No 6 STRESS and PRESSURE

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1. The last talk was about that very odd phenomenon the placebo effect.
2. But now it's back to where I left off in ordinary science and engineering. Among the things we have looked at were the basic engineering ideas of tension and compression. Tension being a pulling apart and compression a pushing together
3. For today, I want to talk about another two very basic engineering ideas: **STRESS and PRESSURE.**
4. Taking stress first, we have the various common uses of the word. I am completely stressed out trying to cope with the pressure of preparing and delivering these talks. A lot of the physical and emotional problems people suffer from are a result of stress.
5. And there are the brochures which say the AT helps us to reduce stress or manage stress and so on – without being quite sure what exactly they mean by stress.
6. As usual, when it comes to such popular uses of these words, the engineers are the linguistic spoilsports. Engineers see nothing intrinsically wrong with stress. In fact, life on earth is inconceivable without it. If we did not have a certain amount of muscular stress we would lose our shape completely – or at least go extremely squidgy and floppy. I think jelly-fish are fairly stress free.
7. So what do we mean by stress in the strict technical sense? Let us think of this weight hanging from a piece of string. With the downward pull of gravity acting on the weight, we know the string is in a state of tension.
8. But even though we know the string is in a state of tension, we do not know exactly how it feels about it. It may be perfectly happy – carrying this weight is easy-peasy, no problem. Or it may be in a state of complete desperation; if even a fly lands on the weight, I'm going to break.
9. This is where the concept of stress comes in. Stress is a description of the internal state of an object when it is subjected to a load or force.
10. So let us imagine for simplicity that we have a piece of fairly thin material – a wire - with a cross-sectional area – the area of

the wire when we cut it straight across – of 1 mm^2. When we use this piece of wire to support a load of, say, 1 kg we say it is under a tension stress of 1 kg/ sq mm.

11. If we increase the weight to 10 kg we say the tension stress is 10 kg/sq mm.

12. If we continue increasing the load until the wire is just on the point of breaking, at say 20 kg, we say the stress is 20 kg/sq mm. And since the wire would break if we applied any more weight, we say the maximum tensile stress the wire can carry is 20 kg/sq mm. This is its breaking stress. It is a measure of the strength of the wire.

13. We can now do this with 1 sq mm strips of various materials: other kinds of wire, string, muscle tendon, different kinds of plastics – hanging weights from them and finding the maximum stress that each type of material can carry.

14. We could draw up a table showing each material and its breaking stress. We might have cooked spaghetti at the low end and high strength steel at the other end.

15. But the beauty of the concept of stress is that we are not limited to strips of material with a cross section of 1 sq mm. Once we know what 1 sq mm of spaghetti or of steel can carry, we know what any number of sq mm can carry.

16. This is quite useful when we are trying to work out how thick the rods need to be to hold up the hanging bits in a building or how thick the strings need to be in a parachute. The question we ask is: How many sq mm of cross section of whatever material we are using do we need to do this job?

17. The important thing to get your minds around is that it is not the size of the load that counts, it is the state of the material that is carrying it.

18. We could have a very small load causing a high stress if we try to carry it on something that is not big enough for it – trying to lift a kilogram with a thin piece of thread. Or we could have a big load causing a small stress - say I was swinging from a nice thick rope like they use for tying up ships.

19. And of course, this all applies to the various bits of the body just as much as to inanimate objects in the external world.

20. When we are using our muscles and tendons we want to make sure they are not subject to anything close to their breaking stress.

21. And because we know it is the stress rather than the absolute value of the load that counts, we know that a small tendon can be damaged by a small load if it causes the stress in the muscle or tendon to become too high. Equally, a big load may be perfectly within the capacity of a big muscle because the stress in the tendons is low.

22. So, for example, when we are lifting something heavy, we know we are more likely to cause damage to ourselves if we try to do it with our arms and lumbar area, where the muscles and tendons are relatively small, than if we mainly use the big lifter muscles of the thighs and legs.

23. In engineering language, the stresses in the big muscles and tendons – because they have larger cross sectional areas – will be lower than if we try to do the same job with the smaller arm and lumbar muscles and tendons.

24. When we talk of a pulled muscle, what has happened is that we have overstressed it. When we talk of a stress fracture we mean an incomplete fracture in a bone. It is caused by excessive stress rather than a blow or a fall.

25. One of the important things we are doing as AT teachers is gently persuading our pupils to adjust the way they are using their muscular systems so that they are able to avoid overstressing certain muscle groups when there are others available to do the job at a lower level of stress.

26. I want to turn now to the idea of **PRESSURE**. Once again this is a word that has all kinds of negative connotations. The pressure of work and exams, paying the mortgage and so on.

27. But, as usual, engineers don't think of pressure as either a good thing or a bad thing. They think of pressure as being very similar to stress. Stress is the force per unit area inside a thing; pressure is the force per unit area applied to a thing, or a "body" as engineers like to call it. You might say, stress is on the inside and pressure is on the outside.

28. Let's look at this piece of wood which has a cross-sectional area of 1 sq cm. Suppose I stand it on its end and use it to support a weight of 10 kg. This means the pressure on the top and underneath it is 10 kg/ sq cm.

29. Now, without changing anything, let me slide in something underneath the bottom end which spreads the load. Let's say it has an area of 10 sq cm. The load is exactly the same but the pressure has been reduced to a kg/sq cm.

30. This is something we use all the time. We put things under the legs of tables. We use snow-shoes to walk on snow. Engineers use foundations to spread the load coming down through the columns in a building.

31. In all of these cases, we are not changing the weight being carried. We are changing the pressure.

32. We can also go the other way and instead of spreading the load and reducing the pressure, we can concentrate it and increase the pressure.

33. If I reduce the area of one end of my piece of wood, we can see that each end has a very different effect of each hand.

34. When I squeeze it between my hands, which means the force I am applying at each end is the same, I can feel a very big difference in what is happening to my two hands. If I squeeze hard enough, I could easily break the skin on one hand.

35. If the force in each hand is say 5 kg and the pointy end is one tenth of a sq cm, the pressure on this hand is 50 kg per sq cm – ten times as much.

36. An interesting example of this effect is stiletto heels. We have to do some mathematics here but I'll keep them pretty simple.

37. Suppose we have a 60 kg lady sharing her weight evenly between her two feet – 30 kg each. Let us assume she is putting two thirds of her weight on her heels and the rest on her toes. That is 20 kg on each heel.

38. Let us assume these are fashionable heels about half a cm by half a cm. That is an area of 0.25 sq cm. The pressure underneath the heel is 20/0.25 = 80 kg per sq cm.

39. If we compare this with a more sensible heel which is say 5x5 cm = 25 sq cm then the pressure is 20/25 = 0.8 kg per sq cm. The pressure from the stiletto is 100 times greater than from the flat heel which is why they do so much damage.

40. This also helps explain why knives cut and nails go into wood. We make the area over which the force is applied so small that the pressure is high enough to penetrate the material.

41. It is also why elephants have large feet; they spread their weight so they don't sink in the ground. I did a calculation which shows that the pressure under a stiletto heel can be about two hundred times higher than under an elephant's foot.

42. So my home hint, if you're running away from an elephant on soft sandy ground, take off the high heels.

43. That is a quick look at some of the engineering aspects of pressure. For the rest of the time, I think it is quite interesting to look how these concepts translate into physiology.

44. The body is absolutely packed with little sensors which detect pressure or changes in pressure. A very significant part of the activity of the nervous system is do with registering and responding to the changes in pressure detected by these sensors.

45. Take, for example, the sense of touch. When we put a hand on someone, how do they know it? They know it because in their skin there are various sensors or receptors in their skin which are sensitive to pressure. We also know our hands are on someone because there are similar pressure sensors in our own skin.

46. Therre are various kinds of sensors which do different jobs in the body. In very pressure-sensitive areas of skin, such as the finger tips, palms of the hands, lips, the eyelids and elsewhere, there are very quickly responding tactile sensors called Meissner corpuscles. They are located near the surface of the skin and they are extraordinarily sensitive; we have no problem detecting a fly tramping round on us.

47. In the same areas, there are different kinds of sensors called Merkel discs which lie more deeply in the skin. These are slower to respond and require a greater pressure than the Meissner corpuscles.

48. A little further in through the skin, in the sub-cutaneous layer, there is another type of sensor known as a Ruffini corpuscle. This is sensitive to continuing pressure as opposed to short-duration touch.

49. There are plentiful of Ruffini corpuscles in the plantar area, otherwise known as the sole of the foot. It is these corpuscles which tell us about the distribution of pressure on the soles of our feet. This in turn tells us quite a lot about our vertical orientation, whether we are leaning forward, back or sideways.

50. This is a big element in the way the nervous system monitors our state of balance. This in turn is fed into the various postural and other muscles involved in how we hold and balance ourselves. We notice the way changes in the distribution of weight on our feet can have effects right up through our body.

51. All these sensors, in the skin, tell us about the effects of the interaction of ourselves with the external world. They are often called exteroceptors – they detect the exterior. Our main exteroceptors are, of course, the eyes, as well as the ears and the nose, but we often forget that our skin is hugely important in telling us about the wold around us.

52. Deeper in the body, there are other pressure sensors which are called Pacinian or lamellated corpuscles. These are all over the body, in the subcutaneous layer, in the muscles, around the joints and other parts of the body.

53. They detect fairly large pressure changes inside the body. They tell us about the pressure on the joints and other internal bits of our body. These tell us about how the weight is distributed between the different bits of ourselves. It is because of these that we can tell when we shift our weight from one leg to another and so on.

54. These sensors are telling us about how the body is interacting with itself and they are referred to as proprioceptors – perceptors of the self.

55. A lot of the signals sent out by these pressure sensors, whether they are exteroceptors or proprioceptors, never get near our consciousness. It all happens automatically and we will have a bit more to say about them when we are looking at the postural reflexes.

56. But a lot of the time we do notice change. Quite a bit of our training as Alexander teachers is about learning to become aware of our bodies and what they are telling us. To me, as an engineer, it is interesting that a lot of this information comes to us through our ability to detect subtle changes in pressure.