Structural Reliability
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Lecture –92
Reliability Problem Formulation (Part - 04)

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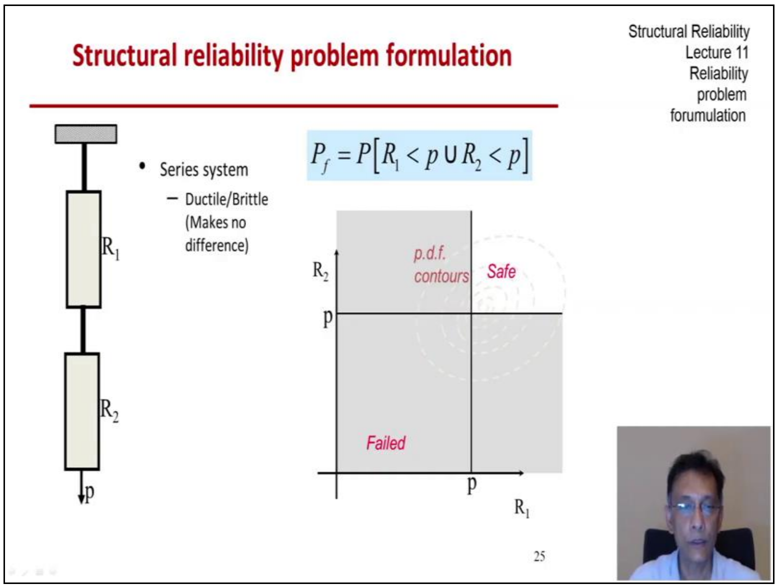

Our next problem concerns a 2 unit system or 2 element system in series. So, there are 2 cables hanging from the ceiling subjected to a point load p and let's see how we set the problem up in terms of the mechanical behaviour of the units or the elements they could be ductile on the one extreme or brittle on the other extreme. But it so, happens that when you have a serious system like that it makes no difference to the failure domain as we will see.

So, the failure is defined as the strength of the first element R 1 less than p or that is the union sign R 2 the strength of the second element is less than p both of them are connected in series it is a very simple system. So, both of them are carrying the same load p in terms of the failure domain on the R 1 R 2 space we see that it is it is a quite a large area that corresponds to failure it is the union of the of the 2 regions R 1 less than p and R 2 less than p.

Now whether the materials were brittle or ductile would make no difference because for brittle it would fail and immediately the system would collapse if any of the elements failed. And if any of the elements started to flow if they were ductile it would lead to the same problem that there would be an unstable flow in the system. When these 2 units are connected in parallel things become a little more interesting and the behaviour the mechanical properties of the materials that actually starts to matter. So, let us take a look at that.

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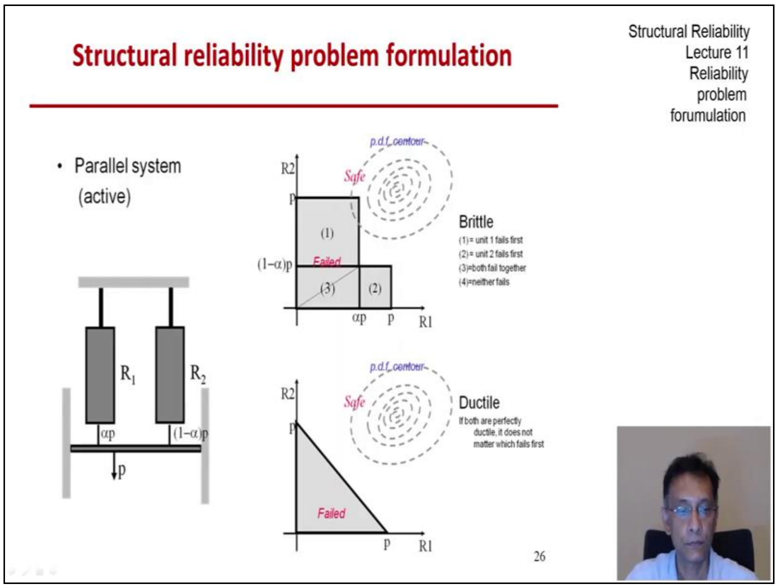

So, we have now a parallel system and later we will see that this arrangement is called an active parallel system. So you have the load p, R 1 and R 2 is connected in parallel it is not necessary that the load be shared equally between the 2 elements. Let us say the loads are shared as in terms of alpha and one minus alpha ratio. So, R 1 carries alpha p and R 2 carries 1 minus alpha p. So, what would be the failure domain or the failure set when the behaviour is brittle.

We actually can look at it from a sequence of failures. So, if R 1 if the first element were to fail first it would mean that it is not able to carry alpha p but R 2 is able to carry 1 minus alpha p so, the region marked 1 on the right that rectangle would be the sequence would correspond to the sequence that one fails first. And then 2 fails because when one has failed in a brittle manner then the entire load is now carried by 2 and if it had to fail then R 2 is less than p.

So, R 2 is greater than 1 minus alpha p because it failed second but it was not able to carry the entire load. So, it is less than p. So, that defines my rectangle 1. Likewise I can define my rectangle 2 which indicates item 2 or element 2 fails first and then element 1 fails. So, element 2 is now less than 1 minus alpha p whereas 1 is greater than alpha p it is able to carry its load in the intact condition but it is not able to carry when it is asked to bear the load by itself.

Now what about the rectangle in the middle the marked the one that I have marked with 3 that is interesting that basically says that it is that combination where neither of them is able to carry the load assigned to them in the intact conditions. So, R 1 is less than alpha p and R 2 is less than one minus alpha p simultaneously. So, together those three regions define the failure region in the brittle case. And so, once I am able to set the problem up I can then undertake probability computations and find out failure priority and so on.

But this would be an important step in the reliability analysis. What would happen if the materials behaved in a completely ductile manner? So, here the failure region becomes smaller because even when one element fails when the first element fails it does not give up the entire load it is able to carry the load at which it yielded. So, failure for a ductile element is plastic flow. So, even if it failed it is able to carry the load at which it fails.

So, the other element needs to carry the difference. So, if you do the math you can see that the failure region now becomes a triangle. So, my ability to set the problem up leads me to this situation where I can now compute the failure probability or the reliability of the system.