Research Proposals

On this page links to new articles describing proposed research projects can be created and also ideas listed for proposed areas of research. Both lists will undoubtedly change as our knowledge base evolves over time but it's hoped the list will grow! Put forth your ideas even if you don't have a specific proposal worked out at this time.

Proposed Areas of Research

Areas requiring research are:

1 Computer Analysis

Fabric-formed concrete member design may be broken into two parts, 1) form-finding the member shape and 2) analyzing the final member shape. At the present time two computer programs have been utilized for form-finding and analyzing the concrete member shape. These programs are ADINA by ADINA R&D, Inc. and ANSYS by ANSYS, Inc. Both of these programs have their positive and negative attributes.

1.1 Form-finding requirements

The form-finding process requires the updating of nodal coordinates as the fabric formwork deflects. If one utilizes ADINA it is necessary to make use of a spreadsheet program to track and update these nodal coordinate locations. A well defined model might make use of the ADINA 27-node 3D solid element. This element has 9 nodes at midlevel and on the top and bottom faces. In order to maintain a stable element, midlevel nodes need to be equally spaced between the top and bottom nodal coordinate locations. Accurate import of nodal coordinates, adjusted by the fabric formwork displacements, into the ADINA model becomes critical.

ANSYS on the other hand has a command called UPGEOM. This command will allow nodes for the 3D solid elements to be automatically updated for each iteration, until equilibrium in the supporting fabric formwork has been reached. This command is very useful but is restricted to 8 node 3D solid elements. It does not work well with elements that contain midlevel nodes.

What is needed is a program with a command feature that will allow nodal coordinates to be automatically updated no matter what order element is used.

Full-blown optimization might also be employed. A concrete wall panel, for example, might be defined with a variety of boundary conditions that represent anchor locations and interior supports that define potential load paths. These variables are then explored to determine the optimal shape of the panel.

While a design procedure for designing and analyzing a fabric-formed concrete panel has been introduced more work is needed to either develop new software or modify existing software to make this analysis process convenient to use in everyday practice. Analysis procedures for other structural and architectural member types will also need to be worked out.

1.2 Testing

Perform model testing to confirm form-finding procedure.

1.3 Member analysis

Material models which can represent concrete and reinforcement, be it FRP rebar or glass fiber textiles in well defined element models will be required. It should be noted that the ADINA concrete material model works with 8 to 27-node 3D solid elements while the ANSYS concrete material model is restricted, at present, to an 8-node 3D solid element. Both programs can model reinforcement be it defined with a truss element for rebar, a 2D solid element or a shell element mesh used for textile reinforcement.

1.4 Testing

Perform full/scale model testing to confirm analysis modeling.

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2 Fabric Formwork

Geotextiles are presently being employed as the formwork for a variety of concrete members and while geotextiles are inexpensive and readily available they may not be the ideal material for everyday CIP and precast work. Some advantages of the material are:

- Very complex shapes are possible.
- Geotextile fabric is strong, lightweight, inexpensive and reusable although how reusable has yet to be determined.
- Improved surface finish and durability of the concrete product are possible due to the filtering of air bubbles and excess bleed water through the fabric.

While disadvantages include:

- Relaxation can occur due to the prestress forces in the membrane.
- There is the potential for creep in the geotextile material, which can be accelerated by an increase in temperature as might occur during hydration of the concrete as it cures.
- Reusability may be limited due to less than full recovery for subsequent member pours.

The development of new fabrics which can replicate the advantages of geotextiles yet minimize their disadvantages would be beneficial. Properties of these new woven fabrics might include:

- The ability to form complex shapes.
- Equally strong in both the machine and cross-machine directions. These fabrics might also have yarn woven not only at 90 degrees but also at ±45 degrees. Additional strength in any particular

direction might be supplied by banding material together.
- Lightweight yet durable.
- Reusable and inexpensive per use.
- Provide excellent surface finish in the concrete product.

Geotextiles, while providing the requisite flexibility have limitations that a fabric formwork, used for everyday cast-in-place (CIP) work or precast panels requiring repeatability, must overcome. Fabrics which lend themselves to forming complex shapes and repeated use without loss of strength will be key to an economical system therefore the development of new fabrics, with improved properties over those of geotextile fabrics should be investigated.

2.1 Testing

Perform testing to determine engineering properties of fabric. Strength, relaxation and creep properties should be determined. Perform full/scale model testing to confirm analysis modeling.

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3 Concrete Mix Designs

Concrete mix designs will also need investigating. As suggested by **Delijani** the effects of bleeding on plasticized concrete should be studied. Admixtures effects and finding that optimum W/C ratio will provide another avenue for research. The use of self-consolidating concrete (SCC), also known as self-compacting concrete is a highly flowable non-segregating concrete that spreads into place and its use should be investigated. As we're all trying to make this earth “greener” the use of fly-ash as a cement replacement can use more research work as to how its use affects the quality and finish of fabric-formed members - Delijani has done some with his research work.

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4 Textile Reinforcement

Along with the idea of a flexible fabric formwork one must consider how the concrete member is to be reinforced. When fabric-formed concrete panel members, for example, have been designed with not only aesthetics but efficiency in mind the panels should not have to be thickened-up to protect corrosive reinforcement. Alternatives need to be investigated. Reinforcement options such as fiberglass rebar, alkali resistant (AR) glass textile and carbon-fiber grids offer alternatives to corrosive steel reinforcement. Research for reinforced concrete panel designs might include:

1. Reinforcement using a combination of fiber-mesh and FRP rebar.
2. Reinforcement using a combination of fiber-mesh and 2D glass textile grids in selective areas.
3. Reinforcement using a combination of fiber-mesh and 2D carbon fiber grids in selective areas.
4. Reinforcement using 2D glass textile or carbon-fiber grids entirely.

The potential exists for forming not only an aesthetically pleasing design but one that is also efficient in its use of materials. The development of textile reinforcement which can adapt to complex panel shapes will be required. Finding the most advantageous reinforcing textiles for the reinforcement of all fabric-formed members including thin-shell shapes.

4.1 Testing

Perform testing to determine engineering properties of the textile reinforced member. Perform full/scale model testing to confirm analysis modeling.

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5 Support Mechanisms

While some fabric-formed members need minimal support from rigid members, columns and piers for example, mechanisms need to be developed which lend themselves to forming complex shapes. While it may not be the primary focus of our research into fabric-formed concrete members the mechanisms used to support the fabric also need to be addressed. These supporting elements secure the flexible fabric in place and provide interior and perimeter support for a variety of shapes. Mechanisms might be developed for both CIP and precast work. Potentially the development of a line of equipment used to support the fabric at both interior and perimeter boundary conditions and prestress it could be made. The development of this equipment should go hand-in-hand with the development of fabric-formed concrete members.

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See Also

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Proposed Research Projects

1. *Fabric-Formed Concrete Systems* by RP SCHMITZ
2. *Proposed Project Title 2* by Researcher 2