

Explore the Nature of Materials

Unit: Historical Perspectives of the Drafting and Design Field Industry

Problem Area: History and Art of Design

Lesson: Explore the Nature of Materials

- **Student Learning Objectives.** Instruction in this lesson should result in students achieving the following objectives:

- 1 Identify characteristics of materials.**
- 2 Describe different materials.**
- 3 Identify future trends, forms, and specific combinations.**

- **List of Resources.** The following resources may be useful in teaching this lesson:

American Concrete Institute. Accessed July 10, 2008.
<<http://www.concrete.org/general/home.asp>>.

American Institute of Steel Construction (AISC). Accessed July 10, 2008.
<<http://www.aisc.org/>>.

French, Thomas E., and Jay D. Helsel. *Mechanical Drawing: Board and CAD Techniques*, 13th ed. Glencoe/McGraw-Hill, 2003.

Hart, Kelly. "Building Today for Tomorrow," *greenhomebuilding.com*. Accessed July 10, 2008. <http://www.greenhomebuilding.com/sustainable_architecture.htm>.

Kicklighter, Cloise E., and Joan C. Kicklighter. *Architecture: Residential Drafting and Design*. Goodheart-Willcox, 2004.

Madsen, David A., David P. Madsen, and J. Lee Turpin. *Engineering Drawing and Design*, 4th ed. Thomson-Delmar Learning, 2007.



Material ConneXion. Accessed July 10, 2008. <<http://www.materialconnexion.com/Home/AboutUs/tabid/57/Default.aspx> /> .

“Sweet’s Network,” *McGraw Hill Construction*. Accessed July 10, 2008. <<http://products.construction.com/portal/server.pt>> .

■ **List of Equipment, Tools, Supplies, and Facilities**

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

■ **Terms.** The following terms are presented in this lesson (shown in bold italics):

- ▶ concrete
- ▶ cradle-to-cradle materials
- ▶ green materials
- ▶ nanotechnology
- ▶ particleboard
- ▶ plywood
- ▶ prestressed concrete
- ▶ reinforced concrete
- ▶ sustainable materials

■ **Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situation. A possible approach is included here.

Ask students to think about how buildings, products, and bridges were constructed 200 years ago. Answers might include from timber, sod, and stones. Then ask students to think about the building materials that are used now in homes, schools, and other construction. Identify the most commonly used materials, and discuss the possible reasons for popularity. Have students brainstorm ideas about what the future may hold for materials and what trends may affect these changes. You may also show students photos of houses around the globe and discuss the materials used elsewhere.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Identify characteristics of materials.

Anticipated Problem: What are the characteristics of materials?

- I. A variety of materials exist, and selection of the right material for the job depends on multiple factors.
 1. Materials are the elements, constituents, or substances of which something is composed or can be made. Materials are commonly referred to as manufacturing materials or building materials. *Sweet's Architectural Catalog* is a ready reference of descriptions of building and manufacturing materials. Architects, engineers, and design teams wishing to review new techniques and “green” ratings often use the catalog. (See the Resources section of this lesson plan for Web site details.) A sample of the *Sweet's Architectural Catalog* offerings include:
 - a. Architectural glass
 - b. Sustainable landscape lighting systems
 - c. Acoustical drywall
 - d. Designing for sustainability
 - e. Building even better concrete
 - f. Sustainable flooring choices and life cycle assessment
 2. Several common characteristics of materials
 - a. Elasticity is the ability to expand and contract in extreme weather conditions.
 - b. Hardness is the resistance to failure under stress.
 - c. Durability is the ability to last over time.
 - d. Heat-resistant materials are less susceptible to damage from high temperatures.

Use VM–A to review the characteristics of building materials. Bring in a copy of Sweet's Architectural Catalog to share with the students as a springboard for further discussion.

Objective 2: Describe different materials.

Anticipated Problem: What materials are traditionally used for the construction of buildings, products, and bridges?

II. Types of materials

A. Wood

1. Dimensional lumber is a wood product available in nominal sizes: 2 inches \times 4 inches, 2 inches \times 6 inches, and 2 inches \times 12 inches.
2. **Particleboard** is a building material made from wood chips that have been glued together. Particleboard is relatively inexpensive; in addition, it is denser and more uniform than other wood products.
3. **Plywood** is a series of thin layers of wood veneer that are glued together at right angles. Plywood is strong and resists shrinking and warping.

B. Concrete

1. **Concrete** is a mixture of gravel, sand, water, and Portland cement. It has limited strength unless specially prepared.
2. **Reinforced concrete** is embedded with steel bars and arranged to bear a greater structural load than regular concrete. When the high tensile strength of steel is combined with concrete's compressive strength, it forms a structural material that is strong in compression and tension.
3. **Prestressed concrete** contains reinforcing bars that are stretched, bowed, and arched before the concrete is poured over them and is engineered to accept a predetermined load. The principle behind it is that compressive stresses caused by high-strength steel bars in a concrete member before loads are applied balances the tensile stresses imposed in the member during service. Therefore, prestressing allows roofs, floors, bridges, and walls to be constructed with longer unsupported spans so architects and engineers are able to design and build lighter and shallower concrete structures without sacrificing strength. The first prestressed concrete structure built in the United States was the Walnut Lane Memorial Bridge in Philadelphia, which was completed in 1951. In short, prestressed concrete is stronger than concrete and reinforced concrete. As it provides long, open spaces and acoustical qualities, the following structures are commonly built from prestressed concrete:
 - a. Shopping centers
 - b. School auditoriums, gymnasiums, and cafeterias
 - c. Parking garages

C. Steel

1. Steel is an alloy mixture of iron and carbon.
2. Adding various elements to the mixture can give specific qualities to the steel, such as hardness or heat resistance.

3. Structural steel is recycled, recyclable, and reusable. It also provides a very sustainable construction material.
 - a. Steel is the most recycled material in the world.
 - b. Structural steel is 97 percent recyclable.
 - c. Architects understand the benefits of steel's sustainable design practices in improving the longevity of the earth's environment and the quality of the work environment.
4. Skyscrapers
 - a. With steel came the first modern skyscrapers.
 - b. The 10-story Home Insurance Building in Chicago was the first tall building to be supported by steel columns and beams.
 - c. The John Hancock Center in Chicago is the 12th tallest building in the world. Engineers needed to make the structure very stiff to withstand wind and earthquakes. The John Hancock Center is an extremely tall steel tube with steel columns and beams concentrated in the skyscraper's perimeter. There are also five huge diagonal braces on the exterior to give the building added strength against the wind. Its tapered design (40,000 square feet at the base to 18,000 square feet at the top) provides additional structural stability against the force of the wind.

Use VM-B to review building materials with students. Bring in samples of plywood, particleboard, etc. Have students examine the materials that can be found in the classroom (e.g., desk materials, wall materials, and more).

Objective 3: Identify future trends, forms, and specific combinations.

Anticipated Problem: What trends may affect the future of building and manufacturing?

III. New trends

- A. **Green materials** relate to or preserve the environmental quality of the earth. For example, materials that are nonpolluting and biodegradable have green characteristics.
- B. **Sustainable materials** enhance our environment over time through reduced energy consumption and/or resource depletion.
 1. Recycled products are made from materials that have been reused and recycled.
 2. Recyclable materials have the potential to be recycled and used again as new products.
 3. **Cradle-to-cradle materials** are:
 - a. Produced efficiently
 - b. Utilize recycled materials
 - c. Produce recyclable materials

C. Examples of green and sustainable materials

1. Structural panels made of two outer layers with a foam inner layer can replace the standard three-part wall system of studs, insulation, and drywall.
2. Low volatile organic compound (VOC) paints have fewer off-gas toxic chemicals that contribute to air pollution.
3. Bamboo has gained in popularity due to its durability and its similarity to wood and fiber materials.

D. Nanotechnology

1. **Nanotechnology** is the engineering of functional systems at a molecular scale or the ability to construct items from the bottom up, using techniques and tools being developed today. Potentially, nanotechnology will create nanoparticles the size of a molecule ($\frac{1}{1000}$ the diameter of a human hair) and be able to make materials more durable and resilient. Nanotechnology is expected to make manufactured products lighter, stronger, cleaner, less expensive, and more precise.
2. Examples of materials made from nanotechnology include stain-resistant fabrics, food packaging, and building materials.
3. Current building materials that use nanotechnologies include:
 - a. Smart materials change in response to the surroundings. For example, “smart” paint alerts homeowners of a gas leak or an electrical fault or changes the color of the house on command. Other smart coatings will not become dirty as they “heal” themselves when damaged.
 - b. Nanopowders are in clear UV absorbing sunscreens (available now), paints, and coatings of high hardness and density.
4. The *Houses of the Future* Web site:
http://www.housesofthefuture.com.au/hof_houses06.html
 - a. It showcases the glass house designed to highlight commercially available nanoproducts that result in lower maintenance costs over the life of a building, improve thermal and acoustic performance of buildings, and increase natural lighting.
 - b. In contrast, the Web site compares the glass house’s challenge to today’s conventional building materials with that of the challenge Mies van der Rohe’s Farnworth House (1945) made to “materiality of architecture,” structure, technology, and design in the 21st century.

Use VM–C to review future trends in building materials. Bring in “green materials” like cloth grocery bags, environmentally friendly cleaners, etc. Ask students to share what green measures they are taking in their homes and what green measures might be realistic for the school.

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used in the review/summary.
- **Application.** Use the included visual masters and lab sheet to apply the information presented in the lesson.
- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

■ **Answers to Sample Test:**

Part One: Matching

1. d
2. f
3. a
4. e
5. c
6. b

Part Two: Short Answer

1. Materials share the following four common characteristics: elasticity, hardness, durability, and heat resistance.
2. “Green materials” relate to or preserve environmental quality, such as materials considered nonpolluting and biodegradable. “Sustainable materials” enhance the environment over time and reduce energy consumption and/or resource depletion.

Part Three: Completion

1. Structural panels
2. recycled materials
3. Bamboo
4. low volatile organic compound (VOC)
5. sustainable materials
6. recyclable materials

Explore the Nature of Materials

► Part One: Matching

Instructions: Match the term with the correct definition.

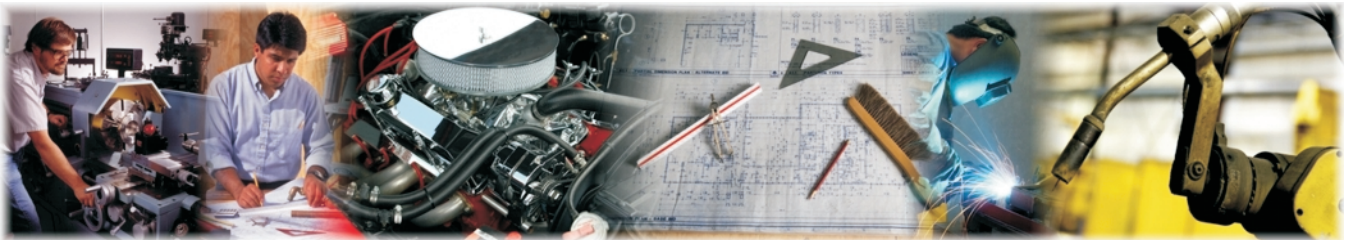
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|-------------------------|------------------------|
| a. concrete | d. reinforced concrete |
| b. prestressed concrete | e. plywood |
| c. particleboard | f. nominal sizes |

- _____ 1. A material (with steel bars embedded in it) that is arranged to bear a greater structural load than traditional concrete
- _____ 2. Lumber that is available in 2 inches × 4 inches, 2 inches × 6 inches, and 2 inches × 12 inches
- _____ 3. A mixture of gravel, sand, water, and Portland cement
- _____ 4. Thin layers of wood veneer that are glued together at right angles
- _____ 5. A material that is made of wood chips that have been glued together, is relatively inexpensive, and is denser and more uniform than other wood products
- _____ 6. A material in which bars are stretched, bowed, or arched before concrete is poured over them

► Part Two: Short Answer

Instructions: Complete the following.

1. List the four common characteristics that materials share.



2. Explain the terms “green materials” and “sustainable materials.”

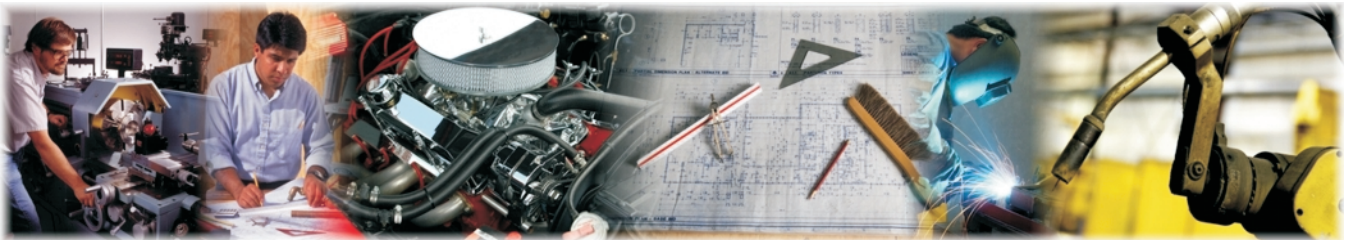
► **Part Three: Completion**

Instructions: Provide the word or words to complete the following statements.

1. _____ are made of two outer layers with a foam inner layer that can replace the standard three-part wall system of studs, insulation, and drywall.
2. Materials made from objects that have been reused are called _____.
3. _____ has gained in popularity as a building material due to its durability and its similarity to wood and fiber products.
4. Paints that have eliminated off-gas toxic chemicals are called _____.
5. Designs and materials that enhance our environment over time and reduce energy consumption and/or resource depletion are called _____.
6. Materials reprocessed and used again as a new product are known as _____.

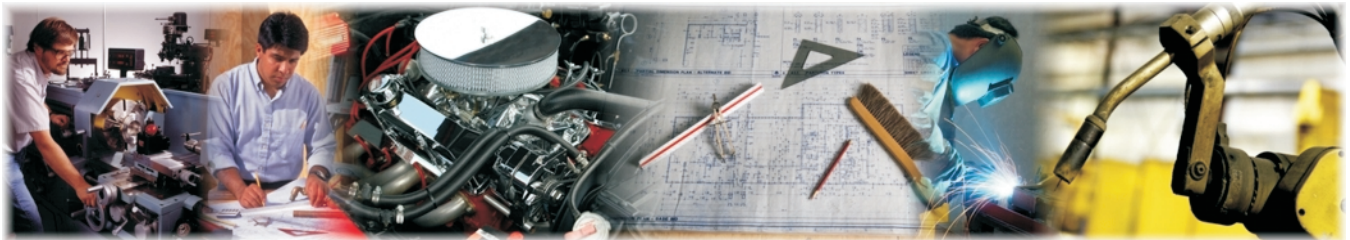
CHARACTERISTICS OF BUILDING MATERIALS

- ◆ Elasticity is the ability to expand and contract in extreme weather conditions.
- ◆ Hardness is the resistance to failure under stress.
- ◆ Durability is the ability to last over time.
- ◆ Heat-resistant materials are less susceptible to damage from high temperatures.



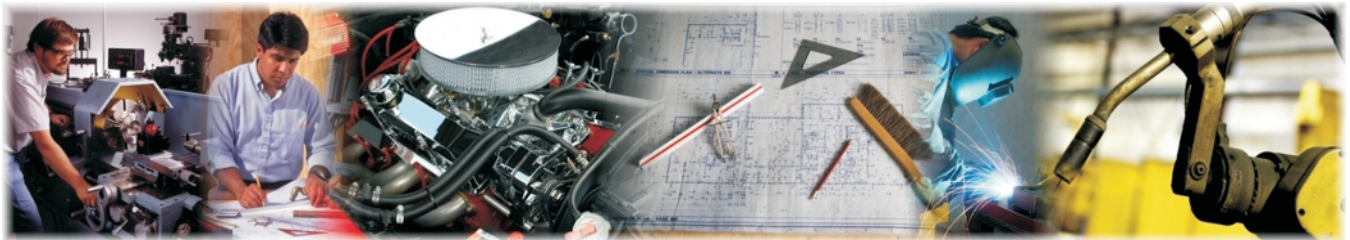
BUILDING MATERIALS

- ◆ Dimensional lumber
- ◆ Particleboard
- ◆ Plywood
- ◆ Concrete
- ◆ Reinforced concrete
- ◆ Prestressed concrete
- ◆ Steel



FUTURE TRENDS IN MATERIALS

- ◆ Green materials
- ◆ Sustainable materials
 - Recycled
 - Recyclable
 - Cradle to cradle materials
- ◆ Green and sustainable materials
 - Structural panels
 - Low VOC paints
 - Bamboo
 - Nanotechnology



New Trends in Materials

Purpose

The purpose of this activity is to identify the latest trends in new materials.

Objectives

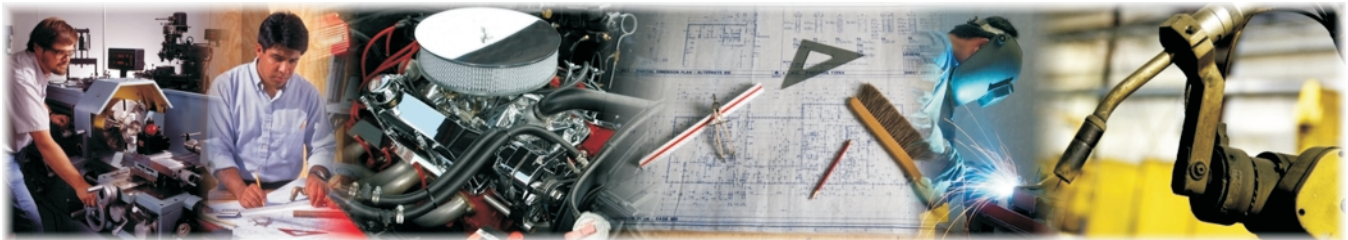
1. Research effectively.
2. Write an organized and thorough report.
3. Present orally with a visual.

Materials

- ◆ American Concrete Institute. <<http://www.concrete.org/general/home.asp>>.
- ◆ American Institute of Steel Construction. <<http://www.aisc.org/>>.
- ◆ *Building Today for Tomorrow* by Kelly Hart.
<http://www.greenhomebuilding.com/sustainable_architecture.htm>.
- ◆ Material Connexion. <<http://www.materialconnexion.com/>>.
- ◆ Sweet's Network. <<http://products.construction.com/portal/server.pt>>.

Procedure

1. Research a new trend in the building or manufacturing materials listed below by using the Internet Web sites listed above (and others, as needed).
 - a. Building materials
 - b. Plastics
 - c. Concrete
 - d. Metals
 - e. Green and sustainable materials



- f. Cradle to cradle materials
 - g. Nanotechnology
 - h. Other choices (per your teacher)
2. Review your proposed topic with your teacher.
3. Write a two- to three-page paper outlining the trend and focusing on:
 - a. History of the trend
 - b. Uses of the product
 - c. Examples of existing buildings, products, etc. (Some additional examples may be identified through contacts with local builders, architects, and engineers.)
 - d. Resources used in the research
4. Present your trend information to the class in a five-minute overview. If possible, bring a sample, picture, or image of the researched trend.