

Editorial

Remo Pedreschi BSc, PhD, CEng, MICE

Professor of Architectural Technology, Edinburgh School of Architecture
and Landscape Architecture, Director of Research, Edinburgh College of Art,
University of Edinburgh, UK



Construction materials are understood in different ways by the architect, the engineer or the builder, depending on their expectations: for example, in form and expression, strength and durability or construction and buildability. This was illustrated in conversation with a group of architecture students from the University of Edinburgh, who had recently returned from a trip to Borneo where they were involved in the design and construction of a community building. Using locally available materials and construction skills they learned directly the importance of matching design to material. The experience they gained was invaluable: paraphrasing some observations, 'I didn't realise how difficult it was to cut a timber log straight', 'Concrete is heavy, especially when you have to carry the aggregate from the river'. Direct experience of construction and materials changes the way we understand, interpret and, consequently, use materials. Sometimes we focus our understanding of materials on their physical or chemical qualities to observe their response to phenomena, such as gravity and the environment, through laboratory investigation or through various forms of digital simulation. This themed issue on architectural approaches to materials presents research from perspectives of both design and performance. The words of the Uruguayan engineer, Eladio Dieste seem appropriate, 'For architecture to be truly built we must understand our materials and their possibilities' (Dieste, 1992). Trained as an engineer, by practice he was also both architect and builder. His innovative and technically advanced brick buildings exemplified the relationship between structural form, innovation, construction and expression of materials. The development of materials is conditioned and influenced by many disciplines.

The papers presented in this themed issue do not always follow the conventional format or are subjects that one would associate with an engineering journal. The papers have been prepared by authors whose background and education may lie in either engineering or in architecture and the subjects of their work are, by selection, diverse. They include traditional materials, such as brick and stone, new plastic materials and composite biomaterials. Other papers question how we understand material qualities, such as colour, or relate physical properties, such as stiffness, to the design and performance of structures.

The first paper, by Llorens Duran (2013), demonstrates an approach similar to Dieste's. It describes the development and evolution of a form of brick construction used for winery warehouses by the Spanish architect Cesar Martinell, which became known as 'wine cathedrals'. The construction developed during a period of austerity immediately following the First World War, when timber and steel were in short supply. Martinell exploited the use of brick following structural principles rather than traditional practice; the primary structure using catenary arches and Catalan vaulting for the construction of roofs. The well-illustrated paper charts the progression in the design of the warehouses through four stages from one primarily concerned with pragmatic economics, concluding in what the author describes as 'decorative mannerism', as the techniques matured.

Chilton (2013) presents an informative and thorough review of ethylene tetra-fluoro-ethylene (ETFE) foils in the design and construction of lightweight translucent envelopes. The material has a relatively short history, some 30 years, placing it at the opposite end of the timeline of construction history to brick. The paper starts with an overview of the physical characteristics of the foils and important design and construction issues, such as inflation, multiple layers and edge restraint. The low weight and translucency of the foil has led to it being used as an alternative to glazed facades and roofs, but as with all materials direct substitution is often not the most effective approach, it does not have the same degree of transparency as glass. The end of the paper describes a series of case studies in which the material is used to take advantage of its particular properties.

Colour is the subject of the paper by McLachlan (2013). Colour is not a material per se but a consequence of material and material selection. The paper argues that colour affects the way that we perceive form, space and surface. Within architecture there has always been debate about the use of colour. Should it be used at all, should coatings be applied or do they betray the honesty of expression of materials? The paper discusses the selection of colour and coloured materials, with reference to recent contemporary examples and reveals that it is not straightforward, should never be arbitrary and should be considered both early in the design and through to

procurement. The online version of the paper has colour versions of the figures.

Gengnagel *et al.* (2013) consider the production, performance and design of natural-fibre-reinforced plastics in actively bent structures, such as gridshells. Actively bent structures require materials that have a comparatively low modulus of elasticity and high tensile strength to optimise the geometry, facilitate erection of the gridshell and ensure the strength of the final structure. The paper reviews different materials suitable for active bending and describes an experimental study of natural fibre composites formed by pultrusion. Natural fibres are seen as a possible alternative to carbon and glass fibres. Despite some inconsistencies in the composite matrix the results with natural fibres are encouraging. A 10 m diameter irregular gridshell using glass-fibre-reinforced plastic tubes was constructed and tested as a benchmark study for numerical modeling.

Rippmann and Block (2013) consider a highly innovative and technically sophisticated application of a traditional material, cut stone, and its application in shell structures. The aim is to produce unreinforced stone shells without mortar. Such structures rely entirely on compression of the stone pieces. The shape of the shell must follow a funicular geometry to maintain compression throughout and the stones have to be cut to ensure alignment with the principle directions of thrust. The paper explains the design and production process using various optimisation procedures to form-find and generate the shapes of the stone pieces. The techniques were used to develop a proposal for a 28 m span vault in Texas, validated using a 1:33 structural model produced by rapid prototyping each individual stone part. It will be very interesting to track the further development of the project.

The paper by Tang (2013) describes practical construction workshops on gridshells and echoes the experience of the students who visited Borneo and the paper by Gengnagel *et al.* (2013), uniting active learning and active bending.

Three-dimensional surface structures have always been of particular interest to both architects and engineers, where the form creates elegant and efficient architecture. During the workshop students studied the properties of timber by simple qualitative tests and explored the geometry of the gridshell through scale models. The final stage of the project was the full-scale construction of the shell. An important part of the learning process is the students' involvement in developing the design, supported, in this case, by input from architects, engineers and builders.

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