Mud house restoration

More than 30 years ago, Maryborough in Victoria was the site of an interesting experiment in low cost construction.

In 1982, Nepalese architect Ramesh Manandhar ran a week-long workshop with Melbourne architecture students and local sustainability enthusiasts in Central Victoria to demonstrate how mud bricks could be used in low rainfall areas to build low cost homes. This project was featured in *The Owner Builder* issue 5 under the title 'Not A Rafter In Sight.'

The building featured a vault and dome, constructed without timber supports, demonstrating techniques which date back over 7000 years. Using material extracted on site, and with the assistance of Maryborough Council, 50 inexperienced volunteers helped to make and lay the mud bricks over a period of several days.

BY PETER COWMAN, JAMES HENDERSON & TERRY WHITE

Plastered with a mixture of fat, salt and lime this building was intended to be part of the Maryborough Energy Research Foundation (MERF) development, which was hindered at the time by a lack of promised funding.

The renovation

In 1978 Maryborough's innovative council had asked permaculture co-founder Bill Mollison to design them a system for their settling ponds and the proposed Maryborough Energy Research Foundation was to be part of this development.

Due to a lack of promised funding the Energy Research Foundation was forgotten about until the charming mud building was rediscovered by the newly-formed Goldfields Sustainability Group in 2011.

In November the group organised a work party and the building benefited from a two-day makeover. Led by James Henderson of Henderson Clayworks, and under the guidance of Maryborough's Terry White – who had been involved in the original construction work – the volunteers began restoration of the external plasterwork.

This work was completed in January, leaving the building with a fresh coat of plaster. ◆

Peter Cowman says...

My own passion for building with mud developed after meeting James Henderson who had seen my 'peter-post' framing system featured in The Owner Builder (issues 149 & 160) believing it to be perfect to use with the light earth, mud based infill that he was passionate about. He could not have been more correct! Once I began working with the mud, entire new possibilities in low cost construction options opened up.

When Terry White visited my EconoSpace, constructed using the peter-post framing and the light clay infill (in walls, floor and even the roof!) he mentioned a 'domed building in Maryborough built of mud.' I subsequently passed this information on to James. Immediately his interest was piqued and a visit was arranged – which led to the restoration work.

Apart from the 'buzz' of the restoration, what was also revealed was the durability, affordability and sustainability of this method of construction. Despite exposure to the weather for 30 years and without any maintenance whatsoever, the structure remained sound and largely watertight.

The significance of Ramesh's concerns regarding 'the pressure on timber resources in countries where rapid deforestation is causing severe ecological repercussions' were also found to be more than relevant – not just to developing countries but to Australia itself in the here and now.

What this little building tells us is that it is possible to owner build ecologically sound, affordable and stimulating buildings without recourse to many manufactured products which, despite their supposed 'sustainability,' are energy demanding in their production as well as in the process of their eventual recycling.

The Maryborough mud house testifies to the increasing relevance of these ideas and methodologies in the world as we know it today.

It also highlights the invaluable role played by The Owner Builder magazine in 'joining the dots' and connecting us all together!

Links & resources

◆ **James Henderson**
James runs Henderson Clayworks, a construction company specialising in straw and earthen building.
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◆ **Peter Cowman**
Peter is an architect, eco-builder, teacher, writer and director of the Living Architecture Centre, an online school of vernacular architecture.
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◆ **Terry White**
Terry initiated the Central Victorian Greenhouse Alliance in 2000, an organisation that works to reduce greenhouse emissions on small and large scales.
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James Henderson says...

Earth buildings have captivated my attention for many years. The pure magic of digging up some earth, mixing it up with a little water and building something out of it still amazes me. Sure, it is a little more complicated than that, but so is life. I have been fortunate in my life to have first-hand experience of some amazing earth buildings. The mud dome in Maryborough is one such experience.

Manifested from passion, inspiration and manual labour, the little building had been sitting quietly for 30 years. That is until I suggested fixing her up a little. The original render was in very poor shape; most of it was completely gone. Surprisingly, the pure earth building stayed standing as a testimony to earth building. The new render would have to be made from materials found on site as there is a 100 metres walk in from the road.

Render recipe

Earth render consists of clay subsoil, aggregate and fibre. Normally the subsoil is screened before sand and straw are added. We carried in a 6mm screen to use on the subsoil, four straw bales were carried in for fibre, the aggregate we would have to do without. This fact dictated a subsoil with a low clay content and lots of naturally occurring aggregate, to be mixed with lots of straw. As the straw was used straight off the bale without chopping, the mix was fairly rough, almost cob like. This meant the tarp mixing method, where bare feet and a plastic tarpaulin are used to mix the materials, was perfectly suited. The render was then dragged over to the wall on the tarp and applied by hand. A little while later a wooden float was used to smooth out the wall.

The final result was not perfect, but the little building now has a lifespan of a few more years. The experience was perfect: soaking in some of the passion that manifested the building to begin with and sharing that passion with new and old friends.

Terry White says...

Back in the early 80s, when Ramesh's workshop was held, there were many mud brick projects underway in Maryborough. As Community Liaison Officer at a local secondary college, I had just spent a year supervising the voluntary building efforts of students and their parents as we built a mud brick and rammed earth art and craft wing. At the same time, friends were working on a mud brick restaurant, while low income families were building themselves mud brick homes and a Neighbourhood Centre as part of a very innovative Ministry of Housing project.

In this context, the workshop generated a lot of excitement because, while we were all familiar with the use of mud for making walls, none of us, including the architect, had had any hands on experience of the ingenious methods that had allowed the people of Iran, Iraq and Africa to use mud to build beautiful domed and vaulted roofs. I think all of us came away from the workshop experience somewhat awed at the thought that given what we'd learned, mud brick buildings need not be confined by the rectangular post and beam formulas we were familiar with but could take on a range of shapes we'd never imagined.

Mud house restoration – original article from *The Owner Builder* № 5, 1984

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NOT A RAFTER IN SIGHT

A low cost dome in Maryborough

Ramesh Manandhar

As a part of my Ph.D. work, I became interested in the idea of self reliance. I noticed people here in Australia engaged in owner-built housing, and in particular, many were using mud. If people in the developed West are rediscovering mud as an appropriate material, why are we in the developing countries giving up our vernacular mud architecture? In fact, developing countries are the home

Perhaps, the first building in Australia to have a mud brick wall covered with a mud brick dome and a mud brick vault. Pic. shows the dome and the vault after it was plastered with mud in Maryborough, Victoria. The dome and vault constructed without a formwork!

of mud brick houses. Unfortunately in a pursuit of 'modern western development,' the developing countries have opted for the use of high energy and capital intensive materials, such as cement & steel, instead of their own 'cultural building material,' mud. Mud in these countries is looked down upon as an inferior material and as an inferior technology.

The role of mud so far has been limited to wall construction protected from rain by large overhanging eaves, but the author is of the opinion that mud can also be used as a roofing material in the form of domes and vaults. Such a construction would be a tremendous aid for people in the developed and the developing world who are interested in building their own roofs. Such a non-wood roof would also have the advantage of reducing the pressure on timber resources in countries where rapid deforestation is causing severe ecological repercussions. Such countries like Nepal urgently need an appropriate roofing material that does not use timber. Could mud bricks be an answer?

In order to explore the possibilities of mud brick roofing, a project led by the author, on behalf of the Department of Architecture at the University of Melbourne and in cooperation with the Maryborough Energy Research Foundation (MERF) was carried out at the beginning of 1982. MERF is a voluntary organisation interested in exploring the use of alternative energy sources such as solar, wind etc. It was decided that the building thus built would be used by MERF as an appropriate technology centre cum experimental demonstration house in Maryborough. Victoria.

We first had to make a large number of mud bricks but with our limited number of hands, we would run into perhaps several weeks or months in just making mud bricks. Therefore it was decided to ask for help from the Maryborough community. The officers of the Community Youth Support Scheme (CYSS) who had previous experiences in building with mud assisted us in organising a 'Mud Brick Weekend.'

In response to our call in the local newspaper for community participation, more than 40 people came to help make the mud bricks. The 'Mud Brick Weekend was a great success,' despite the fact that it was perhaps one of the hottest days of the year.

Above left shows the dome and the vault under construction. Notice the mud bricks for the vault resting on an inclined plane. Arches and pendentives are completed to receive an octagon to receive the base of the dome.

Above right: The author on top of the dome immediately after the building was completed and before plastering began.

We made in all about 1000 big bricks for walls of size 380 X 250 X 125, about 800 bricks of a smaller size 250m X 150 x50 for the vault, and about 600 bricks of an intermediate size 250 X 250 X 50 for the dome. The bricks for the dome and the vault were made smaller because the lighter bricks would be easier to lay. The straw content in the brick was very high. One part of sand was added to two parts of earth for the dome and vault bricks. Hasan Fathy's project at New Gourna in Egypt used a mixture in the proportion of 45 lbs of straw with one cubic metre of earth and a third of a cubic metre of sand. We did not follow this rule as it was impractical at that moment. The soil was obtained from scraping the top surface of the site, which also gave us a very hard ground surface for our building.

Prior to the workshop, I had collected information from different sources in Australia and abroad and compiled this into a working manual for dome and vault construction. To put the theory into practice, I built, with the help of CYSS kids, a small mud brick dome and two small mud brick vaults using the full size bricks. After the successful completion of these dome and vaults, we gained the confidence needed to begin the actual workshop project. First, foundation was constructed in stones set in cement mortar. My suggestion of using stones in mud mortar was vetoed by others including the city engineer arguing that we were not experimenting with the foundation. Fortunately some of our participants had several bags of cement lying idle and they donated them for use on the building. While constructing the foundation, we found that it consumed a lot of cement – much more than we had imagined. That was perhaps the most costly item that went into the house.

350 X 250 X 125 size bricks were laid over the foundation to a height of about one and half metres. Due to the lack of money, we used metal drums as formwork for arched lintels over openings. Because, we had to finish the whole building in one week, we used 1:l soil and sand to make mud mortar for the laying of the mud brick walls. We kept on building without a break to meet the deadline. Immediately after the walls were completed, we started laying courses for vaults and domes.

How it was rendered:

Although one can render the dome and the vault building as one pleases, similar to the external mud brick wall, we suggest taking extra care and precaution on the exterior surface particularly where water collects and runs down.

We rendered our surface with a special mixture of lime, salt and fat, a recipe suggested by the alternative energy expert from Queensland, Dr. Ruth Cilento. She has discovered that this mixture used since ancient times, had withstood the effect of rain on her mud brick building for two years. Since, we did not want the building to be too white in color for aesthetic reasons, we mixed mud mortar with her recipe before applying it. The details of the recipe is reproduced here (overleaf) in the original with the consent of Dr. Cilento.

Some questions commonly asked on mud brick roofing:

Q.1 How to determine the number of bricks required for the dome and the vault? The thumb rule is: For vault construction, one metre length of vault spanning 3048mm has 17 rings with 20

bricks in each ring and therefore the total number equals to 340 bricks (brick size: 250 X 150 X 50). For dome construction, one dome of span 8 feet uses about 400 bricks. (brick size 250x250~50

Q.2 How to get a shape of a parabola for vault construction? Use your free hand and draw a smooth parabola or use any metal, timber or bamboo stick that deflects into a natural parabola. When you hold a string at its two ends and let it deflect due to its own weight, the resulting shape is a parabola. Remember to construct a tall parabola instead of a shallow parabola, so that it becomes easier to lay bricks for the vault construction.

Q.3 What is an ideal shape of a dome or a vault for construction? The experience shows that shallow vaults are difficult to construct with mud bricks. Try not to reduce the height of the parabola less than half the span. We think shallow domes with bricks cantilevering and sloping towards the centre are stronger than simply cantilevered domes. Shallow domes give more thrust to walls than tall domes and hence the walls have to be further strengthened to resist the side thrust. Do not cantilever the bricks more than 20% of the cantilevered length. Do not slope the bricks more than 75 degrees to the horizontal.

Q.4. How big can we construct the domes and vaults in this manner? I would say theoretically there is no limit. There are very large mud brick domes and vaults still standing today built by our ancestors. Some are more than one hundred feet! The bigger the span, the bigger the load and the thrust on the walls and hence walls will have to be really thick. Sometimes, some tension may develop within the structure in a very large dome or vault and hence it may be necessary to introduce metallic rods (steel or bricky's toll) in the lower rings of the dome. Normally, domes are stronger than the vaults and hence we suggest to use the dome construction for the bigger span than the vault. We would also suggest for domestic use for amateur builders to build with a 3 to 5 metre span dome and about 3 metre for the vault. With larger spans, the necessary scaffolding becomes difficult and expensive.

Q.5. What holds the domes and vaults from falling? Principles of domes and vaults construction with adobe blocks: Domes and vaults construction with adobe blocks lie in the principle that all the members of the domes and vaults are able to take load by compression stress only. It is therefore extremely important that no part of the dome and the vault comes into tension at any time. Because the dome and the vault have walls and roofs usually of the same material (monolithic), bonded in the same mortar, the structure is quite stable. This may explain why the mud brick structures in the middle east have withstood time and some of them are still in excellent conditions. In domes, the corbelling bricks cannot fall because: brick A is tightly butted on the sides against bricks B. As it tries to move downwards, it must rotate or overcome friction against bricks B and the rotation will put bricks A and B under compression at all times.

The vault bricks rest on the top of each other dry and dry forming an inclined parabola to give plenty of support and thus friction for bricks to resist falling. "Earth bricks cannot take bending and shearing so the vault is made with the shape of a parabola conforming with the shape of a bending moment diagram, allowing the material to work only under compression ... thus the whole vault could be built straight out in the air, with no support or centering, with no instrument, with no drawn plan ... Hasan Fathy, Architecture for the Poor.

'WATERPROOF WHITEWASH'

Purported to be The Original Pilgrim Fathers recipe.

METHOD OF USE: 1 or 2 coats, hand brushed.

INGREDIENTS:

7 lbs. fresh rock lime.

1 lb coarse salt.

¾ lb clean dripping.

Place all ingredients in an old 2 gallon bucket. Cover with cold water. The lime makes the mixture bubble and boil. Leave overnight. Stir well and keep adding water as your work.

The first coat looks grey but dries white.

CAUTION: WEAR GLOVES.

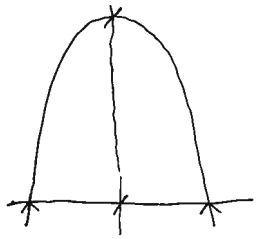
The lime must be used when it is fresh or it will not boil.

We also had to render down the fat from our neighbour's tallow. Put fat from any beast, calf. goat, pig, sheep, in an A10 (1 gallon) tin and stand it on the side of the stove. For quickest results, cut the fat into 1" cubes. From time to time when the stove is hot rendered fat can be drained off. Collect 3/4 of this to use in the whitewash. We have used hydrated lime as successfully as fresh rock lime. It is best to still wear gloves though and to mix the salt with the lime dry. The coarse salt used for water-softening is suitable and can be purchased bulk. Heat some water in a large saucepan or kerosene tin. Add the rendered fat. When the fat has melted, shake in the dry ingredients whilst stirring well. Keep stirring and adding the dry ingredients until a thick creamy consistency is obtained.

This will set on cooling but will not separate into layers. Stir well before applying with a 6-8" white-wash brush.

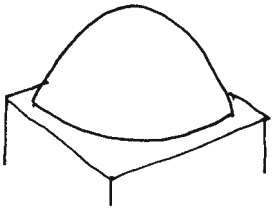
If stirring does not bring the mixture back to a creamy consistency, add more water.

This can be added when cold. When using this white-wash, two coats are better than one.

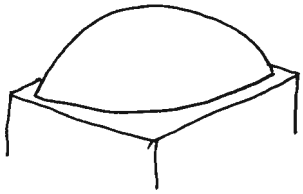


A tall parabola

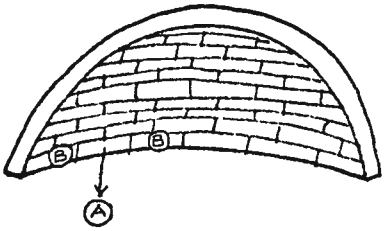
A shallow parabola



A tall dome



A shallow dome



Brick A is tightly butted on the sides sides against bricks B. As it tries to move downwards, it must rotate or overcome friction against bricks B and the rotation will put bricks A and B under compression at all times.

Ramesh Manandahar is an architect from Nepal. He studied at the J.J. School of Architecture at the University of Bombay. For the past year Ramesh has been at Melbourne University doing research and writing for his thesis on "Self Reliance". He returned to Nepal in June, and there he intends to carry out a similar project to the one at Maryborough. (Vic). ■

Experiment Revisited

By Russell Andrews

It was just a bit spooky, wandering around a quiet bit of deserted bush with camera in hand and a head full of memories. The last time I had been at this place it had been a lot different. Early in 1982 it was the site of an experimental building project on the outskirts of Maryborough in Central Victoria. A group of earth building enthusiasts gathered to help an architect from Nepal explore the ancient art of building domed and vaulted roofs using mud bricks. The process was documented in an article written for issue five of *Owner Builder Magazine*.

Ramesh Manandhar was an architect in the process of completing a Ph.D. at Melbourne University. He was keen to return to his native Nepal with experience of building domes and vaults.

In Nepal, timber is in very short supply and materials such as steel and concrete are unaffordable by ordinary people in need of housing. Ramesh did return to Nepal and continued in various ways to demonstrate a concern for the poor and homeless. Tragically, he died in an airline crash several years ago when returning to Kathmandu.

I found the little building recently on my second visit to the area. I didn't know quite what to expect. It was unlikely that any maintenance would have been given in fifteen years and I would not have been surprised to see it in a state of collapse or for it to have been totally vandalised.

To my delight nothing had happened to the building apart from a normal aging process resulting in a change in its cosmetic appearance. The structure remains stable and solid and had it been occupied and given simple inexpensive loving care and attention it would be as good as the day we walked away from it in 1982. Ramesh would have been pleased. Revisiting the job for me meant reliving some pleasant times spent with Ramesh and other friends.

Some Technical Details

The building consists of a 3m. square dome abutting a 3m. square vaulted room. Footings consist of rough fieldstone laid in cement mortar.

In strictly material cost, the cement mortar was the biggest outlay for the entire building.

Walls are vertical up to about 1.5m. and form the two 3m. square rooms with a connecting opening and external door.

A total of 1000 bricks were made for the walls. These measured 380 x 250 x 125 and were of local soil which is high in clay of a type that is not especially reactive.

Bricks were laid in mortar of a similar but sandier soil.

It is noticeable that, fifteen years later, the mortar has eroded more than the bricks.

The Dome

The dome began off the square base. "Squinch" arches were laid across the corners to create an octagon which grew to become a circle.

Successive rings or courses of bricks that measured 250 x 250 x 50 were laid in a circle of ever decreasing diameter. Each course tilted towards an imaginary centre point.

Each brick forms a dry butt joint with the next on the underside surface of the dome. Mud mortar is only used as a bed and to fill the tapered gap between bricks on the outer surface.

Ramesh demonstrated the strength of the dome by standing on top of it as soon as the last brick was laid. Because of those butt joints a lot of bricks would need to be crushed before a collapse occurred. It's what is known as a "compression structure.'

The Vault

Construction of this part of the roof is more difficult to explain.

It began by extending the wall between the two rooms up and finishing it in the shape of a parabola. This gave the profile of the vault and something to begin laying it against.

Bricks used for the vault were 250 x 150 x 50 laid to produce a 150 thick roof. Laying began from each side wall with a brick that stood on its end and leaned against the dividing wall at an angle of about 30 degrees off vertical.

The second course on each side consisted of one and a half bricks which reached a bit further up the parabolic wall. So it went on until after 10-12 courses the bricks laid off each side wall met at the apex of the parabola.

Finishing Off

After all the bricklaying was completed there was a certain amount of chipping off of square edges and filling with mud mortar to produce the more curvaceous shape.

A final render consisting of lime, salt and dripping was brushed on in two coats. ■

Mud house restoration – workshop 2011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1. *Mud house before restoration.*
2. *Volunteers get the restoration underway.*
3. *The mud house in its natural setting, after restoration.*
4. *The interior dome – remarkably well preserved.*
5. *Restoration team gather in front of their finished job.*
6. *The finished result – restored to its former glory.*
7. *Re-plastering the roof.*
8. *Screening dirt before mixing with straw and water.*
9. *Peter does the mud shuffle to mix the plaster.*
10. *Restored roof; wall awaiting new coat.*
11. *Arch in the cool interior.*

Photos by Alanna Moore, Peter Cowman and Suzy Keys.


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