

**Activity 2.1.1** **Aerospace Materials Investigation**

Introduction

Within aerospace design,material selection has a large impact on overall design performance as well as production and maintenance costs. Aerospace designers and developers must always be aware of the impact that material selection has on design specifications ranging from propulsion requirements to environmental factors.

In this activity you will investigateproperties of materials in several categories. Within each category you will consider the suitability of the materials in aerospace applications.

Equipment

* Computer with access to PBS Forces Lab
* Engineering notebook

Procedure

1. Open the PBS Forces Lab at the following link : <http://www.pbs.org/wgbh/buildingbig/lab/forces.html>
2. Click the Forces tab along the top.
3. Click Squeezing option. Click and drag the slider and observe the effect on the material.
4. Observe images by clicking See It In Real Life.
5. Repeat this exploration for each force and use what you learned to complete the following table.

| **Forces** | **Engineering term**  **(look above the block)** | **Definition**  **(in your own words)** | **Two examples of how this force can affect airplanes (your ideas)** |
| --- | --- | --- | --- |
| **Squeezing** |  |  |  |
| **Stretching** |  |  |  |
| **Bending** |  |  |  |
| **Sliding** |  |  |  |
| **Twisting** |  |  |  |

1. Now that you understand forces, let’s observevarious materials used in aerospace applications.Click on the tab labeled Materials.

**Metals**

1. Click on each material shown below and move the slider until the material cracks. Use the tick marks on the scale to assign a number to the force, cost and weight.Record this number on the following table. Move the slides completely to the maximum to see a message about the material. Complete the table below using what you learn.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Material | Strength in Tension (Stretching) | Strength in Compression (Squeezing) | Cost | Weight | Pros and Cons | Applications |
| Aluminum |  |  |  |  |  |  |
| Steel |  |  |  |  |  |  |

1. Based on your results, in which loading condition (tension or compression) are metals strongest?
2. Even though steel is an exceptionally strong metal, why wouldn’t it be a good choice for use inside jet engines?

**Polymers**

1. Click on thematerial shown below and move the slider until the material cracks. Use the tick marks on the scale to assign a number to the force, cost and weight. Record this number on the following table. Move the slides completely to the maximum to see a message about the material. Complete the table below using what you learn.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Material | Strength in Tension (Stretching) | Strength in Compression (Squeezing) | Cost | Weight | Pros and Cons | Applications |
| Plastic |  |  |  |  |  |  |

1. As noted in the investigation, plastics are strong and very light, both of which are desirable characteristics to engineers. However, watch carefully as you apply tension and compression to the plastic. Note how it behaves. Based on your observations, would plastic be a suitable alternative to aluminum for airplanes, or steel for buildings? Why or why not?

**Ceramics**

1. Click on thematerial shown below and move the slider until the material cracks. Use the tick marks on the scale to assign a number to the force, cost and weight. Record this number on the following table. Move the slides completely to the maximum to see a message about the material. Complete the table below using what you learn.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Material | Strength in Tension (Stretching) | Strength in Compression (Squeezing) | Cost | Weight | Pros and Cons | Applications |
| Brick |  |  |  |  |  |  |

1. Based on your observations, in which method of loading (tension or compression) are ceramics strongest? In your opinion, why do you think ceramics behave this way?
2. Since ceramics can be so strong (and relatively inexpensive), why aren’t they used to make aircraft or other transportation machines? Why do we only seem them used in buildings or structures?
3. Why wouldn’t brick be used to make the cables which hold up a suspension bridge?

**Composites**

1. Click on each material shown below and move the slider until the material cracks. Use the tick marks on the scale to assign a number to the force, cost and weight. Record this number on the following table. Move the slides completely to the maximum to see a message about the material. Complete the table below using what you learn.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Material | Strength in Tension (Stretching) | Strength in Compression (Squeezing) | Cost | Weight | Pros and Cons | Applications |
| Wood |  |  |  |  |  |  |
| Reinforced Concrete |  |  |  |  |  |  |

1. Note the arrangement of the steel rods in the reinforced concrete and the fibers of the wood. Why were these materials strongest pulled along the rods and fibers?
2. In your opinion, what would have happened if we would have pulled on the wood/reinforced concrete from the top and bottom instead of the sides? Why?
3. Click on the unreinforced concrete and perform a tension/compression test. How does adding the steel rods improve the strength of the concrete (and in which mode, tension or compression)? Explain.
4. As noted in the investigation, wood and reinforced concrete are relatively strong and inexpensive. Why don’t we use these particular composite materials to construct aircraft or other transportation vehicles?
5. The PBS Forces Lab is a resource designed to show qualitative comparisons between broad material categories. Engineers need accurate material properties to design safe and predictable products. These material properties were measured using stringent testing standards.These properties are published in sources for reference such as MatWeb<http://www.matweb.com>. Use this site or a similar site to find properties of the materials shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| Material | Density or Specific Gravity | Tensile Strength  (Yield) | Elongation at Break  (if available) |
| Steel  (AISI Type S14800 Stainless Steel condition A) |  |  |  |
| Aluminum  (6061-T8) |  |  |  |
| Plastic  (PVC, Extruded) |  |  |  |
| Wood  (American Sitka Spruce) |  |  |  |

1. Based on the information from the table rank the material for selection for an aircraft material choice for best strength to weight ratio. Use density as a substitute for weight. Show calculations.

**Conclusion**

1. What role does material selection have in aerospace design?
2. Why would an aerospace designer specify an inferior material compared to other materials if both materials meet the design specifications