Built for the Moment: Designing for a Fast-paced World

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Lena Kleinheinz of Magma Architecture discusses her studio's experience designing temporary structures to house the shooting competitions for the 2012 London Olympic and Paralympic Games, highlighting the sustainable advantages offered by temporary architecture and how harm can be incorporated into cost calculations.

Industrial production has become the ever-accelerating pulse generator of contemporary life. Objects of human production are purchased, used, and discarded at a speed unimaginable to past generations. The laws of the global economy scatter production and consumption across the continents. Raw materials and goods are transported by ship, plane, train, and truck. Humans themselves are also becoming more mobile. We travel farther and more frequently—for work, holidays, and events, across short or long distances, monthly, weekly, even daily.

In complete opposition to the growing mobility and adaptability of our societies is our built environment. Architecture is built to last for centuries. Many of the buildings that line the streets of our cities were designed generations ago. Many architects believe that, to be sustainable, architecture must be permanent, a counter-pole to the fast-moving throwaway society. Designers go to great lengths to make buildings more durable. It almost seems like the focus is on sustaining the buildings rather than the global environment: the longer the buildings last, the more sustainable they are assumed to be. At first glance, this idea of sustainability seems coherent. Construction exhausts natural resources and consumes vast amounts of energy. Architects assume that, once constructed, durable buildings do not require repair or replacement for a long time.

On the other hand, the impact our global economy is having on the natural environment makes it necessary for our built environment to change. It is no surprise that century-old buildings fail to meet contemporary standards. In Germany and throughout the European Union, we are currently embarking on massive government-supported programs to retrofit the existing built environment to meet our continuously rising standards for energy performance—something that was unforeseeable a century ago. We can assume that the buildings we are designing today will encounter similar paradigm shifts and subsequent alterations in the future: the longevity of buildings results in a recurring obsolescence, an everlasting process of construction to update historic buildings to new demands. We struggle endlessly with the inadequacy of buildings that reflect parameters and challenges of past times. What seemed to be a solution in the past finds itself at the heart of the problem today.

A re-evaluation of temporary, mobile, and adaptable architecture can offer better and more sustainable answers to certain conditions. In particular, such structures may be better-suited to housing one-time or infrequent events than conventional, permanent buildings. Temporary and mobile buildings for the London 2012 Olympics are a strong example of impermanent buildings proving to be the more sustainable option.

International sporting competitions and expos are temporary events with growing visitor numbers. They require elaborate preparations including large-scale construction. Neither temporary buildings nor the Olympic architecture of the past have contributed positively to global sustainability. Whereas temporary expo architecture is widely attributed to the highly unsustainable throw-away society, Olympic buildings have often become “white elephants,” infamous burdens to cities because of their underuse and excessive maintenance costs. The organization of the Olympic Games as a traveling event guarantees their unsustainability. For most sports, the Olympics are the marquee event, attracting by far the largest number of athletes and visitors. Hardly any other sporting event requires facilities at such a scale. However, because the Olympic Games travel to a new host city every four years, new large-scale sports venues are constructed in every new location, even though it is unlikely they ever will be used to their full extent beyond the few weeks of the Games. Because of this extremely short time span—a few weeks every four years—even fixing the Olympics in a permanent location would prove unsustainable, as the buildings would still remain underused for most of the time.

One sustainable answer to this problem could be to imagine the Olympic Games as a travelling circus of mobile facilities. The Olympic buildings would be assembled only for the duration of the Games and put in storage for the years between events. This solution has its challenges too: moving such large structures—a stadium capable of seating 80,000 spectators, for example—over long distances would be a massive logistical feat and consume a great amount of energy. Additionally, the design of the buildings would have to accommodate varying climates, site-specific topographies, the availability of local construction technology, and different building regulations in various host countries. Developing structures that function sustainably under any climatic or political conditions in the world would be a fascinating, but most probably insoluble design challenge. It remains a fact that there are contradictions between the effects of a large-scale, one-off event like the Olympics and the principles of sustainable development; nevertheless, the appeal of the temporary has not failed to reach the International Olympic Committee, which, a decade ago, opted for temporary venues if there is no legacy need.[1]

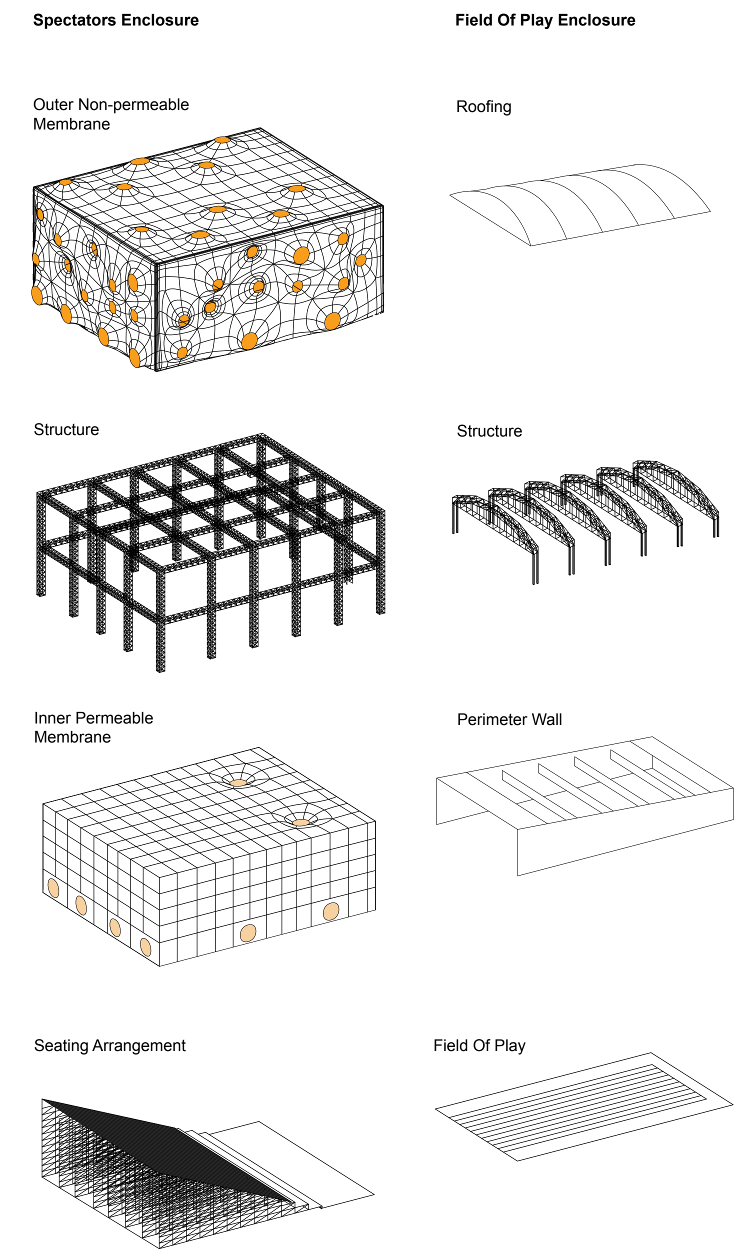
In 2012, London hosted the Olympic and Paralympic Summer Games. London won the bid for the Olympic Games in part because it aimed to create a social, economic, and environmental legacy, leveraging the Games to make lasting improvements to the city. The bid demonstrated a long-term commitment to inspiring the broader population to engage in sportive activities by planning to establish a variety of facilities for popular—rather than professional—sports in London. Another focus was the improvement of the urban fabric, specifically regenerating East London by building the Olympic Park on an underused postindustrial site. The construction industry also anticipated long-term benefits, particularly knowledge about how to make a sustainable event of such size and complexity succeed.

The London 2012 delivery body, the Olympic Delivery Authority (ODA), strove to maximize "the benefits that may be derived after the Games from its preparation, whilst contributing to sustainable development."[2] This emphasis on sustainability and long-term impact had many implications for the architecture designed and built for the occasion. To avoid "white elephants," the London Olympics became the Olympics with the largest-ever proportion of temporary and mobile buildings. As many temporary spectator seats were provided in London as had been during the three previous Olympics—Bejing, Athens, and Sydney—combined. Most of the buildings for the London Olympics were commissioned by the ODA to be converted, partially or completely dismantled, and, ideally, reused in other locations.

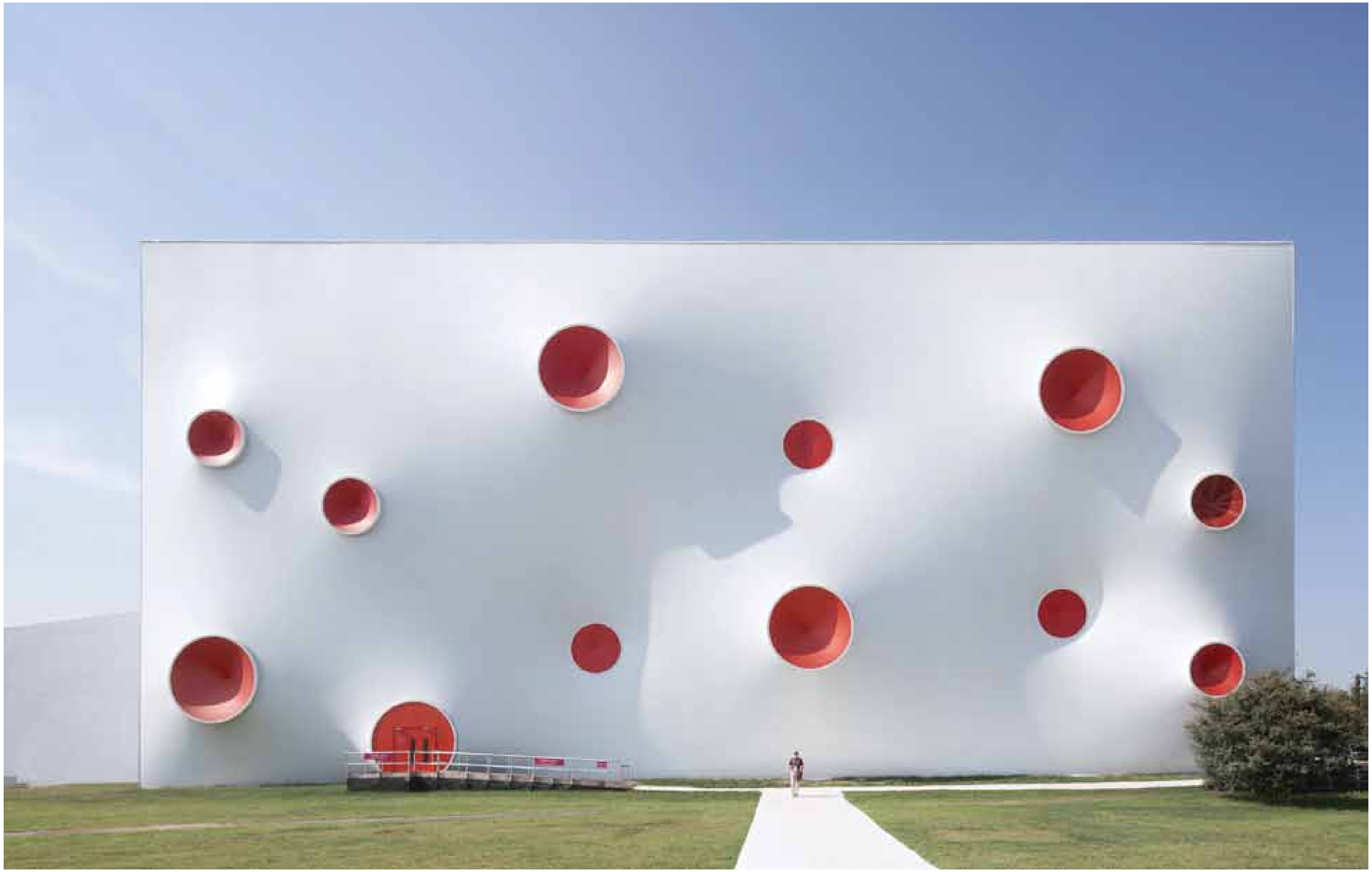
The Aquatics Centre that Zaha Hadid designed for the 2012 Olympics demonstrates the balance and trade-offs made in order to meet different requirements during and after the Games. Hadid's Aquatics Centre is designed as a swimming pool for the local community. Only for the duration of the Games did two temporary extensions, attached like wings to the building, provide seating for the Olympic spectators. In contrast to the skillfully curved shapes one expects from the studio, the extensions looked clumsy and awkward. On the two-time Pritzker Prize winner's website, the wings do not appear in photographs of the Aquatic Centre taken during the Games; there are only shots of the interiors. From a design standpoint, the appearance of the arena during the Olympics is easy to criticize. On the other hand, one can also praise the courage required to build something for a high-profile event that does not reveal its true beauty until after the event is over. We can look at this process of "skinning" as a sort of metamorphosis, like a caterpillar becoming a butterfly.

Hadid's mindset for balancing the event and afterlife of buildings matches our own experience at Magma Architecture designing for the ODA. In 2010, we were commissioned to design the 10-, 25-, and 50-meter ranges for the London 2012 Olympic and Paralympic shooting events, held in the southeastern district of Woolwich. The envisioned legacy for the buildings of the shooting venue was either to be recycled or to be reassembled for a different use in a new location. We were therefore asked, in addition to meeting the specific requirements of the sport and providing 6,400 spectator seats, to develop fully mobile structures.. Like all Olympic architects, we had to meet the ODA's extensive sustainability requirements, which were laid out in a Sustainable Development Strategy. The usual BREEAM and CEQUAL assessments, which were not deployed due to the temporary nature of the buildings, were replaced with an emphasis on eliminating waste. With their sustainable development strategy, the London Olympics sought to dispel the myth that temporary buildings prompt waste and inefficient use of materials; the ODA therefore demanded that all materials and construction methods be tested against the principles of "eliminate, reduce, reuse, recycle, recover, and dispose," in descending order of emphasis. Key objectives were minimizing the use of materials in construction and consumption of energy in use; out of the material that couldn't be eliminated, at least 90 percent had to be reused or recycled.

We implemented these requirements in a shooting venue that could be built rapidly,

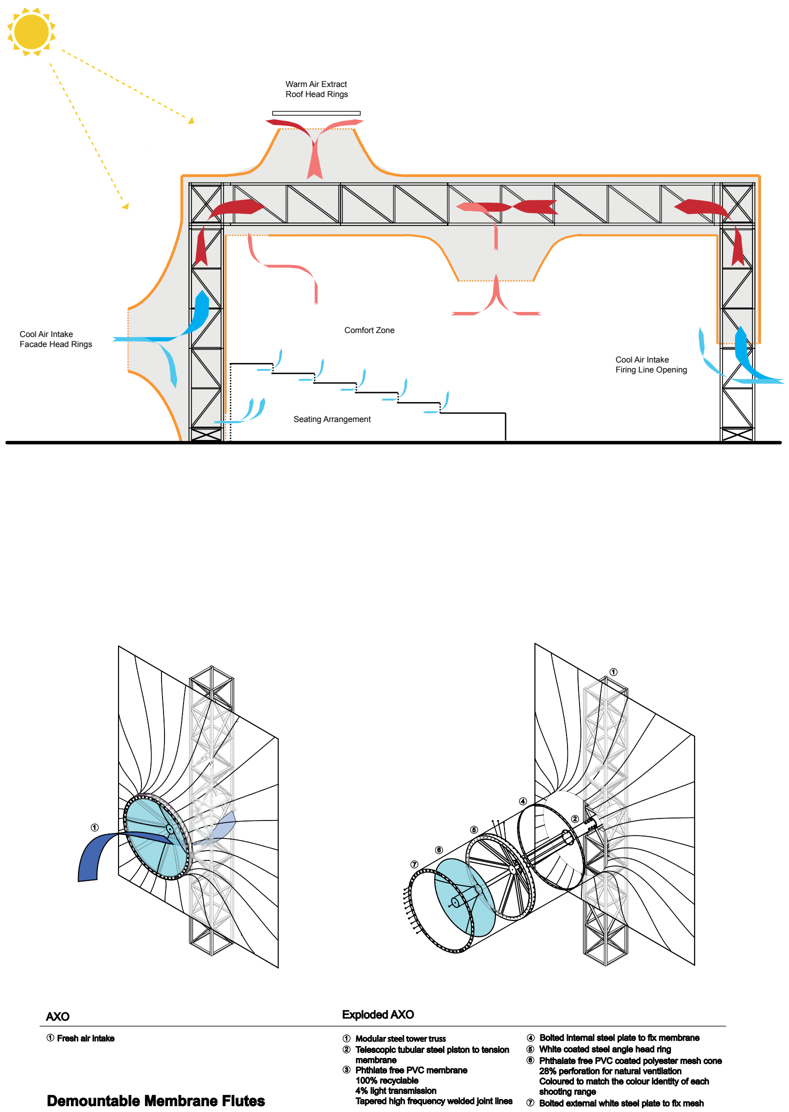


↑ 1. All joints of the three shooting ranges were designed so that they could be disassembled and reassembled, meaning that the different components could either by recycled or reused.

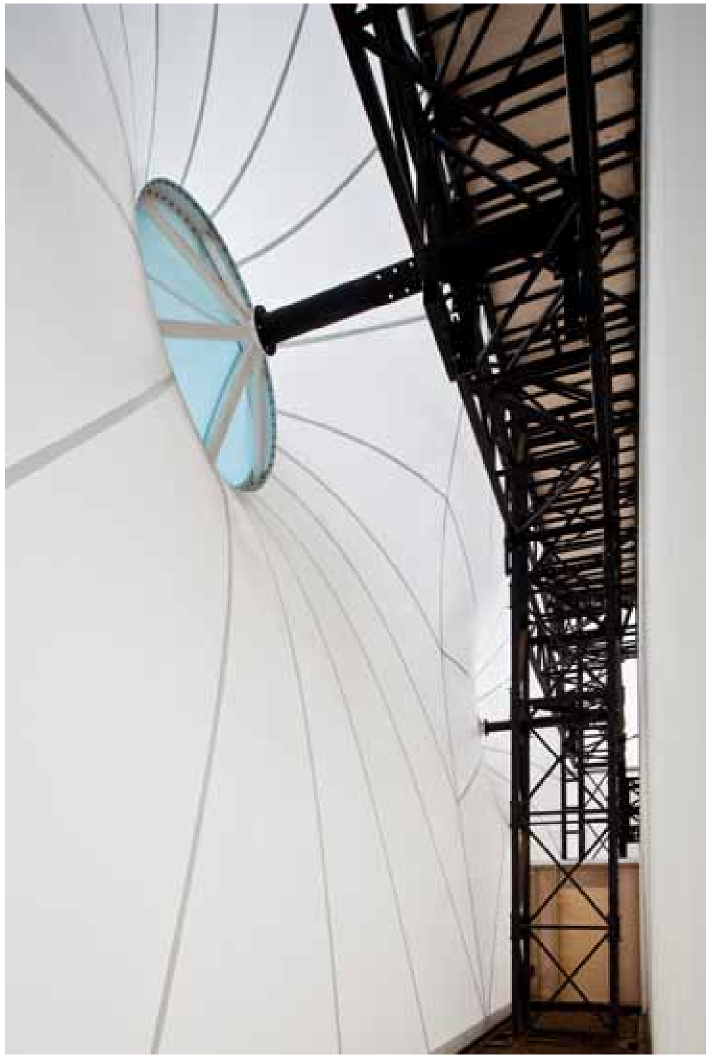


↑ 2. Exterior of the shooting venues for the London 2012 Olympic Games, as erected on London's Royal Artillery Barracks in Woolwich

↑ 3. Interior of the shooting range during the 2012 London Olympic Games



↑ 4. The pink, red, and blue protrusions in the facade and double membrane serve to ventilate the interior of each venue, drawing in fresh air at the bottom and releasing warm air through vents in the ceiling.



↑ 5. The membrane was tensioned using the circular steel components, creating a double-curvature geometry that optimizes the use of the membrane.

↑ 6. A white translucent membrane minimizes the amount of artificial light needed inside the shooting venues. Only the finals range is covered with an opaque membrane to meet broadcasting requirements.

↑ 7. Plywood panels help protect athletes and spectators from ricocheting bullets and also allow for more daylight to filter into the building.

then taken apart and relocated. As early as in our method statement—part of our bid for the commission—we explored the possibility of using standardized, lightweight steel trusses clad with a bespoke membrane skin. Creating mobile, rather than just temporary, buildings meant that we had to design all material connections so that they could be disassembled and re-assembled elsewhere. The mobility of the buildings was added to the design commission as a separate task. Accordingly, we reviewed all built-ups of the foundations, structure, and skin in order to ensure they could be dismantled and reassembled. All connections would be fixed mechanically, mostly screwed and bolted.
A result of this review was that, where feasible, composite materials were avoided and no adhesives were used anywhere in the building. The only exception was the rubber flooring under the firing line, which was glue-fixed to a single concrete foundation—an inevitable, sport-specific requirement. Even though the buildings were used only during the summer, we made allowances for snow loads and stronger wind forces in potential future locations.

Throughout the design process, we had to prove that our building adhered to our sustainability goals by studying and comparing alternative solutions. The maxim was to “reduce, reuse, or recycle” any materials or works involved.

Reduce

One of the project’s major achievements in terms of reducing material consumption was the reduction of what was originally planned as four buildings to three. We found that the 10- and 50-meter prequalification events can be carried out in one space with the same width and number of shooting lanes. The difference stems from the fact that 50-meter shooting requires an open-air space between the shooters and their targets, the so-called field of play. For 10-meter shooting, air guns are used; the field of play has to be fully enclosed to prevent any interference by wind. We installed a mobile outer wall between the competitions to convert the 50-meter range to a fully enclosed 10-meter air gun range, allowing us to combine the two buildings into one. The challenge of this operation was not just spatial; the tight training and competition program of the Games had to be arranged so there would be sufficient time for the conversion.

On other occasions, when asked to remove materials, we were able to prove that doing so was not always the most sustainable solution. The buildings were designed, for example, with a double membrane—one external and one internal—tensioned around a steel frame with circular openings that act as doorways and exhaust vents. The ODA asked us to remove the interior skin; they assumed it was introduced to visually disguise the modular steel inside the outer skin. However, the roughly two-meter-wide void between the outer and inner skin provides an insulation layer, reducing the heat transfer between the inside and the outside and creating an airflow, with warm air rising and exiting through vents above and drawing in cooler fresh air below.
The lower circular openings are covered with a different type of perforated and colored membrane that allows them to draw in fresh air. Thanks to the second inner membrane, the buildings could be naturally ventilated, minimizing the use of energy for heating, cooling, and ventilation during the Games. The need for artificial lighting was also reduced through the introduction of a translucent membrane in the two prequalification ranges. The walls of the finals range, however, are covered in an

opaque membrane, as they had to black out all daylight in order to meet Olympic broadcasting requirements.

We were clearly instructed by the client that aesthetics would be no ground for decisions. The underlying assumption seemed to be that what was visually remarkable could not possibly be sustainable. We were therefore asked if we could remove the steel rings, which created brightly colored circular protrusions that matched the Olympic color scheme, or, if they could not be omitted, if they could be made to resemble other, non-circular shapes. We prepared a specific report to compare our solution to a simple, flat-clad box without steel rings. The façades of the buildings were up to 25 meters high and up to 107 meters long, all made of one piece of continuous membrane stretched over rectangular. Wind would strike these large planar expanses forcefully; it would have been difficult to prevent the flexible membranes from fluttering in the wind. Simply pulling the membrane over the corners of the buildings without pushing in and out would have required 40 percent more steel to fortify the frame against wind loads. The steel rings, which are braced against the rectangular structure, are necessary to push and pull the outer skin in order to create tension. The ring shapes help distribute force equally across the fabric. Our report showed that the double-curvature geometry is a result of the optimal use of the membrane material. Any other shape—like a square or cross—would be suboptimal. On this basis, the client accepted the steel ring solution.

Reuse

More rigorously than most of the temporary buildings for the London Olympics, the shooting venue relies on elements that can easily be reused. The entire load-bearing structure is built up using a kit of standardized, lightweight steel trusses that are widely available for rent from temporary-works firms. Trusses are joined using bespoke connection pieces to create large spans without any columns, freeing the space for good spectator sightlines. Rather than having to be recycled—as the bespoke steel structure of the basketball arena was, for instance—the trusses from the shooting venue could be returned to the temporary-buildings market and reused for other temporary structures without transformation. Before becoming the shooting venue, the structural trusses formed the grandstand for Madonna's "Sticky & Sweet" tour. After the Games, they will be transferred to Glasgow, Surrey, and Cornwall.

The prequalification ranges have been divided into parts: the membrane enclosures of the spectator seats were separated from the plywood barriers around of the fields of play. The membrane seating enclosures have been sold to new owners. The combined 10- and 50-meter building will be reconfigured as an equestrian center in Surrey; the 25-meter building is envisioned as part of a leisure development in Cornwall. The parts of the ranges surrounding the field of play—plywood walls, baffles, and canopies above the shooters—are scheduled to be reused for the shooting competitions during the Glasgow Commonwealth Games in 2014.

Recycle

The membrane used for the skins of the buildings was chosen because of its lightness, tensile qualities, and translucency. As a result of the scale of the buildings, the membrane inevitably had to be custom-made. The membrane is a composite material combining the weatherproofing benefits of PVC with the structural strength of polyester. To meet the conditions of the ODA's sustainability strategy, the industry developed a phthalate-free PVC membrane that could be returned to and recycled by the manufacturer. The search for a new location for the finals range after the Games was unsuccessful, so the membrane was fully recycled and the structure reused in other projects.

Sustainable designs are often not pursued because they require additional investment. The cost of building sustainability, however, depends on the parameters we set. The London 2012 shooting ranges were cheaper to build than their permanent Olympic predecessors, like the permanent venue in Beijing, because they were temporary and could therefore be custom-designed for this specific occasion. Because they were used only during the summer, for instance, they did not require any insulation, nor did we have to provide a heating system. Their modular steel structure was taken from the temporary-buildings market and returned after use. It could even have been rented rather than bought.

By meticulously eliminating the building elements that could not be reused or recycled, we were able to create three temporary buildings that left no waste behind and did not require exorbitant maintenance costs into the future. The London 2012 Games have delivered an approach worth pursuing for future Olympics and other large-scale, short-term major events that seek to be more ecologically and economically sustainable. For the rest of the built environment, the process of questioning the merits of longevity and considering the possibilities of a more ephemeral approach to architecture has yet to come; the built environment is still too closely associated with ideas of longevity and stability. To become independent of the politics of the day, manufacturer interest, or just the weight of tradition, we need to develop further a more holistic evaluation system for sustainable building.

Beyond evaluating sustainable buildings differently, a more general way of encouraging their construction is to make them economically attractive. The economist Geoffrey Heal defines sustainability as "keeping the total value of capital stock of a country intact."[3] Capital stock, in his terms, is not limited to what we trade on financial markets, but includes physical, human, intellectual, social, and natural capital. Heal points out that our decisions to deplete or increase these various capitals are economically driven and that there will be no substantial change in unsustainable human behavior unless it is made economically unattractive. This would mean developing a new economic system that, rather than responding only to the interests of financial capital, would serve other types of capital as well—balancing economic gain against the loss of natural capital through the exploitation of fossil fuels, for example.

In the built environment, such an approach would require determining the values of the various factors that go into building. Architects and quantity surveyors are skilled in calculating the construction costs of buildings. A comprehensive model, however, would require determining the monetary exchange rates for the exhaustion of natural capital and incorporate this into a project's construction costs. The calculation would have to include the depletion of raw materials, the production of building materials and energy consumed in that production, emissions, transport of raw materials and building materials, energy used on site, and more. The calculation would not end with the completion of the building, but account for energy consumption during operation, repairs and adaptations, and, at the end of the building's lifecycle, demolition and waste removal.

An economy that reflected the sustainability impact of materials and building resources would change the way we build considerably. In Adrian Forty's book on the ever-popular, highly durable building material concrete, he points out the very high embodied CO^2 level of cement, a result of the chemical reactions and heat required for its production.[4] Cement is produced in such great quantities that it is variously estimated to be responsible for 5 to 10 percent of the world's CO^2 emissions. This gives a rough indication of how expensive concrete construction is when the depletion of natural resources is taken into account. Accounting for this might push concrete production in a more sustainable direction; if not, it would become very expensive and be used much less often. Such a comprehensive valuation system would enable architects to more easily design sustainable buildings: rather than having to weigh the advantages of sustainability against the costs of expensive options like solar panels, geothermal energy systems, or more insulation, architects could be confident that the most sustainable buildings were also the most cost-efficient.

Architecture, as one of the key players in the exploitation of natural resources, will have to change radically if the world is to become more sustainable. The example of the Olympic and Paralympic Shooting Arenas shows that building temporary and mobile structures can be a more sustainable approach to cope with short-term needs. Requirements changing over short periods of time is more often the rule than one might expect. In parts of the world, cities are shrinking; in many others, they are growing at a breathtaking speed. People move to the city to escape poverty in the countryside. Having sustainable—yet timely, livable, and safe—solutions to absorb this mass movement would be a major improvement over the status quo; new migrants to cities often live in poor conditions. Similar solutions could deal with the ebb and flow of tourist trends and seasonal patterns. Temporary accommodation could be made available only during peak times, leaving permanent structures to the permanent inhabitants. Other changes to which temporary structures could respond take place on smaller scales; urban districts gain popularity only to be replaced by new hot spots in other parts of the city, and even small entities like families regularly encounter changes in spatial needs. Temporary, flexible, and adaptable solutions are not a new idea. But with new technologies and a more comprehensive concept of sustainability, they could be more successful and more widely accepted than ever before. Temporary buildings can be more than tents or containers. They can be smart, adaptable, well designed, multifunctional, and eye-opening additions to our urban fabric.

It is unlikely that we as designers will be released from the responsibility to explore and closely evaluate all options and their consequences. Sustainability cannot be achieved by adding well-known plug-ins to conventional architecture. We have to question everything we know about buildings and, with an open mind, test all imaginable solutions. Temporary and mobile architecture may offer new and unexplored solutions to the cities of the future—not just for gala events but to cope, in a more efficient and sustainable way, with the needs of a changing world.

Notes

1 Richard W. Pound, *Olympic Games Study Commission* (IOC: Prague, 2003), http://www.olympic.org/Documents/Reports/EN/en_report_725.pdf.

2 Olympic Delivery Authority, *Sustainable Development Strategy* (London: ODA, 2007), http://www.strategicforum.org.uk/pdf/ODASDSfullpolicy.pdf.

3 Geoffrey Heal, *Valuing the Future: Economic Theory and Sustainability* (New York: Columbia Press, 1998) and "Geoffrey Heal: Managing the Global Commons 2/5," INETeconomics, April 14, 2012, http://www.youtube.com/watch?v=1WvpJ6USrAQ.

4 Adrian Forty, *Concrete and Culture: A Material History* (London: Reaktion Books, 2012).