Basics of Materials Engineering
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Lecture - 35
Static Failure Theories
(Failure of Brittle Materials)

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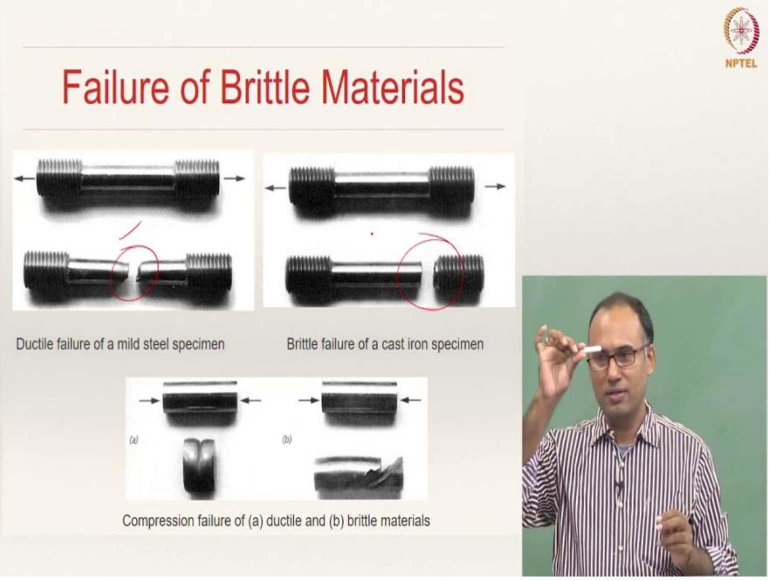

We now look at the failure of brittle materials. A mild steel specimen, when pulled with a tensile loading, breaks by shear at an angle. So, we see that it is not failing normal to the axis right. However, a brittle material such as cast iron breaks normal to the axis.

A chalk loaded in tension breaks normal to the axis. We see that when we pull the chalk apart, it breaks such that the broken surface is perpendicular to the axis of loading. Why do brittle materials fail this way? Also, normally, ductile materials fail at an angle of 45° as we have seen in your mild steel tension test. Why does it do this?

What is the failure mechanism of brittle materials? They fail due to normal strength; they fail by fracture. So, when you are applying this tensile load, the plane on which you have maximum normal stress is the plane in which you are applying the load. Therefore, it has to fail this along this plane perpendicular to the axis of loading.

Similarly, a chalk subject to pure shear breaks 45° to the axis of the chalk. From the Mohr's circle, we know that the normal stress is going to be maximum at a plane incline

45° to the axis. Therefore, the chalk breaks along this plane. This resembles a ductile specimen failing under tension. Unless one examines the specimens at the surface level, it is difficult to distinguish these two cases.

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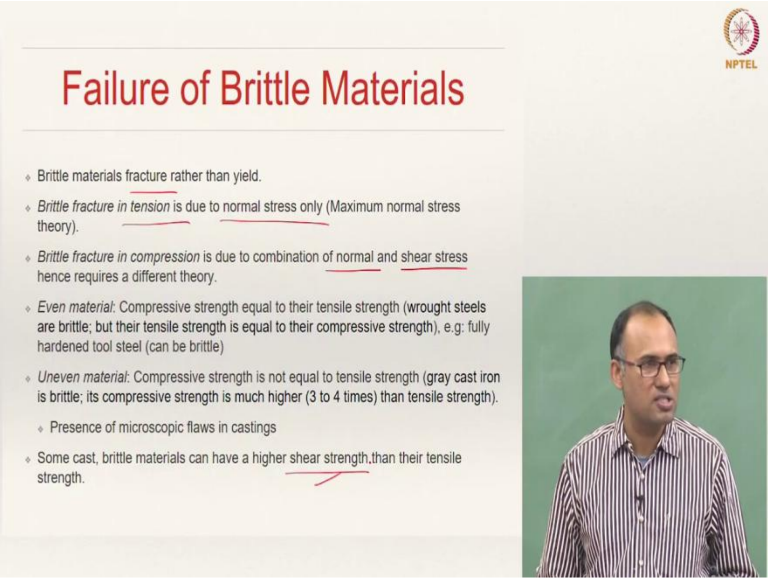

So, brittle materials fracture rather than yielding. The brittle fracture in tension is only due to normal stresses. In compression, however, it does not fail normal to the axis, but at an angle to the normal. This is because, in compression, brittle failure is due to a combination of normal and shear stresses. They do not fail by the same phenomena as in tensile.

In tension, the normal stresses open up the cracks and the material fracture. This is not possible in compression and therefore, you cannot use the same failure theories.

For ductile materials, if the yield strength in compression as well as in tension are the same, such a material is called an even material. If it is not the same, such a material is called uneven material. So, in even materials, we will have same compressive strength as tensile strength, whether it may be yield strength or ultimate strength; whereas, for uneven materials, it will be different. For instance, cast ironss compressive strength is much greater than its tensile strength, and that is precisely the reason why because it has good compressive strength. Therefore, cast iron is a preferred material for lathe beds.

Also, some cast and brittle materials can have higher shear strength than their tensile strength. Normally, the shear strength for ductile materials is one-half of the tensile strength. Whereas, you can have some special materials which can actually show higher shear strength than tensile strength.

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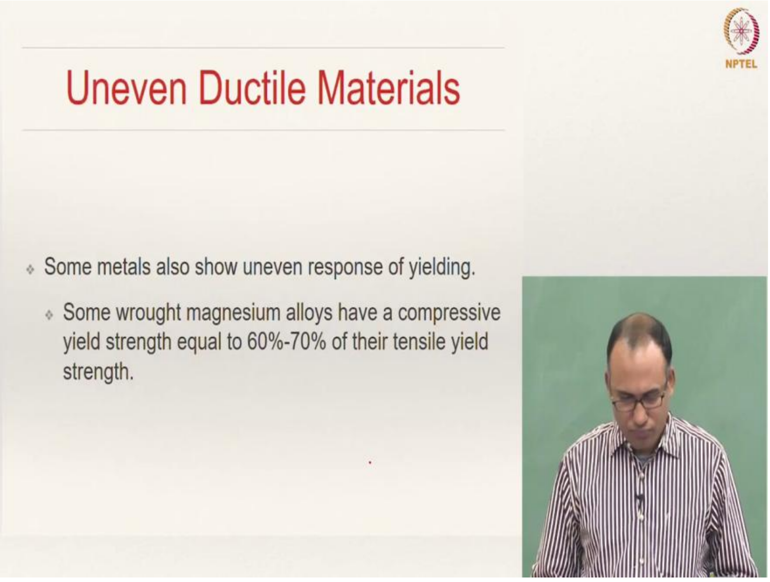

One must remember that you can have uneven materials which shown uneven response in yielding and therefore, the compressive strength can be higher or lower than the tensile strength.