Resources for Sustainable Architecture from Historic, Ancient, and Indigenous Knowledge

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ABSTRACT
The archaeological record of architecture and planning found in the building traditions of ancient to historic, indigenous societies shows a remarkable insight and sensitivity to the landscape and ecology of the place and the region, and a knack for integrating form and material use with the surroundings. Such traditions have the advantage of thousands of years of trial and error, and comprehensive societal participation. This environmental insight and level of design integration may reasonably be of use for modern design challenges. Based on the author's PhD work done in Trondheim and following on from the paper delivered at PLEA 2004, the author will review key points in the methodology of looking at ancient to historic architecture for inspiration for the modern condition, provide a synopsis of types of resources for its study, review some of the interesting lessons for better energy conservative, climatic building in cold and hot climates, and make suggestions for how this area of study should be included in the curriculum of design education, practice, and further research.

KEYWORDS
Vernacular Architecture, History, Local Knowledge, Ancient Architecture

Introduction

Trends in the development of local and planetary environmental conditions now and in the future present challenges to society to find knowledge and methods for continued human survival. These trends are apparently largely the result of anthropogenic action on the land, water, and atmosphere, and are therefore amenable to mitigation, or in some cases reversal and the restoration of some original balance and health to worldwide ecosystems. Goudie (1994), (Pickering and Owen 1997), Huggett (1997). There is therefore a demand for responses from the construction industry and the design community to present viable yet innovative alternatives to the conventional design of settlement and shelter. This is because upwards of 40% of the energy and 50% of the CO2, and a large proportion of land destruction, deforestation, and species/habitat loss, depending on the country, results from construction activity. Pachauri (2006), Juniper (2006).

Widespread environmental degradation is not new and we should learn from the crises of the past. Diamond (2005). Around 10,000 B.C., the Levant experienced drought, high temperatures, over population, and the profligate use of natural resources. Some authors feel that these conditions forced the societies concerned into domesticating wild grasses and animals. This very quickly led them to rework their architecture to be able to accommodate stores of these plants and animals, and further, to concentrate these stores into ever larger warehouses along with the buildings and sacred structures to house people and structure their thought processes. Papanek (1995). Again, by the fifth century B.C., most of the Greek world had been denuded of trees. To reduce the use of wood as fuel for heating and lighting, architects of that age began to design their houses to take advantage of the available solar gain for heat and light through south facing openings and courtyards. (Butti and Perlin 1980). The Romans were even more profligate in their use of wood, which again spurred their building designers to innovate a more efficient use of passive solar energy. In the first century A.D., the Romans began to use clear materials such as mica and glass to glaze the openings of houses, baths, and greenhouses, and so they were able to retain much of the thermal gain, reducing losses due to infiltration and convection, without sacrificing too much of the visible light for interior lighting. Roman architects Faventus and Palladius went further and built under floor heat storage in basements filled with rubble. Finally, this solar innovation spread even into law, the Justinian Code of the sixth century guaranteed the right to solar access for buildings. Ibid (1980). Thatcher’s and Fitch’s analyses of ancient and indigenous architecture from over 50 years ago are two examples of groundbreaking work on this subject and the energy effects of commonsense design that by necessity took account of the surroundings and the climate. Thatcher (1958), and Fitch (1972).

Further, innovation in settlement and shelter provision to meet these challenges must themselves be sustainable, UNEP/IETC (2002), ICLEI (1996), and meet the following proposed criteria:

1. efficient use of energy and resources in manufacture, construction, operation, and re-use/recycling
2. use of renewable energy
3. have a minimal negative impact on the natural environment and human health, or ideally restore and renew the environment

4. based on a holistic conception of the natural environment and human society relationship, in order to integrate their function and aesthetics
5. based on fundamental and complex characteristics of ecosystems in order to build urban areas
6. based on an appropriate sense of scale of human construction in space and time Flyvbjerg (1992)
7. provide a long term vision for urban areas based on equity, individuality, and sustainability
8. help societies to attain long term economic and social equity
9. empower people, foster participation, while enabling cooperative networks and institutions to work towards a common sustainable future (Funtowicz and Ravetz 1992)
10. sustainable structures cannot be considered to be isolated from the culture that built and interprets them or the landscape within which they exist and were constructed from

Nowadays, the construction industry is again looking for inspiration. One other worthwhile area of study is research into ancient to historic architecture, especially from those societies long considered by scholars and the general public to be indigenous or *primitive* and unsophisticated. See Guidoni (1975) for a definition of the field. There is thus a need for an overall view of the study of ancient and primitive architecture in terms of how the subject area has and will in the future provide inspiration for research on, and the professional practice of, architecture and other building sciences. This paper will focus on the following aspects of gaining inspiration from studying ancient and indigenous architecture:

1. methodology of study
2. main types of resources for study, with examples
3. review of useful knowledge for sustainable architecture
4. suggestions for the inclusion of this knowledge in design education, research, and professional practice

Why is this Research Interesting for the Construction Industry?

The environmental challenges faced by the construction industry to build a sustainable built environment at the beginning of the 21st Century are significant. From Table 1, they stem from both natural impacts and societal responses to the environment.

Table 1. Challenges to the Construction Industry to Build Sustainably

Although there has of course been a lot written about ancient to historical architecture and engineering, some aspects of the material on the buildings of these eras has been neglected. Very few authors have looked at the material with an eye to gaining insight applicable to the contemporary settlement situation. Normally the study is undertaken only to learn how to restore ancient or historical still standing structures, not to help in designing new structures. Further, it is usually only buildings with ornament or those that are from an approved category of art history that receive scrutiny; farmhouses, barns, or other often undecorated structures do not receive the same amount of effort as do cathedrals, palaces, or castles. Glassie (2000). Finally, the built environment of pre-literate or indigenous societies until recently received scant attention from engineers and architects, allowing a vast amount of data and local know-how to pass relatively unnoticed into obscurity. However, with the recent advent of anthropology, ethnology, and archaeology in the 19th Century and the ever widening number of life ways descriptions, indigenous architecture is receiving more attention. Rudofsky (1977), Prussin (1995), (Bourdier and Minh-Ha 1996), Farmer (1996) and Myhre (1982), among many others.

Despite this new interest, vernacular, primitive, and historical architecture remains controversial to many as inspiration for our present challenges. After all, the great halls of the English royalty built before the 20th Century were drafty, cold, and difficult and costly to heat. Other authors have commented on the European dwellings of the medieval era with yet more disdain, remarking that medieval houses were, "roughly constructed and probably short lived…", and, "…totally lacking in comfort." Pounds (1989).

Architectural practitioners have on the other hand praised indigenous and ancient building. Mies Van der Rohe (Bugge and Norberg-Schulz 1969)
has commented thus:

Where can we find greater structural clarity than in the wooden buildings of old?
Where else can we find such unity of material, construction, and form?
What warmth and beauty they have! They seem to be echoes of old songs.
What better examples could there be for young architects?

And Frank Lloyd Wright (1911, reprinted in 1986) has further written:

The true basis of for the more serious study of the art of Architecture lies with those indigenous more humble buildings everywhere that are to Architecture what folklore is to literature or folk song to music and with which academic architects are seldom concerned…although often slight, their virtue is intimately related to the environment, to the heart life of the people. Functions are usually truthfully conceived and rendered invariably with natural feeling. Results are often beautiful and always instructive.

Thus, this area of research is in fact worthy of study. Wilkinson (1991). This is because many recent authors have shown interest, it is controversial, there are lacunae in the knowledge, art historians and architectural historians have up to now categorized the knowledge from a narrow and biased viewpoint, and several architects and engineers have actually reported on their own use of historical or primitive knowledge in contemporary construction. (Bruegmann and Prowler 1979), among many others.

Methodology of Studying Ancient, Indigenous Building Traditions

Traditionally, ancient architecture is studied within the well known fields of archaeology, anthropology, and the history of architecture. (Macinnes and Wickham-Jones 1992). Since the 19th Century, two new sub-fields have arisen to gain new insight into ancient and indigenous traditions.

Experimental archaeology started in the 1880s in Switzerland and Denmark with the construction of new buildings based on excavation reports and scholarly speculation. Coles (1979). More and more such buildings have been constructed, and now whole open-air museums are devoted to the professional reconstruction and experimentation with buildings based on what we know of ancient shelter. Not only is traditional archaeology contributing to the re-building of these structures, but both the experimental construction process and trial tests of life within these buildings is offering up valuable new information on their reasonable re-construction, their use in the contemporary economy, and their effects on ancient, local, or regional natural resource and energy use. Draiby (1991), Hansen (1981).

Further, architects and anthropologists have begun to study settlement and shelter from the anthropological viewpoint, or how the built world is both a frame for human production and reproduction, and in turn, how this human culture uses and interprets this framework. Egenter (1992). Much of this work has focused on presently indigenous societies, although some studies do exist examining the over-developed and energy profligate societies. Diamond (2005), Wilk (1990), Lawrence (1990), Gullestad (1984), and Rapoport (1969).

Ancient classical civilizations have provided through written records characterizations of daily life and the use of shelter in the past. Writers such as Tacitus (1963), have provided some idea of life ways and building use when it comes to more ‘primitive’ societies of the past, but this information is supplemented by studies of what we know of indigenous societies from the historical era and through contemporary ethnological work. Benjamin (1995, 1993). Thus, in order to glean useful information for contemporary design practice, it is necessary to combine knowledge of construction methods and building use from the recent past and present, excavation records and archaeological interpretation from pre-history, results from experimental archaeology, and historical/ethnological records of recent spatial, economic, and physical concepts, into some model of ancient, indigenous architecture. Such a model can then be analyzed with the following methods:

1. testing by physical or thought experiments to study some specific aspect of architecture
2. comparison to the models of other authors and comparison to their results, if the original premises, theories, and methods of each study are known and are comparable

In doing so, we learn about the models, how they can be improved, what other aspects of architecture that we missed should be studied, and how the entire methodology and theoretical basis of such studies should be modified in order to improve specific types of results.

One such study by this author looked at farmhouses from the Scandinavian Bronze and Iron Ages. Benjamin (1993). The relationship between architecture and the natural environment during these two eras seemed interesting, and a possible concept to help in studying this architecture was found in a term used today but originating in the Scandinavian Iron Age, the *home.* Modern day studies of the home concept and its spatial/physical consequences were then compared to the ancient concept and its spatial/physical consequences in the houses of the past by examining the archaeological record and interpreting the results of experimental archaeology.

Other studies have looked at still extant ancient structures, making use of their continued use or the verbal/written records of recent dwellers to more closely study the use and interpretation of ancient or indigenous buildings. Cataldi (1992, 1986), Antell (1994), Walker (1996a), and Harrison (1999), among others.

Results from these studies have rediscovered for us:

1. different interpretations of space in settlements and houses
2. how to interpret ownership and the determination of how societies care for their environment though mediating concepts such as home and wilderness
3. the effective and efficient use of natural, local building materials
4. the efficient use of energy in construction and operation
5. the use of either single or hybrid natural materials to construct healthier, more durable structures
6. the ability to relate to the surroundings through the use of locally available natural materials
7. how prudently scaled structures result in more community participation in the design and build process, and how this can result in more capital remaining in the local community
8. differences in perceptual ability and technical aptitude among indigenous informants that affect their acuity, dexterity, and problem solving capability

Main Types of Resources for Study
The main resources for the study of architectural solutions from the past and indigenous societies are as follows:

1. on-site observation of societies with intact building practices known to be remnants of or similar to ancient or indigenous groups
2. archaeological or anthropological interpretations of extant building traditions or the remains of these traditions in structures and informant records (Barber and Welsh 1992), Greeves (1992)
3. ethno-methodology, the study of societies contemporary with the observer
4. architectural history, culture history, technological history, environmental history, and the general history of societies
5. besides the literature of books, journals, and websites, there exist film, audio, and video records useful to this research

Review of Useful Knowledge for Sustainable Architecture

Useful knowledge for the contemporary settlement situation from ancient and indigenous sources can be divided into two categories: First, knowledge of building design, component/assembly manufacture, and materials, and second, capabilities of advantage to designers, such as design skills, locally appropriate knowledge, creativity, mechanical aptitude, and perceptual ability.

Building design and materials
There are several materials that are of consequence for modern construction, including finish and structural materials.

While lime plaster has been used for 1,000s of years by classical civilizations and indigenous groups, practitioners now use lime plaster and variants with linseed oil paint, and concrete to finish masonry, wood frame, adobe, and strawbale buildings in order to produce a tough, paintable, but breathable cover for structural assemblies. Reichel, et al. (2004).

The general category of earth building includes adobe, clay filled walls, clay-stone and clay-turf (moss or grass) hybrid constructions. These structures are known as a part of local tradition and are still standing, from the varied climates of the hot-arid southwestern U.S. and northern Africa, to the cold and wet Scottish Isles and throughout Europe. Steele (1997), Elleh (1997), Walker (1996a and 1996b), Fidler, et al. (2000), and (Hurd and Gourley 2000). Clay has been used as a breathable infill material for wood wattling, and its efficacy is attested to by extant 12th Century wattle and daub buildings in Germany. Andresen (1998), Chappell (1998). This re-discovery of clay has given rise to innovative products such as new ‘light-clay’ mixtures, used to produce mold-able infill material, reed-burlap-clay hybrid prefabricated dry boards for interior finishing, Ibid (1998) and un-burned clay blocks Hugues, et al. (2004), as exterior and interior prefabricated wall panel products.

Thatch is another important old material, used for the roofs of cottages and holiday cabins in Europe even today. Apparently, thick thatch roofs do have some insulating value, but more important, they allow the house to breathe, they last upwards of 20 years, and can often be sourced from the immediate surroundings, from the straw of northern Europe and the American Plains to the sedge of more southerly wetlands. Walker (1996b).

Stone is of course a material popular in the ancient world that can be used as a facing or structural material even today. Stone-clay hybrid walls were popular in the west Nordic tradition for 1,000s of years, and even into the 20th Century. Walker (1996a, 1996b), Myhre, et al. (1982). Most modern building codes require reinforcing of masonry units and thus have made structural stone walls exorbitantly expensive. Retaining and free standing walls can still be built of structural stone, while stone can profitably be used as thermal mass on the exterior or interior to gather solar gain, hold the heat, and release it over time.

Wood is yet one of the best all-round materials as it can:

1. function as structure, wall/roof infill, finish material, and in some environments foundation
2. is rapidly renewable
3. can be easily worked for jointing or other purposes, with hand tools, even tools that are made with hand tools
4. with significant thickness it has some insulating value
5. can be easily worked to produce decorative effects, has apparently a pleasing appearance from natural grain patterns and colors, and is often pleasing to the touch and smell

These properties were long ago recognized, and indeed, the wooden structures of the past in many ways are more impressive than modern day attempts. (Bugge and Norberg-Schulz 1969), Affentranger (2005). For example, the wood of the Viking ships of 1,000 years ago are famous for having a modulus of elasticity higher than aluminum. Haslestad’s (1994) research at the Norwegian Antiquities Office in Oslo provides some insight as to how far we can go in bringing out the true potential nature of wood as a building material. His work involves not only a study of the material, but also work on ancient and historical wooden and iron tools to search for a more sensitive working of the material that does not harm the surface and the grain structure of wood. Through techniques such as the splitting of logs rather than quarter sawing, shaping with axes and adzes to form mortise and tenon or plug, surface forming with knives, and finishing for protection with surface burning and painting with pitch and tar, Haslestad seeks to recover the build quality and durability of the wooden medieval buildings found in open air museums, in villages or towns, and at extant farmsteads across Scandinavia and Europe. Many wooden houses, barns, and other structures, from Europe, such as the Rauland House from Uvdal, Norway, Figures 1 and 2, from about 1030 A.D., still stand in the open after over 900 years. Most of these buildings have had some renovation work done on them, but they are essentially made of literally the same wood as the day they were first constructed.

Figure 1. The 3 room Raulandsstugu dwelling house from South Rauland, Norway, dated to about 1,030 A.D. Now at the Norwegian Folk Culture Museum in Oslo.

Figure 2. Two isometric views of the construction and interior of the Raulandstugu.

This durability is due to the following factors:

1. wood quality is very high with very tight grain and high harpiks content
2. the techniques used to cut the tree down and process it toughened the wood, allowed it to dry over a long time period, while also making it flexible
3. the wood working techniques included splitting the logs along the structure of the tree growth, making joints at the correct position relative to the tree structure, grain, and knots, and using hand tools
4. shaping the surface of the wood with knives to not destroy the grain and to protect the wood from insects, mold, and other pests
5. protecting the wood when necessary by sintering the surface and painting it with pitch or tar

Climatic design according to the conditions of the local context has been known for millennia. Otherwise, it would have been difficult for most societies, especially those that did not have access to far flung networks of resource and fuel supply, to survive. Ljøsne (1993). As noted above, the Greeks and Romans were innovators in the western world in the use of passive solar heating.

In more northern latitudes, solar design is more difficult, but the Inuit and the Scandinavians have made do with using other design techniques to conserve heat and build more efficient envelopes. Nearly spherical Igloos from the arctic have a very small surface area to volume ratio, while snow piled on top of their ice walls tends to insulate the structure, along with fabric hangings on the interior that form insulating interior air gaps. Papanek (1995).

The Nordic longhouse from the Bronze and Iron Ages was made from wood, clay, dung, and sometimes stone-clay-wood or wood-clay hybrid walls, all used for their qualities of insulation, stability, strength, permeability to water vapor, and availability. Low to the ground and rectangular, with hip roofs, and pointed into the prevailing wind, they were made to reduce aerodynamic turbulence and reduce areas where driving snow would pile up. Myhre (1982), Benjamin (1993), Ørum-Nielsen (1996).

This author analyzed several such houses by studying open-air museum reconstructions, analyzing experiment reports, interviewing museum staff, and spending the night in two of the houses, Benjamin (1993), Draiby (1991). One house from the study was based largely on the farmhouse XVII from Grøntoft, excavated by C.J. Becker (1965 and 1987). As shown in Figure 3, there are a succession of villages placed within an area of about 34 hectares on the Jutland plains of the Pre-Christian Iron Age. This region of Denmark had by this time already been largely denuded of trees and was dominated by moss and various grass types, growing on a sandy podzol profile, a soil type requiring supplies of regular and high quality fertilizer for most forms of agriculture. The grazing of cattle was thus important to provide regular supplies of nutrients to the soil.

Figure 3. 1:5000 Site Plan of Successive Grøntoft Villages 500 – 100 B.C.

Figure 4 shows the the location and orientation of the particular village from the period of about 300 B.C. Thus, this house from approximately 300 B.C., was one of a group together with other houses and barns, enclosed by a fence, at the brow of a south south-west pointing hillock. By pointing the village into the wind, and with apparently good site planning, wind studies in the dissertation have shown that there was a minimum of turbulence and velocity loss of driven snow around the fence and the buildings. This allowed continued access to the village and the individual houses throughout the winter, and further reduced infiltration losses to the building envelope.

Figure 4. 1:4000M Site Plan of the Grøntoft village at about 300 B.C.

Figure 5 shows the house plan, with human dwelling to the left or west, and the animal byre to the right. Living with animals may have had beneficial effects, as their heat helped to meet the heating load for human comfort in a mostly treeless environment, and the evaporating urine of the cattle may have purified the interior air, Walker (1996b). Further, a clay-dung-wood hybrid wall, built as wattle and daub, was strong, stable, and vapor permeable, as a self-supporting envelope, since it did not have to support all the weight of the roof, which was instead taken up mostly by the two rows of posts.

Figure 5. 1:50M Plan of House XVII, Grøntoft, Jutland, 300 B.C.

Finally, all the building materials of the house were of course recyclable, and Becker speculates, based on a long series of excavations in the area, that these houses were purposely burned as a group to fertilize fields. The entire village would then move to a nearby location, and farm fields that had previously been fertilized by entire house conflagrations. By thus moving around in a culturally determined landscape, the village was able to fertilize the earth for future generations, as well as the daily fertilization that they performed from cow dung, also produced from the house. Further, since the villagers depended for their livelihood on knowing where previous generations had fertilized the earth, the village probably practiced a sort of community archaeological science over a long time scale, perhaps 300 years. This intense level of integration of human society with the natural environment was thus achieved through the detailed and thoughtful design of the built environment.

Other authors have concerned themselves with the climatic design of buildings in the arid and humid tropics. Here, passive solar design from ancient and indigenous cultures provide some useful guidelines, from natural ventilation techniques, to the use of lightweight or heavy building materials, the judicious use of color, and material selection. Givoni (1998), Olgyay (1963), Lippsmeier (1980), (Fry and Drew 1982), Konya (1980), United Nations (1971), Elleh (1997), Lusk (1997), and Steele (1997).

Qualities of the designer

Most indigenous societies present remarkable skill at designing and constructing buildings appropriate to the local climate and material availability that are also energy and material efficient. Ljøsne (1993), Papanek (1995). This is often due to their:

1. intense and constant training in powers of observation and concentration
2. manual dexterity from early and constant work with local materials from making toys to simple observation of their elders
3. general tool and material know-how from constant training to construct hunting/fishing equipment and building parts or whole structures
4. incentives to be highly skilled with tools and materials because of challenging environments with harsh climates and dangerous flora/fauna regimes, such as the arctic, the deserts of Africa, the tropical Amazon basin, the typhoons of western Norway and the North Atlantic Islands, and the windy, great plains of America.

These keen abilities at observation, interpretation, and material working skill has allowed indigenous societies to construct remarkable buildings that our modern society only now can do with tracing paper, (or computers), calculators, and power tools, and yet modern buildings often look like cheap knock-offs of the real thing. 10 story adobe structures in Yemen, stone and adobe solar housing in the American southwest, Knowles (1974), igloos that maintain interior temperatures of up to 15° C with exterior temperatures of -48° C without damage to the structure, Papanek (1995), timber frame houses with free span beams of over 6 meters supporting rafters and a thatch roof with snow load in windy Denmark, and finally, 900 year old still standing wooden houses from Norway, with some medieval wooden structures still being used as dwellings in central Europe, attest to the high skill and knowledge level of these designers from the past.

There are apparently differences between sustainable and non-sustainable architecture, and the ideal training to acquire beneficial design capabilities. They are enumerated as follows:

The non-sustainable, Ljøsne (1993), Papanek (1995):

1. people own more than they can carry
2. shelter and settlement as the warehousing of purchased goods
3. modern materials cannot be understood and thus dis-empower people, with no evident memory of origin, no evident relationship to humans or the environment, no indication of how to manufacture them or modify them
4. modern complicated buildings with novel materials difficult to disassemble and recycle or re-use

5. space a neutral concept, there being no special places of subjective value or interest
6. buildings resemble drawings, in so far as the built environment strives to imitate geometric perfection

The sustainable, Ljøsne (1993), Papanek (1995):

1. local environment as the provider of building materials, providing a memory of place, occasion, an evident relationship to the environment, to methods of modification and repair, and to the human extraction of the resource
2. built environment provider of the constructed image of the world, a physical interpretation that explains the look, feel, and functioning of the world, thus a production of culture that has didactic and sanctioning value for human development
3. use of all the senses in building and environmental interpretation beyond concentration on the visual, to include hearing, smell, taste, touch, and haptic senses
4. appropriate technology as an answer to profound cosmological/social/environmental questions
5. detailed characterizations of local environmental conditions to enable detailed and accurate use of the natural world and it's stewardship
6. building activity as a conscious imposition on a naturally occurring order, not on an order-less wilderness or wasteland, which therefore demands a study of this order prior to design and construction
7. the familiarity with and ability to read this order and its changes as essential to sustainable life ways
8. important to find exactly the right place (and time) for even the smallest details of domestic and work activities, making the choice of place and occasion important, demanding analysis and interpretation of the local climate, geography, history, and built environment with all the senses, and focusing on the relationships between the contextual factors, not their individual qualities
9. settlement once established, is vertical, tradition continuing by building house upon house, to continue a familial or societal relationship to the past and future culture and to the landscape
10. the detailed placement and use of buildings, fields, fences, and in general the relationship to natural features and other buildings an image of specific ordering principles, concerning how the environmental framework is interpreted, how ownership is ordered, how economic activities to exploit natural resources are ordered, and how these ordering principles are an image of the human relationship to natural or sacred order
11. drawings resemble buildings, in so far as drawings strive to represent building materials in specific situations

Design Education, Research, and Professional Practice

Today, the use of knowledge from ancient and indigenous construction techniques and building design is still used on an ad hoc basis, sourced from a broad variety of literature, websites, films/DVDs, and observation or word of mouth. However, authors such as Paul Oliver (2003, 1997), Enrico Guidoni (1975), and Norbert

Schoenaurer (2000) have over long careers provided organized views of this field of study.

Because of the advantages that this sort of knowledge and skill level may provide to the practice of sustainable architecture, further effort should be pursued to gather more material, incorporate it into the already existing organizational schemata, and test out this knowledge in real buildings, whether in the cause of experimental archaeology or for informant occupation. Further helpful steps would include annotated bibliographies that translate journals and other media from different languages, and research projects on the use of indigenous or ancient architectural knowledge that produce research reports, especially those that build whole buildings or building components for 1:1 tests in real life conditions.

Such programs will also further the cause of research in the field, as the above activities will stimulate dialogue concerning theory, method, research design, and the usefulness to society of such research agendas. Universities with departments of architecture and building engineering, and research institutes should study, criticize, and test out the agendas already enumerated for this field by the Norwegian Office of Antiquities and the Swedish Antiquities Office.

Finally, the education of architects and engineers would benefit from a greater use of this material in teaching as it broadens the perspective of students to include:

1. a greater representation of the world's building traditions
2. provides more examples of low energy, passive, and appropriately human scale settlement and shelter
3. provides models of the skill, dexterity, and perceptual capability that can be achieved through greater concentration on hands-on training
4. provides techniques for training students to attain this greater dexterity and perceptual capability in handling materials, understanding space, and becoming more creative in problem solving, through the use of novel, harsh environments and modeling excellence from experts

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