

A BRIEF DESCRIPTION OF FABRIC-FORMED CONCRETE

-Prepared by Mark West

Director, C.A.S.T. (Centre for Architectural Structures and Technology)

INTRODUCTION

Fabric formwork uses a flexible textile membrane in place of the rigid formwork panels usually used in concrete construction. When wet concrete is contained by a thin formwork membrane, the flexible fabric container naturally deflects into a repertoire of precise tension geometries. This produces naturally efficient structural curves, unprecedented sculptural forms, and extraordinary surface finishes.

Fabric formworks can be used to form columns, walls, beams, slabs and panels in both precast and in-situ construction. It has significant potential for construction and engineering technology in both advanced and basic building economies.

From a sculptural/architectural perspective, the use of flexible formworks awaken concrete to its fluid origins, introducing a new horizon for architectural form and expression.

HISTORY

While several 19th and early 20th Century patents exist for fabric formwork, the first practical applications occur in the mid-Nineteen Sixties with the introduction of fabric formwork for erosion control and pond liners. The work of B.A. Lamberton, E.W. Bindhoff, and others in the field of geotextiles led to the first commercial use of fabric formworks.¹ In the 1970's the Spanish architect Miguel Fisac used thin plastic sheets as formwork for textured wall panels.²

In the late Nineteen-Eighties and early Nineteen-Nineties, three men working independently and unaware of each other, invented a variety of techniques for forming above ground structures in fabric formworks. This work represents the first broad flowering of this technology for aboveground structures. Kenzo Unno, an architect in Tokyo Japan, invented a fabric formwork system for in-situ cast concrete walls.³ Rick Fearn, a builder and businessman in Canada, invented a number of fabric formwork techniques, leading to the development of a series of foundation footing products now manufactured and sold by Fastfoot Industries in Surrey BC.⁴ Mark West, an artist, architectural educator, and builder invented a series of techniques for constructing fabric-formed walls, beams, columns, slabs, and panels.⁵ He is now the director of the Centre for Architectural Structures and Technology (C.A.S.T.) at the University of Manitoba's Faculty of Architecture, in

Winnipeg MB, Canada. C.A.S.T. is the first research centre dedicated to fabric formwork technology and education.

SOME CHARACTERISTICS AND ADVANTAGES OF FABRIC FORMWORK

1. SURFACE

When permeable membranes are used as formwork, air bubbles and excess mix water are allowed to bleed out, leaving a cement-rich paste at the surface of the form. This filtering action produces immaculately fine grained finishes unknown to other methods of concrete construction. These new surfaces eliminate the need for the kinds of additional, and expensive, surface treatments usually required to improve the appearance of traditionally formed concrete (sand blasting, acid etching, veneers, etc.).

The loss of excess mix water through a permeable fabric formwork also produces a stronger and more durable “case hardening” of the concrete through a significant improvement in its compaction and water-cement ratio near the surface.⁶

2. GEOMETRY AND STRUCTURE

Textiles can only resist tension forces, while concrete, on the other hand, is structurally limited to the resistance of compression forces. Some of the more remarkable structural advantages obtained by the use of flexible textile formworks turns on these structurally opposite capacities, and the fundamental physical law that tension and compression forces exist as geometric inversions of each other. The natural gravity laden deflections produced by textile formworks can be used to produce sophisticated three dimensional compression shell and vault structures through the simple act of inversion - a process inherent to pre-cast production.

Even when it is not possible to take advantage of this geometric inversion -- for example in the case of cast-in-place members -- structurally efficient variable section members can be easily formed using fabric formwork. Structural members with a lower dead weight (higher efficiency) are produced by varying the cross-section of a structural member to follow the path and distribution of the forces inside it. This is notoriously difficult to do using traditional panelized, rectangular “box” molds, and relatively simple to do using flexible formworks.

3. LIGHTWEIGHT FORMWORK

Fabric formworks are 100 to 300 times lighter than conventional wooden forms. Many of the best formwork fabrics are also 1/10th the cost of formwork plywood per unit area. This extraordinary increase in material and structural efficiency is the result of a fundamental paradigm shift in formwork structural strategy, and represents the first major advance in concrete formwork technology since the introduction of plywood following World War 2.

Traditional panelized formwork materials, such as wood or steel, lend themselves most easily to the construction of rectangular (prismatic) molds. It is very difficult, however, to hold a material like wet concrete flat. The effort required to do this is so great that the vast majority of a traditional rigid formwork's structure is there only to limit the deflection of the mold. A light fabric membrane, by comparison, naturally deflects into a the most efficient restraint shape possible - a pure tension membrane. In this way, the amount of material required to support the pressure of the wet concrete is dramatically reduced.

Extremely lightweight formworks can result, not only in reduced material, storage, and transportation costs, but in new ways of thinking about how construction gets done. For example, a recent project involving the construction of thirteen reinforced concrete columns (each with a different height and capital design) for a building on the small island of Culebra in Puerto Rico, was done using fabric formworks fabricated in Winnipeg Manitoba, Canada. The builder flew from Canada with the formworks for all thirteen columns in three small duffel bags as "luggage". This flexibility of fabrication and transport is unimaginable using traditional means.

The very low cost and world-wide availability of many excellent membrane fabrics, provides globally accessibility to this technology. Particular value may be seen in locations where traditional formwork materials such as wood (and steel) are scarce. The low cost and reusability of these fabrics provide the options of both sacrificial and reusable formwork.

4. RESEARCH

The first research laboratory in the world dedicated to the development and testing of fabric formwork and fabric-formed concrete structures, is located at the University of Manitoba's Faculty of Architecture in Winnipeg, MB, Canada. This laboratory, the Centre for Architectural Structures and Technology (C.A.S.T.), provides a unique facility for interdisciplinary research involving architects, engineers, and industry.

Endnotes:

¹ “Fabriform” was the first geotextile fabric formwork company. Articles on this use of fabric formworks include: BINDHOFF, E.W. and KING, J.C., *World’s Largest Installation of Fabric-Formed Pile Jackets*, Civil Engineering-ASCE, 1982 March, Pgs. 68-70; PILDYSH, M. and WILSON, K., *Cooling Ponds Lined With Fabric-Formed Concrete*, Concrete International, 1983 September; LAMBERTON, B.A., *Fabric Formwork for Concrete*, Concrete International, 1989 December, Pgs. 58-67.

² SOLAR, A., *Miguel Fisac*, Ediciones Pronaos, 1996, ISBN: 85941-23-3.

³ The work of Kenzo Unno has been published in:
TOTO Magazine, July-August 1999
NIKKEI ARCHITECTURE Magazine, 1998 4-6
DETAIL Magazine No. 139, January 1999 (published quarterly by SHOKOKUSHA Publishing)

⁴ See: www.fastfoot.com

⁵ Articles about Mark West’s research include:
BUILDING AND HOUSING RESEARCH CENTER, Tehran, Iran: Proceedings of the First International Conference on Concrete and Development (Tehran, Iran, April 30-May 2, 2001): Paper by M. West titled Fabric Formed Concrete Structures offers a general description of fabric formwork technology.
SURFACE DESIGN JOURNAL, VOL. 20, #2, 1996: Issue on “Surface/Structure”: Article titled “Columns With A Textile Memory” by Patricia Malarcher.
CANADIAN ARCHITECT MAGAZINE, April, 1995: Photographs and an article by Associate Editor Beth Kapusta on fabric-formed concrete and its implications for architectural design.
WORLD ARCHITECTURE #33, The International Academy of Architecture 1995: Article featuring photographs and a discussion of Storefront For Art an Architecture facade alterations by editor Gregori Stanishev. (pg. 106,7,8)
INTERSITE MAGAZINE #3, Published by the School of Architecture, State University of New York, Buffalo, NY 1995: Article by M. West on speculative drawing, building construction research, and the generation of architectural form.
PROGRESSIVE ARCHITECTURE MAGAZINE, July, 1994: First Annual Architectural Research Awards: Article and photographs under the heading, “Fabric Formwork.”
BODY TECHNOLOGY AND DESIGN, 11th Annual ACSA Technology Conference Proceedings, 1994: Article and drawings by M. West titled “Spontaneous Form Generation Techniques.”
HARVARD ARCHITECTURAL REVIEW #9, Harvard Univ., Cambridge, MA, 1993
REPORTS, published by Storefront for Art and Architecture, N.Y., NY, 1993: see article by Dan Hoffman

⁶ For a more complete description of the effect of filtering fabrics on concrete strength and compaction see: **GHAIB, M.A.A. and GORSKI, J., Mechanical properties of concrete cast in fabric formworks, Cement and Concrete Research 31, 2001 Pgs. 1459-1465**