## Lesson 2.1 Building Design and Construction - Overview

### Preface

Over the last three thousand years, structures have provided shelter from elements such as wind, rain, sun, cold, and dust. Structures today are built using methods and techniques that have withstood the test of time.

It is common to use wood framed construction for residential structures. Although the methods of wood framed construction have changed little, the materials used in the construction of walls and roofs have advanced significantly from early primitive structures. Structures today provide much better protection from harsh temperatures, wind, rain, and snow than structures in primitive times. Glazing is frequently used to allow natural light to enter a structure and create a space that is pleasing to the occupants.

A roof must be designed and constructed with the natural elements in mind. Anticipated wind, rain, and snowfall will determine the size and the shape of the roof system. Engineers also consider the geographic location when designing the roof system. Trusses and beams are used to transfer the load from the space above.

In this lesson students will design a basic shed. This lesson allows students to become familiar with common building practices and terminology.

### Understandings

- 1. Many residential structures are constructed with wood framing systems and are built using standard practices.
- 2. A variety of roof shapes and materials are available for residential structures to address aesthetic preferences, carry design loads, and meet environmental challenges.
- 3. Designers design, modify, and plan structures using 3D architectural software.
- 4. Architects and engineers use a variety of views to document and detail a building project on construction drawings.

### **Knowledge and Skills**

It is expected that students will:

- Identify typical components of a residential framing system.
- Recognize conventional residential roof designs.
- Model a common residential roof design and detail advantages and disadvantages of that style.
- Use 3D architectural software to design, model, and document a small building.

### **Essential Questions**

- 1. Why is wood so often used for residential buildings?
- 2. What alternatives to wood frame construction are available and what are the advantages and disadvantages of each?
- 3. How are trusses able to span large distances?
- 4. What framing systems are used to support residential roofs?
- 5. How are different roof styles and pitches related to different architectural styles?

# 6. Lesson 2.1 Building Design and Construction - Key Terms

Key Term	Definition
Felt	A tar-impregnated paper used for water protection under roofing and siding materials.
Floor Joists	Horizontal structural members used to carry the floor and ceiling loads.
Header	A horizontal structural member used to support other structural members over openings doors and windows.
House Wrap	Engineered materials designed to keep out liquid water and prevent air infiltration while water vapor to escape from inside the home.
Insulation	Material used to restrict the flow of heat, cold, or sound from one surface to another.
Sheathing	A covering placed over exterior studs or rafters that serve as a base below the exterior materials.
Siding	Material, such as boards or shingles, used for surfacing the outside walls of a frame built
Sill	A horizontal wood member placed at the bottom of walls and openings in walls.
Solar Orientation	Consideration of the solar orientation of a building based on the relative position of the s to purposely increase or decrease the amount of light or heat transferred to the building
Source Reduction	Reducing waste by changing patterns of production and consumption.
Stud	The vertical framing member in frame wall construction.
Subfloor	The structural floor joined to the joists that support the finish flooring.
Sustainability	Meeting the needs of society in ways that can continue indefinitely into the future withou or depleting natural resources.
Top Plate	A horizontal structural member located on top of the studs used to hold the wall togethe
Truss	An assembly of structural members joined to form a rigid framework, usually connected triangles.

#### Wood Framing Systems

Gable & Valler

<ul> <li>Floor Joists</li> </ul>	1
<ul> <li>Subfloor</li> </ul>	
•Walls	
<ul> <li>Top Plate</li> </ul>	ł
•Window Opening	
<ul> <li>Roof Trusses</li> </ul>	

Insulation Sheathing Vapor Barrier Siding Underlayment Asphalt Shingles



Roof shingles made of asphalt-saturated felt and covered with mineral granules.

#### **Residential Wall Systems**

- Building Walls
- · Wood Framed Walls
- · Precast Concrete Walls
- · Light Gauge Steel Framed Walls
- · Sustainable Walls

#### Wood Framed Walls Sustainable Walls Manufacturers who create construction materials and components use ENERGY STAR and LEED Wall cavities are **Building Walls** filled with criteria during the production process of their products. This practice ensures that builders will insulation after Walls are typically constructed from wood, select products that will create a sustainable wiring and structure pre-cast concrete, and steel. plumping is installed. w.usgbc.org **Roof Types** Roof Pitch Roof pitch Run 12 in. Gable with Dorme determined by rise/run Rise 7 in. Control and i Dig 🖉 Example.

### Lesson 2.2 Cost and Efficiency Analysis - Overview

Hin & Valley

#### Preface

Low-Slope

Gambrel

Cost and guality are concerns as any structure is built. In fact customers often have a general idea of the type of structure they desire. Companies must often compete through a bid process to try to gain a job. This can be tricky for even the most experienced in the construction field. Materials and labor must be paid for and profit must be made. Winning a bid by underestimating a project could be a disaster. In such a situation, a job can only be finished at a loss. Reasonable estimates of how long a job will take are also important. Paying employee overtime is expensive, and jobs that take longer than estimated can tarnish a builder's reputation.

A 7/12 (pronounced "seven twelve") pitch means that the roof rises 7 in. for every 12 in. horizontally.

This lesson introduces students to some common costs of construction. Students should also consider how systems implemented into a design can affect the usability and recurring costs that a structure will incur during use. Creating smart designs may be expensive up front, but such strategies make sense for the end user in terms of comfort and cost over time.

#### Understandings

- 1. The combination of concrete and rebar, called reinforced concrete, is an important component of residential foundations.
- 2. Accurately determining the cost and quantities for a construction project can ensure a successful building project providing a high quality structure with less material and financial waste.
- 3. An effective residential structure should include methods for adequate heating and cooling.

4. R-value and U-factor measurements are used to select materials that with ensure a structure is properly insulated.

### **Knowledge and Skills**

It is expected that students will:

- Apply basic math skills to calculate the quantity and cost of concrete needed to pour the pad for a small building.
- Create a cost estimate for a small construction project, including a detailed cost break-down.
- Calculate the heat loss for a building envelope with given conditions appropriate for the project.

### **Essential Questions**

- 1. What is the difference between R-value and U-value? When are they used?
- 2. What are some leading causes of solar gain?
- 3. What key areas of a building can minimize heat loss?
- 4. Why is a cost estimate important to create before starting a project?

Term	Definition
Compression Strength	The maximum compressive stress a material can withstand without failure.
Concrete	A solid, hard material produced by combining Portland cement, aggregates, sand, water and sometimes additional mixtures.
Design Temperature Differential	The difference between the indoor temperature in winter and the outdoor design temperature in winter. The design temperature differential or design range is used in calculating the space heating requirements of a dwelling unit under the engineering-based methodology.
Fascia	The finish board covering the edges of rafters and eaves.
Footing	The lowest, widest part of the foundation that distributes the load over a broad area of the soil.
Foundation	The lower part of a building, which transfers structural loads from the building to the soil.
Heat Loss	The energy needed to warm outside air leaking into a building through cracks around doors, windows, and other areas.
Radiant Heat	Energy radiated or transmitted as rays or waves, in the form of particles.
Rafter	Member of a roof structural frame that supports the sheathing and other roof loads.
Rebar	Steel bar used to reinforce concrete.
R-Value	The numerical value used to indicate the resistance to the flow of heat.
Sole Plate	The plate placed at the bottom of a wall.

### Lesson 2.2 Cost and Efficiency Analysis - Key Terms

Square (Quantity of Shingles)	In roofing, 100 square feet of roofing material.
Tensile Strength	The maximum stress a material subjected to a stretching load can withstand without tearing.
Thermal Conduction	The process of heat transfer through a solid by transmitting kinetic energy from one molecule to the next.
Thermal Convection	Heat transmission by the circulation of a liquid or a heated gas or air.
Transmission Load	Heat loss/gain resulting from the conduction of heat through the building envelope.
U-Factor	A measure of the heat transmission through a building part (as a wall or window) or a given thickness of a material (as insulation) with lower numbers indicating better insulating properties.

#### Estimating the Cost of the Pad

#### Rebar

- Placed every two feet (max.) on a grid
- Sold in 10 ft lengths
- Must be lapped 6 in. to
- maintain strengthMaintain a 3 in. edge distance



#### Estimating the Cost of the Pad



#### Estimating the Cost of the Pad

#### Rebar 16' - D' • Each piece of #4 rebar costs \$4.78. 38 x \$4.78 = \$181.64 Concrete\$392.00 Rebar+\$181.64 Total\$573.64

Other associated costs include material for forms, gravel, and labor.

#### Heat Transfer

Heat escapes through walls and openings when the temperature outside is lower than the temperature inside.



#### **Cost Estimate**

- · A forecast of the cost of a future project
- · Prepared at different levels of a project
- Conceptual Design
- Construction Documents
- Bid Phase
- Includes
  - Quantity take-off
  - Material costs
  - Labor rates and costs
  - Equipment costs
- · Completed with cost estimating software

### British Thermal Unit (Btu)

- 1 watt is approximately 3.4 <sup>Btu</sup>/<sub>hr</sub>
   12,000 <sup>Btu</sup>/<sub>hr</sub> is referred to as a ton in most North American air conditioning applications



#### British Thermal Unit (Btu)

- · Unit of energy used in the United States
- · A Btu is defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit

One Btu is about the amount of energy produced by a burning match.





- Subcontractor quotes

- Indirect costs

- Profit margin

# Formula for Heat Load

### $Q' = AU \Delta T$



**A** = Area under investigation in  $ft^2$ 

Btu

**U** = Coefficient of heat conductivity in  $\overline{\text{fth}_{FF}}$ .

∆T = Difference in temperature between outside and inside conditions in °F

> Click here to return to calculation



#### Convert R-Value to U-Factor



R value does not change with quantity of item ( window, door) R-value is directly related to the materials involved.