Exploring mathematics: a powerful tool

An ancient tradition

Carmen Pryce:
Let's begin by looking at a part of the designed world and investigate some of the mathematics of scaffolding. That's the provision of a platform around buildings to ensure construction workers' safety. Scaffolding technology in the West relies upon metal piping. By using clamps, the pipes are each firmly joined together into a stable grid-like structure. In the Far East though, it's very common to find scaffolding that's not made of metal but, rather, scaffolding made of cheap and abundant bamboo. These Hong Kong skyscrapers were all put up using bamboo scaffolding but, whereas metal scaffolding uses clamps to make inflexible joints, bamboo joints are only lashed into position with cord. So how do these bamboo structures manage to stay up? To learn how to put up bamboo scaffolding requires both theory and practical work. These are students at the Construction Industry Training Authority in Hong Kong. Part of the training requires them to work on scaffolding techniques. The method of lashing together lengths of bamboo involves making knots which rely on friction to keep them together. So how's it possible for some of the tallest structures in the world to be erected using what looks like a crude building technique?

Michael Kan, Construction Industry Training Authority:
In China bamboo scaffolding has a history of more than 2000 years and nowadays we still use it. Scaffolding still has its own dead load so in every nine storeys we have to use a new set of support. Nine storeys is about thirty metres.

Carmen Pryce:
Not only is the 'dead load', or total weight of bamboo significant, there's also a major problem of stability. The solution dates back thousands of years to early civilisations when some of the world's first pure mathematicians devoted time to identifying the laws of geometry. For example, in ancient Greece, Euclid stated that a triangle made by joining any three straight sides can take up just one shape. You can't deform it into another. But the quadrilateral, made by joining four sides, can adopt numerous shapes. That flexibility can be disastrous for scaffolders who are trying to make an easily constructed, yet rigid, structure. The answer lies in tying-in diagonal braces. Each one effectively turns the quadrilaterals into a number of stable triangles, both large and small. Having learnt to produce rigid joints the students leave real scaffolding to turn to small scale model making. This work is a means of developing mental pictures of how whole structures are pieced together. So secure are the finished bamboo structures that scaffolding is itself used as the shell of temporary buildings.

Michael Kan:
We Chinese people, when we want to erect some temporary structure, we usually use bamboo scaffolding. This is the model of our temporary opera house which is built in real life, when we're doing some Chinese ……(?) For a team of about twenty workers it take a week time to make a thing like this in real life. We have to tie every crossing. The way is to wrap the bamboo with a plastic cord in five to seven times, and then twist the end and pull it tight. Every worker in the team, they have a blueprint in their mind, but actually there is a leader who is more experienced and who will give the workers the instruction.

Carmen Pryce:
All that the scaffolders need is a mental image, a mental blueprint, if you like, of the finished structure. The safe dismantling of a building like this takes a fraction of the time it took to construct, as long as you apply the 'inverse' of the building process.

Michael Kan:

This structure is taken down in this way. The knots which we make last, we'll cut off first, that is, we take it down in a reverse order.

Carmen Pryce:
The use of mathematical ideas to describe the world might be straightforward for a simple physical situation like this, but when it comes to explaining phenomena in nature, mathematicians will often turn to mathematical modelling, and work on the assumptions and judgements that go with it.