Scream test

When John Roberts was asked to build the world's most fearsome wooden roller-coaster, it was all a question of making it as frightening as possible without actually causing anyone's head to come off … by Andy Pearson

JOHN ROBERTS PUSHES HIS BODY TO THE LIMIT in the interests of engineering. In his role as director of engineering at consultant Babtie Group, he heads the department specialising in the design of theme-park rides. As such, it falls on him to design ever more exciting ones. This means that he has to follow thrill-seekers to fairgrounds around the world in their quest for screaming acceleration and brain-scrambling forces. "I've worked all over the world. I know what makes a good and a bad ride," he says.

Two years ago, Roberts started work on his most challenging project to date – the world's largest wooden roller-coaster. Roberts' brief was push the medium to the limits, and make it more fierce than any wooden ride experienced to date.

The £4m roller-coaster was destined for TusenFryd, a theme park 15 km south of Oslo, in Norway. It was to perch on a hillside, slotted between rocky outcrops and scattered pine trees, above the theme park's other attractions. To make it the gut-churning experience the client requested, Roberts and his team needed to use the site's topography to the full.

The theory behind a roller-coaster is simple. Pull the cars up to the highest point on the track and let them go. A pair of rails guides the cars and their human cargo around a circuitous track that weaves in and out of itself in one tangled loop, like a hopelessly knotted piece of string. "The higher the first hill, the longer the ride," Roberts explains. The car starts its descent under the pull of gravity. As it picks up speed, wind resistance and friction forces in the wheels and the bearings start to sap at the car's energy. The designers' knowledge of wind and friction loss enabled them to estimate the height of the hill needed to give the ride its required length of about 1.1 km.

The client's brief also included details of how long passengers could be lifted out of their seats and how strong the sideways forces could be. "They described the sensations and quantified them; we turned the sensations into geometry," explains Roberts. The designers had just six months to complete their task.

The design was critical: if Roberts erred on the side of caution, the ride would be boring. Too much acceleration, however, and he could put the passengers' lives in danger. "Forces just four times that of gravity could cause nosebleeds," Roberts says. And if he got it *really* wrong, passengers could pass out under the huge forces to which their bodies would be subjected.

Fortunately, the team at Babtie already had a huge database of technical information from the many rides it had designed. Using an in-house software program, the engineers produced a concept for the ride's layout that criss-crossed the hillside and swooped into the adjacent valley.

Roberts was able to calculate the speed of the cars so that the forces exerted on passengers were within the design parameters, as compared with similar rides around the world. Finally, the team produced a computer-simulated ride with photographs of the site, which gave the client a view from the front seat of the train.

With the design approved, the next task was to build the ride. The contractor had just 18 months from design approval until opening day. This was made difficult by Norway's short summers and harsh winters, which limited the construction period to just seven months a year.

The intention was to construct the ride from locally sourced timber, using local labour. But, perhaps unsurprisingly, none of the Norwegian timber contractors had ever built a roller-coaster, and were unhappy about tendering on a fixed-price basis. So the contract went to a Canadian company, which proposed using southern yellow pine sourced from Florida for the main structure, as this is a "high-grade softwood that is available in big sections", and Canadian Douglas fir, which has a high resistance to splitting, for the track.

Over 1300 m³ of timber was needed to build the intricate structure, all of which was vacuum-treated to help it survive the Norwegian winter, when it would be covered in snow for four months. The timber was cut to size and pre-drilled in Canada before being shipped to Norway. Once there, it was assembled in sections flat on the ground by Manchester-based company Bellingrath.

Track sections comprised nine separate layers of Douglas fir, nailed and bolted together to make a single rail. More than 750,000 fixings, bolts and washers were used. A tower crane then lifted the sections into place. The entire structure was completed between April and October 2000, leaving just enough time to test the performance before winter closed in. This served two functions: it would confirm Roberts' calculations of the forces on the thrill-seekers, and at the same time satisfy the safety assessors that the ride was suitable for the public.

Sandbags were placed in the cars to represent people and were monitored by accelerometers and other equipment. The cars were pulled to the top of the first hill and released. As they sped around the track, forces up to three-and-a-half times that of gravity were measured at the foot of the hills and of negative gravity at the top of the inclines, which would have lifted the sandbags out of their seats had they not been strapped in. "The forces were almost exactly what we'd predicted," Roberts says.

But the ride's toughest test was its opening to the public last month. Roller-coaster enthusiasts from around the world gathered to christen the new thrill. Roberts need not have worried. They rated it one of the best in the world.

Above Deciding the maximum height of the ride was crucial if passengers were not to black out.
Below The vast fir and pine structure took 18 months, under difficult circumstances, to complete.