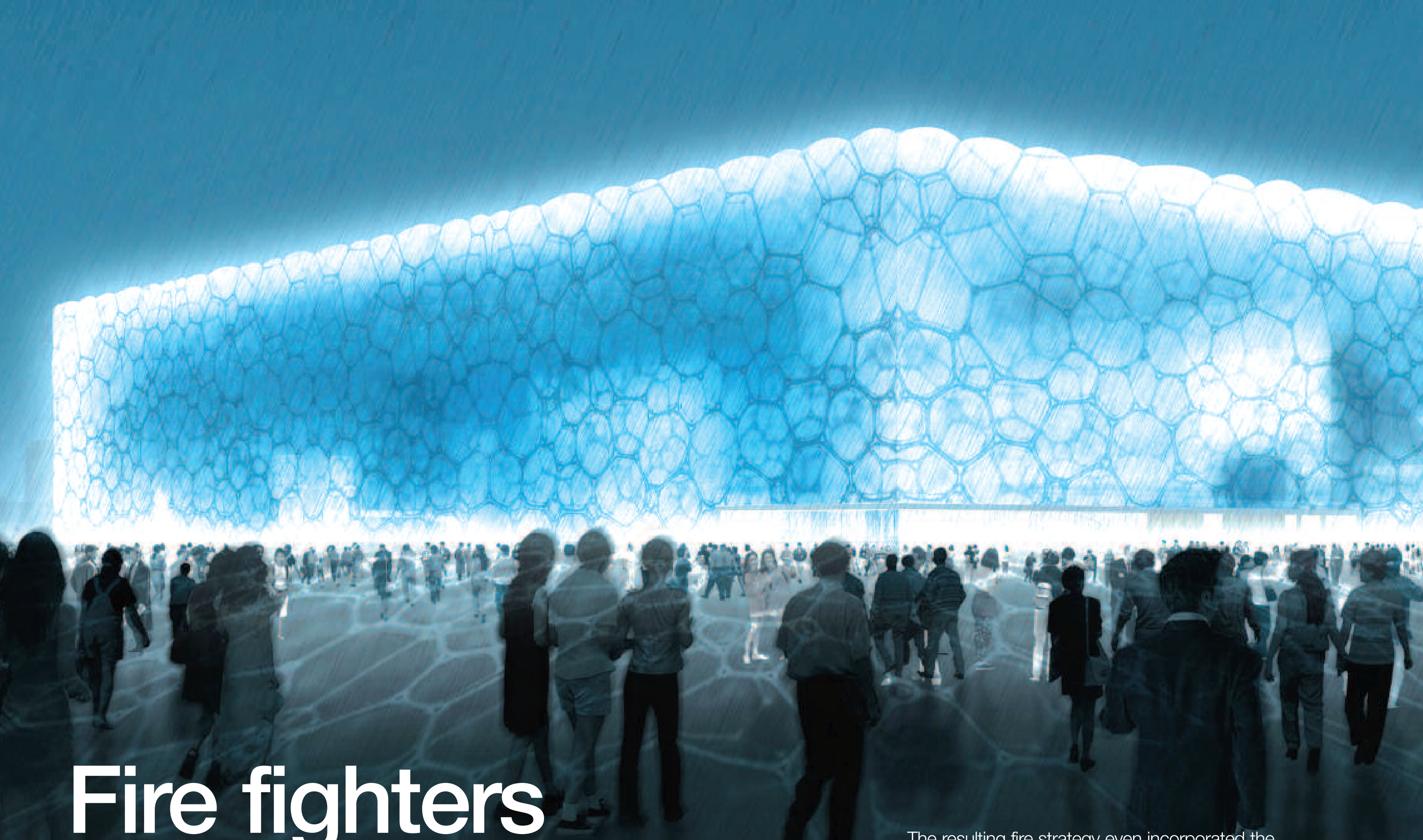


Rendering of Beijing's Water Cube (National Swimming Centre), from an external perspective.

Fire fighters

Stories about the devastation that fire can cause are the stuff of legend. But the solutions are not always simple, which is why Arup has teams across the world that are dedicated to turning up the heat on fire safety.

Words: Nick Kettles

When the American artist Donald Judd passed away, his will instructed the Judd Foundation to preserve his installed spaces by turning them into museums – including his home at 101 Spring Street, New York City. The historic building is not one where the ceiling can be easily torn open to install sprinklers and smoke detectors, as this would impact the building's appearance.

So, when fire safety codes required the main staircase – a key feature of the building – be closed off on one floor, the Judd Foundation considered this an unacceptable intervention.

In fact, meeting this requirement would have caused the organisation to re-evaluate its mission statement. Until, that is, Arup's fire engineering and design teams conceived an innovative fire strategy that limited the impact to the aesthetics of this historic building and its contents, provided a cost-effective solution and met the client's mission statement in one fell swoop.

The resulting fire strategy even incorporated the use of a set of coloured lights (part of an exhibit by artist Dan Flavin) wired-up to the back-up power supply for emergency lighting, avoiding the need for aesthetically intrusive emergency lighting on some floors. This is a typical example of Arup's approach, which tailors its fitting of fire and life-safety measures to meet the individual building's requirements.

Chris Marrion, associate principal at Arup's New York office, says the firm's local and global fire engineering knowledge is paramount to successfully meeting clients' needs on projects like these: "Having already established our credibility with the fire department by working with them on various committees to rewrite the NYC Building Code, they were very willing to listen and work with us when we did our analysis and showed that these alternative approaches would be safe."

Arup's extensive experience in developing performance-based codes and fire engineering guidelines, reflecting the local vernacular and regulatory regimes of cities and countries, is vital in addressing clients' objectives successfully.

Left: exterior view of 101 Spring Street, home of the late artist Donald Judd.
Below: CFD analysis showing a proposed model for a smoke management system.

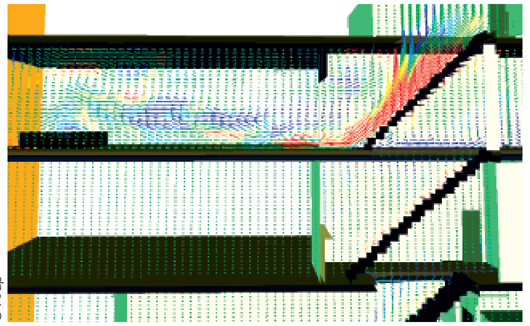
This experience has allowed the firm to adopt an open-minded approach, bridging the gap between individual needs and prescriptive regulatory codes, at times demanding a compromise in building design or functionality. This has created opportunities for Arup to author books such as *Extreme Event Mitigation In Buildings* (Editor: Brian Meacham, Associate Editor: Matthew Johann) and *Egress Design Solutions* (Authors: Jeff Tubbs and Brian Meacham).

Life-safety is reassuringly central to Arup's performance-based design approach, but this does not exclude the need for innovation. Arup's solutions can also embrace broader issues, including business continuity and the protection of assets.

For the US$100M Beijing National Swimming Centre (the Water Cube), Arup addressed fundamental challenges about its design at a conceptual stage of the project, so that it could be used safely for the 2008 Olympics.

Ethylene tetrafluoroethylene (ETFE), the amazing-yet-combustible material proposed as the skin of the Water Cube's revolutionary soap-bubble design, did not conform to local fire codes, until the firm's complex analysis demonstrated that it shrinks away from fire – self-venting to allow smoke out of the building.

The local code would have also required the Water Cube to incorporate over 100m of exit doors, further impacting the aesthetic appeal and creating a significant security issue. Using advanced computer modelling to help predict the spread of smoke and movement of people, Arup was able

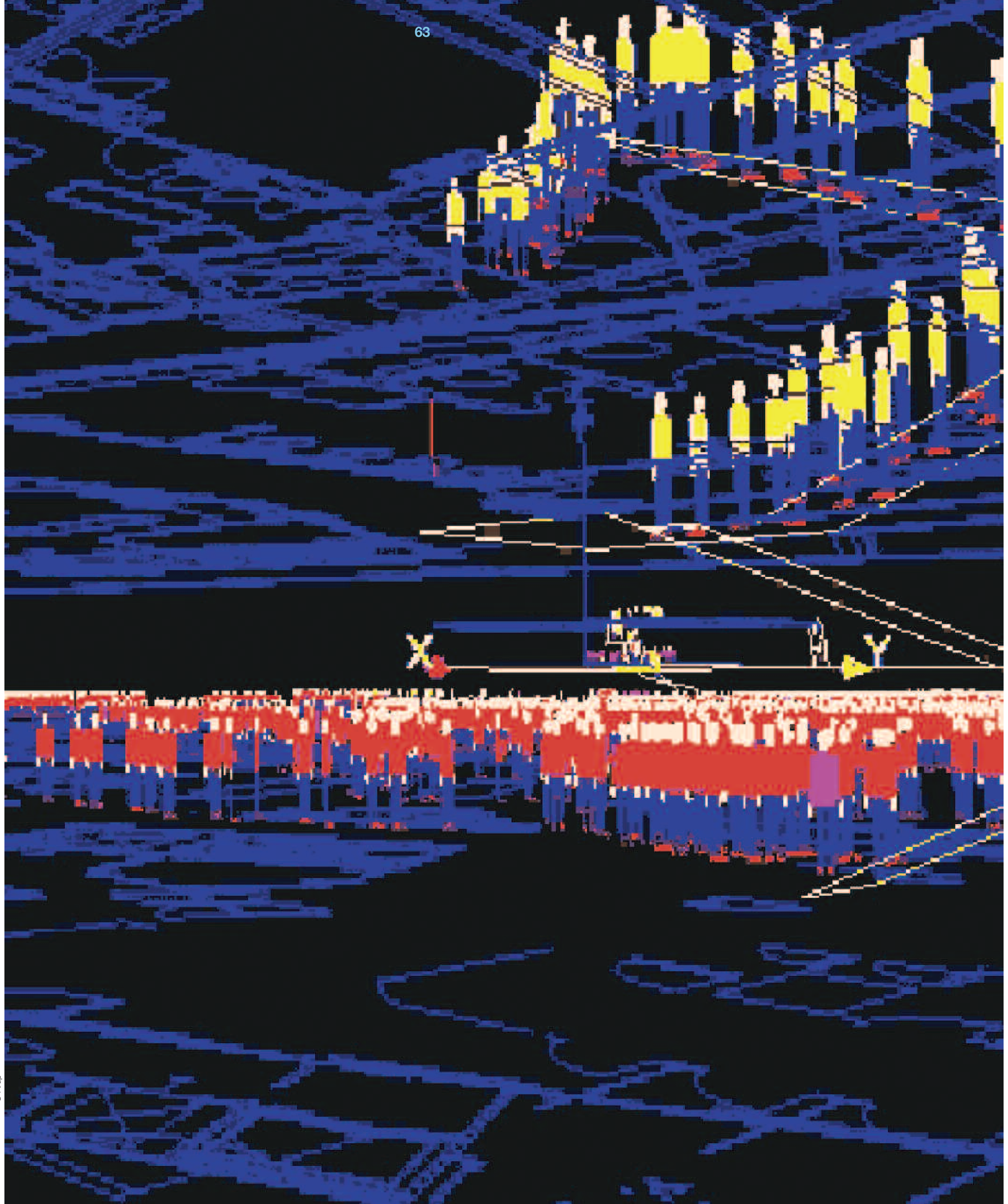


to design for the optimum safety of the Water Cube's capacity: 17 000 spectators and athletes. "People prefer to enter and exit from the same place, so the fire design favours open circulation routes, and incorporates fire safety systems like sprinklers and smoke exhaust – making the building safe for longer periods of time and allowing the more familiar circulation routes to be used for exit," adds Marianne Foley, the project's fire engineer based at Arup's Sydney office.

The value of the performance-based design approach to fire safety can equally be applied to infrastructure-related projects, such as underground stations.

Fiona Tsui, from Arup's Hong Kong office says: "Fire engineering is a viable means to address the fire safety challenges posed by subway stations and tunnels – particularly those entrances with long tunnels located deep underground, where new technology may be applied to approach fire safety issues such as high capacity lifts for underground evacuation."

By considering the performance of each building's structure, service systems and functional planning in case of fire, the result is typically a cost-effective design that meets fire safety objectives, as well as the design and functional objectives of the stakeholders.



Left: computer models such as these help Arup's fire engineering teams to predict the flow of smoke and people in the event of a fire and plan accordingly.

Research breakthrough

As part of their ongoing study into the quantifiable physics of fire, Arup's David Moorehead is researching how unlined tunnels constructed in sandstone, an area of research not well understood, could provide equal or superior safety standards in concrete-lined tunnels.

"Better understanding of this will provide more confidence in the prediction of tunnel performance in fires, both for cases of untreated rock, and where provided with a protective layer such as concrete," explains David. Under laboratory test conditions with additional computer modelling, the sandstone did not break up due to the build up of water vapour pressure within the stone, a key advantage over concrete. And while yet to be completed, the research may also eventually be used to produce a predictive modelling tool for use in real tunnel design, in similar sedimentary rock.

Below: Schematic description of experimental set-up for sandstone lining