



# **BULGE WALL CONSTRUCTION**

Invented and developed at the Center for Architectural Structures and Technology (C.A.S.T.) 2006  
University of Manitoba Faculty of Architecture

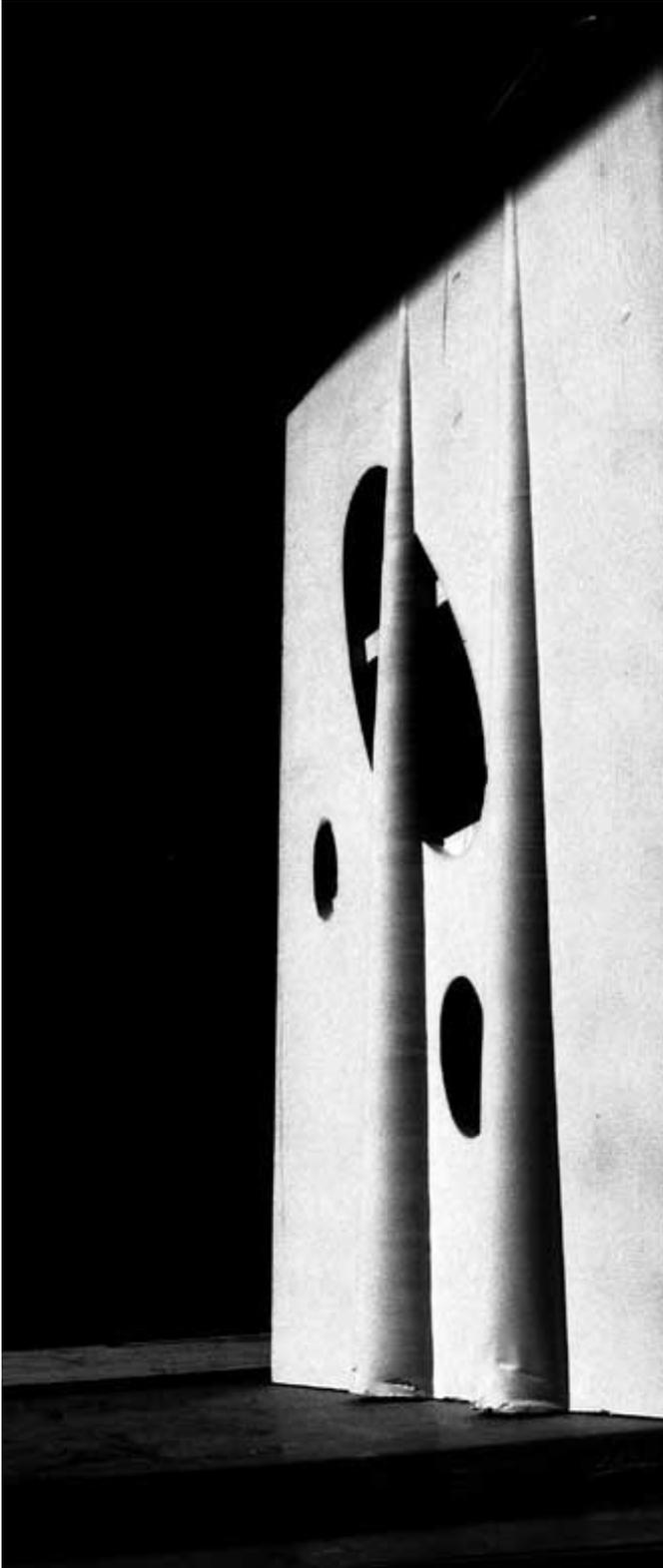
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# BULGE WALL TECHNOLOGY

Complex and efficient concrete walls and columns can be easily made using standard rigid concrete wall formwork lined with inexpensive geotextile formwork fabric. Only flat sheets of fabric are needed, and only conventional construction tools and methods are required, making it easy for builders to construct and price these constructions.

All dimensions and shapes in the x-y plane (the plane of the wall surface) are made using conventional tools and materials. Complex curved geometries are produced in the z-dimension (the thickness of the wall) by natural deflections in the fabric form-liner. Openings cut in standard wall-form plywood allow the fabric liner to bulge outwards. Wall thickness can be reduced in selected areas by placing blocks or other filler pieces on the inside surface of the formwork plywood to push the fabric liner inwards (see below for further illustrations/descriptions)

Left and Right below: Plaster models of Bulge Wall constructions



# BULGE WALL MODEL

This plaster model shows various sculptural and architectural effects that can be obtained using the Bulge Wall method. This model was made in preparation for construction of the Open City concrete Bulge Wall shown below.

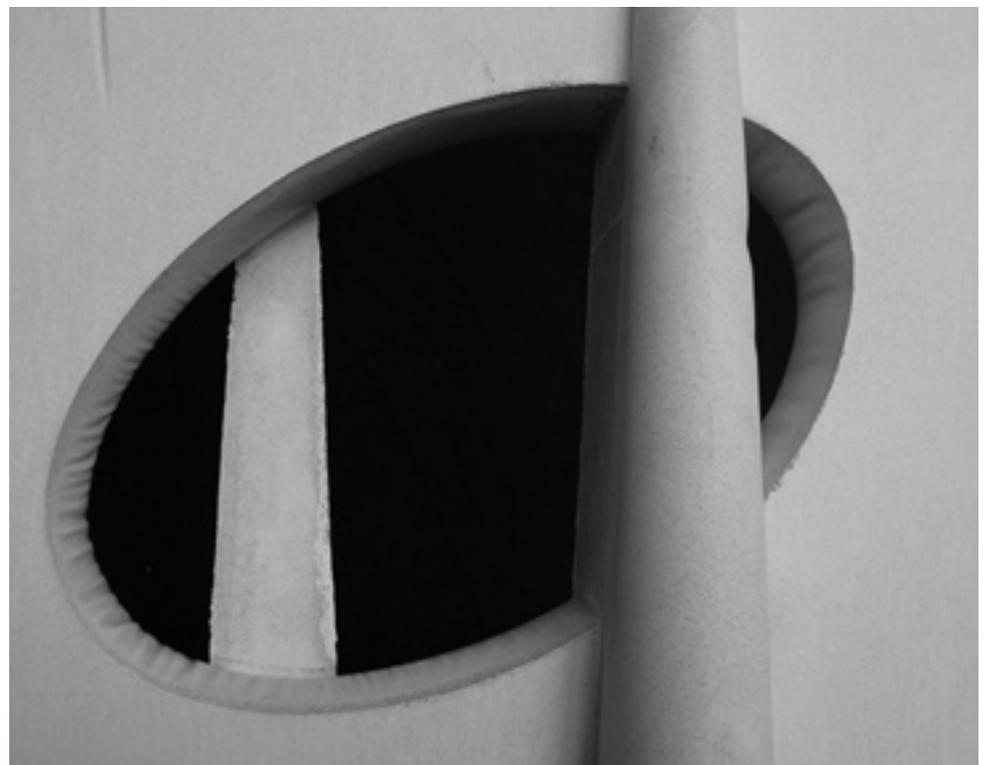
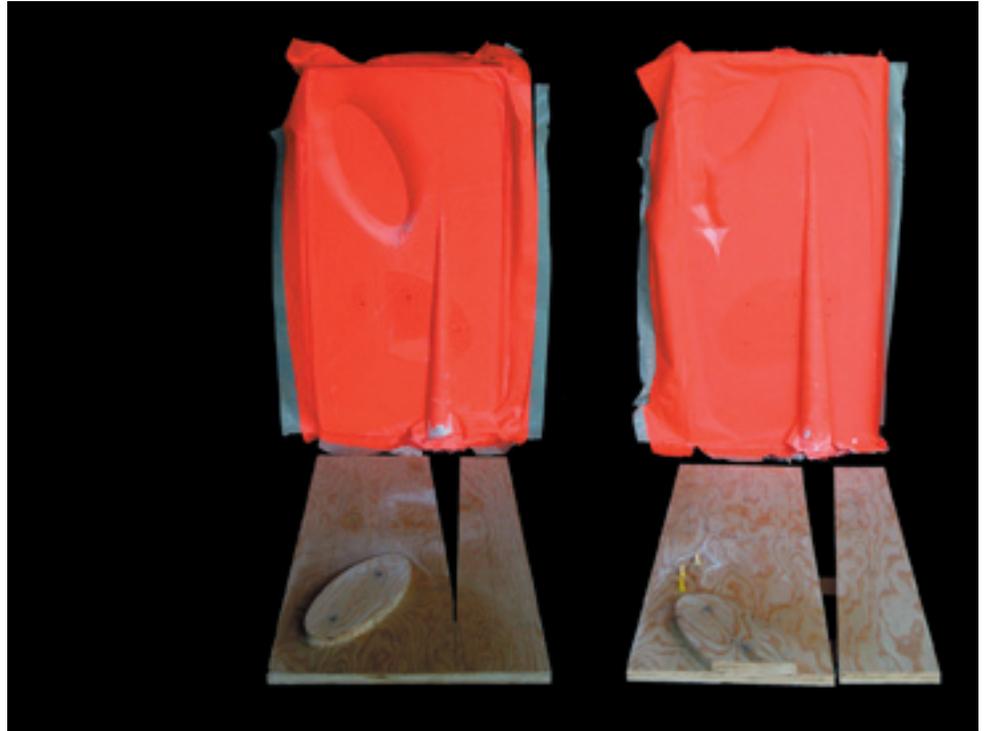
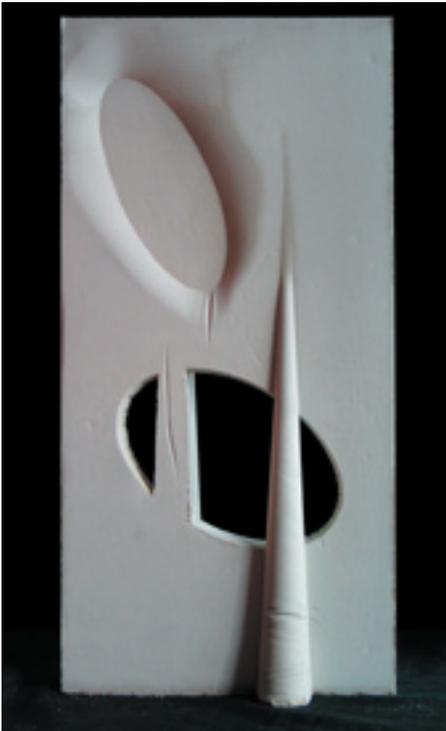
Left Top and Bottom: Two sides of plaster Bulge Wall model

Right Top:

The two sides of model formwork shown with one side of plywood wall formwork removed: Pilasters are formed by making cut-outs in formwork plywood. Impressions are formed by placing "impactos" (things that push the fabric inwards) on the inside surface of the wall formwork plywood - in this case the impactos are elliptical plywood disks and plastic push-pins.

Right Bottom:

Detail of wall model showing fabric-formed opening and the two pilasters formed on either side of the wall



# BULGE WALL THE 'OPEN CITY' - CHILE

Fall 2006: 8-foot x 8-foot (2.4 metre x 2.4 metre) Bulge Wall constructed at la Ciudad Abierta (the Open City) in Ritoque Chile as part of a public washroom facility structure connected to the Open City's athletic fields. Constructed with David Jolly, Miguel Eyquem and Principle Designer Victoria Jolly.

**Top Left:** Nearly complete wall formwork: standing side complete with fabric liner, window block-outs and form-ties; the other side (laying flat without its fabric liner) shows cut-outs and "impactos" located on plywood surface to form bulges and impressions.

**Bottom Left:** Final cast concrete wall shown during construction of the support facilities for the Open City's athletic field.

**Right Side (top to bottom):** Standard wall form construction; Detail of standard framing and form-ties; Block-outs for special wall openings made from two identical plywood cut-outs placed askew; Detail showing form-ties and spacers, and the block-outs skinned in fabric -- the fabric easily follows skewed planes to create complex warped surfaces inside the wall openings.



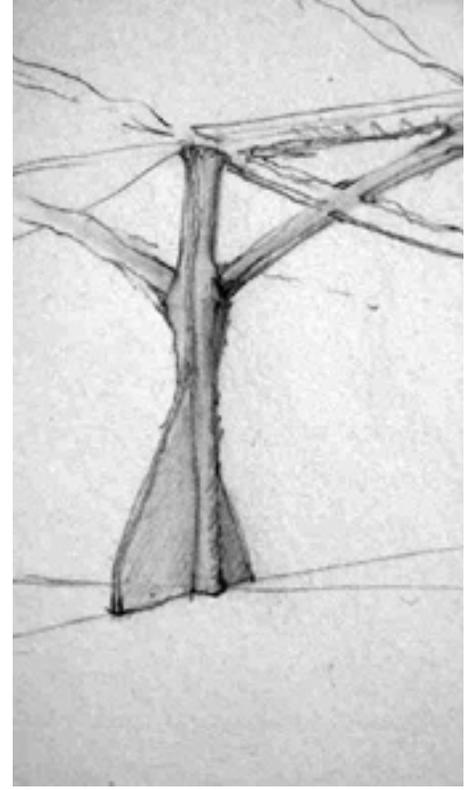
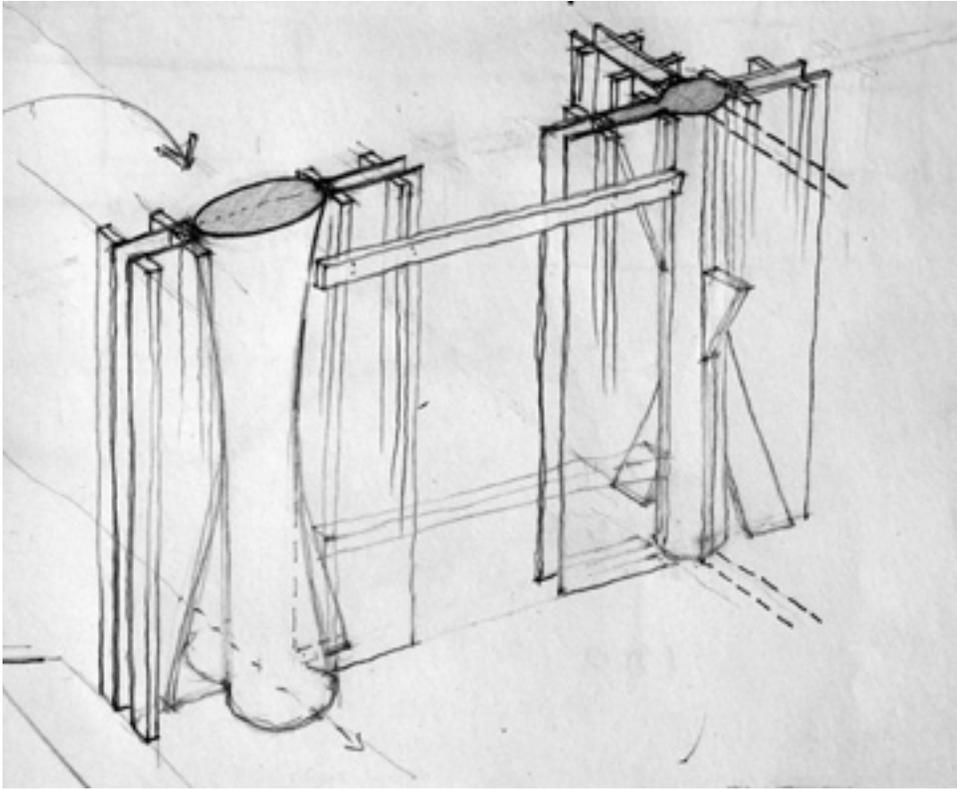
# BULGE WALL COLUMNS

Buttressed and branching column shapes, either independent or engaged with wall casts, can be constructed using standard concrete wall formwork lined with flat fabric sheets (a variation of the "Bulge Wall" technique described above).

Top Left: Sketch showing two configurations of Bulge Wall Column forms for constructing buttressed columns.

Top Right: Sketch of a buttressed and branching column.

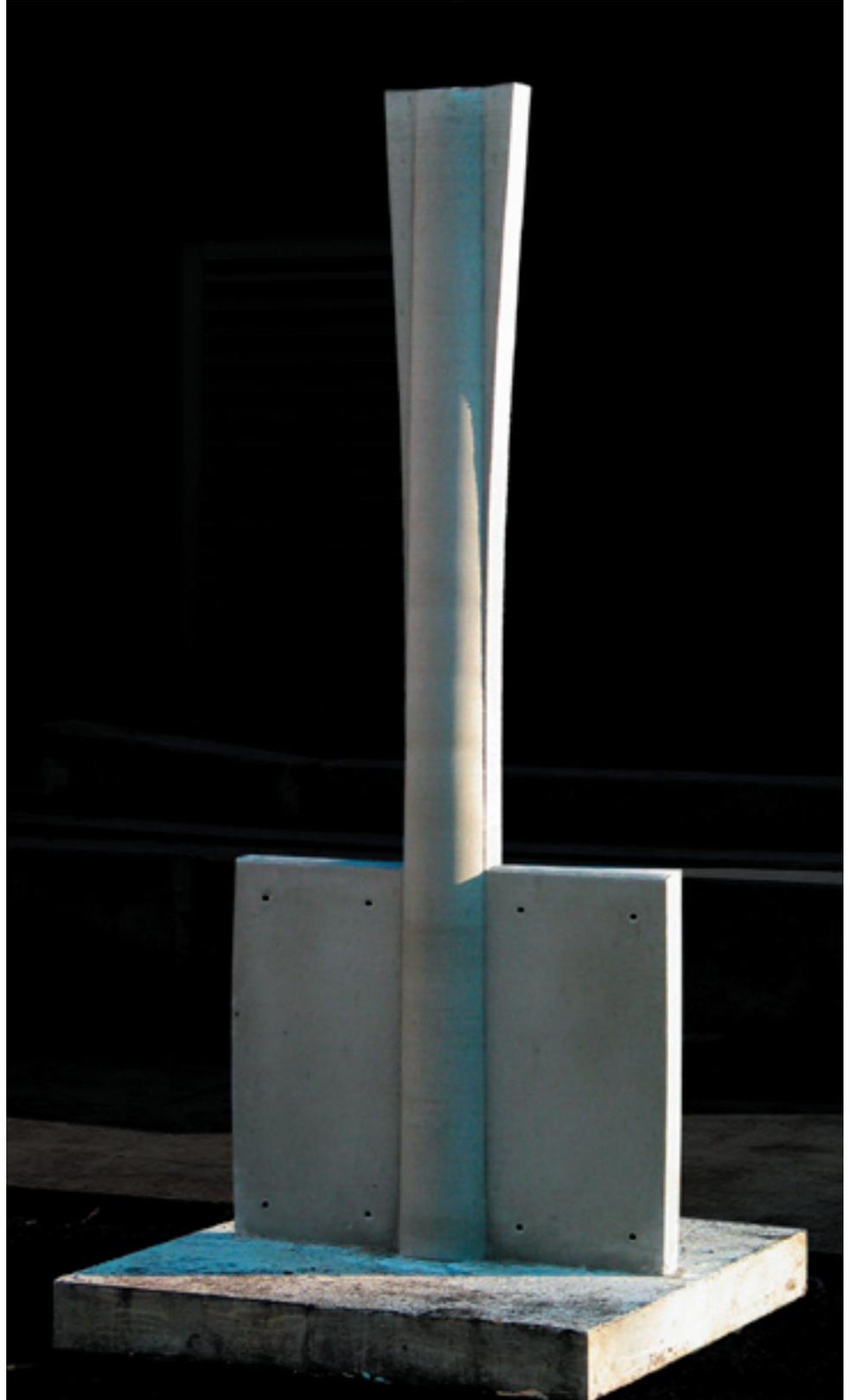
Bottom Row: Plaster models of Bulge Wall buttressed columns.



# MID-SCALE BULGE WALL COLUMNS TEST

Fall 2006, Winnipeg Manitoba: This eight-foot (2.4 metre) tall butrussed column was cast using a geotextile form-liner and simple block-outs placed inside a standard plywood wall formwork.

- Top Left: Interior surface of Bulge Wall form with internal block-outs in place
- Middle Left: Fabric placed on opposite side of the wall form
- Bottom Left: Standard wall formwork construction is used
- Right: Finished column + wall produced from the formwork

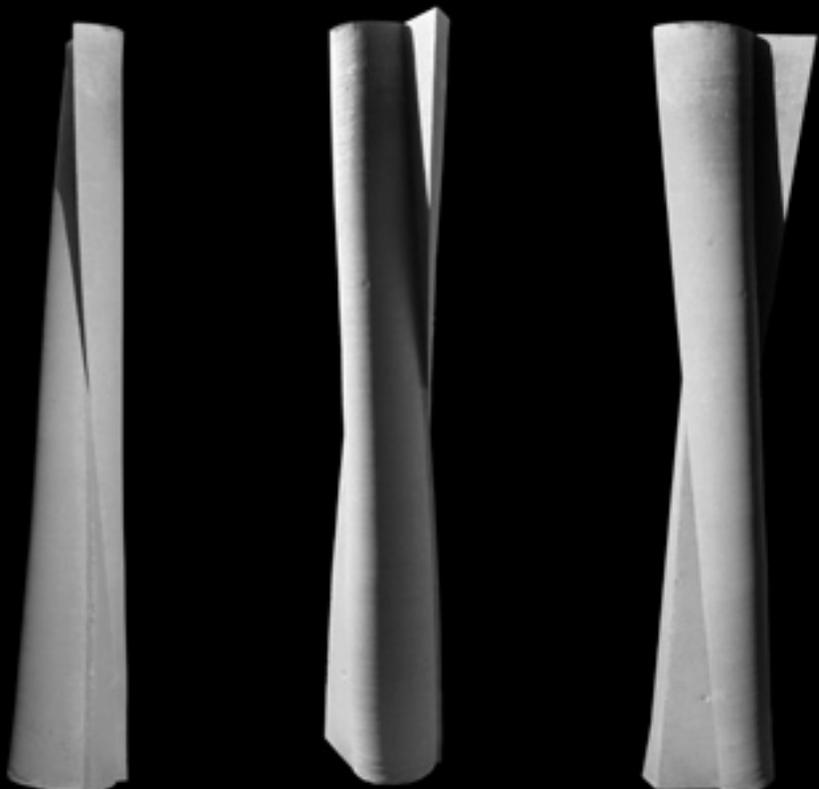


# BULGE WALL “CROSS TORSION” COLUMNS

Fall 2006. Two 8-foot (2.4 metre) Bulge Wall columns constructed at: The Open City (la Ciudad Abierta) in Ritoque Chile, and at CAST in Winnipeg Canada. Simple rectangular sheets of plywood and fabric are assembled to produce sculptural and structural reinforced concrete columns. This design provides a buttressed column, shaped to provide lateral resistance.

**Top** (at the Open City): Left - simple flat rectangular sheets of fabric and plywood crossed in an “X” pattern; Middle - Open City column formwork installed and filled with concrete; Right - Final cast concrete column at the Open City. This column formwork experienced a mild torsion under the relatively low fluid pressures of the wet concrete used in this pour.

**Bottom Row** (at CAST): Top Left - CAST “cross” column formwork (identical to the Open City formwork design) showing the strong rotation caused along the vertical axis by the fluid pressure of wet, highly plasticized, concrete (in this case, Lafarge “Agilia”); Bottom Left - View of final cast concrete column. Right - Three views of the torsioned shape obtained from “x” pattern formwork showing the subtle and complex sculptural geometry resulting from very simple, flat rectangular formwork components.



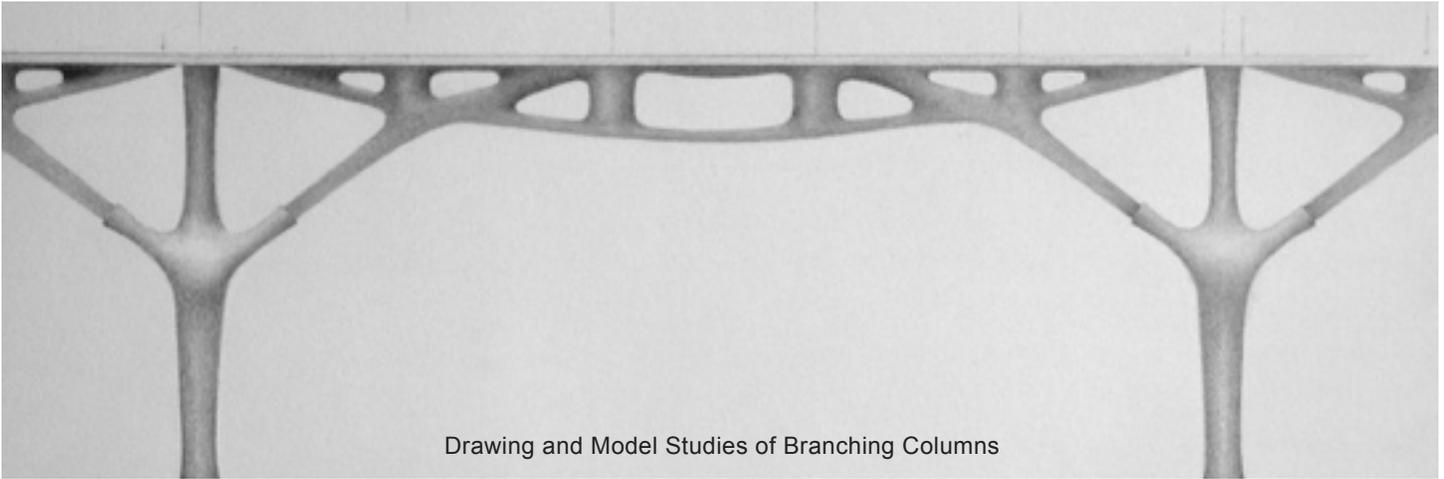
# BULGE WALL BRANCHING COLUMNS

Fall 2007, Winnipeg Manitoba: Branching columns can be constructed using modified wall formwork. A flat sheet of geotextile material is let into the gap formed by cutting a branching column profile into the wall formwork plywood

**Top Row:** Research Assistants Aynslee Hurdal and Mike Johnson (and with Leif Friggstad) smooth the fabric into shape (left); one side of the completed formwork (right).

**Bottom Row:** Formwork filled with concrete (left and right). Note the use of simple twisted rope form-ties in place of steel ties. This was done to test the use of this low-capital connection (borrowed from scaffold builders in Thailand) in concrete construction. Note also the loss of excess mix water through the fabric mold (left) and the lack of any fixed connection at the bottom of the column form (right).



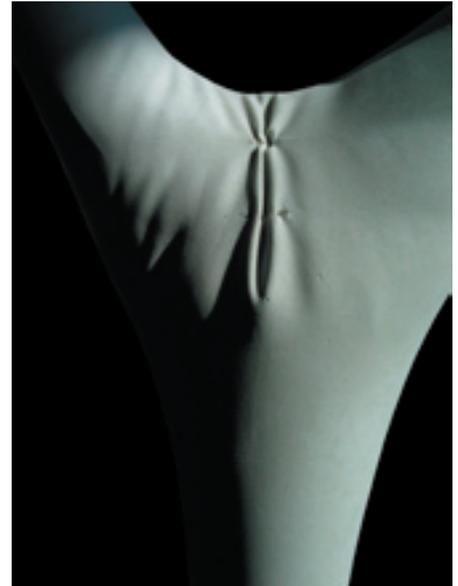


Drawing and Model Studies of Branching Columns

Above: Drawing of branching columns supporting a fabric-cast truss design. Branching arms can reduce effective spans of beams.

Below, Top Row: Plaster models of branching columns (31 cm tall) used to test construction methods. The 10 metre full-scale column test (previous page) was scaled up directly from these small working models, indicating the fidelity of small-scale fabric formwork models.

Below, Bottom Row: Models of more complex branching columns formed with flat sheets of fabric: Illustration of formwork model (left); 55 cm plaster model (middle); Plaster model construction using this branching column design (right).



## **CREDITS**

These “Bulge-Wall” methods were invented, developed, and tested at the Center for Architectural Structures and Technology (C.A.S.T.) by Mark West, with Chris Weibe, Aynslee Hurdal, Jiameng Zeng, Mike Johnson, Leif Friggstad, Toam Alston, Kyle Martens  
2005 - 2007 University of Manitoba Faculty of Architecture

The C.A.S.T. website can be found at: [www.umanitoba.ca/cast\\_building/](http://www.umanitoba.ca/cast_building/)