CONSTRUCTION

Worksheet 6

A worksheet produced by the Native Access to Engineering Programme

What is Construction?

The Merriam Webster Dictionary says the verb "construct" means

1: to make or form by combining or arranging parts or elements

...

3: to set in logical order

Source: Lego
http://www.lego.com

Construction is actually about how to put things together in a logical and complete way. It is one of the things we begin to learn as young children. We learn to do it with sentences, we learn to do it with our thoughts. In a more concrete way, we also learn how to construct things with our hands by playing with blocks and Lego and all other sorts of building toys.

Engineers and Construction

When engineers talk about construction they are referring to something a little more specific. In engineering terms, construction is a field in civil engineering that has to do with the planning, designing and building of structures (homes, hospitals, bridges, airports etc.) and infrastructure.

Infrastructure refers to all the things which support a community' s basic needs. It includes power and water distribution systems, road networks, sewer and sewage systems, and more and more, the cable, telephone or satellite systems which support communication.

What infrastructure elements can you identify in your community?

Like all types of construction, structures and infrastructure need to have all of their parts put together and arranged in a logical order.

If you were building a house, would you put the walls or windows up first? Why?

A lot of the work of construction engineers is about managing all the elements of a project into this logical order. They have to make sure that all of the people, materials and equipment needed come together at just the right time.

Stages and elements of construction

Like any kind of project, a construction project - no matter how big or small it is - has a number of defined steps (or stages) which take it from beginning to end.

Think about projects you do for school, what do you think these steps might be?

A construction engineer needs to know all about the elements which are needed during each stage of a project's development. The elements of construction are:

the people who will do the planning, designing and work;

the materials they will build with; and,

the tools and machines they will use to put it all together.

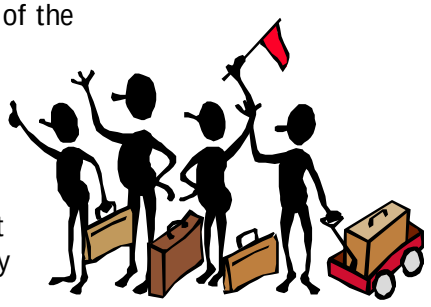
Different combinations of these elements are needed at each stage of construction.

Conception and design: A construction project, whether it's for a house or a huge dam, begins with an idea in somebody's head. That's conception. Design begins when that person talks to some one else about the idea and they start to get things down on paper (or into a computer).

This stage may involve a few people or many. The key here is for the client and engineers and/or architects who will oversee the project, to sit down and clearly determine what the project is, and where it will take place. Then plans will be drawn up and information about the proposed construction site will be gathered. All of the information gathered during this stage will determine how the project will be built, when it will be built, where it will be built and even, if it can be built. At this stage there are often many changes. An estimate of the project's cost must also be made.

What factors do you think could stop a project at this stage?

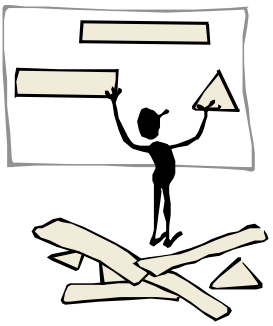
Bidding: On large projects (dams, bridges, housing developments etc.), certain parts of the job are usually contracted out to specialists. For instance, in bridge construction a structural engineering company might be hired to do the steel work and another company might be hired to lay the road bed over the bridge. In this part of the job, the supervising engineer (often a construction engineer) tries to get the best quality work for the best price. He or she will "call for tenders." This means that a public notice will be posted so that interested companies (or contractors) can submit bids to work on the project. The company which gets chosen to do the work is usually the one which gives the best value for the money.



Can you think of any problems that might arise in the bidding stage?

For smaller projects, specialists are sometimes just hired based on their experience.

Planning: Once all of the contractors are chosen, the whole project needs to be planned down to the tiniest detail. This means breaking the actual construction job down into logical steps and answering lots and lots of questions (even more than are listed here). When can the project start? When will it end? How long does each contractor need to finish its work? How much time can each contractor have to finish its work? What equipment needs to be rented? When does equipment need to arrive? Does the climate or site require special machinery? What are the local building regulations? What materials are needed when? How much of each material is needed? Where will materials be stored? What kind of safety hazards exist on the site? Who will be on site at each step of the project? When does the client need delivery of the project?



Once the questions are answered, the construction engineer will build a timeline for the project. Because several things will be happening at the same time in most projects, building a timeline can get quite complicated. Construction timelines often look like this.

	Year	1999												
	Month	June				July				Aug.				
Description	Week	6	13	20	27	4	11	18	25	1	8	15	22	
Site establishment														
Mark off site														
Back fill to pilings														
Foundation excav'n														
Foundation constr'n														
Formwork														

This is just part of a construction schedule. Where the heavy black lines over lap, two or more things are going on at the same time.

Construction: At this point, physical work on the project begins. The construction engineer's job now becomes a lot like a dance choreographer's. He or she must direct the actions of people, machinery and materials into a smooth, coordinated effort. If the job is done right the result is a safe, efficient and busy site.

Looking back at construction

As you can see, construction is quite a complex process which requires lots of skill and effort. It is also something which people have been doing for a very, very long time. In fact, there is archaeological evidence that man's predecessor Homo Habilus began constructing shelters out of stones and branches at least 2 million years ago in Central Africa.

Why do you think the first shelters were built?

Really large construction projects haven't been around nearly that long. Still, we know that there were thriving civilizations in Asia, Africa, Europe and the Americas thousands of years ago, and that these civilizations had developed sophisticated construction methods.

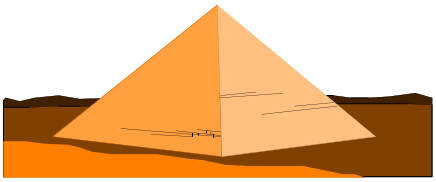
The Greeks built the Parthenon,

the Romans the Coliseum and

the Chinese began the Great Wall all more than 2000 years ago!

What kind of resources do you think they used for these massive projects?

The Great Pyramid is 145.75 m high. It was the tallest structure on Earth for 43 centuries!

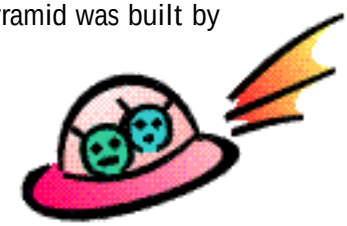


The ancient Egyptians were master engineers. A number of their works were so massive and well-built that they have withstood the test of time. The Great Pyramid of Giza, for instance, is about 4,500 years old. It was built as a "public works" project over a 20-year period. The pyramid (and two others close by) is a marvel of precise and elegant construction. It is made from around 2 million blocks, each weighing about 1 metric ton! Each side of the pyramid is oriented with a cardinal point of the compass (north, south, east and west) and the base is perfectly square; a pretty amazing job for people who didn't have calculators or computers.

Why do you think it took 20 years to complete the pyramid?

We know that the Egyptians had nothing like the construction machines which are used today for lifting, digging, pushing and other heavy construction work. No records or evidence exists of how the pyramid was put together but there are several theories. Some people say the Egyptians used large levers to get the stones in place; others suggest they built ramps which spiraled up around the pyramid and then hundreds of people would drag or push the immense stones into place. One of the strangest theories is that the pyramid was built by aliens from another planet!

How do you think the Great Pyramid of Giza was built?



Construction in the Americas

The people indigenous to the American continents were also master engineers. Depending on where they lived and what materials were available, they developed a number of different construction techniques.

What are the traditional shelters of your nation? How were they built? Can you identify traditional shelters and homes from other nations?

Source: Olmecs
http://www.humanities-interactive.org/splenders/EXO48-02.html

Olmec: The earliest evidence of heavy construction in the Americas is about 3,200 years old and comes from the Olmec people of Central America. They carved huge pieces of stone into altars and decorations. The most amazing thing about their construction is that the stone was generally found far away from their cities and towns and was often dragged about 60 kilometers through hilly, jungle terrain before it was used.

How would you go about dragging really heavy stones through the jungle?

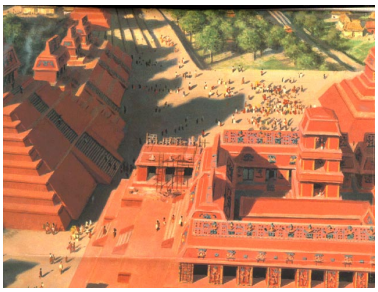
Maya: The Mayan civilization arose around 4600 years ago, but became prominent in central America just over 2000 years ago. The Maya had no metal tools and no wheels, and yet they built huge stone cities, with palaces, temples, homes, streets, public plazas, sports fields and water reservoirs. The larger Mayan cities had up to 10,000 structures and 60,000 people. This meant that their population density was higher than European cities of the same time.

Why would the Maya build reservoirs?
What steps would they have to take to build one?

Mayan temples were built with the same amazing accuracy as Egyptians pyramids. The step-pyramids were aligned with the sun and stars in ways which signified their purpose. For instance, the Pyramid of Kulkulkán in the Yucatán in Mexico was aligned with the sun so that at the spring equinox light would travel down one of the pyramid's four stair cases like a snake and the people would know it was time to plant corn.

Source: El Castillo
http://hanksville:phast.umass.edu/yucatan/El-castillo.html

Inca Engineering



More recent stone city builders were the Inca. Not only were the Inca great engineers, they were great architects. Their structures reflected the nature of the lands in which they lived. The Inca built their cities about 500 hundred years ago, without the use of wheels or metal tools.

How would wheels and metal tools make construction easier?

Inca stonemasons would go to rock falls and carve stones as large as 100 metric tons to very precise measurements using tools called hammerstones. A really big rock might require the work of 20 stonemasons for 2 weeks to get it into precisely the shape and size!

The rocks were very rarely close to where they were needed so they had to be moved several kilometers along steep, rough roads and sometimes through shallow rivers and up mountains. The Inca used inclined planes, rope made from local plants and gravity to help move the cut rocks, but it probably still took about 1800 people to move one 100 metric ton block!

If 1800 people are used to move a 100 metric ton block, how many kilograms is each person pushing or pulling?

Organization and management; Tools and materials

The Egyptians, Romans, Chinese, Inca, Maya and Olmec all required excellent organization and management skills in order to construct their roads, walls, monuments, buildings, arenas and cities. These are the same skills which construction engineers today draw upon to successfully complete projects. In fact, the main difference between today's projects and projects from almost 5,000 years ago are the tools and materials which are used for construction.

Modern construction machines, like cranes, pavers and graders, make it very easy to lift or move even the heaviest of materials. They also cut down on the amount of time and the number of people required to do a job.

Modern construction materials, like steel, plastics, concrete and aluminum, make buildings, roads and other structures light, durable and strong. They also allow for construction under very special circumstances: there are special concretes for building structures in salt water, very lightweight plastics for building in space, expandable insulation for keeping homes in cold climates warm, just to name a few.

Machines and materials can only help in construction. The key to success is always management and organization; knowing who and what is needed and when, where and how to get the job done.

Sources

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Math Problem

One of the families in your community has decided to build a new house over the summer. After discussing the project with them at length, your firm has been hired to do the job. They want a well-insulated, one-storey brick house. Because one of the family members will be running the local Internet Service Provider from the house, it is important that the house be wired for Internet access.

As a construction engineer you sit down with the people who will be involved in the project and build a plan. The project will begin on Monday, June 1, to allow enough time for the snow to melt. First the site will need to be prepared (leveled, some trees cleared, services run-in etc…), which will take 3 weeks. You will be able to begin digging the foundations after 2 weeks and they will take a week to complete. Before you pour the concrete for the foundations (1 day to pour and 3 days to set), you have to build and place the moldings for them, a job that will take 2 days. While you are waiting for the concrete to set you can begin construction of the roof trusses (1 week). Once the concrete is dry you will need 2 weeks to raise the frame of the house. As the framing goes up, the plumbing and electrical services can be installed, they will take 8 and 10 days respectively. The wiring for Internet access can only be done once all other electrical services have been installed, it will take 3 days to do. Once the framing and wiring are complete, a number of jobs can begin at the same time:

- insulation and indoor sheet rock can be installed in the walls (12 days);
- windows and doors can be placed (3 days);
- the roof can be built (10 days).

As soon as the windows and doors are installed, the outside bricks can be laid to complete the walls, this should take 10 days. Plastering (1 week) the inside walls can begin when the indoor sheet rock is installed. Shingling the roof will take 3 days after the roof construction is finished. Final inside finishing will take 12 days once the inside of the house has been plastered.

Your crew will work 7 days a week to make sure the house is completed before the snow comes.

a) Draw out a plan for the project. (You can base it on the example on page 3).
b) When does each job start and finish?
c) When will the entire job be finished?

Bonus question…

If your concrete delivery is delayed by 5 days when will the job finish?