The Arch Never Sleeps
The Arch

Narrator:
Francis Evans gives lectures on why arches stand, using a variety of physical models.

Francis Evans: (Professor, Sheffield Hallam University)
When I made this I was playing with it and one day I lifted one end and I could actually feel it pushing. And this time I viewed it in a completely different sort of way, not as words that I'd been told, but this time I'd learned it with my hands and I think that way it gets into your understanding in a very, very different way. Anyway, to give you an idea of just how strong the arch is I'll bring it down, put it on the floor and show you – and you see I can stand on it, it's taking my weight and yet there's nothing holding it up. You know, there's no glue or cement or chewing gum there. It is just the fact that the blocks are pushing each other.

Narrator:
In an arch the blocks, called *'voussoirs'* by architects, transfer a vertical load on them to the fixed abutments at either end. In doing so, they generate a sideways force. Stone arches are used in the nave at Ely – not, in fact, to cover the main span – that's a job done by this decorated wooden roof - but rather, arches are used in the side aisles. To hear more about the achievements and problems solved by the medieval masons you can't do better than meet Professor Jacques Heyman, an authority on forces within stone buildings.

John Trapp:
At Ely and Jacques, I hope you're going to tell me more about this cathedral.

Jacques Heyman: (Professor, University of Cambridge)
Well I'll try to. It's a French Romanesque cathedral, basically speaking. It was started very soon after the Norman Conquest, about 1080-1090. It took a hundred years to build, starting at the East End for this part of the cathedral, working through to the Great West Tower, finishing about 1190. It's in the typical Romanesque style. There are round arches, there are very massive piers. There are really rather small windows in the side aisles and we have got side aisles because this is a big church so that in the central space we have a timber roof overhead, but in the side aisles we've got a smaller span. It was possible to vault in stone and we've got these drawing vaults which span from side to side down in both directions. There are arches thrusting against the outer wall of the cathedral and pushing it aside as all arches will and, as a consequence, there is one of these hinging cracks running all the way down the centre line of the aisle. So this is one way that an arch can respond to movement of the external environment. The wall moves away, we get a crack at the centre. But there are other modes of definition possible, for example, upper loft there, adjacent to the Great West Tower, the twenty thousand tons of that tower has punched through the rest of the cathedral by thirty centimetres, something like that, and that has dragged with it the adjacent arches and you can see gross deformations there.

John Trapp:
But the stone can sort of work with this, can it?

Jacques Heyman:
Oh, the stonework's alright, yes. The deformation occurs not in the stone itself but in the plains between the stones, the air gaps, if you like, that open up.

John Trapp:
And it still can carry the load?

Jacques Heyman:
It can carry the load perfectly well.

John Trapp:
And these massive pillars that we see here, I mean they are necessary for this are they?

Jacques Heyman:
No. The stresses in such piers are very low indeed so they found that they could cut the piers down without destroying the integrity of the structure.