Report 03/2009

ENERGY EFFICIENT BUILDING METHODS FOR TAJIKISTAN

Gaia architects – Norges Naturvernforbund

This report, "Energy efficient building methods for Tajikistan" has been made by Gaia Architects on commission of The Norwegian environmental NGO Norges Naturvernforbund (NNV). Architect Rolf Jacobsen has been main contributor and architect Arild Berg has been involved through corrections and discussions. NNV is involved in energy saving programs in Tajikistan, and wants to examine and address the possibilities to achieve improvements based on the use of the traditional and natural building methods.

NORGES NATURVERNFORBUND
FRIENDS OF THE EARTH NORWAY

Report:

Energy efficient building methods for Tajikistan.

Architect Rolf Jacobsen. Gaia architects. Jan. 2009.

Innhold

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NORGES NATURVERNFORBUND
FRIENDS OF THE EARTH NORWAY

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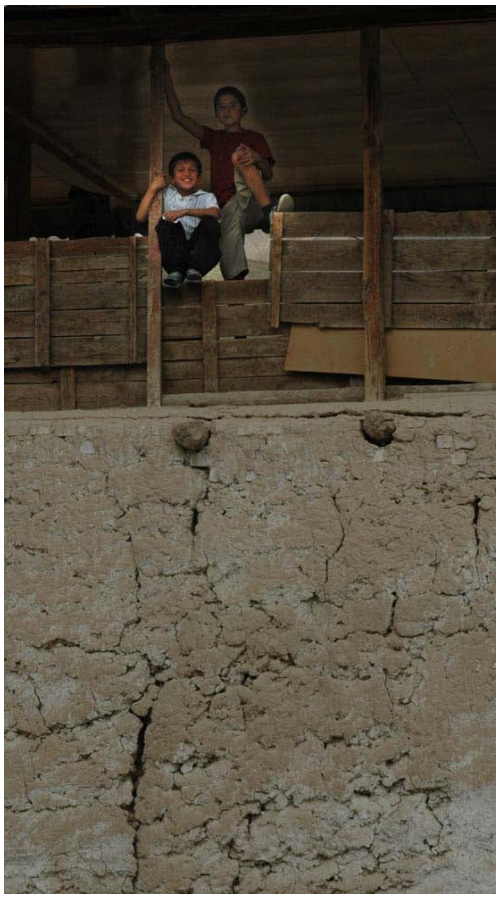
1 SUMMARY

This report, “Energy efficient building methods for Tajikistan” has been made by Gaia Architects on commission of The Norwegian environmental NGO Norges Naturvernforbund (NNF). Architect Rolf Jacobsen has been main contributor and architect Arild Berg has been involved through corrections and discussions. NNF is involved in energy saving programs in Tajikistan, and wants to examine and address the possibilities to achieve improvements based on the use of the traditional and natural building methods.

The main subject for this report is to focus on how to reduce the energy consumption in the buildings in Tajikistan, by using and improving both traditional earth- and clay based building methods like the “cob” and “adobe” technique and modern use of natural building methods, such as the strawbale and straw-clay building technique. This means; improvements for better insulation, methods for making houses of better quality, more sustainable living conditions, and last but not least, improvements on the seismic safety. The report also focuses on the importance of improving the heating of the buildings by use of efficient wood stoves.



The report contains presentations of the most common methods, evaluations and suggestions for improvements of the building methods, based on Gaia Architects experiences and international research on natural building materials and methods during the last 20 years.

“Natural buildings” seek to develop sustainable architecture based on natural materials, appropriate technology and a holistic approach. For more than 20 years there has been a movement in the western countries to develop solutions for “Natural buildings”. New ideas and concepts have been combined with traditional knowledge and building

techniques and can be adopted to very different situations. In this way the concept of "natural buildings" will be relevant to solve the problems connected to the modern houses and be a contribution to develop more energy efficient and healthy houses based on traditional building techniques.

In Tajikistan, traditional way of life in smaller, rural settlements, self-contained household and low income is still widespread. Natural building methods based on local resources and tradition has the potential for substantial improvement in energy efficiency, ranging from a simple, technical level to new concepts and building techniques.

This report suggests different solutions that hopefully will serve as a resource for making decisions of what kind of pilot project that could be accomplish in Tajikistan.

2 OBJECTIVES

The main objective for this report is to examine the possibility to develop building methods for rural areas in Tajikistan that improve the energy efficiency and are climate friendly, also based on natural building materials that are accessible and affordable. An important objective is also to develop building methods that have improved seismic performance compared to traditional earth and stone buildings.

The situation in rural areas in Tajikistan is dominated by buildings of earth or stone with poor qualities regarding thermal insulation and show a general lack of maintenance. In addition there is a tradition to use more or less open clay-stoves for cooking and baking, which is placed in unheated rooms. The consumption of firewood is high and adds little to the heating of the rooms. Room heating is most often provided with iron stoves of poor quality. Windows and doors are leaky; there is little or no insulation in floor and ceiling. The result is high consumption of energy (wood, coal) and therefore also a high proportion of living cost connected to energy. Even then, houses are cold and not very healthy. This causes, especially in the mountain valleys, problems with deforestation and other environmental problems.

The vision of the Soviet system was based on industrialization and of bringing people into modern apartment building of concrete in the cities where they worked in factories. The traditional houses and village living became degraded. Poverty, lack of maintenance and traditional buildings in decay leaves today a general experience of poor people in poor houses and creates thereby a disregard of the traditional earth-building techniques.

The earth-building technique, which is common in Tajikistan (Cob and Adobe), does not have much resistance to earthquakes. Houses built from stone and clay (as in the high mountains) probably perform even worse. Heavy walls from earth and stone will break apart and collapse and be a real hazard to the inhabitants. It is therefore an objective to improve these traditional building techniques or to develop new ones that give more seismic safety.

Solutions

This report makes suggestions for solutions to improve the energy efficiency of the traditional houses of rural Tajikistan and at the same time improve the seismic safety. These are suggestions that operate on different levels; from small improvements of traditional techniques to new materials and building concepts. Three levels have been defined;

Low level; improvement of existing techniques.

Middle level; improving the performance of existing houses by insulation of walls, floors and ceilings, better windows, more efficient wood stoves etc.

High level; develop new and improved building techniques and build model projects.

Project

An objective of this report is to show a range of possible solutions and give the documentation of effects regarding energy efficiency and seismic safety as a resource for making decisions about a pilot project in Tajikistan. Of course, other considerations about site and situation, organization, economy, educational effect, accessibility etc. have to be done.

3 NATURAL BUILDING METHODS – SOLUTIONS FOR A SUSTAINABLE FUTURE

We are facing a climate crisis that needs to be addressed at all levels and in all parts of the world. New and better solutions have to be developed. The building industry and houses consume a large proportion of the total climate gas emissions. We need to develop houses that are far more energy efficient than today. We have to move from the use of building materials that causes large consumption of energy (climate gas emissions) in production – like cement / concrete, metals and plastics, to the use of natural and low energy materials, like wood, straw, earth, stone, clay etc. The widespread use of new and synthetic building materials in modern buildings causes serious health- and environmental problems.

"Natural buildings" seek to develop sustainable architecture based on natural materials, appropriate technology and a holistic approach. For more than 20 years there has been a movement in the western countries to develop solutions for "Natural buildings". New ideas and concepts have been combined with traditional knowledge and building techniques and can be adopted to very different situations. In this way the concept of "natural buildings" will be relevant to solve the problems connected to the modern houses and be a contribution to develop more energy efficient and healthy houses based on traditional building techniques.

The concept of "natural buildings" has a focus on 3 key-issues;

- Energy efficient design; first step is to try to reduce the need of energy to heating and light. Good insulation, compact shape of the house, situating and orientation of the house related to local climate, etc. Second step is to make use of the solar energy. The most simple way is to have south facing windows or greenhouse. Solar panels for heating water and photovoltaic are further options.
- The use of natural and renewable resources for building strong, lasting and highly insulated constructions and houses. This includes the use of straw, straw bales, clay and earth, wood and different insulating materials based on natural fibres.

- Efficient wood stoves for heating and cooking. In addition to modern and technologically more advanced iron stoves it is possible to make highly efficient stoves from stone, brick and clay. The difference in efficiency from some traditional stoves to these new stoves can be as much as three times. That means less firewood, less costs, less pollution and more heat.

EXAMPLES ON MODERN "NATURAL BUILDINGS" IN NORWAY, DENMARK, LATVIA AND USA.

4 SUMMARY OF TRAVEL TO TAJIKISTAN. 5-12. OCT. 2009

A short summary of visit to Tajikistan with excursions, meetings, and discussions.
Dag A. Høystad. Norges Naturvernforbund.
Arild Berg. Rolf Jacobsen. Gaia Architects. Norway.

The objective of this visit to Tajikistan, October 2008, was to learn as much as possible about the situation in the country, about their building techniques and traditions, environmental challenges and available resources. Also, to have meetings with representatives for different NGO`s, environmental organizations and professionals. Our host, guide and co-operating organization in Dushanbe was "Little Earth" and its leader Timur Idrisov.

Excursions;

1 Gissar; ½ hour drive, east of Dushanbe. Madhav Pokharel from Nepal is here making preparations for a course in building of efficient clay stoves. We also got to see the historical fortress and museum in Gissar.
2 Almosi Valley. Village Shamall. From Gissar, further to the east and then to the north and mountainous area. Shamall is a small village in a rather narrow valley consisting of aprox. 30 houses. Generously we were invited to tea and bread in a house, and we got to see how the bread was baked. Some observations: The building technique is mostly Cob, with some additional walls in Adobe technique. We could study both old houses and houses being erected. Foundation was made of concrete. There was no straw mixed into the material. In corners there were some branches to reinforce. We could see serious cracks in both old and new walls. In the clay plaster we could see that straw fibres and animal manure was used in the mix, but there were still cracks. This village is considered to be a partner in this program.
3 Bobo Shurhun. This is a village situated in a more open landscape, closer to Dushanbe. The Swiss organization CAMP, (non-governmental organization for sustainable rural development) has here established a partnership to develop energy efficient initiatives. In cooperation with the energy committee of Bobo Shurhun an efficient stove has been build and a school has been insulated. We also had a look at another school in this village that badly needed improvements; windows, insulation of ceiling, walls, efficient stove etc.
4 Village Chormagzakoni Tochik, north of Dunshabe. We went here to see a project that had been supervised by the Swiss expert Rudi Kunz and supported

by CEEBBA. The house served as a community house and was build with a wooden construction, straw as insulation and clay plaster. This technique did work fine, but it was considered to involve a building process that was unfamiliar for the locals and probably not easy to adopt.

Meetings;

- Little Earth
- Camp; Projektkoordinator Pochoev Mirzokurbon…
- Christian Aid; Richard Ewbank – Climate Change Program Coordinator.
- Unicef: Nurul Islam og Nargis Artushevskaya.

Lectures/ Discussions

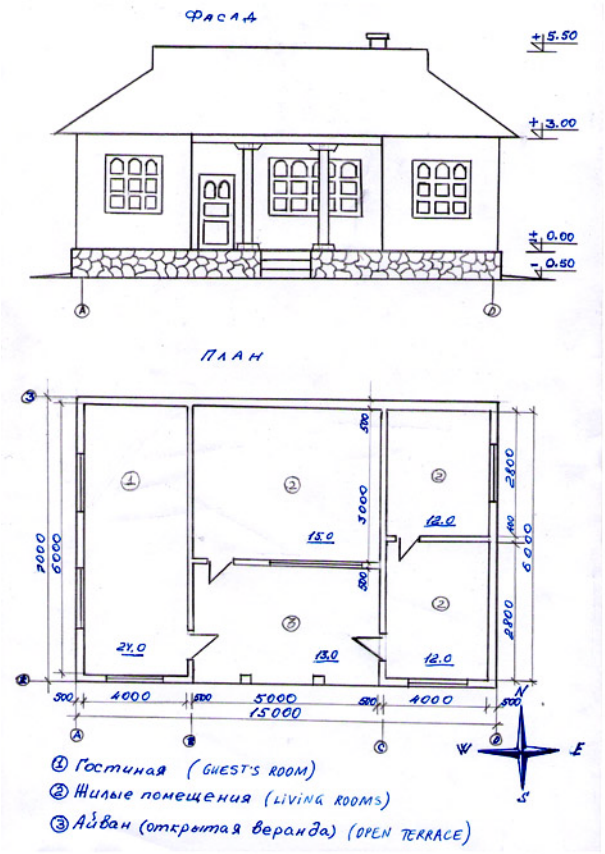
- School of Architecture, University of Dushanbe.
- Seminar on natural buildings; with among others, School of Architecture, University of Dushanbe, Technical Institute, different NGOs and participants from local trade/ industry.

5 TAJIKISTAN – EXISTING SITUATION

5.1 Traditional building techniques

5.11 Building tradition

The building traditions are different in different parts of Tajikistan. Tajikistan is a large country with considerable geographical distances, difficult transportation, different ethnic groups and different climatically conditions. In the region around Dushanbe and more to the south, houses have traditionally been built as earth houses. “Cob” is the dominating technique, but the adobe-technique is also used. In this area the houses will usually have a gable roof. In the mountain area of Pamir; Autonomous Region of Badakhshan, houses are more often built from stone and clay, with clay plaster inside and outside. These houses have often a flat roof that is protected with a clay plaster.



ALMOSI VALLEY. VILLAGE SHAMALL. TYPICAL VILLAGE HOUSE IN TAJIKISTAN

FARMHOUSE IN PAMIR IN TAJIKISTAN

5.12 Cob

This is a traditional earth-building technique known from many parts of the world. It is a quite simple technique; earth with a certain content of clay is mixed with water and normally some fibres (straw or manure). This is worked together to a wet; workable mix which can be laid layer by layer on the walls (which will be laid in sections, each layer aprox. ½ meter high), roughly shaped without any formwork. When this starts to dry, it can be cut and shaped to the more or less straight and final wall. When dry, the clay and the straw bind together and form a strong and monolithic wall that can take loads from the roof. In the corners and above doors and windows it is normal to reinforce with branches. In the end the wall will be plastered with clay inside and outside.

The Cob-houses that we examined in Tajikistan, in villages north and west from Dushanbe, was build in the usual way but with one exception; there was no straw or fibres in the clay mix. We could see this in both old buildings and buildings under construction. As a result of this, the walls did have a considerable amount of cracks. Cracks like this suggest also a relative high content of clay in the mix. The use of straw is a well-known method to reduce cracks and to give more strength to the wall.

One can only speculate about reasons for this Tajik-Cob version. The Soviet system did certainly not promote village living and traditional building methods. Apartment housing of concrete was more the Soviet style. Knowledge of traditional crafts and building methods has been lost during this period. The result is today earth houses

COB HOUSES IN ALMOSI VALLEY. VILLAGE SHAMALL.

of lower quality, lower durability and little seismic safety. Another result of walls with cracks are houses that leak, that are colder and that use more energy.

5.13 Adobe

Soil with a content of clay is mixed with some fibres and often also some animal manure. This is then filled into wooden forms, which has the size of the bricks. These adobe-bricks are left to dry in the sun on the ground. When they are dry, they can be used as bricks with clay mortar. Adobe technique is probably the most widespread clay building technique in the world and has also the advantage of flexibility in use. In Tajikistan, the adobe-bricks are used side by side with the Cob technique.

ADOBE HOUSE IN ALMOSI VALLEY. VILLAGE SHAMALL.

ADOBE BRICK PRODUCTION IN VILLAGE CHORMAGZAKONI TOCHIK

In Tajikistan the normal size of adobe-bricks is aprox. 15 x 15 x 30 cm. This can vary from district to district. Sometimes the adobe walls stands without plaster, but mostly they are covered with a clay plaster. The thickness of the wall depends on situation and size of the building. It can be difficult to find good ways to reinforce adobe walls to obtain more seismic safety.

5.14 Houses of stone and clay.

In the high valleys of Pamir it is more normal to build houses from stones and clay mortar. This is a paradox that is known also from other parts of the world; from lack of good building materials, the coldest houses are built in the coldest areas. The stone houses of Pamir have walls that are 40 to 50 cm. thick, and with clay plaster inside and outside. These houses have most often a flat roof with clay as protection. It is obvious that stone houses neither give any seismic safety nor contribute to energy efficiency.

PAMIR HOUSE.

5.15 Clay plaster.

There is a natural connection between building techniques like Cob and Adobe, and the use of clay plaster. To obtain a more weatherproof, wind proof and also a nice surface, the clay plaster is used. Clay plaster is made of a mix of clay, silt, sand, fibre and possibly some animal manure. In some locations this can be the natural mix of the local soil. In other situations, the different ingredients will be mixed together in proportions. A good clay plaster is made by applying two to three different layers and can remain with its natural surface and colour or be given a surface treatment and colour from lime paint or others. A good clay plaster should be relatively smooth, without cracks and be able to protect the wall. The durability of a clay plaster will depend on the quality of the plaster, the weather situation and also the regularity of maintenance.

The impression from studying earth houses in Tajikistan is that there is a general tendency of the clay plaster to crack. This suggests either a too high content of clay in the mixture or not enough fibres. Applying a too thick layer of plaster will also result in cracks. A plaster with cracks will not give a good protection of the wall and will be more vulnerable for erosion and degradation. Traditional earth houses with visible signs of degradation will consolidate an impression of poverty and houses with low quality and durability.

CLAY PLASTER WITH LIME.

NEW CLAY PLASTER WITH LIME.

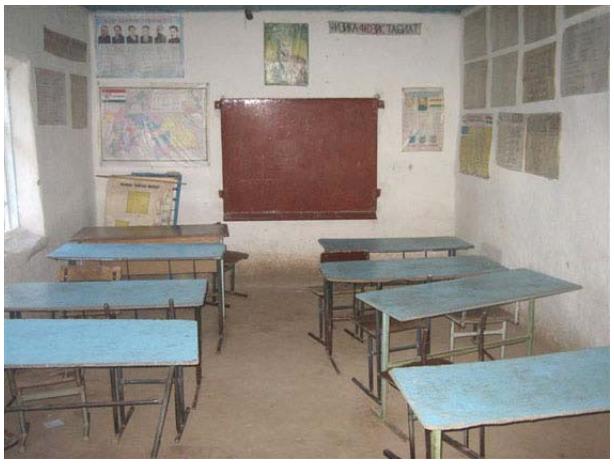
CLAY PLASTER IN DECAY.

5.16 Floors

An earthen floor is quite normal in the village houses. These are made directly on the ground with no insulation.

Normally, there is first a layer with rocks that secure stability and also act as a humidity barrier. On top of this, there are one or two layers of clay with some straw. The surface is not treated in a way that prevents tearing and dust from the clay. Earth floors, like this, are cold, dusty and do not contribute to a healthy living.

Floors made of wood are also in use, but are more expensive. Beams are placed more or less direct on ground supported by stones. On top of these come the flooring boards. There is usually no insulation. Floors made of concrete become more and more common. There is no insulation, but often there is a floor covering (lino or vinyl).



CLAY FLOOR IN SHOOL.

WOODEN FLOOR IN SCHOOL.

5.17 Insulation

In Tajikistan there is no tradition or consciousness about the idea of insulating the houses or giving attention to the energy efficiency. Cold houses, schools that must close doors in cold season and high energy cost does not contribute to improvement of living qualities. As shown above, walls and floors are not insulated. In many situations there seems to be no or very little insulation in the ceilings. In heated rooms a large proportion of the heat loss will leak out through the ceiling. This gives a potential for improving the energy efficiency by simple means, if there are resources of materials with insulating qualities available.

STRAW IS AVAILABLE IN DIFFERENT PARTS OF TAJIKISTAN.

5.18 Foundation

The use of natural stones has been the way to build foundations in the old houses. Today, this has been replaced with concrete foundations. A concrete foundation is stronger and better in an earth-quake area if it is of good quality and with reinforcement. Cement and iron is expensive and one will probably often find concrete foundations where the builder has been very "economic" with both cement and reinforcement.

5.19 Roof

Buildings in the low valleys with a gable roof will normally have a simple wooden construction covered with corrugated iron. Buildings in the high valleys with the flat roofs have a construction with beams, claddings, some insulation in form of thin branches and a covering with a clay plaster. This is in a climatic situation with snow in the winter and regular maintenance must be an integrated part of this solution.

5.2 Climate

Tajikistan has a typical continental climate witch is relatively dry and has large differences in temperature between seasons. There is also a considerable difference between the lower areas (hot and dry), the low valleys (more temperate and humid) and the high valleys (dry and cold). In the low valleys (altitude of 1000 – 1850 meters), there is a yearly mean temperature of 10-11^{0}C (January -1 to -6 ^{0}C and July + 23 to 26 ^{0}C). In the high valleys (altitude more than 2500 meters) the winter climate is very cold. In January the mean temperature is -15 to -20 ^{0}C, and with temperatures down to -45 – 50 ^{0}C!

PAMIR.

5.3 Energy

Energy consumption and energy cost are big issues for the average village family in Tajikistan. 30-50% of household cash income is spent to pay power costs. Prices for energy are increasing. 80% of power consumption comes from heating and cooking. Dried manure or firewood is increasingly used as power resources in order to save costs. The situation in the high valleys of Pamir is even more difficult. The climate is very cold and so are the houses. Forests and fruit trees have been cut down to cook and heat the houses, which leads to poverty and ecological degradation. Electric energy is expensive, unreliable and in some areas not accessible.

There is a potential to improve the energy efficiency of the houses substantially by improved building techniques and insulation (30 – 60%). With the introduction of new, well insulating, but still natural building techniques like the straw bale house, further savings would be possible.

5.4 Stoves, cooking and heating.

The tradition of cooking and baking in clay stoves is still alive in the villages of Tajikistan. This stoves are partly open and therefore not energy efficient in use. The cooking stove is often placed in a shed or in an unheated room or building. The energy for cooking and baking will therefore not contribute to the heating of the living rooms. Small, very simple and not efficient iron stoves are normally used for room heating. One stove in each room. There is in this a potential to develop stoves that are more efficient and can combine cooking and baking with heating. These stoves can be made of clay, be placed inside the house and have a chimney.

5.5 Resources

- Clay and earth; can be found locally in most situations. The natural mix of clay, silt, sand, and small stones will vary from site to site. The earth to build Cob walls or to make Adobe bricks can in many situations be taken directly from the ground. To make clay plasters one has to find earth without any stones or one has to sift the material. Pure clay is probably only possible to find in special locations. It is also possible to disperse the earth in water and by sedimentation be able to separate the different fractions with clay as the top layer.
- Insulation materials; Industrial insulation materials are available in the cities, but is mostly not available in rural areas and besides to expensive for the normal villager. It is therefore the urgent question of what possible resources of material that can be available locally. In Tajikistan there is production of wheat and rice. The straw from this can be used for insulation as straw bales, loose straw or mixed with clay. Traditionally there has also been a production of flax in Tajikistan, but this is today probably non-existent or in very small quantities. In the south there is production of cotton and from this the rush or cotton stems and the cotton flocks could be a potential resource as insulation material. This could also activate some small industry with production of insulation mats from low quality cotton. In some locations, in the vacinity of wood industry, the wood-shavings can be used as an insulating material. To insulate a floor that is in connection with the ground, one has to use an inorganic material. In Tajikistan, there is a production of “Ceramisit” that can be used.

STRAW FROM DIFFERENT KIND OF GRAINS.

INSULATION MATS MADE FROM FLAX

6 SOLUTIONS

6.1 Improving traditional building techniques.

6.11 Cob-technique;

There is a potential for improving the cob-technique in Tajikistan simply by adding straw as reinforcing fibres in the mix. This will make the wall stronger, it will be fewer cracks, it will insulate better and it will give more seismic stability. The Cob-technique that has been developed by the Cob Cottage Company in Oregon, USA, is probably the best from a technical point of view but will also be more work intensive.

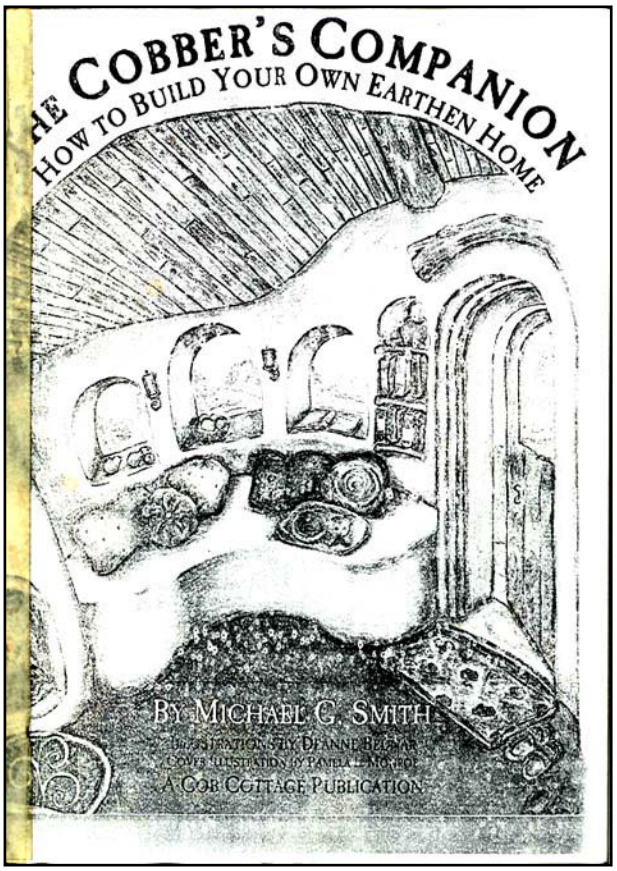
Cob is an old, traditional and simple but efficient earth building technique. The word “Cob” describes “a lump or rounded mass”. From the traditional method to build a Cob-wall, the Cob Cottage Company developed this further. The main improvement is to add more long straw into the mix. This gives the wall a great structural integrity by creating a three-dimensional fabric of flexible reinforcement.

In addition to improved strength and elimination of cracks it will also give as result a wall that insulates slightly better. The energy savings will not be considerable and a Cob wall will have to be insulated in addition, to be more energy efficient. The Cob Cottage technique is closely related to the traditional way of building in Tajikistan and does not introduce new materials or totally different methodology.

This technique was used in Pakistan in a reconstruction program after the earthquake that hit the mountainous areas on the 8. October 2005. The Danish constructional engineer Caroline Meyer White decided she wanted to help and went in the spring of 2006 to Pakistan to lead a program of educating instructors and building more than 3000 simple and earth quake safe houses from the Cob technique (Cob Cottage). The project was carried through in cooperation with local NGO`s and supported by the UN organization FAO.

Cob is an old, traditional and simple but efficient earth building technique. The world “Cob” describes “a lump or rounded mass”. From the traditional method to build a Cob-wall, the Cob Cottage Company developed this further. The main improvement is to add more long straw into the mix. This gives the wall a great structural integrity by creating a three-dimensional fabric of flexible reinforcement.

In addition to improving the building material, the shape of the house has proven to be of importance in developing seismic safe houses. Rounded corners are stronger than sharp corners.



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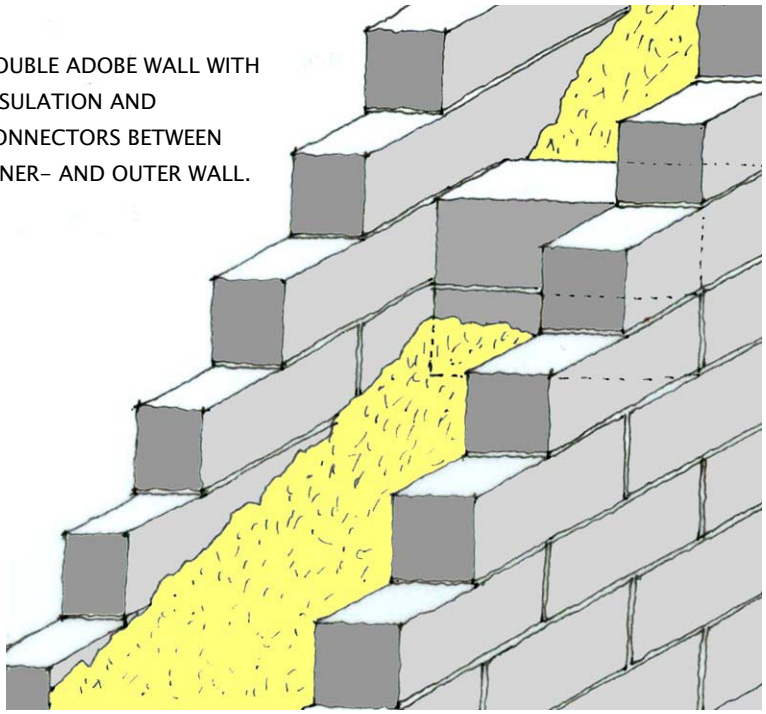
6.12 Adobe

The use of Adobe technique has some advantages in the flexibility of use. It can be used as interior wall, double walls, vaults etc. There is a challenge to improve the adobe technique to become sufficiently seismic safe.

Thermal insulation; from Adobe bricks it is possible to build walls with good insulation qualities. A double Adobe wall can be build with a cavity between. This cavity can be filled with insulating material (straw, wood-shavings etc.) and would typically be 20 – 30 cm. Inner- and outer wall has to be connected to give the wall sufficient strength. This method to build good insulating walls from earth-material will require some more work and also some more specific details and craftsmanship than the traditional houses, but will still be based on the traditional crafts and skills. The question of seismic safety still remains.



DOUBLE ADOBE WALL WITH INSULATION AND CONNECTORS BETWEEN INNER- AND OUTER WALL.

An Adobe wall is made of many bricks held together with clay-mortar. There is nothing that really binds the whole wall together in an earthquake incident. To improve this, one has to develop different ways to reinforce and stabilize an Adobe wall.

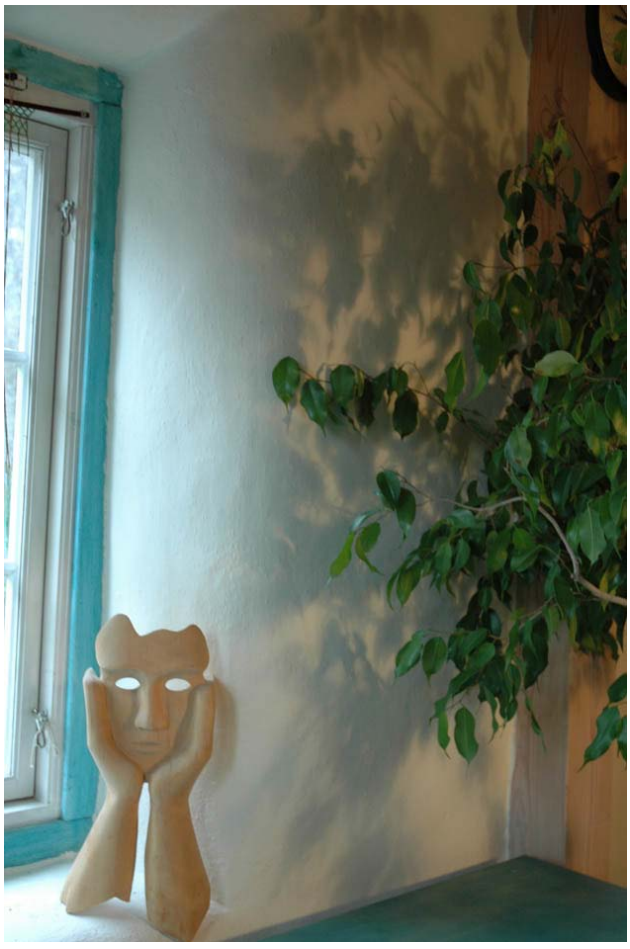
- One solution could be to have strong netting, preferably from natural fibres, that reinforces the clay plaster on both sides.
- Another suggestion is to produce Adobe bricks with holes for bamboo or thin branches from willow or similar. The bricks are naturally built in bond, and as the holes also are filled with mortar, this will all bind together and make strong interconnection. The production of Adobe bricks will probably be more work-intensive and also the bricklaying will be more time consuming. But still, the result might be worthwhile. See illustration 6.52.

6.13 Clay plasters

The quality of the outside clay plaster determines to a large extent the durability of an earthen house. The appearance of this building method, regarding the level of decay or maintenance, will play a major role in the public recognition of the quality and social status of these houses. Today one can witness that the combination of a poor quality clay plaster technique and the lack of maintenance results in houses that look poor and buildings techniques that are seemingly outdated.

COLORTESTS WITH CLAY PAINT ON CLAYYPLASTER, NORWAY..

Two factors have to be improved to give the earth-building techniques better quality and higher social status. First, the quality of the earth-building techniques itself has to be improved to give the houses better appearance and more durability. Second, the attitude towards regular maintenance has to be encouraged.



CLAYPLASTER ON INTERIOR WALL, NORWAY.

The first step to improve the clay plaster would be analyses of the earth to find the proportion of clay, silt and sand. Further, it is possible to adjust the earthmix so that cracks are avoided or limited. If the natural soil contains a too high proportion of clay, the plaster will inevitably crack when it dries. If more sand is added to the mix or if more fibres are added, cracking will be reduced or eliminated. Animal manure is traditionally used in many different cultures to improve the clay plaster. In animal manure there are both fibres and substances that makes clay plaster stronger and more weather resistant.

The second step is to make use of constructive weather protection; roof overhangs, gutters and stone foundations that lifts the earth wall from the ground. The third step is to add surface treatments that give clay plaster more weather resistance. This can be oil (linseed oil) or silicate (calcium silicate). The use of lime will also help, but has to be repeated quite often in order to give protection.

STRAWBALE HOUSE IN RUSSIA, WITH CLAYPLASTER AND OIL.

6.2 Improving existing buildings

6.21 Outside insulation of walls.

The best way to improve existing, traditional houses in terms of energy efficiency, will be to add a layer of insulating material on the outside of the wall. In this way the thermal mass of the existing earth or stone walls will gain and stabilize the temperature inside the house, and the effect of the insulation will be optimized. Available insulating materials (see 5.5) are straw of some kind. There are different possible techniques;

		U-value. W / m^2C
WALL	40 cm stone wall	1,2
WALL	40 cm Cob or mud brick wall	0,95

Straw + clay plaster.

A 10 cm layer of straw will make a significant improvement to an earth or a stone wall. The insulation must be protected by a good clay plaster. Here are two suggestions of different methods;

- On the outside of the wall, a wood structure of 2" x 4" (50 x 100 mm.) is fixed. There is a bottom sill that has to be 25 -30 cm. above outside ground level,

and from this to the roof there are vertical posts at 60 -80 cm distance. On the outside of this structure a strong chicken wire is fixed. Lose straw is filled in and compacted all the way up. The clay plaster will then be applied in three layers and will stick to the wire.

- This method involves local production of straw panels. A production table has to be developed to gather the straw in the right shape and size, be able to compress it and then sew it together. The size could be 10 cm in thickness, 60 cm in width and the height of the wall. Straw panels could then be installed directly on the outside of the wall and one has to develop a method to connect and fix them to the wall. The clay plaster will then be applied in three layers and will stick to the straw, but an additional wire or net as reinforcement should be considered.

	U-value. W / m^2C
Wall; 40 cm mud brick wall +10 cm straw	0,34

Straw-clay + clay plaster

A challenge with the use of loose straw is that it needs a mechanical method to keep it together or in place. If straw is mixed with a thin soup of clay it is possible to make a material that, when dry, holds together by itself. The insulation value will be partly reduced compared to straw. There are different possible techniques;

- On outside of wall a wood structure of 2" x 6" (50 x 150 mm.) is fixed. (or 2"x2" horizontal and 2"x4" vertical). There is a bottom sill that has to be 25 - 30 cm. above outside ground level, and from this to the roof there are vertical posts at 60 -80 cm distance. The straw is mixed with the clay-soup. The result will be best if the clay is as pure as possible. All straw should have a thin layer of the clay and should be left for some hours / one night under plastic before use. The straw-clay mix is filled in between the wood structure and gently compacted. Simple formwork holds it in place. The straw-clay has to dry before a clay plaster is applied.

- From the straw-clay mix it is possible to produce blocks. For this purpose the blocks could have a dimension of 15 x 30 x 50 cm. The blocks have to dry in sun before use. This technique will require a supporting foundation. The straw-clay blocks will then be built up with clay mortar that also gives connection to existing wall. A clay plaster will then be applied.

40 cm stone wall +15 cm straw-clay	0,48

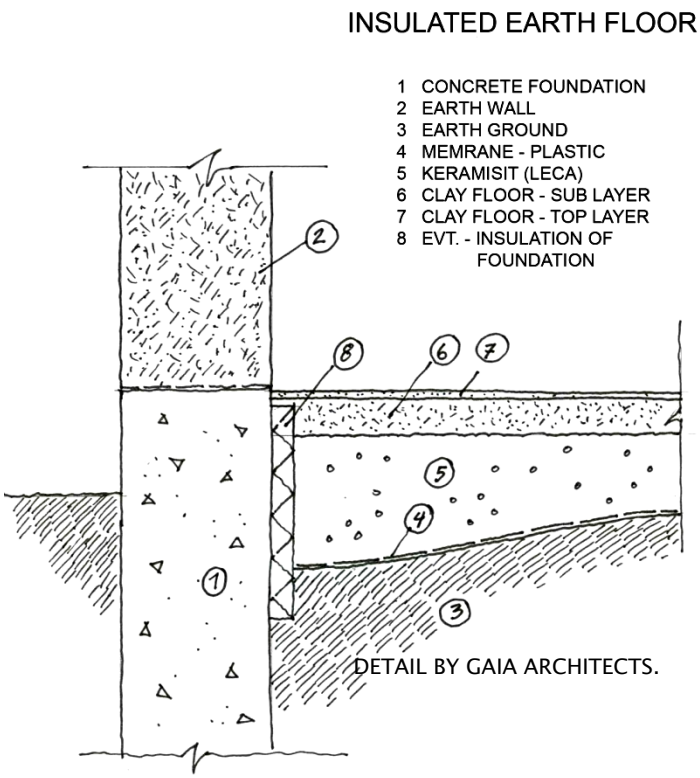
6.22 Insulated earthen floor

It is possible to make a modern earthen floor that is insulated, has a smooth clay surface that does not dust and is easy to clean and wash. Here is a general specification of an insulated clay floor. Adjustments have to be made according to situation. It is also recommended to start with a smaller room first to gain experience.

Dig out if necessary and make sure the ground is well compacted. The shape of the ground should be higher in the middle of the room (see drawing). This is to prevent moisture / water to be able to gather, and also to insulate better in the circumference where the heat loss is highest. The soil should be smooth and without sharp stones. It is then recommended to have a plastic tarp as a humidity barrier before the insulation material. If the situation is considered to be dry, the plastic can be skipped.

“Ceramisit” (Light Expanded Clay Aggregate) is filled at an average thickness of at least 20 cm. and levelled 10 cm under the level of finished floor.(Aprox. 15 cm. thickness in the middle and 30 cm. in the circumference.) The surface of the “Ceramisit” can be stabilized with a thin layer of liquid cement so that it will be possible to walk and work on the surface.

On top of the "Ceramisit" the clay floor will be applyed. This is made of three layers. The sub-layer is made from a Cob mix with straw and will have a thickness of aprox. 8 cm. This must dry before applying the top layer which is made from finer materials. The first coat has a thickness of 1,5 – 2 cm., and is levelled and smoothed as good as possible. On top of this comes the final coat; a thin layer of only 2 – 3 mm.



APPLYING CLAY TO FLOOR IN LIVING QUARTERS, LATVIA

This is preferably made from pure clay (potters clay) mixed with very fine sand and strengthened with wheat-glue and linseed oil. A very fine and smooth surface can be achieved by applying a final layer consisting only of pure clay and linseed oil. When the floor is dry it should be oiled or waxed and will then have a smooth, beautiful surface that is strong and can be washed.

6.23 Ceiling / roof

Insulating the ceiling of a house is an efficient way to reduce the energy consumption. Available materials would be straw (of different kind) and possibly also woodcuttings. The straw can be mixed with clay but the best insulation effect will be from the use of straw without additives. The gable roof above will protect from

weather, but the insulation has to be covered in order to stop air leakages, mice and fire, and do this in a way that allows for natural breathing. A clay plaster will be the best to do this job.

Straw + clay plaster.

- The existing ceiling will probably have a wooden structure with some kind of wooden or plastered ceiling underneath. On top of beams one should build up with wooden materials so to get an insulating layer of 20 -30 cm. The loose straw is filled in between the beams and compacted and kept in place by wooden cross laying boards. A clay plaster with straw-fibre should be applied. One should make sure that all straw is covered with plaster.

Straw-clay + clay plaster

- A mix of straw and clay-soup is made on ground and let to settle and partially dry before applied. One should make sure that the mix contains not more clay than necessary and that it is not dripping wet when applied. There is no need for wooden structure. The straw-clay should be put in a layer of 20 - 30 cm and roughly levelled and slightly compacted. This has to dry before clay plaster can be applied. One has to make sure that the structure is strong enough to carry the extra load.

6.24 Windows and doors

It is obvious that the standard of doors and windows can and should be improved. This is probably the most cost-efficient measure to reduce energy consumption. Simple actions like tightening air-leakages and installing rubber-seals can be done with little costs. Most windows have single glazing, and especially in the cold mountain valleys this will be insufficient and cause great heat loss and probably problems with condensation. Windows that are more energy efficient has to be of double glazing, either as new windows or as a secondary frame on inside of existing window.

THE SPARE- PROJECT OF NORGES NATURVERNFORBUND AND LITTLE EARTH, HAS BEEN FOCUSING ON THESE ELEMENTS AND HAS ACHIEVED GOOD RESULT.

IMPROVING WINDOWS AND ENERGY EFFICIENCY IN SCHOOLHOUSE IN LABETJAI.

6.25 Efficient stoves

There is a strong tradition for cooking and baking on traditional clay stoves in Tajikistan. This is part of the cultural identity and social life in Tajikistan and this has to be respected and integrated in suggestions for more energy efficient stoves and heating systems.

It is obvious that the pattern of cooking / heating and the use of fuel consuming stoves in combination with the standard of the traditional houses in Tajikistan results in high energy costs and in some areas a forest destruction and degradation. This adds to poverty and serious environmental problems.

MADHAV POKHAREL FROM NEPAL LEADING A TRAINING COURSE IN BUILDING OF ICS.

The challenge is to develop more efficient stoves that maintain the function of cooking and baking. In addition the stove should be placed inside the heated room in a central situation, so that the energy could be utilized for heating and distributed to the different rooms.

IMPROVED COOKING STOVE. ICS.

As a cooperation between Norges Naturvernforbund and Little Earth, such a program has already been implemented. Madhav Pokharel from Nepal,has been engaged in this program; “Energy saving stove exchange program”, and “Energy saving by improved cooking stoves (ICS)”. New models of more efficient clay-stoves have been developed and training program has been initiated. This work can probably be developed further; such as a more efficient burning process, chimney above roof and more durability. In end this will cause a radical reduction of fuel consumption, less money and time spent on energy and better conservation of the forest.

HIGHLY EFFICIENT STOVE FOR HEATING AND COOKING. DENMARK.

6.3 New buildings – improved technique

6.31 Strawbale construction

Strawbale construction is a natural building method that utilizes straw, compressed and tied into bales, as building blocks. The strawbale house offers numerous benefits. Foremost, it can be designed to be earthquake resistant. Its energy efficiency can reduce dependence on fossil fuels and firewood, which along with its resource efficiency can reduce deforestation. It is fire and pest resistant. Strawbale construction is well suited for the cold, dry climate like in Tajikistan.

The Strawbale building method was first developed in Nebraska in USA more than 100 years ago. The last 20 years this building technique has been re-discovered and has been spread to most parts of the world. One can utilize all kinds of straw that is dry. The bales are made by normal agricultural equipment but can also be produced by more manual methods. The building process is simple and easy to learn. Some basic rules and correct details have to be made as standard. The strawbale walls will be plastered with a clay plaster, inside and outside.

Today all kinds of research results and documentation on the strawbale technique are available; energy efficiency, fire resistance, strength and stability, humidity, durability etc are documented. There are many different web-sites about the strawbale technique. There are national and international organizations promoting the strawbale house. Many books have been published, in different languages.

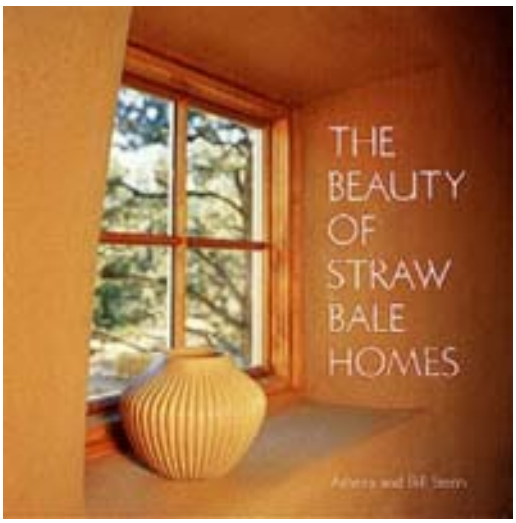
Thousands of strawbale houses have been built the last 20 years. Many have been built in USA and Europe. In Norway 70 strawbale houses have been built, there is a national organization and there is a web-site. The Norwegian network has for 10 years been engaged in strawbale projects in Russia.

Web-site; www.natrurligbyggeri.no/halmhus

Literature; "Halm som byggemateriale" (Straw as a building material") by Rolf Jacobsen. Norway.

Strawbale houses has been introduced and built in countries near Tajikistan; Pakistan, China, Mongolia and others.

THE "BRUKE- HOUSE. 1903



BOOK ON STRAWBALE HOUSE, USA.

STRAWBALE KINDERGARDEN, NORWAY , 2007.

Pakistan Straw Bale and Appropriate Building (PAKSBAB)

This is an international group established in 2006 whose mission is to teach and promote straw bale and other appropriate building methods in Pakistan. In 2006 PAKSBAB built a straw bale women's community centre in Jabori followed by a residence and associated training course in Hillkot. In 2007 PAKSBAB collaborated with the organization Salamat-e-Hazara / TEAM on a residence / training course in Qalanderabad and on a subsequent 3-house project in Mansehra and Shinkiari. In Pakistan a system for manufacturing straw bales from manually operated farm jacks and locally fabricated compression moulds has been developed by PAKSBAB.
http://www.paksbab.org/

China and Mongolia; Kelly Lehrner

For the last five years Kelly Lehrner has worked with the Adventist Development and Relief Agency (ADRA) and the Chinese Center for Environmentally Sustainable Technology Transfer (CESTT) to introduce and adapt strawbale construction to China. Starting with a single strawbale school in 1999, the ongoing project works directly with local communities and has built over 600 houses in 5 Chinese provinces.

Working with the United Nations Development Programme (UNDP) and the Adventist Development and Relief Agency (ADRA), Kelly Lehrner has helped introduce and adapt strawbale construction the newly democratic Mongolia from 1995 – 2000. Working with local architects and contractors, she has designed two-story Mongolian Women's Federation Building in Ulaan Baatar and multiple schools and clinics in rural areas throughout the country.

http://www.one-world-design.com/international.asp?pid=10

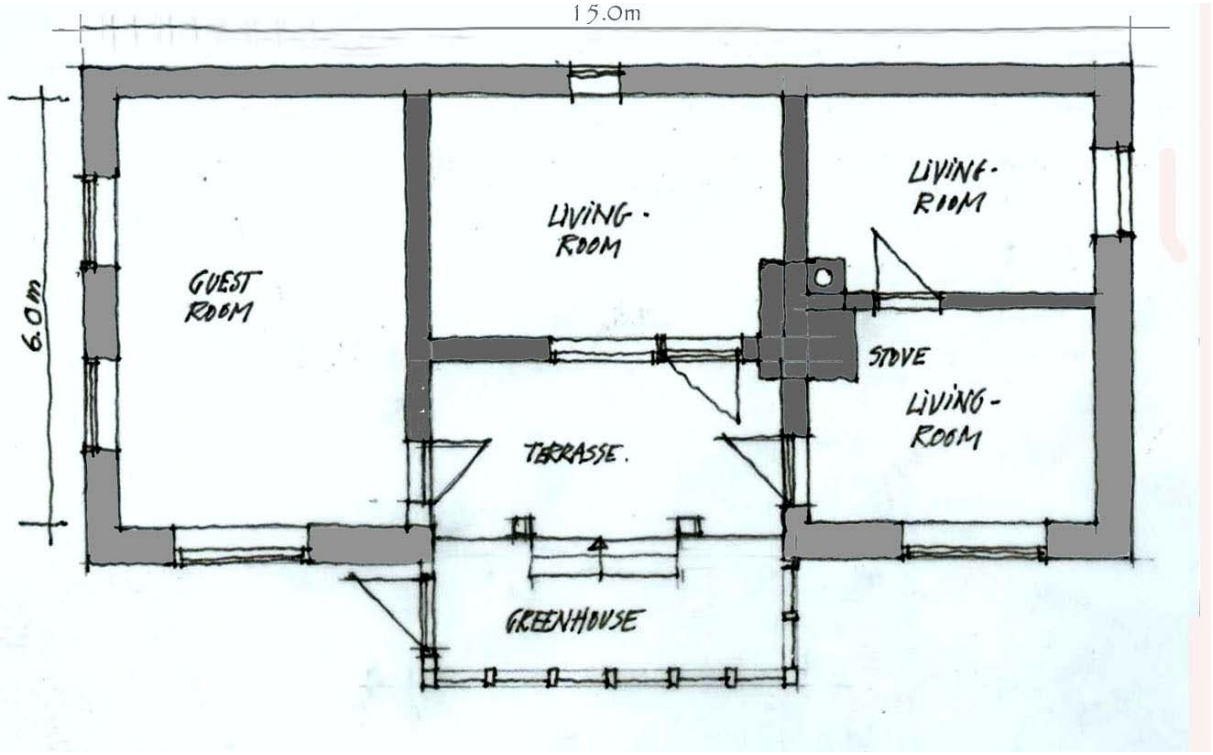
6.4 New buildings – improved technique and design

6.41 Strawbale technique – low energy design

It is possible to develop houses that are even more energy efficient by developing a new house design. Such design principles involves the orientation of the house and windows towards the sun, reduction of the outer surface of the house, organization of the rooms and the heating system (stove) to obtain an efficient distribution of the heat, etc. These are quite simple principles that can be adjusted to different situations, but it will also challenge some traditional concepts of culture and way of living. New concepts will not be implemented successfully if the traditional and cultural aspects are not fully integrated. Good communication and cooperation is a key.

The combination of an energy efficient design and a straw-bale construction will make it possible to develop houses which perform totally different regarding energy consumption and health situation compared to the traditional houses.

EXAMPLES OF LOW-ENERGY, STRAWBALE HOUSES IN NORWAY.



Proposal of a low-energy, strawbale house for Tajikistan.

Plan and south façade. Gaia Architects.

- Based on the layout of a Typical Tajik village house.
- Strawbale walls with high insulation qualities.
- Internal walls of Cob or Adobe
- South-facing greenhouse that will protect entrance, gain solar energy to the house, and reduce exposed wall-surface of the house.
- Efficient stove for cooking and heating placed in a central position.
- Solar energy for heating water or photovoltaic for lighting.

6.5 Seismic safety

6.51 General

Tajikistan is in an area with is seismic active, and serious incidents in the past give good reason to focus on the seismic safety when it comes to buildings. Traditional earth- and stone buildings have shown to be unsafe and give little protection in earthquake situations. There are multiple reasons to this; poor foundations, no flexibility to absorb the seismic energy and no reinforcement (fibres, branches, etc.) that bind walls together. The result is heavy walls that collapse and becomes death traps.

It is possible to make some improvements to these traditional building techniques, but there are also some obvious limitations. The earth-building technique (Cob and Adobe) is possible to improve, but the stone and clay walls can never be considered safe in earthquake incidents.

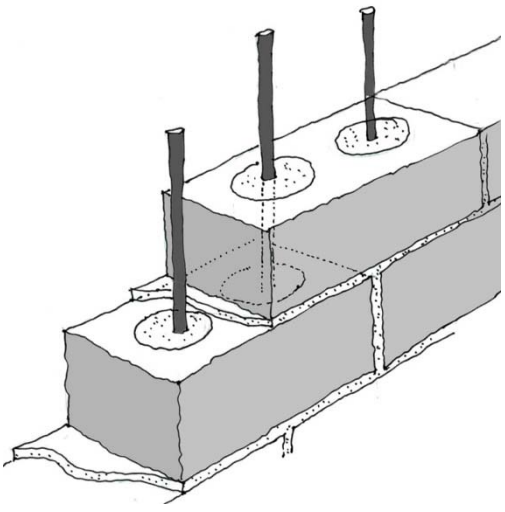
A strong and reinforced concrete foundation will help any building. Rounded corners and walls have shown to give more strength and stability.

6.52 Adobe

It is possible to develop adobe-bricks with holes for reinforcement (bamboo, willow branches etc.). This will probably add significant strength compared to traditional adobe walls, but has to be tested.

SUGGESTION TO A REINFORCED ADOBE WALL.

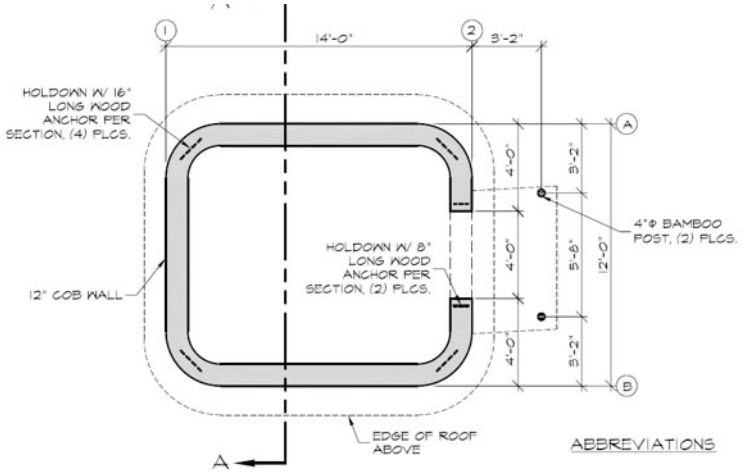
GAIA ARCHITECTS.



6.53 Cob

A Cob wall will be much stronger and keep together when the earth-material has enough and long straw-fibres.

The Cob Cottage technique is probably the best in this respect. The Pakistan reconstruction project, mentioned above, is a good reference.



6.54 Strawbale with wood structure

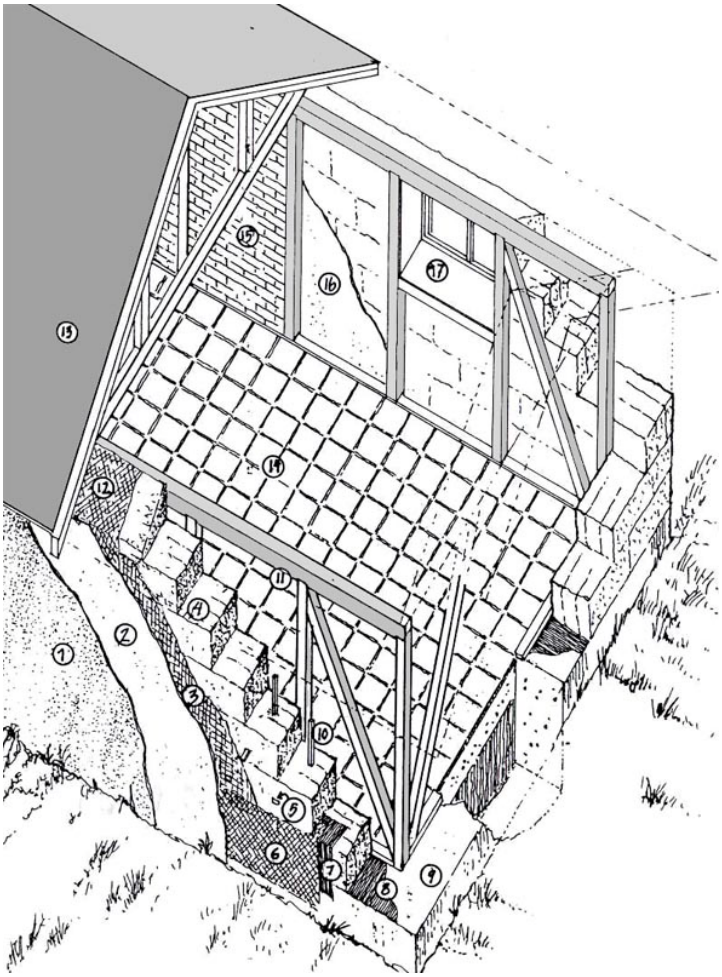
The possibly best solution for obtaining seismic safe houses will be a combination of timber construction and straw-bale walls. A post-and-beam construction will carry vertical loads in a conventional manner, and wind and earthquake loads are carried by means such as diagonal braces that can be conventionally engineered. In addition the straw-bale walls are primarily subjected to wind and earthquake loading against their faces, and will add a significant secondary strength, which is resilient and flexible. The straw-bale walls can absorb some of the force of an earthquake and will provide a backup structural system in the event of failure of the post-and-beam system. Even after the skin starts cracking, the straw-bale has a reserve capacity, so it would be very hard for it to totally collapse. In earthquake simulation tests, straw bale walls have been shown to absorb as much energy as plywood walls without breaking up.

This is why straw-bale construction has been seen as a promising alternative to earth- and stone buildings in earthquake-prone countries like Pakistan, Mongolia and China, in situations quite similar to Tajikistan.

Reference;

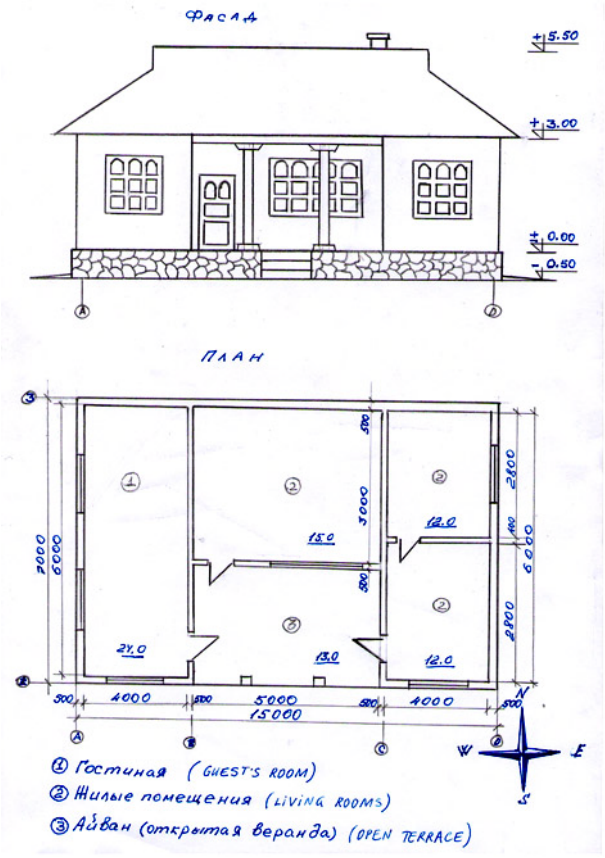
PAKSBAB (Pakistan Straw Bale and Appropriate Building) has recently been awarded a grant from the Earthquake Engineering Research Institute's (EERI) Endowment Fund. The project objective is to determine the in-plane and out-of-plane cyclic performance of earth plastered, load bearing, thin straw bale wall assemblies using shake table simulation. The proposed experiments will be of specific use for our current straw bale construction program in Pakistan but applicable to other developing countries in need of earthquake resistant and affordable housing. Different tests will be performed at the University of Nevada, Reno's (UNR) Network for Earthquake Engineering Simulation Equipment Site.

PAKSBAB has received preliminary endorsement from Pakistan's Earthquake Reconstruction and Rehabilitation Authority (ERRA) and approval for the construction of 20 straw bale widow's houses. Additional pilot projects and training programs will be promoted.



STRAWBALE HOUSE WITH WOODEN CONSTRUCTION. PRINCIPP.

6.6 Energy efficiency



6.61 Existing situation.

There are big differences in household energy consumption in different areas in Tajikistan. This is partly due to differences in climatic conditions in the lower valleys and in the higher valleys, and partly as a result of different building technique. In the higher valleys the climate is very cold in winters and houses are usually build with stone walls – which has a very low insulation value. In the lower valleys the climate is less cold and here the houses are mainly built with earth walls that insulates some more.

To be able to compare different situations and also the effect on different improvements it is useful to make a rough calculation of energy consumption based on a “standard” Tajikistan house, and adjust for climatic conditions and also the use of building materials and techniques.

A typical Tajikistan village home is here defined to have a size of 7,0 x 15,0 meters, with 4 rooms and a open porch. There is one guestroom which is rarely heated. Three rooms are heated. Windows and doors are on the south, east and west sides. To the north there are no windows. In the low valleys the house is a earth house (Cob) and has a gable roof and a uninsulated loft. In the high valleys the house is a stone house and has a flat roof.

HIGH-VALLEYS	U-value. W / m²C
WALL 40 cm stone wall	1,2
FLOOR Clay floor – no insulation.	0,51
ROOF little or no insulation.	0,53
Energy consumption pr. year.	24.000 kwh / year.

LOW VALLEYS	U-value. W / m²C
WALL 40 cm Cob / mudbrick wall	0,95
FLOOR Clay floor – no insulation.	0,51
ROOF little or no insulation.	0,60
Energy consumption pr. year.	11.000 kwh/ year

6.62 Energy efficiency improvements

HIGH VALLEYS ALT. 1

U-value. W / m²C

40 cm stone wall +15 cm strawclay — 0,48

Clay floor – insulated. — 0,25

30 cm. strawclay insulation + double glass windows. — 0,37

Energy consumption pr. year. — 11.000 kwh/ year; Saving; 13.000 kwh/year

HIGH VALLEYS ALT. 2

U-value. W / m²C

Wall; 45 cm strawbale wall — 0,15

Floor: Clay – insulated. — 0,25

Roof : 35 cm. stawbales + clayplaster + double glass windows. — 0,20

Energy consumption pr. year. — 6.600 kwh/ y; Saving; 17.400 kwh/year

LOW VALLEYS ALT 1 U-value. W / m²C

Wall; 40 cm mudbrick wall +10 cm straw

Floor: Clay – insulated.

Roof; 30 cm. strawclay insulation

+ double glass windows.

Energy consumption pr. year.

Saving; 5.200 kwh/year

LOW VALLEYS ALT 2 U-value. W / m²C

Wall; 45 cm strawbale wall

Floor: Clay – insulated.

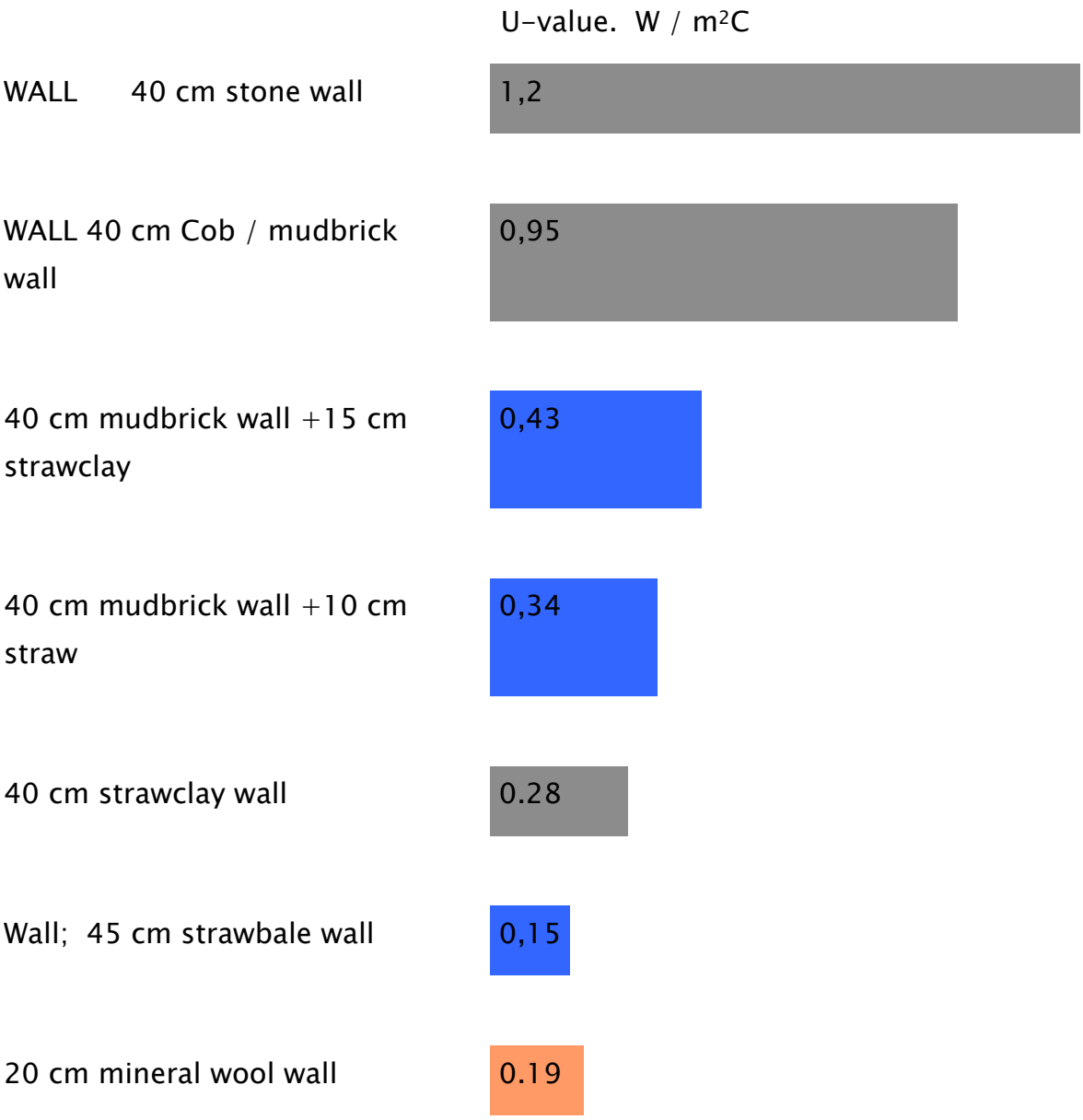
Roof : 35 cm. stawbales + clayplaster

+ double glass windows.

Energy consumption pr. year.

Saving; 7.200 kwh/year

6.63 Insulation values



7 GAIA ARCHITECTS.

GAIA ARCHITECTS

Gaia Architects is cooperation between five architect offices in Norway with special competence on sustainable architecture. GA cooperates with Gaia Scotland and is further connected to the Gaia International network. Gaia Tjøme has specialized in the concept of “Natural Building”, in which the use of natural building materials, traditional crafts and selfbuilding has been developed.

Siv.ark. Arild Berg (AB) og Siv.ark. Rolf Jacobsen (RJ) has been active and leading in establishing the „Norwegian Earth- and Strawbuilding association“ (NJH) and the NGO „BRO“ which has developed a model that combines practical support for mentally disabled people in Russia, workshops for young people in Scandinavia and promoting natural building with earth- and strawbuilding technique.

www.gaiaarkitekter.no/tjome

www.naturligbyggeri.no/halmhus

www.naturligbyggeri.no/bro

Norges Naturvernforbund (Norwegian Society for the Conservation of Nature) is Norway's largest and oldest environmental organization. The organization was established in 1914 and is a non-governmental, nationwide, democratic member organization with around 20 000 individual members, 100 local groups, and regional branches in all counties. After more than 90 years with voluntary work for our common environment, for conservation of the extraordinary nature and wildlife we have in Norway, the organization is well known and respected. Although the organization has a national agenda, many environmental questions have proved to have an international or even global character. Development issues, resource allocations and international cooperation are very much parts of our everyday activities.

Norges Naturvernforbund works actively on international questions on environment, energy, climate and development towards decision makers, the general public and in our own organisation. The International Project Department frequently contributes with inputs on development issues for use in our internal and external information activities. Frequent seminars and workshops are being organized and the department is a regular participant in external forums.

Norges Naturvernforbund cooperates with environmental NGOs and support civil society development in a number of countries in East and South. The objectives are to strengthen our local partners' capacity and influence in their struggle for a better environment. Environmental Education, Sustainable Energy Solutions and Climate Change are key issues for the cooperation. At the present Norges Naturvernforbund initiate, implement and maintain projects regarding capacity building, energy saving, renewable energy, climate and education in 20 countries in former Soviet Union, Eastern-Europe and Africa.

SPARE (School Project for Application of Energy and Recourses) is the largest international school project on energy, climate and environment. 4500 schools and 175.000 pupils in so far 16 countries participate annually in the SPARE educational program. The SPARE program was created in 1996, by Norges Naturvernforbund and is today managed by the International Project Department.

Norges Naturvernforbund is a part of Friends of the Earth International.

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