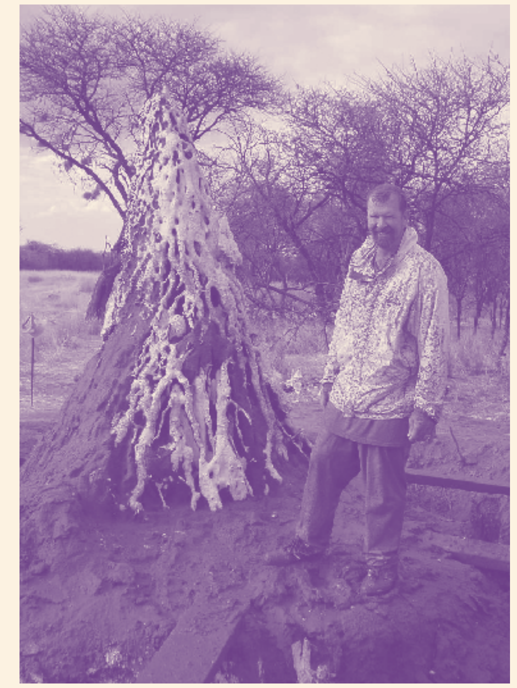
Rupert Soar's Hive Mind

Macrotermes Michaelseni termites.

Rupert Soar slices through structures built by termites to further develop a revolutionary method of fabrication.

Text Terri Peters
Photos Rupert Soar & Freeform construction



Rupert Soar in Namibia.

The termite structure is filled and coated with plaster of Paris.

Digital design, rapid prototyping, 3D printing – these terms are nothing new for avant-garde architects and forward-thinking members of the construction industry. Such technologies exist, at least in part, thanks to the work of Rupert Soar, cofounder of the world's leading RM (rapid manufacturing) research group at the University of Loughborough, England, and, more recently, the brain behind his private consultancy, Freeform Construction. Soar, a mechanical and manufacturing engineer and inventor, has been pioneering research into additive fabrication and RM for more than 15 years.

He regularly helps clients, including Buro Happold and Foster + Partners, to integrate RM and RP (rapid prototyping) into their operations, which now produce an annual output of over 3,500 'prints' of geometries and sketch designs based on the use of these techniques. While at Loughborough, Soar led an ambitious EU-funded research project aimed at building room-scale 3D printers. His dream, he confesses, is to one day 'print' a whole building.

But RM has implications beyond speed and scale. 'We quickly realized that if we could get the material right,' says Soar, 'we could do more than just rapidly produce more and more end-user parts.'

'Termite mounds are the ultimate adaptive architecture'

These new technologies allow for the creation of geometries that are beyond the capacity of previously used fabrication methods. His goal is adaptive, customizable, high-performance architecture, and his fascination with additive manufacturing technologies (which, unlike subtractive processes such as laser cutting and CNC milling, involve the layering of material) has taken him to the 3-m-high termite mounds of Namibia and back again.

Known as 'the termite researcher' in many circles, Soar carries out ground-breaking research into the insects' self-cooling, naturally ventilated structures. In presentations at prestigious architecture schools, and at conferences for material and fabrication companies and academic institutions worldwide, Soar shows images of enormous plaster casts of

A slice of the mound. The white areas show the complex tunnels the termites have constructed.

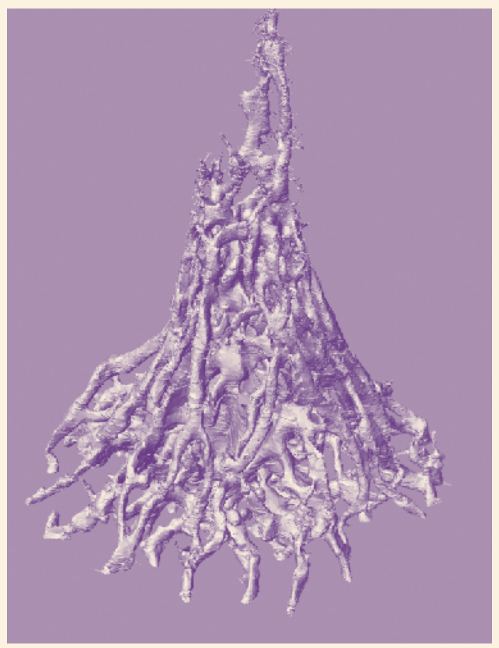
termite mounds and exhibits digital models of termite behaviour. He calls termite mounds ‘the ultimate adaptive architecture’, explaining that the insects’ evolutionary construction technique, which responds to and adapts to constantly changing internal conditions and external weather influences, features certain ecological concepts that he sees as relevant to discussions on adaptive architecture for human use.

‘My story really began in 1990 when I stumbled upon one of the first commercial RP machines in Europe. Coming from a construction background, I immediately spotted the advantage of building things layer by layer; after all, that’s how we construct buildings.’ Soar was immediately fascinated with the potential of the technology. ‘RP was a pretty radical concept for automotive and consumer-goods manufacturers, because machining and moulding don’t allow you to build like that.’ He began using RP to make high-performance parts. ‘We could print moving parts in assemblies, we could print rigid materials as flexible geometries, and we could make whole assemblies from a single material. As materials got better, we stopped talking about the technology as “rapid” and began describing it as “functional” or “with greater function”, but no one seemed to know how to quantify these functions, let alone squeeze more of them into a single design.’

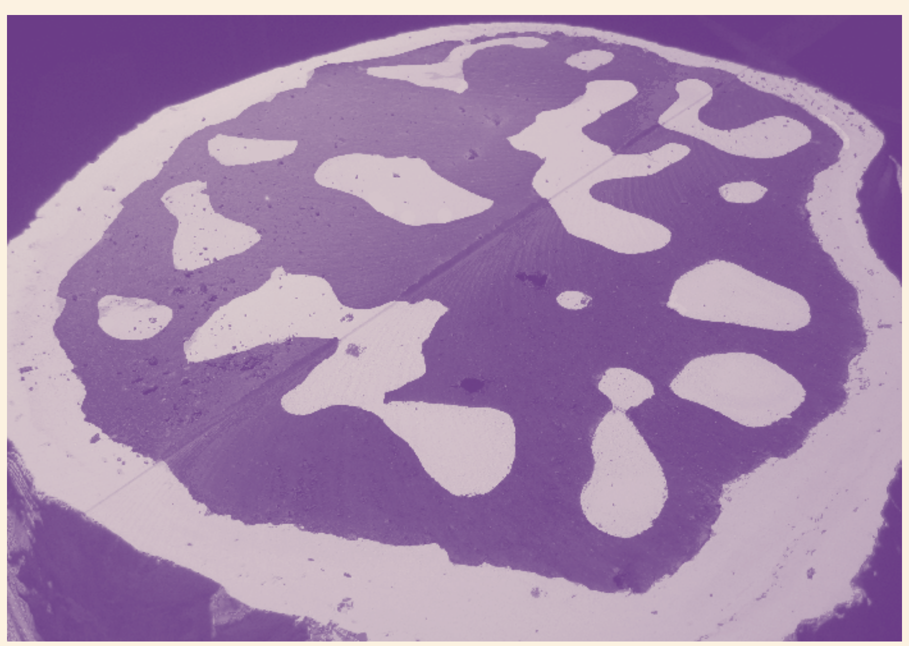
Soar then began finding other ways of using rapid prototyping. ‘Everyone else was down-scaling, but I thought: what if we up-scaled RP to construction? Would we be talking about printing whole buildings or bits of buildings?’ He and his Freeform Construction team went on to develop mineralJet, a 3D-printing machine that uses Soar’s newly patented mineral material to print full-scale building components. The maximum bed size of the printer is 1.5 m, and he thinks this invention fills a niche in the industry: somewhere between model making and mass-production. ‘At the moment, I don’t see a market for whole building-additive manufacturing solutions, but we do anticipate a demand from architects who are looking for new processes for the manufacture of large components with complex external and internal features.’

Soar has tested 3D-printing in the past with great success, but not in a traditional architectural setting. He applied his expertise in the areas of 3D scanning and ‘printing’ objects to his study of insect-built structures: those made by Macrotermes michaelseni termites to be precise. As we talk about the trajectory of his work – from the design of materials to the development of manufacturing technologies

A slice of the mound. The white areas show the complex tunnels the termites have constructed.



A digital model made using the 3D scan of the termite mound.



A slice of the mound. The white areas show the complex tunnels the termites have constructed.

The Termite pavillion – a scaled up 3D section of a termite mound built by Rupert Soar and the TERMES project. Photo Joseph Burns

‘Architecture allows us to cheat natural selection’

– everything seems to relate obviously and naturally to termites. Over a five-year period, he obsessively recorded the precise organization and the complex structures of termite mounds in Africa, using microphones, moulds, huge machines to slice through the mounds, and custom scanners for the rapid manufacturing of identical 3D models on his return to the UK.

It was the coolest research trip imaginable. In 2004 Soar first visited termite mounds in Namibia with the BBC Natural History Unit, which was filming a David Attenborough Life on Earth TV series. Soar arrived with a multidisciplinary team to conduct moisture experiments and to document the precise geometries and structures of two 3-m-high termite mounds, each belonging to a colony of up to 1.5 million termites with an underground nest as well. In an effort to learn how to transfer knowledge of ecology and adaptable structures to the construction industry, he developed bespoke in situ 3D scanning and imaging technologies. The process of documenting the termite mounds involved covering them in 6 tonnes of plaster of Paris, but this was the least of the team’s logistical challenges. ‘We had three months to design, build, test and ship the world’s largest mobile scanning machine to the site in order to make the June-to-August good-weather window, when both temperature and rainfall are low,’ he says. To fully understand and document the complexities of the termites’ mounds and behaviours, they had to scan each mound in 1 mm increments. It took ten minutes to capture each ‘slice’ digitally and two months of night-and-day scanning to secure more than 2,500 images.

‘As part of this research, I produced the weirdest set of sound recordings of the mound reverberating and the millions of termites going about their activities. They have a full communication system which no one had ever heard.’ In May 2010, as part of a team commissioned to create a pavilion for the International Insect Arts Festival in London, Soar provided a glimpse of his experience to the public. ‘The space was designed to transport the visitor from one swarm environment – the bustling Southbank Festival – directly into the heart of an insect swarm.’ His collaborator, Chris Watson, collated the termite recordings into a single looped track, which was played into the space. ‘It was electric’ says Soar, ‘the low-frequency audio components produced deep booming sounds inside. The first time we switched it on the hairs on my neck stood up, and the sense of immersion was instant.’ A total of 50,000 visitors entered the space during the three-day festival. ‘We’d spent all our budget putting it together, and we ended up squatting in it for three days – the only way to keep the planning officers from fining us.’ The pavilion, which was at the London Zoo for the remainder of the year, is currently in Cornwall.

‘I see buildings in strange ways. I see them as living extensions of us,’ says Soar. ‘Architecture allows us to cheat natural selection – to create stability for ourselves, our families and our colleagues within.’ Through his termite research, Soar has inspired architects to think of ways to use natural structures and behaviours to make materials and processes for real buildings. His work also suggests methods for producing complex architectural forms and intricate functions that would be impossible to create by any other means. He believes his newest work with materials and machines is emerging at the perfect time. It addresses the need for architects to consider a building’s whole life, to recognize the impact of their designs on ecology and to work towards a truly adaptive architecture.

The implementation of Soar’s research could lead to incredible step changes in material use and carbon reduction. ‘Sustainable architecture is, at its core, about the ability to generate and integrate process solutions with very few resources, and about using materials so they can be reused and recycled.’ Structures should act as membranes, mediating the relationship between inside and outside and managing energy flows. He thinks it’s all possible, but we need to embrace new technologies and practices. ‘The most important agent of change is us – the occupiers of buildings.’

Unlike his termite research, Soar’s most recent work does not make for exciting imagery. Certain pictures seem to show nothing but piles of white dust and chalky blocks. Called mineralStone, this scaleless, shapeless substance may not look like much, but Soar says it is a potentially game-changing invention. ‘We just patented it,’ he says. ‘The result of years of research, mineralStone is not so much what you see in these images, but what you can do with it.’ Soar goes on to list mineralStone’s surprising properties and advantages. The dense, highly engineered, low-energy material is fully recyclable, has excellent thermal mass, is naturally fire retardant, and is relatively inexpensive. A 5-mm-thick layer has the equivalent strength of 15-mm-thick plasterboard with a skim coat. ‘The material has integrated functional structures, which means we are able to maximize the performance of insulation, utilities and ventilation.’

Soar has various applications in mind, including use as a secondary cladding to retrofit existing housing: he sees an old façade filled with mineralStone providing both insulation and an ‘interstitial space’ between the building and its environment in which additional functions could be embedded. Another potential use is as a ‘functional cladding’ for new buildings; here the material could act as a responsive membrane between inside and outside.

‘I am not an idealist,’ insists Soar, ‘and this isn’t just a load of science fiction.’ What makes these new technologies so exciting is their spot-on relevance to today’s formal and performance-focused contemporary practice. They propose truly new and untested ways of designing and building architecture.

With the building industry desperate for innovative ways to generate alternative energy, the future of architecture lies in creating and adapting buildings that can harvest energy available at a stone’s throw – a bit like the industrious termite does.

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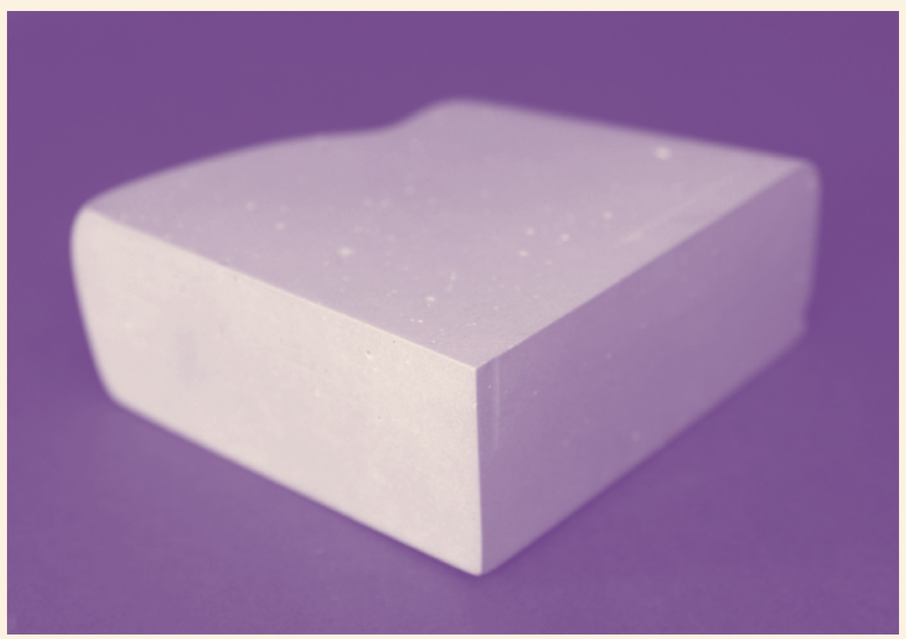
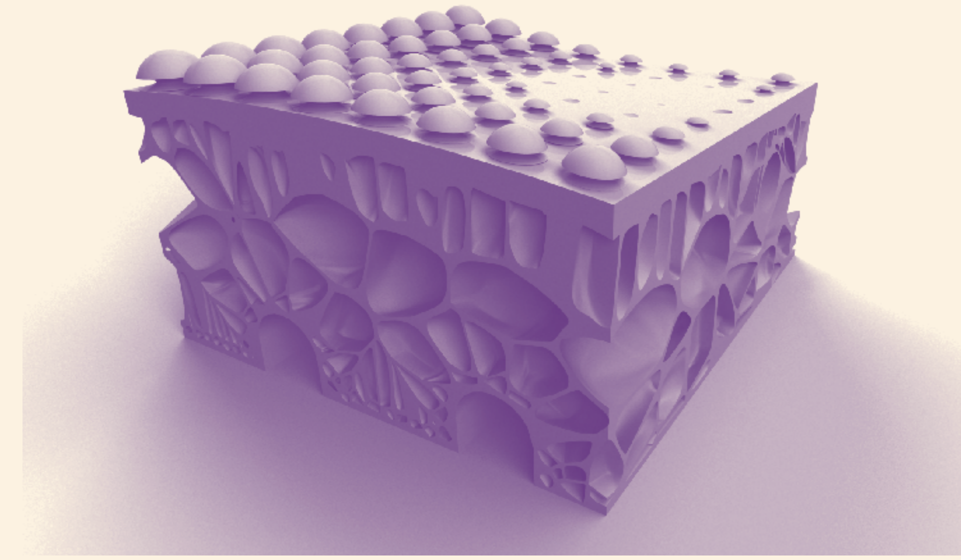


A block of Soar’s MineralStone material.



Computer rendering of a high performance cladding panel, able to regulate thermal, acoustic and ventilation conditions, based on Soar’s termite research and manufactured using RM.

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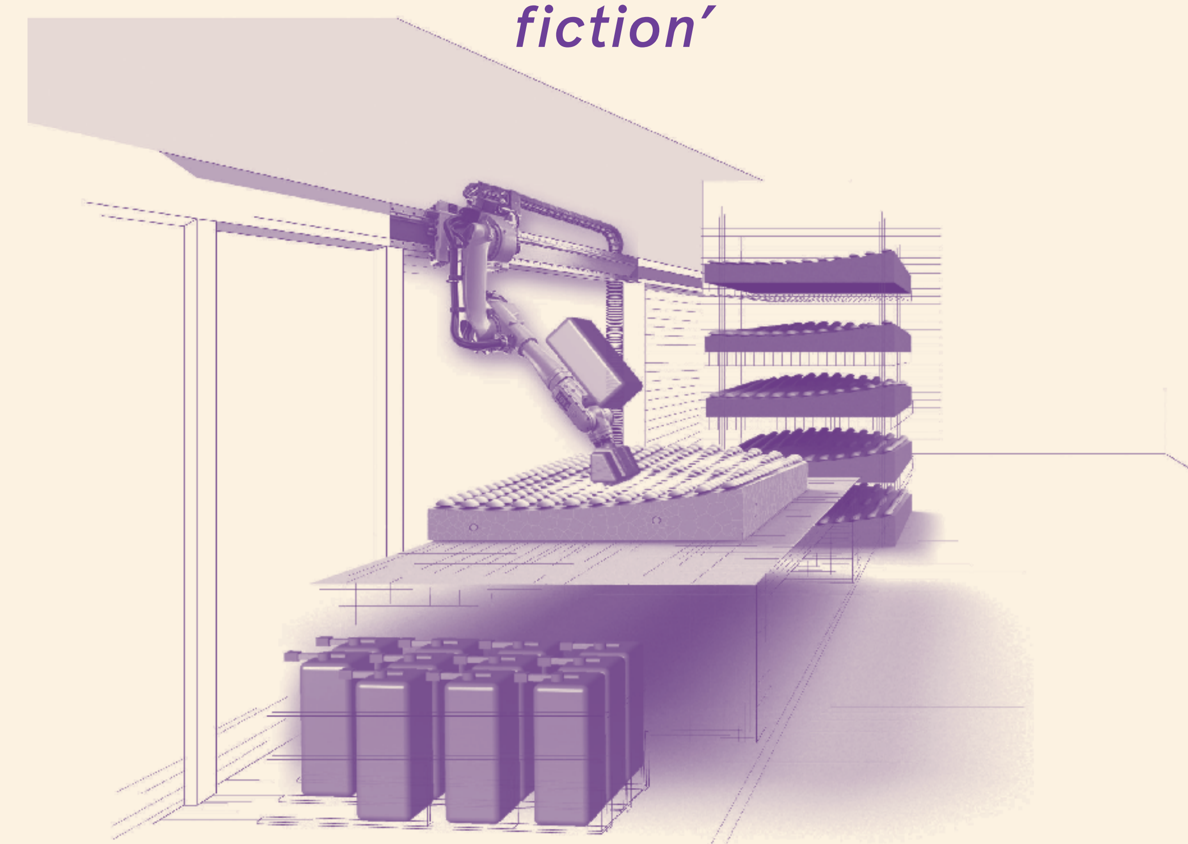

Computer rendering of the MineralJet 3D printing device which uses Soar’s MineralStone material.