Plastered straw bale construction
Roots and Revival

September, 1993
Arthur, Nebraska

Working Group Reports

Scott House, early Nebraska straw bale

Affordable housing
Codes, research and testing
Whole house systems
Low cost building
Information, networks and education

Edited and assembled by David Bainbridge, Steve MacDonald, and Richard Hofmeister

Roots and revival

The plastered straw bale buildings of Arthur, Nebraska were enlivened by 50 architects, builders, designers, and enthusiasts who convened for the first straw-bale building conference September 10-12, 1993.

The warm and friendly community of Arthur (pop. 120) graciously hosted a cast of characters from 13 states and England. Day one included tours of plastered straw bale buildings: the Fawn Lake Ranch bunkhouse (1914), the Martin-Monhart House (1925), and the Pilgrim Holiness Church (1928). The second day included regional updates (perhaps 100 buildings now complete and many more on the way), a review of structural options (Nebraska style, timber frame, truss frame, and numerous hybrids), straw and bale availability, and progress and potential for testing and code acceptance.

The final day the group divided into five working groups to define current challenges, long-term potential, and develop action plans for essential work in the following areas: codes/research/testing; affordable housing; whole house systems for ecological housing (including straw bale, photovoltaics, passive solar heating and cooling, electric, gray water, etc.); low-co building methods and materials; and networking and information needs.

Common themes included the need to consider life-cycle costing, embodied energy and resources, flexibility in specifying requirements and codes to encourage continued innovation and experimentation, and the need for a whole system approach.

The group shared ideas, experiences, experiments (arches, low cost footings, etc.), successes and pitfalls at the meetings and over meals, a dance and jam session at the volunteer fire dept. hall, a bonfire and music session out in the grasslands, and a barbecue in the park.

Good times were had by all thanks to the cooperative weather and the wonderful local support (special thanks to John Valentine! Leo Turner, Jake and Lucille Cross, and the many other families and friends who hosted visitors).

Thanks are due to the organizing committee: Matts, Judy, Joanne, Steve & Nena, Carol & Steve, Dave, and Lance and financial and logistic support from Out on Bale.

Photo: John H. Valentine, Valentine Studio, Box 205, Arthur Nebraska 69121 (color prints 8"x10" $25 ppd)

1. Affordable Housing

The costs of a house (energy, resources, money, time) over its lifetime (a life-cycle that may be more than a hundred years) have been neglected to the detriment of the environment and to building users and owners. Tax and investment policies reward builders who achieve a low initial cost rather than a low life-cycle cost. In contrast environmentally sound, sustainable and affordable housing with a low initial cost and low life-cycle cost can be built in many parts of the country using plastered straw bales.

THE PROBLEM

The problems in affordable housing are many and varied. Many people can't afford a home of any kind. Sixteen million Americans now live in mobile homes. These energy and environmentally irresponsible homes make up to 80-90% of the new "housing" starts in some areas. These buildings, though much improved in recent years, remain expensive to heat and cool and costly to maintain. Other people, especially the elderly and poorest of the poor, are unable to pay the utility cost of maintaining comfort in their homes and are hot in the summer and cold in the winter.

The goal is clear: providing ecologically sound, sustainable building systems that are inexpensive to build and maintain, provide super-energy efficiency and are compatible with renewable energy sources, and can be owner-built to further reduce costs.

AFFORDABLE HOUSING

The working group discussed many issues related to affordability including the following: the need for careful life-cycle costing; accurate cost estimation for both direct and indirect costs; improved banking and lending policies to recognize environmental savings; development of alternative land holding arrangements, including leases, land trusts, mutual housing associations, and co-housing groups to reduce land cost; credits for energy and environmental savings in lending policies and taxation; use of locally available materials to reduce the embodied energy cost (the net energy required to produce, process, transport, and install materials); use of renewable energy resources, with credits from utilities for energy savings; and promotion of self-help and owner-built houses to reduce cost and increase satisfaction of homeowners.

Where does the money go in a house?

	labor	*material*	*labor and material*	*% total*
Foundation	2,582	2,154	4,736	7
Floors on grade	1,238	1,494	2,732	4
Roof system	4,503	4,790	9,293	13
Roofing	1,364	1,720	3,084	4
Exterior walls	**6,183**	**9,104**	**15,287**	**21**
Interior walls	2,546	3,736	6,282	9
Wall finishes	1,236	737	1,973	3
Floor finishes	783	2,679	3,462	5
Ceiling finishes	1,537	779	2,316	3
Fixed equip	1,177	5,737	6,914	10
HVAC	2,957	2,464	5,421	8
Plumbing	3,612	2,323	5,935	8
Electrical	1,878	1,399	3,277	5
Totals	31,596	39,116	70,712	100

HOUSING magazine cost guide 1982, 1500 sf wood frame slab on grade, Albuquerque, NM. Total cost $35.91 sf in 1982/Adjusted cost to 1993 estimated at $55.00 sf.

LIFE-CYCLE COST ESTIMATE (100 years),

Assuming maintenance costs are the same (in fact they should be much lower for a straw-bale house with metal roof and integral color stucco walls) with an 80% conventional loan at 6%, and the same down payment on all houses.

	Construction	*Finance*	*Energy*	*TOTAL*	*Savings*
Conventional	$82,500	396,000	120,000	598,000	--
Straw bale	$78,375	371,200	60,000	431,200	166,800
Straw bale*	$40,000	141,00	30,000	171,000	427,000

(*owner-built walls, finishing, roofing)

The reality of these savings are illustrated by Chuck Bruner and his straw bale house in Douglas, Wyoming, built in 1948 on a pay as you go basis. His 12" deep foundation has worked well in a very cold environment (frost line 5 feet), heating cost is 1/2 neighbors (better detailing could reduce it much more) and the house sailed through a 5.5 earthquake (30 miles away).

RESEARCH NEEDS

While many facets of affordable housing are clear and well understood, others that should be equally well known are not. Research needed to fill these gaps and chinks includes:

1. Improve cost accounting and accurate record keeping, of dollar and environmental costs, both initial cost and operating costs. (like Tony Perry's Santa Fe, NM program)
2. Develop packages to incorporate life-cycle costs in lending programs/utility rebates.
3. Explore, identify, and develop solutions to regulatory obstacles for straw bale, PV, solar, composting toilets, gray water recycling, etc.
4. Improve consideration of community design, density, infrastructure, etc. rather than on a simple stand-alone house basis.
5. Develop research data on the costs and benefits of using salvaged and recycled material, including needed changes to code to encourage these uses.

EDUCATIONAL NEEDS

The key issues that remain to be addressed are the full cost accounting for economic and environmental cost (energy, water, materials, labor, etc.) associated with different types and methods of building. This material is needed for several audiences including: builders, buyers, tenants, regulators, banks, utilities, equipment dealers, manufacturers, etc.

Develop demonstration programs to get buildings on the ground for people to see and help build. This is essential for public and code acceptance. Seek out the doers, movers and shakers in the communities. Explore opportunities for self-help straw bale housing for transition homes for women (victims of domestic violence), migrant workers, homeless people to help develop building skills, pride, and self image.

WORK PROGRAM

1. Develop a cost-accounting survey form, questionnaire, and software package to facilitate cost keeping and accurate comparisons.
2. Prepare a workbook of straw bale building plans that have gone through code approval to make approvals and planning better for others.
3. Develop a school loan/payment community service plan to involve architecture and other students in self-help/affordable housing projects.
4. Develop educational materials to help students of all ages rediscover the joy of building their own shelter.
5. Outreach to adult basic education and prison work release programs.

Contact:

Send house plans of completed houses to:

Jamie Pennington
501 W. Hayes
Bozeman, MT 59715

Accounting survey form suggestions and cost info:

Tony Perry
31 Old Arroyo Chamiso
Santa Fe, NM 87505

2. Codes, Research and Testing

"It is difficult to make anything foolproof, because fools are so ingenious." anon

The group discussion focused on the code & testing issues impeding the acceptance of straw-bale construction as a viable, accessible, and officially approved building system. We observed that research and testing are directly linked because modern straw-bale construction is a different wall building system (assembly) and that code acceptance must be based on local determinants with standards refined as new information becomes available. It is essential to insure that codes do not stifle innovation.

A major concern of the work group is that communication and coordination between regional factions be close and progressive to ensure efficiency and effectiveness as opportunities for testing programs and official codification become available in the very near future. The work group recommends a "Research Advisory Network" be formed to assure continuity, integration, assistance, and rapid communication between regional groups while each is administering testing programs and writing building code prescriptions. The group also outlined testing priorities.

THE PROBLEM

We recognize that testing and code issues are a current impediment to straw-bale construction and must be prioritized and resolved before widespread use with code approval can take place. The following is a list of problems/concerns that surfaced in our discussion:

1. Despite a growing inventory of buildings, incredible interest, and a growing ground swell for straw-bale construction broad institutional acceptance is still pending.
2. A comprehensive, technical database is needed.
3. There is a need for adequate, simple, uniform building codes that are readily understandable, flexible and transferable from location to location.
4. There is a need for a network to provide social/political pressure (friendly education) for local code officials.
6. Building codes need to be revised to encourage straw-bale construction, straw-bale owner-builders, and other environmentally responsible materials (e.g. California Type K, Australian Human Sanctuary, etc.)

Building one's own shelter is a basic human right. (A new constitutional amendment?). As the hurricane damage in Florida showed it is not possible to legislate good building. Personal responsibility , the desire to do things right, and the acceptance of the consequences of doing sloppy work needs to be returned to building and many other aspects of our modern lives.

RESEARCH & TESTING

Discussion of research & testing focused on answering "what are the next steps" and in general how should it be done? We developed a list of needs and priorities, as well as a flow-chart for code integration. We recognize that research and testing are likely to be hand-in-hand at these early stages. The following concerns are outlined:

Research

1. The limits of straw as a building material must be established by testing.
2. Documenting demonstration projects is essential. There is a need to comprehensively investigate and track successes and failures.
3. While there is funding for research (with eager interest by many levels of society, institutions) research should be coordinated to maximize benefits for dollars spent.
4. A resource booklet is needed - including data, documentation of research, demo projects, graphic details, etc.

(Matts Myhrman and Steve MacDonald are finishing a new book on building methods, Dave Bainbridge is working on a revised and expanded overview of Straw Bale Building)

Testing

To attain code approval to increase access to straw-bale construction testing needs to define maximum and minimum standards?

1. Assure efficiency of testing - avoid duplication of tests.
2. Suggest guidelines for appropriate testing -- What is needed?
3. Create guidelines for comparative testing (i.e. rice straw vs. wheat straw)
4. Identify and address local/ regional concerns in testing procedures.
5. Develop uniform analyses, and complete testing procedures for each region.

This would include procedures for examining straw "off-the-field" to account for local/regional variation (straw bale grading -- #2 or better?).
6. What are the minimum standards and range of acceptable assembly methods?
7. Straw-bale construction needs to be tested as a material for performance standards, and as a wall assembly, straw/reinforcing/stucco, for prescriptive standards.
8. Test results should be documented and stored in a readily accessible research library or institution. They should be accessible from around the country and the world at low cost.

WHAT NEXT?

The work group identified the following testing and demonstration needs for straw-bale construction:

Laboratory Testing	Demonstration Projects
1. Compression parameters	1. Air-movement in wall
a. long-term	2. Temperature swings in wall
b. short-term	3. Seasonal wall-movement
2. Dynamic loading	4. Biological reactions
a. seismic	5. Moisture migration
b. wind, other	(footing up, plate down, through wall)
3. Point and uniform loads	6. Pests-vermin
4. Thermal	7. General observations
5. Fire	8. Compression over time
6. Moisture	9. Durability/finishes
7. Interface w/ materials/connections/ utilities	10. Sustainability/energy-use

CODES

The group defined the need for a bare, minimum specification making straw-bale wall approval easy, while being careful not to limit innovation in the prescriptive code. Initially this will allow acceptance into the Uniform Building Code, and later, as more complete performance testing results are developed, straw-bale construction can be addressed through ASTM/HUD/ICBO/CABO/state and local standards.

The work group recognizes that buildings designed using performance codes usually require professional certification by an architect or engineer, off-setting the low-cost benefits of straw-bale construction. Performance codes require intensive testing, but result in maximum flexibility and utilization of the straw bales, allowing assembly variation as proved case by case with engineering.

In general the group outlines the following specific code issues:

1. Institutional acceptance is needed and should be pursued.
2. Identifying methods & supporting the process of local, official acceptance on a case-by-case basis.
3. Close attention to structural assemblies must be maintained.
4. Code must maintain environmental integrity in the choice of materials and assembly.
5. Low-tech solutions must not be hindered by the code.
6. Architectural graphic standard details can be developed for use as a resource for code acceptance.
7. Code must have regional identity (i.e. available straw, snow, seismic, wind, moisture, etc.).

Code officials should be used as consultants & resources (Tucson/Pima County) and invited to participate in testing and research.

PROACTIVE NOT REACTIVE

After discussing the three topic areas of code, research, and testing, we determined by consensus that a "feedback" group is needed to improve the use of limited resources for straw-bale construction research & testing. This group would also offer support in the formulation of code development and implementation.

It was agreed that *the Last Straw* should be the vehicle for disseminating information on straw bale progress (successes and problems). We also identified the need for a technical database beyond *the Last Straw* to provide better access to laboratory tests and the specific, detailed information needed for additional testing, engineering, and construction.

The work group closed by conceiving a mission statement for a new "Research Advisory Network" and urgent agenda items.

RESEARCH ADVISORY NETWORK

MISSION STATEMENT

To create communication between key regional-representatives of straw-bale construction ensuring efficient, non-duplicative testing is performed with understanding of common research directives, regional perspectives, and the best use of testing resources. To assist planning nationwide for testing programs introducing straw bale construction into building code.

The Research Advisory Network might also develop into an extensive group capable of distributing testing results of straw-bale testing. The network might develop a time-efficient peer review process for testing & code projects (via fax & phone) to assist local/regional groups. This could help groups avoid duplicating material available from other groups, as well as provide communication if a test could address specific questions raised by a group not directly involved in the testing. The network could develop into a technical resource capable of addressing straw bale construction from general performance to specific design problems.

THIS SHOULD BE A NETWORK, NOT AN ORGANIZATION

IT COULD PROVIDE A NON-PROFIT UMBRELLA TO SUPPORT TESTING AND EDUCATION AND DEMONSTRATION PROJECTS

NETWORK HOT LIST

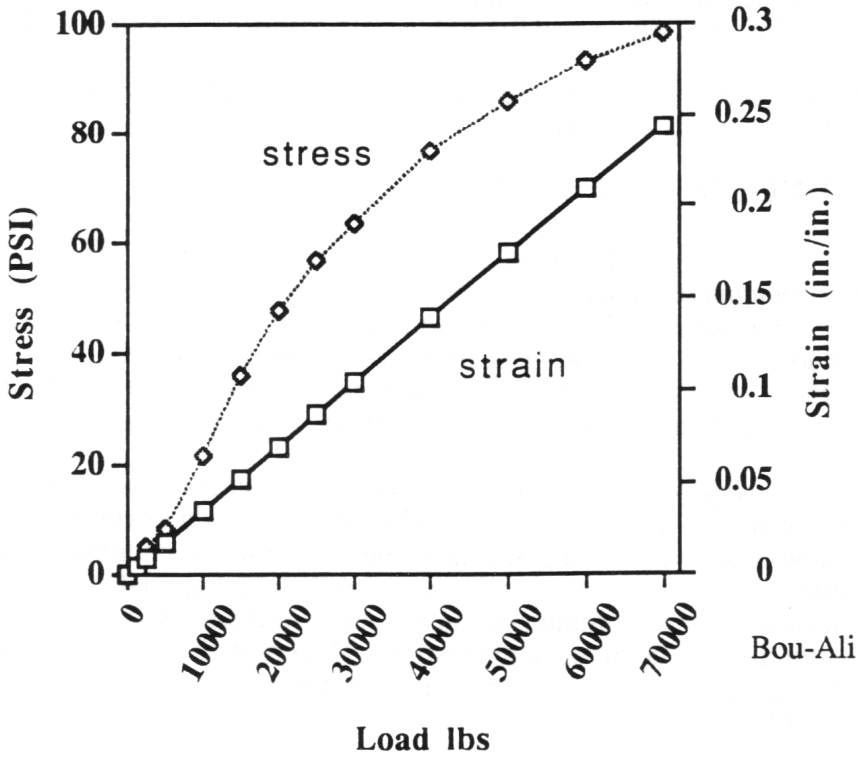
Pressing code issues:

1. Establish Network of Key Representatives
2. Design system for Network Communication
3. Address high-priority issues:
   a. New Mexico testing (Tony Perry, et al)
   b. Livermore Labs testing (Bob Theis, et al)
   c. create and prioritize research directives (Hi-tech/Lo-tech)
   d. identify funding/sponsors
   e. schedule network meetings

For more information and to volunteer for the Research Advisory Network contact:

Bob Theis
c/o D.S.A. architecture
1107 Virginia St.
Berkeley, California 94702
(510) 526-1935

Wheat straw bale #1. Unconfined 3 string poly tied.



Bou-Ali 1992.

For details see: Summary of results of a structural straw bale testing program. CIRC, PO Box 42663, Tucson, AZ 85733 $15 from Out on Bale, unltd.

3. Whole house systems

SYNOPSIS

Using plastered straw bale construction is only one aspect of buildings that are earth- and people-friendly. Integrated designs that consider the whole house as a system, part of the neighborhood, community, ecosystem are needed and possible.

PROBLEM

There is a discontinuity between nature and current architecture and planning. It is compounded by the absence of an architectural/ecological understanding in buyers, builders and renters who don't understand how current systems are supported and maintained. "Where does the water come from? Where does the sewage go?"

The result is expensive, resource-inefficient buildings designed by specialists who use complex, expensive treatments to mask the symptoms of dysfunctional buildings. The air conditioner, for example, is big and expensive because the west facing picture windows are very effective solar collectors in the middle of the summer.

The materials are often toxic, polluting, have high embodied energy cost, and require imported non-renewable energy and resources for maintenance. The often poor fit between buildings and the environment often makes buildings uncomfortable, sometime unhealthful, and costly to operate. The "sick building syndrome" gaining increasing recognition in commercial buildings is also experienced in many homes. These negative attributes are reinforced by the mortgage and utility slavery that the privilege of "owning" a house provides.

Whole house systems design and construction could give homeowners, builders, and renters more control over their housing-- in both the narrower and broader senses. It could help make homes more satisfying for people, families, and communities and environmentally friendly. We need to more clearly identify and portray the benefits of whole house systems design.

SOLUTIONS

Whole house = whole person

Homes can be responsive to life cycles of inhabitants and ecosystem, bioregion, earth. Natural materials from local sources, with low embodied energy and low maintenance cost. Recognition of scale, hierarchy, and ecological context. Self-sustaining and regenerative utilities. Clarifying needs and wants, "How much is enough". Taking personal responsibility to "Do the right thing".

1. Solar heating and climatically adapted cooling
2. Water conservation
3. Gray water recycling and use
4. Composting toilets
5. Composting kitchen and yard wastes
6. Rain water collection
7. Solar electric
8. Community design for people, bike/walk, interact, work together
9. Owner-builder involvement
10. Edible landscaping
11. Co-ownership, sharing resources (Does everyone need a car? Mower? Table saw?)
12. Cooperative process of community building

RESEARCH and EDUCATION

Not a great deal of research is needed to implement excellent whole house systems -- but it won't happen on a large scale without a concerted education program (see reading list at end of paper). Research to improve energy and resource cost accounting of the embodied energy of building (construction, maintenance and recycling) will help move whole house systems into the mainstream.

A comparison of health benefits of responsible housing would also be useful. Breathing houses made with natural materials should demonstrate clear health benefits over traditional resource inefficient homes and the "sealed" energy conserving designs promoted in the 1970's.

ACTIONS

Develop a whole-house compendium to help people understand what is possible and desirable. This would include access to resources, equipment, information, and expertise and how plastered straw bales fit into the equation [The ecosystem/environment--community--neighborhood--house--family--individual]. Site, local and regional resources and constraints must be identified and addressed. Handbooks and videos would collect the scattered information and provide options for the following:

STATIC

FOUNDATION
EXTERNAL WALLS AND WALL COATINGS
PARTITION WALLS AND COATINGS
WALL INSULATION
WINDOWS AND DOORS
WINDOW INSULATION
FLOOR SYSTEMS
CEILING SYSTEMS
CEILING INSULATION
ROOF SYSTEMS AND ROOFING MATERIALS

DYNAMIC

AIR FLOW
OXYGEN AND CO2 BALANCE
POLLUTANTS--INTERNAL/EXTERNAL/MATERIALS/ETC.
MOISTURE FLOW AND BALANCE
ALLERGENS
WATER SYSTEMS--SUPPLY, FIXTURES, USE, WASTE HANDLING, RECOVERY AND REUSE. RAIN COLLECTION, CISTERNS, BIOFILTERS, DISINFECTION, GRAY WATER SYSTEMS, IRRIGATION, ETC.
WASTE HANDLING--COMPOSTING TOILETS, KITCHEN WASTE COMPOSTING AND VERMICULTURE, TRASH MINIMIZATION, RECYCLING AND REUSE
ENERGY SYSTEMS -- HEATING, COOLING, HOT WATER, LIGHTING, COOKING, REFRIGERATION, COOL STORAGE, APPLIANCES AND APPLIANCE REPAIR AND RECYCLING.

Volunteers are needed for this task, including projects on:

1. Listing whole house systems projects, i.e. Integral Urban House
2. Develop reading list
3. Develop catalog list
4. Preparing city information packets, i.e. Austin Green Building Program

4. Low cost building

PROBLEM

The low-tech/low-cost ways of building are rarely considered. These are critical to improve housing accessibility in the U.S. and in the rest of the world. If it can be done as well for less -- lets do it.

Puddled adobe floors are an example of a traditional method that is well suited for straw bale homes. These are found both in fancy custom homes in Santa Fe and in some of the poorest homes....

RESEARCH

Research is needed to identify and test low-cost methods of building from around the world. Key issues include: alternative plasters, alternative foundations, floor finishes, alternative roof insulation (like the French bagged barley straw), thatching, simple climatic adaptations, low-cost trusses, vigas, etc.

Many of these methods will need to be adapted to different materials and climatic conditions and this will demand basic and applied research--much can be done by students and homeowners at low cost. A teaching module based on working with alternative building materials would be ideal.

DEMONSTRATION

Demonstrations are also urgently needed to prove to builders, designers, and home makers that these low-cost materials work and are acceptable or perhaps even better than conventional materials.

EDUCATION

Education is needed to provide the basic information on low cost materials to users and regulators across the country and internationally.

MATERIAL ENERGY COSTS

	Delivered to job site, BTU
Rough softwood, board foot	7,700
Finished softwood, board foot	7,900
8"x8" softwood beam (20')	842,00
8" equiv. viga (peeled, round pole)	50,000
Roll roofing, sf	11,000
Aluminum sheet, sf	32,000
Concrete, cu ft	96,000
Fiberglass insulation, sf 3.5 inch	6,900
Cellulose insulation, sf 3.5 inch	1,000
Fiberglass insulation, sf R-50	**100,000**
Straw bale, sf R50*	**3,400**

(*2 equip hrs acre/1.5 gal fuel hr = 3 gal for 2 tons/44 bales = Long Taylor and Berry, 1978. Hay harvesting costs in Texas, B1171, TAES, College Station Texas.
1.5 gal x 150,000 = 225,000/44 = 5,000 BTU = 1,600 BTU sf. (+ twine and 1,600 for delivery). Bainbridge, 1980, Ch 12: Low energy use materials. In: 2nd Passive Solar Catalog, Passive Solar Institute; see also Hannon et al., Energy and labor in the construction sector. Science 202(24):837-847

An owner-built house emphasizing low embodied energy materials: bales, mud floor, vigas, mud mortared stone foundation, may have an energy cost of construction of 15,000 BTU sf versus conventional residential construction energy cost of 700,000 BTU sf. Operating energy cost can also be <20% of conventional construction.

ACTION

1. Develop a resource list of information on low-cost building options
2. Develop a school and community based program for research and demonstration of low cost methods and materials (including lessons on separating needs from wants).
3. Compile/publish a regional/bioregional directory of straw-bale contacts and information and details on appropriate low-cost building materials and methods.
4. Develop a simple system for ecological and "economic" accounting to encourage integrity in design, material preparation, building and maintenance.
5. Get your hand dirty
6. Tell a neighbor

Contact:

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Gila, NM 88038

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La Jolla, Ca 92037

5. Information, networks and education

PROBLEM

Lack of awareness despite substantial data and a rapidly growing knowledge bank. We need to keep low-cost building on the agenda -- to avoid being swamped by the prevailing U.S. approaches.

A need for local, regional, and national linkages and networking. Some solutions are local specific but all are related and benefit national and international efforts. Needed: low cost, user friendly, flexible approaches.

the Last Straw could be the vehicle for much of this if we can make it clear that it is for all of us and that we each have a responsibility to write for it.

ACTIONS

1. Input and use *the Last Straw* newsletter, keep it grounded and accessible.
2. Focus on straw bale
3. Section for small tech in a regular column.
4. Get resource materials into libraries and databases ask people to request acquisition, review materials, donate materials, etc.
5. Develop regional resource lists:
   - Key people and institutions
   - Key information lists--written materials, sources of supply, etc.
   - Friendly libraries for information collection
   - Computer networks
   - Regionalist Out On Bale mailing lists and develop a user group
6. Translate materials into other languages and media

Contact:

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Bisbee, AZ 85603

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Kingston, NM 88042

Special thanks to Laurie Lippitt for a careful and considerate review. Errors and misinterpretations of notes and intentions of the work goups are my responsibility. db

the Last Straw, the journal of straw bale construction. From Out on Bale (unltd) 1037 E. Linden, Tucson, AZ 85719 $28 yr. Give a subscription to your local library and architecture school.

An introductory guide to whole house systems/green building, favorites underlined. Look for a more detailed list and article to come in *the Last Straw*.

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