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## Fabric Formwork for Concrete

### Fabric formwork can release structures from the restrictions of concrete shuttering

To build a simple concrete wall, make two complicated wooden walls, pour the heavy grey liquid in between, and throw the wooden walls in the skip. This construction method is so ingrained it is rarely questioned, but it doesn't make sense. It's wasteful, and restricts form-making because it's optimised for orthogonal design.

Sustainable design means thinking about how much control, or energy, we apply to material processes. The more control handed over to natural forces, the better. One way of achieving this is by casting concrete with fabric membranes – an alternative to traditional concrete shuttering that allows for more efficient and expressive structures.

Unlike traditional shuttering, fabric formwork uses tensile rather than compressive forces. Tensile structures weigh less and perform better than compressive equivalents, so the material required to resist tonnes of liquid concrete can weigh only kilos. And by utilising natural forces, material usage is minimised to form streamlined structural elements.

Interest in the technology is growing – a conference organised by the International Society of Fabric Formers was held in Manitoba, Canada, in May. Fabric formwork technology is actually very old – rammed earth within hessian sheets was first used 2,000 years ago. But a new generation of designers is reinventing it as a sustainable construction method for the 21st century – the work of three of them is introduced here.



*Stone Renaissance House, Funabashi City, Japan, by Kenzo Unno of Umi Architectural Atelier*



*Concrete column by students at Edinburgh University made using flexible formwork*

For Tokyo-based firm Umi Architectural Atelier's Stone Renaissance House, concrete formwork was created using the 'frame restraint' method, developed by the practice's Kenzo Unno. Netting is stretched along the inside of steel pipes, restrained by standard form ties running through holes drilled in the pipes. Concrete is poured in and, when the walls set, the restraining pipes are removed, leaving a vertical impression. For this project Unno experimented with a diagonal pattern.



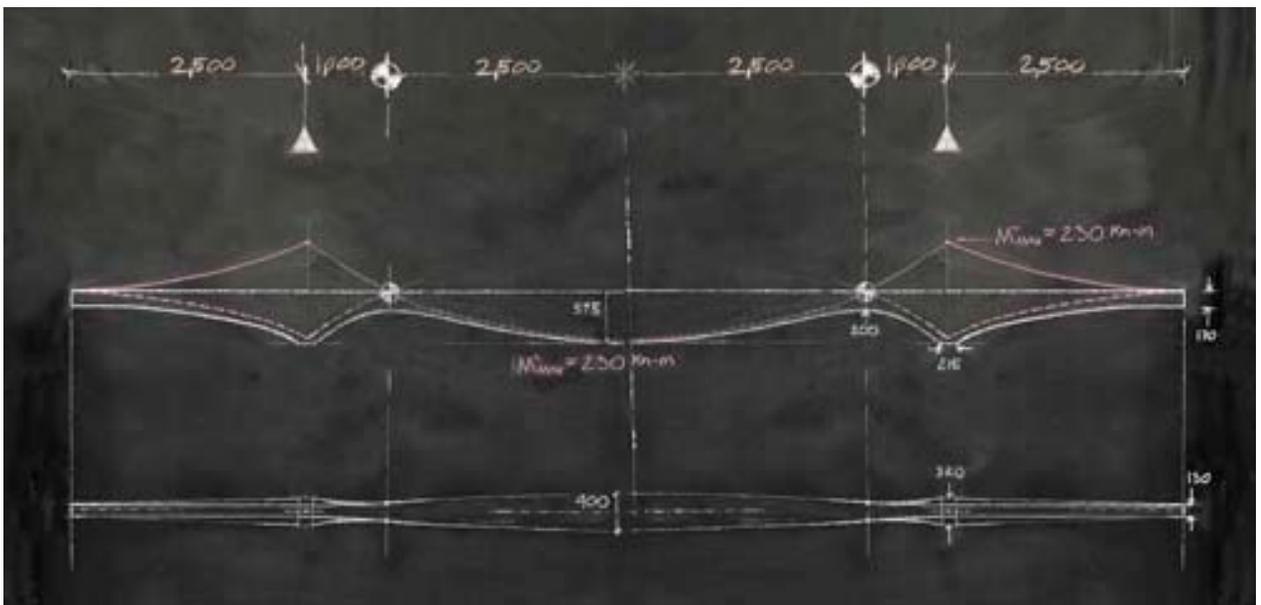
*Kenzo Unno's 'zero-waste' formwork*

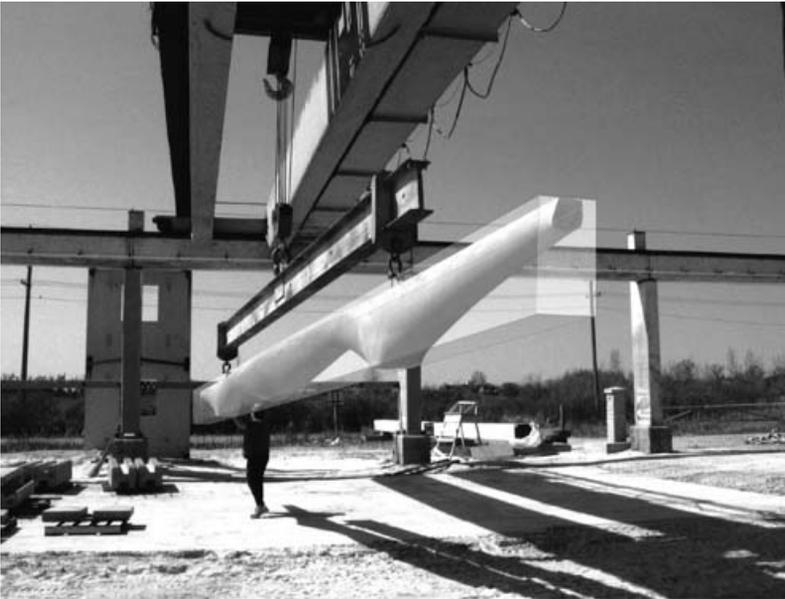
Unno's 'zero-waste' formwork uses a reinforcement cage to support the fabric, so bracing and propping elements are not required. For insulated construction, the fabric, together with rigid polystyrene insulation boards, forms the shuttering. Furring strips – long, thin strips of wood or metal – are used as support, and remain in place after the concrete is formed to provide fixing points for cladding. After use, the fabric, a woven polypropylene geotextile, can be washed and used again.

The wide variety of column-section shapes produced in Remo Pedreschi's workshop at Edinburgh University, where he is a professor, is the result of manipulating the hydrostatic pressure of wet concrete. The formwork, which consists of stretched and twisted fabric tubes, produces figure-of-eight-shaped forms, hollow columns and columns with voids. To connect the various elements, Pedreschi developed interlocking male and female components. A vacuum-formed mould was incorporated into the ends of the formwork to ensure geometric accuracy. Independent of the columns, the prototype connection can be used in other components.



*Remo Pedreschi has researched how a new architectural 'language' of sensual fluid forms could emerge from flexible formwork*





Mark West, a fabric formwork researcher and inventor based at Canada's University of Manitoba, specialises in exploring how fabric provides simple ways of shaping efficiently curved structural members. He has designed a 12m-long double cantilever beam (pictured right) that uses 30 per cent less concrete than a rectangular concrete equivalent, and was made using a flat sheet of geotextile fabric. Once the bearing points and dimensional requirements of a beam are determined, the fabric naturally deflects under the wet load of concrete to create catenary geometries. Using this method, the formwork for a 10m-tall structural column can be carried within a small rucksack.

*Mark West, founder and director of CAST, the Centre for Architectural Structures and Technology*

The term 'catenary' describes the pure tension form adopted by a chain under uniform load when fixed at either end. When flipped, the chain describes a curve under pure compression, a phenomena used by Antoni Gaudi to define the structure of the Guell Chapel near Barcelona. The 'natural' catenary curve describes the profile of any cross section taken through fabric-cast concrete. The hydrostatic pressure of wet concrete exerts a uniform load on the fabric, which is equivalent to gravity on the chain. The fabric 'naturally' forms a continuous fluid surface between fixed restraints. The undulations create a three-dimensional surface governed by catenary geometry.

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