

MUD

LAURIE BAKER

About the Author

Born in Birmingham, England, in 1917, Laurie Baker studied architecture at the Birmingham School of Architecture from where he graduated in 1937 and became an associate member of the, RIBA. During the World War II he was an anaesthetist to a surgical team in China where he also worked on control and treatment. On his way back to England he had to wait for about three months for a boat in Bombay. There he met Gandhi and was influenced by him. He decided that he would come back to India and work here. During 1945 - 1966, apart from his general freelance architectural practice throughout his life in India, Baker was architect to leprosy institutions in India and lived and worked in a hill village in Uttar Pradesh. In 1966, Baker moved south and worked with the tribals of Peerumede in Kerala. In 1970, he came to Trivandrum and has since been designing and constructing buildings all over Kerala. He has served at various times as Governor of HUDCO, on the working group on Housing of the Planning Commission, and on several expert committees at the national and state level.

Introduction

The very fact that you have picked up and opened this book means that at least you wondered however any one could be serious enough about a substance like mud to write a book about it. It may be that your interest is even a bit more than mere idle curiosity and just a faint possibility that you might like to know a bit more about mud.

Before writing and drawing what I think about mud and I think it is important that I, first-of all, let you know why I think it is important. The fact that you are reading a book written in the English language means that probably you are educated and are living in “reasonable” circumstances in quarters of some sort. They may or may not be adequate and according to your tastes and wishes but there is a roof and the walls give you a certain amount of security and privacy. Now, without arguing about the usefulness and veracity of statistics, it is a fact that something between twenty and thirty million families in our country do not have anything like your living accommodation and these 20 odd million families do not have anything that can even remotely be called a home or a house or even a hut. So I wish that we had a collective national conscience about this and seriously all of us, not just ‘the Government’ should set about doing something about it so that this disgrace is removed.

Unfortunately these days so many of us think that we can only build “properly” and “satisfactorily” by using such items as reinforced concrete, cement blocks, burnt bricks, etc. But equally unfortunately the manufacture of steel and cement for reinforced concrete is now called “energy intensive”. An enormous amount of energy that is some sort of fuel-is used to manufacture these so-called essential materials. Furthermore we do

not really have enough cement to go round and quite large quantities are imported, for example, from Korea. Although bricks are made of mud, we burn or bake them to make bricks. In many parts of the country; to do this, we use firewood to make the bricks hard and strong.

If you build an ordinary middle class house of brick-you probably are not aware that two or three large trees were felled, and chopped up and burned to fire your bricks. But we know - or you ought to know, that trees and forests are diminishing and we cut down and use far more than we replace and grow. This is one of the causes for increasingly large floods in places like West Bengal. So, we also ought to develop our consciences about not using expensive and imported materials but also about those building materials which use up a lot of our natural resources to provide fuel for manufacturing many of our currently fashionable materials - not only cement, steel, concrete, bricks and timber, but glass, aluminium, asbestos, galvanized iron sheets and so on.

The natural and reasonable retort to all of this sort of thing is “But what CAN we use? What does not need a lot of energy for its manufacture? One answer is to use more stone-but in many parts of our country there is no usable stone. The other answer is that in many areas there is mud and, believe it or not but the National Census will show you that numerically, there are more houses -in India made of mud than of any other material.

So why we have stopped using it? Actually, we have not stopped using it. Many rural families and many of our poorer people still build with mud but ‘official’ or ‘Government’ housing schemes rarely use it and our growing ‘Middle Class’ also rarely uses it. There are many reasons to explain this -people do not do or make things themselves these days, they get others to build and plough for them, they have jobs to do and older children can’t be used because they now carry on with their education until they are grown up. So there is no time to do and make things. More and more people never acquire the simple rural skills, which were known to all of us fifty years ago. Further more, we seem now; to be much more class conscious and mud is connected in people’s minds with “the Poor”, with “Poverty “. With Cowsheds and Pigsties, with “Rural EWS Schemes”, with ‘Tribal’ and so on. “Who will marry my daughter if I live in a mud house?”

So I want to show that mud may be old fashioned. (That to me is a plus point - it has tested and tried over thousands of years whereas concrete has been in circulation for less than a hundred years), but it could be successfully used even for the best houses, and, indeed, if all of us are to go into 21st century with a roof over our 700-800 million heads we will only be able to do it if we put mud into its rightful status. So, this book is to see how we can go about it.

I have tried in this little book to introduce you to mud. I have tried to make it all as simple as possible, both with word and picture. I have noted that there is a scientific side to-the subject, but far more important is to go ahead and use it, experiment with it, have fun with it and drop the idea that it is only for the rural poor. A lot of the illustrations unfortunately perpetuate the rural path of it. I have shown overhanging grass roofs and so

on, but what is very-very important is to stress the fact that if properly and neatly and expertly finished, the resulting looks can be -5 star. Although I personally prefer to let whatever building materials I use express themselves and their special characteristics in the building - (for example a brick house, I think, should look like a brick house) and it will look different from a stone house. But in general current architectural practice, most people prefer to plaster over their walls and paint them and add tiles and 'claddings'. So there is absolutely no reason why such people and such architects who design for them should not do the same with mud. Indeed, in a country like Australia, for instance many-many houses are basically mud houses - but most of them are not distinguishable as such. So my sincerest hope and wish is that every one, Rich or Poor, Lower, Middle or Upper Class, will come to understand and accept the fact that mud is a reasonable, acceptable, strong, durable, basic building material that has stood the test of hundreds, if not even thousands of years of time.

Mud has its limitations, but so do all materials. So learn what are the limitations of the mud you would like to use - and then build within those limitations, or when economically possible, remedy those limitations.

Usually water has to be used to mould mud into a shape and it is only strong, and will not only "stand up", when that water has dried up. Thereafter water is the constant enemy of a mud wall so you must protect mud walls from water and dampness. This is the one really big limitation of the use of mud and you must never forget to ignore it. Much of this book therefore is to show you how to keep mud dry - even in heavy rainfall areas like Kerala or Assam. Again, keep- in mind that even if mud seems unsuitable for your exterior walls, you can probably safely use it for interior walls and save some expense, and some energy - intensive materials by so doing.

Many of the tricks of the trade of mud building have been empirically developed over thousands of years and they seem some-what "unscientific" but the visible tangible incontrovertible fact remains that in many countries of the world (including some of the so-called Affluent Societies) a large percentage of all housing is of mud, or part mud construction and, furthermore much of it is 50, 75 or even 100 or more years old.

MUD WALLS MUST BE PROTECTED FROM WATER



Very few houses are built entirely of one material. For example only in dense forest areas where wood seems plentiful are piles, floors, walls and roofs all made of wood. A “Concrete house” has a concrete frame and slabs, but walls are often infillings of bricks or glass or metal sheeting etc. A “Brick” house usually means only walls are of brick, but floors and roofs are of other materials and so on. So when you think of a “mud house”, do not expect to make the entire house of mud (though it is a possibility!). Bricks use a lot of fuel to burn them; stone needs quarrying, shaping and transporting. Concrete needs a very great deal of energy to make the steel, cement and then skilled labour to turn these materials into concrete. But in many parts of the world mud is right there on the site as an old, well-ried wall building material. Often all that is needed is the manpower to convert the ground on which you stand into a wall to surround and protect you.

WHAT DOES A MUD HOUSE LOOK LIKE?



IS THIS THE SORT OF PICTURE THAT COMES TO YOUR MIND

THIS ALSO IS A MUD HOUSE



AND THIS TOO CAN BE A MUD HOUSE
(AND YES IT IS MULTI-STORIED AND HAS A
CONCRETE ROOF!)

One of the greatest problems to face during the next fifty years is that of Energy-fuel- Power. The pressure of this problem will be less if we can make use of energy free materials as much as possible. One of India's major tasks is to provide homes for at least 25 million families who have no home. If we are to build with burnt bricks and concrete and steel etc. we add to this vast energy problem, and to the overall cost of housing 25 million families. If only we will apply our twentieth century know-how and techniques to our Age-old mud, we can solve this housing need without adding to this Energy Problem. So don't just say, "Mud is old fashioned". You can make it the latest fashion-mod mud!



All over the country mud of some sort or other is found. Even if the surface soil is unsuitable for wall building, there may be suitable mud beneath. Or by adding stabilisers your mud may be made suitable. Compare this situation with the burnt brick industry. Comparatively few areas have suitable mud for the purpose of burning mud into a burnt brick.

So the ideal is to find mud on your own site. If this is not possible, bring it from as short a distance as possible, or find the nearest stabiliser available and then you only have to transport that to your site.

WHERE WILL THE MUD COME FROM?



A 25-m² house on a 250-m² plot would require about 60-m³ of mud for its walls. By digging all over the plot, except the basement area, to a depth of .266 metres (10.5-inches) you have the right amount of soil to build the house (60-m³ divided by (250 - 25) m²60 = 0.266 metres.

LOCATION OF SOILS

Don't forget that you may not find your ideal building soil visible on the ground surface. If you dig pits you will see the various strata of different soils one below another. A typical hole often shows a top layer of useless building organic soil but below it perhaps a layer of sand, and below that perhaps a bed of clay.

So do not decide that your land is useless for mud wall making until you have dug a few pits and seen what is underneath. A mixture of the soil from two or three of these submerged strata often results in an ideal wall building Combination mud.

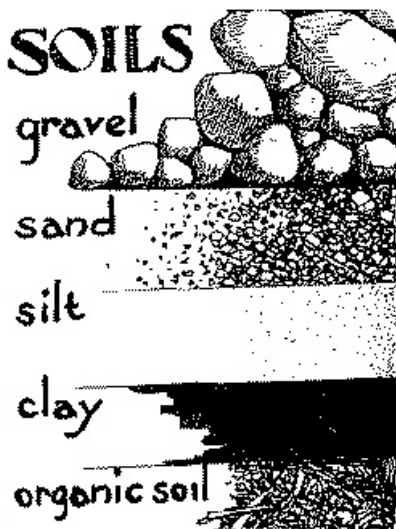
REMOVE THE TOP SOIL



Remove the top soil. Dig a pit and see that there are different layers of soil - on top is organic soil full of decaying leaves and fibre. Below it is sand and even below it is clay. You cannot use the top layers of organic soil for wall building - so remove it in heaps. Excavate the sand and clay for building your walls. When you have finished the work you can replace the organic soil for growing plants.

DIFFERENT SORTS OF SOIL

We usually talk of five varieties of soil.



Gravel: Small pieces of stone varying from the size of a pea to that of an egg. If you soak what you think is gravel for 24 hours in a bucket of water, and if it disintegrates, it is not gravel.

Sand: Similar small pieces of stone (usually quartz), which are small than a pea but each grain, are visible to the eye.

Silt: The same as sand except that it has been ground so finely that you cannot see individual grains.

Clay: Soils that stick when wet - but very hard when completely dry. Some of these clays shrink when they dry and expand when wet, but there are also clays, which do not shrink at all.

Organic Soil: Soil mainly composed of rotting, decomposing organic matters such as leaves, plants and

vegetable matter. It is spongy when wet, usually smells of decaying matter, is dark in colour and usually damp.

Mixtures: Usually these various types of soil are found mixed together, rather than in isolation. We describe them as mixtures such as “sandy clay”, “clayey gravel:” and so on. We must also be particular in these descriptive mixtures to indicate which variety predominates. For example “Sandy Gravel” means that there is a larger proportion of gravel in which a smaller amount of sand is mixed. Whereas “Gravelly Sand” means that it is mainly sand with some gravel also mixed in it!

USABILITY OF DIFFERENT SOILS

Gravel: alone is of no use for mud wall building - the tiny lumps of stone have nothing to bind them together.

Sand: similar to gravel, it is of no use for wall making by itself - but if mixed with clay,

i.e. sandy clays or clayey sands, it is the ideal mud wall building soil.

Silt: by itself is also no good for building walls. It will hold together but is not strong. Furthermore, it will not compact so it is also of no use for pressed blocks or rammed earthwork.

Clay: can be rammed or compressed but in drying out they often shrink. During the monsoon they get damp and expand again and crack form.

Laterite: is also a type of clay, which contains red iron or aluminium material. It is strong and stable and is cut out of the ground in blocks and hardens further when stacked and exposed to the air. It is of course a first class building material and we usually think of it as a stone. It is wise to follow local traditional opinions about clays and laterites. There is some clay which have proved to be unsatisfactory as building material and over many centuries local people have learned to avoid these particular unsuitable clays.

Organic Soils: are mainly useless for wall building. A reliable rule is that if a soil as good for growing plants in, it is not good for building walls with.

Mixtures: Find out which soils are contained in the mixture and then the usability depends on the proportion of the various types of soil listed above. Always look at the old buildings in your district and see for yourself the types of soil that have been used, durability, or shortcomings of these old buildings.

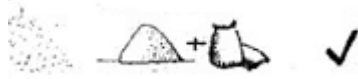
Gravel - No Good



Silt alone - No Good Plus stabiliser - Good



Sand alone - No Good Plus Clay - Good



Organic Soil - No Good



Clay alone - No Good - Plus Sand Good



SIMPLE SOIL TESTS

Of course proper soil testing can be done, but if you yourself want to know the building possibilities of the soil on your site you can find out quite a lot from simple tests. Better still is to go round your locality and see and ask about the mud that other people have already used for building their houses. You may find in many districts homes of mud that are seventy or eighty years old. The results of their “soil testing” are convincingly there for you to see.

THE CIGAR TEST

Roll a small handful of-soil (to which just enough water has been added to make it stick together) into a cigar or Sausage shape. Now with the thumb and forefinger squeeze the end of the cigar until; it is about a quarter of an inch thick and go on squeezing and pushing it out of your palm to see how long it is before it breaks off and it falls to the

floor.

1. If it just falls to pieces and cannot be shaped and pushed out it is too sandy and has practically no clay content at all. So it will only be usable if you add a stabiliser to it, or get some clay and mix it in with the sandy soil.
2. If you can squeeze about two or three inches before it drops off, it means that there is sufficient clay in the sand and it will probably make a good building mud.
3. If you can go on squeezing and pushing it out until it is eight or nine inches long, it means that it is mainly clay and you will have cracking and shrinking problems unless sand or the right stabilisers are added.

Naturally gravels will not stick together and you cannot even make a cigar and, similarly there is no point in testing organic soils as they are no use for building t' work even if you can make a cigar with them. But don't forget the organic soil may be only a surface layer and good building soil may be underneath it.

The Cigar Test



Make a cigar of soil ...
Squeeze it out of your hand
and see long it is before it drops off.

THE BISCUIT TEST

After moistening your soil, make a small fat "biscuit" shape (about 1/4" thick and 2" in diameter). Put it to dry thoroughly in the sun.

1. If when dry it crumbles to pieces and can hardly be picked up, or if you can crumble it easily with your fingers, then it will not be a good building material without stabilisers.
2. If you can break it into pieces without much difficulty, but it takes some pressure to crumble it between your fingers - then it will probably be a good wall building mud.
3. If it is hard and difficult to break, or if it breaks with a snap like an over-baked biscuit, and you cannot powder it, it will be useless unless with stabilisers or unless a sandy soil is mixed with it.

The Biscuit Test



Make a biscuit of soil ...
Dry it in the sun... Break it.

THE HANDWASHING TEST

Play about with your moistened soil until you are thoroughly dirty and then wash your hands clean.

1. If you are quickly clean with no effort it means that you were playing with loose sand, which by itself will not be a good mud wall material.
2. If it takes a little time to get clean and you feel as though you are getting rid of flour (atta or maida) and there is a powdery feel - it means you are playing with silt. You can use it only if you add stabilisers.
3. If you feel that you are using soap and your wet hands are slippery and it takes some time to get clean, you are washing off clay, and again, this will be no use for building without adding sand. Very often the soils are already mixed - so you can feel the gritty sand as well as the soapy slippery clay in "sandy clay" or "clayey sand". This will mean you have a good building mud.

COLOUR You can get quite a lot of information and indications of good or bad mud from the colour of the mud. Deep yellow, orange and red, ranging to deep rich browns indicates iron content and almost certainly this will mean you have a good building mud. Clays often have a greyish or dull fawn colour ranging down to dirty white. Dull browns with a slightly greenish colour indicate too much organic matter.

Hand Washing Test:



Rub your hands in the soil and then see how easy or difficult it is to wash them clean!

STABILISERS

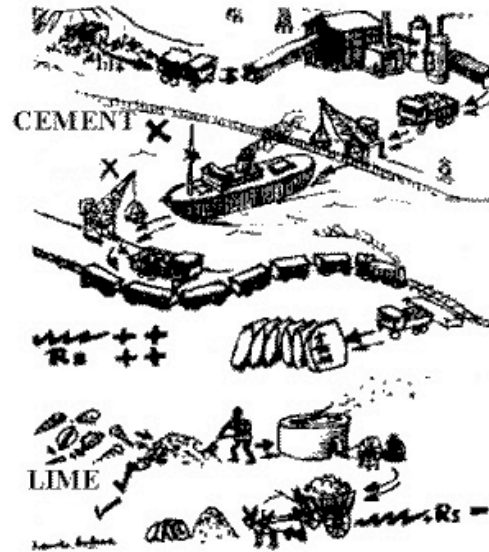
When a material is weak, or if used on its own it tends to collapse. We say it is not stable. Some types of soil like gravel, sand, silt on their own, are not stable and we cannot build a wall with them. This does not mean they are useless. We can remedy their particular defect by adding something that will make them stable. That is, strong and capable of holding together when shaped into a block or a wall. These extra "something" we call stabilisers. In these times, most people think of cement when we say that the mud needs a stabiliser but you must remember that long living mud walled houses have been used all over the world for thousand of years, whereas our modern "Portland Cement" was only "invented" in this twentieth century. Our forefathers, by trial and error, had found many stabilisers and the better ones have lived on, century after century and we are very foolish

if we do not learn from their inherited knowledge and “know-how”.

The need for stabilisers



Cement, as we have just pointed out, is a modern contemporary stabiliser. It is good in most circumstances but there is always the question of availability, cost, and the excessive use of energy in its production, etc. More particularly it is difficult to give precise proportions or quantities. For example, if we write that a proportion of 5% stabilisers to the soil is needed, that means one part of cement and 19 parts of soil. So if you need 100 cubic metres of mud for your house, you will need five cubic metres of cement. But if you have the patience and interest to make preliminary tests on your soil, you may find that all your particular mud needs to make it stable is 2% of cement and you will only need 2 cubic metres of cement. This is a difference between 125 bags of cement and only 50 bags - or, at current prices Rs. 10,000 or Rs. 4,000. So preliminary experimenting and testing is a good thing so that you do not use more cement than is necessary.



It should also be pointed out at this stage that this sort of lack of precision is one of the main factors why mud has not been accepted by the current engineering and contracting fraternity. If you say there might be 5.7362% of cement, they will be happy, but to say “anything between 1% and 5%” is too - vague for them! Science is our Sacred Cow and unfortunately is impatient with and intolerable towards; empiricism. Anything between 3% and 12% of cement may be needed for very sandy or very clayey soils. The average needs is usually about 4% or 5%. However, I prefer to keep off cement unless there is no other alternative.

Lime, on the other hand, is made from the same basic material as cement, but is thousands of years old, can be manufactured almost anywhere, on the spot, for a fraction the energy and cost of cement and is a first class stabiliser for mud. Slaked or un-slaked

lime is both acceptable but slaked lime will give less trouble to the workers hands and feet. Again, the quantity of stabiliser depends on the quality of your soil mix. A lot of sand or a lot of clay means a lot of stabiliser. Lime can be used between 2% and 6%. Usually a 3% mixture is sufficient. A special point about lime and cement stabilisers is that you may need hardly any stabiliser from the strength and stability point of view, but your mud may easily absorb any dampness or moisture. So in such cases very often only a small amount of stabiliser is enough to prevent this damp absorption. Another point is that often a mixture of Lime and Cement is good especially where you want to build quickly. Lime sets slowly but the addition of a little cement speeds up the setting time. For such mixtures, 2% of lime and 1% of cement is often adequate.



LIME

Lime probably is the most used stabiliser. It is made by burning shells and limestones in a mud kiln.

RURAL STABILISERS

Traditional building has used many other stabilisers. There is a list of common, well-tried ones:

Straw: There is no chemical quality about this stabiliser. In clay soils the straw seems to minimize cracking, and in blocks the presence of straw tends to make the damp blocks more handlable. Similar to straw, people in different areas use chaff (bhusa) and various fibres.

Cow Dung often contains a lot of fibrous material and traditionally is often used in all sorts of mud work.

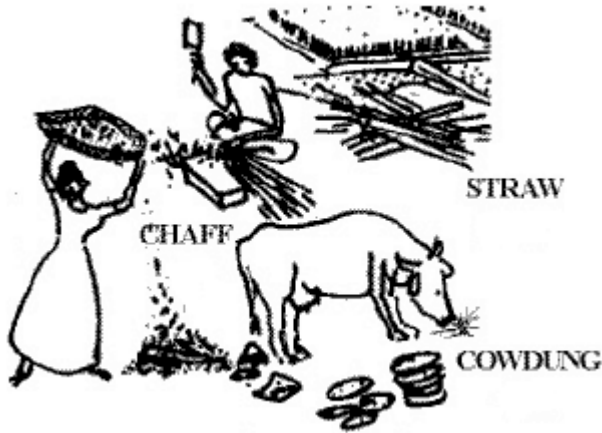
Urine is also used. Probably this is because of the urea content and the urea acts as a 'binder' - a sort of glue.

Gum Arabic and other gums and resins are used, also as binders and water proofing agents.

Sugar and molasses is used. The crude waste jaggery is a binder and it often contains fibrous materials, which is also useful.

Tannic Acid and its wastes, used in other rural industries has proved often to be a good stabiliser.

Oil is used. In such places as Kerala - coconut oil was used, mainly with the intention of water proofing the surface of mud walls. Almost any oil is useful in this way and the modern counterpart is waste engine oil or sump oil. This works well as a waterproofing in cement concrete as well as in mud walling.



RURAL STABILISERS
For some soils 'High Tech' can't improve on these.



PLANT JUICES Stabilisers from
plant juices: sisal, cacti etc.

Many plants have sticky white sap, as from poinsettias, various cactus plants, sisal, and so on. These seem to act as both binders and water proofers. Many of the saps from trees are also resinous and are good water proofing but Often very difficult to use as they will not mix with water and it is not easy to get then well mixed in with the mud. Local “tricks of the trade” often supply simple answers.

BITUMEN: makes a good stabiliser but it is not available to ordinary honest people. If you are offered some, it would means it has been siphoned off from P.W.D. supplies.

The most common and effective stabiliser is Soil itself. If your soil's too sandy clay is the best stabiliser for it. If it is too clayey, sand is the best stabiliser for it.

A modern contemporary stabiliser, the best example is cement, which is costly and has used excessive energy in their manufacture. Most of the older indigenous stabilisers are natural local waste products, which are costless, or almost so, and most important, almost no Energy has been expended, except simple manpower.

Finally in many parts of India the soils, or mixture of soils as you find them, are satisfactory and can be used without stabilisers. Only experimenting and testing will show you whether you need a stabiliser or not.

Now that we have looked at different sorts of mud and talked about the need to protect mud from water, and sometimes the need to use stabilisers to make the mud stronger, our next job is to see how to use the mud so that as we build, it will stick together. There are several systems for building mud house. Usually in any district probably only one way of making a wall is used. Obviously one of the main objects is to make a wall at least the height of a man and, having reached that height it must be capable not only of standing up but also of carrying the weight and thrusts of a roof.



COB is good for anything except height. It is particularly good for curved or round walls.



PISE OR RAMMED EARTH is strong and ideal for solid, squat, single storey houses.



ADOBE or SUN DRIED BRICKS can easily cope with two storey houses.



PRESSED BRICKS smooth and very strong and can build three storeys.



WATTLE & DAUB is elegant and fine for Seismic Zones.

The first, simplest and almost certainly the oldest system is called “COB”. With only a little water to form a very stiff mud, a large lump of it - as much as you can hold together between your two hands - is roughly moulded into the shape of a huge elongated egg. The usual size is anything between 12 to 18-inches, (30 to 40-cm) long and about 6-inches (15-cm) in diameter.

A row of these cobs of mud are laid neatly side-by-side - preferably somewhat pressed together.

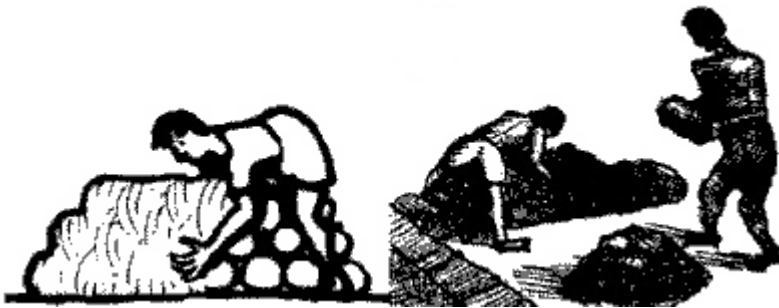


Then another row of cobs is laid on top. This second layer obviously lies in the depressions between the lower rows of cobs.



When three or four courses have been laid, one above the other, the sides are smoothed over so that the holes and cracks disappear.

COB



With care and experience - and perhaps the use of a sharp knife - like instrument, a very smooth flat surface can be acquired.

So far, I have used the word “laid” for putting the cobs together but in practice, the experienced cobber literally throws the cobs with accuracy and force so that the cracks and holes between the cobs are almost non-existent.

You quickly learn that the mud must be kept stiff. If there is too much water the wall as it grows, bulges or slumps and is likely to fall down or subside into a heap of mud.

In any case the wall building is better done slowly. After laying two or three courses of cobs all round the house wait until it has hardened and set a little before carrying on with the next two or three rows.

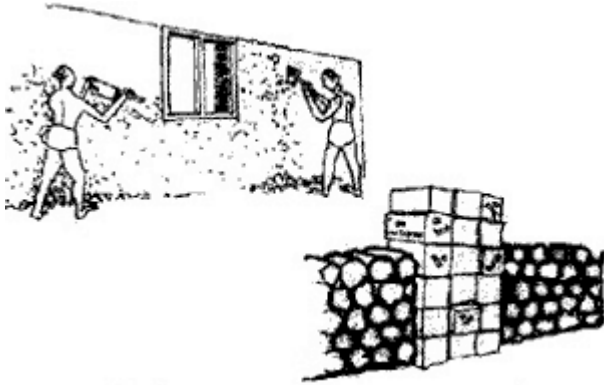
Another cob problem is to keep the walls straight and vertical. The easiest way to overcome this problem is to stand astride the wall while you are working.

The surface of the walls will be somewhat rough if only the hands are used to smooth over the holes and crevices. Soon after completing the wall you can smooth its surface by using a mammaty or an adze or a sharp knife or trowel. Such instruments will slice off bumps and give lumps a clean smooth surface.

Once you have obtained the feel of the right consistency of mud, this cob method is a very simpler straight forwards uncomplicated, way of building a wall and almost anyone can learn quickly how to do it.

If you wish to build curved- or circular walls 'cob' is the ideal system for doing it.

Openings for doors, and windows are a problem, which can be solved by using temporary vertical planks or shuttering.



Another very simple shuttering for openings is to use empty kerosene tins.

The main and very big advantage of cob is that anyone and everyone can have a bash at it and no special tools or moulds or other equipment is required. If, like your child, you can make a mud pie, you can make a cob walled house.

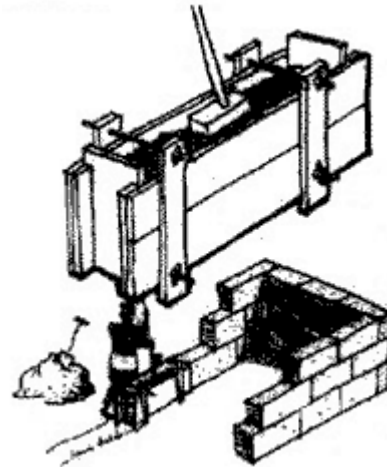
The second method has developed from the cob wall so as to standardise or regularise the thickness of the wall. It is also an attempt to increase the strength of the wall by ramming it. It is known as the Rammed Earth method.

Basically, two parallel planks are held firmly apart by metal rods and clips or bolts, or by small crosspieces of wood. Stiff mud is thrown in between these two planks and rammed down with either a wooden or metal ramrod. When one section is completed and hard, the two boards are moved along and the process is repeated until the whole plan is completed.

The two planks are then raised up and a second course of rammed earth is repeated over the first - and it goes on until the whole wall is completed. It is best to follow a bonding pattern as used in brickwork, so that the vertical joints between one rammed section and next are not vertically one above the other. Otherwise, these vertical joints can later turn into a large vertical crack! The two planks can become quite elaborate frames to refine and improve method of - holding, them rigidly part, and then to be able to move them along or above the already rammed surfaces.

Other refinements are adjustable baffle boards so that wall ends, as at corners, or where door and window holes occur, can be dealt with more easily, while the cob wall can be done by almost anyone, the rammed earth wall calls for a small measure of expertise - though the Handy Man can soon master the system. Similarly, as, already mentioned, an understanding of a large simple type of bonding is also required to avoid cracks developing in the walls.

However, there is no doubt at all that the life of rammed earth walls is usually very long and they can carry heavy floors and roofs and be used for two and even three storey buildings. There are examples in many parts of the world of rammed earth buildings, which are hundreds of years old.



RAMMED EARTH
or PISE (pee-zay)

The third system is known all over the world as 'Adobe' (pronounced a-doe-bee). Here in India we know it as sun dried bricks. This is probably the most popular form of mud walling because the mud blocks or bricks can be made by anyone and after drying, they can be stored until there are enough of them and the right time to build has come.

ADOBE (a-doe-bee)
SUN DRIED BRICK



A small box or mould of wood or metal is used and the stiff clay is squeezed into the mould and then turned out to cure and slowly dry. After that a mason can use them in much the way as he would use burnt bricks or cement blocks. The adobe bricks can be made to any size. They can be the same size as an ordinary burnt brick (about 9" x 4.5" x 3") or they can be bigger (12" x 6" x 4") if a thicker wall is preferred or indicated. (The smaller brick is likely to crack less) If care is taken to dry the bricks slowly (about the minimum for a month) the walls are built in the normal proper way, strong crack free walls are normal and can be used for 2 or even 3 storey houses. Of course, the usual care must be taken to protect them from wet and to use standard bonding patterns. There is

nothing new or risky or even 'rural' about this system of building mud walls and it is an obvious answer to the need for millions of small houses for the homeless without using any fuel or energy for their manufacture.



MOULDS FOR ADOBE BLOCKS

can be of any size.

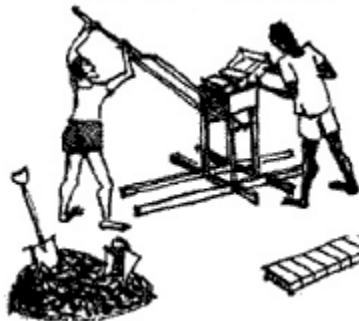
But if the block is too big then it is difficult to lift.

An ordinary, large burnt brick size is good, then masons need no special training to build.

You can make moulds so that several blocks can be made at one time.

The fourth system is similar to the adobe blocks but the bricks are Machine Made and Compressed in a simple machine that at current 1987 rates cost about Rs. 4000/ to Rs. 5000/-. These Machine Compressed blocks are very strong and those using a small amount of stabiliser are usually as strong as the local countr3 made burnt bricks. The same precautions of slow drying, and protection from moisture apply to compressed blocks also. Many people prefer these bricks, because they have a very smooth neat surface but it must be kept in mind that there is quite a lot of hard physical work required in making good compressed blocks. With all due and very great respect and admiration for the makers of these compressing machines, I have to confess that I do not believe their claim that "an ordinary man and his wife can, between them make 500 (or a 1,000 or 5,000) blocks a day", if the next day you wish to interview a couple who HAVE made 1000 blocks, you are likely to find them, at best, in bed, or at worst in hospital. However, that is only a friendly word or warning (after my blisters have healed) and the compressed block is a first class wall building material and can be used for load bearing walls, three storeys high.

PRESSED EARTH BLOCKS



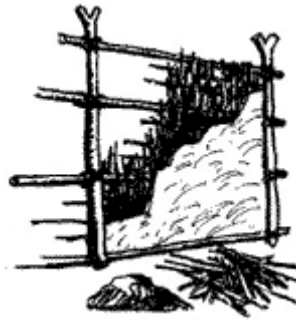
A fifth system uses mud as a plaster to cover thin panels of cane, split bamboo or other stalks that are woven together and held in place by wooden or bamboo posts and beams.

This is called WATTLE AND DAUB. It is very common in areas like Assam and the

North Eastern States, parts of West Bengal, the Andaman Islands, that is, where bamboo and cane grow freely and plentifully. Usually the frame structure supports the roof. Sometimes when rainfall excessive of cyclonic winds dash driving rain against the walls, however, wide the roof overhang is, ordinary solid mud structures collapse and the mud from Wattle and Daub structures gets washed off. However, the structure itself and the mesh of cane or split bamboo remains intact and after the heavy rain is over the mud is plastered on again.

The same sort of rectifiable damage also occurs when there are earth tremors. Even the framework of wooden posts sometimes is thrown out of vertical but does not collapse and can usually be pushed and pulled back into proper shape.

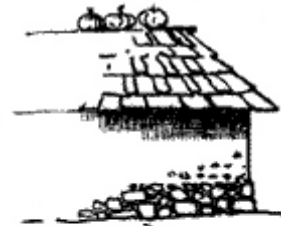
WATTLE AND DAUB



There are other local systems where some mud is used in one way or another to assist other materials to stick together. For example, in many parts of the country small rough stones are found but it is quite difficult to build a wall of any size or height with such pieces. So the stones are often used as fillers to either Cob, Rammed earth or adobe walls.

In many hill and mountain areas the stone is deliberately and carefully added at the external base of the wall and this deals with the splashing of rainwater quite effectively. It can also be said here that for many single and double storey buildings mud can be used as a mortar for ordinary burnt brick walls and for stone random rubble walls. A lime, or lime and cement, or cement mortar is usually used so that driving rain will not weaken the wall, but if the wall is protected by sunshades or roof overhangs these pointing is not-necessary.

Stones bedded in the base of a mud wall



Mud used as a mortar for burnt brick walls

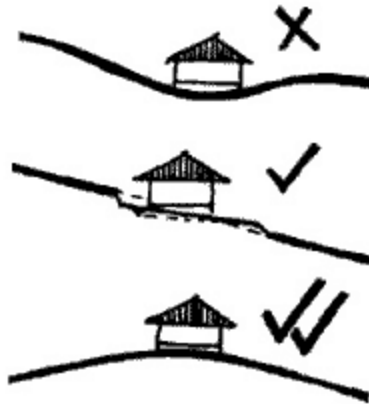


It is quite important to put your mud house in the right place. Obviously in many cases there is no option, for your site is too small and the access to the road and being hemmed in by other surrounding houses determining the only possible position for the house. But if there is a choice of site, then the first thing to remember is that the highest part of your land is probably the best place for your mud house. If the site is a sloping one make sure that you have a trench above the house, - so that rain water will be diverted and flow away from the house. Try and avoid at all costs putting the house in a low-lying trough or depression.

If your district has a driving rain which blows from one direction (probably from South West) then try and design a long rectangular plan, rather than a square plan, and let one of the narrow sides of the house face this driving rain direction.

If your site is a very exposed one with a frequent strong driving rain then of course it is better to protect that side of your building with plaster, or with a veranda, or even construct it from a material like Burnt Brick, or Stone, or Laterite. As we have already pointed out there is no virtue in being fanatical about mud and trying to do every single item with mud.

SITTING A MUD HOUSE CURING MUD BLOCKS



All forms of mud work are less prone to cracking if dried slowly, in the shade and not in strong sun.

After mud blocks are made they should be stacked so that air circulates around the blocks and so that they will not be disturbed or damaged preferably close to where the building will be constructed.

First cover them with wet sacks or leaves or straw. After one or two weeks remove these wet coverings and let the blocks dry out in the shade of a tree or some temporary shelter. Here they should remain for another two or three weeks. After a total of 5 or 6 weeks the shade can be removed for the sun to complete the drying out process.

Some mud workers do not wait for more than a week before building their walls with the block. There is no harm in doing this, but the blocks are likely to break from handling and carrying if they are still wet.

CURING BLOCKS

Put the block for one or two weeks under damp sacks, straw or leaves. Then two weeks or so under the shade.



MORTARS

Use the same soil that was used for the blocks.
Avoid too much clay as this produces shrinkage cracks.
Sieve the soil when dry so that gravel and pebbles are all removed for a smooth mortar.

If stabilisers such as lime or cement were used in the making of the blocks, it is also required in the mortar. In fact twice as much stabiliser must be used in the mortar. So, for example, if you have used a 5% cement stabiliser for the blocks use 10% cement for the mortar (i.e. 1:10 mix).

MORTARS

Always sieve the soil to remove the gravel.



PLASTER

The finish of adobe, rammed earth and cob walls is often a bit rough and the need for plaster is felt. The mortar between the blocks should be left rough to act as a key to hold

the plaster, which may be of mud, or mud and any stabiliser such as cow dung, lime or cement etc.

Pressed earth blocks are usually very smooth and it is difficult to apply plaster to them. It is better to apply two or three coats of whitewash, or thin slurry of sieved earth with lime or cement mixed in it. Colouring matter may of course be added if required.

Where there is driving rain against the bottom of mud walls causing erosion and if plaster will not stick to the smooth pressed blocks, a strip of chicken wire may be nailed or stapled to the bottom of the wall and then the plaster will be held by the wire and not crack or peel off. This need only be done on the walls facing the driving rain, not all the way round the building.

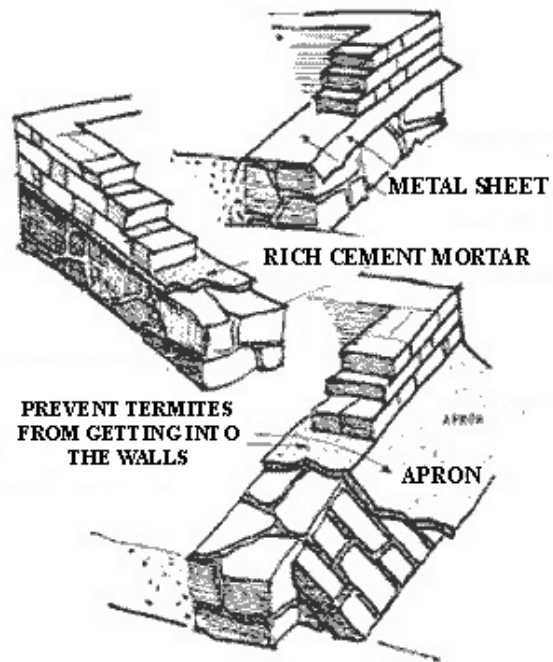


For anchoring plaster to smooth compressed blocks at ground splash level, use chicken wire mesh.

TERMITES

Mud seems to be the natural home of termites so in areas where they are common the same precautions have to be taken as in all buildings to prevent their moving up into the walls and eating wooden frames etc.

1. A one-inch thick layer of mortar (one part of cement to 3-parts of sand) can be laid all over the top of the basement wall before building the mud walls above it. This is helpful in keeping out both termites and damp.
2. Even better is to construct an apron of burnt brick or stone (or it can be rammed earth) all round the building (to prevent damage to the walls by splashing, of rain water) and this too can be plastered over with a rich cement mortar.



3. Any thin sheet metal may be laid over the basement wall with a 3-inch downward projection before starting to build the superstructure mud wall above. This is expensive but very effective.
4. There are various chemicals on the market, which can be used.

FOUNDATIONS

Often it is feasible to build the walls of a home on mud, but some more solid material is needed for the foundation and basement. If stone is locally available it can be used.

But in any case, many builders excavate a wide trench in which they lay concrete, then build up the foundation and basement wall and then fill in the remaining empty sides of its trench with the originally excavated soil. This is mainly wasteful and expensive and unnecessary exercise as far as ordinary house building is concerned. An 18-inch (45-cm) thick random rubble foundation cum base wall is all that is necessary to carry the load of the house above, i.e. the walls, floors, slabs, roofs etc.

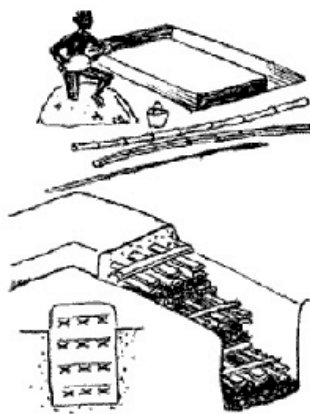
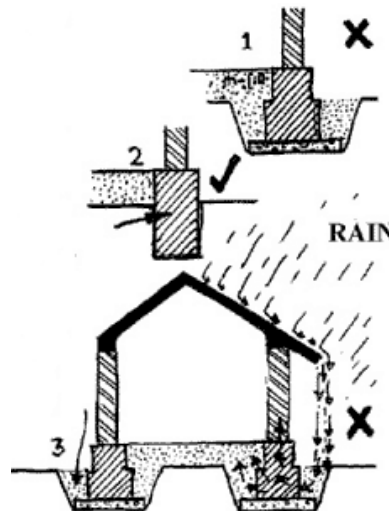
A trench only the thickness of the basement wall should be dug so that no infilling is needed. This will prevent much soaking in of water, which in turn would seep upwards and weaken the mud wall above.

FOUNDATIONS

Fig. 1. An orthodox foundation of a wide trench, lined with concrete on which stepped stone walls form a basement.

Fig. 2. But... A 45-cm stone wall in a 45-cm wide trench is normally adequate.

Fig. 3. The soft infilling often absorbs falling rain and damp walls are the result.



There are times when it is quite in order to have a mud foundation. The topsoil may be soft and useless but there may be reasonable harder subsoil capable of carrying the weight of a single storey mud house. One way of dealing with this situation is to remove the soil from the trench you would normally dig for a stone or brick foundation. Slightly, very slightly dampen the excavated soil and then replace a part of it to fill the trench about 6 to 9-inches. Ram this very hard - then repeat with another few inches of infilling ram it, and repeat until the trench is full.

If there is bamboo (it must be a mature, good “building bamboo”) in your area, you can

make narrow rafts of split bamboo. Having done the first 6-inches infilling and ramming, lay a raft of bamboo strips all around. Then repeat the process until the trench is full.

We started this book by saying that a mud wall's biggest enemy is water and damp. You don't have to be a qualified architect or engineer to deal with the problem of keeping the mud wall dry. All you need is a bit of common sense. The fashionable "modern" cubist style of architecture is not suitable for a mud wall building. The best way of protecting any wall from either rain or sun is to have a good big overhang to your roof. The sloping, or pitched roof is better because the walls need not be so high as for a flat roofed house.

Protection from the rain



The roof MUST overhang.

Even after you have provided a sensible roof overhang, there is still a problem of water that pours off the roof then splashes and dampens and wears away the bottom of your walls.

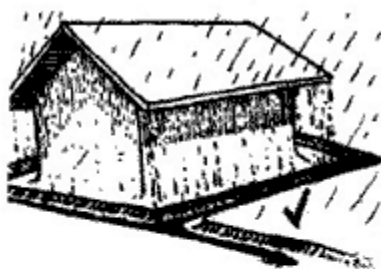
This sort of rural house can be seen all over the country and you must take measures to prevent this destructive splashing.

If you don't protect walls from the splash of dripping water the bottom of your walls will erode away like this.



The easiest way of dealing with the splashing rainwater problem is to observe just where the rain falls and then dig a trench there. Therein falls into the trench, only splashes against the sides of the trench, and is then carried away so that it also does not soak into the ground and make the foundations damp.

Protection from splashing rain.



Provide trenches round the house to receive dripping water and drain it away.

Another way of dealing with splashing rainwater is to construct a sloping “apron” all around the house. The rain then splashes on to the apron and immediately rolls off it. Any material can be used for making this apron - even beaten down mud or mud bricks - and then a thin hard plaster is smeared over the basic apron. Ordinary burnt bricks can of course be used, or stone pieces but these will cost more money than mud.

Protection from splashing rain.

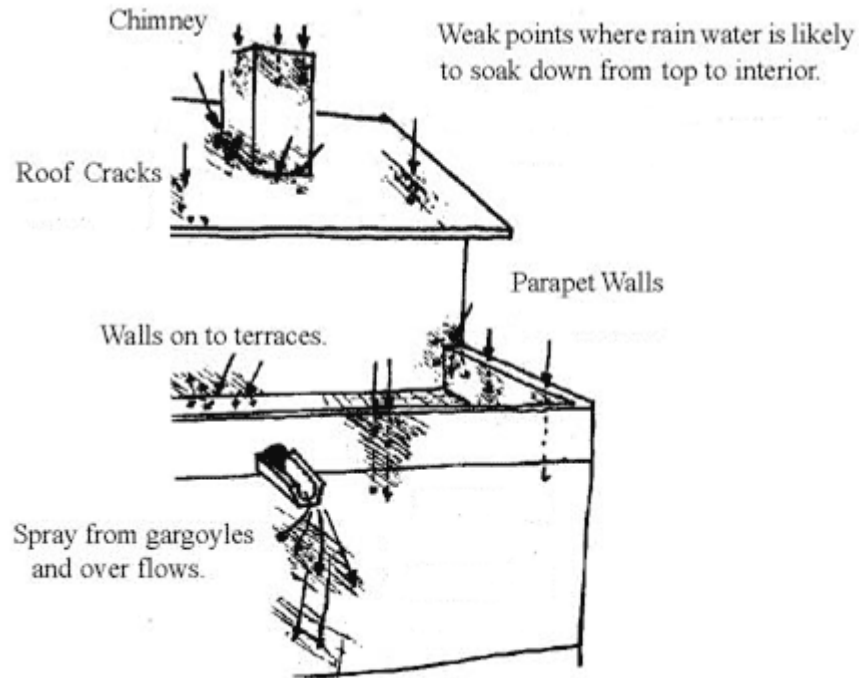


Provide a sloping apron at the foot of the wall.

Leaky roofs are, very bad for mud walls. The drips soak into the mud wall and weaken it. As soon as you see a small damp patch at the top of wall - immediately look to - see whether a tile is dislodged, or cracked, or whether birds and insects wear the thatch away. Whatever the drip or leak, it must be stopped. Chimneys can let in water, which will weaken adjacent mud walls. So make sure your chimney is well roofed over, and that water does not penetrate: the chimney walls and soak down inside the building to weaken the inferior walls. Also protect the lower parts of the chimney wall from heavy rain splashing up the roof.

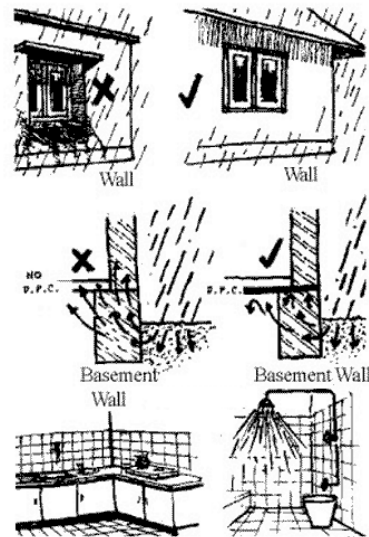
Parapet walls must have some waterproof between them and the wall below, otherwise the unprotected parapet will absorb water, which will soak down into the load bearing wall beneath and weaken it. Make sure water cannot get into the parapet wall and soak down into the load-bearing wall beneath it.

Sometimes Gargoyles and flat roof overflow or drainage pipes are too short and the rainwater pouring from them sometimes gets blown by the wind back on to the wall, soaks in and weakens it.



Window sills are also a place where water (driving rain), can soak down into a wall. Make sure there is a good over hang of the roof and fix the window frame on the outer edge of the wall with a slightly projecting window-sill. Avoid leaky sills.

Damp can also rise up from the ground below into the walls shove and make them unsafe. Always put in some form of damp proof course to prevent this happening. Bathrooms and kitchens have special problems in mud walled houses. Even in Burnt Brick, Cement Block, or Granite Walls you protect the bathroom- wall by putting glazed tiles or a fine smooth waterproof cement- plaster. So it is just- as necessary to protect a mud wall in a similar way. Similarly, the Bathroom floor must have an impervious surface with a skirting of the same material to make sure that water does not soak into the base of the walls.



Seismic Zones (Earthquake Belts) are usually of two main varieties - the areas where from time to time there occurs a massive devastating giant size earth quake. In these few historical tragedies all buildings suffer and most ordinary houses, whether they be of pukka or kutcha building materials, collapse. Many other areas two examples are Delhi in the North West and the Andaman in the South East - come under a seismic zone 5 (or less) and many people are not even aware of occasional tremors. Under such conditions very often it seems as though the more pukka and well-built buildings suffer more than the smaller kutcha houses. Partly this is because a tremor cracked plastered brick wall looks more dramatic and the masons and painters have to be called in - whereas in the wattle and daub, or the cob or rammed earth walls the housewife mixes some mud and cow dung and 'pastes' over the cracks and in few minutes there is no trace of them. Wattle and Daub houses are perhaps the safest and best of all the mud techniques in earthquake zones.

FLOORED AREAS

It would be very unwise to build pure mud walls in areas, which are subject to flooding. Even if the flood comes once in 20 years! There will be a calamity on that twentieth year! In West Bengal more and more frequently you can see whole mud villages completely collapsed and washed away, but only replaceable plaster has gone where wattle and daub has been used.

EARTHQUAKE



I have to admit that there is another basic problem about building with mud. Who will build your mud house?

If you have the time and inclination you can do it yourself!

If not, you have to seek out people who are traditional mud workers. This may not be a great problem in rural areas and on the outskirts of small towns, but it can be quite a problem for really urban areas (and in Development Authority areas you may have difficulty in obtaining permission to build).

It is worth mentioning that people will tell you that it is not possible to build mud houses in a city because there is no mud there to use. Such people have to be reminded that neither is there burnt brick or cement nor steel, if you can bring in these things, you can bring in mud also.

There are a growing number of organisations in different parts of the country, very often

staffed with young scientists and men of advanced education with practical knowledge of civil engineering - who are turning to these various forms of alternative technology as an answer to some of India's tremendous building needs. ' COSTFORD' the publishers of this book, or HUDCO or CAPART of New Delhi would put you in touch with such organisations for advice and help about building with mud.



WHO IS GOING TO BUILD FOR YOU?

One of the wonderful and endearing things about mud is that there is a vast wide range of muds and every single one has its own individual characteristics. All of it is God made and not machine made, so it is not standardised and it is almost limitless in quantity. Therefore to many, especially to the engineering world, it is maddening rather than endearing because you have to get to know your own mud and how to handle it. All ladies have beautiful eyes and bewitching hair and shapely lips but ideally you have to learn to live with, love, cherish and understand your own particular woman. Treat your mud as you should treat your wife and you will have a wonderful house for life!



MUD

*Mud is another name for Earth,
It never gets tired, giving birth,
To dwellings in Agra or in Perth.*

*It is one of the few sources,
Which does not require artificial forces,
And is easy to use, if used in courses.*

*Buildings that use mud,
Have a lot of strength,
Depending on requirement can have any width or length,
Or height, which may reach floor, eighth, ninth or tenth.*

*For thousands of years it had been used in a simple way,
But now they have started, experimenting and play,
With different percentages of sand, silt, aggregate and clay.*

*You can learn how to use it, without going to school,
It follows certain principles, and one simple rule,
That while building with mud, you have to keep your cool.*

- Amit Sharma