

STRUCTURE DESIGN

STUDENT INFORMATION

Area of Study: Construction

Objectives: The student will design and construct a structure to support as much weight as possible, yet be within the design specifications. Students will examine building materials.

Related Occupations:

Architects

design buildings and other related structures. The architect must plan and coordinate the project by incorporating good design, engineering, managing skills, supervision, and communicating with clients & builders. Architects have to earn a license to be able to be called architects and begin practice.

Building Inspectors

examine buildings, dams, bridges, highways and streets, sewer and water systems, and other structures to ensure that their construction or repair complies with building codes and zoning regulations.

Carpenters

construct and repair structures made from wood and other materials. They can be involved in building bridges, highways, skyscrapers, or houses. Carpenters' task will vary with the type of structure being built & many carpenters specialize within the trade.



A Carpenter checks his work during the building of an addition to a residential structure.

Mike Breen Photo

Key Words and Definitions:

1. **Compression strength:** Resistance to being compressed or crushed.
2. **Constraint:** A limiting factor.
3. **Construction:** The act of building a **structure**.
4. **Construction Technology:** All the technology used in designing and building structures.
5. **Kilogram:** A metric system weight that is equivalent to 1,000 grams
6. **Material:** The substance used to make things.
7. **Pillar:** A vertical upright support to a structure i.e.: post [square] or column [round].

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Occupational Choices

Focus: Carpenter

Classes to take in School:

- English
- Math
- Drafting
- Technology
- Construction
- Welding

After High School:

3 Avenues for employment:

- Hire on and learn by on-the-job training
- Go through a formal apprenticeship
- Vocational School such as an ATC

To become a skilled carpenter schooling will be required. Most places that employ will require on the job training too. A carpenter is usually considered fully qualified after 3 or 4 years of on the job training.

Earnings:

In 2010, people employed as Carpenters nationally had an median **salary** of **\$39,500**.

In 2010, the median wage of carpenters in Utah was lower coming in at **\$37,000**.

In 2010, yearly earnings ranged nationally from **\$24,600 to \$71,700**. Earnings vary by experience and location.

The Work:

Carpentry work can be strenuous. Standing, climbing, bending and kneeling for long periods and repetition of motion are often necessary. Carpenters often risk injury working with power equipment or rough materials. Carpenters may be exposed to the heat and cold if working outdoors. Some carpenters change employers each time they finish a construction job and others work for one employer. One third of all carpenters are self-employed in the United States. Many specialize in an area of construction. Those that learn many different aspects of the job have a better chance for advancement.

Employment Opportunities

- Self Employment
- State and Local Governments
- Manufacturing Firms
- Retail establishments

Personal Characteristics

- Manual dexterity
- Eye-hand coordination
- Physical fitness
- Good sense of Balance
- Excellent Math Skills
- Good Communications skills
- Excellent Math Skills
- Good work history

8. **Specification:** Description of work to be done and materials to be used in making something.
9. **Structure:** Something built or erected that is held or put together in a particular way.
10. **Tolerance:** An allowance made for something to deviate in size from a standard.

Materials Needed:

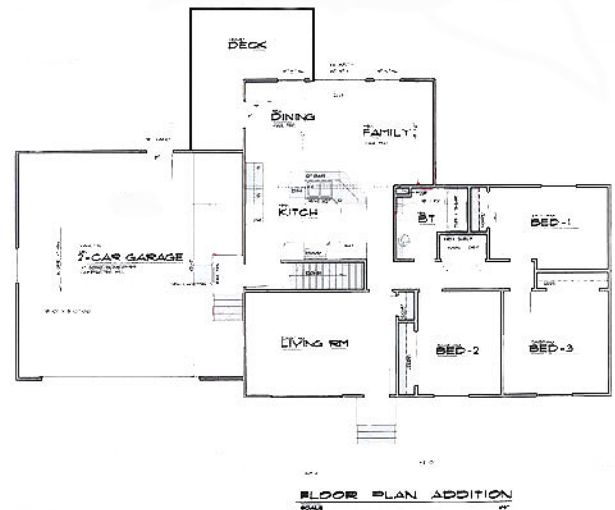
- One sheet 8 1/2" x 11" paper
- White Glue
- Scissors
- Ruler

Construction Technology

Construction Technology is all the technology used in designing and building structures. A structure is something that is built. There are natural structures (i.e. wasp nest, beehive) and there are man-made structures (i.e. road or dam). The design of the structure depends on it's purpose.

Construction System

The technology used to build the structure will also vary with the type of structure being built. For example, a road is going to require a different set of building tools than a house. No matter what type of structure is being built, completing a structure is just one part of a system. A system is an organized procedure for doing something which will include four parts. These parts are the input (activities and ideas that go into a system), processes (actions to make the structure), output (completion of the structure), and feedback (comments on the outputs).



A house plan is part of the input process.

Figure 1

Types of Construction

Construction is the process of building a **structure**. All construction can be divided up into four main types: **Civil** (i.e. roads or bridges), **Commercial** (i.e. mall or business), **Industrial** (i.e. factory), and **Residential** (i.e. home). Each area will have it's own building codes or "rules to build by" that will need to be followed. For instance, building codes stipulate that public buildings are required to have doors that open-out from a room to allow large numbers of people to exit rooms quickly. Residential homes have doors that open-in to a room because opening a door out, in this instance, would block off the smaller width hallways which would not allow the



Scaffolding is set in place to lay cinder block during this commercial construction project in Riverdale, Utah.

Mike Breen Photo

residents to exit. These particular codes have been established for fire safety reasons. It is the job of a building inspector to make sure these requirements are met. Each construction area has it's own unique building codes.

Materials

Every type of structure constructed requires it's own set of building materials. Materials that are used to make a structure are under different amounts of pressure and force. The materials help determine the structures strength, cost, and appearance. It is important to choose the right type of material for each part of the structure.



This deck uses concrete, wood, aluminum, steel, and plastic to give it a unique look. The picture is of the same house as shown on page 1. On page 1 it is under construction; and in this picture, the addition is finished.

Mike Breen Photo

Modern technology has provided us with a variety of materials and processes to use in the design and construction of projects. Some of the most commonly used structural materials include, **aluminum**, brick, concrete, plastic, steel, and wood.

Wood:

Many residential homes will have structural wood like 2 x 4's for the walls. Wood is used in many forms other than boards and posts. The use of glue has greatly increased the versatility of wood products. Wood products are glued together in various ways to form various engineered wood products. **Engineered wood products** include materials such as medium density fiberboard (MDF), oriented strand board (OSB), plywood, laminated beams, glued laminated timber (gluelam), particle board, masonite, laminated veneer lumber (LVL) and I-joist. Wood products can also be pressure treated with chemicals and used underground in place of concrete.

Metal :

Building technology has been greatly improved by the use of metals. Copper, steel, zinc and aluminum are all used in construction today. Several alloys are also used in building projects. An alloy is made by melting at least two **metals** together to form a new type of material. The new metal or alloy has the good qualities of both ingredients. Examples of alloys are steel (iron and carbon) and brass (copper and zinc).

Plastic:

One of the newest materials in construction is plastic. Unlike wood and metal, plastics are made of synthetic (man-made) materials. The source of material to make plastic usually comes from oil or coal. One example used in building a structure is Tyvek, which is made from polyethylene fibers and is used as a house wrap to keep water vapor out of buildings. Another example of a plastic used in construction is Polyvinyl chloride or PVC. It is used for sewer and water pipes, and it is the material in what is called vinyl siding. Many new plastics are being developed to meet the needs of high technology. They are lightweight, heat-resistant and tougher than many metals.

Composites:

Many times two or more materials may be combined. These are called composites. A good example is concrete. It is a mixture of cement, sand, gravel, and water. Plywood also is a composite. It is made by alternating layers of glue and wood. A wood-plastic composite known as *Trex* is used for deck surfaces or park benches. Composites are found in our bathtubs and showers in the form of fiberglass. They are also in our kitchens in the form of plastic laminate, and imitation granite counter tops. Many new plastic composites have been developed that are 20 to 30 times stronger than the plastic alone would be.

Masonry:

The building of structures from individual units laid in and bound together by mortar is known as masonry. Mortar is applied to these individual units to join them together. When mortar is applied, it looks similar to “wet concrete” which is used like a thick glue to bond pieces together. It also dries hard like concrete. Common materials that mortar is used to bond together are brick, cinder block, stone, and tile. Other materials that a mason could fasten in place without mortar are wall tile, granite, and marble.

The challenge of the design engineer or architect is to bring all of these materials together in a way that meets the specifications of the project. It must be strong enough to withstand the forces that may be put on it; and it must be as inexpensive as possible.

Impacts on Society & the Environment:

Structures have benefited people in many ways. A dam is a structure that has allowed cities to grow by capturing water for drinking; other structures like the interstate, have allowed great numbers of people to travel in automobiles more efficiently and safely over longer distances. Composite and engineered materials are being used more today in place of traditional wood products which takes stress off of forests as these new products do not require old growth trees.

Many structures provide shelter from the elements. The creation of structures also provides employment for many different people. Today, construction workers are the largest group of skilled workers in the United States¹

Construction of structures can also have negative impacts as there is **dirt, debris, and noise** that can be problematic during the actual building process. **Road closures and detours** can affect traffic flow during road construction. The **loss of open space** affects many communities and plans to make sure that there is recreational as well as wildlife areas in a community must be weighed against development of the areas. Such concerns are often why cities develop plans for building within the city. The city planners will “zone” areas of construction to hopefully meet the needs of the population.



Civil construction involves road closures and detours which affect traffic flow.

Mike Breen Photo

¹ Harms, H. R., & Swernosky, N. R.

Design Brief:

Your job is to design and construct a paper pillar or pillars that will hold as much weight as possible, yet be lightweight.

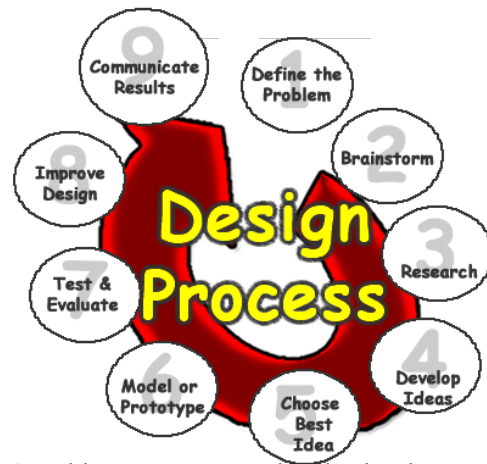
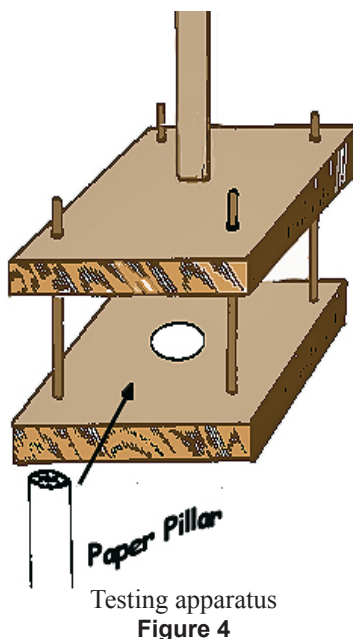
Your teacher will check your paper structure before testing to see if it meets the specifications. If your paper pillar does not meet the specifications, be prepared to modify the structure with paper off of the structure or to start over. Follow your teacher's directions as to where to put it to dry. Study the constraints & specifications listed below.

Constraints:

- It must be made from 1 sheet of paper.
- It must be completed in 1 class period.
- The pillar or pillars must dry overnight.
- The top and bottom of the paper structure must be flat.
This will help the structure stand alone.
- Do not fill full of glue.
Extra amounts of glue slow the drying time, and it will be soft and weak if wet.

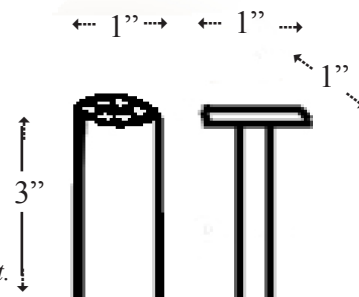
Specifications:

- **Height:** 3 inches tall *Tolerance = 3 inches high + or - 1/16"*
If it is taller than this, it may not fit into the testing device.
- **Width/Diameter:** A minimum of 1 inch
wide in width and depth in at least one
place when viewing the height of
the paper structure. (consult figure 3)



A multi-step process used in the development and construction of a product.

Figure 2



Pillar Examples
Figure 3



A building in a flood plain is built on pillars.
Camp Ashland, Nebraska
Mike Breen Photo

STRUCTURE DESIGN

Student Work Sheet

Name: _____ Period: ____ Date: _____

Directions: In the blank on the left, write the correct answer to the statement or question.

1. _____ kilos _____ lbs. Your structure collapsed on how much weight?
(answer both parts)
2. _____ How many sheets of paper did you use to construct your paper pillar?
3. _____ Construction is the act of building a _____ .
4. _____ A _____ is a description of the work to be done and the materials to be used.
5. _____ There are four main categories of construction and these are: _____, commercial, industrial, and residential.
6. _____ Some of the most commonly used structural materials include, _____, brick, concrete, plastic, steel, and wood.
7. _____ An engineered wood product uses glue to form the material.
An example of an engineered wood product is _____.
8. _____ An alloy is formed by combining at least two _____ together..
9. _____ A negative impact of construction is _____ .

10. _____ After testing your paper structure, what could have been done to make it stronger and still have been with the specifications?

