Material Reduction: Efficient Fabric-Formed Concrete, Canada

**Project description by author**

1. **SUSTAINABILITY & ECONOMY THROUGH REDUCTION** - a new method of forming cast concrete structures that requires far less material than conventional practice, both in the construction of the formwork itself and in the concrete volumes required.

   This method replaces conventional rigid molds with a light, inexpensive, flexible fabric membrane that is allowed to deflect under the weight and pressure of wet concrete, producing concrete members that are more efficient and more beautiful than conventional cast concrete. The fabrics used are woven polyolefin geotextiles, the material used all over the world for common plastic tarps. These are not only extraordinarily well suited for casting concrete, but are universally affordable and accessible. The construction methods, tools, and equipment needed are extremely simple, and available to both low and high technology building cultures.

   This project has produced economical methods of forming columns, panels, slabs, and beams for cast-in-place and precast applications. With the start of structural beam analysis and testing – we development of this technology is now nearing completion as a viable method for construction and architectural/engineering practice worldwide. All my work is done in the public domain. Replacing rigid formwork panels with a flexible fabric membrane achieves the following:

   1. **FORMWORK MATERIAL VOLUMES CAN BE DRAMATICALLY REDUCED** (up to 500 times less).

      Formwork fabrics are less than 1/10th the cost formwork plywood.

      Reusable many times over.

      Very light and compact - they can be manufactured and economically shipped anywhere in the world.

      When discarded, landfill volumes are extremely small. Storage volumes and costs are a fraction of conventional formwork systems.

   2. **FABRIC FORMWORKS EASILY AND ECONOMICALLY FORM EFFICIENT CURVED STRUCTURAL MEMBERS** that place material only where it is needed by following the natural "flow" of forces.

      These naturally efficient structural geometries reduce concrete and steel volumes - we project that curved beams that follow their bending moment diagrams can use as little as half the concrete of an equivalent rectangular section.

      Reductions in material volume produce equivalent reductions in embodied energy - surface mining (aggregates) - dead weight.

      Reductions in dead weight reduce design loads on columns and foundations, providing further material and embodied energy reductions throughout the rest of the structure.

   3. **INCREASED SERVICE LIFE - HIGHER QUALITY CONCRETE**

      Permeable formwork fabrics act as filters concentrating cement at the surface of the mold. Air bubbles and excess mix water bleed through the formwork material, improved water-cement ratios and increasing surface strength, compaction and aesthetic quality.

**Project data**

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<tr>
<th>Type of project</th>
<th>Industrial product</th>
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<td>Start of construction</td>
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**Comment of the Holcim Awards 2005 jury for North America**

The entry contributes a high degree of innovation in material research and testing, inventively challenging the construction industry to achieve increased levels of efficiency and environmentally sensitive techniques of production. The results provide convincing evidence of the as of yet untapped potential of concrete as a material force. To be commended are the substantial material savings yielded by allowing the cross-sectional area to vary according to minimal structural requirements. Of equal merit are the benefits resulting from the estimated cost reductions for formwork material and transport weight. The proposal to deploy geotextile fabrics that are available worldwide and are inexpensive presents a novel opportunity for the concrete industry to deliver products of the level of industrial sophistication. Aesthetically, the work is rich in possible applications and promises to offer a veritably unlimited palette of formal variations for architectural and engineering related work. Research combined with hands-on experience are put to the test to deliver a versatile method, one that promises the sensual and plastic qualities of a known material to achieve unexpected results.

**Relevance to target issues (by author)**

Quantum change and transferability

Since its invention in antiquity concrete has been cast in rigid containers. In fabric molds concrete is "re-born" as a sensual plastic material capable of beautiful and structurally/materially efficient forms. The simplicity of both concept and construction method belies a deep and fundamental change. Flexible forms allow concrete structures and architecture to be re-imagined. By reducing material usage to an absolute minimum through natural curvatures, great beauty is gained. The materials, tools, and processes required are all well known and well understood. What is new is their combination and an approach to form that relies on fundamental natural law - not habit. Any cast concrete construction can use these techniques regardless of scale, location or level of industrial sophistication.

Ethical standards and social equity

This is not a single built project, but rather a building method applicable to many construction projects. Concrete is the most widely used building material in the world, and my work has explicitly developed simple methods that are universally accessible to both "high" and "basic" building cultures/economies using common materials. All my work is done in the public domain and is given freely.

Ecological quality and energy conservation

The most efficient way to resist force is via linear tension (as in a fabric mold). Conventional molds are very stiff (to limit deflection to zero) and hence unnecessarily massive. The minimal structure of fabric molds translates into reduced embodied energy, landfill volumes, and transportation costs. Polyolefin fabrics (made from natural gas) are cheap, reusable and don't require form-release oils. Structural forces "flow" in curves, yet conventional molds require rectangular prismatic shapes thus using far more concrete than a structure requires. Flexible forms may allow up to 50% savings in embodied energy and dead weight by an efficient (curved) distribution of material. Fabrics filter excess water from the concrete mix, improving concrete quality and extending service life.

Economic performance and compatibility

15 years of work using low-cost donated materials and no academic research funding (only infrastructure and in-kind support). Economy: 100-year-old formwork technology is "how hanging fruit" - sustainability innovation a 40 ft. beam can be formed in a reusable plastic tarp costing $550. We project curved fabric formed beams can use 1/2 the concrete and steel of conventionally formed beams.

Contextual response and aesthetic impact

There is no single context for this project; its long term aesthetic quality will be felt in many sites and a multiplicity of functions. Through this method a new architectural language is born: Forms reminiscent of natural structures (vegetation, bodies) and possessed of a new softness, offer an alternative (or addition to) a machine aesthetic. Permeable fabrics also vastly improve surface finish.