Visualizing Information: Internet Guidelines For Distributing Architectural Research

by

Tim Colley

Thesis submitted to the Faculty of the Virginia Polytechnic Institute + State University in partial fulfillment of the requirements for the degree of

Master of Science in Architecture

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October 1997
Blacksburg, Virginia
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I would like to express my thanks and deep appreciation to:

Bob Schubert, Mike O’Brien, and Bill Galloway
for their guidance, support, and friendship

My parents, Gladia and George Colley

My other parents, Anne and Bill McCutcheon

Leslie and Martin Daniel
Anne Collins and Sam Albimino
Paul Battaglia

My wife, Kenna, and our son, Lucas
Words cannot describe the love and gratitude I feel for you
Thank you for allowing me to share with you
A web site was designed and constructed for the Research + Demonstration Facility (RDF) as a master’s thesis project to help educators teach future architects more interactively by using the dynamic medium of the Internet. Students and faculty will learn about evolving architectural research and technology as well as potential consequences of design decisions. Educators will be able to conduct online research, or tele-experiments, in the classroom thus allowing students to learn, in near real-time, the outcome or progress of research on and off campus. This project presents some of the possibilities of how the Internet can enhance research information delivery to students and faculty of architecture.
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The purpose of this master’s thesis is to deliver architectural research information to users of the Internet. This web site was designed and constructed for the Research + Demonstration Facility (RDF) to help educators teach future architects more interactively by using the dynamic medium of the Internet. By its very nature, the Internet allows connections to sources of knowledge not readily available. To envision research information is to work at the intersection of image, word, number, art, and computer (Tufte 9). The Internet allows education to expand outside of traditional limitations of teaching. While not attempting to replace hands-on learning, use of the Internet as a supplemental device permits greater exposure to available information. This project presents some of the possibilities of how the Internet can enhance research delivery to students of architecture.

Students and faculty can learn about evolving architectural research and technology as well as potential consequences of design decisions. This interactivity allows for comparisons across many areas, such as: energy use patterns, solar exposure, atmospheric conditions, research monitoring, and indoor air quality. Educators will be able to conduct on-line research, or tele-experiments, in the classroom thus allowing students to learn in near real-time the outcome or progress of research conducted both on and off campus. The global nature of the Internet provides an opportunity for users at other institutions to collaborate on research conducted at the facility. The ability to share resources will hopefully decrease duplication of research efforts while optimizing valuable research funds.

Following is a partial list of research projects and papers available to view in the Research + Demonstration Facility web site:

- Research Objectives and Proposals for RDF
- Indoor Air Quality Research
- Photovoltaic Powered Lighting
- Solar Hot Water System Application
- Building Materials Research

Presently, the project is set up as a "static" site that allows the user to view and download historic or archived information. In the future this site could be more dynamic and interactive by allowing users to interpret raw data in near real-time. The ability to analyze information immediately after acquisition is a potential benefit of this web site. Authorized users will be able to view information and alter selected parameters as needed to observe results.

The web site also acts as a case study of the Research + Demonstration building. Information about construction drawings, photos, renderings, animations, contributors, planned uses, equipment, and special construction techniques are available for viewing and downloading from the site. Web pages describe how the building utilizes many materials and techniques not found in current structures, such as, biaxial concrete blocks and suspended block floor.
systems. The building was built to perform as a full-scale test bed for innovative designs. Some of these designs are concrete block acoustical walls, concrete masonry interior flexible partitions, and indoor environment systems.

While the Internet is a relatively new tool to gather and disseminate information, architectural research has existed for centuries. This thesis project takes a step towards better understanding the possibilities the Internet presents for distributing architectural research information.
General

Frame based web pages were chosen after consulting with a range of Internet users. Consistent navigational aids and graphics are necessary for confident and competent maneuvering through a web site. Advanced and novice users alike agreed that consistent page structure is very important in designing a successful and accessible web site. Additionally, online “awards” are typically given to web sites utilizing concise information display elements such as navigable frames that are intuitively laid out. The RDF web site’s use of frames provides an easy way to maintain navigational uniformity in one area and information dissemination in another.

Programming differences between present manufacturers of web browsers sometimes treat web pages unexpectedly. Often text and images do not look the same from browser to browser creating confusion for the user. Different operating platforms and systems also display web pages with other than anticipated results. There are also other factors like preferences, and monitor resolution settings that determine display of web pages. The scope of this project does not allow a separate configuration for each browser type though certain modifications were made for the two most used browsers available; Netscape Navigator and Microsoft Internet Explorer. The Research + Demonstration web site looks and operates identically using the two browser applications.

It is important to note that all web pages and images contained in them were created on Apple Macintosh or Macintosh clone computers. Refer to Appendix B for a complete list of computer hardware and software used for this project.

Page and Frame Sizing

Due to the limited size of most computer screens, the maximum width of all pages allows them to fit on a monitor whose maximum resolution is 640 x 480 pixels. The 640 pixel width is the critical dimension as vertical scrolling of a page is more accepted than horizontal scrolling. Two pages of vertical scrolling is acceptable to most users. There are a few instances where the two page scrolling limit was extended because breaking up the page would have interrupted the information flow.

Web pages are divided into two vertically separated frames. The left navigational frame is set to a fixed width of 110 pixels while the right frame is set relative to the maximum width of the monitor. As a rule, the right frame will open at approximately 460-475 pixels and, when combined with the left frame, produces a page 570-600 pixels wide.

The left navigational frame does not allow scrolling by the user. The image and associated map are 100 pixels wide by 300 pixels long, well within the 480 maximum length, therefore vertical scrolling of the left frame is not required. Leaving the left navigational frame static also helps keep the user oriented with a consistent graphical element. The right, or main frame,
offers user controlled scrolling for the length of the document being viewed.

The pages are displayed using borderless frames, therefore, there is no vertical line between the two vertically separated frames. The current versions of Netscape Navigator/Communicator and Microsoft Internet Explorer treat borderless frame HTML (HyperText Markup Language) commands differently. Because of this difference each frameset, or combination of files that make up a viewed page, require separate commands for each browser type. The borderless frames HTML tags, or commands, for each browser are as follows:

Netscape Navigator/Communicator -
\[
<FRAMESET COLS="110,*" bordercolor="255 255 255" border="0" frameborder="no">
\]

Microsoft Internet Explorer -
\[
<FRAMESET COLS="110,*" bgcolor="255 255 255" framespacing="0" frameborder="0">
\]

or, as the RDF web site utilizes, use one command line incorporating correct HTML for both browsers types:

\[
<FRAMESET COLS="110,*" bordercolor="255 255 255" border="0" frameborder="no"
bgcolor="255 255 255" framespacing="0" frameborder="0">
\]

Banner Information

The web site utilizes banners at the tops of pages to help the user find specific information located on the page or one closely related to it. A common banner template was designed to achieve graphic and navigational clarity. All banner image files end with the same letters (xxx_bnr.gif). Banners at the tops of pages use similar, if not identical, design criteria. The black borders at the top and bottom with inverted text are used with an image related to subject matter of the page displayed. The images are manipulated in Adobe Photoshop to produce fun representations of the original image. Colors used for the BACK text areas generally appear as a dominant tint within the image. Helvetica is used throughout the web site as the banner and navigation frame font. Fourteen point Helvetica is used in the upper black band of the banner and twelve point is used in the lower border. Text in the black border areas is centered vertically. Other design standards and dimensions used can best be seen in Figure 1.

This project maintains a direct approach from a graphical standpoint. Consistent navigational elements reinforce clarity and maneuverability within web site pages. Page specific navigation banners always appear at the top of the page with overall site navigation presented in the left red frame. Uniformity and lucidity are also maintained by using the sans-serif font Helvetica in all banner and navigation frame image maps. Keeping the interface as straightforward as possible is critical in helping the user feel in control while navigating through the site.

Graphics Formats

All banners and most displayed images are .GIF format files. This produced the best quality screen image compared to the alternative .JPEG format. Most displayed images found throughout the web site are .GIF format but lead to a larger .JPEG version when clicked on.
Smaller images contain xxx_sm.gif (xxx is the rest of the file name) in the file name if it leads to a larger viewable version. Images in the web site utilize a drop shadow effect like the one in the banner example shown on the previous page. Refer to Appendix B for detailed instructions on how to perform a drop shadow Action on an image in Adobe Photoshop 4.0.1.

Color Information

The color scheme for the research + demonstration facility web site is red and yellow tints. These are primarily used in the navigation frames and were derived from the colors found in the spaceframe and purlins of the building. White is used as the default background color for all pages with a default text color of 82% gray. The components for the colors are as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>0,0%,100%</td>
<td>100%,100%,100%</td>
<td>0%,0%,0%,0%</td>
<td>FFFFFF</td>
</tr>
<tr>
<td>Red</td>
<td>358,97%,38%</td>
<td>74%,1%,3%</td>
<td>0%,73%,71%,26%</td>
<td>CC0000</td>
</tr>
<tr>
<td>Yellow</td>
<td>55,100%,93</td>
<td>255,235,0</td>
<td>3%,2%,95%,0%</td>
<td>FFF00</td>
</tr>
<tr>
<td>Text</td>
<td>0%,0%,18%</td>
<td>18%,18%,18%</td>
<td>0%,0%,0%,82%</td>
<td>333333</td>
</tr>
</tbody>
</table>

All numbers refer to pixels, except for three spaces between words in the lower navigation area.

Figure 1
This section provides an image of each page created for the Research + Demonstration web site and information about its file location and linked graphics. The page’s file name and Uniform Resource Locator (URL) will start with the RDF folder because anything closer to the root directory, i.e. www.caus.vt.edu, is out of this project's control. As of this printing, the RDF web site information is located at URL http://www.caus.vt.edu/caus/facilities/rdf/. Here are a few facts about the RDF web site:

- Approximately 600 files comprise the web site,
- Approximately 900 hyper-links located in approximately 110 HTML pages,
- Average page download time using a 28.8k baud modem is 10 - 15 seconds,
- Average page download time using a T1 network connection is 3 - 8 seconds,
- Took approximately five months to construct the web site for one person working part time on the project,
- The book took three weeks to compile.

The files associated with the Research + Demonstration web site work independent of the RDFs folder location on the server with exception of the `tour.pdf` file which has absolute links to pages in this web site. If the RDF folder is moved to somewhere other than www.caus.vt.edu/caus/facilities/rdf/, the links will not work without manually changing the URLs in the tour.pdf file.

All of the web site page images are screen captures at 72 dots per inch, so please excuse any blurriness. Netscape Communicator 4.0 on an Apple Macintosh was used for the screen captures. Below is a table of the main pages that follow.

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<th>WHAT'S NEW</th>
<th>FACILITIES</th>
<th>RESEARCH PROJECTS</th>
<th>RESEARCH OPPORTUNITIES</th>
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<td>Plan</td>
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<td>Materials</td>
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<td>Proposals</td>
<td></td>
<td>Section</td>
<td>Photovoltaic Arrays</td>
<td>Alternative Energy</td>
<td>Financial</td>
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<tr>
<td>Essay</td>
<td></td>
<td>Elevation</td>
<td>Outdoor Environment</td>
<td>Systems</td>
<td>Architects</td>
</tr>
<tr>
<td>Site Structure</td>
<td></td>
<td>3d CAD</td>
<td>Indoor Environment</td>
<td>Building Sensors</td>
<td>Web Site</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test Cells</td>
<td>Energy Usage</td>
<td>Glazing Systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Details</td>
<td>Test Cells</td>
<td>Indoor Air Quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment</td>
<td>Off Site Research</td>
<td>Other</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Solar Hot Water Sys.</td>
<td>Research Archives</td>
<td></td>
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<td>Remote Sensing</td>
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<td>Devices</td>
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<td>Other</td>
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</tbody>
</table>
The Research + Demonstration Facility is a research project involving the construction of an 11,200 sf experimental building on the VPI&SU campus between 1989 and 1993. The research agenda includes projects relating to investigations of 21 distinct products, materials, and building sub-assemblies, ranging from innovative foundation system components to unique roof, wall, and floor systems, and studies of the interrelations between these systems, undertaken by students and faculty in the College of Architecture + Urban Studies at Virginia Tech. Use the following links for more information concerning research objectives and proposals.

Take a guided tour of the research + demonstration web site via a PDF file (1.4mb). Acrobat Reader is required to view the tour.


This web site is intended to be used for extracting data related to research projects mentioned above. Presently, the site is setup as a "static" device in that you can only view and download historic or achieved information. In the near future this will become a more interactive site allowing the user to interpret data in near real-time.

Please use the navigation frame at left to view more information. You can also view the basic structure of this entire site. Your browser must support image maps and frames to navigate this site.

This site is best viewed using Netscape Navigator 3.0 or Internet Explorer 3.0
The primary objective of the Research and Demonstration facility is to provide a dynamic tool that will be responsive to the needs of an evolving research program. Reconfigurability and overall flexibility are essential components in achieving this goal. These attributes are provided in the Research + Demonstration Facility through reconfigurable building components that allows the basic enclosure system as well as the research agenda to be changed over time. Flexibility is also provided in a star topology local area network that provides an instrumentation and data acquisition system that can simultaneously collect data from twenty one research projects. A centralized file server allows project management, data analysis and report production to be seamlessly integrated to further enhance the overall system flexibility.

Of the twenty one research projects there are three major groupings of research activities found in the facility. The first deals with environmental control systems with an emphasis on the relationship of the thermal characteristics of concrete masonry and its influence on human comfort and energy consumption. Item two
R+D Research Proposal

PHASE ONE: BUILDING PRODUCTS INNOVATION
   Introduction
   Relevence

PHASE TWO: INDOOR ENVIRONMENTAL CONTROLS
   Introduction
   Relevence
A [ RESEARCH + DEMONSTRATION ] BUILDING

William Galloway, Associate Professor
A. J. Davis, Professor

The relation of research to the design disciplines has recently emerged as a progressive educational concept. In the minds of most contemporary educators, architectural research is no longer limited to empirical data collection regarding objective, quantifiable criteria, nor is technology relegated to the status of a mere instrument in the design of services, such as mechanical/electrical systems for buildings. In using the term research, we refer to the diligent seeking-out of the knowledge of architectural principles. The educational environment, both for teacher and student, is dynamically stimulated by the continual presence of this research activity.

The place of research with respect to university teaching has long been based on a paradigm borrowed from the natural sciences which involves the non-discursive transfer of academic information that exists between research, design, teaching and practice. Research is seen as the acquisition of positive knowledge which seeks its application through design. The widely-accepted information exchange may be diagramed linearly, where empirical research, usually focusing on particular technological issues and undertaken in isolated laboratories, is written about in journals to inform academics who then relay the data through the design lab or lecture courses to students, who are then expected to carry the transformed information into practice. In this context, teaching assumes one of two roles: that of conveyors, responsible for the transference or communication of information from researcher to designer, or, that of critic, employing a method of doubt directed toward the exposition of inadequate, premature, or faulty reasoning -- inductive in the case of research, deductive in the case of design. We hope to show that this position evinces a notably myopic definition of research and represents a narrow understanding of both technology and design.

Research activity which does not fit this model, or, in other words, which eschews the application of the scientific method to architectural endeavors, is often criticized as mere conjecture or opinion, based on flights of fancy, or built on the unstable foundation of aesthetic sensibility. How may the results of such research attain the status of true scientific knowledge? It is by the recognition of the research model outlined above that the architectural discipline may achieve the status of a true science.
<table>
<thead>
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<tr>
<td>Main Site</td>
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<tr>
<td>Section</td>
<td>Photovoltaic Arrays</td>
<td>Alternative</td>
<td>Financial Contributors</td>
<td></td>
</tr>
<tr>
<td>North-South East-West</td>
<td>Outdoor Environment</td>
<td>Energy Systems</td>
<td>Architects</td>
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<tr>
<td>Elevation</td>
<td>Indoor Environment Energy Usage Test Cells</td>
<td>Building Sensors</td>
<td>Web Site</td>
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<tr>
<td>North South East West</td>
<td>Glazing Systems</td>
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<td>Indoor Air Quality</td>
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</tr>
<tr>
<td>3d CAD NE Corner SW Corner Without Roof</td>
<td>Off Site Solar Hot Water System</td>
<td>Indoor Air Quality</td>
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<tr>
<td>Animation</td>
<td>Test Cells</td>
<td>Research Archives</td>
<td>Other</td>
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<tr>
<td>plan section elevation</td>
<td>Test</td>
<td>Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Details</td>
<td>Test Equipment Shop Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

what's new

description of new faculty and student research being conducted at r+d

I BACK I
A primary objective of the Research + Demonstration facility is to provide a dynamic tool that will be responsive to the needs of an evolving research program. Reconfigurability and overall flexibility are essential components in achieving this goal. These attributes are provided through reconfigurable building components that allow the basic enclosure system as well as the research agenda to be changed over time. The Research + Demonstration facility incorporates numerous innovative construction techniques not yet found in many buildings.

The facility was built in two phases. The first phase, completed in 1990, was designed to study innovative building products. Phase one houses studio space, a darkroom, offices, a work shop, and a classroom auditorium. Phase two, which serves as a testbed for indoor environmental control, was completed in 1993 and contains offices and two reconfigurable classrooms with raised floors. Total area of the facility measures 11,200 square feet not including the on site test cells building.

The research + demonstration facility is located in the Virginia Tech Plantation Road research complex approximately 1 mile from main campus.

By using the links located above, you can view and download information about the facilities construction and some of the test and shop equipment available for research and prototyping projects. Preview some of the working drawings used to construct the research + demonstration facility. View a complete list of working drawings in .DXF format available to download.
Preview some thumbnail versions of working drawings used to construct the research + demonstration facility. Click on the image to view a larger jpeg version of the drawing or click on the text beneath the image to go to its associated page for other drawings.
The research + demonstration facility was built in two phases. The first phase, completed in 1990, was designed to study innovative building products. Phase one houses studio space, a darkroom, offices, a work shop, and a classroom auditorium. Phase two, which serves as a testbed for indoor environmental control, was completed in 1993 and contains offices and two reconfigurable classrooms with raised floors. Total area of the facility measures 11,200 square feet not including the on site test cells building.

Use the clickable areas above (main or site) to select a plan to view. A 72 dpi version will be displayed with the option of viewing a larger .jpeg or a cad generated .dxf which can be opened in many current cad programs. All .dxf files were exported from AutoCAD R12c3 on a Macintosh. The approximate file size of the image is given so you can estimate the download time required for the larger files.
Main Floor Plan

Click on the image to view a larger version (228k).

View a list of other research + demonstration floor plans and details drawings in .DXF format available for downloading.

I site plan I BACK I
Site Plan

Click on the image to view a larger version (358k)

View a list of other research + demonstration site plans and details drawings in .DXF format available for downloading.

main floor plan BACK
Use the clickable areas above (north-south or east-west) to select a section to view. A 72 dpi version will be displayed with the option of viewing a larger .jpeg or a cad generated .dx file which can be opened in many current cad programs. The approximate file size of the image is given so you can estimate the download time required for the larger files. Some cad programs provide plug-ins to allow viewing of .dx files directly in your browser. Consult your cad program for capabilities.

I north-south section I east-west section I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/section.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/sect_bnr.gif
North - South Section

Click on the image to view a larger version (195k).

View a list of other research + demonstration sections and details drawings in .DXF format available for downloading.

I east-west section I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/section.html#sect-ns
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/sectph2_ns_sm.gif
East - West Section

Click on the image to view a larger version (228k) of Phase 1.

View a list of other research + demonstration sections and details drawings in .DXF format available for downloading.

I north-south section I BACK I
Use the clickable areas above (north, south, east or west) to select a elevation to view. A 72 dpi version will be displayed with the option of viewing a larger .jpeg or a cad generated .dxf which can be opened in many current cad programs. The approximate file size of the image is given so you can estimate the download time required for the larger files. Some cad programs provide plug-ins to allow viewing of .dxf files directly in your browser. Consult your cad program for capabilities.

north elevation south elevation east elevation west elevation BACK
North Elevation

Click on the image to view a larger version (163k).

View a list of other research + demonstration elevation drawings in .DXF format available for downloading.

I south elevation I east elevation I west elevation I BACK I
South Elevation

Click on the image to view a larger version (163k).

View a list of other research + demonstration elevation drawings in .DXF format available for downloading.

I north elevation I east elevation I west elevation I BACK I
East Elevation

Click on the image to view a larger version (130k).

View a list of other research + demonstration elevation drawings in .DXF format available for downloading.

I north elevation I south elevation I west elevation I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/elev.html#east
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/elevph1_e_sm.gif
West Elevation

Click on the image to view a larger version (228k).

View a list of other research + demonstration elevation drawings in .DXF format available for downloading.

I north elevation I south elevation I east elevation I BACK I
Use the clickable areas above (nw corner, se corner, without roof or animation) to select a 3d cad drawing or animation to view. A 72 dpi version will be displayed with the option of viewing a larger .jpeg or a cad generated .dxf which can be opened in many current cad programs. Some cad programs provide plug-ins to allow viewing of .dxf files directly in your browser. Consult your cad program for capabilities. The animation is a QuickTime formatted movie that can be downloaded to a file or played through your browser if you have the correct plug-in installed. The approximate file size of is given so you can estimate the download time required for the larger version.

http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d_bnr.gif
facilities - 3d cad - north.east

Click on the image to view a larger version (98k).

View a list of other research + demonstration 3d cad drawings in .DXF format available for downloading.

I south. west corner I without roof I animation I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d.html#ne
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d_ne_sm.gif
South-West Corner

Click on the image to view a larger version (130k).

View a list of other research + demonstration 3d cad drawings in .DXF format available for downloading.

http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d.html#sw
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d_sw_sm.gif
Without Roof

Click on the image to view a larger version (130k).

View a list of other research + demonstration 3d cad drawings in .DXF format available for downloading.

north, east corner I south, west corner I animation I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d.html#wo roof
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d_plan_sm.gif
Animation

This page is still under construction. The QuickTime 3d cad animation will be available shortly for downloading to your browser, if it's capable, or to file.

I north east corner I south west corner I without roof I BACK I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/3d.html#animation
The research + demonstration facility has a separate building containing 10 thermal environment test cells on the grounds of the facility available for research projects. Each test cell allows for collection and control of data acquired in the customizable space.

Use the clickable areas above (plan, section, or elevation) to select a drawing to view. A 72 dpi version will be displayed with the option of viewing a larger jpeg or a cad generated .dxf which can be opened in many current cad programs. The approximate file size of the image is given so you can estimate the download time required for the larger files. Some cad programs provide plug-ins to allow viewing of .dxf files directly in your browser. Consult your cad program for capabilities.

http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells_bnr.gif
Test Cells Plan

Click on the image to view a larger version (195k).

View a list of other research + demonstration test cell drawings in .DXF format available for downloading.

I section I elevation I BACK I
Test Cells Section

Click on the image to view a larger version (163k).

View a list of other research + demonstration test cell drawings in .DXF format available for downloading.

I plan I elevation I BACK I
Test Cells Elevation

Click on images to view a larger version (163k) of the test cells from the southeast. View a list of other research + demonstration test cell drawings in .DXF format available for downloading.

North Elevation - (163k)
West Elevation - (260k)
South Elevation -

http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells.html#elev
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells_elev_se_sm.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells_elev_n_sm.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells_elev_w_sm.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/tcells_elev_e_sm.gif
Use the clickable areas on the highlighted areas of the image below to view detailed images and descriptions of specific building details of the research + demonstration facility. View a complete list of special masonry details.

Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/details_bnr.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/detail_axon.gif
**Special Masonry Details**

**TABLE OF CONTENTS:**

- Project #1 - Grid Pavers
- Project #2 - Interlocking Solid Pavers
- Project #3 - An Interlocking Drystack Retaining Wall System
- Project #4 - Thermal-Thru-Wall Units
- Project #5 - Thermal Break Ties For Cavity Wall Construction
- Project #6 - Thermal Mass Characteristics Of CMU
- Project #7 - Undergrade Waterproofing
- Project #8 - Radon Transmission Through Foundation Systems
- Project #9 - Masonry And Metal Building Components Interface
- Project #10 - Segmental Footing
- Project #11 - Suspended Block Floor System
- Project #12 - Formwall Investigations
- Project #13 - Cladding / Block Veneer System
- Project #14 - Acoustical Absorption / Transmission Characteristics Of The Biaxial Block
- Project #15 - Development Of A Concrete Masonry Interior Flexible Partition System
- Project #16 - Roof Pavers
- Project #17 - Electrical / Mechanical Distribution Attributes Of The Biaxial Block
- Project #18 - Concrete Masonry Units As Integral Air Distribution And Radiant Release Space Conditioning Components
- Project #19 - CMU Floors On Grade
The research + demonstration facility has a large assortment of equipment available to faculty and students to assist in conducting research. These range from a very accurate CNC milling machine to relatively inexpensive test probes. Student use and availability of equipment is approved on a case-by-case basis by appropriate faculty.

Please click on the image above for the type of equipment you want more information.

http://www.caus.vt.edu/caus/facilities/rdf/facilities/equip.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/equip_bnr.gif
Test Equipment

This is a list of test equipment available to faculty and students for conducting experiments at the research + demonstration facility. A list of descriptions about the equipment is available for viewing. Click on the equipment name to view an image of the equipment or click on Description to view a brief description about the equipment. All images are approximately 65K .jpeg files.

- 12 volt Power Supply
- 4 Channel Recorder
- Air Velocity Meter
- Alnor Anemometer
- Alnor Hot Wire Anemometer
- Alnor Thermocouple
- Amp Probe
- BK. Climate Analyzer
- BK. Gas Analyzer
- BK. Thermal Comfort Meter
- Blower Door
- Campbell 21X Datalogger
- Caspar Temperature Standard
- CLIMET Particle Analyzer
- CO2 Detector
- CR10 Datalogger
- CR10 Datalogger Keypad
- Flow Rate Sensor
- Flow Hood
- Flow Meter
- Gas Analyzer Multiplexer
- Heat Stress Meter
- HOBO Temperature
- Hot Wire Anemometer
- Humidity Indicator

http://www.caus.vt.edu/caus/facilities/rdf/facilities/equip.html#test
Test Equipment Descriptions

Click on equipment name to view an image of the test equipment. All images are approximately 65k unless otherwise noted.

12 volt Power Supply
4 Channel Recorder
Air Velocity Meter
Alnor Anemometer (98k)
Alnor Hot Wire Anemometer
Alnor Thermocouple
Amp Probe
BK Climate Analyzer
BK Gas Analyzer
BK Thermal Comfort Meter
Flow Door (08k)
Shop Equipment

This is a partial list of shop equipment available to faculty and students for producing prototypes at the research + demonstration facility. A list of descriptions about the equipment is available for viewing. Click on the equipment name to view an image of the equipment or click on Description to view a brief description about the equipment. All images are approximately 98K .jpeg files.

<table>
<thead>
<tr>
<th>CNC Milling Machine</th>
<th>Laser Cutter</th>
<th>Hot Wire Foam Cutter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Description</td>
<td>Description</td>
</tr>
<tr>
<td>Vacuum Extractor</td>
<td>Injection Molder</td>
<td>Soil Compactor</td>
</tr>
<tr>
<td>Description</td>
<td>Description</td>
<td>Description</td>
</tr>
<tr>
<td>Soil Brick Maker</td>
<td>Large Assortment of Power Tools and Machinery</td>
<td>Description</td>
</tr>
</tbody>
</table>

![Image of shop equipment](http://www.caus.vt.edu/caus/facilities/rdf/facilities/indexfac.html)
Facilities - Shop Equipment Descriptions

Shop Equipment Descriptions

Click on equipment name to view an image of the test equipment. All images are approximately 98k unless otherwise noted.

CNC Milling Machine
Laser Cutter
Hot Wire Foam Cutter
Injection Molder
Vacuum Extractor
Soil Compactor
Soil Brick Maker
Large Portable Air Compressor
Large Assortment of Power Machinery and Tools

Top of Page

http://www.caus.vt.edu/caus/facilities/rdf/facilities/shopequip/shop_descr.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/facilities/shopequip/default1_bnr.gif
Below is a complete list of .dx files available to download. The approximate size and a brief description are associated with each file. All .dx files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dx files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

I Plans I Section I Elevation I 3d CAD I Details I Test Cells I Projects I
Floor + Site Plans

All .dx files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dx files in one compressed file (5.4M). StuffIt Expander is required to decompress the .sit files.

planph21_a1.dxf.sit (163k) - Plan of Phase 1 + 2 - overall plan drawing of both phases.

planph1_a1.dxf.sit 163(k) - Plan of Phase 1 - more detailed main floor plan drawing of phase 1 which contains offices, studios, darkroom, shop, and lecture space.

planph2_a2.dxf.sit (163k) - Plan of Phase 2 - more detailed main floor plan drawing of phase 2 which contains offices and testbed/ seminar rooms. Phase 2 also supplies HVAC for Phase 1.

planph21_sitclos_c2.dxf.sit (98k) - Phase 1 + 2 Site Plan - closer site plan drawing of phases 1 + 2.

planph1_detail_a2.dxf.sit (195k) - Plan of Phase 1 - detail drawings of the main plan.

planph1_detail_a3.dxf.sit (195k) - Plan of Phase 1 - detail drawings of the main plan.

planph1_detail_a5.dxf.sit (130k) - Plan of Phase 1 - detail drawings of the main plan.

plansectph1_detail_a4.dxf.sit (98k) - Phase 1 - details drawings of plan and sections.

plansectph2_detail_a3.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.

plansectph2_detail_a4.dxf.sit (195k) - Phase 2 - details drawings of plan and sections.

plansectph2_detail_a5.dxf.sit (195k) - Phase 2 - details drawings of plan and sections.

plansectph2_detail_a6.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.

planph2_siteall_c1.dxf.sit (325k) - Phase 1 + 2 - site plan drawing of phases 1 + 2.

planph2_siteclos_c4.dxf.sit (98k) - Phase 1 + 2 - closer site plan drawing of phases 1 + 2.

planph2_siteall_c5.dxf.sit (228k) - Phase 1 + 2 - drawing of site construction details.

planph21_siteall_c1.dxf.sit (325k) - Phase 1 + 2 - site plan drawing of phases 1 + 2.

Go to Main Floor Plan + Site Plan Page
Section

All .dxf files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxf files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

sectph1_ew_a9.dxf.sit (390k) - Phase 1 - East-West Section drawings through phase 1.
sectph1_ns_a10.dxf.sit (455k) - Phase 1 - North-South Section drawings through phase 1.
sectph2_ew_a10.dxf.sit (195k) - Phase 2 - East-West Section drawings through phase 2.
sectph2_ns_a9.dxf.sit (228k) - Phase 2 - North-South Section drawings through phase 2.
sectph1_wall_a11.dxf.sit (293k) - Phase 1 - wall section drawings of phase 1.
sectph1_wall_a12.dxf.sit (260k) - Phase 1 - wall section drawings of phase 1.
sectph1_wall_a13.dxf.sit (228k) - Phase 1 - wall section drawings of phase 1.
sectph1_wall_a14.dxf.sit (228k) - Phase 1 - wall section drawings of phase 1.
sectph2_wall_a11.dxf.sit (163k) - Phase 2 - wall section drawings of phase 2.
sectph1_int_a18.dxf.sit (130k) - Phase 1 - wall section drawings of phase 1.
plansectph1_detail_a4.dxf.sit (98k) - Phase 1 - details drawings of plan and sections.
plansectph2_detail_a3.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.
plansectph2_detail_a4.dxf.sit (195k) - Phase 2 - details drawings of plan and sections.
plansectph2_detail_a5.dxf.sit (195k) - Phase 2 - details drawings of plan and sections.
plansectph2_detail_a6.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.

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http://www.caus.vt.edu/aus/facilities/rdf/facilities/dxf/dxf.html#section
Elevation

All .dxr files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxr files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

- elevph21_a7.dxf.sit (195k) - Phase 1 + 2 - North and South Elevation drawings, Phase 2 East and West elevation drawing
- elevph1_ns_a7.dxf.sit (195k) - Phase 1 - North and South Elevation drawings
- elevph1_ew_a8.dxf.sit (98k) - Phase 1 - East and West elevation drawings

Go to Elevations Page

I Plans I Section I 3d CAD I Details I Test Cells I Projects I TOP I

http://www.caus.vt.edu/caus/facilities/rdf/facilities/dxf/dxf.html#elevation
3d CAD

All .dxf files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxf files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

3d.dxf.sit (228k) - Phase 1 + 2 - 3d Version of r+d

Go to 3d CAD Page
Details + Miscellaneous

All .dxf files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxf files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

detailphi_biax_a21.dxf.sit (195k) - Details of Biaxial Block usage in Phase 1.
planphi_detail_a2.dxf.sit (195k) - Plan of Phase 1 - detail drawings of the main plan.
planphi_detail_a3.dxf.sit (195k) - Plan of Phase 1 - detail drawings of the main plan.
planphi_detail_a5.dxf.sit (130k) - Plan of Phase 1 - detail drawings of the main plan.
plansectphi_detail_a4.dxf.sit (98k) - Phase 1 - details drawings of plan and sections.
plansectphi_detail_a3.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.
plansectphi_detail_a4.dxf.sit (195k) - Phase 2 - details drawings of plan and sections.
plansectphi_detail_a6.dxf.sit (130k) - Phase 2 - details drawings of plan and sections.
planph12_sitedetail_c5.dxf.sit (228k) - Phase 1 + 2 - drawing of site construction details.
roofphi_detail_a6.dxf.sit (130k) - Phase 1 - Roof plan of spaceframe.
schedphi_doorwin_a19.dxf.sit (98k) - Phase 1 - schedule of doors and windows.
schedphi_fin_a20.dxf.sit (130k) - Phase 1 - schedule of floor and wall finishes.
schedphi_sill_a15.dxf.sit (98k) - Phase 1 - schedule of CMU sills.
schedphi_doorwin_a8.dxf.sit (130k) - Phase 2 - schedule of doors and windows.
schedphi_dwglist_t1.dxf.sit (65k) - Phase 2 - list of drawings.
schedphi_sill_a13.dxf.sit (65k) - Phase 2 - schedule of CMU sills.
schemphi2_mechplan_m4.dxf.sit (228k) - Phase 1 + 2 - drawing of mechanical systems plan.

Go to Details Page
Test Cells

All .dxf files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxf files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

tcellsph1_e22.dxf.sit (130K) - Phase 1 - Plan, Section and Detail drawings of the test cell building.

Go to Test Cells Page
Projects

All .dxf files were exported from AutoCAD R12c3 on a Macintosh. Download all of the .dxf files in one compressed file (5.4M). Stuffit Expander is required to decompress the .sit files.

- airfltr1.dxf.sit - (260k) - Phase 2 - Drawing of the Union Carbide Air filtration research system
- airfltr2.dxf.sit - (195k) - Phase 2 - Drawing of the Union Carbide Air filtration research system
- schemph2_airflow_m2.dxf.sit (96k) - Phase 2 - drawing of HVAC air flow through phases 1 & 2.
- schemph2_waterflow_m2.dxf.sit (163k) - Phase 2 - drawing of water and steam piping through phases 1 & 2.

Go to Research Projects Page

http://www.caus.vt.edu/caus/facilities/rdf/facilities/dxf/dxf.html#projects
Particular attention has been given to the flexibility and reconfigurability of the research +
demonstration facility, which allows system integration issues to be studied in a full scale test
situation. The building, with its various modules, functions as an on-going research facility
providing test-cell areas that are instrumented, and that have the capability to be physically
altered as the research program develops. Material handling provisions allows for the removal
of tested sub-assemblies and the replacement of new ones, without disrupting other tests.

The research program has six primary objectives. These objectives address the concerns in the
areas of product testing and development, product interaction with other materials, on-site
construction issues, and the opportunity for full scale performance analysis. In addition,
radon gas penetration, building automation systems, and work sampling studies will be
conducted. View a summary of research objectives.

Please utilize the clickable areas above to explore the research projects at the r+d facility.
Summary of Research Objectives

1. To test complex utility options by demonstrating the installation of electrical and plumbing components into composite building assemblies. This work will provide the basis for new product development and provide a point of comparison to conventional methods of placing utilities.

2. To evaluate on-site construction practices through work sampling studies, focusing on the installation of innovative building products by trained craftsmen.

3. To evaluate the thermal performance and energy related characteristics within an occupied full-scale prototype through real time data acquisition. The implications of thermal and energy performance on natural lighting will be studied.

4. To develop methods of simulating the diffusion of radon gas through soil and to use these methods to develop wall and floor systems specifically developed for the removal of radon gas in basement and crawl space applications.

5. To provide a method of evaluation that simulates the migration of moisture in foundation and wall systems. This information will be used to develop building details that best combat moisture penetration.

6. To investigate automation systems that allow the sequencing of heating and cooling equipment with natural thermal delivery systems in the prototype. Overall energy usage will be monitored to provide a point of comparison between dynamic building control systems and conventional steady state (on/off) controls.

http://www.caus.vt.edu/CAUS/FACILITIES/rdf/projects/projects.html#summary
A variety of research projects can be found at the research + demonstration facility. Research projects range from the study of radon gas penetration through wall and floor systems to indoor air quality analysis to advanced construction techniques to name a few. Projects may be driven by grant funded research, faculty, and student initiated investigations among others.
System Overview

The RDF Photovoltaic (PV) system is composed of identical twin units each powered by four polycrystalline modules in parallel for a total of 460 Wp installed on the roof of the Research + Development Facility of the College of Architecture + Urban Studies. The systems provide lighting during the evening for 4-5 hours. MSX-60 PV modules from Solarex are utilized. Each module has a peak power of 60 W under standard test conditions. The open circuit voltage and short circuit current ratings are 21.1 Vdc and 3.8 Adc respectively, making the MSX-60 module suitable for 12 Vdc applications. Each array of four modules is fixed on a frame inclined at 52° (latitude+15°) facing due South. The overall system sizing and tilt-angle determination were made using Sandia Lab’s design worksheets for standalone photovoltaic systems.

The balance of the system consists of a 300AH gel-cel battery bank designed with a five day autonomy and 80% depth of discharge capability. It is connected to the PV array through an M-16 charge controller. Table 2.1 lists the components of a 240 Wp standalone unit installed at the RDF site.
photovoltaic energy data

System Voltages

The performance of a PV system can be gauged from the state of charge (SOC) of its storage batteries or in the case of the RDF plant, from the mean battery voltage. Two periods of interest were considered: startup and post-start-up or normal operation. During the startup period (November-December 1993), the twin units were operated at reduced load for 3-4 weeks to revive the batteries which were in deep state of discharge. Although the GC12Y100B batteries were designed to recover 100% from deep discharge situations, it is possible that some of the batteries may have lost some charging capacity due to prolonged discharge prior to November 1993. However, it appears that this possible reduction in capacity did not affect system performance. After startup and during the monitoring period (January to December 1994), the mean battery voltage was in the range between 12.5 and 13.5 Vdc (Figure 2.6 - click on the image for a larger version .gif) indicating a normal state of charge. Overall, the batteries recovered well and performed as expected in supplying the load.

Download a PDF version of the complete report on the photovoltaic system. The .PDF file will require Acrobat Reader for viewing.
Insolation Received and Array DC Energy

Well into the monitoring phase, it was discovered that the pyranometer was out of calibration, resulting in readings that were slightly lower than expected values. To provide the most accurate results, the insolation data collected at the Virginia Tech Solar Test Facility (VTSTF) were used to calculate module efficiency at RDF. Since the VTSTF is less than two miles away from the RDF facility, this data substitution was considered reasonable.

Figure 2.4 (click on the image for a larger version .gif) gives the average array DC energy produced by the RDF system. The .

Figure 2.5 (click on the image for a larger version .gif) shows the average array conversion efficiency, comparing the DC energy produced to the estimated plane of array radiation based on the VTSTF data. It should be noted that the computed monthly average values do not represent the true PV conversion efficiencies since external controls, namely the battery charge regulator and the data logger, frequently override system operation.

Download a PDF version of the complete report on the photovoltaic system. The .PDF file will require Acrobat Reader for viewing.
research projects - on site - photovoltaics.other

Site Meteorological Data

Figure 2.8 (click on the image for a larger version .gif) shows the monthly average ambient temperature and the average wind speed recorded at the RDF site. Higher wind speeds were observed during the winter months while the reverse occurred during the summer months. Temperature and wind speed are important parameters which affect the conversion efficiency of PV modules since output power is derated with rise in the ambient and module temperatures.

Photovoltaic Data Files

Raw data spreadsheet files are available for downloading. The files allow you to interpret or manipulate the collected data. Included in the 500k - 800k file is a separate spreadsheet for each day of the month along with a summary spreadsheet for the entire month - or - you can choose the 30k-60k summary only. Click on the data file you want to explore further. Choose the compressed files (Microsoft Excel .xls decompressed) that best suit your computer's ability to decompress it. All files were compressed on a Macintosh - ZipIt 1.2 was used for the .zip files, StuffIt Classic 1.6 was used for the .sit and .hqx files.

January 1994

<table>
<thead>
<tr>
<th>January.sit</th>
<th>January.sit.hqx</th>
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February 1994

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<th>February.zip</th>
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http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/pv.html#other
Image: http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/pv_fig2.8_sm.gif
summary of indoor environment conditions

internal links:
http://www.caus.vt.edu/CAUS/FACILITIES/rdf/projects/onsite/indoor.html#temp
http://www.caus.vt.edu/CAUS/FACILITIES/rdf/projects/onsite/indoor.html#light
http://www.caus.vt.edu/CAUS/FACILITIES/rdf/projects/onsite/indoor.html#hvac
http://www.caus.vt.edu/CAUS/FACILITIES/rdf/projects/onsite/indoor.html#other
research projects - on site - energy usage

http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy.html

Image: http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy_bnr.gif

internal links:
http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy.html#elect
http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy.html#gas
http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy.html#solar
http://www.caus vt.edu/caus/facilities/rdf/projects/onsite/energy.html#other
research projects - on site - test cells

Image: http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/tcells_map.gif

internal links:
http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/tcells.html#instr
/onsite/tcells.html#a /onsite/tcells.html#b /onsite/tcells.html#c
/onsite/tcells.html#d /onsite/tcells.html#e /onsite/tcells.html#f
/onsite/tcells.html#g /onsite/tcells.html#h /onsite/tcells.html#i
/onsite/tcells.html#j /onsite/tcells.html#equip
research projects - on site - other

http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/other.html

Image: http://www.caus.vt.edu/caus/facilities/rdf/projects/onsite/other_bnr.gif
Off site monitoring of projects gives the research + demonstration facility a global ability to control and conduct experiments globally. Currently, there are funded research projects conducted utilizing the facility’s computer and communications network capabilities.

Click on the above links to explore some of the research being conducted off campus.
research projects - off site - solar hot water system

System Overview

This section describes the monitoring and performance evaluation of a domestic hot water solar thermal installation at Caroline Correctional Unit #2 located on Route 677 in Caroline County, Virginia. This facility consists of a single story main building of approximately 15,783 sq. ft. The solar installation was sized to supply the partial thermal loads generated by the hot water demand in the kitchen, daily showers and washroom needs for approximately 120 inmates and washroom needs for 25 employees. The size of the ground mounted collector array is 1920 sq. ft and is located outside the secure area of the prison approximately 165 ft. from the mechanical room. The information found here documents the systems operation and thermal performance during the period of January through December 1994. Data obtained during this period was measured by a Level I monitoring system. Evaluation at this level consists of a dedicated datalogger that reads and records all sensor signal inputs, converts these raw signals to engineering units and records these values every ten minutes.

Download a PDF version of the complete report on the solar hot water system installed at the Caroline County Correctional Facility. The 98k PDF file will require Acrobat Reader for viewing.

Performance and Reliability

http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/solarh2o.html
Water Temperature

Temperature is measured with Campbell Scientific 107B thermistor temperature probes. Linearization of this thermistor type is supported by the firmware of the 21X datalogger. According to manufacturer literature, over the range of -35 degrees C to 50 degrees C, the worst case error should be no greater than .4 degrees C. Significant error is introduced when temperatures exceed 50 degrees C. This temperature limitation of the 107B thermistor resulted in an under prediction of BTUs collected by the array. This error progressively got worse when the collector loop temperature exceeded 50 degrees C. A method to correct for high temperature error >50deg.C is discussed in the following section on temperature measurement correction. The results of this correction process can be found in Table 3.4 which shows the corrected monthly values compared to the uncorrected values.

Temperature Measurement Correction

During this study an error was detected when a comparison of Array BTUs Collected to Total Energy Contribution - Solar System indicated energy contributed to be larger than BTUs collected. These values should be reversed as you can not extract more energy from a system than what you put into it. There are three sensors that can influence these values, these include two temperature sensors and one flow meter. This configuration is found both on the collector loop and the demand side. Previous on-site ice point calibration of the temperature probes indicated that they were reporting ice point correctly. The flow meters were suspected as introducing the error. Both flow meters were checked against a Controlotron Ultrasonic Flow meter by John Anderson from Sandia Labs. The results of the comparison indicated that the Controlotron and the Hersey flow meters were within 4% of one another over the entire range of 5 gpm to 34.2 gpm.

The second check was to calibrate the temperature probes. This was done by placing a temperature standard (NIST traceable Caspar DPT-6000 digital thermometer) into a temperature controlled water bath along with the Campbell Scientific 107 temperature probes. The results of this can be found in...
insolation data

Solar Radiation Measurement

Solar radiation is measured in the plane of the collector array (45 Deg. from horizontal) with a LI-COR model LI200S silicon pyranometer. The sensor is physically attached to the photovoltaic array powering the 21X. The angle of the PV array was set to that of the collector array by using an inclinometer. Setting the array with the inclinometer assured the pyranometer to be within one degree or better to the angle of the collector array. Two conductor shielded cable is used to bring the approximate 0 to 12MV signal to the 21X datalogger. A differential voltage measurement is performed at the datalogger because of improved noise rejection.

I water temps I weather info I other I BACK I
research projects - off site - solar hot water system.weather

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**weather information**

**Wind speed**

A 3-cup anemometer utilizing a magnet activated reed switch is used to measure the speed at a point directly above the last bank of solar collectors (see Figure 3.1). The pulse frequency generated by the reed switch is proportional to wind speed. Two conductor shielded cable connects the anemometer to a pulse channel on the 21X datalogger.

http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/solarh2o.html#weather

Image: http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/solarh2o_weather_sm.gif
research projects - off site - solar hot water system.

http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/solarh2o.html#other
research projects - off site - other

other off site research being conducted through r+d

http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/other.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/projects/offsite/other_bnr.gif
archive of projects/research conducted primarily at or through R+D
There are many opportunities for research in building materials at the research + demonstration facility. Use the clickable areas on the highlighted areas of the image below to view detailed images and descriptions of specific building details requiring further investigation. View a complete list of research opportunities in masonry details and materials.

http://www.caus.vt.edu/caus/facilities/rdf/opport/materials.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_bnr.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_axon.gif
View a **larger version of the axon** without the text or colored areas (65k)

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Building Materials Research and Special Masonry Details

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http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj_bnr.gif
Project #1 - Grid Pavers

OBJECTIVE OF STUDY

To investigate the structural integrity of the paver under typical parking lot loads, and to look at its ability to facilitate with water removal.

METHOD OF EVALUATION

The porous grid pavers structural integrity will be monitored through observation. The pavers will be subjected to standard parking lot loads. The number of units broken will be assessed on a monthly schedule for the duration of one year. The installation of the grid pavers will be recorded by time marked video tape.

Water run-off studies will be performed utilizing a comparative test area of a non porous paver to that of the porous grid pavers. These equivalent areas will be compared to one another using a device that indicates moisture content. These devices will be placed in a grid beneath and extending beyond the edges of the two test areas. Soil moisture content will be combined with environmental data such as rainfall, wind speed at varying heights, ambient temperature, solar insolation measured on a horizontal surface, and relative humidity.

The soil beneath the test areas will be characterized as to its soil type, compaction and porosity, to guarantee that both soil conditions are identical under the test areas.

The evaluation entails a visual inspection of the grid pavers for a prescribed time interval. The initial installation will be documented with the time motion analysis videotape equipment.

INSTRUMENTATION

The visual assessment will be done utilizing time marked videotape. Soil moisture probes (16) interfaced to a multi-point data logger will be used to collect comparative data. Environmental data (as described above) will also be connected to a centralized data logger.
Project #2 - Interlocking Solid Pavers

OBJECTIVE OF STUDY

METHOD OF EVALUATION

Horizontal patterns of movement in the interlocking pavers will be detected utilizing photographic overlays. Reference targets will be placed on a test section of the interlocking pavers.

The photographic overlays will be taken on a monthly basis to indicate paver movement over time. With the appropriate rectified camera viewpoint small test sections can be monitored as well as the overall parking lot area.

Vertical movement will be detected using the same location points for horizontal assessment but using a vertical stadia with a reference laser as an indicator of vertical movement.

INSTRUMENTATION

1) A grid of load cells, the number of which is determined by the area of the test section. (Recommendations are needed from the NCMA as to the size of the test sections)

2) Multispectral Infrared Thermography

3) Time Marked Videotape

TIME FRAME OF ANALYSIS

One year of observation with monthly observations of paver movement. Critical seasonal observations will be performed on the snow removal aspects of the interlocking pavers. Load distribution studies will be conducted over a period of 6 months.

PRODUCT

1) A report describing the movement observed during a period of one year, including a photographic summary of the monthly observations.
Project #3 - An Interlocking Drystack Retaining Wall System

OBJECTIVE OF STUDY

The objective of the study is to conduct a visual assessment of:
Movement found in the retaining wall over time.
To observe the impact that frost heave will have on
the walls integrity.
Efflorescence due to moisture saturation of the
surrounding soil.

METHOD OF EVALUATION

The visual assessment will be conducted in a
similar fashion described in project #2. Video
digitizing techniques will be used to assess
movement in the retaining wall system as well as
gauge surface tonality changes due to
efflorescence. Sections of the retaining wall will be
subjected to varying degrees of saturated soil to
accelerate the process of efflorescence. Sections of
the non-saturated wall will be monitored using
embedded soil moisture probes to assess the
drainage capability of the retaining wall.

INSTRUMENTATION

1) Visual assessment will be done with referenced marked photographic plates that will be
analyzed using 300 dots per inch scanning technology. The scanned images will then be
analyzed using image processing techniques to extract dimensional information as well as
determine surface tonality changes. Crack movement detection gauges will also be used to
provide a series of benchmarks for the video
digitizing techniques.

2) Soil moisture probes will be used in
conjunction with a multiple channel data
logging system. In addition to the soil
moisture data, the amount of water supplied to
the saturated test section will be regulated and
measured. For the non-saturated sections a
tipping rain gauge will be used. Other
environmental data important in the
determination of evaporation will be available from the other research projects, I.E. wind
research opportunities - masonry project 4

Project #4 - Thermal Thru-Wall Units

OBJECTIVE OF STUDY

To determine the thermal characteristics of different concrete wall systems with and without insulation systems.

METHOD OF EVALUATION

A series (10) of side-by-side thermal test cells (8' x 8') will be constructed to investigate the thermal performance of discrete wall sections. The evaluation process will consist of temperature data taken within each cell plus mean radiant temperature. In addition to the thermal data being taken each test cell will be equipped with electric resistance heaters in which power consumption will be monitored. The electric resistance heaters will be thermostatically controlled with minimum dead band devices. The same control will be applicable for the cooling component of each test cell.

Environmental data will be taken in conjunction with the already mentioned data on a 5 minute interval. (See proj. #21 Monitoring/Data Acquisition) A representative wall from the thermal test cells will be configured in the middle bay of the research and demonstration facility. Comparative data will be taken between the discrete cells and the occupied building. This wall will be changed once during the two year monitoring period. At the end of the first year comparative data taken from the test cells will be used to select the wall to replace the full scale test panel.

INSTRUMENTATION

All temperature data will be taken with high impedance platinum resistive detectors (pRT) (1000 OHMS). These devices will be used throughout the thermal evaluation projects because of their accuracy and interchangeability. Mean radiant temperature will be taken by a black globe using a PRT as the detector element. Power consumption will be measured using clip-on ammprobes. The status of the cell thermostat will be monitored on a continuous basis.

TIME FRAME OF ANALYSIS

The duration of the test will run a minimum of 2 years with continuous data being taken.

PRODUCTS

http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj.html#4
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_sm/
Detail4_ThermWall_Constr_sm.gif
Project #5 - Thermal Break Ties For Cavity Wall Construction

OBJECTIVE OF STUDY

To investigate the thermal advantage of minimizing conductive transfer utilizing the thermal break tie. In addition to the thermal benefits the structural advantage of wind load transfer will be investigated. Time motion studies will be done to assess the productivity aspects of the three piece tie system.

METHOD OF EVALUATION

1. The thermal aspects will be investigated in a comparative analysis done in two thermal test cells. These side-by-side test cells will be of identical construction except for the type of tie system being used. Comparative temperature data will be collected on the wall assemblies in conjunction with heat flux measurements. The test cells will be heated and cooled to observe the influence of bi-directional heat flow.

2) Wind load transfer will be investigated using test sections identical to the construction types used in the thermal test cells. Simulated loading will come from a pressurized air bag.

3) Productivity assessment will be done using time marked videotape. Comparative areas will be identified in the research and demonstration facility in which a conventional tie system will be compared to the three piece tie system.

INSTRUMENTATION

Thermal test cells will be used to provide a temperature differential across the two test sections. A broad band infrared thermographic imaging system will be used to observe the isothermal zones of the test sections. This observation will be done at varying temperature differentials and recorded over time.

TIME FRAME OF ANALYSIS

The analysis will be conducted over the period of one year for the thermal test cells with thermographic imaging done during critical seasonal times. Discrete
Project #6 - Thermal Mass Characteristics Of CMU

OBJECTIVE OF STUDY

To determine the impact of thermal mass on the comfort conditions maintained in the Research and Demonstration Facility and to look at the influence of thermal mass and the thermal time lag characteristics on minimizing overall energy consumption.

METHOD OF EVALUATION

The method of evaluation will be similar to that described in project #4. Additional focus will be given to human thermal comfort conditions maintained in the facility using a predicted mean vote scale and a Fanger thermal comfort meter. The thermally interactive probe from the B&K Thermal comfort meter will be moved from location to location in the building on a weekly basis. The probe will be located in area #5 in the building for longer periods of time to look at the influence of the full scale thermal test panel. In addition, thermal comfort conditions will be investigated during periods of heavy internal heat gain caused by the occupancy of the auditorium. Immediately adjacent to the R&D facility, are located a series of metal buildings. Negotiations are being made to obtain access to evaluate them from a human thermal comfort standpoint. This information, in conjunction with energy consumption data will provide a point of comparison between two building case studies representative of a low mass building enclosure system and a high mass enclosure system.

INSTRUMENTATION

A B&K thermal comfort meter will be interconnected to a centralized data acquisition system that will also be monitoring thermal conditions in the space as well as the outdoor ambient conditions.

TIME FRAME OF ANALYSIS

One year

PRODUCTS

The reduced data will be presented in the form of the predicted mean vote of comfort mapped to different parts of the building. In addition comparative data will be represented for both of the building mass enclosure systems.

ESTIMATED PROJECT COST: $5K

REFERENCED LOCATION IN BUILDING
Project #7 - Undergraduate Waterproofing

OBJECTIVE OF STUDY

To look at moisture migration in building assemblies that represent typical residential basement conditions.

METHOD OF EVALUATION

A moisture differential will be generated across a representative below grade wall assembly. Moisture surface contact probes will be distributed across the face of the interior walls. Soil moisture probes will be used to assess the degree of saturation of the surrounding soil. In conjunction with the surface contact probes, infrared thermographic imaging will be used to assess moisture distribution as related to changes in thermal conductivity. Initially two wall assemblies will be tested side-by-side comparing the influence of surface treatments to retard moisture migration.

INSTRUMENTATION

A metered water flow head will be used to saturate a contained soil bed. The soil bed will be provided with moisture probes to insure a even moisture distribution across the face of the test wall sections.

TIME FRAME OF ANALYSIS

The duration of the study will be for a period of 6 months.

PRODUCTS

A report will be provided upon completion of the investigation relating moisture diffusion observed in the test sections.

ESTIMATED PROJECT COST: $8K

REFERENCED LOCATION IN BUILDING

The test area occupies the same location as the radon migration study area.

http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_sm/Detail8_Radon1_sm.gif
Project #8 - Radon Transmission Through Foundation Systems

OBJECTIVE OF STUDY

The purpose of this study is to observe the diffusion of radon gas through different foundation systems.

METHOD OF EVALUATION

A tracer gas that most closely approximates the diffusion characteristics of radon gas will be injected through a diffusion grid located adjacent to a candidate foundation system. The concentrations levels of the tracer gas will be sampled on a prescribed time interval and then analyzed using a gas chromatograph. The enclosure system in which the tests will be done will be able to be pressurized and depressurized to generate pressure differentials across the test area. A series of two foundation systems will be tested.

INSTRUMENTATION

Experimentation will be used to determine the final configuration for the diffusion grid. Reusable grab sample bags will be used to take samples of the air at prescribed intervals. The tracer gas concentration will be determined using gas chromatograph analysis techniques.

TIME FRAME OF ANALYSIS

9 months

PRODUCTS

A finished report showing the concentration levels related to different foundation system types at various pressure differentials across the building shell.

ESTIMATED PROJECT COST: $12K
Project #9 - Masonry And Metal Building Components Interface

OBJECTIVE OF STUDY

To investigate the structural - flexural aspects of masonry building components in conjunction with metal building parts. The primary emphasis will be on the connection of masonry to the metal spaceframe roof system.

METHOD OF EVALUATION

Points of movement in the spaceframe will be determined by the spaceframe manufacturer. These points in conjunction with the major bearing points between the spaceframe and the masonry support system will monitored over time.

INSTRUMENTATION

Linear absolute encoders (LVDT) that use a moving core differential transformer to determine position will be mounted at critical interface points between masonry and the metal spaceframe. Multiple data points will be recorded by a multi-channel data acquisition system. Comparative environmental data will also be available from the environmental monitoring module.

TIME FRAME OF ANALYSIS

The duration of analysis will take place over a period of one year with data reduced to critical times of seasonal variation. Diurnal cycles as related to temperature fluctuation and solar radiation variation will also be reported.

PRODUCTS

A report will be provided showing linear displacement between metal and masonry interface points and how that is related to major environmental forces experienced during critical seasonal times of the year as well as diurnal fluctuations.
Project #10 - Segmental Footing

OBJECTIVE OF STUDY
The primary objective is to investigate the productivity aspect of the segmental footing block. An additional objective is to look at uplift conditions between the segmental block and a wall system.

METHOD OF EVALUATION
A comparative time-motion study between will be conducted between the segmental footing and a conventional poured foundation system. The segmental system will be represented by the foundation in the Research and Demonstration facility with the conventional poured foundation represented by the solar test cells.

A discrete test section independent of the proposed buildings will be fabricated to investigate upload conditions. A hydraulic cylinder equipped with a load cell will be used to simulate uplift conditions. LVDTs will be used to record the vertical displacement as related to multiple uplift loads generated by the hydraulic cylinders.

INSTRUMENTATION
The time-motion analysis will be done using time-marked videotape. LVDTs will be used in conjunction with the appropriate interface modules to record vertical displacement on the data acquisition system.

TIME FRAME OF ANALYSIS
The duration of the time-motion study is directly related to the beginning of the Research and Demonstration facility foundation construction. The foundation for the solar test cell will also be done during the same three month time frame. The testing of the discrete wall/foundation will also be done during a three month time interval.

PRODUCTS
Images will be due to comparing the comparison.

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http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj.html#10
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_sm/Detail10_SegFng_Promo2_sm.gif
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_sm/Detail10_SegFng_Constr1_sm.gif
Project #11 Suspended Block Floor System

OBJECTIVE OF STUDY

To investigate the structural attributes of a suspended block floor system and to develop a system that will allow composite interaction of the system components. In addition to the aforementioned components, time-motion studies will be performed on the installation of the flooring system in the Research and Demonstration facility.

METHOD OF EVALUATION

A series of test sections will be constructed and subjected to a point load. Deflection will be measured at three locations along the test section. This will be used to determine an effective modulus of elasticity for the test component. Individual components of the composite assembly will be tested to determine their crushing strength. The joist will also be tested in tension and compression.

INSTRUMENTATION

Hydraulic cylinders will be used to load the different test sections. LVDTs will be used to measure the deflection during different loading conditions. High resolution videotapes will be recorded for the different test sections. These tapes will then be video digitized and analyzed using X-Y software measurement techniques. The specimens under test will be provided with reference targets that will become the measurement points for the analysis.

TIME FRAME OF ANALYSIS

The time-motion study will be conducted during the construction period of the R&D facility. The structural tests will be conducted upon receipt of the suspended block floor system. The existing Price’s Fork Research Center Environmental Systems Laboratory will be used to test the floor system components. Duration of the analysis will be 9 months.

PRODUCTS

The results of the structural testing will be used to produce a Design Manual.
Project #12 - Formwall Investigations

OBJECTIVE OF STUDY
To investigate the productivity and constructibility aspects of the Formwall system and to determine the maximum number of pours that can be made in a vertical direction.

METHOD OF EVALUATION
A free-standing experiment will be conducted independent from the R&D facility to investigate the maximum number of vertical pours that can be accommodated by the Formwall system. A reference frame will be constructed around the test sample to provide a point of measurement to observe movement during pours. Particular attention will be given to investigating the overturning moment as the formwork is filled.

INSTRUMENTATION

TIME FRAME OF ANALYSIS
These experiments will be conducted over a period of 9 months with the start date being after the completion of the Research and Demonstration Facility.

PRODUCTS
The products will include a design manual that will provide recommendations made for the maximum number of pour heights. Included with the design manual will be a videotape archive showing how the forming system can be used.

ESTIMATED PROJECT COST: $10K

REFERENCED LOCATION IN BUILDING
This will be a free-standing experiment done in a space that can accommodate the vertical access height required to determine the maximum number of pours for the system. There are two possible locations to conduct the experiment, one being in the High-Bay test area located in the existing Environmental System Laboratory the other being in the Building Construction lab located in the Research and Demonstration facility. The possibility of using the segmental footing system in conjunction with the Formwall system is also being considered.

FACULTY CONTACT: Jerry Householder, Building Construction

http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj.html#12
Project #13 - Cladding / Block Veneer System

OBJECTIVE OF STUDY

To investigate the constructiblity and productivity of the cladding/block veneer system. In addition, the water penetration and thermal performance aspects of the veneer system will be evaluated.

METHOD OF EVALUATION

Time-marked videotape will be taken of the cladding system during the construction phase of the Research and Demonstration Facility.

The water penetration tests and the thermal performance analysis will be conducted in the isolated thermal test cell area. An eight foot square test section will be subjected to a combination of air pressure and water spray. The simulated wind driven rain will be represented by a fan module the equivalent area of the test section. A grid of water spray points will occur downstream of the fan module. The speed of the fan will be varied to represent different wind driven rain conditions. Moisture penetration detection in the test sample will be measured by using implanted moisture conductivity probes will be distributed throughout the wall section. Continuous thermographic measurements of the internal wall face will be recorded to videotape during the testing interval. This data will indicate moisture saturation due to increased thermal conductivity. The moisture penetration test will be done towards the end of the thermal evaluation of the test sample to investigate how moisture penetration influences overall thermal characteristics.

The thermal analysis will be conducted in the test cell area. See Project #4 for a description of how the thermal testing will be performed. Simultaneous temperature measurements will be taken from the exterior wall of the middle bay in the Research and Demonstration Facility. This wall represents the same type of construction found in the thermal test cell. Comparisons of thermal data set will be made with the test cell representing a set of controlled interior conditions versus the R&D facilities varying load profile.

INSTRUMENTATION

In conjunction with the thermal analysis equipment described in Project #4, a variable speed wind driven water spray module will be constructed. This device will be mounted on a horizontal track system that will move parallel to the face of the thermal test cell area. This will allow water penetration tests to be conducted on any test wall section. Over spray will be carefully controlled so as not to interfere with adjacent thermal test sections.

TIME FRAME OF ANALYSIS

http://www.caus.vt.edu/CAUS/FACILITIES/rdf/opport/materials_proj.html#13
Project #14 - Acoustical Absorption + Transmission Characteristics Of The Biaxial Block

OBJECTIVE OF STUDY

To investigate the absorption - reveralation time constant of the Biaxial Block with face openings filled with an acoustically absorptive material. In addition to the absorption / reverberation characteristics of the block, sound transmission attributes will also be investigated.

METHOD OF EVALUATION

A test wall located at the back of the auditorium in the Research and Demonstration facility will be constructed of Biaxial Block with 4" face openings. An absorption / reverberation evaluation will be done with the face openings plugged with a masonry insert and then evaluated using an acoustically absorptive insert. Sound transmission characteristics of the Biaxial wall will also be evaluated using a sound source on one side of the wall and measuring the attenuation on the opposite side. Multiple conditions will be tested representing different inserts of varying acoustical absorptivity.

INSTRUMENTATION

A random noise generator, frequency analyzer and level recorder will be used during the evaluation.

TIME FRAME OF ANALYSIS

The duration of the test will be for 4 months. The analysis will start upon completion of the auditorium space in the Research and Demonstration Facility.

PRODUCTS

A report will be produced that describes the acoustical characteristics of the Biaxial Block with and without acoustical insert material.

ESTIMATED PROJECT COST: $8K

REFERENCED LOCATION IN BUILDING

http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_proj.html#14


Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/materials_sm/Detail14_AcoustWall_sm.gif
research opportunities - masonry project 15

Project #15 - Development Of A Concrete Masonry Interior Flexible Partition System

OBJECTIVE OF STUDY

To investigate the constructibility aspects of a concrete masonry flexible partition system.

To develop a set of post-tensioning details that would be appropriate for a flexible wall system.

To develop a set of details that would allow the wall system to become a means of air distribution for a radiant panel for heat distribution or heat absorption.

METHOD OF EVALUATION

The evaluation component of the constructibility aspect would be one of videotaping the erection sequence of the partition system. The thermal analysis would evaluate the resultant human thermal comfort conditions maintained by a vertically positioned radiant release thermal partition system. In addition to the thermal data collected, there will be questionnaires handed out to the occupants to assess their perception of comfort in the space.

INSTRUMENTATION

For the constructibility aspects of the system a time-marked videotape will be recorded. The thermal evaluation component will be done with a Fanger Human Thermal Comfort Meter.

TIME FRAME OF ANALYSIS

The duration of the test will be for one year.

PRODUCTS

A report describing the details of the post-tensioning system that was developed will be provided. A report summarizing the resultant thermal environment for a heated or cooled radiant release panel will also be submitted.

ESTIMATED PROJECT COST: $6K

REFERENCED LOCATION IN BUILDING

These will primarily be the wall systems that forms the corridor for the R&D facility. The areas that will be evaluated from a human thermal comfort standpoint will be the student...
Project #16 - Roof Pavers

OBJECTIVE OF STUDY

To investigate the water run-off characteristics of the roof paver block system as well as investigate the thermal transmission properties of this particular roof ballast system.

METHOD OF EVALUATION

Water run-off studies will be conducted on the Research and Demonstration Facility roof. The roof will be subdivided into two discrete test sections of equivalent area. One section will be comprised of the roof paver system while the other will be covered with conventional roof ballast rock. Each section will be connected to a discrete roof drainage pipe equipped with a water flow gauge. Water run-off from each system will be compared to a roof mounted reference rain gauge. The water flow gauges as well as the rain gauge will be interconnected to a data acquisition system that will provide continuous data collections during periods of rainfall. The rate of rainfall as well as the quantity of rain will be compared to the rate of drainage from the roof paver ballast and the conventional rock ballast.

Thermal transmission characteristics of the roof ballast system will be evaluated in the thermal test cell area. Two test cells of identical area and construction will be evaluated with one utilizing rock ballast and the other the roof paver block. Roof surface temperature as well as a temperature profile will be taken through each roof section. Interior test cell temperature, mean radiant temperature and input energy to the space conditioning system will be monitored. This data will be compared to the data collected from the environmental module providing information on the impact of solar radiation on the different surfaces.

INSTRUMENTATION

In addition to the sensor data used for the thermal test cell evaluation (see description in Project #4), a paddle water flow gauge will be required for each test section. A tipping bucket rain gauge (part of the outdoor environmental parameter module) will be used to...
Project # 17 - Electrical + Mechanical Distribution Attributes Of The Biaxial Block

OBJECTIVE OF STUDY

To validate the original concepts of integrating plumbing and electrical wiring in the Biaxial Block related to a full-scale building context. In addition to this aspects of constructibility and productivity will be investigated.

METHOD OF EVALUATION

All aspects of utility integration will be recorded with a time-marked videotape system. Comparative data will be collected from installations methods of conventional services. For example, the time involved with running electrical wiring in the Biaxial Block and terminating it at a junction box will be compared to making a comparable run in electrical conduit. Every effort will be made to maintain an equitable comparison between the two systems, i.e. the work crew will be the same, accessibility from work height will be the same and variations due to experience in working with the Biaxial Block will try to be eliminated by using a comparison done towards the end of the learning curve. The method for the comparative analysis of plumbing will be done in a comparable fashion.

INSTRUMENTATION

Time-marked videotape will be the primary analysis tool.

TIME FRAME OF ANALYSIS

The duration of the test will be directly tied to the construction schedule of the Research and Demonstration Facility and it is anticipated that it will occur in the last two months of the six month construction schedule.

PRODUCTS

Information from phase one of the Biaxial Block study will be included with the information from this
Research opportunities - Masonry Project 18

Project #18 - Concrete Masonry Units As Integral Air Distribution + Radiant Release Space Conditioning Components

Objective of Study

To investigate the potential of a concrete masonry floor system as a means for distribution of conditioned air and as a mechanism of radiant transfer (heating and cooling) to thermally condition space.

Method of Evaluation

A comparative analysis will be performed on two adjacent spaces in the Research and Demonstration Facility. One of the spaces will be equipped with a conventional forced air distribution system while the other will be equipped with a radiant release floor system. Both spaces will be evaluated from a thermal comfort standpoint as well as energy consumption required to maintain the spaces at predetermined set-points. The comfort analysis will be done utilizing the Fanger Thermal Comfort Analysis method. Continuous data will be collected from a B&K Thermal Comfort Meter interconnected to a data acquisitions system. In addition to the predicted mean vote scale (PMV) of thermal comfort, individual environmental parameters that influence comfort will be recorded. Those parameters include; dry bulb temperature, wet bulb temperature, air velocity, and mean radiant temperature. Power consumption for space conditioning for each space will be individually monitored. Each space will be evaluated from both a heating and cooling standpoint.

Air velocity readings will be taken throughout the air floor distribution system to provide information on the pressure drop that occurs throughout the system. In addition to the air velocity readings, the thermal distribution of the conditioned air stream and its influence on the surface temperature of the masonry floor system will be mapped using a thermographic imaging systems.

Prior to the construction of the radiant release wall and floor system a test assembly of equivalent construction and area will be fabricated to predetermine the manifold arrangement between the flexible partition system and the floor system. Internal airflow distribution for the floor system will be investigated to achieve even temperature distribution and balanced flow. Air velocity profiles and thermographic imaging will be used to determine these parameters experimentally.

Instrumentation

http://www.caus.vt.edu/CAUS/FACILITIES/rdf/opport/materials_proj.html#18
Image: http://www.caus.vt.edu/CAUS/facilities/rdf/opport/materials_sm/Detail18_AirDistr_sm.gif
Project #19 - CMU Floors On Grade

OBJECTIVE OF STUDY

To investigate the competitiveness and practicality of concrete masonry units as a flooring system.

METHOD OF EVALUATION

Time-marked videotape will be used to record the installation of the various concrete masonry flooring systems in the Research and Demonstration Facility. Test panels will be constructed investigating various floor coverings to be used in conjunction with concrete masonry. Specific bedding arrangements will be investigated as to their appropriateness. These test sections will be subjected to accelerated wear induced by uniformly distributed and point loads. Contact adhesives for bonding floor coverings and cementitious coatings will also be investigated.

INSTRUMENTATION

A test assembly will have to be fabricated to provide accelerated loading for the test samples. Cycling hydraulic cylinders will be used to introduce the uniform and point loads.

TIME FRAME OF ANALYSIS

Duration of this investigation will be 4 months.

PRODUCTS

A design manual that suggests appropriate floor coverings for concrete masonry units. An edited videotape will be provided that describes the installation of the CMU flooring systems.

ESTIMATED PROJECT COST: 8K

REFERENCED LOCATION IN BUILDING

All areas that contain CMU flooring systems.

FACULTY CONTACT: To be determined.
research opportunities - alternative energy systems

http://www.caus.vt.edu/caus/facilities/rdf/opport/altenergy.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/altenergy_bnr.gif
description of research opportunities in building and environmental sensors at r+d
research opportunities - glazing systems

http://www.caus.vt.edu/caus/facilities/rdf/opport/glazing.html

Image: http://www.caus.vt.edu/caus/facilities/rdf/opport/glazing_bnr.gif
research opportunities - indoor air quality

description of research opportunities in indoor air quality at r+d

http://www.caus.vt.edu/CAUS/FACILITIES/rdf/opport/indexopport.html

Image: http://www.caus.vt.edu/CAUS/facilities/rdf/opport/iaq_bnr.gif
research opportunities - other

description of research opportunities in other areas at r+d

BACK
Building trades and suppliers have embraced the Research + Demonstration Facility as a unique opportunity to participate directly, in a "hands-on manner," with building related research. Over 47 local and national suppliers have contributed more than $350,000 in donated materials. This material has been carefully integrated and coordinated into a cohesive, yet expressive facility. Many of the products are being used for the first time and will be available for the suppliers and their clients to visit and see the products in use.

Use the clickable areas above to learn more about materials and financial contributors for the research + demonstration facility. You can also find more information on the architectural "dream team" assembled to design the facility. There is also information on the design and creation of this web site.

http://www.caus.vt.edu/caus/facilities/rdf/credits/indexcredits.html
Frame: http://www.caus.vt.edu/caus/facilities/rdf/credits/navcredits.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/credits/nav_credits.gif
Frame: http://www.caus.vt.edu/caus/facilities/rdf/credits/credits.html
Image: http://www.caus.vt.edu/caus/facilities/rdf/credits/contrib_bnr.gif
materials contributors

The faculty of the College of Architecture + Urban Studies would like to thank the many people and companies that contributed materials for construction of the Research + Demonstration Facility. Without these contributions, the facility would not have been possible.

Download a complete spreadsheet (33k Microsoft Excel .xls decompressed) of materials contributed and by whom. Choose the compressed file that best suit your computers ability to decompress it. All files were compressed on a Macintosh - ZipIt 1.2 was used for the .zip file, Stuffit Classic 1.6 was used for the .sit and .hqx files.

Material Contributors.xls.hqx I Material Contributors.xls.sit
Material Contributors.xls.sit.hqx I Material Contributors.xls.zip

Financial Architects Web site BACK
financial contributors

The faculty of the College of Architecture + Urban Studies would like to thank the many people and companies that contributed financially towards construction of the Research + Demonstration Facility. Without these contributions, the facility would not have been possible.

Virginia Tech Research Division

Johnson Controls
H.C. Yu
Skylight Manufacturing, Inc.

Philip Morris, USA

Mero Structures, Inc.
W.P. Hickman + Co.
Betco Block + Products Co.

National Concrete Masonry Association

Optical Cable Corp.
Carlisle Rubber Inc.
Bluestone Block Inc.

College of Architecture + Urban Studies

contributors - architects

The Research + Demonstration Facility was designed by three members of the College of Architecture + Urban Studies faculty in the late 1980’s. These architects are distinguished educators and researchers as well as award winning designers.

**Contributors**

- Professor Robert P. Schubert
  silven@vt.edu

CAUS Assistant Dean for Research + Public Service

- Professor A. J. Davis
  davisa@vt.edu

Chair, Architecture Undergraduate Professional Program

- Associate Professor William U. Galloway
  galloway@vt.edu

Architecture, Professional Program Faculty

Click on their respective names to view more information about them or on their e-mail address to contact them.
web site

This web site was designed and constructed by Tim Colley in 1996-1997 to partially fulfill academic requirements towards a Master of Science in Architecture degree with a concentration in Building Science at Virginia Tech in the fall of 1997. Tim also received his Bachelor of Architecture degree from Virginia Tech in 1994.

The decision to design a web site for the research + demonstration facility as a thesis project was made to help educators teach future architects, in a more interactive and dynamic medium, about evolving architectural research and technology as well as potential consequences of design decisions. Educators will be able to conduct online research, or tele-experiments, in the classroom allowing students to learn, in near real-time, the outcome or progress of conducted research both on- and off campus. Graduate thesis committee members from the College of Architecture + Urban Studies are:

Professor Robert P. Schubert, Chair
Associate Professor Michael J. O'Brien
Associate Professor William U. Galloway.

If you have any questions or comments about the web site or content contained within, please feel free to contact Tim and he will be glad to answer any questions or redirect them to the appropriate person for a satisfactory response. Acknowledgements

I materials I financial I architects I BACK I
The Research + Demonstration Facility (RDF) web site project provides accessibility to all available web page documentation. This book provides a point of reference for future maintenance and updates to the web site. As new projects and information are added to the site, documentation of new content will need to be recorded in this book. Complete page information including embedded hyper-links, associated images, active Uniform Resource Locators (URL), and other details are vital for continued successful and intuitive organization of the web site. Strict adherence to the web page format established will increase future maintainer’s ability to sustain the level of quality and clarity produced. The RDF web site companion guide exists for others to view and use to maintain a coherent and somewhat uniform web presence.

All files presently linked to the web site are included on the accompanying CD-ROM. With Netscape Communicator 4.0 browser installed on the CD, the user can launch the RDF web site locally, however, access to outside links are not available unless the user is connected to a network or modem allowing Internet accessibility (using the CD installed version of Netscape Communicator requires using an Apple Macintosh). The CD contains original versions of images saved in Adobe Photoshop 4.0.1 format (saved as xxx.ps4.0.1 where xxx is the rest of the file name) allowing for alterations to existing banners, images, or navigation map images. Photoshop 4.0.1 format retains image layer information therefore, making it easier to manipulate certain characteristics within images.

There are areas in the web site that allow for the inclusion of future project information. This expandability leads to one of the more important attributes of the RDF site, to serve as an archive of research by students and faculty. This project provides a place for students and faculty to record and provide valuable architectural research information. Placeholder pages exist that include all navigational aids necessary to maneuver through the site. Some of the research areas with placeholders include:

- Test Cell Experiments
- Indoor Air Quality
- Remote Sensing
- Glazing Systems
- Alternative Energy Systems
- Building Sensors
- Energy Usage

This built-in expansion makes adding information much easier. Refer to the Design Guidelines section on page three for additional web page creation criteria. The RDF site is divided into six main areas; introduction, what’s new, facilities, research projects, research opportunities, and contributors. There are folders representing each area with the exception of the introduction - see Appendix A for a complete list of files and folders. Presently, all files and folders are accessed on the College of Architecture + Urban Studies server at Uniform Resource Locator (URL) http://www.caus.vt.edu/caus/facilities/rdf/index.html. Web site files are located in the CAUS WWW Server>WebSTAR>CAUS>FACILITIES>rdf folder. The current college server is an Apple Macintosh 8500/120 PowerPC computer running WebSTAR 2.1 Internet access software. All web pages were created on Apple Macintosh or Macintosh clone.
computers.

Future Considerations

The current web site was created using hard coded HyperText Markup Language (HTML) for all pages. This project’s potential exists in its ability to incorporate more interactivity and dynamism by using database served information. A database front end provides flexibility by making the site searchable and easier to update. Static HTML is more time consuming than adding new database delivered information. Database delivery is more efficient by calling on information from other computers thus freeing the server from having to maintain all information. This project does not utilize a database format because previous database centered web sites have relied on refined programming skills. Evolving software is making the conversion of HTML to database served information much easier and faster.

Another advance in software includes making animations easier to use in web sites. Limitations due to present telecommunications bandwidth constraints make delivery of large animations and movies too time consuming to download. The RDF web site will benefit from proper use of interactivity by using new software. Javascript is a software development tool enabling more interactivity within web pages and can enhance the RDF web site by providing a more interactive interface for experiments. Students could watch photovoltaic voltage changes or a rain gauge fill up during a rain storm - all from a computer screen. These are just a few examples of where advanced software tools can strengthen a concept by improving the interface.

Possibilities have been presented for the future direction of this project. Currently, these recommendations coincide with the needs of the college, however, predicting future hardware and software capabilities, research priorities, or funding sources is an impossible task. The Research + Demonstration Facility web site will become a tool that evolves and progresses with the college and its research agenda.
Appendix A provides the complete research + demonstration facility web site directory and file structure information. This list contains the files used in the web site. Consult the downloadable rdfsite.pdf file from the introduction/site structure section of the web site for an Adobe SiteMill 2.0 generated list of files and anchors within the files. The names in red are the main folders located on the left navigation frames of the web pages.

**rdf folder**

- BGEssay.html
- BGScarpaGate.gif
- BGVerumFactum.gif

**credits**

- contrib_bnr.gif
- credits.html
- fin_contrib.gif
- indexcredits.html
- mat_contrib.gif
- Mat_Contrib.xls.hqx
- Mat_Contrib.xls.sit
- Mat_Contrib.xls.sit.hqx
- Mat_Contrib.xls.ZIP
- navcredits.html
- nav_credits.gif

**default1_bnr.gif**

**facilities**

- 3d.html
- 3d_bnr.gif
- 3d_ne.JPEG
- 3d_ne_sm.gif
- 3d_plan.JPEG
- 3d_plan_sm.gif
- 3d_sw.JPEG
- 3d_sw_sm.gif
- Biaxial_block_sm.gif

**details**

- Detail10_SegFtng2.gif
- Detail10_SegFtng_ad.gif
- Detail11_SuspFir.gif
- Detail11_SuspFir_dwg.gif
- Detail14_AcoustWall.gif
- Detail14_AcoustWall2.gif
- Detail16_roofpavers.gif
- Detail16_RoofPaver_ad.gif
- Detail16_RoofPaver_Sect.gif
- Detail17_BiAxElect.gif
- Detail17_BiAxElect_Dwg.gif
- Detail17_BiAxPlumb.gif
- Detail18_AirDistr.gif
- Detail1_GrdPaver_Types.gif
- Detail1_GrdPvr.gif
- Detail2_solidpaver.gif
- Detail3_drystack.gif
94_01jan.zip
94_01jansum.sit
94_01jansum.sit.hqx
94_01jansum.zip
94_02feb.sit
94_02feb.sit.hqx
94_02feb.zip
94_02febsum.sit
94_02febsum.sit.hqx
94_02febsum.zip
94_03mar.sit
94_03mar.sit.hqx
94_03mar.zip
94_03marsum.sit
94_03marsum.sit.hqx
94_03marsum.zip
94_04apr.sit
94_04apr.sit.hqx
94_04apr.zip
94_04aprsum.sit
94_04aprsum.sit.hqx
94_04aprsum.zip
94_05may.sit
94_05may.sit.hqx
94_05may.zip
94_06jun.sit
94_06jun.sit.hqx
94_06jun.zip
94_06junsum.sit
94_06junsum.sit.hqx
94_06junsum.zip
94_07jul.sit
94_07jul.sit.hqx
94_07jul.zip
94_07julsum.sit
94_07julsum.sit.hqx
94_07julsum.zip
94_08aug.sit
94_08aug.sit.hqx
94_08aug.zip
94_08augsum.sit
94_08augsum.sit.hqx
94_08augsum.zip
94_09sep.sit
94_09sep.sit.hqx
94_09sep.zip
94_09sepsum.sit
94_09sepsum.sit.hqx
94_09sepsum.zip
solarh2oSum.xls
solarh2oSum.xls.hqx
solarh2oSum.xls.sit
solarh2oSum.xls.zip
solarh2o_site.gif
tcells_map.gif
projects.html
projects_Bnr.gif
proposal.html
rdfsite.html
rdfsite.pdf
rdfsite_index.html
rdfsite_sets
contrib_arch.html
contrib_financial.html
contrib_materials.html
contrib_web.html
fac_3d.html
fac_3d_anim.html
fac_3d_ne.html
fac_3d_norof.html
fac_3d_sw.html
fac_details.html
fac_dxf.html
fac_dxf_plans.html
fac_elev.html
fac_elev_e.html
fac_elev_n.html
fac_elev_s.html
fac_elev_w.html
fac_equip.html
fac_equip_shop.html
fac_equip_test.html
fac_plan.html
fac_plan_main.html
fac_plan_site.html
fac_section.html
fac_section_ew.html
fac_section_ns.html
fac_tcells.html
fac_tcells_elev.html
fac_tcells_plan.html
fac_tcells_sect.html
fac_thumb.html
opport_altenergy.html
opport_glazing.html
opport_iaq.html
opport_materials.html
opport_materials_11.html
opport_materials_17.html
opport_other.html
opport_sensors.html
proj_archives.html
proj_offsite.html
proj_offsite_other.html
proj_offsite_remote.html
proj_offsite_solarh2o.html
proj_onsite.html
proj_onsite_energy.html
Appendix B lists all of the hardware and software used to design and construct the research + demonstration facility web site and this document. Appendix B also contains information on how to perform a Drop Shadow effect on an image using Adobe Photoshop 4.0.1.

Hardware And Software Used

Software:
Netscape Navigator 3.0 - Internet browser
Netscape Communicator 4.0.1 - Internet browser
Microsoft Internet Explorer 3.0 And 4.0p1 - Internet browser
Adobe PageMill 2.0 - WYSIWYG html software
Adobe SiteMill 2.0 - web site analyzer software
Adobe Acrobat 3.0 - pdf file creator and reader
WebOutliner 1.0.1 - analyzes web site and creates an outline html file
HTML Markdown 2.0 - removes html tags and converts to text file
HTML Editor 1.1.2 - creates and edits html pages
Adobe Photoshop 4.0.1 - image manipulation software
Adobe PageMaker 6.5 - desktop layout and publishing software
Aldus Fetch 1.0 - image database creator
Microsoft Word 6.0.1 - word processing software
Microsoft Excel 5.0 - spreadsheet software
AutoCAD R12c3 - computer aided design software
MicroStation 95 - computer aided design software
Aladdin Systems Stuffit Classic 1.6 - file compression software
ZipIt 1.2 - file compression software
JPEGView 3.3.1 - image conversion software
GraphicConverter 2.2.2 - image conversion software

Hardware:
Macintosh Computers
Power Computing Computers ( Macintosh Clones)
SyQuest EZ135, 44, 88, And 200 Mb Removable Media Storage Devices
Apple Flatbed Scanners
Nikon Coolscan and LS-3510 Slide Scanners
Apple Quicktake Digital Cameras
RasterOps 364 Video Capture Board
Fuji 8mm Video Camera
Drop Shadow in Adobe Photoshop

4.0.1 Instructions

To perform a Drop Shadow Action on an image follow the instructions in Photoshop for creating a new Action then use the image to the right as a guide to create the Drop Shadow. (the image is continued on the next page)
Drop Shadow Instructions - continued
McClelland, Deke, and John San Filippo.
PageMill 2 for Dummies.

Lemay, Laura.
Web Publishing with HTML.

McCluhan, Marshall, and Quentin Fiore.
The Medium Is The Massage.

Teague, Jason Cranford.
How to Program HTML Frames.

Tufte, Edward R..
Envisioning Information.

Wurman, Richard Saul.
Information Anxiety.
vita

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Blacksburg, Virginia

1994  Bachelor of Architecture
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Blacksburg, Virginia

experience
September 1996  College of Architecture + Urban Studies
August 1997  Virginia Polytechnic Institute + State University
Blacksburg, Virginia
Instructor, Digital Technologies

August 1994  College of Architecture + Urban Studies
May 1996  Virginia Polytechnic Institute + State University
Blacksburg, Virginia
Graduate Assistant

1995  Ewing Construction
May - August  Blacksburg, Virginia
Designer and Carpenter

1994  Marshall Erdman + Associates
February - July  8550 Cinder Bed Road, Suite 1300
Newington, Virginia
Architectural Designer

April 1986  General Electric Company, Aerospace Division
August 1990  8080 Grainger Court
Springfield, Virginia
Electronics Technician

March 1982  United States Army
March 1986  The White House Communications Agency
The White House/Old Executive Office Building
Washington, D.C.
Senior Satellite/Radio Technician