

BUILDING WITH EARTH IN AUROVILLE

INTRODUCTION ON BUILDING WITH EARTH IN AUROVILLE

Raw earth for building has been used worldwide for millennia but during the 20th century most of the skills of earth builders were lost and building with earth became marginal. Through the endeavour of the Auroville Earth Institute, Auroville is today reviving these traditional skills and demonstrating that earth is a noble building material which can be used for manifesting modern, harmonious and progressive architecture for the third millennium.

From the early days of Auroville, in the 1970's, different experiments have been made with earth building, with mixed results. The creation of the [Auroville Earth Institute](#) in 1989, the construction of the [Visitors' Centre](#) from 1989 to 1992 and the development of [Vikas Community](#) from 1992 to 1998, started a new era in earthen architecture in Auroville.

This Visitors' Centre of 1200 m² was granted the "Hassan Fathy Award for Architecture for the Poor" in 1992. Built of compressed stabilised earth blocks, it demonstrated the potential of stabilised earth as a quality building material. Vikas Community was a finalist for the "World Habitat Award 2000" and its 3rd building was built on 4 floors. Since then, the value of earth as a building material has been acknowledged for its economic advantage, as well as its comfort and quality, which promotes indigenous and sustainable development. Today, Auroville can show a wide variety of earthen projects: public buildings, schools, apartments and individual houses.



Visitors Centre
"Hassan Fathy Award for Architecture for the Poor" in 1992



Vikas Community on 4 floors
Finalist of the "World Habitat Award 2000"



Training centre of the Auroville Earth Institute

Most of the projects are built with compressed stabilised earth blocks (CSEB), as this technology benefits of more than half a century of research and development worldwide. Stabilised rammed earth is also used extensively for foundations and to a lesser extent for walls. In Auroville, CSEB present several advantages compared to the local country fired bricks:

- Walls made of CSEB and stabilised rammed earth are always cheaper than fired bricks.
- The initial embodied energy of CSEB produced on site with 5 % cement is ~ 4 times less than the local country fired bricks.
- The strength of these blocks is most of the time higher than the local country fired bricks.

There are also three other earth techniques used in Auroville. These techniques are very marginally used as only about 10 buildings have been built with them:

- Raw rammed earth
- Adobe blocks, the traditional sun dried mud brick
- Wattle and daub which is mud plastered on a wattle made of split bamboo or palmyra tree

A GOOD EARTH TO BUILD WITH

The Auroville red soil got its colour from iron oxides, which give excellent properties and make remarkable building materials. In Auroville, the earth is stabilised with about 5% by weight of cement. The lime quality around Auroville is not high enough to be used. Further the soils from Auroville are mostly silty sands and they are not suitable for lime stabilisation. Hence cement is more suited to stabilise the earth.

MANAGEMENT OF RESOURCES

When building with earth, one should pay a lot of attention of the management of resources. Topsoil should be scraped away, so as to be re-used for agriculture or gardens. One should always plan how the excavation would be used afterward. A proper management of the earth resources can create a new and harmonious balance between nature and the buildings, where each enriches and completes the other. Auroville shows various possibilities for the use of quarries: as water harvesting ponds, waste water treatment ponds, pools, basement floors or shallow depressions which are used for landscape design, work or play areas, gardens, etc.



Quarry used for a shallow percolation pit



Quarry used for a biological wastewater treatment (lagooning)



Quarry used for a biological wastewater treatment (baffle reactors)

COMPRESSED STABILISED EARTH BLOCKS

CSEB is nowadays the earth technology, which is the most used worldwide, as well as in Auroville, because it represents a synthesis between traditional practices and a modern technology.



Auram Press 3000 for producing about 75 different blocks



About 75 different blocks produced by the Auram Press 3000

In Auroville, CSEB are stabilised with 5% cement and have an average dry compressive crushing strength of 50 kg/cm^2 (5 Mpa) and a wet compressive crushing strength of 25 kg/cm^2 . The water absorption is around 10%. Country fired bricks have resist at around 35 kg/cm^2 for the dry compressive strength and have a 12% water absorption rate.

The Auroville Earth Institute has designed manual presses for CSEB, the [Auram](#), which are manufactured in Auroville by Aureka, one of its steel workshops. Today, the press 3000 for compressed stabilised earth blocks is being sold worldwide on all continents. Many machines have been sold in Asia, South Asia and Africa. Nowadays, more and more presses are being sold to USA, Middle East and Europe.

STABILISED RAMMED EARTH

In Auroville, the earth is rammed by hand. Until 1994, Auroville had only one house made of raw rammed earth. Stabilised rammed earth was promoted since 1995, after the construction of Mirramukhi School (presently named Deepanam). Stabilised rammed earth presents the advantage of being cheaper than compressed stabilised earth blocks.

APPROPRIATE BUILDING TECHNOLOGIES BASED ON EARTH

This research aims at making extensive use of raw earth as the main building material, thereby using a local resource to help develop technologies that are energy saving, eco-friendly and sustainable.

The main research and development is focussed on minimising the use of steel, cement and reinforced cement concrete (RCC). Most of the technologies developed have now been mastered and the present research is focussed on alternative stabilizers to cement and alternative water proofing with stabilized earth, composed of soil, sand, cement, lime, alum and tannin. To date the main synthesis of this research is achieved with the Training Centre of the Auroville Earth Institute. This building is constructed entirely with stabilised earth, from the foundations to the waterproofing:

- Stabilised rammed earth foundations (with 5 % cement)
- Stabilised rammed earth walls (with 5 % cement and a "homeopathic" milk of lime and alum)
- Composite columns (round and hollow CSEB with reinforced concrete)
- Composite beams (U shape CSEB with reinforced concrete)
- Stabilized earth mortars and plasters
- Wide variety of compressed stabilised earth blocks (17 moulds are presently available for producing about 75 different types of blocks)
- Various vaults with compressed stabilised earth blocks
- Alternative stabilizers to cement ("homeopathic" milk of lime and alum)
- Alternative waterproofing with stabilized earth (various mixes of soil, sand, cement, lime, alum and juice of a local seed)

VAULTED STRUCTURES

This R&D seeks to increase the span of the roof, decrease its thickness, and create new shapes. Note that all vaults and domes are built with compressed stabilised earth blocks which are laid in "Free spanning" mode, meaning without formwork. This was previously called the Nubian technique, from Egypt, but the Auroville Earth Institute developed it and found new ways to build arches and vaults.



Segmental vault, 10.35 m span built free spanning in 3 weeks



Semicircular vault, 6 m span built free spanning in 6 weeks



Equilateral vault, 3.6 m span built free spanning in 6 weeks

DISASTER RESISTANT BUILDINGS

Since 1995, research has been oriented towards the development of a cost-effective technology which is based on reinforced masonry with hollow interlocking CSEB. Three types of blocks have been developed:

- The square hollow interlocking block 245. It is laid with mortar and reinforced with cement concrete. It allows building up to 2 storeys high.
- The rectangular hollow interlocking block 295. It is laid also with mortar and reinforced with cement concrete. It can be used only for ground floor buildings.
- The dry interlocking 300. It used dry stacked (without mortar) and a cement concrete grout is cast in the holes with reinforcement bars.

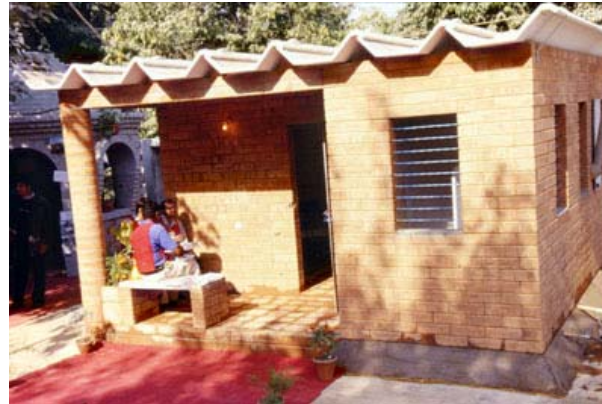
Note that this technology has not been used in Auroville as our area is not earthquake prone. This technology has mostly been used for the rehabilitation of the zones affected by disasters, such as Gujarat after the 2001 earthquake; Bam, after the 2003 earthquake and Tamil Nadu / Sri Lanka after the 2004 tsunami.

Our technology for earthquake resistance has been approved by 3 governments:

- The Government of Gujarat, India, (GSDMA) as a suitable construction method for the rehabilitation of the zones affected by the 2001 earthquake in Kutch district. It is allowed to build up to 2 floors.
- The Government of Iran (Housing Research Centre) as a suitable construction method for the rehabilitation of the zones affected by the 2003 earthquake of Bam. It is allowed to build up to 2 floors (8 m high).
- The Government of Tamil Nadu, India, (Relief and Rehabilitation) as a suitable construction method for the rehabilitation of the zones affected by the 2004 tsunami of Indonesia.



Minimum emergency house built at Istanbul, Turkey, in 8 days
During the City Summit habitat in 1996



Aum House built in 66 hours at New Delhi as a demonstration
Project granted gold medal by ITPO



Aum House built in 62 hours in Gujarat
For the rehabilitation after the 2001 earthquake

EARTH VERSUS OTHER BUILDING MATERIALS

The traditional building material used around Auroville is fired brick. Villagers fire their own bricks in country kilns, which are not very efficient. They consume a lot of wood, pollute a lot and give at the end poor quality building materials: Villagers around Auroville burn about 100 Tons of wood for 250,000 fired bricks... Good quality fired bricks are also available from factories and they are called wire cut bricks.



Half CSEB 240 (24 x 24 x 9 cm)



Wire cut fired brick (22 x 10.5 x 7.2 cm)



Country fired brick ($\pm 22 \times 10.5 \times 6.5$ cm)

ENERGY EFFECTIVENESS

Costs are too often limited only to a monetary value. Another important aspect is the environmental cost, especially with the embodied energy into the material. The production of earth-based materials consumes much less energy. The initial embodied energy of CSEB is about 4 times less than country fired bricks. Of course the carbon emission is also about 4 times less for the CSEB, compared to the country fired bricks.

Initial embodied energy (MJ/m ³ of materials)	Carbon emission (Kg of CO ₂ /m ³ of materials)
CSEB are consuming 4 times less energy than country fired bricks: CSEB produced on site with 5 % cement = 1,112.36 MJ/m ³ Country fired bricks = 4,501.25 MJ/m ³	CSEB are polluting 4 times less than country fired bricks: CSEB produced on site with 5 % cement = 110.11 Kg of CO ₂ /m ³ Country fired bricks = 444.12 Kg of CO ₂ /m ³

COST EFFECTIVENESS

Earthen buildings have the advantage of using local resources and being labour intensive. Therefore, most of the time, they cost less than conventional materials and technologies. The final cost of a building will depend mainly on the design, the type of finishes and the project management. In all cases, the technologies implemented are cost effective.

In Auroville, a finished m³ of CSEB masonry is always cheaper than fired bricks: 15 to 20 % cheaper than country fired bricks. Walls made of compressed stabilised earth blocks are already cheaper than fired bricks but stabilised rammed earth walls are even cheaper than CSEB masonry. The material for CSEB or stabilised rammed earth is the same, but the difference comes from the fact that the blocks have to be cured on the ground, lifted and built by masons later on. In the case of stabilised rammed earth, the walls are made by semi skilled labour and they stand in place at the end of the day. Therefore, a finished m³ of rammed earth wall is 20 to 30 % cheaper than CSEB wall and 30 to 50 % cheaper than fired bricks.

COMPARISON OF BUILDING MATERIALS AT AUROVILLE (April 2009)

	DETAILS	WIRE CUT BRICKS	COUNTRY FIRED BRICKS	CSEB 240	RAMMED EARTH
PRODUCT INFORMATION	Brick size (L, W, H, in cm)	22 x 10.5 x 7.2	22 x 10.5 x 6.5	24 x 24 x 9	(Wall cast in situ)
	Volume of brick	1.66 Litres	1.50 Litres	5.18 Litres	(Wall cast in situ)
	Weight per unit	3.12 Kg = 1,876 Kg/m ³	2.81 Kg = 1,871 Kg/m ³	10.00 Kg = 1,929 Kg/m ³	~ 1,950 Kg/m ³
	Stabilisation	Fire	Fire	5% cement	5% cement
	Wastage of raw material	3 %	12 %	5 %	0 %
	Units per m ³ (raw material)	601 No.	666 No.	193 No.	No bricks
	Pollution emission (CO ₂)	202.25 Kg / m ³	441.12 Kg / m ³	110.11 Kg / m ³	16 Kg / m ³
	Energy consumption	2,247.28 MJ / m ³	4,501.25 MJ / m ³	1,112.36 MJ / m ³	110 MJ / m ²
	Dry crushing strength	100 Kg / cm ²	35 Kg / cm ²	50 Kg / cm ²	50 Kg / cm ²
	Water absorption	9 to 11 %	10 to 14 %	9 to 12 %	8 to 11 %
WALL DETAIL	Wall thickness	22 cm	22 cm	24 cm	24 cm
	Mortar used	1 cement: 5 sand	1 cement: 5 sand	1 cement: 6 soil: 6 sand	No mortar
	Mortar Qty per m ² of wall	72.4 Litres	76 Litres	36.1 Litres	No mortar
	Units per m ² of wall	98 (with 1.5 cm mortar)	106 (with 1.5 cm mortar)	40 (with 1 cm mortar)	No bricks
	Daily output per team	3.3 m ² = 320 bricks	4.6 m ² = 490 bricks	3.8 m ² = 150 blocks	8 m ²
COST (Rs.)	Unit (Brick) on site	6.00 Rs./unit	2.80 Rs./unit	9.12 Rs./unit	No bricks
	Raw material per m³ *	3,716 per m³	2,036 per m³	1,847 per m³	1,897 Per m³
	Mortar per m³	2,583 per m³	2,583 per m³	1,404 per m³	No mortar
	Finished wall per m³	4,893 per m³	3,266 per m³	2,763 per m³	2,106 Per m³
	Finished wall per m²	1,076 per m²	719 per m²	663 per m²	505 Per m²
DATA	Sieved sand	525 per m ³	Mason : 300 per day	Labour male : 200 per day	
	Sieved soil	250 per m ³	Helper : 200 per day	Labour female : 130 per day	
	Cement (43 grades)	280 (50 Kg bag)			
NOTES	All costs are in Indian Rupees			Value: Auroville, April 2009, 1 US \$ = ~ 50 Rs.	
	* The cost of raw material include the wastage		Wire cut bricks are also called kiln-fired or chamber bricks		
	All material costs includes the delivery on site		Country fired bricks are also called village bricks		
	Block laying team = 1 mason, 1 helper, 1/2 labour male, 1/2 labour female		The CSEB price is the production cost on site		
	The labour cost includes the yearly bonus and the employee providence fund		Team for producing CSEB = 9 labour male		
SUMMARY	ENVIRONMENTAL COST	MONETARY COST		STRENGTH	
	CSEB and rammed earth are more eco-friendly than fired bricks	CSEB and rammed earth always cost less than fired bricks		CSEB and rammed earth are:	
	Pollution emission: 2 times less than wire cut bricks 4 times less than country fired bricks	A finished m³ of CSEB wall is: 15.4 % cheaper than country fired bricks 43.5 % cheaper than wire cut bricks		1.4 times stronger than country fired bricks	
	Energy consumption: 2 times less than wire cut bricks 4 times less than country fired bricks	A finished m³ of rammed earth wall is: 23.8% cheaper than CSEB wall 35.5 % cheaper than country fired bricks 57.0 % cheaper than wire cut bricks		0.5 times weaker than wire cut bricks	

TOWARDS THE FUTURE

Building with earth has a great past, but also a promising future, especially in Auroville. It is definitely an appropriate, cost and energy-efficient, and eco-friendly technology which can promote a sustainable future. Obviously, one has to master the material techniques so as to obtain the optimum possibilities for a harmonious, durable, agreeable and efficient architecture. One can note these advantages of earth as a building material:

- The earth is a local material, contributing to sustainable development.
- The production of the building components demands a lot of semi-skilled manpower.
- The technology is easily adaptable and transferable.
- The monetary and environmental costs are much lower than that of most other materials.
- The thermal comfort and quality of space are in general better than conventional materials.

One has also to master the disadvantages of the material which, normally, are variations in the soil quality, and hence the block quality and the production of blocks on site. These reductive aspects can be underlined:

- Mechanical qualities are less regular.
- Sensible building details are required.
- The constraints of organizing and managing the production of one's own building material on site.

Despite the possibilities and advantages offered by stabilised earth materials, building with earth in Auroville is still not the common practice. Either people don't want to acknowledge the advantage of this material or they don't want to get the burden to organise the block production on their site and manage everything themselves.

The generalised use in Auroville of compressed stabilised earth blocks and other earth techniques needs a centralised production of blocks and a coordinated management of resources – physical and human. This development step would insure a controlled and more regular quality of raw materials and finished products. This is one of the aims for the next years to come.

The Challenge in front of us:

How to realize architecture full of light, suppleness, simplicity, imagination and beauty with a heavy and formless mud? This is what we are trying to achieve in Auroville and what we are proposing to the World.

"Auroville, the city the earth needs" ... and the earth the city needs ...