UNITED STATES MARINE CORPS
ENGINEER INSTRUCTION COMPANY
MARINE CORPS DETACHMENT
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FORT LEONARD WOOD, MO 65473-8963

LESSON PLAN

DESIGN A VERTICAL CONSTRUCTION PROJECT

EAC-A04

ENGINEER ASSISTANT CHIEF COURSE

A16EAV1

REVISED 08/01/2014

APPROVED BY _____________________ **DATE** _______________

INTRODUCTION: (5 Min)

1. **GAIN ATTENTION**: Our mission as Marine engineers is to construct structures that are temporary in nature. This has not prevented our engineer units from periodically being tasked with a mission to construct a building that is considered semi-permanent. This has normally occurred outside CONUS, and has been happening more frequently for humanitarian purposes. All the time and effort that is put into the creation of drawings is wasted if the structure to be built is not carefully and properly designed.

(On CS #1)

2. **OVERVIEW**: Good morning/afternoon class my name is ______________, the purpose of this lesson is to provide you with the fundamental knowledge to design a temporary facility that is structurally sound, using the proper building materials and construction methods. I will do this by discussing: the phases of design, characteristics of building materials, design considerations for foundations, and framing.

INSTRUCTORS NOTE:
Have students read the Learning Objectives in their student outline.

(On SLIDE #2)

3. **INTRODUCE LEARNING OBJECTIVES**:

a. **TERMINAL LEARNING OBJECTIVES**: Provided a vertical construction mission, a scientific calculator, a survey set (GP), soil test set, computer, software applications and references, design a vertical construction project to safely support all calculated loads. (1361-SRVY-2003)

(On SLIDE #3-5)

b. **ENABLING LEARNING OBJECTIVES**:

(1) Given a vertical construction mission, a scientific calculator and references, calculate all dead loads for the proposed structure per the MCRP 3-17.7H. (1361-SRVY-2003a)

(2) Given a vertical construction mission, a scientific calculator and references, calculate all live loads for the proposed structure per the MCRP 3-17.7H. (1361-SRVY-2003b)

(3) Given a vertical construction mission, calculated loads, a scientific calculator and references, design the structural foundation requirements to support the proposed structure per the MCRP 3-17.7D. (1361-SRVY-2003c)

(4) Given a vertical construction mission, calculated loads, a scientific calculator and references, design the structural framing requirements for the proposed structure per the MCRP- 3-17.7C. (1361-SRVY-2003d)

(5) Given a vertical construction mission, calculated loads, a scientific calculator and references, identify finish materials for the proposed structure per the MCRP- 3-17.7C. (1361-SRVY-2003e)

(6) Given a vertical construction mission, calculated loads, finished design sketches, a computer, software applications, and references, produce finished design plans of the proposed structure per the TM 5-581B. (1361-SRVY-2003f)

(7) Given a vertical construction mission, calculated loads, finished design sketches, a computer, software applications and references, create project design specifications for the proposed structure per the TM 5-581B. (1361-SRVY-2003g)

(On SLIDE #6)

4. **METHOD/MEDIA**: This lesson will be presented by lecture, demonstration, and practical application. I will be aided by the dry erase board, and computer slides to present this period of instruction.

(On CS #7)

INSTRUCTORS NOTE
Explain lesson critique forms to students.

(On SLIDE #8)

5. **EVALUATION**: A closed book written and performance examination, covering the materials in this lesson, will be administered at the end of this period of instruction as noted on your training schedule.

INSTRUCTOR NOTE
Refer to the training schedule to give the exact date of the exam.

(On SLIDE #9)

6. **SAFETY/CEASE TRAINING (CT) BRIEF**: In the event of fire, we will consolidate outside where the pavilion is located at and account for everyone. In the event of a tornado, the passageway on the first deck of Brown Hall will be our consolidation area.

TRANSITION: Are there any questions concerning what will be covered in this lesson or how you will be evaluated? Let's start by discussing the basic phases of the construction process.

(On SLIDE #10)

BODY: **(14 HRS 10 Min)**

1. **PHASES OF CONSTRUCTION**: **(20 Min)** There are three distinct phases that we must go through to successfully complete any vertical construction mission our unit has been tasked with. Each phase of the construction effort is interdependent on the other.

(On SLIDE #11)

a. **Design Phase**: The design phase is the initial step in the successful development of a project. Design involves the transfer of basic sketches into final working drawings, and the creation of project specifications which guide the construction work for the intended structure. Design activities can be informal or formal.

(1) Informal design happens when a project is developed without the use of a formal plan.

(2) Formal design involves the calculation of all structural loads, designing all structural components of the structure, identifying all finish materials, development of design sketches, and the creation of design project specifications. The complete preparation of required design information leads to the creation of finished working drawings. A complete set of working drawings must be prepared before the actual construction can begin.

(On SLIDE #12)

b. **Planning Phase**: The planning phase normally begins after the design phase has been completed. During this phase of the project, material estimates are compiled from the working drawings, critical path diagrams are developed to help identify the logical sequence of work activities so the project is completed on schedule, and resources such as man power and equipment are identified for each activity in the construction process.

(On SLIDE #13)

c. **Construction Phase**: During this phase, the actual construction work begins. Working design specifications and drawings are provided to each party involved in the construction of the project. The work that must be performed by the Combat Engineers, Heavy Equipment, and Utilities is dependent on how well we have done our job during the design phase. The construction phase has 4 major components:

(1) Site Work/Excavation. (Heavy Equipment)

(2) Concrete/Masonry work. (Combat Engineers)

(3) Carpentry/Finish work. (Combat Engineers)

(4) Electrical/Plumbing work. (Utilities)

(On SLIDE #14)

d. There are certain guidelines that are used as the basis for your design efforts. Building codes are a collection of laws that outline minimum acceptable standards that control the design, construction methods, and materials to be used to build a structure. All reference materials dealing with construction are based on these standardized national codes.

(On SLIDE #15)

TRANSITION: We have covered the phases of construction. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning the phases of construction? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. What are the three phases of construction?

ANSWER: Design, Planning, and Construction phases.

b. What standards control the design, construction methods, and materials to be used to build a structure?

ANSWER: Building Codes.

TRANSITION: We have spent the last 20 minutes discussing the phases of construction. Next I will demonstrate how to make concrete.

INSTRUCTORS NOTE:
Perform the following demonstration using dry erase board or actual samples to illustrate and clarify.

(On SLIDE #16)

DEMONSTRATION. (10 min) Gather the students' attention to the dry erase board and chosen table/desk for a brief demonstration of concrete as building material.

STUDENT ROLE: Observe component materials that make up concrete.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', typical components that make up concrete.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: The materials you have just seen are typical components of concrete used in most of our vertical construction project.

INTERIM TRANSITION: Are there any questions about the demonstration? Next we will discuss the fundamental characteristics of concrete as a building material.

2. **CONCRETE**: **(30 Min)** Concrete has a great variety of uses that meet structural demands.

(On SLIDE #17)

a. Concrete is a mixture of aggregate, Portland cement, and water.

(1) Aggregate: Filler materials (usually sand, stone or gravel) make up between 60 and 80 percent of the volume of concrete. The size, shape, and grade of the aggregate influences the amount of water used in the mix.

(2) Portland Cement: This is a carefully proportioned and specially processed chemical combination of lime, silica, iron oxide, and alumina. This is the most commonly used hydraulic cement for concrete.

(3) Water: The basic ratio of cement to water determines the strength of the concrete. The less water that is added to the mix, the stronger, more durable, and watertight the concrete will be. The more water that is added to the concrete mix results in a concrete that is weaker and more porous.

(**On SLIDE #18)**

b. A chemical reaction between the Portland cement and water causes the concrete to harden. This chemical reaction is referred to as hydration. Because hydration hardens concrete, and not air drying, freshly placed concrete submerged underwater will harden.

(On SLIDE #19)

c. There are two types of concrete that we deal with in vertical construction when it is required for that structure.

(1) Plain concrete is defined as concrete without any type reinforcement. Sidewalks, driveways, and floors that do not carry heavy loads can be built with plain concrete.

(2) Reinforced concrete is concrete that contains steel rods, bars, wire, and mesh as reinforcement to absorb tensile and shearing stresses. Concrete footings, walls, slabs, columns, and piers must be reinforced to attain its necessary tensile strength.

(On SLIDE #20)

d. Concrete has a very high compressive strength which is reached at 28 days after being poured and allowed to cure. Its ability to resist stretching, bending, or twisting (tensile strength) is very low. Because of concrete's low tensile strength, it must be reinforced with steel bars or wire mesh. This type of reinforcement is required in beams, girders, footings lintels, walls, and columns.

(1) Steel is the best material for reinforcing concrete because at normal temperatures the steel and concrete will expand and contract at an equal rate. Reinforcement bars (rebar) also works well as reinforcement because it makes a good bond with the concrete.

(2) Welded wire mesh (WWM) comes in either rolls or sheets, and is manufactured in square or rectangular patterns, welded at the intersections. The rectangular pattern sizes range from 2" x 4" to 6" x 12". Square patterns come in patterns of 2" x 2", 3" x 3", 4" x 4", and 6" x 6". This type of reinforcement is normally found in slabs, walls, sidewalks, and driveways.

e. Structural concrete is made by placing concrete into forms. Forms for concrete must be strong, rigid, and watertight. In addition, forms must be built strong enough to resist the high pressure exerted by concrete while it is being poured and while it is in place curing. Wood, plywood, steel, and stable earth are commonly used for form work.

(On SLIDE #21)

TRANSITION: We have just covered concrete as a building material. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning the characteristics of concrete building materials? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. What are the three elements that make concrete?

ANSWER: Aggregate, Portland Cement, and Water.

b. What process causes concrete to harden?

ANSWER: Hydration process.

(BREAK 10 Min)

TRANSITION: Before the break we covered concrete as building material. Do you have any questions? If not, let's discuss the fundamental characteristics of masonry as a building material.

(On SLIDE #22)

DEMONSTRATION. **(10 min)** Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of masonry as building material.

STUDENT ROLE: Observe typical designs and dimensions of concrete masonry.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', concrete masonry.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen are typical concrete masonry units used in vertical construction project.

INTERIM TRANSITION: Are there any questions about the demonstration? Let's move on.

(On SLIDE #23)

3. **CONCRETE MASONRY**: **(30 Min)** Concrete masonry has become increasingly important as a construction material. Properly designed and constructed, concrete masonry walls comply with building requirements such as fire prevention, safety, and durability.

a. Concrete masonry units (CMU) are used in all types of masonry construction, such as:

(1) Exterior load-bearing walls below and above grade.

(2) Interior load bearing walls.

(3) Piers and columns.

(4) Retaining walls.

(On SLIDE #24)

b. The most common type of concrete masonry unit is the concrete block. There are two types of concrete block:

(1) Heavyweight block is made from cement, water, and aggregate (sand, gravel, and crushed limestone).

(2) Lightweight block is made from cement, water, and lightweight aggregate (cinders, pumice, expanded shale, and vermiculite). Lightweight units weigh about 30 percent less than heavyweight units.

c. Concrete block units are made in different sizes and shapes to fit the different construction needs. These units are made in full or half sizes. Concrete blocks are referred to by their nominal sizes. A concrete block that has an actual size of 7 5/8" x 7 5/8" x 15 5/8" is referred to as an 8" x 8" x 16" unit.

(On SLIDE #25)

d. Concrete block walls must be designed to make maximum use of full and half blocks. This type of design is called modular planning. The length and height of walls, the width and height of door and window openings, and wall areas between doors and windows are the major considerations that aid in modular planning.

(1) Wall lengths are modulated in increments of 8" and 16".

(2) Wall heights are modulated in increments of 8".

(3) Door and window openings should be placed where vertical joints occur as much as possible.

INTERIM TRANSITION: Are there any questions on what we just covered? If not I will demonstrate the typical concrete masonry units used in vertical construction project.

(On SLIDE #26)

INSTRUCTORS NOTE:
Use dry erase board to illustrate and clarify.

DEMONSTRATION. **(5 min)** Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of reinforcing bars and CMU.

STUDENT ROLE: Observe placement of vertical/horizontal reinforcing bars in CMU.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', placement location of vertical/horizontal reinforcing bars.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen are typical concrete masonry units used in vertical construction project.

INTERIM TRANSITION: Are there any questions about the demonstration? If not, let's move on.

(On SLIDE #27)

e. Vertical reinforcement bars are placed in the cores, and filled with concrete or mortar. When block walls will be supporting heavy structural loads, cores will be filled with a 1:2:4 concrete mix ratio at places where girders will rest. The cores must be filled from the footing to the bearing surface of the wall.

f. Horizontal truss type reinforcement is placed every second course (16 inches) vertically up the wall to reduce shrinkage and settlement cracks.

g. In walls 20 feet and longer, 8" x 16" vertical pilasters are placed every 10' and filled with concrete to make the walls more rigid.

(On SLIDE #28)

TRANSITION: We have just covered the fundamental characteristics of masonry building materials. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning the characteristics of masonry building materials? (Answer student's questions.)

2. QUESTIONS TO THE CLASS:

a. What are the two types of concrete block?

ANSWER: Heavyweight, and Lightweight.

b. What size are CMU's manufactured?

ANSWER: Full and Half block sizes.

(BREAK 10 Min)

TRANSITION: Before the break we covered the fundamental characteristics of masonry building materials. Do you have any questions? If not, let's discuss the fundamental characteristics of wooden building materials.

(On SLIDE #29)

4. **WOOD**: **(50 Min)** Materials made of wood come in a variety of species, grades, and sizes. All wooden members must be carefully selected to serve their intended purpose when designing a structure.

a. The particular species of wood dictates its intended use in the construction of a structure.

INSTRUCTORS NOTE:
Use wood species chart in outline to clarify.

WOOD SPECIES AND USES		
TYPE	**USES**	**CHARACTERISTICS**
BIRCH	Cabinet work, interior finishes, plywood	Hard, durable, fine grain, heavy, stiff, strong, works easily, but is not durable when exposed to the elements.
DOUGLAS FIR	Building construction of structural members requiring higher strengths.	Excellent structural lumber, strong, easy to work, clear straight grained, soft but brittle. Best structural timber.
MAHOGANY	Furniture, decks, interior trim.	Most useful for cabinet work, hard, durable, but checks, swells, shrinks, and warps slightly.
RED OAK	Interior finish, cabinets, millwork	Tends to warp, coarse grain, does not last well when exposed to weather, Heavy, tough, and strong.
WALNUT	Furniture, cabinets,	Fine cabinet wood, coarse

	interior woodwork	grained but takes finish well, medium weight, hard, strong, easily worked but brittle. Does not warp or check.
WHITE CEDAR	Shingles, siding, posts, poles	Soft, light weight, close grained, very durable when exposed to water, not strong enough for building construction, generally knotty.
WHITE OAK	Framing for buildings, furniture, fence posts.	Heavy, hard, strong, medium coarse grain, tough, dense, most durable of all hardwoods. Easy to work, but shrinks, and checks.
WHITE PINE	Interior trim, cabinets, millwork	Easy to work, fine grain, free of knots, durable when exposed to water expands when wet, shrinks when dry. Soft, does not split when nailed.
YELLOW PINE	Most important and widely used lumber for construction and exterior work, joists, studs, rafters, posts, truss's	Hard, strong, grain varies, heavy, tough.

(On SLIDE #30)

b. In construction, the terms board, dimension lumber, and timber have distinct and separate meanings:

(1) Boards are less than 2" thick, and 1" to 16" wide (Nominal), and are primarily used in cabinet work, trim, and as diagonal bracing in wall framing.

(2) Dimension lumber is 2" to 4 1/2" thick, and 1" to 16" wide (Nominal), and is primarily used as the structural framing members for a building.

(3) Timbers are greater than 5" thick, and 5" wide (Nominal), and are primarily used as columns, beams, and girders when a high load carrying capacity is needed.

c. Standard lumber sizes have been established in the U.S. to permit uniformity in designing structures and ordering materials. Lumber is identified by nominal sizes. The nominal size of a piece of lumber is always larger than its actual dressed dimensions.

INSTRUCTORS NOTE:
Use lumber size chart in outline to clarify.

(On SLIDE #31)

LUMBER SIZES				
	THICKNESS (INCHES)		WIDTH (INCHES)	
ITEM	NOMINAL	ACTUAL	NOMINAL	ACTUAL
			2	1 ½
	1	3/4	3	2 ½
			4	3 ½
	1 1/4	1	5	4 ½
			6	5 ½
	1 1/2	1 1/4	7	6 ½
BOARDS			8	7 ¼
			9	8 ¼
			10	9 ¼
			11	10 1/4
			12	11 1/4
			14	13 1/4
			16	15 1/4
			2	1 ½
	2	1 ½	3	2 ½
			4	3 ½
	2 ½	2	5	4 ½
DIMENSION			6	5 ½
LUMBER	3	2 ½	8	7 ¼
			10	9 ¼
	3 1/2	3	11	10 ¼
			12	11 ¼
			14	13 ¼
			16	15 ¼
			2	1 ½
	4	3 ½	3	2 ½
DIMENSION			4	3 ½
LUMBER	4 ½	4	5	4 ½
			6	5 ½
			8	7 ¼
			10	9 ¼
TIMBERS	5" and thicker		5" and thicker	

d. Lumber is also graded for quality. The two types of graded lumber are select lumber and common lumber. Select lumber and common lumber are also subdivided for quality:

(1) Select lumber has a good appearance and has good qualities for finishes or painting.

(a) Grades A and B are suitable for natural finishes.

(b) Grades C and D are suitable for painted surfaces.

(2) Common lumber is used for general construction and utility purposes.

(a) No. 1 common is sound, tight-knotted, and contains minor defects. It is used in high quality construction (studs, roof trusses).

(b) No. 2 common contains limited defects, and no knotholes. It is used in ordinary light frame construction (girders, joists, rafters, studs).

(c) No. 3 common contains a few defects, and occasional knotholes. It is used for low cost construction (blocking, concrete forms).

(d) No. 4 common contains serious defects like knotholes and checks. It is used when quality is of no concern. (boxes, crates, dunnage)

(On SLIDE #32)

e. Lumber is classified according to its use and size, and falls into three categories:

(1) Yard Lumber: Grades, sizes, and patterns which are intended for ordinary construction and general building purposes.

(2) Structural Lumber: 2 or more inches in thickness and width for use where working stresses are required.

(3) Factory (Shop) Lumber: Produced mainly for the manufacture of furniture, doors, cabinets, and other millwork.

INSTRUCTORS NOTE:
Use lumber grade chart in outline to clarify.

LUMBER GRADES AND USES		
LUMBER TYPE	GRADE	TYPICAL USES
DIMENSION: Structural light framing 2" to 4" thick 2" to 4" wide 8’ to 16’ long	Select Structural	High quality, free of defects, which impair strength or stiffness. Used where high strength, stiffness, and appearance is needed.
	No. 1	Provides high strength, and has good appearance. Used for general utility and construction purposes.
	No. 2	Less restricted than No. 1, has tight knots. Used for all types of construction.
	No. 3	Provides high quality at a low cost. Used in general construction.
LIGHT FRAMING: 2" to 4" thick 2" to 4" wide 8’ to 16’ long	Construction	Good appearance, strong, and durable. Used for general framing.
	Standard	Has larger defects, but has some uses as Construction grade.
	Utility	Strong and economical. Used for blocking, bracing, and plates.
	Economy	Used for bracing, blocking, and other utility purposes.
STUDS: 2" to 4" thick 2" to 4" wide 10' and shorter	Stud	Strict requirements for straightness, strength, and stiffness. Used primarily for load-bearing walls.
STRUCTURAL: Joists and Planks 2" to 4" thick 5" and wider 8’ to 18’ long	Select Structural	High quality, free of defects, which impair strength or stiffness. Used where high strength, stiffness, and appearance is needed.
	No. 1	Provides high strength, and has good appearance. Used for general utility and construction purposes.
	No. 2	Less restricted than No. 1, has tight knots. Used for all types of construction.
	No. 3	Provides high quality at a low cost. Used for general construction, where appearance is not a critical factor.

(On SLIDE #33)

f. Treated lumber has a high resistance to decay and insect infestation. This type of lumber is used in structural areas that are prone to decay and/or insect damage such as sills attached to the tops of foundation walls, and sole plates that come in contact with concrete slabs. Another area where treated lumber is used is in exterior stairs and decks.

(On SLIDE #34)

TRANSITION: We have just covered the fundamental characteristics of lumber materials. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning the characteristics of lumber building materials? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. What are the three classifications of lumber?

ANSWER: Yard, Structural, and Factory (Shop).

b. What are the two grades of lumber?

ANSWER: Select and Common.

(BREAK 10 Min)

TRANSITION: We have spent the last 60 minutes discussing the fundamental characteristics of lumber materials. Are there any more questions? Next I will demonstrate typical plywood sheathing used in vertical construction project.

INSTRUCTORS NOTE:
Use dry erase board to clarify as necessary.

(On SLIDE #35)

DEMONSTRATION. **(5 min)** Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of plywood sheathing.

STUDENT ROLE: Observe characteristics of plywood sheathing.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', characteristics of plywood sheathing.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen is a typical plywood sheathing used in vertical construction project.

INTERIM TRANSITION: Are there any questions about the demonstration? Let's continue our discussion of the fundamental characteristics of plywood sheathing building materials.

(On SLIDE #36)

5. **PLYWOOD SHEATHING:** **(30 Min)** Plywood sheathing material is used to cover the structures framework, provide additional lateral stability to the framing members, and provide a base surface that finish materials are fastened to.

a. Plywood is a wooden panel product made from thin layers of wood called veneers. Because of plywood's cross-sectional strength, it is one of the strongest building materials available. It is the most versatile building material in use today. Some of the uses of plywood are:

(1) Concrete forms.

(2) Exterior wall sheathing.

(3) Roof sheathing.

(4) Floor sheathing.

(5) Cabinets.

(6) Shelving.

(On SLIDE #37)

b. Plywood is classified by two types exterior and interior.

(1) Exterior plywood is made of high quality veneers and more durable water resistant adhesives so it can withstand exposure to the elements.

INSTRUCTORS NOTE:
Use exterior plywood grades chart in outline to clarify.

EXTERIOR PLYWOOD GRADES

GRADE	FACE GRADE	BACK GRADE	INNER PLYS	USES
A-A	A	A	C	Outdoor work where appearance of both sides is important.
A-B	A	B	C	Alternate for A-A, where appearance of one side is less important.
A-C	A	C	C	Siding, soffits, fences. Face is finish grade.
B-C	B	C	C	For utility uses.
C-C (Plugged)	C	C	C	Base for tile and linoleum, backing for wall coverings.
C-D	C	D	C	Unsanded, for backing and rough construction exposed to weather.
B-B (Plugged)	B	B	C	Concrete forms, can be reused until wood literally wears out.

PLYWOOD VENEER GRADES:		
	N	Special order natural veneers
	A	Smooth and paintable
	B	Solid surface veneer
	C	Minimum veneer permitted in plywood
	C Plugged	Improved C veneer
	D	Permits knots and knotholes to 2 1/2" wide

INSTRUCTORS NOTE:
Use interior plywood grades chart in outline to clarify.

(2) Interior plywood can withstand an occasional wetting, but not prolonged exposure to the elements.

INTERIOR PLYWOOD GRADES

GRADE	FACE GRADE	BACK GRADE	INNER PLYS	USES
A-A	A	A	D	Cabinet doors, built-ins, and furniture where both sides will show.
A-B	A	B	D	Alternate for A-A. Face is finish grade, back is solid and smooth.
A-C	A	C	D	Finish face grade for paneling, backing, and built-ins.

B-C	B	C	D	Utility grades. One paintable side. Cabinet sides.
STANDARD	C	C	D	Sheathing and structural uses such as temporary enclosures and subflooring. Unsanded.

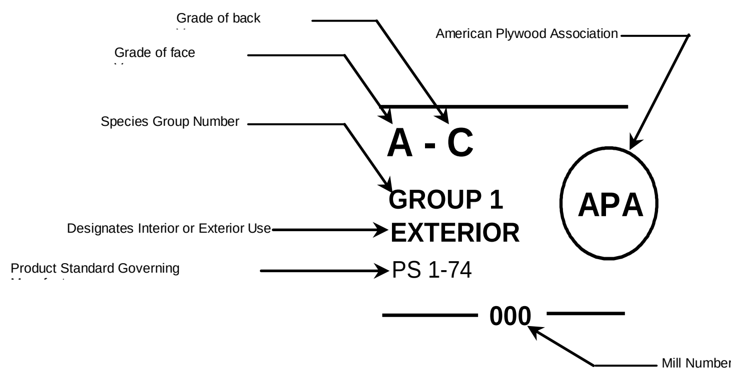
PLYWOOD VENEER GRADES:	N	Special order natural veneers
	A	Smooth and paintable
	B	Solid surface veneer
	C	Minimum veneer permitted in plywood
	C Plugged	Improved C veneer
	D	Permits knots and knotholes to 2 1/2" wide

c. There are several veneer grades within each type of plywood. These grades help identify the specific use for exterior and interior plywood.

d. Finish materials are attached to sheathing and protect the structure from the elements as well as giving the structure a "finished" appearance.

e. Though various combinations of covering materials can be used on a structure, careful selection of plywood sheathing material is critical to strengthen the framework properly, and finish material must be affixed to the sheathing correctly to ensure that the structure will not be damaged by the elements.

(On SLIDE #38)



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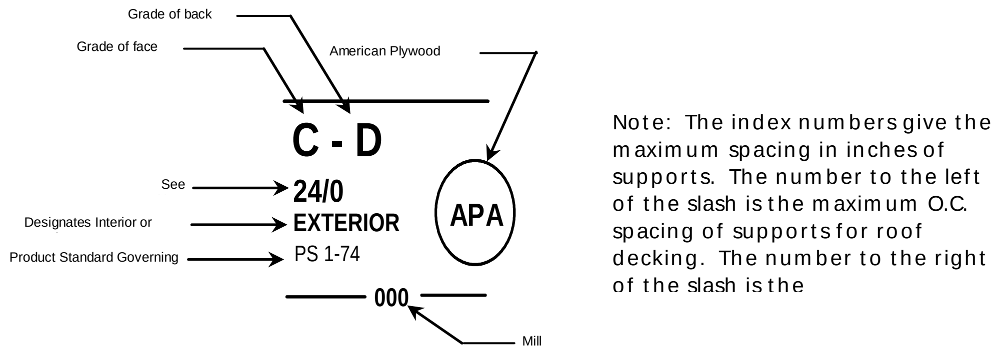
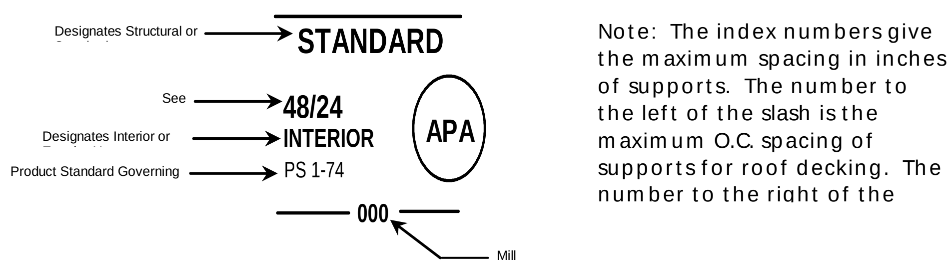




STRUCTURAL and STANDARD

(On SLIDE #40)

TRANSITION: We have just covered the fundamental characteristics of plywood sheathing materials. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning the characteristics of plywood sheathing building materials? (Answer student's questions.)

2. QUESTIONS TO THE CLASS:

a. What are the two classification types of plywood?

ANSWER: Exterior and Interior.

b. What dictates a plywood's specific use?

ANSWER: The veneer grade.

(BREAK 10 Min)

TRANSITION: Before the break we covered the fundamental characteristics of plywood sheathing materials. Do you have any questions? If not, let's discuss the fundamental characteristics of foundation systems.

(On SLIDE #41)

6. **FOUNDATION SYSTEMS**: **(30 Min)** The basic principles of foundation construction are the same regardless of the construction method. Every structure requires some type of foundation to support it. The foundation however, must be built on a soil that is stable enough to support the entire structure to include the foundation. An unstable soil will result in major structural damage as shifting occurs.

(On SLIDE #42, 43)

a. The function of the foundation is to provide a level surface and uniformly distributed support for the structure. Every exterior wall and bearing partition wall for the structure is supported by the foundation.

b. The foundation must be strong enough to support and distribute the load of the structure. The most critical element of a foundation is the footings. Footings support the foundation walls and any columns, and distribute the weight of the entire structure over a large area of load-bearing soil.

c. The type of foundation you select for a structure depends on the type of soil it is to be built on, and the size and weight of the structure that will be supported.

(On SLIDE #44)

GENERAL SAFE SOIL BEARING CAPACITIES	
SOIL TYPE	**SAFE LOAD BEARING CAPACITY (PSF)**
Soft clay, loam, soft broken shale	2000 lb. per sq. ft.
Dry, firm sand, or clay	4000 lb. per sq. ft.
Compact, course sand	6000 lb. per sq. ft.
Course gravel, hard dry clay	8000 lb. per sq. ft.
Compact gravel, sand-gravel	20000 lb. per sq. ft.

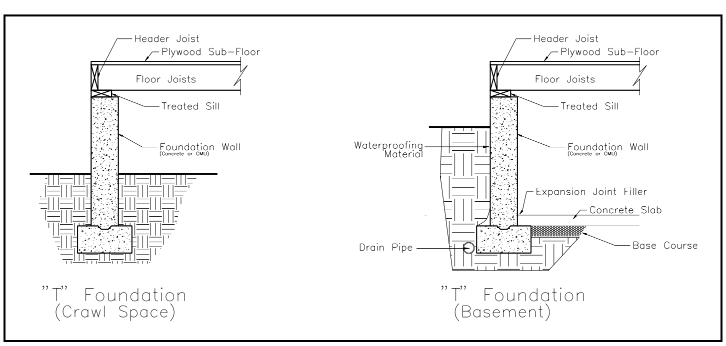
UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)				
CHARACTERISTICS				
SYMBOL	Foundation Value (No frost action)	Potential Frost Action	Base Value	Drainage Characteristics
GW	Excellent	None to Very	Good	Excellent

		Slight		
GP	Good to Excellent	None to Very Slight	Fair to Good	Excellent
GM	Good to Excellent	Slight to Medium	Fair to Good	Fair to Poor
GC	Good	Slight to Medium	Poor to Not suitable	Poor to Not suitable
SW	Good	None to Very Slight	Poor	Excellent
SP	Fair to Good	None to Very Slight	Poor to Not suitable	Excellent
SM	Fair to Good	Slight to High	Poor	Fair to Poor
SC	Fair to Good	Slight to High	Not suitable	Poor to Impervious
ML	Poor to Fair	Medium to Very High	Not suitable	Poor to Fair
CL	Poor to Fair	Medium to High	Not suitable	Practically Impervious
OL	Poor	Medium to High	Not suitable	Poor
MH	Poor	Medium to Very High	Not suitable	Poor to Fair
CH	Poor to Very Poor	Medium	Not suitable	Practically Impervious
OH	Poor to Very Poor	Medium	Not suitable	Practically Impervious
PT	Not suitable	Slight	Not suitable	Poor to Fair

d. There are three basic types of foundations used for the construction of any type of structure. As the mission dictates, these types of foundations can be combined.

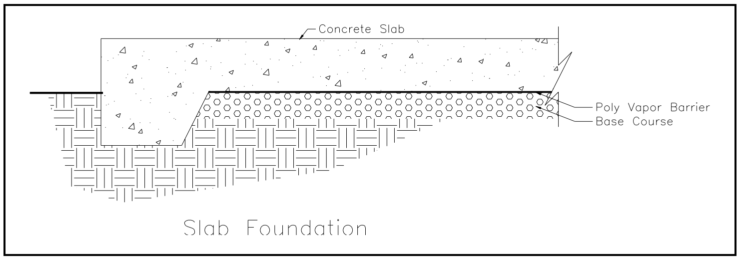
(On SLIDE #45)

(1) “T” foundations have a trench footing with a concrete wall or concrete block wall resting on top of it. This type of foundation is used if the structure requires a basement or crawl space.



(On SLIDE #46)

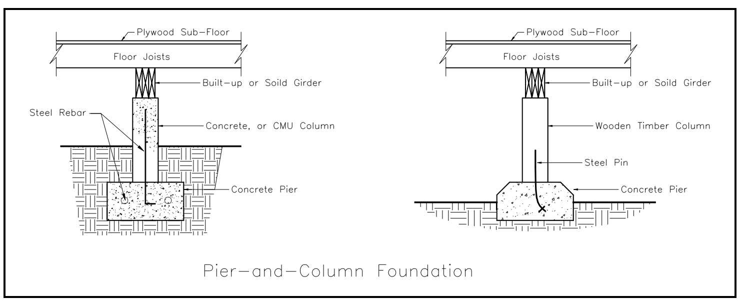
(2) Slab foundations are prevalent in light construction where a basement or crawl space is not required. This type of foundation consists of a concrete slab which is poured directly on the ground, with trench footings poured at locations where additional support is required.



Slab Foundation

(On SLIDE #47)

(3) Pier-and-Column foundations consist of individual footers with a column placed on top of it. This type of foundation combination is used primarily for the support of girders and beams which support structural floor members.



Pier-and-Column Foundation

(Off SLIDE #48)

<u>TRANSITION</u>: We have just covered foundation systems. Are there any questions?

<u>OPPORTUNITY FOR QUESTIONS</u>:

1. <u>QUESTIONS FROM THE CLASS</u>: Do you have any questions concerning foundation systems? (Answer students' questions.)

2. <u>QUESTIONS TO THE CLASS</u>:

a. What are the three types of foundation systems?

<u>ANSWER</u>: "T", Slab, and Pier-and-Column.

b. What type of foundation system would be used if the structure did not require a basement or crawl space?

ANSWER: Slab foundation.

TRANSITION: If there are no more questions we will discuss footings.

(On SLIDE #49)

7. **FOOTINGS**: **(50 Min)** A properly constructed building must be supported by an appropriate foundation that will support the weight of the building. The footing is the enlarged base of the foundation wall and must be massive enough to distribute the weight of the building to the ground below.

a. Footings must be placed a minimum of 12" below the frost line to reduce the effects of freezing and thawing actions which will cause shifting that causes structural damage.

b. Concrete is commonly used for footings because it can be poured into the excavated trench to maintain firm contact with the supporting soil, and can support heavy weights.

(On SLIDE #50)

c. The soil on which the footings rest must be level, stable, and compact. In light soils, reinforcement bars must be placed into the footings. The load-bearing capacity of the soil must be considered when designing the footings. This data must be obtained from the Combat Engineers to enable you to design the footing requirements for a structure.

(On SLIDE #51)

d. The design of the footings must be able to support loads of the structure. Footings must have a compressive strength of at least 2500 psi at 28 days to effectively support the weight of the structure for combined dead loads and live loads.

(1) Dead loads refers to the weight of the structure and any stationary equipment fastened to it. These weights are represented as pounds per square foot.

(2) Live loads are loads that are not permanently stationary within the structure. These types of loads include people, furniture, equipment, wind, snow, and rain. These weights are represented as pounds per square foot.

INSTRUCTORS NOTE:
Refer students to design load chart in outline to clarify.

DESIGN DEAD LOADS & LIVE LOADS			
Construction Materials	**PSF**	**Construction Materials**	**PSF**
Ceilings: Sheet Rock (per 1/8" thickness) Acoustical Tile	 0.55 1.0	**Frame Partitions**: Wood Studs w/1/2" sheet rock Wood Studs (uncovered)	 8.0 4.0
Roof Covering: Asphalt Shingles 3-ply Roll Roofing Copper or Tin 20 gage Corrugated Metal 18 gage Corrugated Metal Batt Insulation (per 1”) Plywood (per 1/8" thickness) 1" Wood Decking w/ paper Wood Shingles 2 x 4 Rafters (16" O.C.) 2 x 6 Rafters (16" O.C.) 2 x 8 Rafters (16" O.C.) 2 x 10 Rafters (16" O.C.)	 2.0 1.0 1.0 2.5 3.0 0.70 0.40 2.5 3.0 2.0 2.5 3.0 3.5	**Frame Walls**: 2 x 4 Studs at 16", 5/8" Sheet Rock, Insulation, 3/8" Lap Siding, 1/2" Plywood	 12.6
		Frame Walls: 2 x 6 Studs at 16", 5/8" Sheet Rock, Insulation, 3/8" Lap Siding, 1/2" Plywood	 13.6
Wall Covering : Batt Insulation (per 1”) Sheet Rock (per 1/8" thickness)	 0.70 0.55	**Foundations**: 8" Concrete Block (heavy aggregate) 8" Concrete Block (light aggregate) 8" Poured Concrete (150 lb. pcf) 12" Concrete Block 4" Concrete Slab Concrete Footing, 16" x 8"	 55.0 35.0 100.0 80.0 48.0 100.0
Floors: Lumber Sub-flooring (3/4") Plywood (per 1/8" thickness)	 3.0 0.40	**Roof Live Load**: Snow & Wind (varies locally)	 30.0
		Ceiling Live Loads: Attics (light storage)	 20.0
		Floor Live Loads: National Code Requirement	 40.0

Floor/Ceiling Joists			
Joist Size (in)	**PSF @ 12" O.C.**	**PSF @ 16" O.C.**	**PSF @ 24" O.C.**
2 x 6	6.0	5.0	5.0
2 x 8	6.0	6.0	5.0
2 x 10	7.0	6.0	6.0
2 x 12	8.0	7.0	6.0

(On SLIDE #52)

e. Footing size design in stable soil can be done using the “Basic Rule” for continuous concrete footings for foundation walls.

(1) Footing Width: The width of the footing is equal to twice the width of the foundation wall it will be supporting.

(2) Footing Depth: The depth (thickness) of the footing is equal to the width of the wall it is supporting.

(On SLIDE #53)

f. The design of continuous footings in unstable soil must be done using the "Computation Method" to determine the required width of the continuous concrete footings to support the foundation walls.

(On SLIDE #54)

(1) Step 1: Compute rafter length.

(a) $\frac{\text{Span + Overhang length (both ends)}}{2}$ = Run

(b) Run x Multiplying Factor = Rafter Length

Roof Slope	**Multi. Factor**
2:12	1.015
3:12	1.030
4:12	1.055
5:12	1.083
6:12	1.120

(On SLIDE #55)

(2) Step 2: Compute Design Loads. All values computed in "Pounds"

(a) Total live and dead loads for roof x calculated rafter length.

(b) Total live and dead loads for ceiling x half span of ceiling.

(c) Total dead load for exterior wall x design wall height.

(d) Total live and dead loads for floor x half span of floor

(e) Total dead load for foundation wall x design wall height.

(f) Total dead load for concrete footings x trial design footing width (1.33') in feet and decimal parts of a foot.

(g) Add all totals to compute the sum for "total area of footing per lineal foot of wall".

(On SLIDE #56)

(3) Step 3: Determine Design Footing Width.

(a) Required area of footing = total area of footing per linear foot of wall divided by soil bearing capacity.

(b) Design footing width = Required area of footing x 12" (Round value to nearest whole number)

(c) If the calculated design footing width is less than or equal to the trail footing width, then the trial footing size can be used to safely support the structures loads.

(d) If the calculated design footing width is greater than the trail footing width, then the calculated footing size must be used to safely support the structures loads.

INTERIM TRANSITION: We have just covered footings. Are there any questions? Let's take a break before the demonstration?
____
____
____

(BREAK 10 min)

INTERIM TRANSITION: Are there any questions before the demonstration?

(On SLIDE #57)

INSTRUCTORS NOTE:
Conduct load calculation demonstration to clarify students understanding.

DEMONSTRATION. **(1.5 Hr)** Gather the students attention to the dry erase board and student handout for a demonstration of the dead load and live load calculation.

STUDENT ROLE: Observe load calculation and footing size determination demonstration utilizing the proper steps taught.

INSTRUCTOR(s) ROLE: Demonstrate dead and live load calculations to properly and safely design a footing/foundation system for a vertical construction project.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Be sure to have students follow along in their student outline along with the instructor's supervision.

DEBRIEF: Now that I have demonstrated dead and live load calculations, you will now be able to determine the proper footing dimensions to safely support a vertical construction project.

INSTRUCTOR DEMONSTRATION:

(1) Review and read to the students the vertical project dimension specifications. Use the Dry Erase Board and write the calculations. Use the "Dead and Live Loads" Standards Table. Note: All numbers for calculations will be in the decimal feet/inches format.

(2) Rafter Length:

(a) Emphasize that the overhang needs to be multiplied by 2 and convert English inch format to decimal feet/inches.

(b) (Bldg Span + TTL Overhang) ÷ 2 = Run

(c) Run x Slope Ratio (refer to the multiplication factor table) = Rafter Length

(3) Roof System:

(a) Live Load = 30psf; Constant value for snow and wind. Explain that evnt though it's a constant, the number will vary particular to the environment the vertical construction will be built.

(b) Referring to the table, input the remaining "dead load" per construction materials used.

(c) Add Live Load and Dead Loads

(d) Multiply the Rafter Length with the TTL Load sum to come up with the Roof System load product.

(4) Ceiling System:

(a) Live Load = 20psf; Constant value.

(b) Referring to the table, input the remaining "dead load" per construction materials used.

(c) Add Live Load and Dead Loads

(d) Multiply the Half Span of the building (28 ÷ 2 = 14.00) with the TTL Load sum to come up with the Ceiling System load product.

(5) Wall (exterior) System:

(a) Referring to the table, input the “dead load” per construction materials used.

(b) Multiply the Wall Height with the TTL Load sum to come up with the Wall System load product.

(6) Floor System:

(a) Live Load = 40pfs; Constant value.

(b) Referring to the table, input the remaining “dead load” per construction materials used.

(c) Multiply the Half Span of the building (28 ÷ 2 = 14.00) with the TTL Load sum to come up with the Floor System load product.

(7) Foundation Wall System:

(a) Referring to the table, input the “dead load” per construction materials used.

(b) Multiply the Foundation Wall Height (4.00’ in this case) of the building with the TTL Load sum to come up with the Foundation Wall System load product.

(c) Foundation wall thickness is 8” so the Trial Width is double that, 16”, equaling to 1.33’. Use 1.33’ and multiply that to the 100psf constant (for a 16” x 8” concrete footing) = 133.00lbs

(8) Total Weight (Live and Dead Loads:

(a) Add all products (in lbs) that were calculated from #3 to #7. In this project the sum loads is 2299.10 lbs.

(9) Required Footing Area:

(a) Divide the Soil Bearing Strength (2000 lbs/sqft) from the Total Weight (2299.10 lbs) = 1.15 sqft.

(10) Required Design Footing Width:

(a) Multiply the Required Footing Area (1.15 sqft) with 12” (ft) = 13.80”

(11) Verification to the Class:

(a) 13.80” < 16”. 16” being the Trial Width of the footer design for this particular vertical construction project. 16” footer width will work and will safely support the structure per soil bearing strength.

(b) If the resultant “Required Design Footing Width” is greater than the design footer width, then a REDESIGN of the footer/foundation will need to be made to the drawing.

LOAD CALCULATION EXAMPLE

Building span = 28’-0”
Roof slope = 5:12 (1.083)
Exterior wall height = 8’-0”
Foundation wall height = 4’-0”
Overhang = 18” (both sides)
Soil bearing strength = 2000 lbs per sqft.

Rafter length:

$\frac{\text{Span + Overhang}}{2}$ = “Run”

Run x Mult. Fact. = Rafter Lgth

$\frac{28' + 3'}{2}$ = 15.5’ (or 15’-6”)

15.5 x 1.083 = 16.79’ (16’-9 1/2”)

Roof:	Live load =	**30.0**	psf
	Dead load (asphalt shingles) =	**2.0**	psf
	Dead load (1/2” plywood) =	**1.6**	psf
	Dead load (2x6 rafters @ 16” o.c.)	**2.5**	psf
	Total Load =	**36.1**	psf

Rafter length **16.79’** **x** **36.1** = **606.1** **lbs**

Ceiling:	Live load =	**20.0**	psf
	Dead load (1/2″ sheet rock) =	**2.2**	psf
	Dead load (1/2″ plywood) =	**1.6**	psf
	Dead load (2x6 joists @ 16″ o.c.)	**5.0**	psf
	Total Load =	**28.8**	psf
	Half Span **14.0′** **x** **28.8** **=**	**403.2**	**lbs**
Exterior Wall:	Dead load (wood studs uncovered) =	**4.0**	psf
	Dead load (1/2″ plywood) =	**1.6**	psf
	Dead load (1/2″ sheet rock) =	**2.2**	psf
	Dead load (3″ batt insulation) =	**2.1**	psf
	Total Load =	**9.9**	psf
	Wall Height **8.0′** **x** **9.9** **=**	**79.2**	**lbs**
Floor:	Live load =	**40.0**	psf
	Dead load (3/4″ plywood) =	**2.4**	psf
	Dead load (2x10 joists @ 16″ o.c.)	**6.0**	psf
	Total Load =	**48.4**	psf
	Half Span **14.0′** **x** **48.4** **=**	**677.6**	**lbs**
Foundation Wall:	Dead load (8″ poured concrete walls) =	**100.0**	psf
	Wall Height **4.0′** **x** **100.0** =	**400.0**	**lbs**
	Dead load (16″ wide conc. footings) =	**100.0**	psf
	Trial Width **1.33′** **x** **100.0** =	**133.0**	**lbs**

Total Weight = 2,299.1 lbs

Required footing area:

Total Weight: **2,299.1 lbs**
Soil bearing capacity: **2,000.0 lbs psf** **=** **1.15 sqft**

Required design footing width:

Footing Area: **1.15** x **12″** = **13.80 in**

Note: The calculated design footing width 13.8″ is less than the trial footing width (16″), so the trial footing size can be used to safely support the structural loads.

INTERIM TRANSITION: We have just completed the demonstration for load calculations. Are there any questions? Let's take a break before the practical application?

(BREAK 10 min)

INTERIM TRANSITION: Are there any questions before the practical application?

(On SLIDE #58)

INSTRUCTORS NOTE:
Conduct load calculation practical exercise.

PRACTICAL APPLICATION: (0.5 Hrs) Have the students conduct Live and Dead Load Calculations in the classroom in order to determine proper footing/foundation system dimensions.

PRACTICE: Conduct Live and Dead Load Calculations utilizing the proper steps taught.

PROVIDE-HELP: Ensure students have all training aids, such as: Practical Exercise Worksheet, calculators, extra sheets of paper, and references. Walk around the classroom and aid the students in their calculations, reminding them of the reference tables provided in their handouts. Ensure they have a thorough understanding of the trial width footing dimension and the design width dimensions as to how those numbers relate to the safe load of the proposed structure.

SAFETY BRIEF: No safety concerns with this class.

SUPERVISION & GUIDANCE: Be sure to follow the step by step directions covered in your student outline and from the demonstration presented earlier.

DEBRIEF: Now that we have conducted Live/Dead Load Calculations on different proposed building dimensions and construction materials, you will now be able to properly determine what proper footer/foundation system dimensions that can safely support your future vertical construction projects.

INSTRUCTORS NOTE:
The Student Outline will have a blank computation sheet. Prior to the brief practical exercise, erase all computations from the dry erase board.

INTERIM TRANSITION: We have spent the last 30 minutes determining proper footing dimension. Are there any questions? Let us finish up our discussion on footings.

(On SLIDE #59)

g. Steel reinforcement is added to the footings to prevent the concrete from cracking and add additional support. The steel reinforcement bars are normally 3 or 4 lengths of 3/8" or 1/2" bars that run parallel to the length of the footings. These reinforcement bars must be placed 1 1/2" below the top of the footings to be effective.

h. When a concrete wall is to be poured on top of the footing, a key-way must be formed in the top of the footing, and steel rebar must extend vertically into the wall form, so footings will interlock with the concrete wall and provide a stronger bond between footing and wall.

i. Column footings are required to carry concentrated loads inside the building. They are usually square with a tapered top which the post or column rests on.

j. The size of the footing depends on the load-bearing capacity of the soil, and the load it will support. An ordinary column footing that is 24" x 24" x 12" will support 16,000 lbs if the soil bearing capacity is 4000 lbs per square feet.

(On SLIDE #60)

k. A steel pin is inserted into the footing during the pour, and extends a minimum of 14" through the top if a wooden column is going to be used. After the concrete has cured, the wooden column is seated onto the steel pin so it will be interlocked with the footing.

l. If concrete blocks are to be used as a pier, then rebar must extend from the footing into the cores of the concrete block for reinforcement. The cores of the concrete blocks are filled with masonry cement for additional stability, and the base course of block is bonded to the footing with masonry cement.

m. In the case where poured concrete will be used as a pier, steel rebar must be used in the column to prevent bending. Rebar extends vertically from the footing into the column form, and the rebar is tied together with tie wire to prevent the rebar from bulging during the pour.

n. The maximum spacing of pier-and-column footings must not exceed 8' o.c.. This spacing will provide more than sufficient support for built-up girders that are to be supported.

(On SLIDE #61)

TRANSITION: We have just covered footings. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning footings? (Answer students questions.)

2. QUESTIONS TO THE CLASS:

a. What type of loads must footings be able to support safely?

ANSWER: Live and Dead loads.

b. What is the maximum pier footing spacing when supporting girders?

ANSWER: 8 foot on center.

TRANSITION: If there are no more questions next we will discuss foundation walls.

(On SLIDE #62)

8. **FOUNDATION WALLS**: **(30 Min)** The function of the foundation wall is to support the superstructure of the building above the ground line, and to transmit the weight of the structure to the footing.

a. Foundation walls can be constructed from concrete, concrete block, brick, or stone.

b. Poured concrete walls are considered more reliable, but require more labor to construct forms, and also requires time for the concrete to set and harden.

c. Concrete walls should not be less than 8" thick. Anything less than that will cause the walls to fail in shear or buckle due to earth pressures.

d. Foundation walls, supporting wood frame construction, must extend a minimum of 8" above the finish grade to prevent decay of wooden sills that are fastened to them.

INTERIM TRANSITION: Are there any questions before I demonstrate?

(On SLIDE #63)

INSTRUCTORS NOTE:
Use dry erase board to illustrate and clarify.

DEMONSTRATION. **(5 min)** Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of wooden sill construction.

STUDENT ROLE: Observe typical wooden sill fastening procedure to foundation wall.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', wooden sill material and construction procedure.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen is a typical wooden sill construction used in a vertical project.

INTERIM TRANSITION: Are there any questions on the demonstration. If not, let's move on with our discussion on wooden sills.

(On SLIDE #64)

e. When fastening wooden sills to the top of concrete foundation walls, anchor bolts are initially set at a distance of 6" in from each outside corner of the walls.

(1) Thereafter, anchor bolts are spaced at every 6' to 8' O.C. There must be at least 2 anchor bolts in each wooden sill.

(2) The hole that is drilled in the wooden sills must be 1/16" larger than the diameter of the bolt. The diameter of the anchor bolts, used in light frame construction, must not be less than 1/2" in diameter.

(3) Once anchor bolts have been set it is important that the alignment is not disturbed. These types of anchors allow the structural floor to be securely fastened to the foundation walls.

(On SLIDE #65)

TRANSITION: We have just covered foundation walls and wooden sills. Are there any questions?
OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning foundation walls? (Answer students questions.)

2. QUESTIONS TO THE CLASS:

a. What is the purpose of a foundation wall?

ANSWER: To support the weight of the superstructure, and transmit the loads to the footings.

b. How far above the ground line must foundation walls extend when supporting wood frame walls?

ANSWER: A minimum of 8 inches.

(BREAK 10 Min)

TRANSITION: Before the break we covered foundation walls and wooden sills. Do you have any questions? If not, let's discuss the fundamental characteristics of concrete slabs.

(On SLIDE #66)

9. **CONCRETE SLABS**: **(50 Min)** Ground-supported slabs rest directly on a base course (slab bed) consisting of undisturbed soil, compacted fill, or base course material. Ground-supported slabs are designated as types I, II, III, or IV.

(On SLIDE #67)

a. **Types of Slabs**

(1) Type I Slabs:

(a) Type I slabs are at least 4" nominal thickness, placed directly on dense or compacted base course (slab bed) material. They are generally unreinforced concrete slabs.

(b) Type I slabs should be rectangular or square in shape. No dimension of the slab perimeter should exceed **32' feet** in length. Contraction joints should be placed 15 to 20 feet apart.

(c) The slab bed soil types for Type I slabs may be GW, GP, (all densities); GM, GC, SW, SP, SM, SC, (dense or medium dense); and ML, or MH (loose if compacted to entire depth).

(On SLIDE #68)

(2) Type II Slabs:

(a) Type II slabs are at least 4" nominal thickness, and can be constructed on the same soils suitable for Type I slabs. They are reinforced concrete slabs.

(b) No dimension of the slab perimeter should exceed **75' feet** in length. Expansion joints should be placed 15 to 20 feet apart.

(c) Reinforcement wire for dimensions up to 45 feet requires 6x6 10 ga. wire mesh, 6x6 8 ga. wire for dimensions of 45 to 60 feet, and for dimensions from 60 to 75 feet, 6x6 6 ga. wire is required.

(On SLIDE #69)

(3) Type III Slabs:

(a) Type III slabs are constructed over problem soils. They are reinforced and stiffened to transmit structure loads to the foundation soil.

(b) Type III slabs can be built on problem soils such as CL, OL, CH, OH. High organic soils (PT) should not be used to support Type III slabs.

(On SLIDE #70)

(4) Type IV Slabs:

(a) Type IV slabs are greater than 4" nominal thickness. The base course (slab bed) material functions as only as a form to provide temporary support during curing.

(b) They do not depend on the foundation soil for support.

(c) The soil types for Type IV slabs can be CL, OL, CH, OH, and PT.

(d) Type IV slabs must be designed by professional structural engineers. Structurally supported slabs are independently supported and rest on foundation walls, and piers. They are structurally reinforced, and can be used over very poor soils and are designated as Type IV.

(On SLIDE #71)

b. The type of slab to be poured falls into 6 specific classifications for projects requiring slab work. These classifications enable us to design the minimum thickness required for a slab to carry a load without failing.

(On SLIDE #72)

(1) Class 1:

(a) Light foot traffic.

(b) Used for light frame structures.

(c) Minimum of 4" thick.

(d) 28 day compressive strength of 3,500 psi.

(On SLIDE #73)

(2) Class 2:

(a) Medium foot traffic.

(b) Used in offices and class rooms.

(c) Minimum of 4" thick.

(d) 28 day compressive strength of 3,500 psi.

(On SLIDE #74)

(3) Class 3:

(a) Pneumatic wheeled traffic.

(b) Used for drives, sidewalks, and garages.

(c) Minimum of 4" thick.

(d) 28 day compressive strength of 3,500 psi.

(On SLIDE #75)

(4) Class 4:

(a) Heavy foot and pneumatic wheeled traffic.

(b) Used for light industrial structures.

(c) Minimum of 6" thick.

(d) 28 day compressive strength of 4,000 psi.

(On SLIDE #76)

(5) Class 5:

(a) Heavy foot and abrasive wheeled traffic.

(b) Used for medium industrial structures.

(c) Minimum of 6” to 8” thick.

(d) 28 day compressive strength of 4,500 psi.

(On SLIDE #77)

(6) Class 6:

(a) Heavy foot and steel tire traffic.

(b) Used for heavy industrial structures.

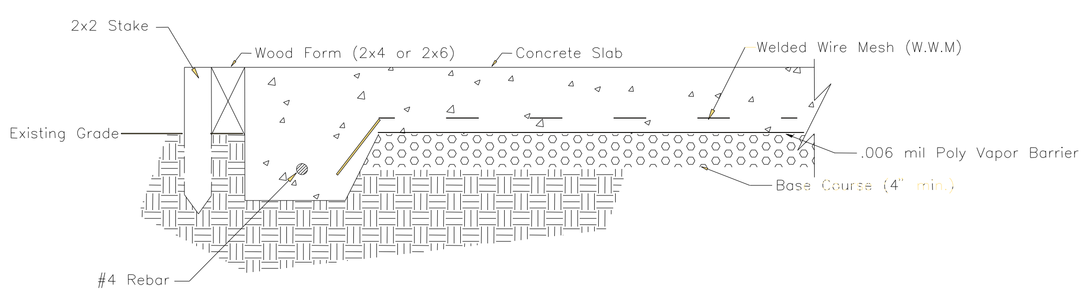
(c) Over 8” thick

(d) 28 day compressive strength of 5,000 to 8,000 psi.

(On SLIDE #78)

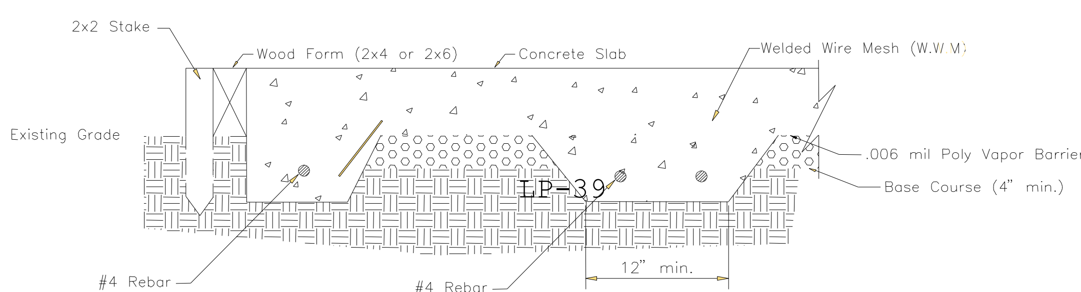
c. The excavation for the slab foundation is made for the footings only. The depth of the footings is dictated by the depth required to ensure the bottom of the footing is below the frost line. If bearing walls are erected on the slab, the width of the footing base is twice the width of the wall itself.

On SLIDE #79)



SLAB–ON–GRADE ELEMENTS

(On SLIDE #80)



d. The slab itself is placed on the ground surface and is formed using either 2" x 4" or 2" x 6" form material.

e. Slab foundations must have a base course lift of a minimum of 4" of compacted gravel, sand, or crushed rock under the concrete slab to act as an insulator and provide additional stability for the slab itself.

f. A polyethylene vapor barrier of at least .006 mil plastic is placed between the gravel base course and the concrete slab to prevent moisture from seeping through the concrete to its surface. For large areas that need to be covered, the poly vapor barrier is lapped a minimum of 6".

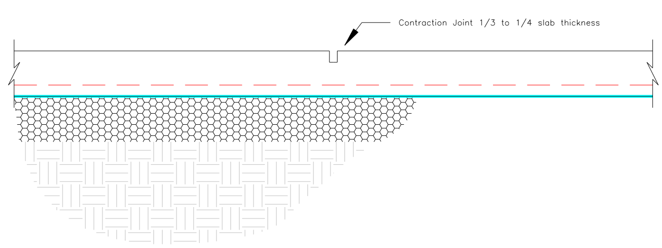
g. The entire foundation is poured in place, and the top of the slab is leveled. Prior to the slab being poured, 6" x 6" #10 gage wire mesh reinforcement is placed to reinforce the slab (minimum of 1" above the base), and 1/2" reinforcement bars are added to the footings (minimum of 1 bar at 1 1/2" above the base).

(On SLIDE #81)

h. Construction joints are divisions made between concrete work that is placed at intervals, and spaced widely enough to allow partial hardening of the concrete. These construction joints are found in large concrete slab work. Foundation walls are bonded to the footings with a construction joint called a key-way. The other two types of construction joints are contraction joints and expansion joints.

(On SLIDE #82)

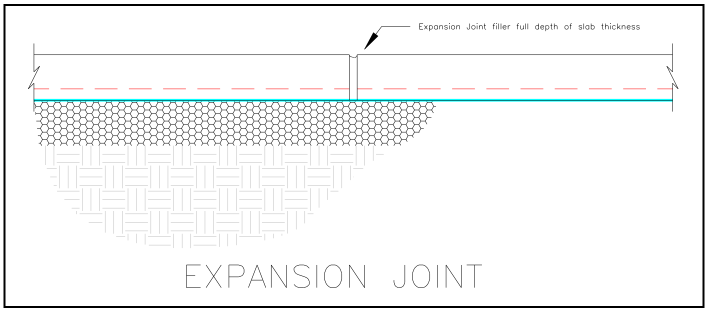
(1) Contraction Joints: The purpose of contraction joints is to control cracking caused by temperature changes which case concrete to shrink. A contraction joint is made by cutting a joint at a depth of 1/3 to 1/4 the thickness of the slab, and then filling the joint with asphalt. These joints are placed at 15' to 25' intervals in both directions in the slab.



CONTRACTION JOINT

(On SLIDE #83)

(2) Expansion Joints: Expansion joints are placed between section pours of large concrete slab work and walls. These joints are made from a mastic filler or bituminous material which are placed every 20'.



(On SLIDE #84)

TRANSITION: We have just covered concrete slabs. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning concrete slabs? (Answer students questions.)

2. QUESTIONS TO THE CLASS:

a. What is the maximum perimeter length for a type II slab?

ANSWER: 75 feet.

b. What class of slab would be constructed for a light frame structure?

ANSWER: Class 1.

(BREAK 10 Min)

TRANSITION: Before the break we covered the fundamental characteristics of concrete slabs. Do you have any questions? If not, let's discuss concrete form construction.

(On SLIDE #85)

10. **CONCRETE FORMS**: **(30 Min)** Forms play a major role in concrete construction. They give concrete its shape and hold it in place until it hardens, and support any reinforcement bars placed in the concrete. Concrete will have a honeycomb effect if designed forms are not tight when constructed.

(On SLIDE #86)

a. The basic components for wooden forms for concrete walls are:

(1) Sheathing: Sheathing forms the vertical surface of the concrete wall. Sheathing is placed horizontally, and for economical reasons plywood is the best choice. Plywood of 1/4" is used for curved form work, and 5/8" and 3/4" are more suitable for straight walls.

(2) Studs: Sheathing must be reinforced with studs to prevent bulging. Studs are attached vertically to the sheathing, and are made from either 2" x 4" or 2" x 6" lumber and spacing is dictated by the height of the form walls. Spacing starts as low as every 6” on center, to as much as 4 feet on center.

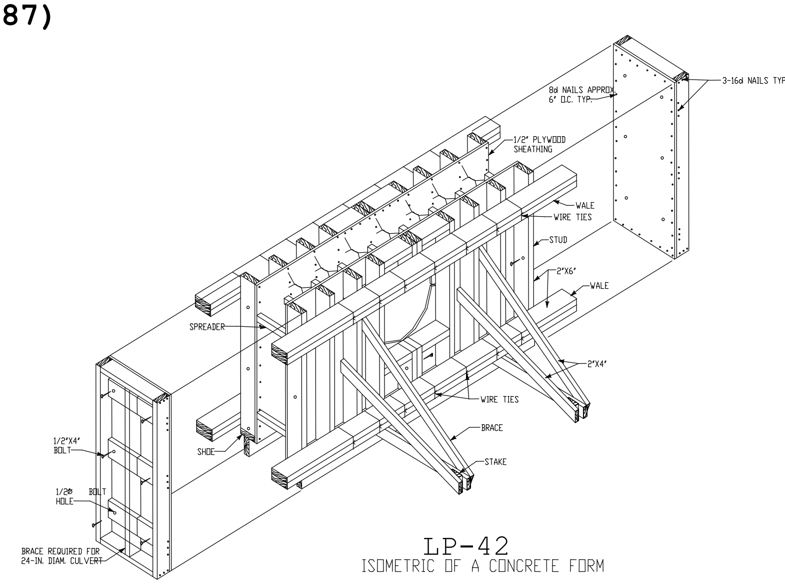
(3) Wales: Wales must be designed as an integral part of the forms to reinforce the studs when they extend more than 4 feet. Wales are made from doubled 2" x 4" or 2" x 6" lumber lapped at the form corners. Wales also help ensure that the form work stays aligned.

(4) Braces: Braces are not actually part of the forms itself, but are used to help stabilize the form work from shifting. The combination most used is made of a diagonal 2" x 4" nailed to the wale, and a horizontal 2" x 4" nailed to the stud. The ends of the braces are nailed to a stake which is driven into the ground.

(5) Spreaders: Small pieces of wood called spacers are placed between the sheathing panels to maintain the correct wall thickness. A wire is attached to the spreader to pull it out of the fresh concrete once enough pressure has been exerted against the sheathing.

(6) Tie Wire: Tie wires secure the form work against the lateral pressure of the fresh concrete. Tie rods, also called snap ties, are frequently used instead of tie wire because they are much easier to work with.

(On SLIDE #87)



LP-42
ISOMETRIC OF A CONCRETE FORM

(On SLIDE #88)

TRANSITION: We have just covered concrete forms. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning concrete forms? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. What is the purpose of concrete forms?

ANSWER: They give concrete its shape, and holds it in place until the concrete hardens.

b. What form material forms the concrete's vertical surface?

ANSWER: The sheathing.

TRANSITION: Are there any questions before I demonstrate typical framing construction used in a vertical project.

INSTRUCTORS NOTE:
Use dry erase board to illustrate and clarify.

(On SLIDE #89)

DEMONSTRATION. (10 min) Gather the students' attention to the dry erase board and chosen table/desk for a brief demonstration of typical framing construction.

STUDENT ROLE: Observe typical framing construction.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', framing construction with special attention to exterior and interior wall framing.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen is a typical framing construction used in a vertical project.

INTERIM TRANSITION: Are there any questions about the demonstration? If not, let's move on.

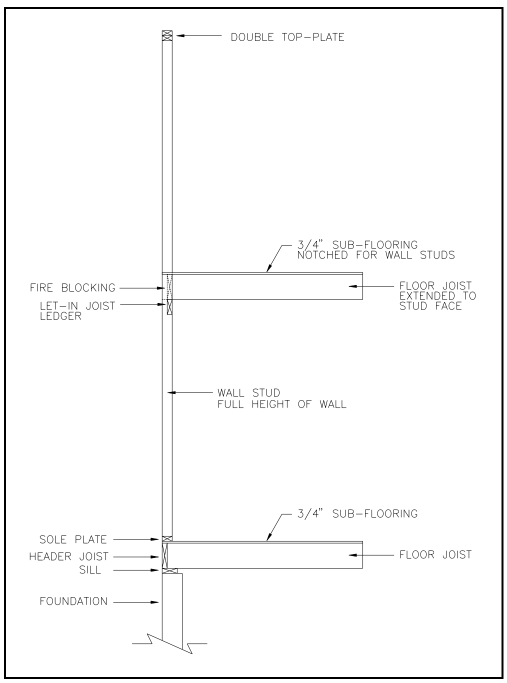
(On SLIDE #90)

11. **FRAMING**: **(50 Min)** The framework of a structure is the skeletal frame that will be covered with sheathing and finish materials.

a. There are two methods used to design the framework of a structure.

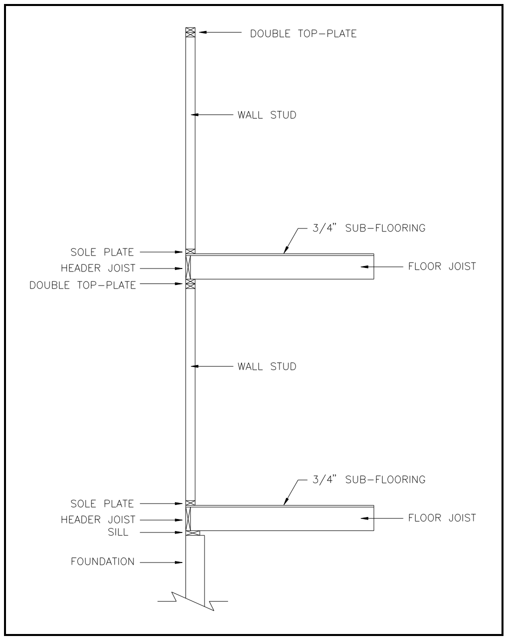
(On SLIDE #91)

(1) Balloon Framing: This method was widely used in the construction of multistory structures. The studs run full length, from sill to rafter. Balloon framing is less rigid than Western framing (Western Platform Framing).



(On SLIDE #92)

(2) Western (platform) Framing: This method is used extensively in light military construction. This is the preferred method when constructing one-story structures since it permits bearing and nonbearing walls to settle uniformly.



b. The stability of the structure depends on the strength of the framing materials that are used and the method of connecting each of the framing members.

(On SLIDE #93)

c. The structure must be designed so the framing materials have the strength to overcome four types of actions:

(1) Tension (Stretching actions)

(2) Compression (Compaction actions)

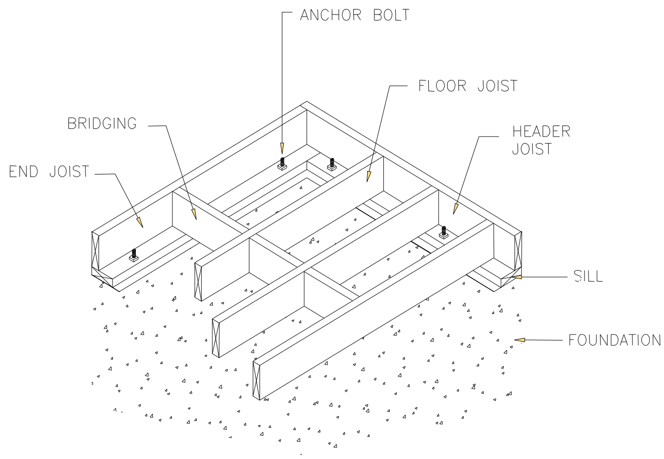
(3) Shear (Cutting actions)

(4) Torsion (Twisting actions)

d. Regardless of the materials and the construction methods that are used, the basic principles of framing have not changed that much over the last couple centuries. Framing is broken down into three basic categories:

(On SLIDE #94)

(1) <u>Floor framing</u> is supported by the foundation walls, and girders with columns.



(On SLIDE #95)

(a) Wooden sills are the first part of the framing to be put in place. The box sill is the most commonly used sill system in platform framing. Sills must be treated lumber to guard against decay and insect damage.

(b) Sills resting on 8" foundation walls, are fastened to the top of the foundation with 1/2" anchor bolts at 6' centers. They are normally treated 2" x 6" or 2" x 8" lumber.

(c) Structural floor members must be supported by built-up wooden girders resting on piers or columns, when the building is wider than 15'. The spacing of the columns which support the girders must not exceed 8' o.c.

(On SLIDE #96)

<u>INSTRUCTORS NOTE</u>:
Refer students to post load chart in outline to clarify.

MAXIMUM LOADS FOR WOODEN POSTS						
Nominal size, inches	3 x 3	4 x 4	4 x 6	6 x 6	6 x 8	8 x 8
Area in square inches	9.51	13.14	20.39	30.25	41.25	56.25
HEIGHT OF COLUMN:						
4 Feet	8,720	12,920	19,850	30,250	41,250	56,250
5 Feet	7,430	12,400	19,200	30,050	41,000	56,250
6 Feet	5,630	11,600	17,950	29,500	40,260	56,250

6.5 Feet	4,750	10,880	16,850	29,300	39,950	56,000
7 Feet	4,130	10,040	15,550	29,000	39,600	55,650
7.5 Feet		9,300	14,400	28,800	39,000	55,300
8 Feet		8,350	12,950	28,150	38,300	55,000
9 Feet		6,500	10,100	26,850	36,600	54,340
10 Feet				24,670	33,600	53,400
11 Feet				22,280	30,380	52,100
12 Feet				19,630	26,800	50,400

INSTRUCTORS NOTE:
Refer students to girder load chart in outline to clarify.

(On SLIDE #97)

(d) Girders carry a large portion of the building weight, and should be large enough to support an ordinary load. When the depth of the girder is doubled, the safe load it can carry is 4 times greater.

SAFE LOADS FOR GIRDERS Safe loads in pounds for spans from 6 to 10 feet					
GIRDER SIZE	**6 ft**	**7 ft**	**8 ft**	**9 ft**	**10 ft**
6 x 8 SOLID	8,306	7,118	6,220	5,539	4,583
6 x 8 BUILT-UP	7,359	6,306	5,511	4,908	4,062
6 x 10 SOLID	11,357	10,804	9,980	8,887	7,997
6 x 10 BUILT-UP	10,068	9,576	8,844	7,878	7,086
8 x 8 SOLID	11,326	9,706	8,482	7,553	6,250
8 x 8 BUILT-UP	9,812	8,408	7,348	6,544	5,416
8 x 10 SOLID	15,487	14,732	13,608	12,116	10,902
8 x 10 BUILT-UP	13,424	12,768	11,792	10,504	9,448

(On SLIDE #98)

(e) Joists are the major structural members of the floor. They are fastened to the sill, and are normally 2" x 8", 2" x 10", or 2" x 12" for spans greater than 10 feet.

(f) A quick method to determine the maximum distance a joist can span, and safely support a live load of 40 lb. per square feet when the joists are spaced every 16 inches is:

1.5 x Joist width = Maximum joist length in feet.

1) 1.5 = A multiplication factor constant that is used to calculate the safe load bearing length of a joist at one and one-half times its nominal width.

2) Joist width = The <u>nominal</u> width of the joist being calculated.

(g) Double joists must be used under all interior partitions walls that run parallel with the joists to support the load of the interior wall.

<u>INSTRUCTORS NOTE</u>:
Refer students to joist span chart in outline to clarify.

MAXIMUM JOIST SPANS							
Selected Species		Southern Yellow Pine	Southern Yellow Pine	Douglas Fir	Southern Yellow Pine	Southern White Pine	Douglas Fir
Grades		**NO. 1**	**NO. 2**	**NO. 3**	**NO. 1**	**NO. 2**	**NO. 3**
Size	**Spacing O.C.**	**30# Live Load**			**40# Live Load**		
2 x 6	12	12-6	11-3	12-0	11-4	10-3	10-11
	16	11-4	10-10	10-11	10-4	9-4	9-11
	24	9-11	8-8	9-7	9-0	7-9	8-8
2 x 8	12	16-6	14-11	15-10	15-0	13-6	14-5
	16	15-0	13-6	14-5	13-7	12-3	13-1
	24	13-1	11-6	12-7	11-11	10-3	11-3
2 x 10	12	21-0	19-0	20-3	19-1	17-3	18-5
	16	19-1	17-3	18-5	17-4	15-8	16-9
	24	16-8	14-7	16-1	15-2	13-1	14-6
2 x 12	12	25-7	23-1	24-8	23-3	21-0	22-5
	16	23-3	21-0	22-5	21-1	19-1	20-4
	24	20-3	17-9	19-7	18-5	15-11	17-6

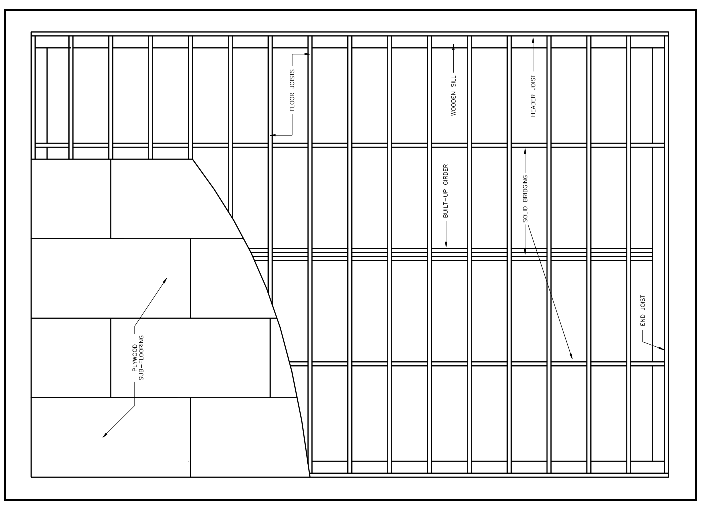
(On SLIDE #99)

(h) Bridging stiffens the floor joists and prevents them from swaying. One line of bridging is required between floor joists when the joists are no more than 8' long, and two lines are required for joists 16 feet long.

(i) Plywood sheathing, 5/8" or 3/4”, is used as sub-flooring to tie all structural floor members together and provide a smooth surface for finish floors. The joist spacing should not exceed 16" O.C. when a finish floor will be laid parallel to the joists.

(j) Plywood sub-flooring must be laid perpendicular to the floor joists to prevent low spots (sagging) in the floor.

(On SLIDE #100)



(On SLIDE #101)

(2) <u>Wall framing</u> is supported by the foundation and is the vertical skeletal framework of the structures walls.

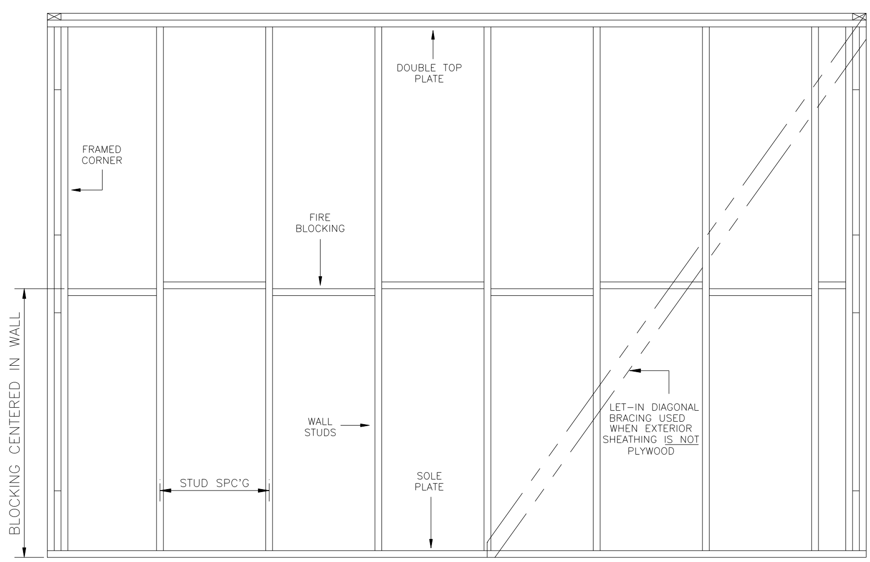
(a) Sole plates and top plates are the nailing bases for studs themselves. After the studs have been nailed to the sole plate and top plate, the walls are stood up and the sole plates are then nailed directly to the floor.

(b) Studs are the vertical framing members for exterior and interior walls of a structure. The normal spacing of studs is 16" O.C., but 24" spacing can be laid out if the correct sheathing material is applied. The top of the studs are capped with a double top plate, and over lapped to tie in the top of one wall with another.

(c) Let-in diagonal bracing is required at the exterior corners of the walls to stiffen the frame work and counteract wind pressures and lateral movement. Diagonal bracing is laid off at a 45 degree angle from top plate to sole plate. If the exterior walls are covered with plywood sheathing, this type of bracing is not required.

(d) Horizontal fire blocking is nailed between the studs halfway between the sole plate and top plates to help stiffen the walls and reduce the flow of air between wall sections which will slow the spread of a fire inside of the walls.

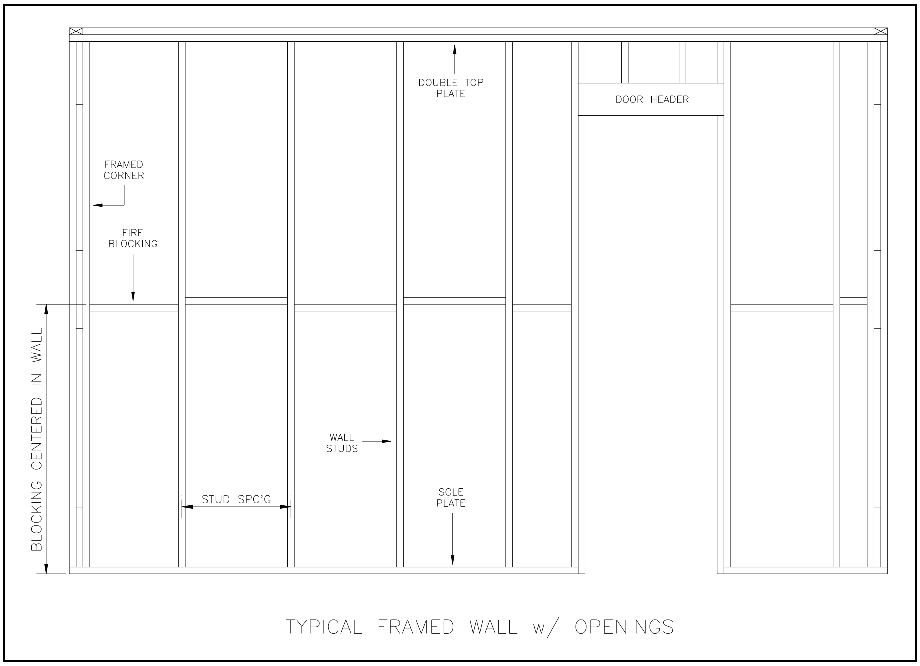
(On SLIDE #102)



TYPICAL FRAMED WALL

(On SLIDE #103)

(e) All door and window openings in walls must have double studs at the jambs. Headers must be placed at the top of all door and window openings to transmit loads from the ceiling and roof to the jamb sides of the opening. Two 2" thick lengths of lumber with a length of 1/2" plywood between them is nailed on edge over the opening.



TYPICAL FRAMED WALL w/ OPENINGS

(f) Plywood sheathing is applied to exterior walls to further stiffen all the walls, and tie all exterior walls together. Plywood of 1/2" is the normal sheathing size used. Plywood sheathing also provides a smooth solid surface to attach siding to.

INTERIM TRANSITION: Any questions on what we just covered before the demonstration.

INSTRUCTORS NOTE:
Perform the following demonstration.

(On SLIDE #104)

DEMONSTRATION. (5 min) Gather the students' attention to the dry erase board and chosen table/desk for a brief demonstration of partition walls.

STUDENT ROLE: Observe the difference between load-bearing and non-load bearing partition wall.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', load bearing and non-load bearing partition wall.

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen are the differences in partition walls.

INTERIM TRANSITION: Are there any questions on the demonstration before we move on?

(On SLIDE #105)

(g) Interior partition walls are of two types:

1) Bearing partition walls.

2) Nonbearing partition walls.

(h) Bearing partitions support ceiling joists, and nonbearing partitions support themselves. These types of walls are framed in the same fashion as the exterior walls, excluding the diagonal bracing.

(i) Interior partition walls are normally covered with paneling or 1/2" sheet rock.

(On SLIDE #106)

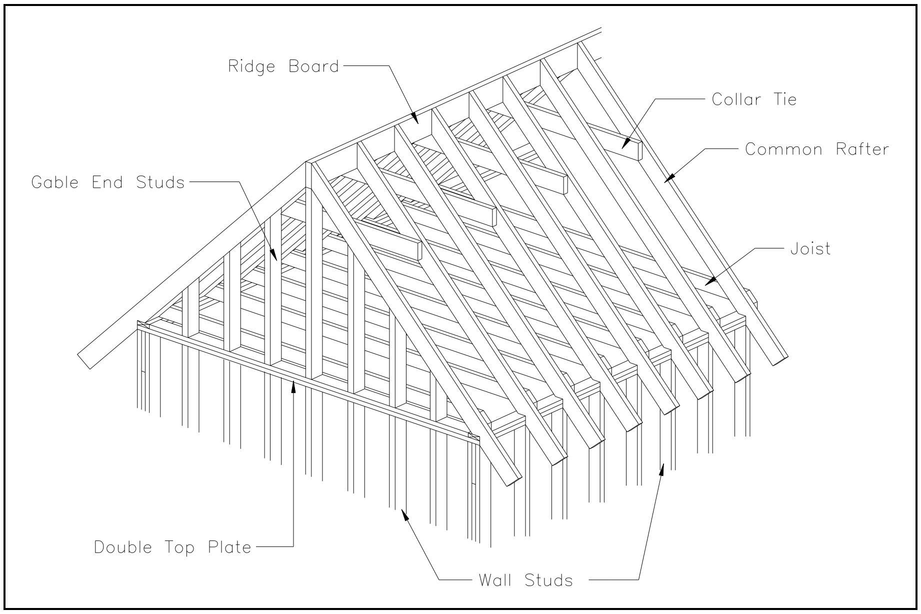
(3) Roof framing is supported by the exterior walls and any interior bearing partition walls.

(a) Roof systems must be sloped to allow water to run off.

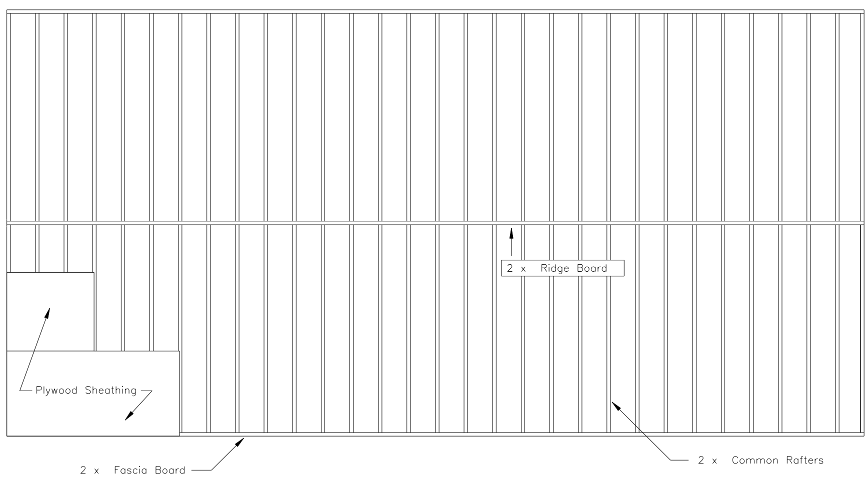
(b) Even though there are several different styles of roofs that can be built, the roof of a structure is designed using one, or a combination of the following three major roof types:

(On SLIDE #107)

1) Gable end roofs have vertical ends with sloped sides.



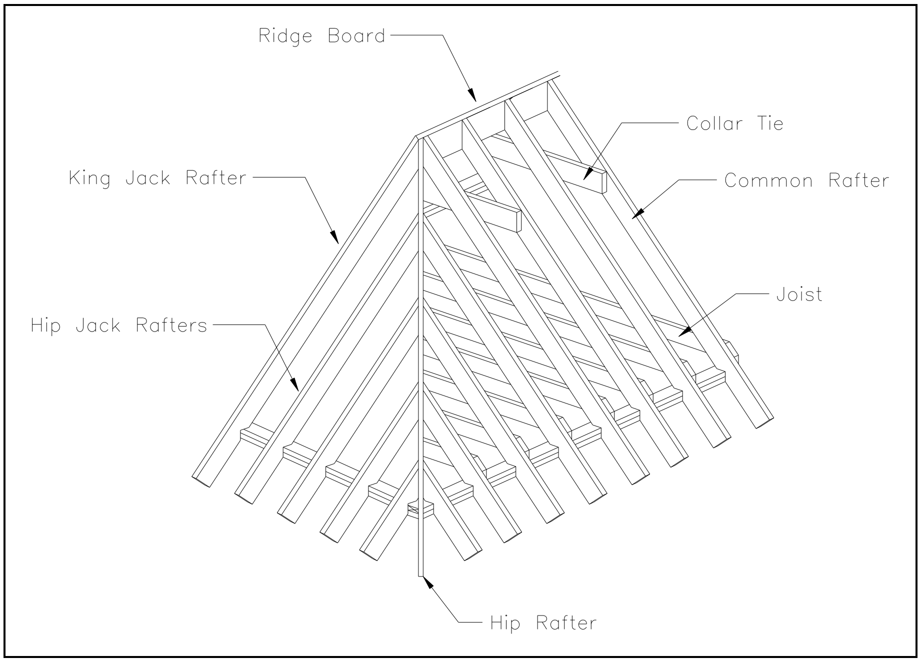
(On SLIDE #108)



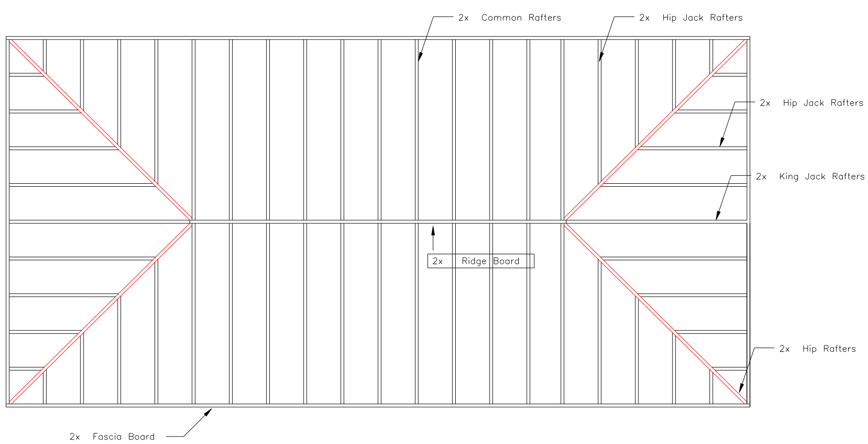
GABLE ROOF FRAMING PLAN

(On SLIDE #109)

2) Hip roofs have all sides sloped with no vertical ends.



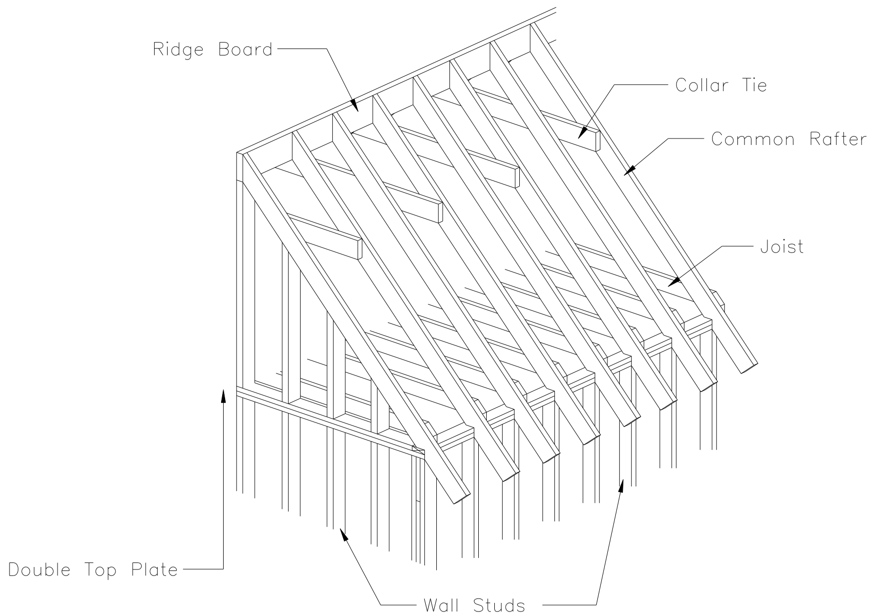
(On SLIDE #110)



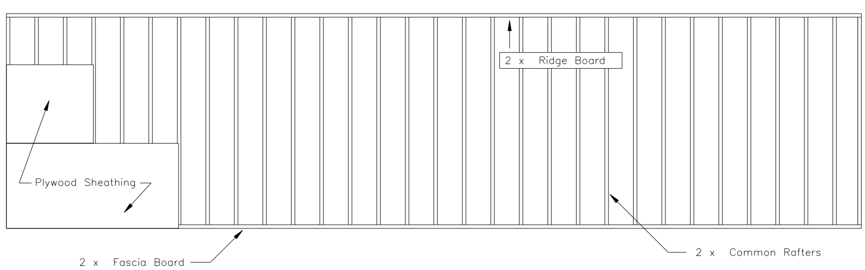
HIP ROOF FRAMING PLAN

(On SLIDE #111)

3) Shed roofs have a single sloped side with vertical ends.



(On SLIDE #112)



SHED ROOF FRAMING PLAN

(On SLIDE #113)

(c) The framework for a roof is designed to be constructed using two methods, and dependent on the type of roof being constructed, each member serves a specific purpose.

1) Joist and rafter construction.

2) Truss construction.

(On SLIDE #114)

(d) <u>Rafters</u>: Rafters make up the main framework of all roofs. They are spaced every 16" or 24" O.C., and their sizes vary depending on their length and spacing. Rafters must fall directly over the top of the framed-in studs to properly transfer the load of the roof to the footings. There are 4 types of rafters that are used in the design of a roof:

(On SLIDE #115)

1) Common rafters.

2) Hip rafters.

3) Valley rafters.

4) Jack rafters.

INSTRUCTORS NOTE:
Refer students to rafter span chart in outline to clarify.

MAXIMUM RAFTER SPANS							
Selected Species		Southern Yellow Pine	Southern Yellow Pine	Douglas Fir	Southern Yellow Pine	Southern White Pine	Douglas Fir
Grades		NO. 1	NO. 2	NO. 2	NO. 1	NO. 2	NO. 2
LOW SLOPE (3:12 or Less)							
Size	**Spacing O.C.**	**20# Live Load-No Finished Ceiling**			**40# Live Load-Finished Ceiling**		
2 x 6	12	16-5	14-2	15-4	13-0	11-0	11-11
	16	14-8	12-4	13-3	11-9	9-6	10-3
	24	12-8	10-0	10-10	9-9	7-9	8-5
2 x 8	12	21-7	18-9	20-3	17-2	14-6	15-8
	16	19-6	16-3	17-6	15-6	12-7	13-7
	24	16-8	13-3	14-4	12-11	10-3	11-1
2 x 10	12	27-6	23-11	25-10	21-10	18-6	20-0
	16	24-8	20-8	22-4	20-0	16-0	17-4
	24	21-3	16-11	18-3	16-6	13-1	14-2
2 x 12	12	33-5	29-1	31-4	26-6	22-6	24-4
	16	30-0	25-2	27-2	24-4	19-6	21-1
	24	25-10	20-6	22-2	20-0	15-11	17-2

MAXIMUM RAFTER SPANS							
Selected Species		Southern Yellow Pine	Southern Yellow Pine	Douglas Fir	Southern Yellow Pine	Southern White Pine	Douglas Fir
Grades		NO. 1	NO. 2	NO. 2	NO. 1	NO. 2	NO. 2
HIGH SLOPE (Over 3:12)							
Size	**Spacing O.C.**	**20# Live Load-Light Roofing**			**40# Live Load-Heavy Roofing**		

2 x 4	12 16 24	11-6 10-5 8-6	10-3 9-1 7-4	11-0 9-6 7-9	8-5 7-3 5-11	7-4 6-4 5-2	7-8 6-8 5-5
2 x 8	12 16 24	18-1 16-4 13-4	15-0 13-0 10-7	16-2 14-0 11-5	13-2 11-5 9-4	10-6 9-1 7-5	11-4 9-10 8-0
2 x 10	12 16 24	23-8 21-6 17-7	19-9 17-1 13-11	21-4 18-5 15-1	17-5 15-1 12-4	13-10 12-0 9-9	14-11 12-11 10-7
2 x 12	12 16 24	30-3 27-5 22-5	25-2 21-10 17-10	27-2 23-7 19-3	22-2 19-3 15-8	17-8 15-3 12-6	19-1 16-6 13-6

INTERIM TRANSITION: Any questions on what we just covered before the demonstration.

INSTRUCTORS NOTE:
Use dry erase board to illustrate "birds-mouth" cut.

(On SLIDE #116)

DEMONSTRATION. (5 min) Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of the "birds-mouth" cut technique.

STUDENT ROLE: Observe the "birds-mouth" cut technique.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', the "birds-mouth" cut fastening technique.

1. **SAFETY BRIEF**: No safety concerns with this class.

2. **SUPERVISION & GUIDANCE**: Ensure all students can see and touch materials being presented.

DEBRIEF: What you have just seen is the type of cut used in fastening rafters to the top-plate of a vertical construction project.

INTERIM TRANSITION: Are there any questions on what we just covered in the demonstration before moving on.

(e) The top of the rafters are fastened to a common ridge board made of 2" nominal lumber, and the end of the rafters are seated and fastened to the wall top plate with the aid of a horizontal bearing cut known as a "birds-mouth". The birds-mouth must be cut deep enough so the rafter bears on the full width of the top plate.

(f) The ends of the rafters extend beyond the outside walls to form an eave (overhang). The ends of the eaves generally extend 6 to 24 inches past the outside walls in increments of 6 inches.

(On SLIDE #117)

(g) <u>Ceiling Joists</u>: Joists run parallel to the roof rafters and bear on the top plate of the exterior walls, and on the top plate of interior bearing walls, or girders for large spans. The bottom of these joist provide the nailing surface for a ceiling of all interior spaces which call for a finish ceiling.

<u>INSTRUCTORS NOTE</u>:
Refer students to ceiling joist span chart in outline to clarify.

MAXIMUM CEILING JOIST SPANS							
Selected Species		Southern Yellow Pine	Southern Yellow Pine	Douglas Fir	Southern Yellow Pine	Southern White Pine	Douglas Fir
Grades		NO. 1	NO. 2	NO. 2	NO. 1	NO. 2	NO. 2
Size	**Spacing O.C.**	No Attic Storage-Drywall Ceiling			No Attic Storage-Drywall Ceiling		
2 x 4	12 16 24	13-2 11-11 10-5	11-10 10-9 9-5	12-8 11-6 9-11	9-1 8-3 7-3	8-3 7-6 6-6	8-9 8-0 7-0
2 x 6	12 16 24	20-8 18-9 16-4	18-8 16-11 14-2	19-11 18-1 15-7	14-4 13-0 11-4	12-11 11-9 10-0	13-9 12-6 10-11
2 x 8	12 16 24	27-2 24-8 21-7	24-7 22-4 18-8	26-2 23-10 20-6	18-10 17-2 15-0	17-0 15-6 13-2	18-2 16-6 14-5
2 x 10	12 16 24	34-8 31-6 27-6	31-4 28-6 23-1	32-9 29-9 26-0	24-1 21-10 19-1	21-9 19-9 16-10	23-2 21-1 18-5

<u>INTERIM TRANSITION:</u> Any questions on what we just covered before the demonstration.

<u>INSTRUCTORS NOTE</u>:
Use dry erase board to illustrate and clarify.

(On SLIDE #118)

<u>DEMONSTRATION</u>. (5 min) Gather the students attention to the dry erase board and chosen table/desk for a brief demonstration of collar beam and gable end construction.

STUDENT ROLE: Observe the collar beam and gable end construction technique.

INSTRUCTOR(s) ROLE: Visually demonstrate, by illustration and/or actual samples, to the students', collar beam and gable end construction and fastening technique.

1. **SAFETY BRIEF:** No safety concerns with this class.

2. **SUPERVISION & GUIDANCE:** Ensure all students can see and/or touch materials being presented.

DEBRIEF: What you have just seen is typical collar beam and gable end contruction technique.

INTERIM TRANSITION: Are there any questions on what we just covered in the demonstration before moving on.

(h) Collar beams are short lengths of 2" x 4"s or 1" x 6"s nail across opposite rafters to stiffen the roof against wind pressures. They are place approximately 1/3 the distance down from the ridge board, and are only fastened to every third set of rafters.

(i) The gable ends of a roof must be framed with gable studs using the same spacing as the wall studs below. This provides a nailing surface for the exterior sheathing and any siding that will be attached. For ventilation of the attic space, a screened vent with louvers is framed into the gable ends and ~~are~~ the opening size must be 1/300 of the area of the ceiling below.

(On SLIDE #119)

(j) Sheathing: The roof covering can be made of 1" x 6"s butted side-to side and end-to-end, or more commonly, can be exterior grade plywood. Plywood is the easiest to work with and for light roof coverings 1/2" plywood is used, and for heavier roofing materials 3/42" plywood must be used. Another critical factor that dictates the size of plywood to use is the spacing of the rafters or truss's below. Regardless of what material is used for the roof decking, it must be run perpendicular to the rafters or truss's to properly stiffen and tie the roof framework together.

(On SLIDE #120)

(k) Truss's: The basic shape of a truss is a rigid structural triangle. Trusses are lightweight framed wood members, which have gusset plates that connect and reinforce the intersections of the webbing to the joist and rafter members. Truss's can be made of thinner dimensional lumber to cross larger spans, and are less time consuming to erect in place.

(On SLIDE #121)

TRANSITION: We have just covered framing. Are there any questions?
OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning framing? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. What are the two types of framing methods that are used?

ANSWER: Balloon and Western (platform) framing.

b. What is the main framework member in rafter and joist roof construction?

ANSWER: The rafter.

(BREAK-10 min)

TRANSITION: We have spent the last 90 minutes discussing framing. Next we will discuss frame finishes.

(On SLIDE #122)

12. **FRAME FINISHES**: **(30 Min)** Finish materials come in several classifications of use. We will discuss only a few of these types of finishing materials as they relate to temporary structures.

a. For exterior walls 15 lb. roofing felt is applied to the sheathing to protect it against moisture damage. Vertical siding (T1-11, or board-and-batten), or horizontal siding (lap siding or wooden shakes) are normally used as the exterior wall covering.

b. After the plywood sheathing has been laid for the roof deck, 30 lb. roofing felt is applied to the sheathing to protect it against moisture damage. Then either asphalt roll roofing or asphalt shingles are applied to all roof surfaces. Galvanized flashing must be applied to roof valleys, and eave stripping is applied around all roof edges to protect against water damage.

c. Paint is another exterior covering material that will help protect exposed exterior siding materials against the elements, and improve rough appearances.

(On SLIDE #123)

d. Doors and Windows are available in various types and sizes. Determining what size and style to use does not take a lot of effort to decide. To aid you in your decision making, use the follow guidelines:

(1) Select door sizes appropriate for the room it will provide access to. (i.e. Exterior doors are normally 3/0 wide, and interior doors are 2/10 to 2/6 wide depending on its need.)

(2) Exterior doors are normally solid core doors, for security reasons, and interior doors are usually hollow core constructed.

(3) Window styles are determined by their intended need. Normally Double-hung windows are sufficient for temporary structures requiring windows.

(On SLIDE #124)

TRANSITION: We have just covered frame finishes. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning frame finishes? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. Why is roofing felt used to cover the plywood sheathing on exterior walls and roof decking?

ANSWER: To guard against moisture damage.

b. What type of window is normally used in temporary structures?

ANSWER: Double-hung windows.

INTERIM TRANSITION: Are there any other questions before we start on your practical applications?

(On SLIDE #125)

INSTRUCTOR NOTE:

Perform the following Practical application

PRACTICAL APPLICATION: (3.5 Hrs) Have the students conduct Live and Dead Load Calculations in the classroom in order to determine proper footing/foundation system dimensions.

PRACTICE: Conduct Live and Dead Load Calculations utilizing the proper steps taught.

PROVIDE-HELP: Ensure students have all training aids, such as: Practical Exercise Worksheets, calculators, extra sheets of paper, and references. Walk around the classroom and aid the students in their calculations, reminding them of the reference tables provided in their handouts. Remind them that these practical exercises will be part of their examination. Ensure they have a thorough understanding of the trial width footing dimension and the design width dimensions as to how those numbers relate to the safe load of the proposed structure.

SAFETY BRIEF: No safety concerns with this class.

SUPERVISION & GUIDANCE: Be sure to follow the step by step directions covered in your student outline and from the demonstration presented earlier.

DEBRIEF: Now that we have conducted Live/Dead Load Calculations on different proposed building dimensions and construction materials, you will now be able to properly determine what proper footer/foundation system dimensions that can safely support your future vertical construction projects.

(On SLIDE #126)

TRANSITION: We have just completed the practical application of conduct Live and Dead Load Calculations. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS: Do you have any questions concerning Live and Dead Load Calculations? (Answer students' questions.)

2. QUESTIONS TO THE CLASS:

a. If your trial width number is greater than the calculated required design width dimension, is your proposed vertical construction design structurally safe and sound?

ANSWER: Yes.

b. Why is the soil bearing capacity (psf) divided from the total live and dead load (psf) of your proposed vertical construction?

ANSWER: The soil bearing capacity (psf) is divided from the total live and dead load (psf) of the proposed vertical construction in order to determine calculated and required footer width. Also, in order to determine if the proposed footer width (trial width) can support the superstructure.

(On SLIDE #127)

SUMMARY: **(5 Min)**

During this lesson you have learned the three phases of construction, properties of construction materials, and design considerations for foundations and framing. You have also spent plenty of time performing load calculations in proper determination of footer and foundation dimensions. Keeping these basic fundamentals in mind during the design of a structure will ensure the building is structurally sound and safe. Please turn in your IRFs and take a break.

(BREAK-10 min)

REFERENCES:

Engineering Field Data	MCRP 3-17A
Materials Testing	MCRP 3-17.7H
Drafting	ANSI A-A-52034A
Carpentry	MCRP 3-17.7C
Concrete and Masonry	MCRP 3-17.7D
Construction Drafting	TM 5-581B
Construction Print Reading in the Field	TM 5-704
Engineer Aid 3	NAVEDTRA 10696
General Drafting	FM 5-553
General Engineering	MCWP 3-17.7
Plumbing, Pipe Fitting, and Sewerage	MCRP 3-