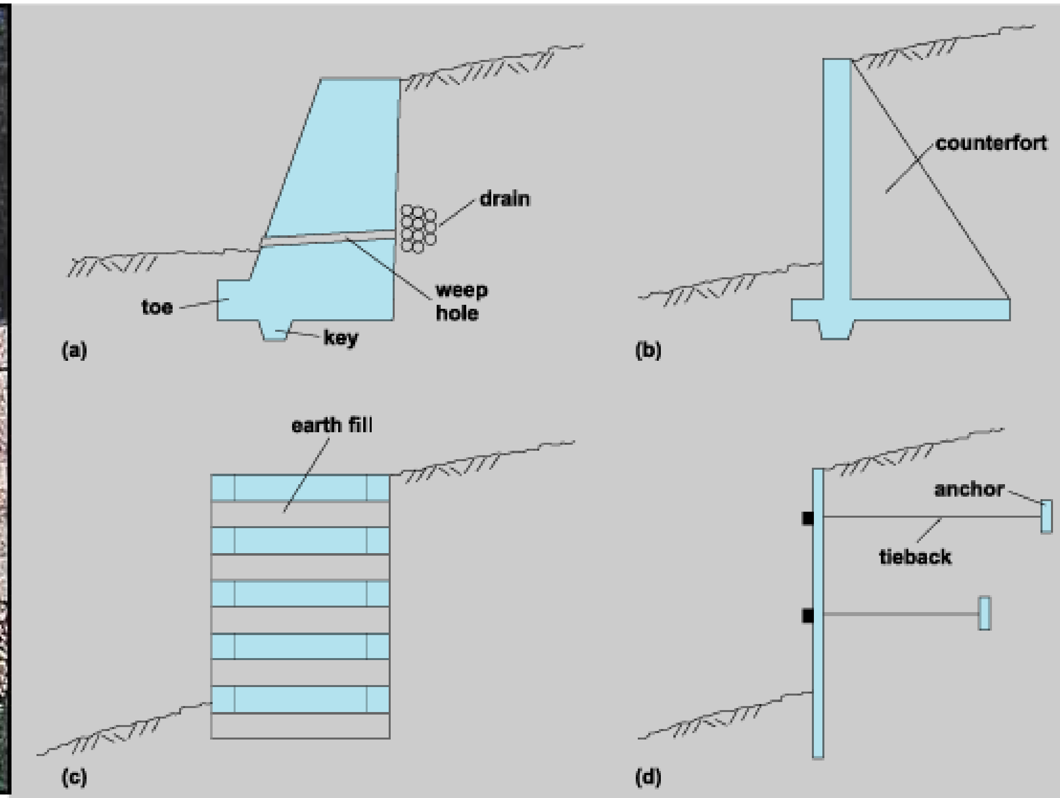
Other Related Concepts:

Seismic Base Isolation
(Shock absorbers for Buildings)

Underpinning
(Remedial intervention for an existing Building)

This Week: ***Foundations*** (Allen, Chapter 2)

RETAINING WALLS

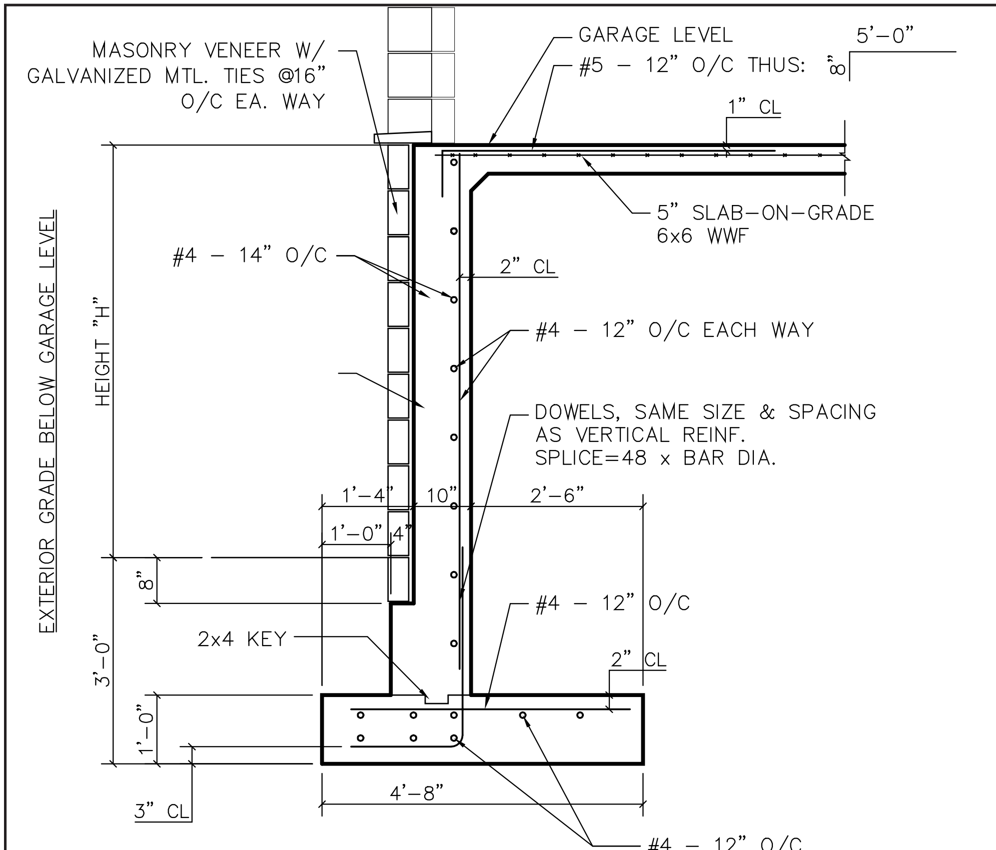


Types of Failure include "Overturning," "Sliding", and "Undermining."
Each of these failure modes correspond to constructional solutions:

Cantelever (Asymmetrical footing), keyed footing, and tie-back...

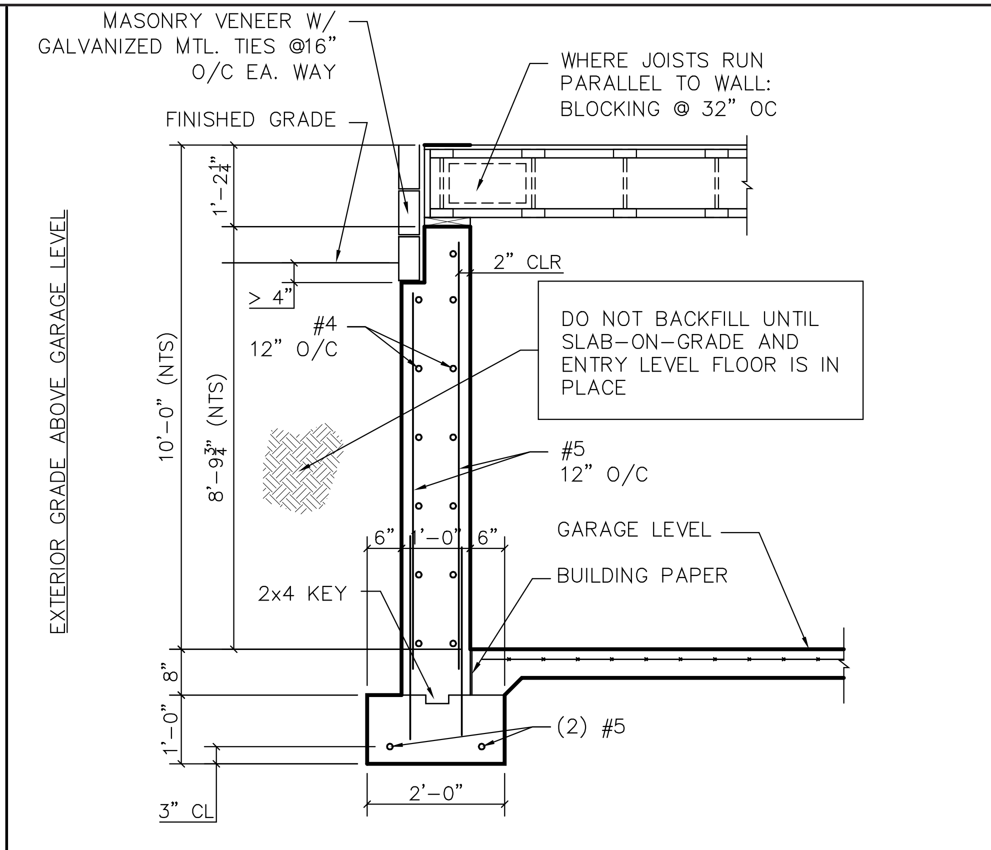
This Week: *Foundations* (Allen, Chapter 2)

RETAINING WALLS (Examples from Professional Practice)



HEIGHT "H" < 4'

STRUCTURAL DETAIL, $\frac{1}{2}$" = 1'0" **3**

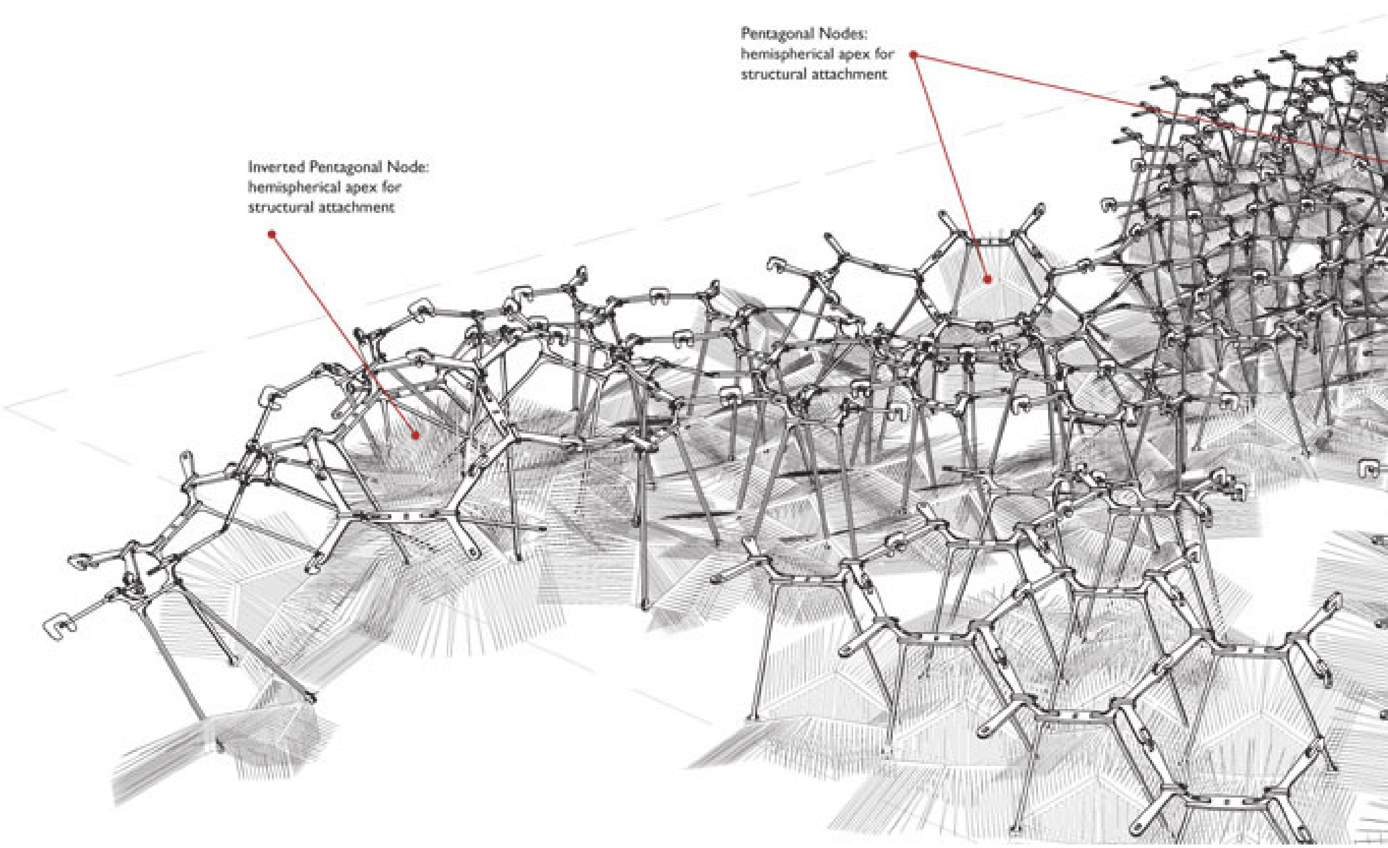


STRUCTURAL DETAIL, $\frac{1}{2}$" = 1'0" **4**

This Week: ***Foundations*** (Allen, Chapter 2)

RETAINING WALLS: ***Earth Reinforcing & Geotextiles***

What is a Geotextile?



This Week: ***Foundations*** (Allen, Chapter 2)

WATERPROOFING AND DRAINAGE

As mentioned before, excavation and contact with the soil often results in an "inverted bathtub" condition, where the water is on the outside, and you want to keep the inside dry.

Many techniques and products exist for preventing water and its frozen states from affecting the behavior of the building.

"**Water-proofing**" requires drainage and heavy-duty barriers.

"**Damp-proofing**" requires light-duty barriers to resist infiltration from water which is not under pressure.

This Week: ***Foundations*** (Allen, Chapter 2)

TYPICAL FOUNDATION ASSEMBLY

(See Figure 2.57, on page 60.)

From the inside out...

Wall,
Waterproofing membrane,
Drainage mat,
Protection board,
Soil...

Don't forget the drainage piping at the base of the assembly!

This Week: *Foundations* (Allen, Chapter 2)

TYPES OF MEMBRANES

Bituminous (asphaltic), plastic, synthetic rubber
(May be sheet-applied or fluid-applied)

Clay-based (bentonite) -- often used as waterstops at joints

Cementitious/plaster-based coatings,
(Sometimes known as parging... for light-duty uses only)

This Week: ***Foundations*** (Allen, Chapter 2)

SHALLOW, FROST-PROTECTED FOUNDATIONS

(Not used in typical practice here in Maryland.)

But mention of this kind of foundatino does raise the question about why we do put our footings as deep as they are.

What is the danger of "frost" to foundations?

This Week: ***Foundations*** (Allen, Chapter 2)

UP-DOWN CONSTRUCTION

(Whoopsie Daisey!)

When area to be excavated is considerable, yet when project schedule requires that the construction of superstructure procedes quickly.

> ***Deep foundations are put in place, and structural elements extending from those foundations are introduced to allow above-ground construction to proceed before excavation.***

Why might doing this be advantageous? What are possible disadvantages?

This Week: ***Foundations*** (Allen, Chapter 2)

DESIGNING FOUNDATIONS

Foundation design often drives many of the logistical issues surrounding buildng constructability and cost.

Foundation challenges may even determine the type of superstructure due to trade-offs concerning dead load and construction speed.

The book cites these "thresholds" which significantly change the cost impact of your design decisions:

Building below the Water Table;
Building Close to an Existing Structure;
Increasing Building Load beyond what can be handled by shallow foundations.

This Week: ***Foundations*** (Allen, Chapter 2)

DESIGNING FOUNDATIONS

In certain regions deep foundations are a given;
otherwise, in most places the rationale is to "keep it cheap."

The former might include areas with typically poor-capacity soils, or seismically active locations. Areas where real-estate is expensive also leads to buildings which make greater use of below-grade areas, in addition to their above-grade envelope.

This Week: ***Worksheet #3***

Exercises in Building Construction, # 2.1, 2.2, 2.3

> Waterproofing and Drainage

> Soil Types and Bearing Capacities

> Foundation and Slope Support Systems

This Week: *Making Buildings*

Are we through yet?

> Reading for next week: Allen, Chapter 3, 5, & 6 (Wood)