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Building Safety JOURNAL

THE PROFESSIONAL JOURNAL OF CONSTRUCTION AND FIRE SAFETY

ICC INTERNATIONAL CODE COUNCIL®

May/June 2004

- Straw-Bale Construction
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Alternative Materials and Methods of Construction

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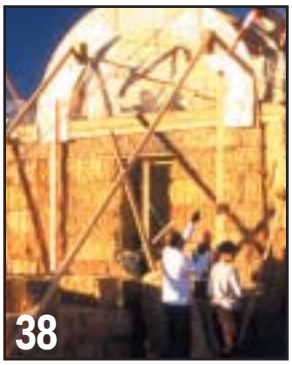
Alternative Materials and Methods of Construction



Setting the Standard for Building Safety

BY ANNE R. VONWELLER

"Setting the Standard for Building Safety" is a phrase that ICC prints on letterhead, embroiders on hats and streams across banners. We identify with it so strongly that we registered it as an ICC trademark. A worthy mission it is, and a substantial one.

How do we approach such an undertaking from a truly "International" viewpoint? Are the solutions the same for us in the U.S. as for emerging nations? Is safe, affordable housing according to U.S. standards achievable in the majority of the world? Are there more sustainable ways to regulate construction here? What is the future role of the code community in facilitating alternative, appropriate technology? These are complex questions which will take time to answer. Hopefully, this issue of *Building Safety Journal* will provide some constructive contributions to the discussion.

Among the articles in this issue is an update on straw-bale construction by California structural engineer Bruce King, who has the distinction of having written an article on the subject that was published in the first-ever feature on alternative materials to appear in a model code group magazine in September 1998. That first feature not only initiated a valuable trend of providing access to information outside the current mainstream, but also provided a different frame of reference within which to consider our work and responsibilities.

There is a common thread running through the articles on alternative materials, green building and the Global Policy Summit on Performance-Based Building Regulations featured in this issue and through most of the related features and articles published since 1998. That thread is the influence of a small, non-profit organization in Tucson, Arizona: the Development Center for Appropriate Technology (DCAT). DCAT's contribution to the codes community hasn't been limited to its work with our publications, but extends to a deeper kind of influence which helps reconnect us with why we do this work.

My first direct experience with DCAT occurred in St. Louis five years ago while attending an educational session by Bob Fowler and David Eisenberg entitled "Building Sustainability Into the Codes." David's work had a profound impact on Bob, and together their presentation dramatically affected the way I would think about the future of building construction. I now consider connections, responsibilities and unintended consequences of "business as usual" that I never did before. That broader sense of context informs David's recurring *Building Safety Journal* column, "Building Codes for a Small Planet," and was no less apparent at a summit held in Washington, D.C., last November on the subject of performance-based building codes.

Brian Meacham has contributed an article about the summit, the official title of which was "The Global Policy Summit on the Role of Performance-Based Building Regulations in Addressing Societal Expectations, International Policy and Local Needs." While the name did not exactly lend itself to a catchy acronym, the conference itself was outstanding. With a diverse group of nearly 100 experts on codes and regulations, risk, and global trends, we were treated to two and-a-half days of informative and often thought-provoking perspectives from around the world. James Lee Witt served as a keynote speaker, and I was honored to have the opportunity to give a presentation.

In his comments during the closing of the summit, David Lucht of Worcester Polytechnic Institute again connected to DCAT, stating that after three decades in the industry, David Eisenberg's presentation had recalibrated everything for him. Along with another presentation from South Africa, David had illuminated a set of issues that we in the U.S. don't typically consider, but which seriously impact everyone everywhere.

Among the things that David pointed out in his presentation was that the work DCAT carries out is based on deeply conservative values. In fact, he included a quote from the 18th-century British philosopher and statesman, Edmund Burke, who is widely recognized as the father of modern conservatism. Burke believed that conservatism was based on a "societal contract" between "those who are living, those who are dead, and those yet to be born." He saw this as an essential partnership because the aims of science and art cannot be achieved without deep regard both for past generations and those who will follow.

David cited another quote that I thought was especially relevant to our work in safeguarding the public health, safety and welfare: Burke believed that government or any other entity "possessing any portion of power ought to be strongly and awfully impressed with an idea that they act in [the public] trust." We all must remind ourselves of that reality as we go through our day-to-day challenges, balancing the interests and welfare of our communities today with those interests in the future, with deep regard for what we have inherited from those who have gone before.

Green Building Resource Update

by Tony Novelli, Assistant Director,
Development Center for
Appropriate Technology

When I joined David Eisenberg and the Development Center for Appropriate Technology (DCAT) just over six years ago, I embarked on an educational experience that I had hardly thought possible. Since the Planning Summit for Sustainable Building Codes that DCAT spearheaded back in 1997, there has been phenomenal growth in everything related to green building.

Here at DCAT, we are embedded within several related circles of activity dealing with sustainability and the built environment, and we thought it would be useful to give the readers of *Building Safety Journal* an updated list of resources in this field to help you deal more effectively with green projects and alternatives that come before your jurisdiction. Our goal is to point you toward some of the best resources that we know of in the hopes of helping you play an even more beneficial role in the crucial shift toward sustainability.

The continued interest in green building is illustrated by the results of a recent survey published in the March 2004 issue of *Environmental Design+Construction* magazine in which 85 percent of respondents anticipated that their firms would pursue U.S. Green Building Council LEED™ certification at least occasionally, with 60 percent indicating that they would do so "frequently" or "somewhat frequently." Energy guarantee programs and residential green building programs are popping up all over the nation, and it is challenging to stay abreast of the steady stream of new products and technologies. There is truly a green revolution taking place.

Another growing trend is the connection between green building and the field of building science. A number of the resources included here represent the "green" aspect of greater durability, indoor air and environmental quality, and integrated design using a whole-building approach—much of which has been greatly informed by research and advances in building science.

As more integrated design of buildings moves to the forefront, it is rapidly becoming clear that aside from energy savings and lowered environmental impacts, many of these approaches can yield equivalent or lower "first costs" when considered from the start of the design process. Many large national builders are successfully demonstrating the viability of building science-driven systems, thereby dramatically improving performance with minimal and sometimes beneficial cost impacts. The U.S. Department of Energy's Building America Program is a great starting point for information on this subject.

Before moving on to the list of resources, let me point out a few things. First, a fully comprehensive list of such resources would fill this magazine cover-to-cover. What we have provided is only intended to serve as a representative sample in order to provide some background information and contacts to help you find out more about specific subjects. Second, a great deal of this information is web-based but phone numbers are also listed when available. Finally, we are devoting a special section of the DCAT web site to links to these organizations and direct access to reports. Just go to *www.dcat.net* and click on "Resources."

We hope that this issue of *Building Safety Journal* offers a clear view into what's happening on the green building front. Investing some time in exploring these resources will leave you with both more information and more questions. We also think it likely that seeing the growing wealth of interest and information in the shift to more sustainable design, building and development will leave you with more hope about the positive changes taking place in the building industry. ◆

Thanks to Bill Christensen at Sustainable Sources (web site www.greenbuilder.com*) for his assistance in compiling the following list of resources. If you feel that we missed a valuable reference, feel free to forward the information to* anovelli@aol.com *for future inclusion.*

Green Building Programs

Governmental

U.S. Department of Energy Center for Excellence for Sustainable Development—web site *www.sustainable.doe.gov.*

Alameda County Waste Management Authority—Alameda County, California; phone (510) 614-1699; e-mail *wsommer@stopwaste.org*; web site *www.stopwaste.org/fsbuild.html*.

Bay Area Build It Green—Northern California; e-mail *info@build-green.org*; web site *http://build-green.org*.

Austin Energy's Green Building Program—Austin, Texas; web site *www.ci.austin.tx.us/greenbuilder*.

Build a Better Clark—Clark County Home Builders Association, 5007 NE St. Johns Rd., Vancouver, WA 98661; phone (360) 694-0933; e-mail *Leiko@biasw.org*; web site *www.cchba.com/build_a_better_clark_page.htm*.

Build a Better Kitsap—Kitsap County Home Builders Association, 5251 Auto Center Way, Bremerton, WA 98312; phone (360) 479-5778; e-mail *info@kitsaphba.com*; web site *www.kitsaphba.com/bbk.html*.

Built Green—Master Builders Association of King and Snohomish Counties, Washington; phone (425) 451-7920 or toll-free 1-800-522-2209; e-mail *builtgreen@mbaks.com*; web site *www.builtgreen.net*.

Built Green Colorado—Home Builders Association of Metro Denver, Colorado; phone (303) 778-1400; e-mail *info@builtgreen.org*; web site *www.builtgreen.org*.

Earth Craft House—Greater Atlanta Home Builders Association, Georgia; phone (770) 938-9900; e-mail *vdiamond@atlantahomebuilders.com*; web site *www.atlantahomebuilders.com*.

Florida Green Building Coalition—e-mail *info@floridagreenbuilding.org*; web site *http://floridagreenbuilding.org*.

Green Builder Program—Home Builders Association of Central New Mexico; phone (505) 866-6479; e-mail *ldconsulting@msn.com*; web site *www.bapartner.org.*

Green Building—San Jose, California; phone (408) 277-4111; e-mail *mary.tucker@sanjoseca.gov*; web site *www.ci.san-jose.ca.us/esd/gb-home.htm.*

Green Built Home—Wisconsin Environmental Initiative; phone (608) 280-0360; e-mail *info@wi-ei.org*; web site *www.wi-ei.org.*

Green Points Program—Boulder, Colorado; phone (303) 441-3280; web site *www.ci.boulder.co.us/environmentalaffairs/green_points/newoptions.htm.*

Green Building Program—Maryland Department of Natural Resources; phone (410) 260-8727; e-mail *smcguire@dnr.state.md.us*; web site *www.dnr.state.md.us/ed/index.html.*

Scottsdale's Green Building—Scottsdale, Arizona; phone (480) 312-7990; web site *www.ci.scottsdale.az.us/greenbuilding.*

Utility Industry Programs

Earth Advantage Homes—Portland General Electric; web site *www.earthadvantage.com.*

Local Initiatives

Austin Sustainable Building Coalition—Austin, Texas; web site *www.greenbuilder.com/sbc.*

Build Green—developed by the Home Builders Association of Greater Kansas City; phone (816) 942-8800; web site *www.kchba.org/buildgreenkc.*

Efficient Building Program—City of Aspen and Pitken County, Colorado; phone (970) 920-5090; web site *www.aspenpitkin.com/depts/41/bldg_efficient.cfm.*

Greater Cleveland Green Building Coalition—Cleveland, Ohio; phone (216) 961-8850; e-mail *info@clevelandgbc.org*; web site *www.clevelandgbc.org*.

Green Building Alliance—Santa Barbara, California; phone (805) 654-4169; e-mail *info@gballiance.com*; web site *www.gballiance.com.*

Green Building Association of Central Pennsylvania—phone (717) 234-7107; e-mail *info@gbacpa.org*; web site *www.gbacpa.org.*

Green Rated—City of Portland Office of Sustainable Development, Oregon; phone (503) 823-7725; e-mail *green-rated@ci.portland.or.us*; web site *www.green-rated.org.*

GreenHomeNYC—New York, New York; web site *www.GreenHomeNYC.org*.

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Northwest Ecobuilding Guild—phone (206) 575-2222; e-mail *membership@ecobuilding.org*; web site *http://ecobuilding.org.*

Pittsburg Green Building Alliance—Pittsburg, Pennsylvania; phone (412) 431-0709; e-mail *info@gbapgh.org*; web site *www.gbapgh.org.*

Southface Energy Institute—Atlanta, Georgia; phone (404) 872-3549; e-mail *questions@southface.org*; web site *www.southface.org.*

Associations and Membership Groups

Architects/Designers/Planners for Social Responsibility has been working for protection of the natural and built environment and socially responsible development for the past 20 years. Phone (415) 974-1306; web site *www.adpsr.org.*

Advanced Energy offers training, consulting and applied research to improve houses and small commercial buildings. Phone (919) 857-9000; web site *www.advanced energy.org.*

Affordable Comfort, Inc., has a mission of increasing the performance of residential construction. Phone (724) 627-5200; web site *www.affordablecomfort.org.*

The American Solar Energy Society is a national organization dedicated to advancing the use of solar energy for the benefit of U.S. citizens and the global environment. Phone (303) 443-3130; web site *www.ases.org*.

Building America is a private/public partnership that develops energy solutions for new and existing homes. Follow the "About" link at *www.eere.energy.gov/ buildings/building_america* for contact information.

The Building Envelopes Program at Oak Ridge National Laboratory is a program within the Buildings Technology Center, the premier U.S. research facility devoted to developing technologies that improve the energy efficiency and environmental compatibility of residential and commercial buildings. Phone (865) 574-4345; web site *www.ornl.gov/sci/roofs+walls.*

Building Science Corporation has a focus on preventing and resolving problems related to building design, construction and operation. Phone (978) 589-5100; web site *www.buildingscience.com.*

The California Straw Building Association is dedicated to furthering the practice of straw building by exchanging current information and practical experience, promoting and conducting research and testing, and making that body of knowledge available to working professionals and the public at large. Phone (209) 785-7077; web site *www.strawbuilding.org.*

The Center for the Built Environment provides timely, unbiased information on promising new building technologies and design techniques. Phone (510) 642-4950; web site *www.cbe.berkeley.edu.*

The Collaborative for High Performance Schools aims to increase the energy efficiency of schools in California by marketing information, services and incentive programs directly to school districts and designers. Their publications are of universal value. Phone (877) 642-CHPS (2477); web site *www.chps.net*.

The Community Office for Resource Efficiency is a nonprofit organization that promotes renewable energy and energy efficiency in western Colorado and beyond. Phone (970) 544-9808; web site *www.aspencore.org*.

The Ecological Building Network is a growing international association of builders, engineers, architects, academics and developers committed to promoting intelligent building methods and materials for a sustainable future. This is a resource for the most up-to-date straw-bale construction research. Phone (415) 331-7630; web site *www.ecobuildnetwork.org.*

Energy & Environmental Building Association promotes the awareness, education and development of energy-efficient, environmentally responsible buildings and communities. Phone (952) 881-1098; web site *www.eeba.org.*

Environmental Building News is a monthly newsletter which has been published by Building Green since 1992 and features comprehensive, practical information on a range of topics related to sustainable design in the built environment. Phone (802) 257-7300; web site *www. buildinggreen.com.*

Fred Webster Associates is a civil/structural engineering consulting company. Webster is an internationally recognized authority on seismic and structural engineering for earthen materials. Phone (650) 321-6939; web site *www.fawebster.com.*

The Last Straw: The International Journal of Straw Bale and Natural Building is the only journal published to record the revival and development of straw-bale worldwide. Phone (402) 483-5135; web site *www.strawhomes.com.*

The New Buildings Institute, Inc., is a not-for-profit public benefits corporation helping to make buildings better for people and the environment. Phone (509) 493-4468; web site *www.newbuildings.org.*

The Pennsylvania Governor's Green Government Council has a mission to help state agencies lead the Commonwealth toward a goal of zero emissions to air, land and water by having all employees routinely consider the environmental effects of their policies, practices and daily actions at all levels of decision-making. Web site *www.gggc.state.pa.us.*

Solar Energy International has the mission to provide education and technical assistance so that others will be empowered to use renewable energy technologies. Phone (970) 963-8855; web site *www.solarenergy.org.*

Southwest Solaradobe (SWSA) has conducted yearly classes in adobe construction around the Southwest and beyond. SWSA is active with The Earthbuilders Guild in the protection and development of codes for earthen construction and publishes Adobe Builder books on practical earthbuilding. Phone (505) 861-2287; web site *www.adobebuilder.com/southwest-solaradobe-school-1.html.*

The Sustainable Buildings Industry Council is a nonprofit organization whose mission is to advance the design, affordability, energy performance and environmental soundness of residential, institutional, and commercial buildings nationwide. Phone (202) 628-7400; web site *www.sbicouncil.org.*

Sustainable Sources offers a multitude of resources in the field of green building. Web site *www.greenbuilder.com/general/BuildingSources.html.*

The U.S. Green Building Council (USGBC) is the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work. Its LEED™ (Leadership in Energy and Environmental Design) Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. It has over 50 regional chapters, organizing groups and affiliates. Phone (202) 828-7422; web site *www.usgbc.org*.

Green Building Topics

Green Roofs

The mission of **Green Roofs for Healthy Cities** is to develop a multi-million dollar market for green roof infrastructure products and services in cities across North America in order to take full advantage of the multiple benefits of these proven technologies. Web site *www.greenroofs.ca/grhcc/main.htm.*

Community Resources is a regional nonprofit organization that provides innovative ideas, tools and experience, empowering urban communities to improve their social, physical and natural environments. They work in Washington, D.C., Baltimore and Philadelphia. Web site *www.communityresources.org/greenroof.html.*

A very informative article on green roofs was published in **Environmental Design & Construction** magazine and can be found online at *www.edcmag.com/CDA/ArticleInformation/features/BNP__Features__Item/0,4120,18769,00.html.*

Environmental Building News has featured several excellent articles on green roofs (as well as many other pertinent topics). Web site *www.buildinggreen.com.*

Pervious Pavement

The Sustainable Materials Sourcebook has comprehensive listings of a variety of building materials and systems. Web site *www.greenbuilder.com/sourcebook/PerviousMaterials.html.*

Dane County, Wisconsin, has published a useful paper on pervious pavement systems, which can be found at *www.co.dane.wi.us/commissions/lakes/pdf/stormwater/perviouspavementsystems.pdf.*

The U.S. Environmental Protection Agency (EPA) **Stormwater Technology Fact Sheet** on porous pavement can be found at *www.epa.gov/owmitnet/mtb/porouspa.pdf.*

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Constructed Wetlands/Alternative Wastewater Systems

The EPA publications, **Economic Benefits of Runoff Controls and Constructed Wetlands for Wastewater Treatment** and **Wildlife Habitat**, can be found at *www.epa.gov/OWOW/NPS/runoff.html* and *www.epa.gov/owow/wetlands/construc/content.html* respectively.

The U.S. Department of Agriculture's **A Constructed Wetlands Bibliography** is available online at *www.nal.usda.gov/wqic/Constructed_Wetlands_all.*

Constructed Wetlands: Using Human Ingenuity, Natural Processes to Treat Water, Build Habitat is located at *www.ag.arizona.edu/AZWATER/arroyo/094wet.html.*

A list of **Frequently Asked Questions about Onsite Wastewater Treatment and Disposal Systems** is available at *www.ci.austin.tx.us/wri/faq.htm.*

Waterless Urinals

Waterless Company—web site *www.waterless.com.*

Falcon Waterfree Technologies—web site *www.falconwaterfree.com.*

Environmental Design & Construction and **PM Engineer** published an article on waterless urinals, which is available online at *www.edcmag.com/edc/cda/articleinformation/coverstory/bnpcoverstoryitem/0,,93925,00+en-uss_01dbc.html.*

Oikos is a good resource for product information. Their listing of waterless urinals is located at *http://oikos.com/products/category2.lasso?cat=755.*

The EPA did a **pilot study on waterless urinals** that is available at *www.epa.gov/ne/assistance/univ/pdfs/bmps/MUSCH20LessUrinals.pdf.*

Water Harvesting

The Texas Natural Resource Conservation Commission provides information on rainwater harvesting at *www.tnrcc.state.tx.us/exec/sbea/rainwater/rainwater.html.* Additional information from the **Texas Water Development Board** can be found at *www.twdb.state.tx.us/assistance/conservation/alternative_technologies/rainwater_harvesting/rain.asp*

The Pima County, Arizona, Flood Control District offers helpful guidance at *www.dot.co.pima.az.us/flood/wh.*

The City of Austin provides information about its water conservation efforts online at *www.ci.austin.tx.us/watercon/rainwaterharvesting.htm.*

Ole Errson has a city-permitted system for drinking filtered rainwater. To find out more, direct your web browser to *http://users.easystreet.com/ersson/rainwatr.htm.*

The City of Tucson, Arizona, offers a manual for rainwater harvesting at *www.ci.tucson.az.us/planning/whm.pdf.*

Graywater

The Arizona Department of Environmental Quality has its permit guidelines for graywater usage available at *www.water.az.gov/adwr/Content/Conservation/GreyWater/grayv3_1.pdf.*

The New Mexico Environment Department has a graywater irrigation guide located at *www.nmenv.state.nm.us/OOTS/GRAY%20WATER%20IRRIGATION%20GUIDE1.pdf.*

Oasis Design offers resources on a full range of water treatment and harvesting techniques and technologies at *www.oasisdesign.net.*

The Arizona Water Resources Research Center has a report on the use of graywater and rainwater available at *http://ag.arizona.edu/AZWATER/arroyo/071rain.html.* ◆

Global Policy Summit on Performance-Based Building Regulatory Systems

by Brian Meacham, Ph.D., P.E.

In early November 2003, nearly 100 leading thinkers, policy-makers and practitioners from 11 countries gathered in Washington, D.C., to address issues and offer their insights on the role and challenges of performance-based regulatory systems. The success of the three-day Global Policy Summit on the Role of Performance-Based Building Regulations in Addressing Societal Expectations, International Policy and Local Needs might best be expressed by the fact that the outcomes were different than the organizers and most participants likely would have predicted beforehand.

Although such meetings rarely resolve such unarguably complex issues, the ideas, discussions and suggestions presented will serve as a milestone in the future of global collaboration on performance-based building regulations in this larger context. Surprisingly, a number of key conclusions reached at the Global Policy Summit are as relevant for prescriptive building regulatory systems as performance-based systems, having emerged from growing awareness of aspects of risk and rapidly changing global realities seldom considered in the past.

"People everywhere deserve buildings that meet basic requirements for health, safety and amenity. . . ."

The IRCC and the Purpose of the Global Policy Summit

The world continues to shrink as more goods and services are traded across borders every day. With construction-related activity representing as much as 12 percent of the gross domestic product in some countries, this sector contributes significantly to the global economy. Similarly, at all scales from local to global, construction significantly impacts society and the environment.

The global transition to performance-based building regulatory systems has broad implications for the construction industry, society and the building regulatory community. The Inter-jurisdictional Regulatory Collaboration Committee (IRCC) was formed to facilitate the international exchange of information in support of construction-related, performance-based regulatory systems. The IRCC identifies and helps address public policy, education, regulatory infrastructure and technology issues for successful implementation and management of such systems. It aims to foster a common understanding of the international regulatory environment through information exchange and to promote more open inter-jurisdictional commerce in building design and construction.

Building regulations are legal instruments intended to ensure that buildings perform in ways that provide essentially equivalent, socially acceptable levels of health, safety, welfare and amenity for building occupants and for the community in which the buildings are located. The rationale for adopting a performance-based regulatory system includes increased design flexibility, facilitation of trade and the reduction of unnecessary costs. Specific rationale notwithstanding, one observable result in many transitions to performance regulations is the significant challenge in establishing the societal goals and objectives, which then need to be reflected in performance-based requirements.

As the structure and content of building regulation change, however, several issues arise. These include whether the new regulations adequately address societal expectations and requirements for the performance of buildings and, more fundamentally, what those societal expectations are and how they can be incorporated into regulation, implemented and enforced. These are not simple questions, as there are myriad impacts on building regulation ranging from the form of government and legal system; to the role of special interest groups; to the question of what should be government regulated versus market driven; to the constraints of technology, resources and ecological capacity.

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Convening of the Global Policy Summit and development of the Summit Report were supported by Arup, the Australian Building Codes Board, the International Code Council, the National Research Council of Canada and the National Science Foundation under NSF Grant No. 0322760.
Any opinions, findings and conclusions or recommendations expressed related to this Summit and related materials are those of the author and do not necessarily reflect the views of Arup, the Australian Building Codes Board, the International Code Council, the National Research Council of Canada, the National Academies or the National Science Foundation.

A number of looming policy challenges face today's building regulatory community, including sustainability, security and housing affordability. Although they may vary somewhat by country, the challenges are very similar and much can be gained by discussing both the specific concerns and the lessons learned from countries where performance-based building regulatory systems have already been implemented.

With this in mind, the IRCC organized the Global Policy Summit to draw together key policy makers, regulatory officials, industry representatives, researchers and others to explore key issues, identify potential solutions and—if possible—draft a research and development perspective on future challenges and opportunities for advancing performance-based building regulations to meet societal needs. (See the "Agenda" sidebar for the topics and presentations covered at the Global Policy Summit. For more information, the 38-page Summit Report is available on the IRCC web site at *www.ircc.gov.au.*)

About the IRCC

The Inter-jurisdictional Regulatory Collaboration Committee (IRCC) is an unaffiliated organization of ten of the world's leading building regulatory agencies and organizations.

- The Australian Building Codes Board
- New Zealand's Building Industry Authority
- The Office of the Deputy Prime Minister (UK)
- The International Code Council
- Japan's Ministry of Land, Infrastructure and Transport
- Spain's Minsterio de Fomento (Ministry of Public Works)
- The National Fire Protection Association
- The National Institute for Land and Infrastructure Management, Japan
- Norway's National Office of Building Technology and Administration
- The National Research Council of Canada

A Different Perspective Emerges

Reviewing the list of key themes and speakers gives a sense of the breadth and depth of expertise, perspectives and resultant discussion at the Global Policy Summit. Topics included the "typical" consideration of performance quantification as well as social and demographic issues, terrorism, sustainability and global climate change.

One of the most striking and important observations and outcomes was that participants clearly recognized a shifting frame of reference from the perspective of a local, wealthy, developed country to the recognition that much of the world's population currently lives in relative poverty, with little access to the money, resources, technology and infrastructure that most modern codes assume are readily available. People everywhere deserve buildings that meet basic requirements for health, safety and amenity, and the participants of the Global Policy Summit recognized that regulatory requirements must respond appropriately to actual needs, limitations and societal desires rather than to ideals.

The message from David Eisenberg that "appropriate technology" is the way to go—appropriate to the actual need and use, to the place and culture, to the environment, and to available resources—resonated with the summit participants. There was general agreement that, as a global community, we need to stop looking at everything through the lens of developed countries and adapt our worldview to include everyone. Echoing the late Bob Fowler, Eisenberg emphasized that we have a responsibility for those who cannot speak for themselves, including roughly half of the world's population currently living on less than two dollars a day and all future generations. According to UN population statistics, the world's population is expected to peak later this century at about 9 billion—3 billion more than are now living—and levels of consumption are rising in both developed and developing countries. The enormous risks associated with these trends require us to re-examine all of our assumptions about technology and progress.

Eisenberg addressed issues of finite resources and the need to consider the entire life cycle of buildings from raw material through ultimate end state. He spoke of the problem of assuming that what works in developed countries will work for developing countries, especially the insistence on industrially-based, labor-efficient, resource-intensive building systems in regions where the available labor pool is large and inexpensive while resources, infrastructure, technology and capital are scarce and costly.

Eisenberg explained that because "appropriate technology" is the simplest level of technology that can do a job well, it usually has the lowest level of negative unintended consequences. This is the case whether the technology employed is classifiable as being low, intermediate, high or some combination thereof. He suggested that these kinds of technologies typically also enhance the local capacity of communities and people to meet their own needs, shortening vulnerable supply lines while creating more efficient and resilient systems of supply and more robust, durable local economies.

South African Civil Engineer Ron Watermeyer's presentation expanded on many of these themes. As he reported, building regulations do not currently address traditional construction and informal settlements despite estimates that these account for just over one-third of the world's building stock. To address this concern, performance descriptions for sustainable housing that reflect

societal goals for sustainable development have been developed. Watermeyer spoke about which aspects of these performance descriptions can be used to regulate housing units in terms of performance-based building regulations, and suggested how societal objectives can be accommodated at a local level by establishing different levels of performance in different market sectors. Although the concept of different levels of performance has been discussed in other venues, this was perhaps one of the first applications of the concept to address the range of socioeconomic conditions that exist within or between countries.

Taken together, these two presentations made clear the need to re-examine our assumptions about acceptable levels and types of risk. Watermeyer's presentation revealed an approach to the regulation of building and development that allows a level of local control and decision-making balancing the needs of society as a whole with those of individuals and their communities in a way that is responsive to the real conditions, resources, traditions and aspirations of people in differing circumstances.

The Future—A Destination

As the Global Policy Summit drew to a close, it was agreed that a clear and concise destination is needed for the future development of performance-based regulatory and design concepts. Based on all of the presentations and discussions, the following destination was agreed upon.

Destination

To achieve appropriate facility performance for the largest possible fraction of the world's population, taking into account:

- appropriate technology;
- the level of performance desired by the indigenous culture;
- traditional health and safety concerns; and
- life cycle factors like sustainability, environment, security, affordability, human rights, energy and climate change.

This destination will not be arrived at easily. Doing so will require international collaboration, strong leadership and vision, and sufficient resources. The following strategies were suggested to help the global building regulatory community realize this goal.

- Support the IRCC in providing a holistic vision, stimulating awareness and acting as a catalyst.
- Solicit support from other groups such as the World Health Organization, World Bank, U.S. Agency for International Development and the UN.
- Identify realistic models that can be adapted to a spectrum of cultures.
- Identify credible data, best practices, case studies and benchmark criteria.
- Support the creation of a stakeholder organization to foster dialog and the identification of a "champion."
- Hold additional policy summits.

Discussions are currently underway to schedule a second Global Policy Summit within the next two years, perhaps in Europe or the Asia-Pacific region, but ideally in a developing country that is looking to embark on the performance path with the help of those who have already made progress in that direction.

In the nearer term, a "mini summit" is being planned just prior to the 5th International Conference on Performance-Based Codes and Fire Safety Design Methods to be held in Luxembourg this October, organized by the Society of Fire Protection Engineers (SFPE) in cooperation with the European Commission. The intent is to bring together representatives from developing countries who were unable to attend last year's event to discuss the same themes and dive more deeply into the issues associated with changing frames of reference on risk, performance and equitability of risk distribution. For more information about the SFPE conference, direct your web browser to *www.sfpe.org/sfpe/education/eventdetail.cfm?eventid=57*. It is anticipated that more information about the "mini summit" will also be posted on the SFPE website. Also, be sure to check IRCC's web site regularly for information about future Global Policy Summits and activities in the area of performance-based building regulatory development. ◆

Acknowledgements

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Meacham also currently serves as Associate Team Leader of Risk Management Products for the Applied Technology Council's ATC-58 project to develop performance-based seismic design guidelines. He is a licensed Professional Engineer in Connecticut and a Fellow of the Society of Fire Protection Engineers. Meacham is an Adjunct Associate Professor in the Fire Protection Engineering program at Worcester Polytechnic Institute in Worcester, Massachusetts.

Agenda of the Global Policy Summit on the Role of Performance-Based Building Regulations in Addressing Societal Expectations, International Policy and Local Needs

Welcome and Introductory Comments

Robert Bowen, Chair of the IRCC and Director of Codes and Evaluation, National Research Council, Institute for Research in Construction, Canada.
Richard Little, Director, Board on Infrastructure and the Constructed Environment, National Research Council, U.S.

Keynote Speakers

Dr. Jack Snell, Director (retired), Building and Fire Research Laboratory, National Institute of Standards and Technology, U.S. James Lee Witt, C.E.O., International Code Council, U.S.

Session 1: The Role of Building Regulation in Meeting Expectations

Session Chair—Paul Everall, Office of the Deputy Prime Minister, London, UK.

Why Building Regulations?
Anne vonWeller, President, Board of Directors, International Code Council, U.S.

Building Codes—A Good Tool in the Right Context
Bruce Clemmensen, Chairman, Canadian Commission on Building and Fire Codes, Canada.

Performance-Based Regulations and Regulatory Regimes
Prof. Peter May, Center for American Politics and Public Policy, University of Washington, U.S.

Shaping Expectations for Extreme Events
Prof. Daniel Alesch (emeritus), Public and Environmental Affairs, University of Wisconsin, U.S.

Session 2: Demographic and Urban Issues

Session Chair—Olav Berge, Office of Building Technology and Administration, Oslo, Norway.

The Impact of Rapid Ageing in Japan on Accessibility Issues
Dr. Satoshi Kose, Professor, Shizuoka University of Art and Culture, Japan.

Changing Demographics, Disability Access and the Use of Performance-Based Design
Garry Fielding, Director, Local Planning Regional and Rural Planning Division, Department of Infrastructure, Planning & Natural Resources, Australia.

How Do We Solve This Problem? Aftermath of 9/11
David Maola, Council on Tall Buildings and Urban Habitat, U.S.

Session 3: Emerging Societal Expectations, Pressures and Threats

Session Chair—Milosh Puchovsky, National Fire Protection Association, U.S.

Brave New World—Emerging Societal Expectations, Pressures and Threats
Patricia Lancaster, AIA, Commissioner, Department of Buildings, City of New York, U.S.

A Larger Context for Risk and Responsibility
David Eisenberg, Director, Development Center for Appropriate Technology, U.S.

The Use of Performance-Based Building Codes to Attain Sustainable Housing Objectives: The South African Approach
R.B. Watermeyer, Technical Committee for Construction Standards, Standards South Africa, and Director, Soderlund and Schutte Consulting Engineers, South Africa.
Dr. Rodney Milford, Director, Division of Building and Construction Technology, Council for Scientific and Industrial Research, South Africa.

What Do People Want from the Coming Global Performance Regulatory World?
Dr. John Hall Jr., Assistant Vice President, National Fire Protection Association, U.S.

Towards a Sustainable Built Environment Prepared for Climate Change?
Dr. Frank Henning Holm, Managing Director, Norwegian Building Research Institute, Norway.

Session 4: Performance Regulation and Regulatory Alternatives

Session Chair—Dr. Kathy Notarianni, National Institute of Standards and Technology, U.S.

Designing and Implementing Performance-Based Regulation: Lessons from Health and Safety Policy
Prof. Cary Coglianese, Harvard University, JFK School of Government, U.S.

Performance-Based Regulation in Theory and Practice: Lessons from EPA's Performance Track Program
Dr. Dan Fiorino, U.S. Environmental Protection Agency, U.S.

Towards a New Model of Performance: The Role of Standards and Market-Driven Solutions
Pat Keindel, President, Canadian Standards Association, Canada.

Eurocodes—A Building Code for Europe
Pascal Bar, DG Enterprise: G5 Construction Unit, European Commission.

Session 5: Setting Goals to Deliver on Expectations

Session Chair—Brian Ashe, Australian Building Codes Board, Australia.

Regulatory Effectiveness and Performance-Based Regulations
Prasad Kadambi, U.S. Nuclear Regulatory Commission, U.S.

Performance with Uncertainty: Quantifying Expectations of Performance in Fire Safety Engineering Calculations
Dr. Kathy Notarianni, National Institute of Standards and Technology, U.S.

Public Safety is Not Enough!
Dr. Paul Croce, FMGlobal, U.S.

Three Useful Tools for Goal Setting: Judgment Analysis, the Taylor Russell Diagram and the Systems Dynamics Model
Dr. Elise Weaver, Social Science and Policy Studies, Worcester Polytechnic Institute, U.S.

Whose Needs and Expectations and the Performance of What?
Prof. Eric Burnett, Civil and Environmental Engineering, Pennsylvania State University, U.S.

Session 6: Performance-Based Building Regulation in Practice

Session Chair—Beth Tubbs, International Code Council, U.S.

Performance-Based Code, Seven Years On: The Norwegian Experience
Olav Berge, Director General, National Office of Building Technology and Administration, Norway.

Performance-Based Codes: Contemporary and Emerging Policy Challenges, Lessons for Strengthening the Performance Regulatory Framework and Future Directions
Brian Ashe, Australian Building Codes Board, Australia.

Performance-Based Building Regulation: The UK Experience
Paul Everall, Head of Building Regulations Division, Office of Deputy Prime Minister, UK.

How to Make Performance Codes Perform
Zophia Zager, Director of Building Code Services, Fairfax County, Virginia, U.S.

Performance-Based Regulation in the Building Sector: The New Zealand Experience
Peter Mumford, New Zealand Ministry of Economic Development, New Zealand.

Session 7: International Trade Issues

Session Chair—Richard Okawa, International Code Council, U.S.

The Role of European Technical Specifications and Their Impact on National Regulations: The Road Towards Harmonization
Julio Salazar Mitchell, Ministry of Public Works (Minsterio de Fomento), Spain.

Changing Dynamics of the Global Standards Community and the Potential Impact on Trade
James Thomas, American Society for Testing and Materials, U.S.

Facilitating Trade Through Technical Assessment
John Berndt, General Secretary, World Federation of Technical Assessment Organizations, Canada.

Summary Discussion

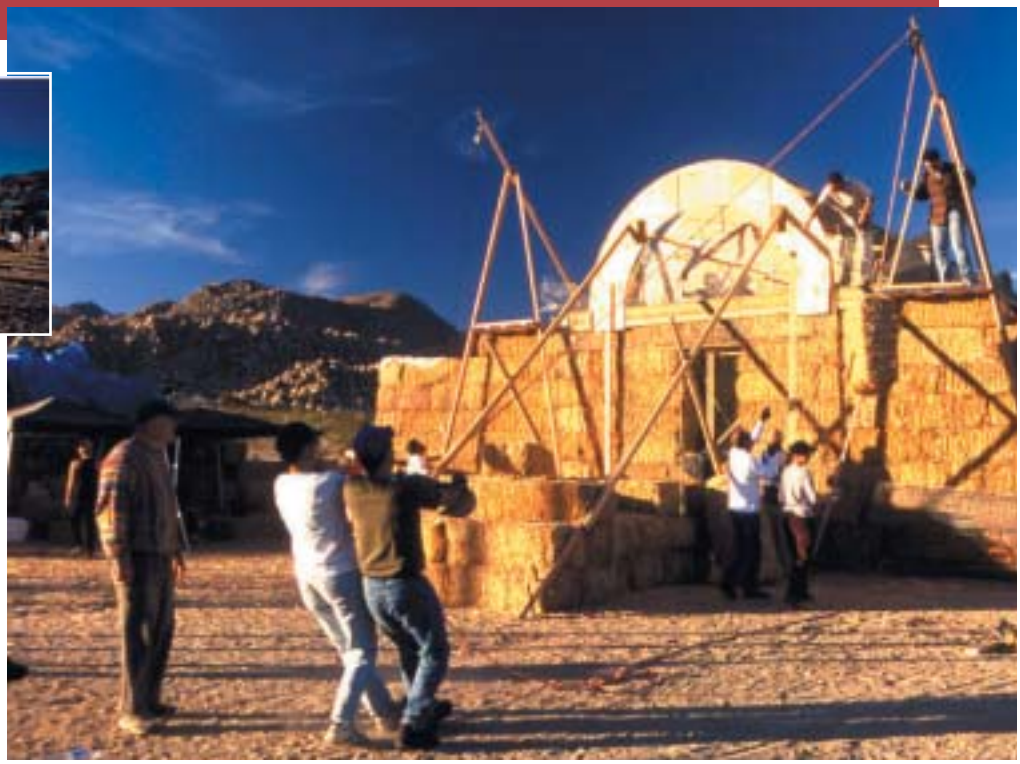
Facilitators
Prof. David Lucht, Worcester Polytechnic Institute, U.S.

Jon Traw, Traw Associates Consulting, U.S.

Straw-Bale Construction

A Review of Testing and Lessons Learned To Date

by Bruce King, C.E.



Straw-bale barrel vault house under construction in Joshua Tree, California. *(Engineering by Tipping-Mar Associates, design and photograph by Skillful Means Construction.)*

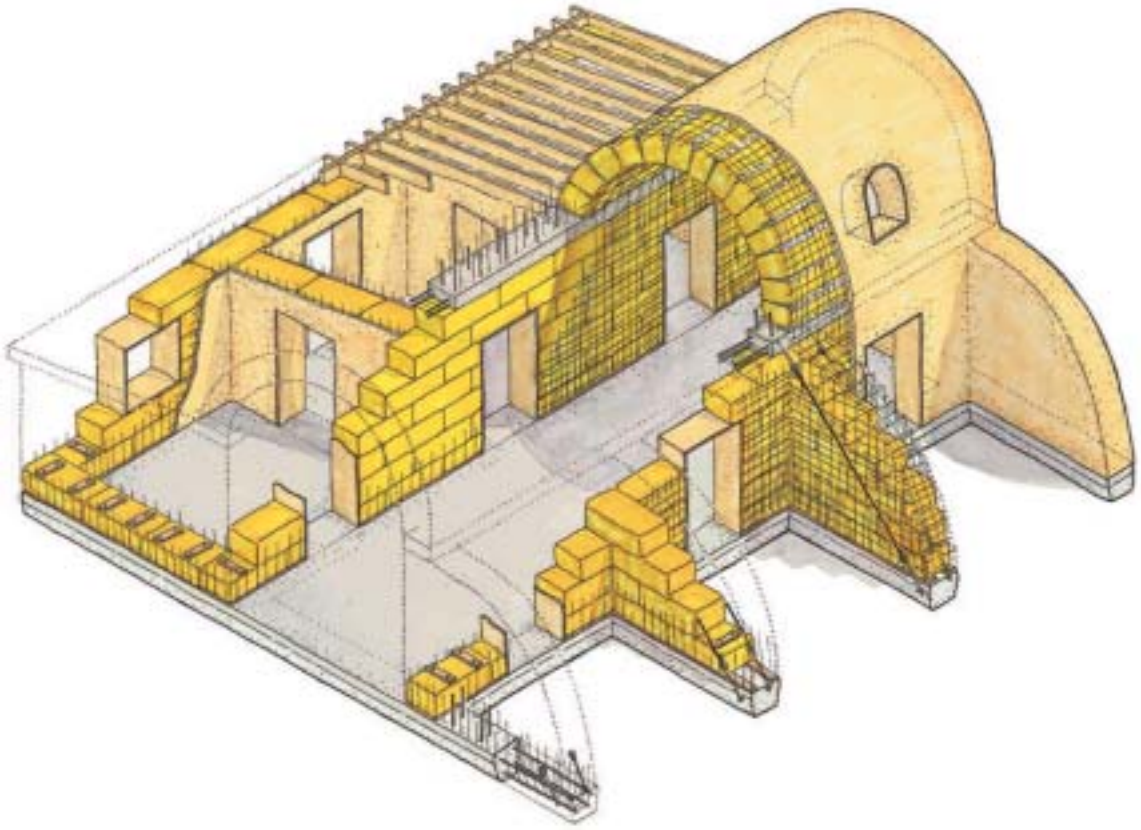
The first straw-bale structures we know of were built more than a hundred years ago by European settlers in the Sand Hills region of Nebraska. Many of those homes still exist, and a revival in straw-bale construction began in the American West in the late 1980s. As more professional architects, engineers, inventors and builders have begun to explore this new material, a variety of styles and techniques has emerged, and straw-bale construction has spread all over the world. A recently completed quarter-million-dollar research and testing project, funded mainly by the State of California, has answered some common technical questions. This article describes some of the basics of straw-bale construction and reviews the accumulated body of laboratory and field experience to date.

Bales

Straw is the plant structure between the root crown and the grain head (*hay* includes grain and should not be used for building). Bales are masses of straw compressed into rectangular blocks that are bound with polypropylene twine. Building bales might be "two-string" (generally 16" x 18" x 36" ±) or "three-string" (generally 15" x 23" x 46" ±), and are ideally stacked in a running bond. Bales are usually stacked flat, i.e., with the longest dimension parallel to the wall and the shortest dimension vertical. In other applications, the bales can be stacked on-edge, i.e., with the shortest dimension horizontal. The slimmer wall achieved with this second option saves interior space and, interestingly, appears to offer the same net insulation value due to the slightly different orientation of the fibers.

Experience (and some laboratory testing) strongly suggests that four qualities determine the usefulness of a bale for building.

- **Moisture content**. The drier the better—very generally, a moisture content hovering for an extended period of days above 30 percent and 40° F is considered cause for concern about decay.
- **Density**. Dry density (i.e., with moisture content accounted for and subtracted) should generally be at least 6 pounds per cubic foot if the bales are intended for load-bearing or shear walls, and the material should be bound tightly enough such that lifting a bale by one string will leave no more than a fist-sized gap between bale and string.
- **History**. Bales that have been moistened once or repeatedly will show grey or black areas where mold spores have begun proliferating. Such bales are always discarded, even if very dry at the time of construction, as they are especially likely to experience problems if the wall is ever wetted.
- **Fiber length**. Some baling machines chop the straw into very short lengths before baling, resulting in bales that are not as coherent as is desirable for construction. Fibers must be long enough that the bales easily remain intact during handling.



Straw-bale barrel vault house isometric. Recipient of the 2002 Innovative Design of the Year Award from the Structural Engineers Association of California. *(Illustration by David Mar, S.E.; engineering by Tipping-Mar Associates; design by Skillful Means Construction.)*

Wall Assemblies

Many details and wall systems are now in use, and dozens have been tried and discarded for one reason or another—in other words, straw-bale construction is still very much a developing technology. It is nonetheless true that, as with every other building material, the ideal wall assembly depends very much on area climate and seismicity, building function, and aesthetics.

Until very recently there were two basic styles of straw-bale construction: *load bearing* and *nonload bearing* or *post-and-beam*, in which bales are used as infill panels between or around a structural frame. Post-and-beam style predominates because it is more adaptable and allows the construction of a protecting roof prior to bale delivery and placement. However, the more important distinction is really between *structural* straw-bale construction, in which bale assemblies are designed to carry vertical and/or lateral loads, and *non-structural* construction, in which the only structural demand on a wall assembly is to remain intact and in place under out-of-plane load.

Despite the many variations, there are several qualities common to all straw-bale buildings.

- All straw-bale buildings inevitably have irregular spaces between the bales and the surrounding framing, windows, doors, etc. The conventional practice is to fill these spaces prior to plastering with a straw-clay mixture, which draws any intruded water away from the wood and bales as it dries, as well as serving as a fire and pest retardant. Alternatively, some builders use a sprayed insulation like cellulose to fill the cavities.
- The bales must often be braced during stacking for stability and alignment (akin to the temporary bracing of a stud wall). Internal or external pinning of the walls with rebar dowels has been prescribed in early straw-bale codes, but is no longer considered to provide much structural value.
- The predominant experience with straw-bale buildings is that moisture vapor intrusion is not a problem if the wall can "breathe"—that is, if both exposed surfaces are vapor permeable. There have certainly been leaks and degradation failures, but without exception they have been due to outright moisture intrusion, not vapor intrusion. In short, it seems that water vapor should be allowed to move in and out of the wall assembly without condensing on internal surfaces, while extra care must be taken to keep liquid water out. Tops of bale walls, exposed horizontal surfaces (i.e., windowsills) and joints with wood frames must be designed to shed water and carefully sealed. As with fire, straw bale structures are especially vulnerable to water damage during construction, as bales and walls can be wetted by rains, appear to dry out, and then develop problems after the wall is completed.

(continued)

Plaster coatings should always be worked directly into the straw, as there is a huge increase of strength from an unplastered to a plastered wall assembly when the plaster skins are bonded to the straw substrate. In areas prone to heavy snow, temperature extremes or seismic activity, the plaster skin of the system will require tensile reinforcing. This can be achieved through the use of conventional hexagonal 17-gage stucco mesh, but for heavy loading should take the form of welded wire mesh with a comparatively tight weave, such as 2-inch × 2-inch, 14-gage wire. The design and detailing of fasteners at boundary elements will greatly affect the ability of the skin to carry and transmit loads. Because the bond provided by working the plaster into the straw is typically quite strong, many (including this author) generally believe that mesh reinforcing need only be attached well enough to stay in place during plastering; weaving or tying mesh reinforcing to or through the bale wall is probably only necessary in high seismic zones or for straw-bale vaults.

Mechanical Properties

Thermal Insulation (R-Value)

A definitive test using state-of-the-art equipment at Oak Ridge National Laboratories yielded an R-value of 27 for an 18-inch-thick straw-bale wall (and, by inference, a value of 36 for a 24-inch-thick wall). The California Energy Commission currently accepts an R-value of 30 for all plastered straw-bale walls.

Moisture Resistance and Durability

Due to the nature of the material, moisture resistance is by far the most worrisome issue for straw-bale builders and designers. Rot constitutes a degradation of the structural core of the "sandwich panel," and mold is a potential health hazard common to any cellulose-based building material. As previously indicated, all failures to date have been caused by outright liquid moisture intrusion or internal condensation; moisture vapor, if unimpeded and not allowed to condense on cold (e.g., metal) surfaces, will generally move through and out of a straw-bale wall without causing problems.

Experience with other materials, especially wood, in contact with cementitious materials would suggest that cement plaster applied directly to the straw would lead to degradation problems. There have been some problems, typically where an unprotected wall is exposed to heavy, driven rain, but far fewer than might be expected. Decade-old walls have been investigated and exhibited no decay at the stucco/straw interface. It may be that the straw will eventually degrade in the alkaline cement environment, if only in conditions where the plaster "holds" water against the straw, but to date walls in various climates are performing substantially better than would be expected.

It should be noted that the historic, 100-year-old cement-plastered structures in Nebraska are still in good condition, even after some neglect, and that straw in protected conditions such as an Egyptian pyramid has lasted for thousands of years. Straw-bales are more sensitive to moisture intrusion than other materials, but—as with any other building material—durability is primarily a matter of careful and intelligent detailing of the building envelope.

Fire Resistance and Flame Spread

A number of straw-bale structures have passed intact through wildfires that completely incinerated adjacent wood buildings. This is easily explained and understood analogously by anyone who has ever tossed a telephone book into a fire and expected it to burn. Fire requires fuel, flame and oxygen to survive, and straw-bales are simply too dense to provide the necessary oxygen—particularly when coated with a thick layer of plaster.

Two ASTM E119 small-scale fire tests were completed in 1993 by SHB Agra Engineering and Environmental Services Laboratory in Albuquerque, New Mexico: one on an unplastered straw-bale wall panel, and the second on a straw-bale wall that had been gypsum-plastered on the heated side and stuccoed on the outside face. The results of those tests have been interpreted to show equivalency to a 2- or even 3-hour firewall. A subsequent full scale ASTM E119 test conducted at the University of California, Berkeley, Richmond Field Station demonstrated that plastered straw-bale walls constitute at least 1-hour fire-resistive construction. Finally, an ASTM E84 flame spread test conducted in 2000 by Omega Point Laboratories in Elmendorf, Texas, on unplastered two-string straw-bales yielded a flame spread index (FSI) of 10 and a smoke development index (SDI) of 350. The 2000 editions of the *International Building Code*® and *International Residential Code*® require a maximum FSI of 25 and a maximum SDI of 450 for insulation. This means that the bales easily surpass both requirements and are acceptable for use in both commercial and residential construction where flame spread and smoke development ratings are required.

As an emphatic and precautionary note, it must be added that a straw-bale building site presents an extreme fire hazard—most especially during the brief period of bale placement, when the area can quickly become buried in a thick and highly flammable layer of loose straw. This debris should be cleaned up regularly and fire hoses kept at the ready.

(continued)

Bearing

In a 1999 test conducted at the University of Colorado, Boulder, three types of 8-foot-high cement-stuccoed straw-bale wall assemblies were loaded to failure in compression and averaged failure loads of 4,328 pounds per foot. A later experiment testing a single 13-foot-high wall was stopped at a load of 3,327 pounds per foot. In both cases, it was concluded that the ability of typical plastered bale walls to carry vertical loads was more than enough for typical one- and two-story applications.

Out-of-Plane Strength

In both laboratory settings and unplanned field tests, many plastered and unplastered straw-bale walls have been subjected to hurricane-level winds without distress. In another test conducted in 1998 by Consolidated Engineering Laboratories, a plastered straw-bale arch was point loaded out-of-plane to mimic seismic loads. The arch retained load-carrying capacity even after the test rams had completely punctured the stucco skins, and abstract author David Mar, S.E., observed that "the structure remained stable as it was loaded well into the plastic deformation range, carrying 1.26g with an average displacement ductility of 12.6."

In a series of subsequent tests conducted in late 2003, various eight-foot by eight-foot walls plastered with earthen and lime-cement plasters, with and without reinforcing mesh, carried loads varying from 94 pounds per square foot (no plaster) to 250 pounds per square foot (reinforced earth plaster) to 343 pounds per square foot (reinforced lime-cement plaster)

In-Plane Strength

Early monotonic tests led to establishing a 360 pound-per-linear-foot allowable in-plane shear load on walls in California, which was found to be roughly one-quarter of test failure loads. Subsequent cyclic tests yielded even better results, showing that a well-detailed straw-bale wall can perform as well as the strongest plywood shear walls listed in the IBC, with allowable loads of over 700 pounds per linear foot.

Summary

In the hundred years since straw-bale building technology was first pioneered, the basic technique has remained as straightforward as stacking the bales and plastering both sides. Our knowledge of the material properties of these walls has blossomed in tandem with the extraordinary revival of the past 15 years, and we are now equipped to design with confidence for any conditions. ◆

***Bruce King, C.E.**, is a registered Civil Engineer with a structural engineering practice in Sausalito, California, and 26 years of experience designing commercial and residential structures. He has done extensive research and work with various alternative materials, and is the author of* Buildings of Earth and Straw: Structural Design for Rammed Earth and Straw-Bale Architecture*, as well as several magazine articles on the subject.*

King is the founder and Director of the Ecological Building Network (EBNet), an educational non-profit organization in San Francisco currently completing testing and research on straw bale construction. Additional resources on straw-bale construction and results of a recent testing program can be found at the EBNet web site, which is located at www.ecobuildnetwork.org.