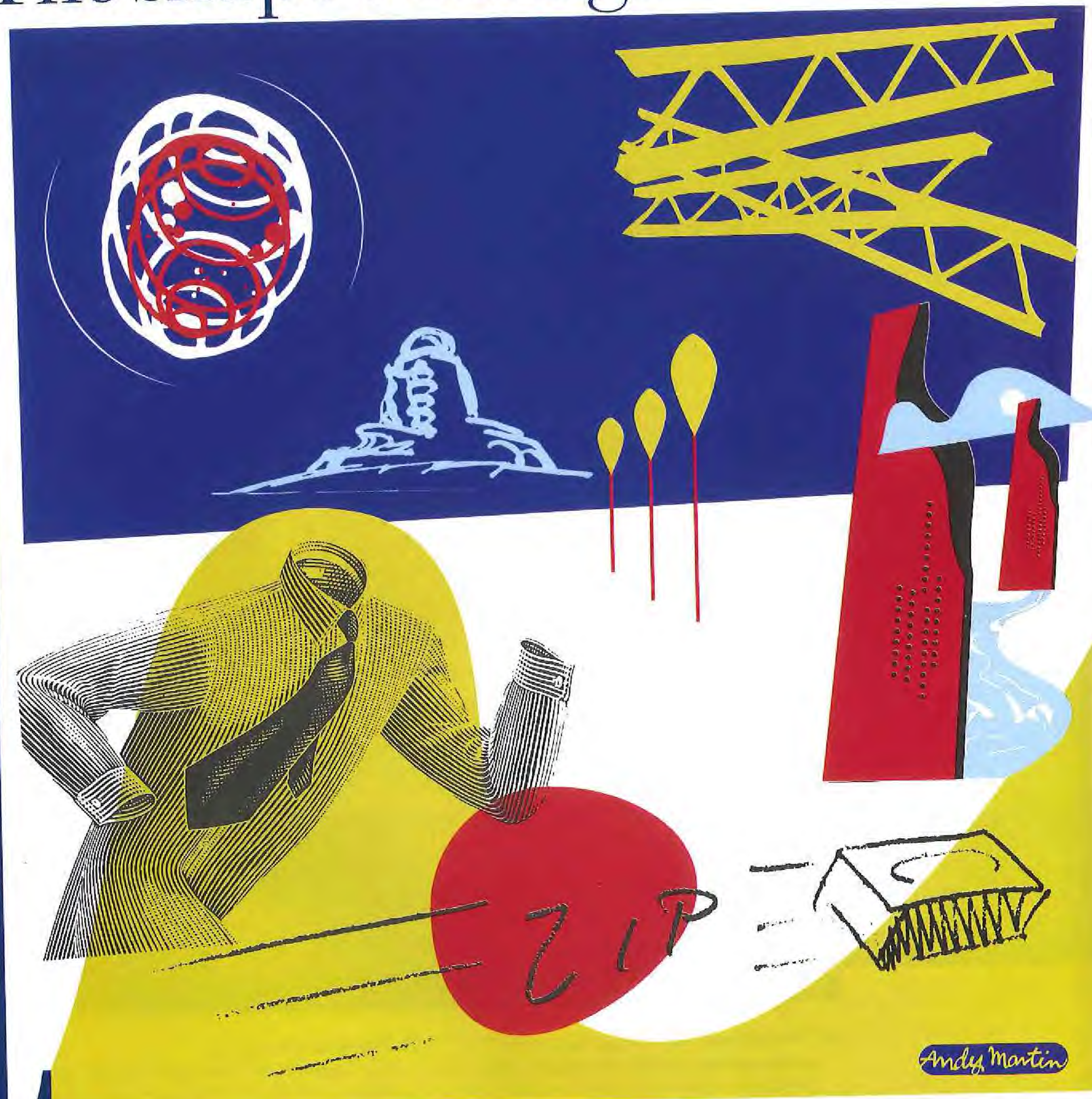
The shape of things to come



Structural engineering is not renowned for changing course rapidly. But increasing environmental and financial pressures mean the search never ceases for innovative methods and materials that will allow extra efficiency in the construction process and the lifespan of structures. James Macneil talks to seven engineers about the developments they expect to see over the next 10 years.

Ian Liddel
managing director
Buro Happold

The cost of a construction is always a balance of materials and labour costs. In the 1950s and 1960s, labour costs were relatively low and the choice of structure was influenced by the cost of materials. The balance of labour costs to materials and energy costs has gradually changed – we now have minimum labour construction, which maximises the use of machine-produced prefabricated elements.

Recent developments in this field have been towards eliminating the process of protecting steelwork against fire, which is a messy, on-site, labour-intensive job. The process can be avoided by using heavier sections with some off-site concrete filling, which means more materials and less labour.

It is likely that this process will continue for major buildings, and that there will be further changes that will reduce on-site labour. Maintenance now accounts for something like 60% of building industry output, and it is rising.

The long-term performance of motor cars has improved enormously over the past 29 years, through huge investment in development engineering and prototype testing. But buildings, which do not get the same level of development and testing, are expected to last much longer than cars.

It is likely that building expertise will move to consultants, who will set the standards of performance and who will find ways of controlling their liability for the end product. The outcome will probably be a greater number of standardised details, developed and tested to ensure satisfactory performance.

There is a strong pressure towards better environmental performance – the control of the flow of heat, light and air through the skin of buildings. The mass of the construction can be used to smooth out fluctuations in temperature, and clever glass and steel structures can provide the light. Both of these are controlled by the selection of suitable structures by the structural engineer.

In recent years, there have been dramatic developments in the field of translucent skins. Glass has been used for structural beams or compression members within a space frame. These developments look set to continue, with more complete rod and strut elements supporting glazed walls and roofs. It will require a change in glass manufacturing, with, say, the production of an insulating glass foam to make a major change.

We have seen the introduction of coated fabrics – mainly PVC-coated polyester and PTFE-coated glass. Both materials have serious environmental disadvantages for permanent buildings, because they give insufficient insulation and their translucence gives a yellow/brown light. They also tend to discolour or collect dirt.

We now have several examples of the use of ETFE foil as a cladding material. This has magic properties as far as environmental control is concerned. It can be used in three or four layers to give effective insulation and it allows a wide range of translucencies, as well as staying clean. But the material is difficult to fabricate and has unusual structural properties. Although it has been around for 15 years, engineers and fabricators are only now learning how to use it.

It is likely that new foils and fabrics will appear. The problem with most of these developments is that the new high-performance materials are horrendously expensive, so their use is discouraged. An example of this is woven PTFE fabric (Tenara). This is a very attractive material that has excellent durability and stays clean. But as well as being expensive, it is difficult to fabricate and almost impossible to repair. Therefore, it has been used only for special projects, mostly with deployable canopies.

There is increasing pressure to use low total energy materials to protect the environment. However, the process of defining this is unclear. Another similar pressure is recyclability. One can envisage this becoming a requirement for building materials, which would put additional pressure on their selection.

Today, there is a move towards high-strength and monolithic materials. These give durability but, on demolition, they are only suitable for hardcore. Future generations may not thank us for this. If recyclability becomes a requirement, it could bring into question all the materials we use.

Elizabeth King
associate director
special projects division
Mott MacDonald

In the future, I think there will be more control in the design of structural repairs. There will be greater understanding of how structures deteriorate, so repairs will take place when they are truly necessary, rather than just when they might appear to be needed.

Techniques such as electrochemical repair will become more popular and will help maintain buildings in a stable form, overcoming the necessity to renew sections by controlling the rate of deterioration. There will be a trend towards more radical solutions to structural decay. More effort will be put into understanding why damage is caused, in order to stop the same problem happening again.

Design will start to involve looking at the cost of taking a structure out of service. This is especially important in the utilities sector – with power stations, reservoirs and highways.

Bob Cather
non-metallic materials research
Arup Research

The emphasis for concrete is on higher strength. While 70-80 kN/m² strengths are not unusual, we are looking at 90-100 kN/m² plus. These require interesting concrete technology and carefully selected materials. Mixes of this strength can be made in laboratories. Ove Arup & Partners and Taywood are part of a European research project looking at the economic use of such materials, in an attempt to move the technology out of the lab and on to site.

Although many people associate high-strength concrete with tall structures, in the UK it will be used in bridges and low-rise offices. Its use will save money by reducing the size of the structural members and therefore increasing the lettable floor space. The obvious approach is to use high-strength concrete in columns, but there are indications it could also very useful in horizontal members.

There will be two developments in steel. The first will be the development of high-strength structural steels. At present, these are relatively easy to make but tend to be brittle. This drawback will be overcome in the next decade.

The second development will be the widespread use of structural castings. Although these have already been used in projects such as Terry Farrell's Alban Gate in the City of London and Pond's Forge swimming pool in Sheffield, the use of computers to design the moulds and ensure the reliability of the production process should encourage their broader use.

In the USA, engineers are developing castings that form standard joints, allowing structural systems to be jointed like plumbing systems. This type of standard cast construction has great potential to improve productivity.

Life-cycle costing is waiting to take off across all aspects of construction. This will increase the use of more expensive materials to improve service life and reduce the need for maintenance functions such as painting.

Fibre composites are an example of a technology that has been waiting to take off for several years. Ove Arup has used it for secondary elements such as handrails, gantries and walkways in aggressive environments. When you use bigger sections, you have got to think about fire performance and long-term creep.

There should also be developments in adhesive fixing rather than mechanical methods. The first step may be combination mechanical and adhesive joints, with the mechanical element providing a degree of safety.

Peter Flynn
associate
RMJM

In the next 10 years, more and more projects will be redesigned at tender stage, when there is a lot of pressure to find cheaper approaches to structural problems. The solutions will come from looking at the combination of insitu, precast and hollow-rib slabs. Insitu post-tensioning also has a lot of potential. Although these techniques are known, they are starting to filter through to smaller engineers.

I can also see environmental issues starting to have an effect. This will be seen in the integration of services and structures – for instance, the use of structure to provide thermal mass. This will lead to a breakdown of the divisions between the engineering specialities and will result in a more multidisciplinary approach to design.

David Tasker
consultant structural engineer
sole practitioner

I think a lot of future trends and developments will be driven by energy considerations. The whole energy costs of materials and their ecological impact will become more important. On this basis, steel is on its way out. There is too much energy and material wasted in the manufacture of hot-rolled sections. When it is included, steel will have to be far more effectively and efficiently used.

There is going to be a role for plastics. One application will be as fibre reinforcement for concrete. I also expect to see resin additives for concrete to combine the properties of glass-reinforced plastic and concrete in a hybrid. Timber has also got great potential. We use one-tenth of the amount that is used in Scandinavian countries. The use of micro-laminated timbers gives opportunities for design development, but there has to be a revolution in jointing. Multiple nail fixing plates are far too crude an approach; finger jointing could provide an effective alternative.

Masonry will also figure in the future, both in highly efficient, highly articulated, low-energy structures and traditionally in massive masonry buildings. Before we use a lot more, we will need to learn more about how to design such structures and implement quality control on site. At present, the latter is often appalling.

The golden rule of structures is that the most inefficient way of carrying a load is in bending, and the most efficient is when a member is in tension. We need to devise forms of structure that take advantage of tension or compression. This will take designs into the realms of double curves and folded plates.

Matthew Wells
director
Techniker

In the next 10 years, there will be ductile glass. The architectural pressure for bigger glass roofs and walls is unrelenting. The theoretical possibility of adding hydrogen atoms to the SiO_2 matrix will be realised, giving glass that does not have the brittle quality of existing panes, and huge glass structures will follow.

Genetically engineered timber will result in a renaissance for timber. Genetic manipulation could give European spruce the size of American redwoods and provide perfect timbers that are strong but workable.

Prefabrication of carefully crafted components that are sophisticated, simple and very robust – like a MASH hospital kit – will become more common. Buildings will become very crude and services will be concentrated into tiny, automatic, mobile maintenance machines that crawl over the building tirelessly cleaning and performing routine maintenance.

John Parker
associate director
WSP Consulting Engineers

There could be major developments in the use of glass. We are designing handrails and parapets in glass, and it will not be long before we have glass floors. The development of photo-sensitive glass that reacts to the light outside or to electronic messages sent to it by a lightmeter will also be important.

The number of joints in structures will also be reduced.

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