The Arch Never Sleeps
Vaults and Flying Butresses

Narrator:
The masons were aware that the resultant forces must lie within the stonework. By the Gothic period they'd begun to have the nerve to try to reduce the amount of stone they used. Instead of rounded Romanesque arches, they used the pointed Gothic arch which was closer to the shape of the line of thrust.

Jacques Heyman:
Well we're here in the 1240 part of the cathedral, about a hundred years after Gothic started so it's still fairly simple and straightforward. You can see the rims on the high vaults collecting together into these colonnettes, bringing the forces down, if you like, onto the main piers. The piers are slenderer than they are in the Romanesque part of the cathedral. There are big windows behind.

John Trapp:
Right, so what we have really got is a different style here. We've got very slender stonework.

Jacques Heyman:
That's correct, yes.

John Trapp:
And also we've got a stone vault up here as to the wooden one over there.

Jacques Heyman:
Yes, that's right. This, of course, was a Gothic invention really to lighten the vault sufficiently so that you could build it as fire proofing really because the timber roofs always caught fire and destroyed, when they fell in, a lot of the cathedral.

John Trapp:
Now presumably this kind of style of architecture must have led to completely different building techniques?

Jacques Heyman:
There are different requirements of course. Just like the masonry arch thrusting sideways always, so the stone vault that we see here also thrusts sideways and you have to have a more elaborate system of buttressing on the outside of the cathedral to take those thrusts. If you don't have side aisles it's fairly straightforward. You can put the buttresses up against the sides of the cathedrals to take the thrusts down to the ground. But if you've got side aisles, as we have here, then somehow you've got to get these thrusts from the high vault, over the side aisles, to the outside world and this, of course, led to the invention of the flying buttress.

Francis Evans:
It's not the downward pressure that's the problem. The stone is quite happy in compression. The stone likes being a pillar. What stone like, doesn't like, and pillars don't like, is being pushed sideways, you know, put into bending. It's very, very easy, as you see, to turn that over. And so this is what they did, these little pieces added – it's called the flying buttress – and once you have that flying buttress it makes an enormous difference to the stability of the building. You can really thump that but the sideways force, the really dangerous one, is going through that and can be transferred to a small buttress to the ground. The flying buttress, I think, is what really got our engineering brains going again in the Middle Ages. It's the beginning I think of a whole development of science and technology in Europe.

Narrator:
The masons arranged for flying buttresses to be positioned at discrete points to collect the sideways forces from the vault.

Jacques Heyman:
Well we're standing here in the roof space above the Choir vault. We've got a lead-covered roof here and this is the weather-proofing for the whole cathedral. Water will run off this and not get inside. But of course the timber roof is a fire hazard and below all this we've got the stone vault which is the fire-proofing. The vault itself is 25-30 centimetres thick and, as you can see, it's got on the top of it, a sort of concrete, mortar, small bits of stone all mixed up, and the whole of this is a very effective fire barrier indeed. And you can see from the shape of these walls a sort of arching action, how the forces are taken down into the vaulting pocket there, passed through the wall and on that, on the other side, resisted on the other side by the flying buttress which is therefore placed fairly low down on the cathedral compared with the parapet level of the roof.