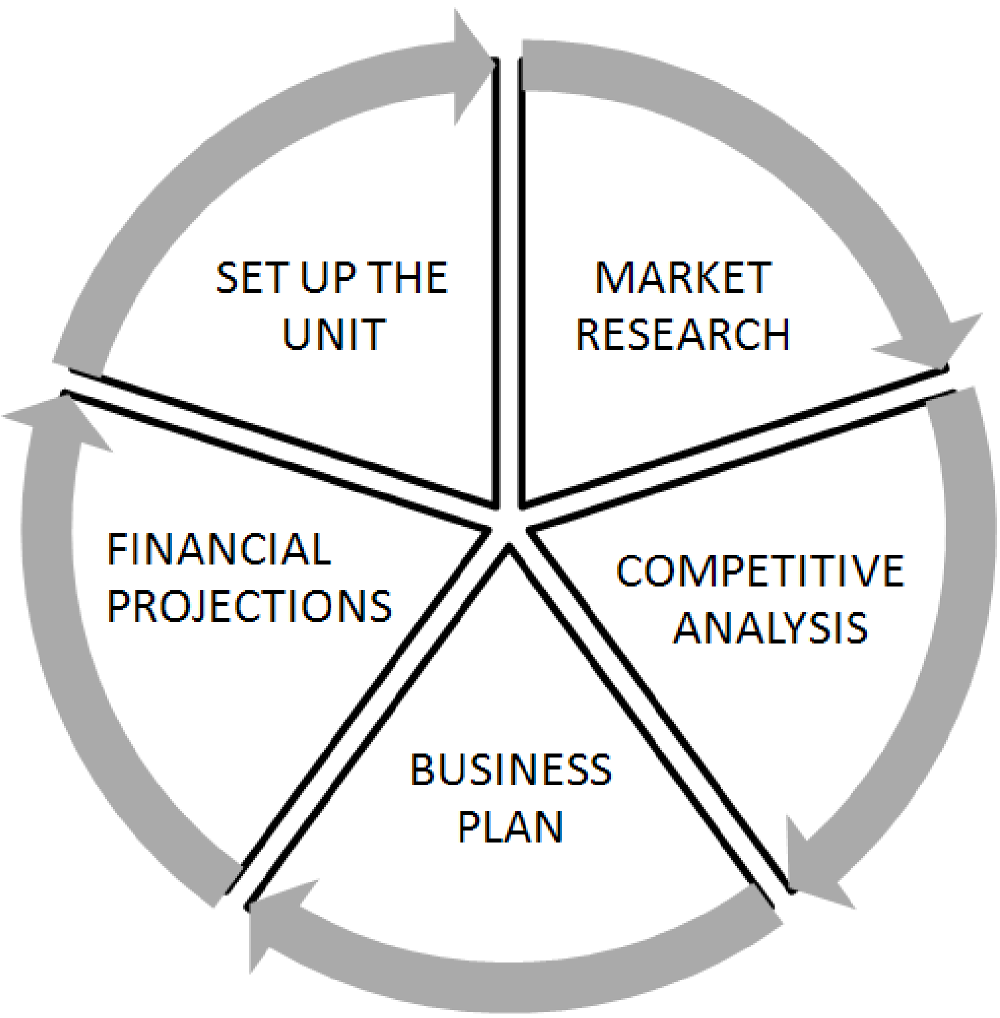
Auroville Earth Institute
UNESCO CHAIR EARTHEN ARCHITECTURE

Economic Feasibility to Set up a CSEB Unit

AN INTRODUCTION



AN AUROVILLE EARTH INSTITUTE PUBLICATION

ECONOMIC FEASIBILITY TO SET UP A CSEB UNIT— AN INTRODUCTION
PUBLISHED BY AUROVILLE EARTH INSTITUTE

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FIRST EDITION | 2001
SECOND EDITION | 2011

REF: I 11
PAGES: 37

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GRAPHIC DESIGNER: Amandine Haviez
COVER TEMPLATE: Amandine Haviez
PRINTING: Auroville Earth Institute, Auroville, Tamil Nadu, India

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Foreword

CSEB (Compressed Stabilized Earth Blocks) or E'Blocks can be produced anywhere in the world where soil and labour are available.

But before starting a CSEB production unit, an economic feasibility study is required to answer some questions.
What is the investment I need? Would it be a cost-effective solution? How much will one block cost? Could I open a business by selling CSEB?

The following document aims to overview the situation and gives all the clues to start a successful business. It is divided into four parts:
1. Before starting the unit
2. Strategy for implementation
3. Feasibility study with the Economics tool
4. Viability of the project

This publication focuses for two types of units:
1. The blocks are for a single project, requiring a minimum of 100,000 blocks.
2. The blocks will be sold to multiple clients

In the first case, the unit would be implemented on the site itself. You are not concerned by marketing your product and creating a portfolio of potential clients: you can skip the second part of the publication, which is of relevance only for people who wish to open a unit for multiple clients.

Introduction

Building with earth, like any other technique, will use a natural resource. This resource should be used with a lot of care and respect for nature and the environment.

Today, our world sees an increasing degree of pollution and an abuse of resources, especially petrol-based fuel and wood for building or firewood. Any technology, which is being developed, should take these crucial issues into account. Therefore any earth-based technology, like CSEB, should first of all aim for sustainable development and affordability for a majority of people.

The first two steps in assessing whether CSEB production is feasible involve technical and ecological considerations. First, is the soil technically suitable? This question can be answered through simple soil analyses. The Auroville Earth Institute (AVEI) is providing services for these tests.

Secondly, how can the earth be quarried without causing permanent ecological damage? Answering this question involves determining how the excavation should be organised and managed and how the hole can be used later on for local development. For this, you can refer to the AVEI publication *Earthen Architecture for a sustainable habitat* (Ref. I. 12).
Once the proper choices are made to ensure sustainable and ecological development, it should be possible to produce a quality product at a low and competitive cost.

For supplementary information, we invite you to visit our website: http://www.earth-auroville.com

I. Before starting the unit

The following studies can be applied in any country where soil and labour are available, to produce blocks with the Auram press 3000.

Proceeding step by step with the publication, you will collect the appropriate data and define your project goals. You will then get a feasibility study, including the cost per block and a five years prediction. The last would be especially useful to create a business plan if planning to open a business by selling CSEB's to multiple clients.

I.1 AVAILABILITY OF MATERIALS

First of all, what is the availability of soil? How far would it be from the potential unit? How will the quarry be used afterward?

The soil quarries are selected according to:
- The soil suitability defined in the mapping phase
- The proximity of the quarry to the possible production site
- The quantity which can be excavated from the site
- The options for rehabilitation of the quarry.

It is advisable to explore the needs of an area, which might need excavations for certain developments.

To get an idea of volume of soil, you would need about 700 m^3 of sub-soil in order to produce 100,000 blocks 240-4/4-9 (24 x 24 x 9 cm).
Please refer to Annex 4 for the different types of blocks.

Do you plan to have multiple quarries? If yes, would you need a moveable unit? How many years do you plan to use each quarry?
Supposing that you want to produce 100,000 blocks. Only for extracting the soil, the unit shall need resource in the form of a leasable/useable land of :
- 700 m^2 if digging 1 meter deep
- 230 m^2 if digging 3 meters deep

What is the availability of other materials? Depending on the quality and type of soil, you may need gravel, sand, cement, and / or lime. We recommend the use of local materials, which are usually cheaper and will economically benefit the area.

I.2 INFRASTRUCTURE AND LOGISTICS [1]

In order to set up properly your unit, you would need the following infrastructures:
- A storeroom to keep the cement and tools in a safe and dry place
- A shelter for the workers, to protect them from the sun / rain.
- A production platform (with levelled ground).
- A connection to water supply (borewell or public network)

If you don't have done any infrastructure yet, you can ask for a quote. For an on-site production with one press only, a simple storeroom (15 m^2) and a simple shed (75m^2) are enough. They could be re-used at the end of the project by the owner, for another purpose. For a blockyard or research centre, you need an office (10 m^2), a storeroom (20 m^2) and a production shed (75 m^2).

FOR MORE DETAILS SEE THE ANNEX 3 BLOCKYARD ORGANIZATION.

The Auram equipment can provide the shed. If the production unit is already set up, you have to gather all the bills related to the work produced on your site: materials bought for construction (shelters, storerooms, etc.), rented machines (lorries, GCB, etc.), and calculate its cost.

I.3 AVAILABILITY OF LAND

Would it be a free land, rented or purchased land?

Even if the quarry is separated from the blockyard, you would need some space for stacking the blocks. CSEB must be cured during one month and then dry during one more month. For making the blocks with two machines and then stacking them, you would need around 1,200 m^2 of land, if the blockyard produces on a daily basis.

I.4 PRODUCTION EQUIPMENT

How many machines do you plan to buy? Which types of moulds do you intend to use? This choice will change if you are in earthquake prone area for example.

FOR MORE DETAILS SEE THE ANNEX 4: BLOCKS DATA.

All the peripherical tools that you need for one machine Auram Press 3000 are given in the Annex 1: Production equipment.

I.5 MIX SPECIFICATION

You should know beforehand regarding the type of soil:
- which stabilizer to use
- which percentage of stabilizer
- the percentage of each aggregate (soil, sand or gravel)
- the cost of each material

For this, a sample of your soil has to be analyzed by an expert who could tell you how to improve it.
The ideal mix of aggregates for cement stabilization shall contain approximately 15% of gravel, 50% of sand, 15% of silt and 20% of clay.

1 *For more information, you can refer to the AVEI publication I. 01 blockyard organization.*

The ideal mix of aggregates for lime stabilization shall contain approximately 15% of gravel, 30% of sand, 20% of silt and 35% of clay. [1]

I.6 HUMAN RESOURCES

♦ Groundwork

Groundwork shall involve:
- Study of labour availability and seasonal changes over the year
- Current employment and occupations of villagers
- Number of interested parties/ trainees.
- Seasonal employment rates of workers.
- Factors affecting labour (other industries)
- Conditions for block production in villages

You will then get the average daily wage for a worker, and for a supervisor.
One week of training is required to set up an efficient team, so we strongly advise the selected people to be permanently employed (long term contract), or at least half of them. To ensure a good quality product, everyone should know how to adjust the machine, prepare properly the mix, stack the blocks, etc.

♦ The workers

The requirements for a good worker are:
- Physically in good condition
- Able to work in team
- Comprehension of the project
- Believe that CSEB is a good product when properly produced
- Willing to learn and improve his condition
- Dedication to sustainable practices a plus

More details are given while filling the tool, such as the number of workers for each task, etc. [2]

♦ The supervisor

The supervisor should be rigorous with team management skills, be able to work on site, and check the quality at every moment of the production.

♦ Training

This team would be trained before starting the production: 7 workers per machine, plus the supervisor. Will you be sending the trainees to other institutions for training of will you bring trainers? This cost will be included in the set up of the unit. For that, you can ask for a quote to the Auroville Earth Institute.

I.7 PRODUCTION DETAILS

What type of blocks do you plan to produce? Please refer to Annex 4 for all types of blocks, their references, their function and technical details such as volume, daily productivity, etc.

The most used types of blocks for solid load bearing masonry are the Block 240 "240-4/4-9" (full size, 9 cm thick = 24 x 24 x 9 cm), and then Block 240 half size "240-1/2-9" (24 x 11.5 x 9 cm), which usually comprises 20% of the full blocks for a building.

If you are planning to make simple vaults and domes, you will need to produce blocks mini-5 (14 x 7 x 5 cm) and Blocks 190-5 (19 x 9 x 5 cm). If you plan to build more complex vaults and domes, you might need more variety of blocks.

1 *For more information, refer to the AVEI publication Intro 10 - Soil identification.*
2 *For more information, you can also refer to the AVEI publication Intro 01 - Blockyard organization.*

II. Strategy for implementation

You may have already a project to build and you are then only concerned about the final cost of the block, But during this consideration, it is important also to compare the quality, strength, eco-friendliness, comfort (regulation of humidity and heat through the wall). In that case, you can go directly to the section III. Feasibility study - The Economics tool.

However, if you are interested in a business with multiple clients, you are probably looking for stakeholders. This section attempts to give all the clues to get a proper business plan, to convince banks for example, through a SWOT analysis. The next section will also help you by a complete prediction over five years of your business, with the Economics tool.

II.1 MARKET RESEARCH - DEMAND SIDE

If you are planning to start a business, some preliminary studies are required. What is your strategy for implementation? What is the demand for building materials? What is the demand in the cities and / or villages for particular clients? Are there commercial projects, housing, public spaces, related to contractors, builders and architects? What is the estimate of public investments in housing and infrastructure?

You may need to invest in branding, packaging, or other marketing activities. Market research will have a cost that you would need to add separately, as the economic tool is not taking it into account. The Auroville Earth Institute can send you advertisements, posters, banners, publications to help you.

Note that the evolution of the market will depend on the acceptance of the building material by the market, but also the growth of business over the first year over the established units.

We recommend selling the blocks not further than 50 km, in order to reduce cost transportation but also CO2 emissions. Note that in the tool, the cost transportation to deliver the blocks is not taken into account into the cost of the blocks and the client has to pay separately for it.

II.2 WHY CSEB

You first need to make contact with architects, contractors and builders in your area, and sell your product. You may get a long term contract with some of them. You will then create a portfolio of potential clients and stakeholders.

♦ A local material limiting deforestation

Ideally the production is made on the site or nearby areas, thus reducing transportation costs. Unlike the production of fired bricks, firewood is not required to produce CSEB. Hence, building with CSEB can prevent the depletion of forests.

♦ A job creation opportunity

This technology allows otherwise unskilled and unemployed people to learn a new skill, gaining both employment and social values.

♦ Local management of resources

Top soil has to be scraped away, to uncover the subsoil. Later on, the top soil can be put back into the resulting cavity and the land can be used for agricultural purposes.

If planned in advance, quarries resulting from sourcing soil on site can be converted into rainwater harvesting tanks, wastewater treatment systems, reservoirs, basement floors or landscaping features. This can be beneficial for the development of the site, but disastrous if unplanned.

♦ Market opportunity

According to the local costs (stabilizer, soil, sand, labour, equipments, etc.) the final price will vary, but CSEB are usually cheaper than fired bricks or sand cement blocks.

♦ Energy efficiency

Requiring only a little stabilizer (thus little fuel for it) the embodied energy for one cubic meter ($1m^3$) of CSEB is about four times less than one cubic meter of country fired bricks.

♦ Dimensional uniformity and flexibility

CSEB have consistent dimensions and they are available in several sizes and types. The Auram press 3000 can produce blocks with half millimeter precision.

♦ Thermal comfort

Exposed E'Block walls regulate indoor humidity, helping you achieve thermal comfort through the year. With proper planning and design, less energy is needed to achieve a comfortable indoor environment. Earth buildings have proven over the decades to be healthier than concrete buildings.

♦ Strength of load bearing structures

CSEB can be used for load bearing structure, as they are strong enough to bear four floors without concrete columns. Arches, vaults and domes can replace concrete beams and slabs, thus bringing the overall cost lower than with conventional structures. Furthernore, CSEB don't necessarily need to be plastered.

♦ Reducing imports

As it can be produced locally by semi-skilled labour, there is no need to import expensive materials or transport over long distances heavy and costly building materials.

♦ Carbon credits revenue

The company might gain from the sale of carbon credits and use the revenue as a financial stimulus to make it economically viable to promote/facilitate block production and alleviate the economic, social and technological barriers. The validation of the production process makes it possible for future block producers to be represented by one brand organized under one company and collectively gain from the sale of Carbon Credits. Note: for more information, see http://cdm.unfccc.int/ website.

♦ Social acceptance

CSEB has long demonstrated its ability to adapt to various needs: from low income to high income, government buildings, multi-storey and disaster resistant housing. Its quality and regularity allow a wide range of final products. To help facilitate its acceptance, banish from your language "stabilized mud blocks" when speaking of CSEB. Mud blocks refer in the mind of most people as inferior building material. CSEB has benefited from more than half century of research and development.

♦ Creative design and aesthetically pleasing

Blocks are readily available in different sizes and types, and they have consistent dimensions. Furthermore, you can build arches, vaults and domes which help save costs. You can also use them in flooring, composite beams and columns. CSEB achieve natural, exposed, high quality finishes and create convivial living spaces with the natural colours of the earth.

II.3 SWOT Analysis

You need a SWOT analysis (Strengths – Weaknesses – Opportunities – Threats) to get a better overview of the possible failures of the projects and its potential, but also because it may be required by your bank for a loan.

The aim of any SWOT analysis is to identify the key internal and external factors that are important to achieve the objective. These come from within the company's unique value chain. SWOT analysis groups key pieces of information into two main categories:
- Internal factors – The strengths and weaknesses internal to the organization.
- External factors – The opportunities and threats presented by the external environment to the organization.

You will find here examples that can help you to draft your business plan.

♦ Strengths

The strengths were given in the previous section II.2.

♦ Weaknesses

However, due to hurdles in social acceptance of earth as a modern material, it can be difficult to enter the mainstream market. But there is a common perception from the market about earthen materials as being a sub-standard material.

The attempts to produce CSEB could fail because of the following reasons.

First is a lack of standardization and quality control of block production, if the workers are not sensitive enough to the quality of their work. Quality control has to be done regularly and at every stage by the supervisor.

The difficulty of finding workers in adequate physical condition is the second weakness: nowadays it becomes difficult to find people working so hard eight hours per day. For that, manual presses are still a good ratio quantity / cost but in few years we will go for a mechanised process, with hydraulic machines, automatic mixer, and a crusher.

The third weakness would be the production lag: blocks need to be cured one month and then dry during one month for walls and 3 months for arches, vaults and domes. A stock is needed in order to answer quickly to the demand.

♦ Opportunities

The first opportunity is the context: the business unit broadly operates in construction and environmental markets. The Indian construction industry is growing at the rate of 10% per year, since 2008.

The manufacture of energy intensive building materials like fired bricks and cement to cater for this development proves to be non sustainable in the long run.

The second opportunity is a growing awareness of the consequences of such non-sustainable growth and hence the demand for a 'clean' development which necessitates the promotion of an alternative mainstream building material which is cost effective and less energy intensive.

Building materials made from earth prove to be cheap and less energy intensive at all levels of production as the basic raw material is readily available and labor involved is manual. CSEB will have tremendous potential of hitting the market as a sustainable, cost effective alternative with performance characteristics similar to conventional building materials.

♦ Threats

Systematic Risks

The first risk is the current market fluctuations for materials such as cement and sand: the cost can increase quickly. The second systematic risk is the seasonal changes in labour availability and rates. In India salaries have to be increased by 10% at least per year in order to keep the workers.

Another threat is the preconceived ideas of CSEB as a substandard building material: people still have in mind that earth architecture is not as good as concrete building. But building a demo house and awareness campaigns will help to change minds.

Economical and political risks

Control on earth mining is based on local governments and legislation that are bound to vary. National codes need to be set in place to govern soil mining and environmental impact assessment. For example, in Tamil Nadu and Pondicherry[1] it is officially forbidden to transport red soil, even for a distance of few kilometers. However, a manufactured product containing soil, such as CSEB, can be transported without problem.

1 *South India*

III. Feasibility study The Economics tool

III.1 INTRODUCTION TO FEASIBILITY STUDY

Once you have got estimation of the demand in the market and got some financial data (cost of labour, land, etc.), let's start with the Economics tool.

The principal costs to be incurred in the setup of a production unit involve:
- the machines and other production equipment
- the land and shelter
- the training
- the production cost for the first month of production

The costs of the block are basically divided into:
- The fixed costs
- The variable costs

The fixed costs are costs that you will have to pay even without producing such as loan refund, offices expenses, subscriptions, etc.
The variable costs are only linked to production. These are the costs of materials, labour, energy, etc. that you will have to pay only if you produce.

Note that the file "Economics new" is only a design tool in order to predict which amount can be earned by your unit of production. **The numbers entered must be as close to the reality as possible for it to be reliable.**

Open the file "Economics new" with Excel software and follow our recommendations step by step.

The first section, called "Currency", allows you to choose the currency that you want to use in this simulation. Select your country and the default currency appears in the right side. If it is not the currency you need, tick the "Other currency" checkbox and choose the right one in the appearing drop down list.
This currency will be used in the whole file, and the values that you enter will have to be corresponding.
Warning: the values entered by default are for India (Rs currency) and will not be erased!

III.2 SET UP OF THE UNIT OF PRODUCTION

SECTION 2 OF THE TOOL
The setup of the unit of production is composed of two sections:
- The blockyard setup contains all the infrastructures (buildings, ground works, borewell, etc.)
- The equipment on site contains all the machines, wheelbarrows, tools, etc.

♦ Blockyard infrastructure

Details have already been given in the section I.2.
You have different options available for the land (free, rented or purchased) and for the water connection. The cells to fill in each case are filled in grey and the calculations are automatically completed for each option.
Enter the lifetime of your infrastructure. This number depends on the type of infrastructure that you have built: temporary installation will have a lifetime of maximum 2 years; solid installations can last for

more than 10 years. To take the depreciation into account allows you to save the money needed to renew your infrastructure.

♦ Production equipment

In this section, you can enter how many presses you own and the price for one of them. The price should comprise the frame and the different moulds purchased. To get the last update prices, you can write to the Aureka workshop at aureka@auroville.org.in.

Transportation of the machine from the producer to your unit of production can be entered separately, or if it is comprised within the machine cost, transportation value should be 0.
A default cost is given in Rs. for the Auram 3000 and several moulds in Auroville in January 2011. If your machine is different, you should tick the "Custom Value" checkbox and enter your value in the resulting grey cell.

The lifetime of the machine is the number of years during which the machine will serve properly. After that, you will have to buy a new machine. This depreciation of the machine should then be taken into account for you to be able to buy a new one when needed.

A new Auram press 3000 will do about 1 million strokes (1 million of blocks 240-4/4-9) over a period of ± 5 years, with proper maintenance.
You will also be able to sell the machine when not usable anymore. A certain percentage of the machine price will then be saved. To calculate this percentage, divide the amount obtained from the re-sale of the machine by the machine cost.

The default cost of the tools is given per machine. If you buy two machines, multiply by two the wheelbarrows, sieves, hand tools costs.

III.3 MIX AND MATERIALS

Section 3 of the tool
This section allows you to manage the quantity and the cost of the materials needed for each mix (soil + sand + stabilizer).
It is divided in six sub-sections:
- Mix Proportions, in which the mix of aggregates (soil, sand or gravel) and stabilizers (cement or lime) is defined.
- And one sub-section for each material (soil, sand, gravel, cement and lime) in which the parameters of this material (cost, density, etc.) are defined.

♦ Mix Proportions

In this sub-section, you have to compose your mix.

In the **Stabilizer parameters** frame, first choose your stabilizer and its percentage in the mix. Enter the weight (in kg) and density (in kg/L) of the bags of cement available to you. If you don't know the density of your stabilizer, an easy test is to fill 1 litre container, fill it with soil, dry the soil under the sun or on a pan and measure its dry weight: the dry density is the weight of 1 litre of dry soil.

The quantity of aggregates to add to the mix is calculated from the quantity of stabilizer entered in the mix. So you have to indicate with which quantity of stabilizer (fraction of bag), you want to start the mix with. One mix shall not be more than 250L because it should be compressed before the stabilizer starts to react. Therefore, you may have to adjust this value to get a total mix volume that is less than 250L. However, if there is no stabilizer, the theoretical weight of aggregates is taken by default as 300Kg and the mix doesn't have a volume limit.

In the **Equipment parameters** frame, enter the capacity of your wheelbarrow and buckets. The mix has to be made with round numbers of wheelbarrows and buckets of aggregates. The file will calculate how many of them you have to put for the mix to be as close as possible to the theoretical one.

In the **Aggregates** frame, enter the percentage of soil, sand and gravel in the aggregates and their density.
Warning: the stabilizer is not taken into account here. The percentage of each component is considered in the Aggregates, i.e. Soil + Sand + Cement.

The **Proportion Calculator** frame will now calculate the number of wheelbarrows and buckets of each component to add in the mix when starting with the defined quantity of stabilizer.

For example, a mix is made with 5% cement and aggregates composed with 85% of soil and 15% of sand. The densities are respectively 1.3kg/L for cement, 1.35kg/L for soil and 1.45kg/L for sand. If the mix is started with 1/3 of bag of cement, you will then have to add 1 wheelbarrow of soil (200L) and 2 buckets of sand (2x15L).

The percentages by weight of all the components in the mix (soil, sand, gravel, cement or lime) are also calculated. You should check that all the obtained values are acceptable. A warning in red will appear if the final percentage of stabilizer in the mix is too far from the theoretical one. You will then have to adjust the different parameters (quantity of stabilizer to start with, capacities of the wheelbarrows or buckets) to find the right percentage.

♦ First Material: Soil

This section allows you to define more precisely the type of soil, compression ratio of the block and the prices.

The density and volume of soil added to the mix have already been defined in the "Mix Proportions" section. They are referenced here for better clarity. If you want to change these parameters, you have to go back to the previous section.

Enter the **compression ratio** of the wanted block. This compression ratio is related to the type of soil. If you don't know the compression ratio you are using, please analyze your soil and refer to the diagram.

If you have any doubt about the compression ratio, you should ask an expert to give you the needed value after checking your soil. The compression ratio will be between 1.35 and 1.8. The higher the compression ratio, the stronger the blocks will be, but also the more materials you will have to add.

You can then enter or calculate the **cost of your soil** by taking into account sourcing, transportation and sieving.
To enter the price directly, choose the "Custom Value" option and fill the resulting grey cell.

To calculate the cost of the soil, choose the "Calculate Cost" option and follow the procedure:
First enter the cost of sourcing. You have different options: dug by hand, dug by machine, purchased or other. This rate doesn't take into account the costs of transportation or the sieving of the soil.
Be careful to take into account the bulking ratio of the soil: once extracted, the soil expands with a coefficient of 1.4 in average. The quantity of soil excavated is then bigger that the volume of the hole.

The transportation can then be entered. The tool calculates the transport cost based on the rate in Rs./km and the distance from the source to the unit of production. Several options are also available to specify the type of transportation: truck, tractor, no transport or custom.
Note that purchased soil can be delivered already sieved. Otherwise the soil has to be sieved. The sieving has to be taken into account in the labour section by assigning workers for this activity.

♦ Other materials: sand, gravels, other aggregates, cement and lime

These sections are similar to the "Soil" section but without cost calculation.

Density, proportions and volume in the mix are referenced for better clarity. To change these values, go back to the "Mix Proportions" section.

III.4 PRODUCTION DETAILS

This section allows you to manage production from the types of blocks produced to the diverse costs of production (labour, energy, overhead costs, etc.).

Different options will be offer to you, and the cells to fill appear in grey.

♦ Block types and production

In this subsection, you have first to enter which **kind of blocks** you are producing, You can enter maximum four block types but less is also possible.

Then the minimum production rates have to be entered. Default values appear based upon the number of machines you are planning to use. For example, the output of block 240-4/4-9 for one machine is 850 per day, and would be 1700 if you have 2 machines. The numbers given assume eight hours of production per day.

These rates are the optimized number of blocks produced per day with a seven-man team, and to be profitable your production rate should not be less than the values proposed. You can however enter different values by ticking the "Custom Values" checkbox. A table of grey cells will then appear for you to fill. Please refer to the Annex 4 for the production rates we use in Auroville with the Auram Press 3000.

Finally, **the distribution of your production** has to be set (in % of year). For example, if you produce 240-4/4-9 blocks half of the year, you will then enter 50% for this block on the wanted year. You have to fill the distribution for the first five years. This allows you to adjust your production year after year. If you don't know yet what will be your production in the future, enter the same distribution for the 5 years. You should make sure before carrying on that all the status notes are green.

♦ Labour

In this subsection, your working team has to be defined. The workers are organized by activity: sieving, mixing, pressing, initial curing (just after compression when stacking temporarily), final stacking (transport of the blocks between initial curing and final stacking, plus curing), and others tasks like truck loading, cleaning and maintenance of the unit, etc. The number of men or women working for this activity is entered in the column "No. Workers"; the wages associated with this activity are in the column "Wage (Rs./Day)"; and finally the number of days worked for this activity is entered in the column "No. Days/ Year".

The number of days for Mixing, Pressing and Initial Curing should be identical because this part of the production happens simultaneously. Sieving and others tasks can be different.

If you are in India, default values are given (number of workers, wages and number of days worked per year). The optimal allocation of a team of 13 workers would be:
- 3 for sieving (2 men for soil and 1 woman for sand),
- 7 for the production: 3 men for mixing, 2 men for pressing, 1 for filling the machine, 1 man for initial curing
- 2 men for stacking.

We consider that the woman sieving the sand is help-

ing to cure the blocks twice a day with the team for final stacking.
For more details, refer to the Annex 2: Manpower.
The wages associated with each worker are given in Rs. However, you still have the possibility to enter your own value by ticking the "Custom Value" checkbox. The same table will appear next to the previous one highlighted in grey.

Note:
If some of your workers do different activities on the same day, then they should be entered only once in one of these activities.

For example, with a three-man team, the mixing can be made just before pressing and initial curing by the same team. You can then assign 2 workers for Pressing, 1 into Initial Curing and 0 into Mixing for example.
- If the wages of your workers in the same activities are different, you can enter an average wage.

For example, you employ three men for sieving, two of which earn 200Rs./Day and one of which earns 250Rs./Day. You will then calculate an average wage of (200 x 2+250)/3=217Rs./Day that you can enter for sieving.

The annual production, for the Auroville context, is considered as 286 days: a monthly production of 26 days over a period of 11 months. Every year, one month is deducted for the heaviest rains and for the maintenance of the equipment.

The training fees paid to train your workers or supervisors before starting the production have to be entered after the table for the definition of the team. This amount will be taken into account in the fixed costs that you have to spend per year.

♦ Equipment depreciation

Based upon the lifetime or life cycle of the machine(s) and tools, you get the equipment depreciation, which is included in the fixed cost. For instance, after 1,000,000 strokes the machine has to be replaced and you need to have reserved this amount in order to buy a new one.

♦ Energy consumption

This section allows you to manage and calculate the energy costs of the unit of production (Electricity, Fuel or others).
The Electricity sub-section gathers all the information about electrical equipments such as pumps, electrical engines, lights, etc.

You have the choice between 3 options:
- No electricity: if your production is fully manual and you don't have a borewell. By ticking this option, you won't have to fill anything in the Electricity subsection.
- On the Electrical Grid: if the electrical equipment is powered by the public network. Please see below to get the details of this option.
- Generator: if the electrical equipment is not linked to the public network, but powered by a generator. Please see below to get the details of this option.

♦ Electrical Grid

Fill in the grey cells the values of the energy subscription per year and the cost of electricity for 1kWh. You can calculate these values from the electricity bills that you receive from the public network.

Select the equipment you have on site in the first column of the table "Equipment". If it is not in the list, enter it in the row "Others" or add it in the "Data" sheet.
Then specify the number of equipments of this type,

their power requirements and how many hours a day they run. Recommended values for power are given next to the table to help you. The program calculates automatically the consumption per year linked to this equipment.

The electricity consumption linked to human activities (ex: lights for watchman at night, fridge, computers, radios, TV, etc.) has to be entered after the equipment table. A default value is proposed and calculated as shown in the Data sheet.
If you want to enter your own value, tick the "Custom Value" checkbox.

♦ Generator

Enter the purchase cost of your generator. Then give the characteristics provided in the generator user manual: the power in kVA and the load with which you use your generator. These cells are drop-down lists in which you can set prefixed values. If your characteristics are not in the list then choose the superior value. Fill also the number of hours per day during which you use the generator and the price of the fuel you use.

The yield is the ratio between output energy and input energy. Therefore to know the energy consumption of the generator, we need to divide the Output (Power x No. Hours) by the Yield.

The amount of fuel consumed per hour depends of the type of generator, its size and the load with which it is used. Values for fuel consumption have been taken from the "Diesel, Service and supply Inc." (http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx). If the values for your generator are different from the one proposed, then choose power and load in order to customize the fuel consumption.

The energy consumption and its cost per year are summed up in the green frame on the right side.
The Fuel Consumption sub-section records the different sources of fuel that you use for production.

You can enter in the first table the average quantity consumed for each kind of fuel and the prices associated. If the fuel you use is not in the list, input the values in the row "Others".

♦ Water consumption

This section calculates the quantity of water used each year for human consumption and the quantity needed per mix (in average).

Default values are given but can be changed by ticking the "Custom values" checkbox. The quantity of water used for mixing and for curing depends on the water content of the soil and on the ambient humidity, and will be different in summer and in winter. However these values can be averaged for calculations: 10 L/day for human needs, 15L/mix for mixing, and 180L/mix for curing. Note that for curing, it depends on how many piles you have in stock.

The cost of subscription to the public network and the cost per m^3 of water have been defined in the "Blockyard Infrastructure" section. To change these values, please refer to this section.

The file calculates the quantity of water used for human consumption per year, and takes into account the quantity needed for block production into the cost of materials.

♦ Maintenance

Enter the average cost that you pay per month for maintenance of the infrastructure and equipment (blockyard, buildings, machine, equipment, etc.).

To calculate this amount more accurately, take all the bills that you have accumulated from the beginning of the production unit and divide per the number of months taken into account. If you haven't started your unit yet, the default value would be sufficient, as the machine would be new and does not need any repair.

♦ Overhead Costs

The overhead costs correspond to all the different costs not linked to production or infrastructure, such as office costs (books, paper, pens, Internet subscription, etc.), management costs (employees hired for accounts, marketing, etc.). These are fixed costs that you will have to pay even without producing. It is then very important to bring costs down as low as possible; your unit becomes profitable when the fixed costs are compensated.

To find out how much money is spent on overhead costs, keep the bills for all the office expenses and average the number of months taken into account. If you are starting a unit, enter your salary and the salary of account / public relations if needed, etc.

♦ Franchisee

Imagine that after six months your business is working well and you want to open another unit. You can then become a franchisor, linked by a franchisee agreement with the franchisee. In that case, in return for some services, you will get a commission on the sales of the franchisee. But to start a business, unless you would be a franchisee, you are not concerned by this option.

III.5 FINANCES

♦ Capital

This section calculates the capital that you need to start your unit. It is divided in two parts:

- **Capital Investment**: amount of money that you need to invest to create infrastructures, to buy equipment, etc.
- **Working Capital**: amount of money that you need to start and run the production without having any resources from the sales. For CSEB production, the working capital will be the cost of materials, labour, etc. for 1 month of block production. During this month, the blocks are curing and thus cannot be sold.

The Capital Investment is calculated automatically from the values you entered previously. If you want to change them, please go back to the "Setup of the Production Unit" section.

To calculate the Working Capital, you need to enter in the grey cell the period during which you cannot perceive any income from sales.

♦ Loan

To start your unit, you need to have money available to pay the Capital Investment and the Working Capital. You should be able to bring part or whole of the amount. Enter this amount in the "Amount Provided". The program calculates the amount of money that you will need to get from the bank as a loan.

For the rest of the capital that you cannot bring personally, you will need to take a loan. Enter the loan interest rate and the number of years in which you will have to refund your loan. The total amount refunded at the end is calculated automatically.

If the amount of your investment was placed in a bank account, you would have earned some interest. This represents a shortfall which must be included in the cost of the block. Enter the interest rate of the account in which you had the money, the investment cost will be calculated automatically.

III.6 COSTS AND PRICES

This section calculates the costs of production of the blocks and allows you to choose an appropriate price for these blocks.

♦ Production Costs

This sub-section gathers the types of blocks chosen, all the sources of costs, and calculates the final cost of production of each block. Costs are organized by the fixed costs and variable costs (see section III.1).

The costs of the blocks are then calculated by adding the variable costs and the fixed costs and dividing by the number of blocks produced during a certain amount of time.
For example: The production distribution is as followed: 60% of the year 240-4/4-9 (132,600 blocks produced), 40% 240-1/2-9 (145,600 blocks produced). The variable costs are respectively 6.96Rs. and 3.72Rs. The fixed costs per year are up to 287,000Rs. The final cost of the blocks will then be:
- 240-4/4-9: 6.96 + 287,000 x 0.6/132,600 = 8.26Rs.
- 240-1/2-9: 3.72 + 287,000 x 0.4/145,600 = 4.51Rs.

♦ Summary and Prices

This sub-section gives you the summary of the different costs of production and allows you to choose appropriate sale prices. Enter these prices in the grey cell. The margins that you will make on the global production cost are highlighted in green. The margins on variable costs (without the fixed costs taken into account) are also calculated.
You ultimately choose one pricing scheme, taking into account that you should be competitive to other local materials, but that your business should work.

IV. Viability of the project

Once you have filled the tool with all the data, you can analyze the results and adjust the parameters.
The graph below the table in the tool shows the costs distribution in the block price.

IV.1 PREDICTION OVER FIVE YEARS

In this section, you calculate the overall accountancy of your unit over 5 years.

The cash flow is directly the difference between incomes and outcomes; it is what you will have on your bank account at the end of the year.

The outcomes comprise the fixed costs without the infrastructure depreciation (loan refund, subscriptions, etc.), the variable costs linked to the production, and the infrastructure and equipment costs (paid on the first year for both and few years after to buy new equipment and build new infrastructure as defined in the "Setup of the Production Unit" section).
If the lifetime of the equipment (machine, tools, wheelbarrows, sieves) is more than 5 years, the cost to buy new equipment is not included in the first 5 years.

The incomes come from the sales of blocks, the acquisition of loans, and the equity participation or grants, etc.

Only 91% of the blocks produced are considered sold. This takes into account bad blocks, blocks with broken edges, etc that cannot be sold.

However, this cash flow doesn't represent the money your unit has really made. Outstanding amounts of money are not taken into account there. You might still have loans to refund or money owed prior to opening the unit. These outstanding amounts are taken into account in the Net Present Value calculation. This is the Cash Flow minus the amount of loan not refunded yet and minus the equity participation.

IV.2 HOW TO MAKE YOUR BUSINESS FINANCIALLY SUSTAINABLE

The Net Present Value really represents what your unit of production is worth. It is usually negative for 1 or 2 years and then goes positive. If it takes more than 2 years to break even, then you may have to change some parameters such as sale price, etc. to establish a more profitable business. These values are represented as graphs below for you to visualize more easily.

IV.3 PROFITABILITY THRESHOLD

Another interesting graph is the Profitability Threshold of your unit of production. The figures given in the Cash Flow and Net Present Value are the most optimistic and are calculated with the supposition that all of your production will be sold at the end of the year. If you sell less blocks, then the unit will be less profitable. The profitability threshold is calculated as being the intersection between the margin on vari-

able costs (MCV) and the fixed costs. For each block sold, you earn the margin on variable costs calculated beforehand. The sum of all the margins earned at the end of the year (i.e. MVC x No. Blocks Sold) should be enough for you to pay your fixed costs. If the number of blocks sold per year is lower than the threshold, you will lose money; if it is bigger you will earn more money. This threshold is represented as a black dot on the graph.
The Internal Rate of Return (IRR) is an additional indicator of your profitability, especially if someone (investors, business angels) wants to invest in your unit of production. An investment is considered acceptable if its internal rate of return is greater than the addition of risk-free interest rate (an Indian Government bond is a risk-free investment, its current rate is 9.75% in February 2011) and manufacturing brick market risk (around 5%).

IV.4 HOW THE PARAMETERS INFLUENCE THE COST OF CSEB

The values given are taken from the block making in Auroville, Tamil Nadu, India, in 2011. But if you are from another country or if the costs differ greatly in your area, the results would then be quite different.

♦ Production details

Number of presses

In case you are producing with two machines instead of one, the cost per block will decrease by 30%.

If you are producing on site, one press is enough to be viable. Two presses would increase the profit a lot, but on-site production should not be seen as a business for selling blocks. If some blocks are sold, keep in mind that:
- The blocks are produced only for the site building.
- The land cost is not included in the feasibility.
- The site pays for the water.

If you open a unit for selling the blocks to multiple clients, **two presses are needed to be viable**.
Profits will increase by 1.5 times with 3 presses, and 2 times with 4 presses.

For the next studies, data is based upon the production with two pressses.

Daily production

This influences, substantially, the production cost of the block. For example, if the productivity of 240-4/4-9 blocks decreases from 850 to 625 blocks per day (then decreasing by 25%), the variable cost increases by 11%.

Annual production

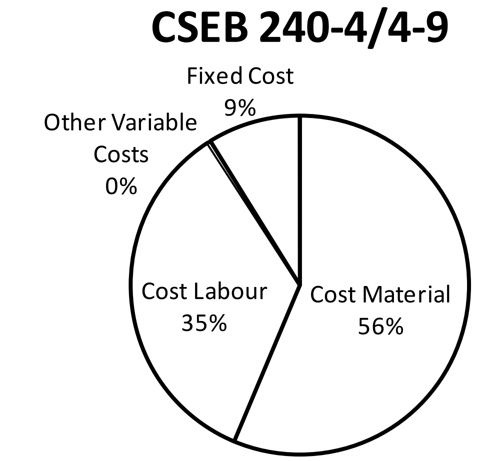
The number of months worked yearly has very little influence on the production cost. For example, instead of working with two machines during 300 days, one machine works 300 days/year and the other only 160 days/year (you then enter an average of working days: (300+160)/2=230 days), it varies only by 2% (the fixed cost will be less distributed).

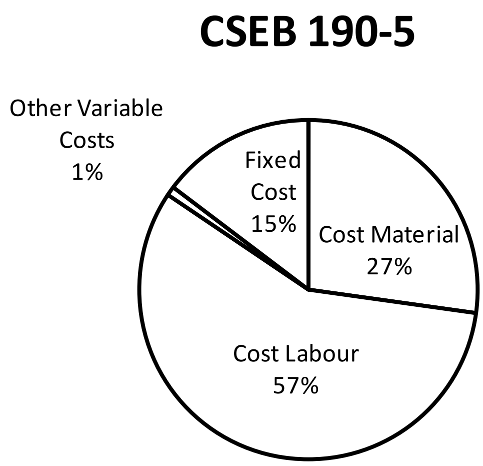
Compression ratio

This influences substantially the production cost of the block. A decrease of 5%, from the maximum given in the sheets, will give a block about 4% cheaper. Note that the compression ratio is given by the soil quality and one should try to compress it to a maximum. Trying to reduce it, in order to decrease the cost, will also reduce the block's quality. The quality decreases more rapidly than the cost: Do not try it!

- ♦ **Labour cost**

The classic distribution for a block is:





The labour cost is increases when the size of the block decreases. So changing the salaries will influence much more blocks such as 190-5 or mini-5.
The labour cost influences substantially the production cost of the block. An increase of 25% will increase the production cost of the block 240-4/4-9 by about 8%, but by 15% for the 190-5.

- ♦ **Material costs**

Costs of Soil and Sand

Contrary to the labour cost, increasing the soil or sand cost will increase the variable cost faster for 240-4/4-9 than for 190-5.
They influence less the production cost of the block: an increase of 25% for soil and sand will increase the production cost of the block 240-4/4-9 by about 4%, but190-5 by less than 3%.

Cost of Cement

This has a high influence on the production cost of the block: an increase of 25% will increase the production cost of the block by 10%.
Of course, this result can vary depending upon your area and the subsequent cost of the stabilizer.

Cost of Water

It has only a very small influence on the profit of the unit, as water is cheap.

Fixed costs

For the block 240-4/4-9, the fixed cost represents 10% while for 190-5 it represents 15% of the total cost.
This distribution mainly depends on how many blocks are produced during the year, and the percentage of blocks produced by type. But again, the fixed costs varies depending upon the the following costs, detailed below.

Investment cost and Maintenance cost

For each case considered, this variable has a small influence on the production cost of the block. Doubling the investment and maintenance costs will increase the production cost of the block by less than 2%. However, the maintenance would increase on the last year of the machine, as more and more repairs would be required.

Depreciation cost

This has very little influence on the production cost of the block for the reason that the equipment costs represent a very small percentage of the block's cost. Doubling the depreciation cost will increase the production cost of the block by less than 1%.

Management costs

This has very little influence on the production cost of the block. Increasing by 25% overhead costs will increase the total cost of the block by one percent..

- **Finances**

Amount provided for loan

It will not effect the cost of the block, but in the profitability.

Profit margin

Its base, for a healthy unit, is determined by the economic feasibility.
The adjustments of the profit margins, presented for the following cases, are done with this single aim:
To find the break-even point of the business and to have enough net cash flow at the end of the exercise so that it can be re-invested again in the same type of enterprise with 100% equity participation.
Other strategies (i.e., less than 100% equity participation) will give different results.
This adjustment does not take into account the market situation and demand. Once the technical and economic feasibilities have been done, a market study will determine the selling price of a block, in order to be competitive with other materials. Therefore, the margin should be adjusted again, along with other parameters, in order to obtain the most efficient and competitive production unit.

Conclusion

You have now all the clues to start a healthy business. Once the market study has been completed and grants have been obtained, you can begin to train your team and set up the block yard.

Note that this tool could also work with automatic machinery. You could have to include a higher price for the investment (at least 4 times the manual presses), plus the increased cost of electricity, diesel, etc. Using automatic machinery would be advisable in cases where labour costs are higher than material costs, or in areas where labour is in short supply.

Annexes

♦ Annex 1: PRODUCTION EQUIPMENT

2 hoes + 2 pans
1 sieve # 10 mm, 1 x 2 m
2 thick tarpaulin 9 x 9 m (Quality : 6 to 7m^2/kg and UV stabilised)
1 wheelbarrow 200 Litres.
1 reaper 1 m long
1 barrel 200 Litres and 1 hose pipe 30 m
4 bucket of 15 Litres
5 buckets of 10 Litres
1 heavy manual press
3 thick plastic sheets (2.75 x 10 m) (Quality = 6 to 8 m^2/kg)
1 flat wheelbarrow, capacity 350 Kg
Jute cloth: 4 strips 4m long 4' wide, per pile of 500 CSEB

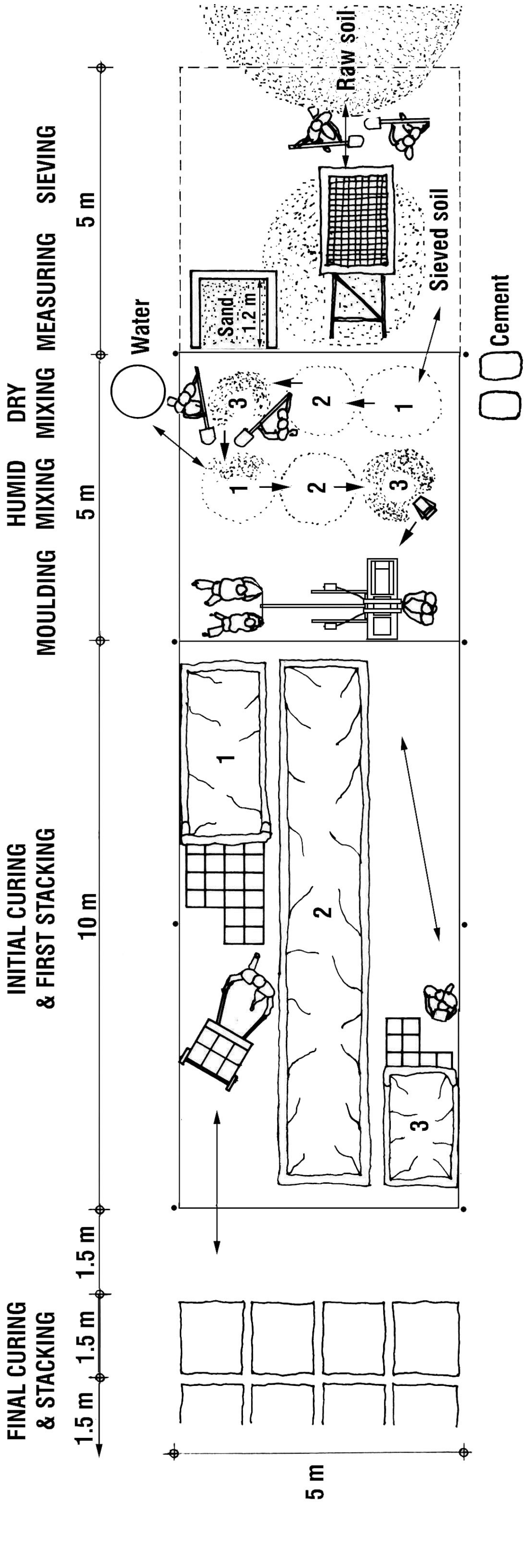
♦ Annex 2: MANPOWER

These workers are required for a production of 1000 plain blocks per day with an Auram Press 3000.

Preparation team	*2 to 4 men*
• Digging and sieving, which is preferably done in the quarry itself	
Machine team	*7 men*
• Measuring, in the sieving area, and transportation to the blockyard	(1 man)
• Mixing dry first and then wet. Done in the blockyard	(2 men)
• Moulding with the press. Done in the blockyard	(3 men)
• Humid curing and stacking, in the blockyard	(1 man)
Stacking team	*1 to 2 men*
• Final cure and stacking: Transportation from blockyard to the site	
TOTAL PRODUCTION TEAM	**10 to 13 men**

♦ Annex 3: BLOCKYARD ORGANISATION

The number of men necessary for digging and sieving will depend upon the quality of soil: a clayey soil will require more manpower, as the soil often needs to be crushed. The labour required for the final cure and stacking will depend upon the distance from the blockyard to the site or the stacking yard.



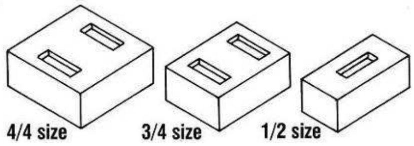
♦ Annex 4: BLOCKS DATA

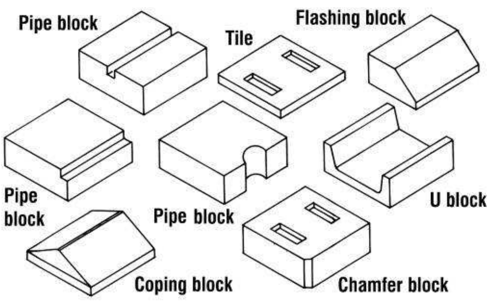
The frame of the Auram press 3000 can presently fit 17 moulds to produce about 75 different types of Compressed Stabilised Earth Blocks. All block heights can be adjusted from 5 to 10 cm.

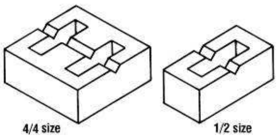
All the following data are for a compression ratio of 1.83 and 5 % cement stabilisation with Auroville soil.

The daily productivity mentioned for the remainder of the annex is with 7 people in the block yard: 3 people for mixing, 1 operator, 2 people on the lever and 1 man stacking for the initial curing.

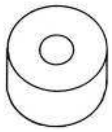
The quantities of materials which are mentioned in the following tables are calculated with 5 % cement for a soil/sand mix which has a ratio of 80% soil and 20 % sand.

BLOCK PLAIN 240		
 This block is used for building plain load-bearing walls, 24 cm in thickness. It can be used up to 4 floors high. possesses the advantages of saving mortar and allowing for fast block laying.	Full block size (L x W x H, in mm) = 240 x 240 x 90	
	Net volume of material = 5.184 Litres	
	Gross volume of block = 5.184 Litres	
	Bearing area = 576 cm²	
	Practical daily productivity for the full size block = 850 Nos.	
	Number of blocks per bag = ~78	
	Quantities of materials per 1000 Blocks	
	Soil:	7.70 (m^3)
	Sand:	1.90 (m^3)
	Cement:	12.82 (bag)

SPECIAL BLOCKS 240		
	Nominal block sizes (L x W x H, in mm) = 240 x 240 x 90	
	Net volume of material = *Varies with the block*	
	Gross volume of block = *Varies with the block*	
	Bearing area = *Not relevant*	
	Daily productivity for the full size block = *Varies with the block*	
	Number of blocks per bag = *Varies with the block*	
	Quantities of materials	
	Soil:	*Varies with the block*
	Sand:	
	Cement:	
These blocks are used in conjunction with the plain block 240 to accommodate particular architectural attributes. These blocks are produced in the mould plain 240. U-shaped blocks are used for precasting the composite lintels and beams, as well as casting plinth and ring beams		

BLOCK HOLLOW 240		
 This block can be used for light load bearing structures up to 2 floors. It presents the advantage of saving materials and providing better heat insulation.	Full block size (L x W x H, in mm) = 240 x 240 x 90	
	Net volume of material = 3.969 Litres	
	Gross volume of block = 5.184 Litres	
	Bearing area = 451 cm²	
	Void = 21.6 %	
	Practical daily productivity for the full size block = 600 Nos.	
	Number of blocks per bag = ~107	
	Quantities of materials per 1000 Blocks	
	Soil:	5.60 (m^3)
	Sand:	1.40 (m^3)
	Cement:	9.34 (bag)

BLOCK ROUND 240

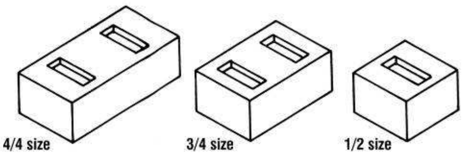


This block is used for building composite columns (Reinforced cement concrete in the middle hole).

It has the advantage of saving reinforced cement concrete.

Block size = Ø 240 - Ø 88 x 90 mm	
Net volume of material = 3.524 Litres	
Gross volume of block = 4.071 Litres	
Bearing area = 391 cm²	
Void = 14 %	
Practical daily productivity for the full size block = 750 Nos.	
Number of blocks per bag = ~119	
Quantities of materials per 1000 Blocks	
Soil:	5.04 (m^3)
Sand:	1.26 (m^3)
Cement:	8.40 (bag)

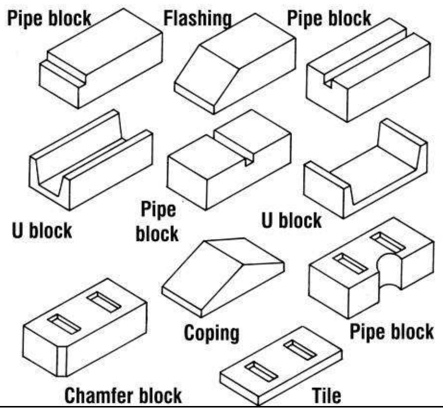
BLOCK PLAIN 290



This block is used as a single block width for light load-bearing structures, or as a double block width for heavy load-bearing structures.
It has the advantage of saving mortar and allowing for fast block laying.

Full block size (L x W x H, in mm) = 290 x 140 x 90	
Net volume of material = 3.654 Litres	
Gross volume of block = 3.654 Litres	
Bearing area = 406 cm²	
Void = *Not relevant*	
Practical daily productivity for the full size block = 850 Nos.	
Number of blocks per bag = ~116	
Quantities of materials per 1000 Blocks	
Soil:	5.17 (m^3)
Sand:	1.29 (m^3)
Cement:	8.62 (bag)

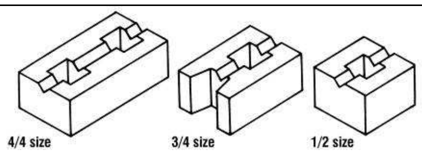
SPECIAL BLOCKS 290



Nominal block sizes (L x W x H, in mm) = 290 x 140 x 90 mm	
Net volume of material = *Varies with the block*	
Gross volume of block = *Varies with the block*	
Bearing area = *Not relevant*	
Void = *Not relevant*	
Daily productivity for the full size block = *Varies with the block*	
Number of blocks per bag = *Varies with the block*	
Quantities of materials	
Soil:	*Varies with the block*
Sand:	
Cement:	

These blocks are used in conjunction with the plain 290 block. These blocks are produced in the mould plain 290.
U shaped blocks are used for precasting the composite lintels and beams, as well as casting plinth and ring beams

BLOCK HOLLOW 290

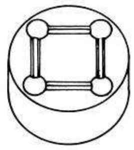


This block can be used for light load-bearing structures up to 2 floors.

It possesses the advantage of saving materials and providing better heat insulation.

Full block size (L x W x H, in mm) = 290 x 140 x 90	
Net volume of material = 2.846 Litres	
Gross volume of block = 3.654 Litres	
Bearing area = 326 cm²	
Void = 19.5 %	
Practical daily productivity for the full size block = 600 Nos.	
Number of blocks per bag = ~156	
Quantities of materials per 1000 Blocks	
Soil:	3.84 (m^3)
Sand:	0.96 (m^3)
Cement:	6.40 (bag)

BLOCK ROUND 290

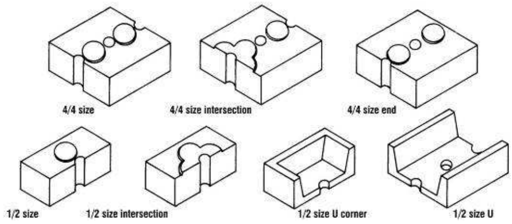


This block is used for building composite columns (Reinforced cement concrete in the 4 holes).

It has the advantage of saving reinforced cement concrete.

Block size = Ø 290 x 90 mm	
Net volume of material = 5.413 Litres	
Gross volume of block = 5.940 Litres	
Bearing area = 660 cm²	
Void = 7.6 %	
Practical daily productivity for the full size block = 750 Nos.	
Number of blocks per bag = ~79	
Quantities of materials per 1000 Blocks	
Soil:	7.60 (m^3)
Sand:	1.90 (m^3)
Cement:	12.66 (bag)

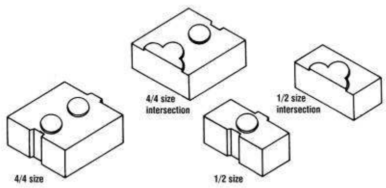
BLOCK HOLLOW INTERLOCKING 245



These blocks are used for building disaster-resistant constructions, as it has provisions for vertical and horizontal reinforcing elements.
They can be used up to 2 floors high in seismic zones 3, 4, and 5 (Indian zones).

Full block size (L x W x H, in mm) = 245 x 245 x 95	
Net volume of material = 5.439 Litres	
Gross volume of block = 5.702 Litres	
Bearing area = 560 cm²	
Void = 8 %	
Practical daily productivity for the full size block = 500 Nos.	
Number of blocks per bag = ~78	
Quantities of materials per 1000 Blocks	
Soil:	7.63 (m^3)
Sand:	1.90 (m^3)
Cement:	12.71 (bag)

BLOCK PLAIN INTERLOCKING 245

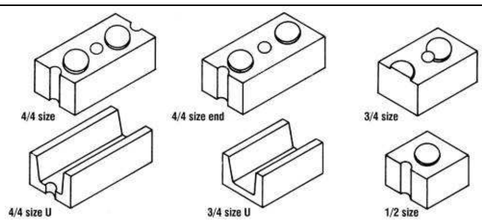


These blocks can be used by semiskilled labour.
They can be used up to 2 floors high.

They cannot be used for building disaster-resistant constructions, as they have no provisions for reinforcing elements.

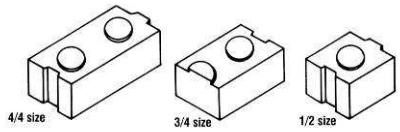
Full block size (L x W x H, in mm) = 245 x 245 x 95	
Net volume of material = 5.702 Litres	
Gross volume of block = 5.702 Litres	
Bearing area = 600 cm²	
Void = *Not relevant*	
Practical daily productivity for the full size block = 500 Nos.	
Number of blocks per bag = ~74	
Quantities of materials per 1000 Blocks	
Soil:	8.06 (m^3)
Sand:	2.00 (m^3)
Cement:	13.43 (bag)

BLOCK HOLLOW INTERLOCKING 295



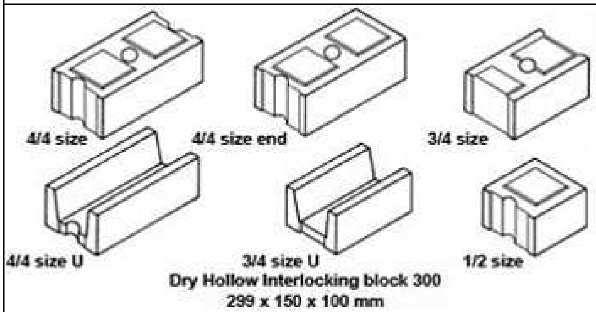
These blocks are used for building disaster-resistant constructions, as they include provisions for vertical and horizontal reinforcing elements.
They can be used only for ground floor structures in seismic zones 3 and 4 (Indian zones).

Full block size (L x W x H, in mm) = 295 x 145 x 95	
Net volume of material = 3.800 Litres	
Gross volume of block = 4.063 Litres	
Bearing area = 384 cm²	
Void = 9.3 %	
Practical daily productivity for the full size block = 500 Nos.	
Number of blocks per bag = ~109	
Quantities of materials per 1000 Blocks	
Soil:	5.48 (m^3)
Sand:	1.37 (m^3)
Cement:	9.14 (bag)

<table>
<tr><th colspan="2">BLOCK PLAIN INTERLOCKING 295</th></tr>
<tr><td rowspan="10">

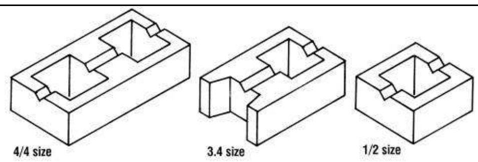
These blocks can be used by semiskilled labour. They can be used for ground floors only.

They cannot be used for building disaster-resistant constructions, as they have no provisions for reinforcing elements.</td><td>Full block size (L x W x H, in mm) = 295 x 145 x 95</td></tr>
<tr><td>Net volume of material = 4.063 Litres</td></tr>
<tr><td>Gross volume of block = 4.063 Litres</td></tr>
<tr><td>Bearing area = 427 cm²</td></tr>
<tr><td>Void = Not relevant</td></tr>
<tr><td>Practical daily productivity for the full size block = 500 Nos.</td></tr>
<tr><td>Number of blocks per bag = ~102</td></tr>
<tr><td>Quantities of materials per 1000 Blocks</td></tr>
<tr><td>Soil: 5.87 (m^3)</td></tr>
<tr><td>Sand: 1.47 (m^3)
Cement: 9.78 (bag)</td></tr>
</table>

<table>
<tr><th colspan="2">BLOCK HOLLOW DRY INTERLOCKING 300</th></tr>
<tr><td rowspan="11">

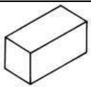
These blocks are used for building disaster-resistant constructions, as they have provisions for vertical and horizontal reinforcing elements. They are dry stacked and a concrete grout is cast in the holes to bind all vertical and horizontal joints.

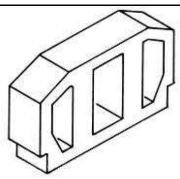
They can be used only for ground floor structures in seismic zones 3 and 4 (Indian zones).</td><td>Full block size (L x W x H, in mm) = 299 x 150 x 100</td></tr>
<tr><td>Net volume of material = 4.009 Litres</td></tr>
<tr><td>Gross volume of block = 4.225 Litres</td></tr>
<tr><td>Bearing area = 390 cm²</td></tr>
<tr><td>Void = 10 %</td></tr>
<tr><td>Practical daily productivity for the full size block = 500 Nos.</td></tr>
<tr><td>Number of blocks per bag = ~109</td></tr>
<tr><td>Quantities of materials per 1000 Blocks</td></tr>
<tr><td>Soil: 5.80 (m^3)</td></tr>
<tr><td>Sand: 1.40 (m^3)</td></tr>
<tr><td>Cement: 9.75 (bag)</td></tr>
</table>

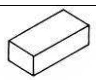
<table>
<tr><th colspan="2">BLOCK HOLLOW 390</th></tr>
<tr><td rowspan="11">

This block can be used for light load-bearing structures up to two floors high.

It possesses the advantage of saving materials and providing better heat insulation.</td><td>Full block size (L x W x H, in mm) = 390 x 190 x 90</td></tr>
<tr><td>Net volume of material = 4.582 Litres</td></tr>
<tr><td>Gross volume of block = 6.669 Litres</td></tr>
<tr><td>Bearing area = 520 cm²</td></tr>
<tr><td>Void = 29.7 %</td></tr>
<tr><td>Practical daily productivity for the full size block = 600 Nos.</td></tr>
<tr><td>Number of blocks per bag = ~95</td></tr>
<tr><td>Quantities of materials per 1000 Blocks</td></tr>
<tr><td>Soil: 6.30 (m^3)</td></tr>
<tr><td>Sand: 1.57 (m^3)</td></tr>
<tr><td>Cement: 10.50 (bag)</td></tr>
</table>

BLOCK PLAIN 190	
 This block is used with the hollow block 390 for the partition walls. It can also be used for very light load-bearing structures composed only of a ground floor.	Full block size (L x W x H, in mm) = 190 x 90 x 90
	Net volume of material = 1.539 Litres
	Gross volume of block = 1.539 Litres
	Bearing area = 171 cm²
	Void = *Not relevant*
	Number of blocks per bag = ~270
	Practical daily productivity for the full size block = 1,400 Nos. (3 blocks per stroke)
	Quantities of materials per 1000 Blocks
	Soil: 2.18 (m^3)
	Sand: 0.54 (m^3)
	Cement: 3.63 (bag)

BLOCK HOURDI 400	
 This block is used to create floors and roofs. It rests either on reinforced concrete T beams or on ferrocement channels.	Block size (L x W x H, in mm) = 400 x 240 x 85
	Net volume of material = 5.266 Litres
	Gross volume of block = 7.708 Litres
	Bearing area = *Not relevant*
	Void = 31.7 %
	Practical daily productivity for the full size block = 400 Nos.
	Number of blocks per bag = ~84
	Quantities of materials per 1000 Blocks
	Soil: 7.14 (m^3)
	Sand: 1.78 (m^3)
	Cement: 11.9 (bag)

MINI BLOCK	
 This block is used to build vaults and domes. It can be used alone when these structures have the same thickness (7 cm) or it can be used in combination with other blocks when the thickness varies (case for optimised vaults and domes).	Block size (L x W x H, in mm) = 140 x 70 x 50
	Net volume of material = 0.490 Litres
	Gross volume of block = 0.490 Litres
	Bearing area = 35 cm² (Block laid on edge)
	Void = *Not relevant*
	Practical daily productivity for the full size block = 1,400 Nos. (4 blocks per stroke)
	Number of blocks per bag = ~820
	Quantities of materials per 1000 Blocks
	Soil: 0.736(m^3)
	Sand: 0.186 (m^3)
	Cement: 1.22 (bag)