NCSEA HIGH SCHOOL OUTREACH

START-UP GUIDE

v.1.0

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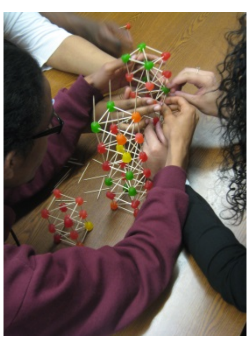


NCSEA
National Council of Structural Engineers Associations

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PURPOSE OF THIS GUIDE

This is a guide to aid your local NCSEA Member Organization (MO) in the creation of an impactful outreach program that can be implemented at local high schools.

This guide was created as a step-by-step outline of implementing this outreach program. It serves as a set of recommendations and processes based on lessons learned in implementing similar programs throughout NCSEA. It can be followed strictly or loosely based on the resources and inclinations of your local MO.

The primary requirement for implementing this outreach program is to have a coordinator and a group of passionate volunteers. This outreach tends to work very well as a program for a Young Members Group (YMG) or a Public Outreach Committee; however, any committee along with an outreach coordinator and set of volunteers can implement it.

Many NCSEA members have found this program incredibly rewarding. Have fun with it and do not hesitate to contact NCSEA if you have any questions, comments, or concerns.

PROGRAM OBJECTIVE

Engagement of the community through the classroom setting is the hallmark of this program. Therefore, the outreach should be thought of as an excellent volunteering opportunity for every member of your MO.

The purpose of this outreach is (3) fold:

- To generate excitement about structural engineering practice,
- To engage your NCSEA MO with the community at large, and
- To provide guidance to aspiring engineers.

In addition, this outreach fulfills a very specific general requisite being pushed by teachers, education policy stewards, and local communities, to try and include more Science Technology Engineering and Mathematics (STEM) programs from local professional organizations in everyday curricula. This momentum has generated great demand for programs like this.

The outreach described herein will fulfill these duties in a very impactful way without requiring the very intensive nature of enacting a full curriculum-based program.

BENEFITS OF HIGH SCHOOL OUTREACH

There are multitudes of internal and external benefits inherent in establishing this outreach program within your local MO.

Internally, from the prospective of the engineering volunteers, it allows for the following:

- Gaining experience creating, modifying, and tailoring a presentation for a specific audience
- Becoming an active member in their community
- The opportunity to translate complex structural engineering fundamentals to simple terms to a non-technical audience
- Establishing camaraderie with each other as well as officials in the education community
- Creation of a database of local school contacts and presentations (both locally and nationally) for future use at other public forums or NCSEA events

Externally, from the prospective of the local community, the following are just a few important benefits:

- Allows local schools to engage with professionals in their community
- Fulfills guest speaker and engineering unit requirements typical to many schools and states
- Allows teachers some additional prep time during the day while engineering volunteers teach the class
- Demystifies structural engineering and architecture to students and teachers
- Shows a specific example of a real world professional application of math and science

You will find many more benefits from creating a High School Outreach program than what we list above. These benefits can only be realized once you start the program. The following pages are a suggested rubric for creating and maintaining a High School Outreach program in your local MO. Remember, teaching is a highly localized endeavor. Please do not hesitate to update any aspect of this guide based on your own experiences.

OUTREACH PROGRAM DESCRIPTION

The High School outreach program is a workshop put on by a member organization to local high schools. It is used to increase awareness of the role structural engineering plays in everyday life. The workshop includes a PowerPoint presentation and a hands-on activity. Each portion of the workshop is designed to teach some of the basic principles of structural engineering in a fun and simple way.

In addition, the entire workshop may also easily be tailored to be given to middle school students both as a way of introducing students to engineering who may be interested and by giving them the opportunity to choose a high school that focuses on the subjects and coursework invaluable to becoming a strong engineering candidate

<u>PowerPoint Presentation</u>

The PowerPoint presentation generally consists of several sets of visual aids used to perform the following tasks:

- Define structural engineering
- Define the role of a structural engineer within the building industry
- Define the building industry itself
- Describe different types of structures
- Describe different types of materials used as part of structures
- Describe the various types of loads imparted on a structure
- Describe failure mechanisms
- Describe future trends
- Describe tools used by structural engineers
- Describe the recommended educational path to becoming a structural engineer
- Describe some of the benefits of being a structural engineer

The presentation portion of the workshop should be designed to take anywhere between 10 and 30 minutes. This is important because different teachers at various schools will have different time blocks that can accommodate the program in its entirety.

Hands-On Activity

The hands-on activity can either be a single more involved task or a group of shorter tasks. The purpose of the hands-on activity is to teach some basic tenant of structural engineering in a way that is easy to visualize.

The following are a few examples of types of hands on activities:

- Paperclip and Toothpick Bending Test
- Paper Bridge Construction
- Gumdrop and Toothpick Structure
- Edible Concrete

Similar to the presentation, the hands-on activity should also be designed to take anywhere between 10 and 30 minutes.

The program is designed to be flexible. Each workshop should take no more than 1 hour, but also be able to be completed within 30 minutes. Typically, we recommend that these workshops take place in a math, science, art, or architecture class at any high school, however, the program may also be altered to also be suitable for middle school students.

Each workshop requires the following:

1. A minimum of (1) Lead Instructor and (1) Volunteer (see volunteer descriptions in following sections)
2. The PowerPoint presentation
3. A laptop (if required)
4. A portable projector (if required)
5. Materials for the hand-on activity
6. A camera to document students (usually requires permission from teacher and/or school administration)

As is evident from the previous description, most of the resources needed to plan and enact a successful high school outreach workshop are a group of engaged volunteers and a set of participating teachers and schools. Finding enough of these two resources is probably easier than you think. We will describe each in the forthcoming sections of this guide.

OUTREACH PROGRAM ORGANIZATION

The organization and hierarchy of a High School Outreach program is very simple. At the basic level all you need is an Outreach Coordinator, Lead Instructors, and Volunteers. As previously mentioned, each of these positions can be held by any volunteering member of your local MO, however, typically this program offers a great way for members and officers of your local Young Member Group (YMG) to gain leadership experience and utilize their enthusiasm so beneficial to making this program a success.

Below is a detailed description of each outreach position, including pertinent information about the level of involvement and specific tasks.

All volunteers will likely have to give outreach workshops during the school day which will conflict with regular work hours. Usually this can be accommodated due to the relatively low frequency of the outreach workshops.

Position: Outreach Coordinator

Involvement/Description: High / Coordinates broad range outreach efforts
Tasks:

1. Gathers contact information for prospective volunteers from local MO
2. Lead effort in customizing outreach program materials, including PowerPoint presentation, Hands-On activities, possible handouts, etc.)
3. Sets-up online sharing site to disseminate pertinent information and materials (FTP, Dropbox™, Google Drive™, etc.)
4. Coordinates effort in contacting teachers and setting up program dates
5. Assigns lead instructors and volunteers to schools
6. Collects and saves any back end items including possible teacher surveys and picture documentation

Position: Lead Instructor

Involvement/Description: Medium **/** Leads and coordinates logistics of an outreach workshop
Tasks:

1. Coordinates day-of logistics with teacher for specific outreach engagements, including projectors, laptops, hands-on activities, picture release forms, and school outside visitor protocols
2. Delegates day-of tasks for performing workshops
3. Requests teacher participation in follow-up survey

Position: Volunteer

Involvement/ Description: Low **/** Accompanies lead instructor to school in order to deliver outreach program
Tasks:

1. Engages in agreed upon outreach presentation with Lead Instructors and other volunteers
2. Assists teacher, lead instructor, or other volunteers in any clean-up, picture taking, or other activities needed during presentations

STARTING AN OUTREACH PROGRAM

Starting an outreach program at your local MO requires the following:

Step 1: Generate Interest

Try to generate interest in the YMG program at your local MO. Some good ways to generate interest are:

- Including a blurb asking for volunteers in a newsletter
- Contacting your local community outreach committee
- Contacting your local Young Members Group
- Contacting your local ASCE group
- Asking people from your office or place of work to participate

Step 2: Establish an Outreach Coordinator

It is important to establish a coordinator, or set of coordinators early on as you will need a few people to coordinate efforts both in training the volunteers and in establishing contacts with possible instructors and schools. If you are reading this guide, you are likely going to be one of the initial coordinators

Step 3: Create/Edit a PowerPoint Presentation

Either use guidance from this document to create a PowerPoint™ presentation or edit an existing presentation from the database available on the NCSEA website or from volunteers within your MO who have put on workshops similar to the one described herein. Typically, editing an existing presentation can save some time during this process.

Step 4: Choose Various Hands-On Activities

Use this guide to choose a few hands-on activities that peak your interest. It is likely that different volunteers are going to create additional activities to add to your library. Make sure to collect a database of each. Usually the schools like to try something new with each workshop so having a variety of activities is preferred.

Step 5: Set up an online file storage:

Use Dropbox™, Google Drive™, or another online storage provider to set up a location where your volunteers will have access to your various files. Files should include:

1. PowerPoint presentations
2. Description of activities
3. List of participating schools, including administrative contacts (coordinators only)
4. List of participating teachers/instructors contacts (coordinators only)
5. Photos of outreach events for local MO documentation/publication

Step 6: Kick-Off Meeting/Training Event

After you have a number of volunteers signed up or showing interest, throw a welcome event. At this event you want to accomplish a few things:

1. Introduce yourself and your core group of volunteers
2. Introduce the program
3. Introduce officers and different volunteering categories
4. Get to know your volunteers
5. Run through the PowerPoint presentation (as you would in a typical classroom)
6. Run through at least one of the hands-on activities
7. Discuss classroom expectations and etiquette – (See forthcoming sections)
8. Charge your volunteers with contacting teachers to solicit outreach opportunities – (See forthcoming sections)
9. Establish minimum (2) people per outreach workshop

Step 7: Contact Teachers/Give Presentations:

You should have already been in the process of contacting teachers to establish a few outreach dates to occur soon after the Kick-Off Meeting to capitalize on your initial momentum.

Have your volunteers start contacting teachers to set up outreach dates using the Teacher Solicitation and Classroom Etiquette guidelines in the forthcoming sections of this guide.

Have sets of (2) or (3) volunteers set up outreach times and dates with teachers. Remember these times have to be during the school day, so they will conflict with regular work day hours.

Step 8: Follow-Up

Remember to follow up with your teachers to gather information about their experience. Please try to find out the following information:

1. What parts of the presentation they liked
2. What parts of the presentation they did not like
3. What parts of the presentation they would change for their classroom setting
4. If they had a good experience with the volunteers from your local MO
5. If they would be willing to recommend the program to other teachers

Step 9: End-of-Year Meeting

Hold a meeting at the end of the school year to:

1. Congratulate volunteers on their work
2. Disseminate pictures of classroom activities possibly for a newsletter or MO board of directors update
3. Review the experiences of the volunteers to determine what they liked, did not like, and what they would change in the future
4. Garner support for more participation in the following school year

TEACHER SOLICITATION

Soliciting possible classroom locations can sometimes be a worrisome experience. However, we have included a few pointers below to help. Again, as with all local municipalities, each school and each teacher is different. All the descriptions below are best practices based on previous experience. Feel free to augment or change your own suggestions with your particular group of volunteers

1. Sales Pitch:
    a. Before soliciting any schools for the program come up with a short sales pitch which should describe the following:
        i. The NCSEA professional organization you are volunteering for
        ii. Briefly what the program is
        iii. Briefly the amount of time the program will take
        iv. Briefly the amount of materials you will need for the presentation and hands on activity
        v. Description of the benefits of the program
            1. Always remember to mention that your program will allow the teacher to have up to an hour of prep time to work on other things during class
            2. Teachers generally could always use more prep time for their typical day so mentioning this is very important
    b. Disseminate your sales pitch to all of the members so they can have it as a reference/guide for contacting teachers or administrators

2. Contacts:
    a. Have all volunteers including core members come up with possible contacts within the secondary school education industry. These contacts can be anyone from counselors, to principals, to teacher’s assistances, to teachers.
    b. Your primary goal is to establish direct communication to math, science, or architecture teachers
        i. Most teachers tend to have quite a bit of autonomy when deciding what outside presentations they can have in their classrooms at what time, so direct discourse with the teacher is paramount
    c. Generally, after a few successful presentations at a particular school, a teacher will likely recommend you to other teachers in their department or district. In this way, the contact list will begin to build on itself

3. Teachers
    a. Generally you want the person closest to the teacher contact to establish communication, although this is not a hard and fast rule
    b. Approach the teacher as a professional even if you have a very close relationship
    c. Go through the sales pitch
    d. If they accept, establish a date and time for the workshop and ask if there are any additional procedures or checks that you have to go through as a guest presenter to the class

4. Schools
    a. Every school is different and has different procedures for having guest presenters or lecturers
        i. Be aware of these differences and keep a running list of these procedures for future reference
    b. Some religious private or charter schools have specific goals and ideals beyond education.
        i. Discuss within your core group if you are willing and able to approach these schools
        ii. Run your progress by the MO in general to make sure you are still within the framework of the organization

5. Database
    a. Remember to keep a database of as much information as you can for future use.
    b. Many of the same people and procedures come up frequently, having a contact or information beforehand generally helps

CLASSROOM ETIQUETTE

The following are few examples of best practices while conducting an outreach workshop in a high school classroom setting. Each point listed is a suggestion. Your own experience will likely vary from school to school and from classroom to classroom.

1. Arrive Early
    a. Give yourself at least 15 minutes before your scheduled presenting time to familiarize yourself with the school, classroom, and teacher

2. Check-In at Administration
    a. Regardless of your direct contact with the teacher, always check-in with administration when entering a school.

3. Dress Professionally
    a. Dress codes at different schools vary. Dressing professionally indicates that you are at the school for a purpose to the school administrators and also gives the students an indication of the professionalism of our industry

4. Check Presentation
    a. As with all PowerPoint presentations, set-up your presentation either on your own equipment or the equipment provided by the instructor as soon as possible
    b. Check to ensure everything works before beginning the presentation

5. Discuss Classroom Rules
    a. Talk with the teacher about the overall rules of the classroom before your presentation.
    b. Often teachers have a specific way they like to run their class. While you are giving a presentation, students often like to deviate from their typical day. At times this deviation may lead to aggravation later for the teacher

6. Introduce Yourself
    a. Make your introduction to the classroom
    b. Try to include a few notes about yourself beyond your structural engineering profession, like where you grew up, what school you went to, etc.

7. Establish Rules for your presentation
    a. You should have discussed the typical rules of the classroom with the teacher by now.
    b. Talk to the students specifically about what rules you are going to lead the workshop by (especially if they deviate from their typical classroom rules)
    c. If you do not establish yourself as an authority figure leading the discussion and the activity, you will likely lose control of the classroom relatively quickly

8. Establish Rules for the Activity
    a. Same as with the presentation, the classroom environment during the activity can get loud and rambunctious.
    b. Try to establish rules that allow for creativity but not out-of-control behavior

9. Clean-Up
    a. Teachers tend to like a clean classroom. The activity can get messy
    b. Have yourself, your co-volunteers, and the students help with the clean-up process

10. Pictures
    a. Establish with your teacher beforehand if it is acceptable to take pictures during the outreach workshop for our internal purposes and/or to disseminate to school administrators for their own purposes
    b. It is key that you bring this up before the day of as there may be waivers that either the volunteers, the teacher, or the students have to agree to or sign
    c. Have a volunteer take pictures throughout the program. The hands-on activity is usually a great time for pictures, but it is good to capture the PowerPoint presentation as well

11. Follow-Up
    a. After the workshop follow up with the teacher to see how the event went.
    b. This will be useful for your own future presentations and well as possible future presentations at the school and/or classroom to which you were presenting

PROGRAM COSTS

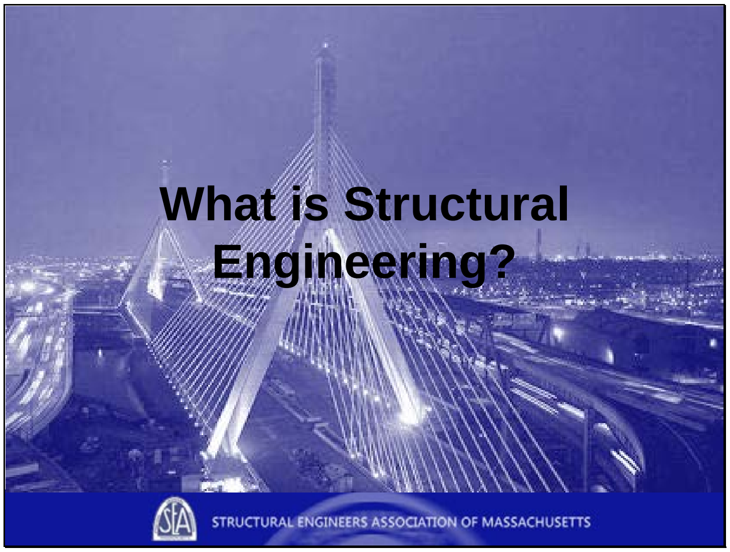
As with all programs within your local MO, costs need to be reviewed before programs can be approved. The costs for the high school outreach program are primarily associated with 1 of 3 items:

1. Food, beverages, and possible room and equipment rental for the kick-of-meeting/training session
2. Materials for the hands-on activities
3. Food, beverages, and possible room and equipment rentals for the End-of-the-Year meeting

In 2012, the costs for the Kick-Off and Wrap of Meetings for a local MO were approximately $40 dollars each, while the costs of the material for each hands-on activity averaged about $3 per workshop.

SAMPLE PRESENTATION

Slide 1

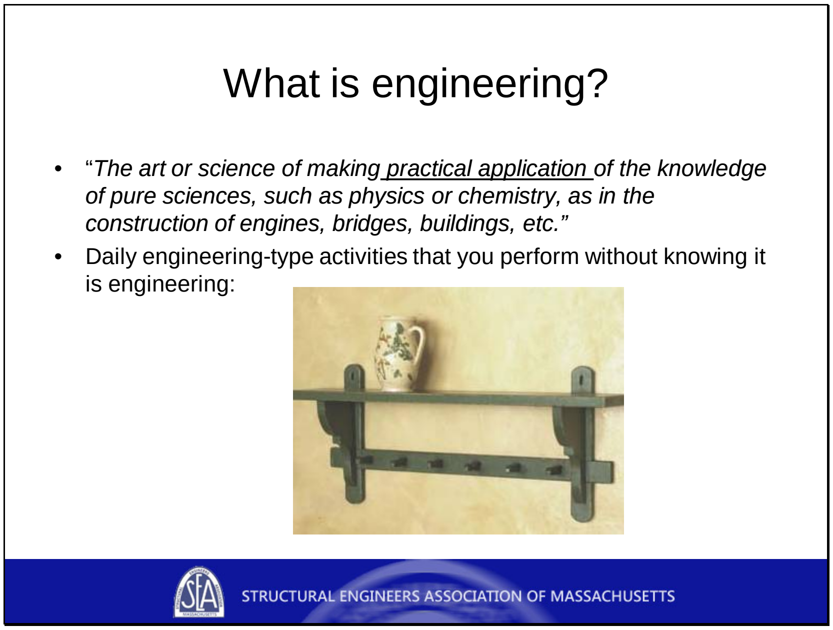


This presentation will describe the major roles of structural engineers, how they fit within the construction industry, what structural engineers typically work with, and how students can prepare for the engineering field.

During this introduction slide, the speaker should introduce himself or herself with name, title, company they work for, etc. The speaker should introduce the plan for the presentation: PowerPoint presentation and then a group game.

The speaker may want to open the presentation by asking the students this question,' What is structural engineering?' and allow the students to offer their ideas. If no responses are offered, try prompting the students with questions like, 'What is this a picture of?' (The Leonard P. Zakim Bridge) 'So who do you think designed the Zakim Bridge?' (A structural engineer) 'What about all those other towers, roads, and other buildings in the background? A structural engineer designed all of those, too. So let's look at more details about engineering and structural engineering in particular.'

Slide 2



Purpose: To summarize quickly and in general terms what engineering is

The speaker is to explain to the audience what engineering is by giving some examples of simple, daily activities that people perform even without knowing that they are considered engineering. For example, building a bookshelf, poking two holes on the lid of can for easy pouring, or swinging a bat effectively, are applications of science and laws of mechanics to daily activities. This slide is to engage the audience into thinking that engineering is all around us, and it does not always have to be buildings, cars, or computers.

Verbatim Format

Engineering is the application of science, such as chemistry, biology, and physics, to real life problems.

You probably have done some engineering design on a daily basis without knowing that you have done engineering. For example you probably have designed and installed a bookshelf before. What kind of engineering did it involve? Did you have to use mathematics to help you measure the wood planks before you cut them? If you have to cut out a triangular piece of wood, did you use equations (such as the Pythagorean Theorem) to measure the lengths of the different sides? How did you make sure that the shelf would be level? Did you think about what would go on the shelf? Did you pick out a certain material for a specific reason? How do you attach the shelf to the wall? Where did you get the tools and materials from?

These are all similar questions engineers face when they design almost anything.

Outline Format

I. Define Engineering
II. Examples of daily activities that are considered engineering

Slide 3

Purpose: To summarize the major different basic everyday problem solving and professional engineering activities in different fields, scaling up type and quantity of simple solutions.

In this slide the speaker is to focus on the use of simple concepts that come from simple problem solving. From there the speaker is to show how professional engineers really take these simple solutions and scale them up. Express to your audience that an engineer identifies all the simple things going on, and scales them up as the complexity increases. Build on the previous slide with creating a bookshelf. Two examples are shown. First is a paper airplane. Second is a model bridge.

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Verbatim Format

Many people think you have to be a math genius or happy with number crunching to be a professional engineer. As it turns out, that's not actually true. What engineers do is take the same simple concepts that we just talked about and scale them up for larger objects. For instance, with paper airplanes we figure out what size to make the wings so that the plane can stay up in the air and how hard to throw it so it can travel far. The same goes with jet planes, engineers design the size and shape of the wings so that it can stay in the air and give it powerful engines so it can travel far and fast.

The same can be said with large structures like bridges. Can you think of the things you would watch out for when building a paper bridge? We think about the size, shape, and the strength of the paper. We also think about how we connect the pieces. When we build real bridges we think of these same things but we just scale them up both in size and quantity.

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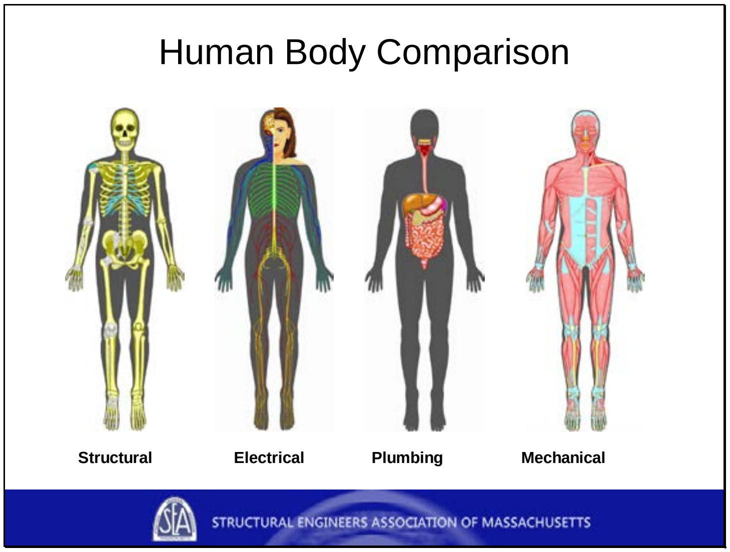
Outline Format

- Simple Engineering Solutions
- Scale Up Simple Solutions
    - Paper Airplane Example
    - Paper Bridge Example

Slide 4



Purpose: To explain to the audience the different parties involved in building construction by the human body analogy

The speaker is to explain to the audience the different types of engineers involved in the design of a building and what their roles are. Since it is difficult for middle school and high school students to relate to the different types of engineering, a comparison between the different systems of a human body and the different types of engineering may be helpful.

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Verbatim Format

The human body consists of many different systems working together, much like how the different engineering systems in a building work together. The human body contains the skin, the skeletal system, digestive system, nervous system, etc., and buildings have their exterior façade, the structural columns and beams, air-conditioning system, and plumbing system.

Many different types of people help design a building, and they often specialize in a particular system of a building. To use the human body as an analogy, if several engineers would work together to design a human body, it would look something like this: The architect designs the aesthetics, the way buildings look, which correlates to how the skin looks. Structural engineers design the skeletal system of a building (such as beams, columns, and roofs), very similar to the bones of our body, so that we support ourselves standing up. Plumbers design the piping necessary to drain all the waste away from the toilets, similar to our digestive system. Mechanical engineers design the air-conditioning and heating system, similar to how our lungs work. Electrical engineers provide the electrical needs, very similar to how our nervous system functions.

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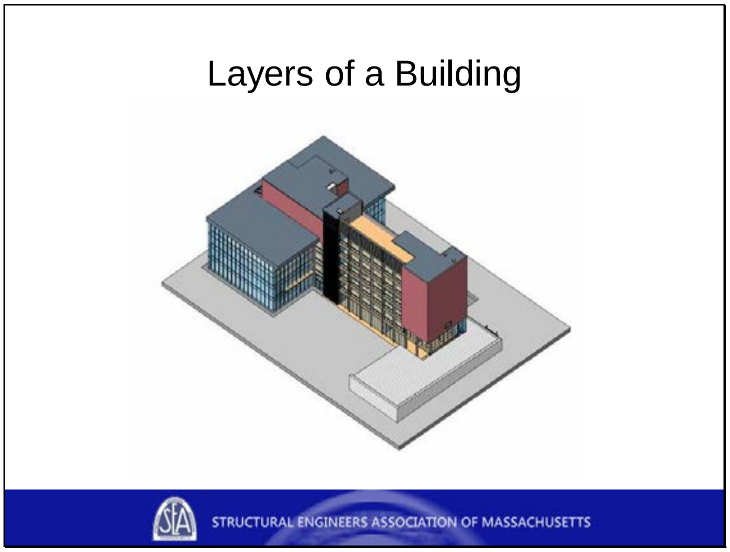
Outline Format

I. Compare the human body with engineering
- A. Structural engineering = bone skeleton structure
- B. Electrical engineering = nervous system
- C. Plumbing engineering = digestive system
- D. Mechanical engineering = muscular system or respiratory system
- E. Architecture = puts everything together and make it look pretty (the skin)

Slide 5



Purpose: To introduce the idea of what a building is made of, by looking at the exterior and then looking underneath the building's skin.

This slide shows a typical building from the outside. Windows and the exterior walls are all that are visible.

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Verbatim Format

Here we have the skin of a building. This slide shows a typical building as we would normally see it - from the outside. What do you normally see when you look at a building? (Allow students to offer answers.) You might see windows, right? What else? The exterior wall material, like concrete or brick. Maybe you see siding on a house. All these things on the outside are important to give the building a certain look, just like how the skin gives us the look. But these exterior elements may or may not be structural. They may just be for looks or to keep the building waterproof, like in our tent example. When you look at a building as a structural engineer, you can start to think about what is on the inside, too.

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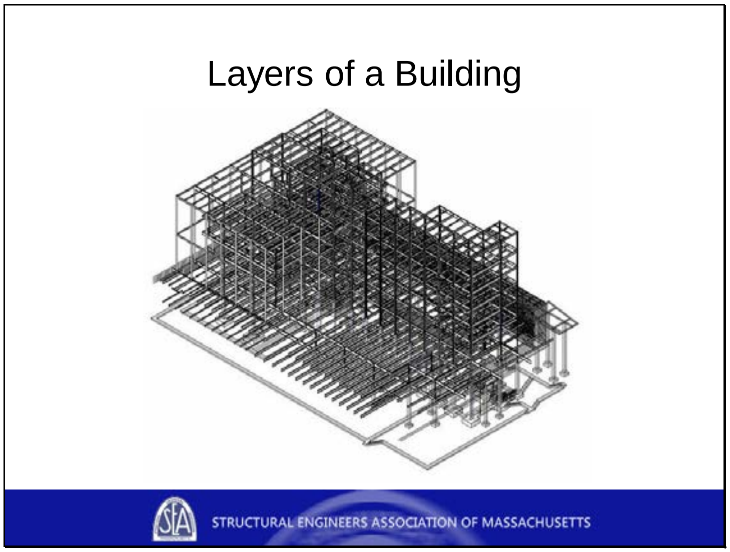
Outline Format

I. Point out that the building's exterior is only a part of the building.
- A. Ask the students what they normally see when the look at a building (windows, architectural elements)
- B. Explain that the exterior of a building may or may not be structural.

Slide 6



Purpose: To introduce the idea of what structural elements lie inside the building's exterior cover.

The speaker is to introduce the idea that the structural portions of buildings may not be visible in a finished building. They are often covered up by architectural elements. If the structural elements were exposed, we would be able to see columns, beams, structural walls and foundations.

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Verbatim Format

This slide shows the same building as in the previous slide, except here the exterior façade has been removed to expose the structural elements underneath. What you can see now that you couldn't before are the columns, beams, and foundations that hold the building up. A structural engineer would design the size and strength of these members.

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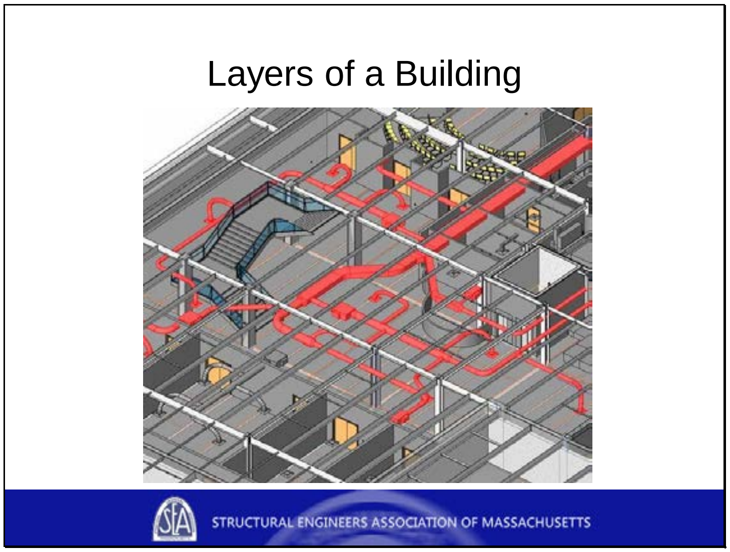
Outline Format

I. Layer 2
    A. Structural engineer
        1.Designs the part of the building that makes it stand

Slide 7



Purpose: To explain to the students about the layers of the building that the architect and mechanical engineer are in charge of.

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Verbatim Format

Now we see a close up of the interior of the same building. In this view, you can see things that you normally see when you walk around a building, like walls, doors, and seats. The architect designs all that. In this picture you can also see the ductwork for heating and air conditioning, shown in red, which the mechanical engineer designs. The mechanical part of the building is usually not seen in most buildings. The ducts are usually hidden in the floors, ceilings and walls.

In this room the vent for the heating and/or air conditioning is most likely located in the ceiling. That diffuser over there is part of it (Point to diffuser in the room if exists). When you see a vent like that in a ceiling, you can imagine that there are ducts just like the ones here in the picture running over your head in the ceiling above.

These ducts I am talking about are the ones that get so much attention in a movie where someone is trying to escape a room, and they take the grate off the vent and go crawling around in a duct until they are led to freedom. Not completely realistic, but it shows how the ducting system goes throughout entire buildings.

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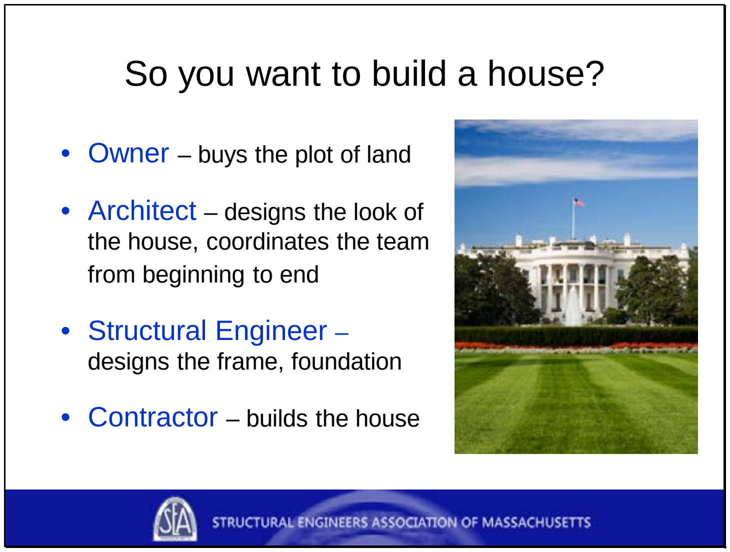
Outline Format

I. Layer 3
- A. Architect
  - 1. Wall layouts, door locations, stair locations, seating arrangement
- B. Mechanical engineer
  - 1. Heating and air conditioning flow

Slide 8



Purpose: To provide a simple example of the roles of the building team, including owner, architect, contractor, and structural engineer.

The speaker is to explain to the audience what roles are typically involved in a building project by using a very simple camping tent model.

Verbatim Format

In the previous slides we have looked at different systems designed by different engineers in a building. Let's take a look at some other roles or jobs involved in a building project.

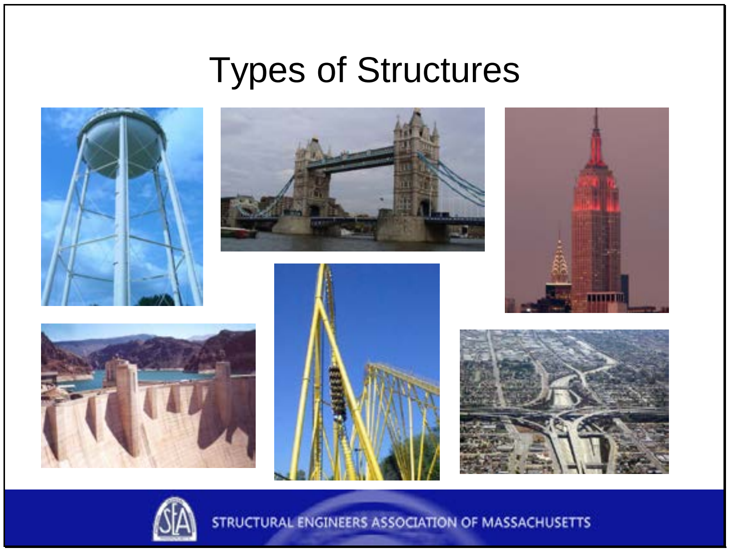
Let's say that you are going camping and you need to have a tent to sleep in. In this example, the first person involved is the person who has the campsite. That person is called the owner. The owner typically owns land and wants to have a building or other structure built on that land. The owner will then hire a team to design and build the structure. The owner will hire an architect to design the look of the structure. For our tent here, that could mean how big the tent is, what materials it will be made from, what color the canvas will be, and even where the door to get in will be. The architect also coordinates all the team members throughout the project. The structural engineer will either be hired by the owner or by the architect. The structural engineer's job would be to design the poles that hold up the tent and the stakes that hold the tent down to the ground. The architect and structural engineer would work together to make drawings explaining how to build the tent they designed, kind of like the instruction manual that comes with a tent that you buy. The owner will then hire the contractor. The contractor's job would be to use the drawings that the architect and structural engineer prepared to actually build the tent.

If we were building an entire building, we would use this same process with an owner, architect, engineer, and contractor. It could be any type of project, but it's the same idea.

Outline Format

I. Define roles involved in a building project team
- A. Owner
  1. Owns the land the structure is to be built on – campsite
  2. Hires the architect, contractor, and maybe engineers
- B. Architect
  1. Designs the look of the structure – size, color, shape
  2. Coordinates the building team
  3. May hire the engineers
- C. Structural Engineer
  1. Designs the structural parts of the building – poles, stakes
- D. Contractor
  1. Builds the structure (tent)

Slide 9



Purpose: To give examples of different types of structures that structural engineers design.

The speaker is to go over the six photos while mentioning how all of them require structural engineering. Photos: (top left, clockwise) water tower, bridge (Tower Bridge in London), skyscraper (Empire State), freeway interchange, roller coaster, dam (Hoover Dam). The speaker can then ask for some more examples, possibly adding some more of his/hers to get the discussion going.

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Verbatim Format

Here are some of the projects structural engineers can work on. I'm assuming most of you have been on a roller coaster before, but probably didn't think that it took a lot of engineering to make the cars run the way they do. Other examples…dams, water towers, freeway interchanges, skyscrapers and bridges. Can anyone think of any other examples of structures that require structural engineering?

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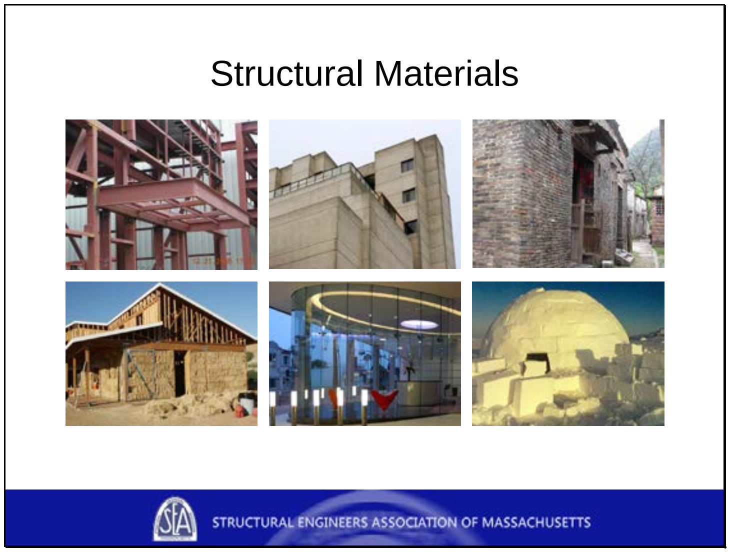
Outline Format

I. Types of structures.

- A. Water tower
- B. Bridge
- C. Skyscrapers
- D. Freeways
- E. Roller coaster
- F. Dam

Slide 10



Purpose: To inform the audience about various construction materials used in structural design.
The speaker is to explain to the audience about the six major construction materials used in the design of most structures. The slide is intended to be an interactive exercise between the speaker and audience. The speaker is to ask the audience to identify the construction materials. When all the materials has been identified, the speaker should provide examples of when these materials are commonly found in design.

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Verbatim

Engineers design the different types of structures we just looked at using various materials. Each material has different strengths and weaknesses, and are used more commonly in some structures than others. Can you guess some of the construction materials used in design (Let audience answer the question)? Good. It is common for engineers to design structures using steel, concrete, wood, and masonry. Glass and even ice and straw bales are used in some structures, but not as common as the other four. Of course, other materials are used but these are the primary materials.

Because each of these materials has different properties which make it act differently, there are common ways each material is used. For example, what are a lot of houses made of? (wood.) Wood is used for smaller structures like houses or smaller buildings. What about concrete? Where would you see concrete used? Today, concrete is typically used to design most bridges.. Concrete is also popular in the design of dams. Most designs of high rise buildings use a combination of concrete and steel.

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Outline

Some materials are used for structural design.

- A. Steel
- B. Concrete
- C. Masonry
- D. Wood
- E. Straw
- F. Glass
- G. Ice

II. These materials are found commonly in some types of structures.

- A. Wood – houses, small buildings
- B. Concrete – bridges, dams, high-rise buildings
- C. Steel – bridges and high-rise buildings

Slide 11

Purpose: To inform the audience about the common design loads.

The speaker is to identify the common design loads in structural engineering. Six design loads are illustrated in the slide. Top (left to right) represents seismic, wind, and blast loads. Bottom (left to right) represents gravity, soil, and hydraulic loads. The speaker should encourage class participation by asking the class to identify the different design loads. When all the loads have been identified, the speaker can briefly provide examples of structures designed to resist the discussed forces.

Verbatim

Now that we have looked at the types of structures and materials that structural engineers use, let's look at what these structures are designed for. Structures are designed to resist many forces. Can anyone think of some forces used in structural engineering? If you lived in or around Boston, you can probably guess heavy snow and wind are common design loads. Other forces considered in structural designs are earthquake loads, water loads, earth loads, and blast loads. A structure must also be designed to supports its own weight and the weight placed on it, such as a truck on a bridge.

The common design loads are considered in the design of many structures. Dams are designed to resist water loads. Retaining walls are designed to hold back soil. Bridges are designed for wind and seismic forces. Important buildings, such as foreign U.S. embassies, federal government buildings, and military buildings are designed to resist blast loads. Can anyone give more examples?

Outline

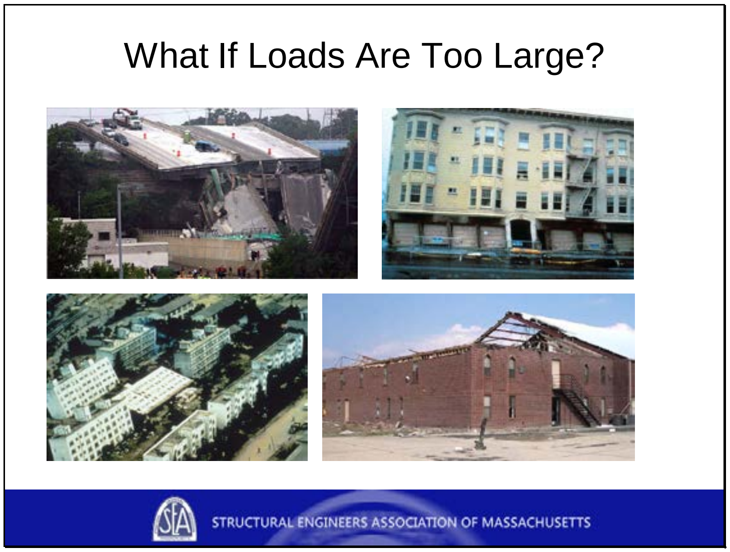
I. Structural design typically involves six common design loads.

- A. Seismic forces
- B. Wind loads
- C. Blast loads
- D. Gravity loads
- E. Soil pressure
- F. Water pressure

II. There are many structures designed to resist these forces.

- A. Most long-span bridges are designed for wind, seismic, and gravity loads
- B. Retaining walls designed to resist earth pressures
- C. Dams resist hydraulic pressures
- D. Government buildings, such as embassies, are designed for blast loads

Slide 12



Purpose: To explain to the audience that if structures are not properly designed, disasters can happen, and people can get hurt.

The slide is a follow-up to the previous slide. In the previous slide, the different loading conditions are explained. This slide shows what would happen to buildings if the loading conditions are not estimated or designed properly.

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Verbatim Format

What if loads are too large? Buildings can collapse under many different circumstances. The lower left picture shows what happen to buildings after the Kobe earthquake in Japan. The soil supporting the buildings liquefied (become quick sand) and the buildings sank to the ground and tilted over. The upper left picture shows what happened to the I-35 highway bridge at the Mississippi River crossing in Minneapolis in 2007. The bridge was overloaded during rehabilitation preparation activities. The bridge collapsed, causing major traffic problems for months. The upper right picture shows an apartment building in the Marina district of San Francisco after an earthquake. The first story, because of the many garage door openings, is weaker than the stories above. The first story was strong enough so that the upper stories drifted to one side. The lower right picture shows what happened to a building after the Katrina hurricane. The roof was not strong enough to withstand wind forces, so it was blown away.

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Outline Format

I. Buildings can collapse as a result of different types of loading

- A. Picture 1 (Upper left – 2007 Rehabilitation Construction) – Caused by overloading as a result of pre-construction activities
- B. Picture 2 (Upper right – 1989 Loma Prieta Earthquake) – Caused by soft story as a result of large openings at garages
- C. Picture 3 (Lower left – Kobe Earthquake) – Foundation failure as a result of liquefaction (Building above ground stays intact but tilts)
- D. Picture 4 (Lower right – 2005 Katrina) – Roof

Slide 13

Purpose: To illustrate some of the trends and challenges that the structural engineers will be facing in the future.

This slide is intended for a more mature audience who is more serious about choosing structural engineering as his or her major. This slide discusses the future trends and challenges that structural engineers will face. They include the use of BIM (Building Information Modeling) technology, and Sustainability Design ("green" design).

Verbatim Format

What is the future like for structural engineers? If you do decide to go into structural engineering, here are some trends that are expected to gain popularity. By the time you finish school and become a practicing engineer, these issues are most likely to be affecting your day-to-day job.

The use of BIM (Building Information Technology) is becoming more and more popular. BIM technology usually refers to one single model (usually 3-dimensional) such that architects, engineers, contractors, etc. will share information contained in the same model. It is a smart model because when you model a beam, for example, the program knows all the properties that are associated with that beam. Therefore, the model no longer only shows lines depicting the beam, but it knows all properties including dimensions, strength, material type, etc.

With the current awareness of global warming, sustainable design is going to be important for the next few decades to come. Constructing a building requires a lot of materials, and if the materials are not carefully chosen, it could lead to a lot of waste. Even if you are not aware of it, buildings use electricity and need air conditioning to make the occupants comfortable. Architects and engineers nowadays are coming up with designs such that the use of energy is minimized. Some buildings would have solar panels installed on the roof. Some buildings may use natural ventilation so that no air-conditioning will be required. The list goes on and on.

Outline Format

I. Future Trends of structural engineering

A. Picture 1 (Upper right – Seaport Revitalization) – Buildings that that incorporate sustainable design elements such as roof gardens, rain-water catchment, proximity to public transportation, and balcony/sunlight offsets and dense urban design.

B. Picture 2 (Upper left – BIM model) – 3-D model such that architects, engineers, owners, and contractors share information

C. Picture 3 (Lower right – Solar panels on roof) – Installation of solar panels will minimize the use of energy in the building, thus minimizing the production of greenhouse gases.

D. Picture 4 (Lower left –San Francisco Academy of Sciences Building) – Uses natural ventilation, roof garden, and other sustainable building design features. Largest green roof in the nation.

Slide 14

Purpose: To inform the audience about different types of lateral resisting systems that are required.

The speaker is to explain to the audience about the types of lateral resisting systems that are commonly used. The pictures…Left: steel braced frame structure. Top middle: space truss system. Bottom middle: brick masonry shear walls. Right: Concrete shear walls. This slide is more of an informative slide as opposed to an interactive one. Most likely the students will not know these systems, although they may recognize them.

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Verbatim Format

The failure of structures caused by instability due to wind loading is something we are very concerned with. We live in an area that has the potential to be in the path of a Category 3 hurricane. When designing structures in New England engineers must not only design for gravity and snow loads but also for high wind loads; loads that act in the lateral direction…left to right. The first photo is of a 400 ft tall building in downtown San Francisco. The braces, the diagonal members you see on the building face, help the building resist sideway forces, like the kind you get from an earthquake or big wind storm. They stiffen up the structure and without them, any decent sized earthquake could cause this building to fail. The top middle photo of the Transamerica building, has a similar system to the braced frames. This system is called a space truss. The last two photos are of structures with shear walls, brick masonry and steel cladded concrete.

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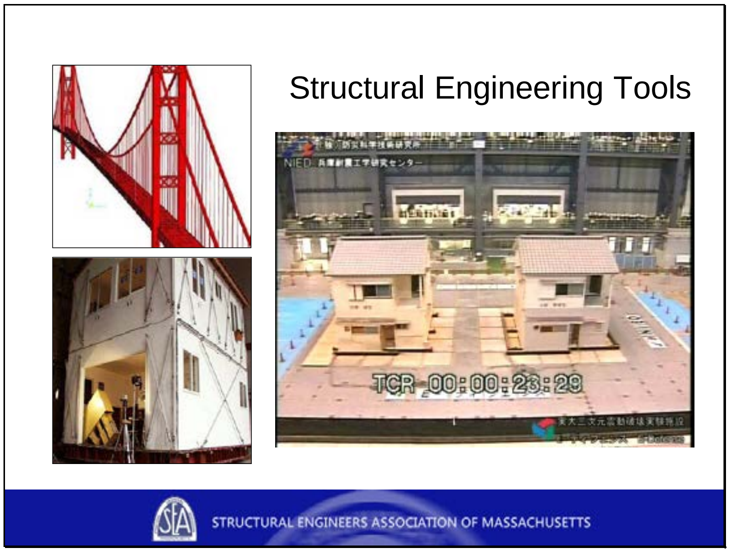
Outline Format

I. Different lateral systems.
- A. Brace frames
- B. Shear walls
- C. Moment frames

Slide 15



Purpose: Illustrate exciting aspects of structural engineering.

The speaker is to illustrate the two common tools used in structural engineering. The first item involves the use of computer simulations to predict structural response. The second item involves the use of experimental tests to study structural behavior. The speaker is encouraged to provide their personal experience with these engineering tools, if applicable.

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Verbatim

Since disasters are hard to predict, computer modeling and experimental tests are some tools used in structural engineering to help us understand what happens to a structure when a large scale event happens, like a hurricane. A structural engineer uses computer models to predict the response of a structure under different loadings (such as the forces describe in the design criteria slide). Earthquakes can be incorporated in the computer models to illustrate how a structure will react under the given seismic event. Results from these computer models are then used to design the real structure. This particular model was created on a commonly used structural engineering program called SAP2000.

Besides testing structures in computer models, structural engineers can perform experiments. Shake tables, which are platforms that can move, simulate ground movement as a result of an earthquake in order to test full size structures. These tests are not only fun to watch, but have provided invaluable information for designing earthquake resistant structures. For instance, the two-story house shown on the right slide is placed on top of a shake table. Information from this test will help engineers identify the strengths and weakness of the walls panels and overall structural response during an earthquake. Explosions, to study impact forces on structures, have also been simulated in structural engineering labs. These are just some aspects of the field that makes structural engineering a fun career.

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Outline

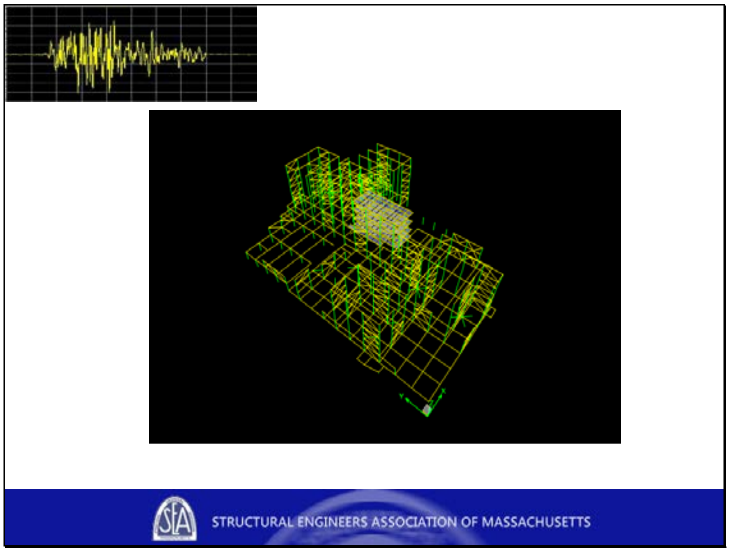
Structural engineers use computer models to predict forces and responses on a structure.

- A. Computer model can predict response of structure due to wind, seismic, and other forces.
- B. Results of computer analysis are used to design the structure.
- C. Model shown on slide is from a common structural engineering modeling program (SAP2000).

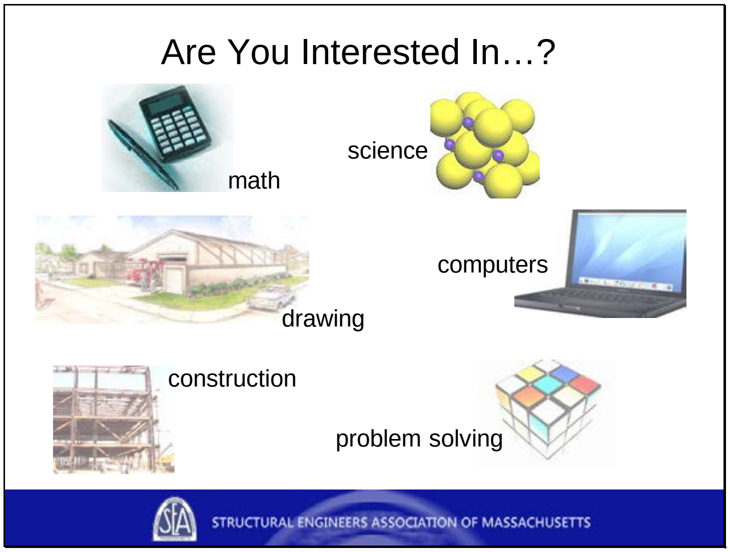
II. Experimental tests are performed to develop a better understanding of structural engineering behavior.

- A. Structures are tested on shake tables to study effects of earthquakes.
    - 1. Featured slide shows a full scale model on a shake table. This test was performed to quantify the contribution of the wall panels to the overall structural response during an earthquake.
- B. Other experimental tests, such as blast mitigation experiments, or wind tests, study the effects of impact on structures.

Slide 16



Slide 17



Purpose: To explain to the audience how they can tell if they might like to pursue engineering as a major or career

Middle school and high school students like to know whether pursuing engineering as a major or career is right for them. The speaker will inform the audience that there are signs that will allow the students to guess whether they will like engineering. If they are interested in the above subject matters, then engineering may be right for them.

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Verbatim Format

Do you think you have what it takes to be an engineer? Becoming an engineer takes many years of school work and experience. Do you think engineering right for you? Think about it for yourself and reflect on what naturally draws your attention. What are your favorite classes in school? If you enjoy studying math, science, doing the homework problems, or if you enjoy working with computers, enjoy drawing, or if you like to stare at bridges or buildings under construction when you drive by it, there is a good chance that you will like engineering (or civil engineering) as a career.

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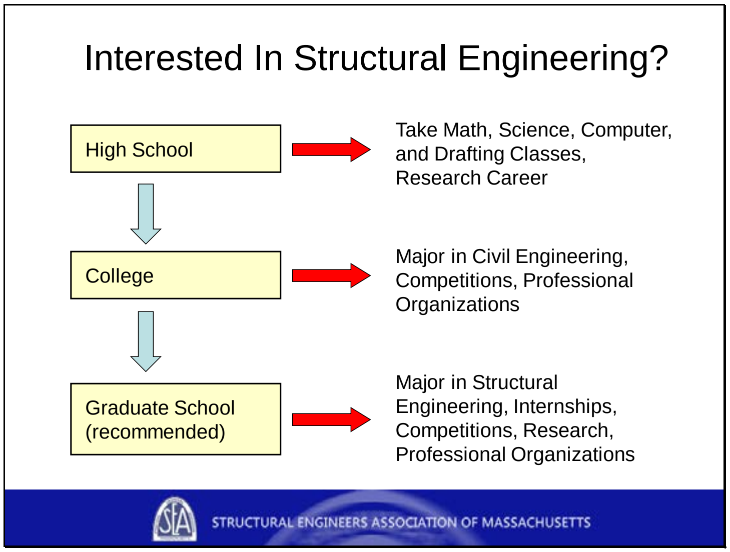
Outline Format

I. Interests necessary to enjoy pursuing civil engineering

- A. Math
- B. Science – may be physics
- C. Drawings
- D. Use of computers
- E. Problem solving – working on math or science problems
- F. Like to see things being built

Slide 18



Purpose: To inform the audience about what they should study or classes they should take in school.

The slide is primarily targeted to high school students because middle school curriculum is usually set and has very little flexibility. The speaker may choose to either delete this slide or talk about it briefly when presenting to younger audience.

Verbatim Format

How do you become a structural engineer? What classes should you take? If you are in high school, I suggest taking as many advanced math or science classes as you can. Engineering is based on a strong fundamental understanding of mathematic principles and scientific concepts. You will benefit quite a bit if your school offers art, drafting, or architecture classes.

In college, you may want to consider majoring in civil engineering. Some schools offer a similar major called architectural engineering in which the focus is entirely on buildings and structures. Almost every university will have student engineering organizations that you can be a part of. These are student-led professional organizations that help sponsor engineering talks and seminars, career fairs, and student competitions such as concrete canoe competition or steel bridge competition. Take advantage of those. Not only will you get a better understanding of engineering, you will also meet a lot of people and make your college experience a lot more memorable.

It is quite common for civil engineering majors to pursue a graduate (masters) degree before working. It is actually highly recommended in the industry now. You may want to concentrate on graduate structural engineering programs. In graduate schools, you will have the opportunity to join graduate-level professional organizations and work with professors on research projects that interest you.

Outline Format

I. How to prepare to be an engineer?

- A. High School – Take Classes in advanced math, science, art, architecture, drafting, computer
- B. College – Major in Civil Engineering or Architectural Engineering, join professional organizations
- C. Graduate School – Major in Structural Engineering, do research, try job internships

Slide 19

Purpose: To identify some of the rewards of being a structural engineer

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Verbatim

So what are the rewards for being a structural engineer? I think one of the coolest things is that you are able to see your work built. As a structural engineer, after you design the structure, you get to watch it being built, and you get to say, 'I designed that building that all those people are using'. So you get to make your mark on the physical world that everyone lives in and uses. I'm sure most of you recognize the pictures on the bottom here. What's the picture on the left? (Zakim Bridge Downtown Boston). And on the right? (The Hancock Tower in Copley Square)

And you get to help people by making the structures safe. As a structural engineer, you are making sure that whoever is using your building is not going to be harmed if there is a hurricane. For example, if a hurricane hit during a Boston Celtics game, the building keeps the people safe. Even the lights that are hanging are designed not to fall on somebody and hurt them.

You also get to learn a lot - you learn about the different construction materials we talked about, like steel and concrete and wood. You get to learn about how buildings are built by working with the contractors. You get to learn how to work with people by working in the design team with the architect and other engineers like we talked about in the beginning.

And, you get paid. That's the question everyone wants the answer to, right? The average starting salary for someone graduating with a Bachelor of Science degree in 2010 was $58,000 per year. With a master's degree, which is highly recommended, the starting salary in 2010 was $65,000 per year.

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Outline

There are rewards to being a structural engineer.

A. See your work built - make an impact on the built environment
B. Help people – keep the built environment safe
C. Learn stuff
D. Get paid – provide average starting salaries of BS and MS
E. Other rewards?

Slide 20

Purpose: To provide an opportunity for the audience to ask questions.

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Verbatim

Does anyone have any questions?

SAMPLE HANDS-ON ACTIVITIES DESCRIPTIONS

Sample Activity #1: Paperclip and Toothpick Comparison

Estimated Time: 20 minutes

Materials (per student):
- 3-4 small paperclips
- 3-4 jumbo paperclips
- 3-4 toothpicks

Objectives:
- To observe the difference in material properties of two construction materials: metal and wood
- To observe the effect of area of material when under stress
- To understand how testing and statistics is used in structural engineering

Instructions:
- Distribute materials as stated above to each student.
- Have the students bend the outside leg of the paperclips back and forth until it breaks off, counting how many times it takes before breaking. The students should record the result of each test sample.
- Have the students repeat with the toothpicks, bending in the middle.
- Have the students calculate the average number of times it took to break the paperclips and the toothpick.
- Have students share their averages.
- Lead discussion about what they learn.

Example questions to ask the students:
- What did you notice about how the paperclips broke verses how the toothpicks broke? *The toothpick broke faster; the paperclip took longer to break. The toothpick snapped, while the paperclip bent very easily without breaking.*
- What does that tell you about the difference of these materials? *Metals like steel are more ductile than wood. Ductility is the physical property of being able to take large deformations without breaking. The opposite of ductile is brittle. Brittle materials are not able to take large deformations without fracture.*
- What did you notice about how the small paperclips broke verses how the jumbo paperclips broke? *The failure of both sizes of paperclips was ductile because they are made from the same material. But the jumbo paperclips took longer to break because the jumbo paperclips have more material, or more area, to break.*
- From this, what can we say affects how something breaks? *What the material is and how much of it there is affects how something breaks.*
- How would engineers use the results of tests like this one? *Engineers test the materials to determine the properties, like how ductile a material is. Once they know the result of the tests, they reduce the result by a ‘safety factor’. That way, engineers can be sure that the material won’t break before they thought it would. This helps to make their structures safer.*

Relation to the slideshow:

- Emphasize the Earthquake load (cyclic loading like the loading in this game) in the “Common Design Loads” slide. Perhaps ask the students which load is most like the loading that they impose during the game.
- Highlight that different materials have different strengths (like paperclips and toothpicks) on the “Materials” slide. Possibly allow for a discussion of which structure in the photos would be strongest under loadings like the ones done in the game. For example, if we were pushing the steel building back and forth, how would its strength compare to pushing the wood building back and forth? Relate this back to the paperclip and toothpick testing
- Highlight the experimental element shown in the “Structural Engineering Tools” slide

Sample Activity #2: Paper Bridge

Estimated Time: 10 minutes

Materials (per group of 5-6):
- 6 paper clips
- 1 scissor
- At least 25 pennies or similar small weights
- 1 sheet of 8 $^1/_2$" x 11" paper
- 2 books or similar props

Objectives:
- To allow students the opportunity to design and build their own paper bridge
- To illustrate the concept of material strength from modifying the shape of the material
- To demonstrate the basic design process

Instructions:
- Break the students up into groups of 5 to 6.
- Distribute the materials as stated above to each group.
- Ask the students to build a bridge to support the pennies within 10 minutes. Each bridge must span at least 8 inches and have enough "deck" space to put the pennies.
- The bridge must be constructed with 1 piece of paper. Allow additional sheets of paper for practice, if necessary. The sheet of paper can be cut, folded, and modified in any way with the given materials.
- Keep track of time and give the students 5-minute, 2-minute and 1-minute warnings
- Load the bridge with the pennies and determine the strongest bridge
- Lead discussion about what they learn

Example questions to ask the student:
- What are some ideas to make the paper stronger? Lead to discussion about material shapes, such as I-beams.
- Where did your bridge fail? Did the bridge fail by bending? Relate to discussion about predicting structural failure in buildings and bridges.
- Was there a difference in distributing the pennies along the bridge and placing the pennies all in one location?
- Did you build a sample model before you build the main bridge? Lead to discussion about engineers using computer simulations and models before building a real bridge.
- How did you utilize the ideas of every group member? Illustrate the importance of communication and teamwork in engineering.
- What bridges have you seen before? What were these bridges designed to support? Are there other considerations in designing a bridge (i.e. seismic and wind)?

Relation to the slideshow:
- Point out the bridges throughout the slideshow, as bridges are one of the most recognizable (and researched) areas of structural engineering
    - Golden Gate Bridge on the title slide
    - Left photos (top and bottom) in the "Common Design Loads" slide

    - The Bay Bridge in the “Failed Buildings/Elements” slide
    - Tower Bridge in the “Types of Structures” slide
    - Golden Gate Bridge model in the “Structural Engineering Tools” slide
- Emphasize the impact of live loads on bridges in the “Common Design Loads” slide (bottom left photo is of humans on a bridge)
- In the “Failed Buildings/Structures” slide, point out that there is a serious traffic and economic impact of having a bridge failure, as shown in the bottom left photo.

Sample Activity #3: Gum Drop and Toothpick Structure

Estimated Time: 20 minutes

Materials (per group of 3 to 5 students):

- 1 cup of mini gumdrops (marshmallows may also be used; see last bullet under Relation to slideshow.)
- 100 toothpicks

Objectives:

- To let the students build the tallest tower with gumdrops and toothpicks within a certain time limit
- To expose the students to the process of design and construction within a team environment

Instructions:

- Break the students up into groups of 3 to 5.
- Distribute material as stated above to each group.
- Ask the students to build the tallest tower within 10 minutes (time can change depending on time constraints) – a deviation of this can be allowing the students to talk among themselves for the first 5 minutes and working in silence for the last 5 minutes.
- Keep track of time and give the students 2-minute and 1-minute warnings.
- Determine winner (tallest structure standing).
- Lead discussion about what they learn.

Example questions to ask the students:

- What are the difficulties in working with the materials?
- Was the tower able to hold up? If not, can you figure out why?
- Did you think about the design first and then build? Or did you jump into building it right away? Do you think you will do that differently next time? How or why?
- Did one person make the design decision? Or did everyone participate?
- When you had a good idea, were you able to convince other people of your idea?
- Did your design change along the way? How or Why?
- *If you allow them to work in silence for the last 5 minutes*, did communication cause any problems? Relate with presenter's own experience.

Relation to the slideshow:

- Highlight the fact that bones are used to support the body in the "Building vs. Human Body" slide.
- Emphasize that the shape of the tent in the "So you want to build a tent?" slide will have an impact on how tall the tent can be, as well as how much weight it can support.
- Highlight that the rectangular shape in the "Layers of a Building" slide does not allow for a structure as tall as those with triangular braces in the "Earthquake Country" slide. The triangles are very good for stability, and are thus used in many bridges and tall structures.
- If some students use marshmallows and others use gumdrops, use the "Materials" slide to highlight that some materials are stronger than others, and are thus better to use for connections (the stiffness of the gumdrops

makes them preferable to marshmallows as a means of connecting the toothpicks).

- Call attention to the triangular elements used in the “Types of Structures” slide.

Sample Activity #4: Edible concrete

Estimated Time: 10 minutes; 5 for prep, 5 to chill “concrete”

Materials (per group of 5-6):
- 1 box of pudding
- 1 mixing bowl
- 1 spoon
- 2 Tbsps of cocoa powder
- ½ cup of Oreos^{TMh}, crushed
- 2 cups milk (water may be substituted, but will affect taste and consistency)

Objectives:
- To allow students the opportunity to design a “concrete” mix
- To illustrate the concept of differing concrete textures based on the relative quantities of coarse aggregate (oreos), fine aggregate (cocoa), cement (pudding mix), and water (milk)
- To demonstrate the curing process via chilling the “concrete”

Instructions:
- Break the students up into groups of 5 to 6.
- Distribute the materials as stated above to each group.
- Ask the students to mix materials together in any proportions they choose
    - Have the students record how much of each material they put into their mix
- Have each group compare their mix design to other mixes before chilling
    - Look at the “workability”: how easily can the concrete move?
- Chill the “concrete”
- Have the groups record what has happened to their mix after chilling
    - Is the “concrete” stiffer?
    - Have the “aggregates” separated from the rest of the mix? (Hopefully not)
- Enjoy!

Example questions to ask the student:
- What is the effect of adding more milk? *The mix seems to be more workable/flows easier.*
- What happens after the “concrete” is chilled? *The concrete has “cured” or stiffened into place. This is the time when the strength in the concrete is developed.*
- What are the differences between mixes with varying amounts of coarse aggregate? *The mixes with more coarse aggregate are less homogeneous.*
- What does the cocoa, or fine aggregate, do to the mix? *The fine aggregate should make the pudding seem thicker. This is analogous to concrete becoming less porous when fine aggregates are used.*

Relation to the slideshow:
- Emphasize the building materials slide, especially the concrete building (top row, center photo)
- Ask students to find concrete in the Earthquake Country slide (the photo on the right is a concrete building)

ACKNOWLEDGEMENTS

This guide was written with the experiences gained from participating in High School Outreach programs in the San Francisco Bay Area in association with the Structural Engineering Association of Northern California (SEAONC) and in the greater Boston area in association with the Structural Engineering Association of Massachusetts (SEAMass) from 2008 to 2013.

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Finally, I would like to thank Brent Perkins and the folks of the National Council of Structural Engineering Associations Basic Education Committee for allowing me the time and opportunity to put this guide together.