Presentation Script

Series 1 Show 1

I. Possible benefits

II. Introduction to bridge trusses

III. Modeling for structural analysis

Slide 1

This series of slide shows was prepared for parents and teachers of technology students.
It provides a method to introduce students to structural engineering design.
Structural considerations for the design and construction of trusses for model bridges is discussed and an example is presented.

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Slide 2

Possible benefits
The reasons for using school time to introduce this topic.
Introduction to bridge trusses
A suggested method for introducing the truss.

Modeling for structural analysis

A look at the symbols and tools used to describe the model to the program.

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1. >>>>

The most basic Engineering Design equation states:

The actual force in a member must be less than or equal to the allowable force in the member.

This is an inequality.

Structural analysis and ModelSmart3D provide the opportunity to reinforce math concepts such as: inequalities,negative numbers,3d Cartesian system (x,y,z) ,measurement,% and many others.

Structures also involves science concepts such as implementation of Newton’s laws and other science skills.

2.>>>>>

Also as an added benefit the student will spend some time with engineering concepts.

This leaves the student with a “feel” for engineering.

3.>>>>>

At what age did the inventers of mathematics, science and engineering make most of their discoveries?

Early on. Now is the time to train our most inventive minds.

4.>>>>>

Children live up to their labels. Visually oriented students that are weak in their verbal skills are sometimes, along the way, labeled as poor students.

They are our Engineers!!

We can properly re-label them as good students using their success with this topic.

5.>>>>>>

We need to learn to do more and more with less and less until we can do everything with nothing.

Buck Minster Fuller

Supplies are expensive.

ModelSmart3D makes it easy to try ideas without wasting materials.

ModelSmart3D can give you vast bridge building experience in a morning.

To summarize

Motivation and Enhancement

An Aside:

ModelSmart3D should not become the focal point for their design.
It is not a game. It is an analysis tool. It does not think!
The student should be encouraged to keep a written journal
for recording notes and sketching ideas.

Slide 4

"I started out as a child"

Bill Cosby

Let's start our discussion with a child sized bridge.

Why build a bridge?
Short answer: To span a gap.
Gap - An obstruction to the free movement of pedestrian or vehicular traffic.

Possible discussion:

Can we fill in the ditch or is it needed for drainage?
Could we use a pipe or culvert?
What about a simple beam?

Let's span the ditch with a single board.
This drawing is a front elevation of the bridge
drawn on a cross section of the ditch.

Cross sectional view – Take a perpendicular slice of something and look into the slice.
A yard stick – draw the cross section on the board.

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Here's a small foot bridge built by children.

This one is along a short-cut to the neighborhood swimming pool.

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Should we just use a bigger (chunkier-larger cross section) board?
For really long spans it could take a really big board.
Too much material, may be.
The self-weight of the beam might be enough to fail it.

Let's look at how a beam supports load.

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Newton's Law #3 **–** For every action there is an equal and opposite reaction.
Remember this?
"You push the wall and the wall pushes back on your hand with equal and opposite force."

Discussion:
How does the wall push back?…………
The wall is made of springs.

Imagine a spring. You apply a load of one pound on the spring it squishes or stretches an amount and stores the energy to push back with one pound of force.

How does a beam support load?
It too is made of many itty bitty springs.
Not helical (the way you usually visualize a spring) just straight cellulose fibers that stretch and squish.

When the beam is loaded as shown,
the wood fibers in the lower half of the beam are stretched (in tension)
and the wood fibers in the upper half are squished (compressed).

Nothing happens (in terms of stretching and squishing) to the wood fibers at the neutral axis.

The greatest forces are in the extreme fibers – those farthest away from the neutral axis.

Let's take a closer look.
Image a big knife and cut the beam at the line "A".

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This is called a cross section of the beam.
The fibers are like little springs. (And they can break!)

In a since, we are not using the material close to the NA(neutral axis) very efficiently – at least not in bending.
Although this other material is bracing the compression fibers to prevent individual fibers from buckling, but there may be a more efficient way to "Build a beam".

How could we reduce the bending in the beam to prevent it from breaking without making the beam larger?

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We could reduce the span.

It will bend less with a smaller span.

Discussion:
What if the stream was navigable and we wanted to keep it free from obstructions?
What if the mud at the bottom was too soft to support the post?

Can you think of another way to support the beam in the middle?

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What about support from above?
We could support the hanger with a helicopter!
That could get expensive!

Any other ideas?

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Let's build a structure to support the middle member.

(Note: The diagonal members are in compression and the vertical member in the middle is in tension.)

Discussion:
Can we just stick the poles in the ground?
Will they last in the ground?
Is the soil too soft?

Is there a better way?

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Here’s a better idea!
What have we built? A truss.

How can we extend this truss for larger spans?

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Just pick up the end of the first truss with another overhead support
and extend it with triangles.

Is the top chord in tension or compression?
(Assuming there is a load directed downward in the middle of the truss.)

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Don’t overlook what is really happening.
Visually color in the truss. What do you see?
A plain old garden variety beam.

And how does a beam support load?
Remember the springs?

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The springs near the top of the beam get compressed.
So the top chord of the truss is in what? Compression

The bottom chord is in what? Tension

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What overall shape will your bridge be?
An arch? A suspension bridge? A bowback ?

The shape of your model bridge will probably
be governed by the available supports.

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Your bridge will be what engineers call simply supported.
That is, you are probably going to just set the bridge on the test machine or block at each end.

I doubt you are going to glue it to the table top.
Therefore, you cannot consider it as fixed.
It will be free to rotate at both ends.
And we'll assume it will not slip off.

Therefore,
a hinge at one end is appropriate.

A hinge allows rotation, but not motion up or down.
The hinge also keeps this joint of the model from moving left or right – this will prevent the model from slipping of the base.

(The program will not be able to analyze the model if it is not in an externally stable configuration.)

A roller at the other end is appropriate because it prevents up and down movement (I know it look like it can lift up but this is engineering symbol and it is defined to resist upward motion), allow rotation and will allow a little slippage to occur in the left and right directions.
Only one end need have a hinge (if the model is internally stable) to prevent is from slipping off of its base.
Note:
There is no way to tie back a suspension cable and there is no way to buttress an arch.
Given our restricted selection of supports to simply supported (hinge-roller combination), what will the overall shape of our bridge be?

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Let's think 2D for a while.

Which of the shapes would make a good (simply supported) bridge?
Remember, there will be no way to tie back the cables of a suspension bridge or prevent the outward movement of the base of an arch.

In "B" you are essentially cutting away part of your "beam".
This would only work if you could tie back a cable.

In "D" , this is also analogous to cutting away part of a beam. Not good.

(The roller would kick out and the shape would break in the middle.)

We can’t get “E” to work. We can’t make it externally or internally stable
as a simply supported structure.

A,C,F,G,H are all good possible shapes
provided you design them well internally.

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Once you have an idea for the overall shape, you must then decide on the arrangement of the interior structure for the truss.
Here are a few suggestions.

The student should study the different bridge shapes.
(Look at bridges in your area and in reference books at your home and in the library. The PESC Web site has many photos of bridges – www.pre-engineering.com)

After studying the different possibilities,
the student should decide on a preliminary design and sketch this design layout in his or her journal.

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Here’s an example of a preliminary sketch.
This is the starting point for **your** design.

We need to now convert this sketch into something that the program can understand.

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Here are the symbols that the program understands.

Joints or Nodes are point locations on the Cartesian coordinate system.
They are used to describe the location of the member end points.

Cartesian Coordinate System **************************
The Cartesian coordinate system was invented
by Rene' Descartes' (pronounced DAY cart) in 1500.
The 2D Cartesian coordinate system consists of 2 number lines
oriented at right angles to one another.
An ordered pair (x,y) is used to locate a point on the coordinate system.
(Draw the 2D Cartesian coordinate system on the board and plot some points.)
The positive directions are usually up and to the right.
(You could name the Y axis "V" (for vertical) if you wanted to and name the X axis "H" (for horizontal). It's up to you.)
****
Joints represent locations on the coordinate system – your graph paper.
Members represent the structural elements used to build the model (ie balsa wood sticks).

Supports are symbols that represent the attachment of the model to the outside world.
Supports modify joints. They represent assumed restrictions to movement of a joint.

For simple supports we classically use a hinge-roller combination.

Load Vectors represent externally applied loads on the model. (ie the test weight)
Load vectors show magnitude (by their length), direction, and point of application
(Loads are applied at joints).
Use these symbols to construct the "Computer Model Sketch".

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Here's a picture of a real hinge.

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Let's draw the "Computer Model Sketch".
We must use a coordinate system and symbols that the computer program can understand.

First draw the X-Y axes of the coordinate and decide on an appropriate scale.
Next, locate each joint by drawing a solid dot at its proper coordinate.

Label the joints with their coordinates as shown in this slide.

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Draw the members from joint to joint.
Make a note on the drawing for the member sizes you plan to start with.

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Show your supports.
Use a hinge and a roller for simple supports if the model will be placed on blocks for testing.

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Show the design load.
Do not put a negative sign in front of the magnitude as this will mean the vector points in the other direction.

This complete your Computer Model Sketch of the main truss of your bridge.

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We need to start thinking in 3D.
One truss is not very stable – it could just flop over.
By providing two trusses – one on each side of the deck (the roadbed), we can use the structure connecting the two trusses to add some lateral stiffness to the bridge. That is, resistance to flopping over.

Transverse load can arise due to imperfect construction, unbalanced load or a phenomenon call lateral torsional buckling.
Lateral torsional buckling it the tendancy of the top (compression) chord of the
You should always test your model for sensitivity to transverse load.

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Here's a real truss.
Note the lateral support.
Note that the roadbed is behind the truss.
Gravity load does not bend the truss members.

Gravity load enters the truss at a joint.

Classically, trusses only carry axial load – tension or compression.