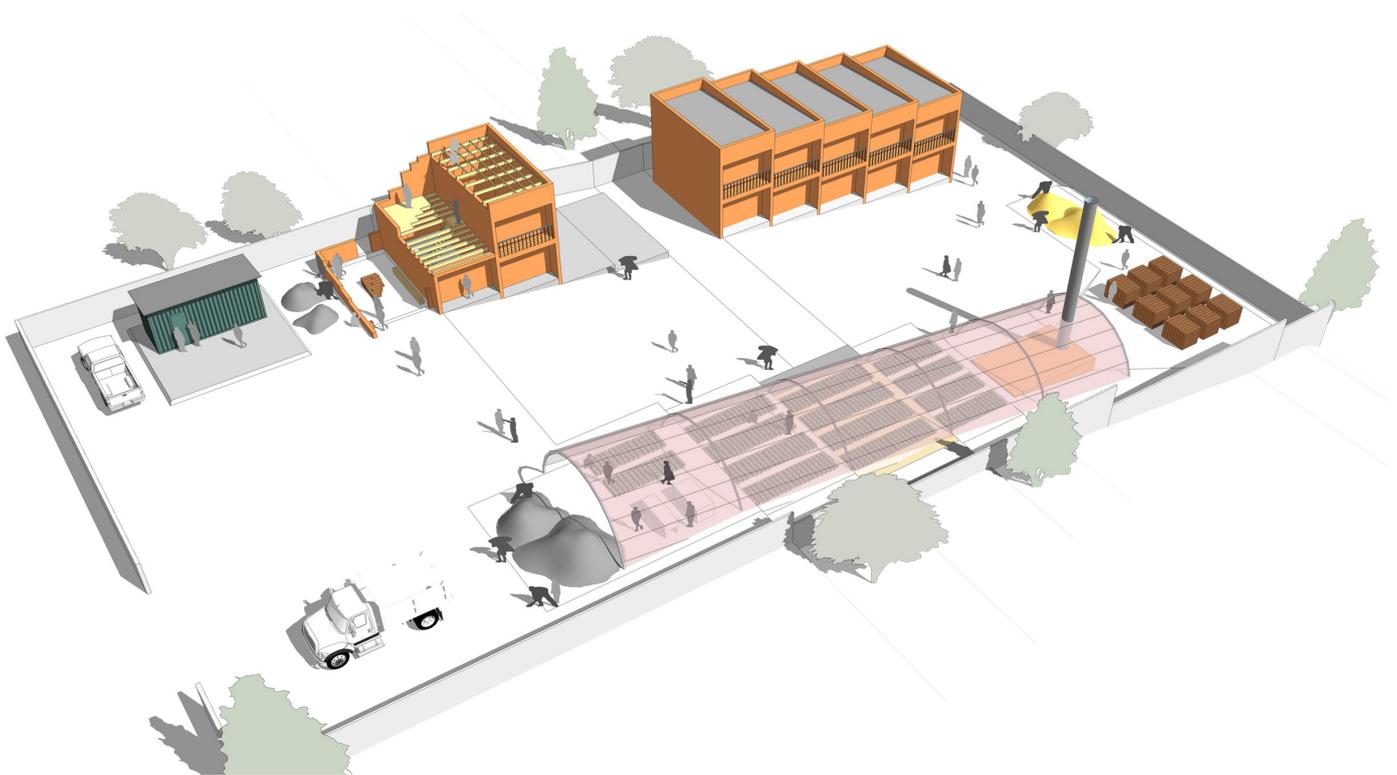


# STARTER UNIT FOR LOW-CARBON CLAY BRICKS PRODUCTION OPERATIONAL MANUAL



September 2022



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Agency for Development  
and Cooperation SDC

**skat** Swiss Resource Centre and  
Consultancies for Development

**PROECCO** **PRO**moting **E**mployment through  
**CL**imate Responsive **CO**nstruction

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## 1 Preface

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The concept of a mobile manufacturing method called In-situ production was developed and tested by the PROECCO program in 2018.

Modern bricks supply have to tackle two main challenges in the market, which are shortage of bricks and limited investment portfolios availability.

This self-supply model of in-situ production is adopted by investors looking at providing locally produced construction material for residential, commercial and educational facilities. This type of in-situ production unit, compared to other production supply units, requires a minimum investment for setting-up the infrastructure (brick kiln, drying hangars, and extruder machines) necessary for manufacturing quality products.

Additionally, the majority of the production unit can be transported, adapted and reused in a number of different locations, further minimizing the impact of the initial investment and eventually supplying the local markets with a more sustainable and affordable construction material.

## 2 Author

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PROECCO (Promoting Employment in the Great Lakes Region through Climate Responsive Construction Material Production) is a project of The Swiss Cooperation Implemented by Skat Consulting Ltd (Switzerland, Rwanda, Burundi, Bukavu.) It supports the creation of jobs in improved artisanal and Semi-industrial brickyards. The people targeted by the project are the young laborers and innovative entrepreneurs willing to pioneer environment friendly modern production of bricks, tiles and slab blocks, as well as other actors of the supply chain who help to make modern brick walls and building affordable.

The modern clay bricks production exists from modern highly sophisticated/fully automated manufacturing methods to a variety of mechanized manufacturing processes with simple labor-intensive methods.

The labor-intensive production methods are the most suitable for small and medium enterprises that require low investment.

## 3 Objectives

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The primary objective of this guide is to enable the decision makers, Inspectors, brickyard designers, Investors and production managers to have a clear understanding on the requirements in the installation and operationalization of in situ low carbon brickyards, and small-scale artisanal brickyards constructed for the purpose of delivering bricks to a specific construction project or to employ permanently a group of people in a cooperative or association.

In this guide, we shall dwell only on underground kiln as a means of firing clay products with in-situ production setup. It is an intermittent type of kiln, with an average annual production of 400000 to 500000 bricks per year. In addition to that we shall describe the entire low carbon bricks production process taking place in brickyard with an underground kiln as firing technology.

## 4 Low carbon Modern Brick Production Chart



*Low carbon and modern brick set up*

*Climbing kiln production set-up*

- The manually operated low carbon and modern brick production line is set up on a location designated by the contractor/developer or Investor, and allows for the raw materials supply, brick production and sometime building construction process to happen simultaneously.

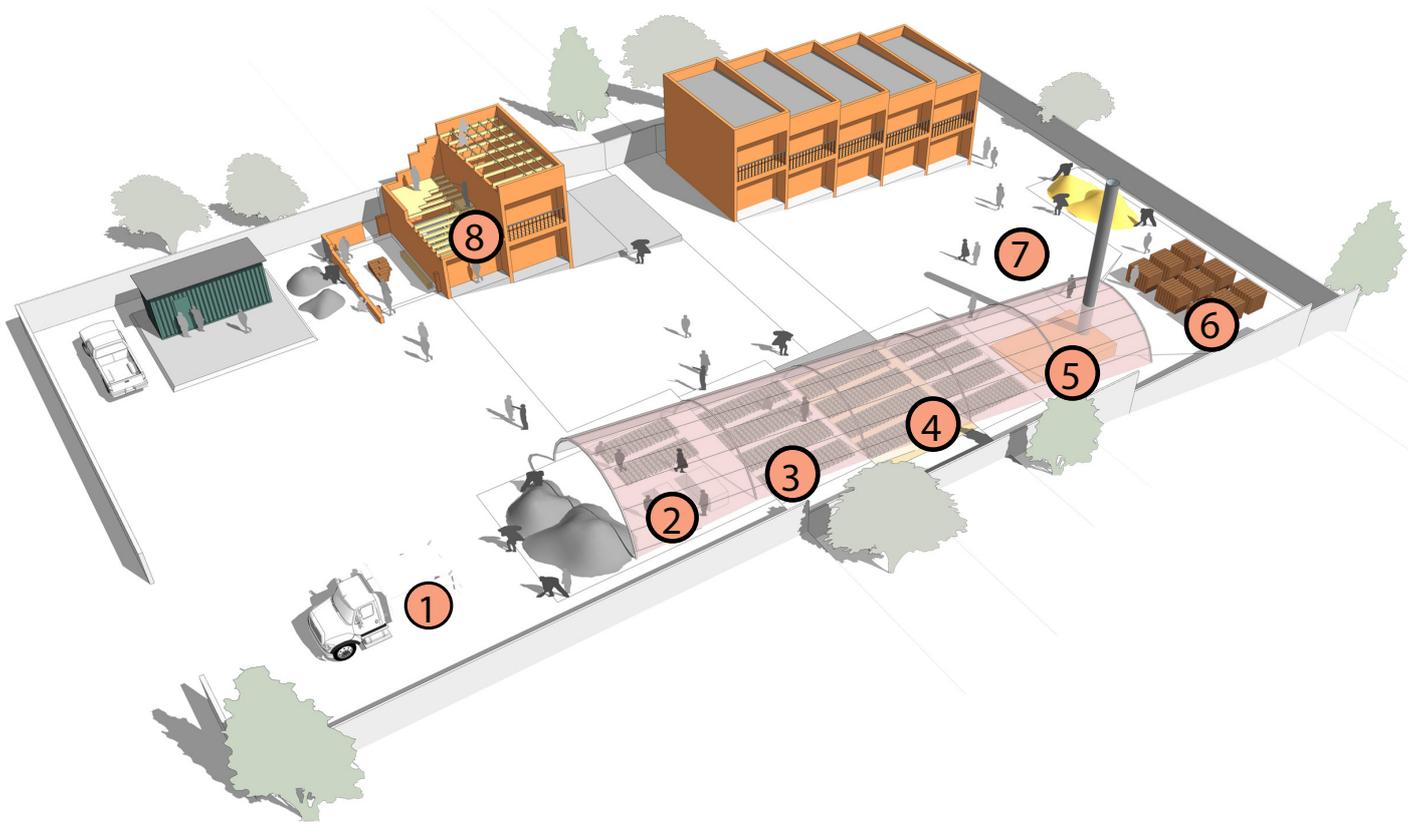
- The low carbon clay brick production set-up requires a minimum of 600 m<sup>2</sup> area, largely occupied by the bricks drying process.

- In case of an in-situ low carbon production, to fire the bricks, an underground kiln is used. Once the bricks production is concluded, the kiln area becomes the underground Septic Tank.

- In case of an in-situ low carbon brick production, after firing, the bricks are directly used for the construction of the new facilities without incurring in extra transportation costs and reducing brick damages, carbon emission and wastage to the minimum.

# INTRODUCTION AND BACKGROUND

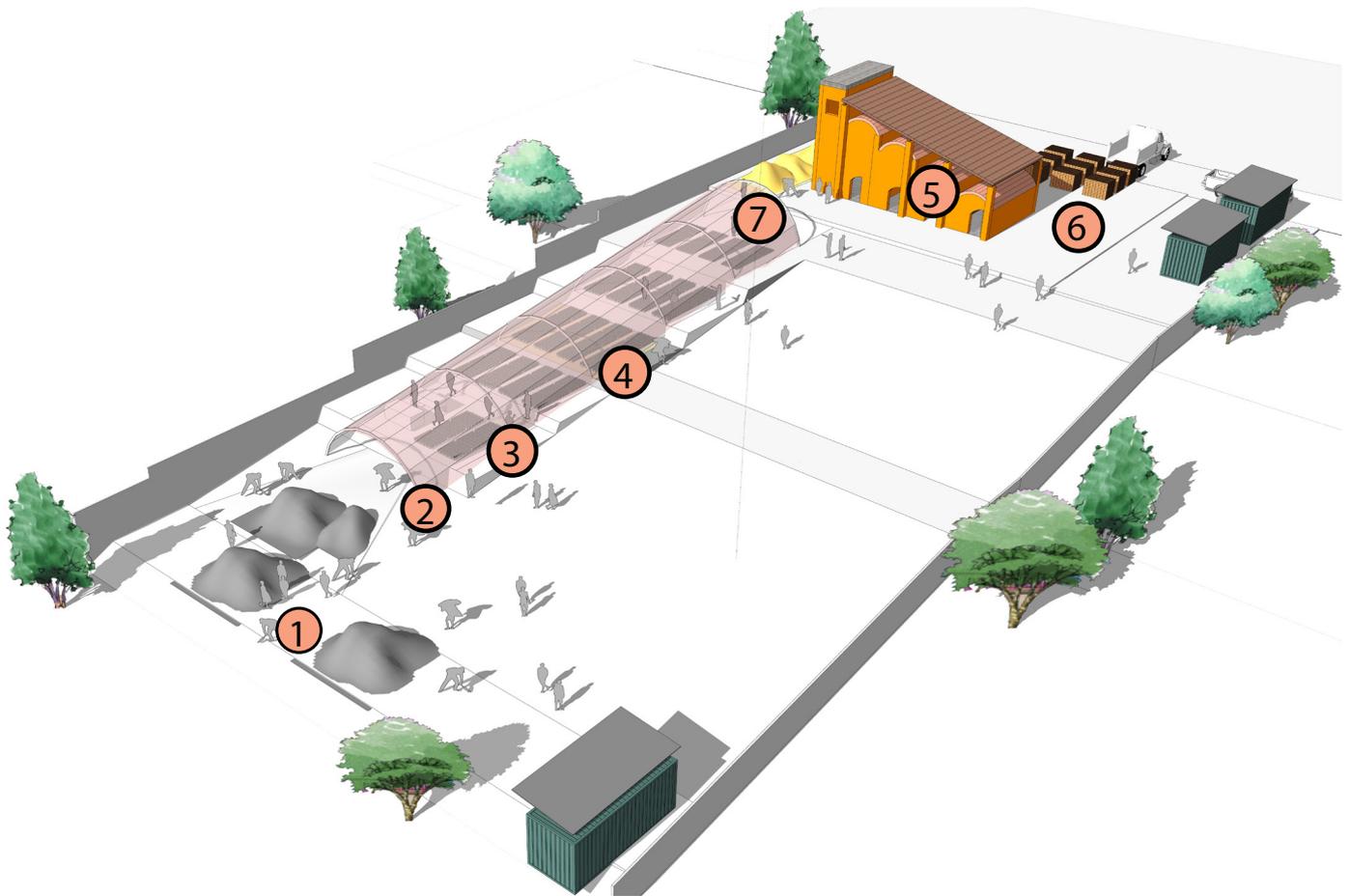
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*In-situ low carbon and modern brick set up*

## THE PRODUCTION SET-UP/LAYOUT

1. Extracted clay storage and weathering area
2. Bricks production area
3. Bricks primary drying area
4. Bricks secondary drying area 3 to 5 days depending on weather condition
5. Kiln firing
6. Fired bricks storage area
7. Sawdust and kaolin storage area
8. Construction site



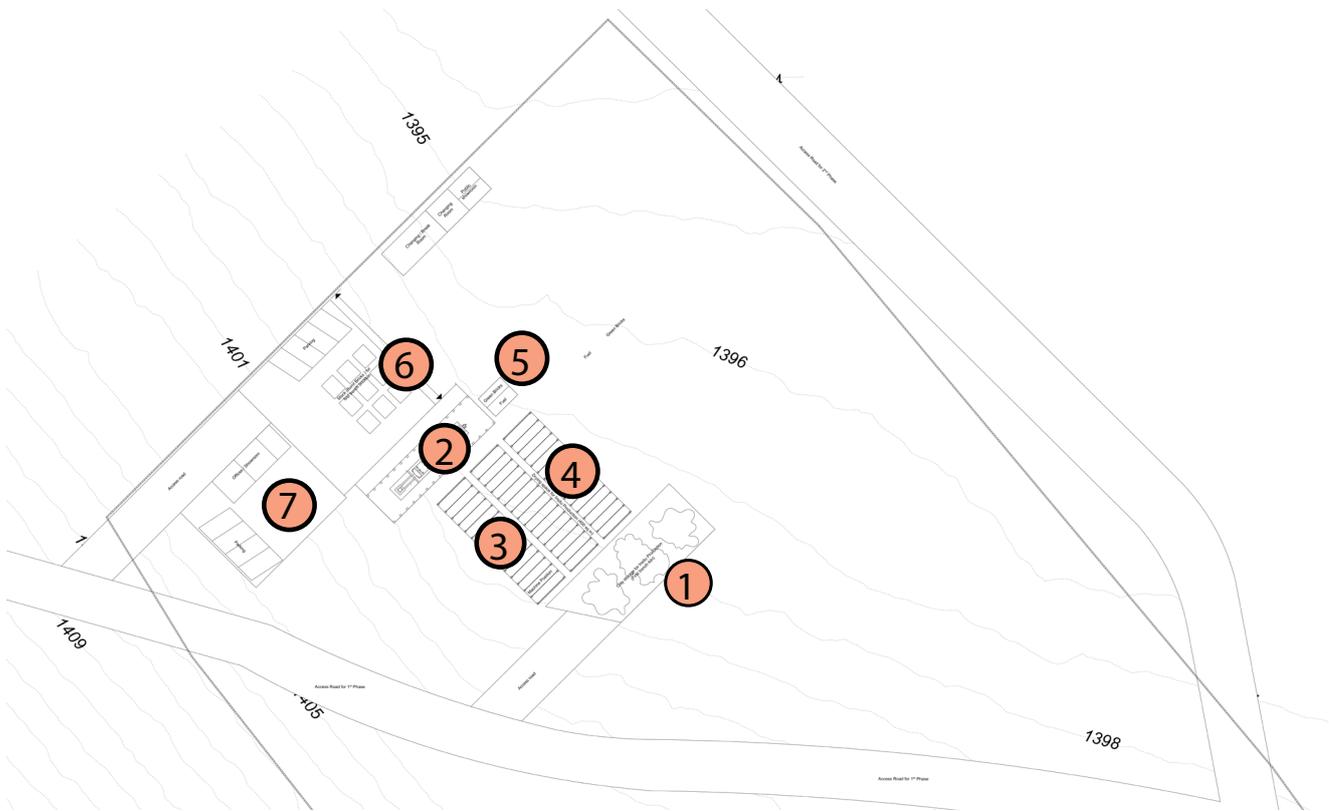
*Climbing kiln low carbon and modern brick set up*

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# INTRODUCTION AND BACKGROUND

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*In-situ low carbon and modern brick set up*

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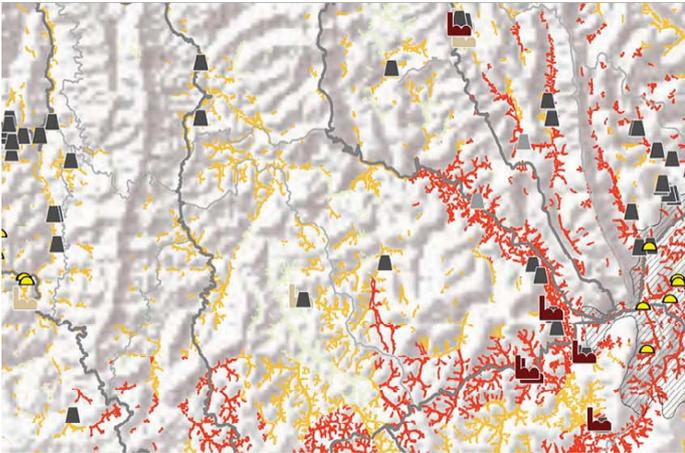
5 Production Team Composition

Job Category	Supervisory level	Related upskilled labor	Responsibilities/ Role
Technicians	Machinists	2-3 Extruder operators by machine	<ul style="list-style-type: none"> <li>• Set up the machine to start a production cycle.</li> <li>• Feed raw materials to initiate the production activity.</li> <li>• Fix issues that may impact quantity/quality during the shift.</li> <li>• Carry out routine maintenance.</li> <li>• Maintain a production activity logs.</li> <li>• Communicate with team members and support teams to ensure continuous production of high-quality products with minimal time material waste.</li> <li>• To ensure the presence of a clean and safe working environment in accordance with approved health and safety standards.</li> <li>• Be performance driven and accountable.</li> <li>• Must be hands-on, team oriented and committed.</li> </ul>
	Fire master	4-6 Fire Helpers	<ul style="list-style-type: none"> <li>• Monitor the drying process and ensure that only well dried bricks are loaded into the kiln.</li> <li>• Implement continuous improvements on the efficiency, consistency and productivity of the drying and kiln firing processes.</li> <li>• Manage and reconcile fuel used for the kiln firing, ensure that the kiln fuel received is of the desired quality level or else reject it.</li> <li>• Coordinate the kiln firing launch, firing process, cooling and unloading.</li> <li>• Must be hands on, team oriented and committed.</li> </ul>

## PRODUCTION TEAM COMPOSITION

Job Category	Supervisory level	Related upskilled labor	Responsibilities / Role
Management	TMT Team Leader / Foreman	2-3 Extruder operators by machine	<ul style="list-style-type: none"> <li>• Ensure the timely delivery of good quality clay at the site</li> <li>• Maintain production activity logs</li> <li>• Ensure good conditions of the machinery</li> <li>• Ensure the availability of competent machine operators and Kiln Fire Master</li> <li>• Monitor the drying process and ensure that the drying protocol is strictly followed</li> <li>• Ensure that the drying losses are reduced to the barest minimum (&lt; 5%).</li> <li>• Adhere to the kiln production schedule on a daily/ weekly/monthly/annual basis.</li> <li>• Strive for continuous improvements on the efficiency, consistency and productivity of the drying and kiln firing processes.</li> <li>• Manage and reconcile fuel used for the kiln firing, ensure that the kiln fuel received is of the desired quality level or else reject it.</li> <li>• Ensure that only quality products exit from the kiln to the construction site.</li> <li>• Coordinate the maintenance activities for both machines and kiln.</li> <li>• Ensure the optimization of existing infrastructure and human resources.</li> </ul>
Other Upskilled labor		Bricks drying team: 2 permanent workers (Preferably women)	<ul style="list-style-type: none"> <li>• Handle bricks properly.</li> <li>• Ensure the presence of a clean and leveled drying area.</li> <li>• Be able to sort good and bad quality products at the drying stage.</li> <li>• Keep the Drying logs.</li> </ul>

## 6 Quarry Prospecting and Analysis



Map of clay potential zones in Rwanda

Once the suitable site is selected according to the criteria indicated by the geologist, a series of tests will be run by the “Ceramic raw materials & products testing Laboratory”, in order to ensure that the site will be economically viable.

Quality and quantity of clay will be assessed so that there will be little risk for waste. The clay quality is expressed in terms of [percentage (%)] of clay, silt and sand, and in clay quantity [volume ( $m^3$ )].



Soil sampling

# RAW MATERIAL

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*Soil sampling etiquette*



*Sieve analysis*

## SOIL SAMPLING

Observation to the changing of soil layers, type of soil, nearby basic infrastructure, landscape, collection of field coordinates. Then the team proceeds with the collection of samples to be brought to the laboratory. Soil samples are collected in basins according to their layers and depth. Each sample is labeled (name of site and the depth).

## SIEVE ANALYSIS

The sieve analysis concerns the particles larger than 0.08 mm of diameter, ranging from fine to coarse sand. It is useful to determine the distribution of the coarser, larger-sized particles

## SEDIMENTOMETRIC SOIL TEST

A portion of the soil sample (specimen 1) is used for the sedimentometric soil analysis or hydrometer test that is needed to determine the distribution of the finer particles of the soil contents. This process is also known as Bottle Test, determining the proportion of clay and sand particles in the soil.



*Sedimentometric soil test*



*Mini brick extrusion*



*Shrinkage test*



*Firing test*



*Different type of briquette after firing test*

## SHRINKAGE TEST

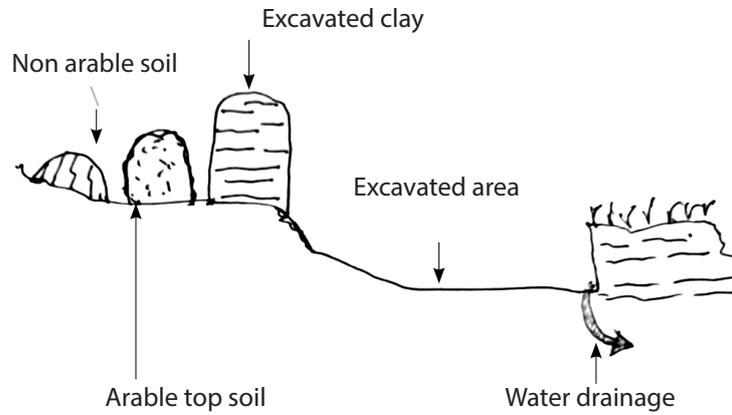
The other part of the soil sample (specimen 2) is moulded with a mini extruder to fabricate a briquette that will be used for the clay shrinkage test. The briquette is measured, then dried and measured with precision again.

Finally, after being fired in the kiln, the briquette is measured once again. The shrinkage test gives an idea on the brick dimension reduction during the drying and firing and helps to know the measurements of the mould to be fabricated.

## FIRING TEST

The firing test gives an idea on the brick color, shrinkage rate of the clay and helps to determine the best firing temperature in the kiln.

## 7 Excavation of clay at the clay quarry



*Clay excavation process*



*Clay excavation at the quarry*

The excavation happens preferably on the lowest part of the quarry, with due regard given to draining water away from the pit and mixing purer clay with sandy sections.

The excavation activities should be performed during the dry season and the equipment used are a Wheel Loader (in case of motorized excavation) and spades, axle and etc. (in case of manual excavation).

The first step is to clear off the top soil (overburden) and load the excavated clay onto the tipping lorries/dumper/Wheel barrow.

The laborers then sift the clay depositing it onto an open area created in the quarry for temporary storage and weathering process.

8

## Transfer the quarried clay to the production unit



*Clay loading activities*

The clay is loaded and transported to the production site and each load is recorded on the Clay Loading Form that records the number of trips and timing. The driver shall sign for each load carried to the in-situ site.

In case the clay quarry is near the production site the clay transportation can be done manually in sacks or metallic buckets.



*Clay transportation*

## 9 Stockpiling of clay at production unit



*Removing the foreign material such as roots*



*Clay storage*

The choice of type of clay storage depends largely on the production capacity of the plant. However, the popular methods of storage are listed below:

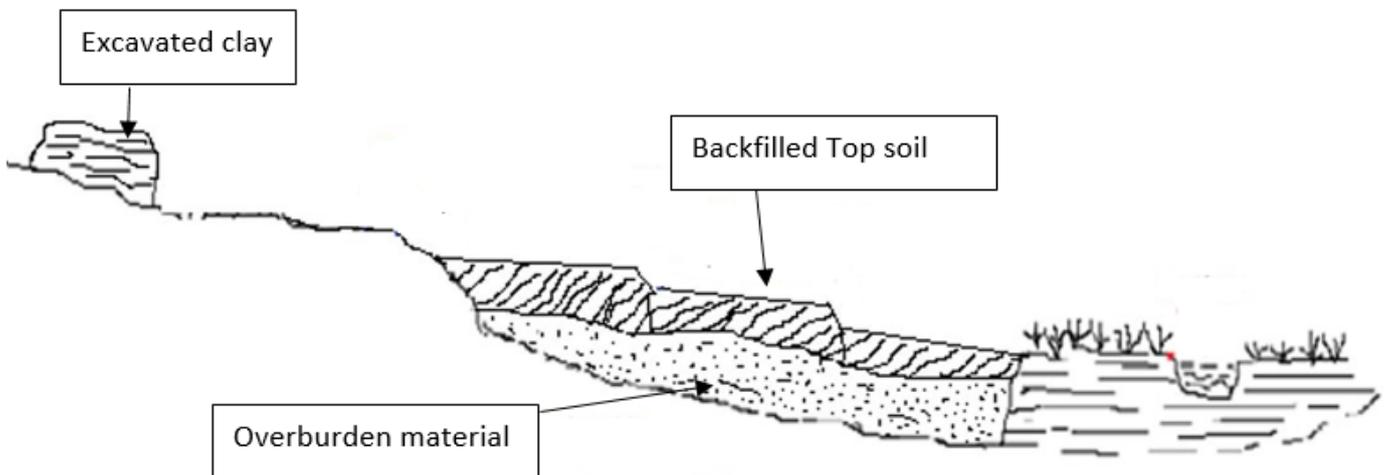
- Open-air storage
- Storage Sheds
- Large Volume feeders
- Tempering, aging and souring silos
- Dry material silos

In case of the in-situ production, at arrival of the clay at the site, its details (quantity of clay/kaolin) are recorded in a Clay/Kaolin Receiving Form. The clay/kaolin is stored separately at the Clay Bank. The new clay is positioned in the stock pile away from old clay in order to avoid the usage of fresh clay and allowing for the weathering time.

The First In First Out (FIFO) principle is employed.

The clay shall be stocked in a way that allows for long period of weathering. A period of 3 or more months is deemed adequate for weathering. The foreign materials such as stones and roots shall be removed.

## 10 Quarry rehabilitation



Quarry rehabilitation process



*Rehabilitated quarry under use for rice agriculture*

The Mining and Quarrying Code of practice (RS 566:2011) stipulates that all sites excavated for mining purposes should be rehabilitated once the mining activities are completed. Even if it is not easy to restore to its previous condition, the objective of the clay quarry rehabilitation is to convert the post-clay extraction landscapes into attractive areas depending on the modified ecological conditions.

The quarry rehabilitation is necessary to allow future use of the extracted areas in agreement with the District authorities and local communities and in compliance with the local land-use plan.

The rehabilitation process happens in two steps: Reclamation and Recultivation.

## 11 Production records



Production recording



Temperature recording

At the beginning of every month the developer/ site engineer shall forward to the in-situ Production / Operations Manager a list of products on demand based on the contract requirements or Standing Orders.

The Product Order Form shall be used for new products under trial. The Procedure "Product Design and Development" shall be followed.

A Weekly Production Program shall be drafted based on the above and it's then forwarded to the Production Machine Operators for execution. A copy of the Production Program shall be issued to the Developer/Site Engineer.

Production recording is a requirement in order to monitor the productivity and take timely action.

The recorded data are the basis of any improvement recommendations on productivity, quality, costing and maintenance.

Below is the list of records that should be kept:

1. Green bricks production per each machine
2. Involved labor per production on daily basis
3. Drying progress on a daily basis

## 12 Clay Preparation



*Manual clay preparation/crushing*



*Clay crushing using a 30hp motorized diesel crusher*



*Final manual preparation before extrusion*



*Clay crushing using a double roller electrical crusher*

According to the product schedule, determining the mixing ratios of clay and kaolin (in case mixing is required) is done in addition to assessing the shrinkage. Also, an initial test firing is helpful in ensuring the clay will yield strong products. With the assistance of the PROECCO laboratory, the TMT leader can determine the clay and kaolin content in the event mixing is required.

The mixing happens manually at the suggested ratios and in portions that are acceptable to run through the mixing/crushing machine, or manually crushed by labour. The moisture content is adjusted in the mixers (primary and extruder mixers) to give a pressure reading of about 18-21 bar for soft mud extrusion on the Plastometer (in case it is available).

### 13 Shaping/Moulding/Extrusion



*Demonstration of clay box feeding of manual extruder*



*2 to 3 teams of extruder operators in an insitu production site*

According to the product on schedule, the right mold must be mounted onto the extruder barrel/mouth.

In case of manual extrusion, a well-prepared is compacted into the box and then the box is closed and locked.

Maximization of the extrusion process must be considered by ensuring that the drying space is availed at the right time to receive freshly extruded products.

The proper working parameters of the moulds (dimensions, weight, squareness etc.) shall be inspected and tested by the TMT Foreman once a day.

Good handling practice shall be emphasized at this stage to avoid dents, scratches as well as deformation. Orderly arrangement of the products in the dryers shall be ensured with due regard for effective drying.

14 Clay column cutting



Column cutting after extrusion



Column cutting and direct handling from the cutting table

As the extruded clay column exits the die mouth, it is cut into fixed measured bricks dimensions by a high tensile wire, fixed to a swinging frame.

The cut dimensions are adjusted mechanically. The wire cutting dimensions and angles shall be set to give the expected plastic sizes and shapes with reference being made to the of dimensions list provided by the lab.

### 15 Natural Drying



*Green product drying (first stage on the left and second stage on the right)*

The extruded clay bricks are laid out on the drying area in stacks. In this phase the clay must lose all its moisture content through evaporation to the air.

In most cases, the freshly extruded clay brick would be having a moisture content of 19-22 %. After this process, the moisture content is brought down to 2%, before the product can be loaded into the kiln for firing. The intervening time is the Drying Time.

Clay bricks are exposed to the danger of cracking or deformation, if dried too rapidly. The process of evaporation causes differences in moisture concentration within the brick and because clay shrinks to varying degree as water evaporates, stresses arise within the green product.

The magnitude and effects of these stresses on the green product depend on the shape and on the plastic properties of the clay, as well as on the geometrical form of the product and the operating conditions during the drying process. The freshly, moulded product may acquire stresses during shaping in addition to those occurring during subsequent drying and thus increase the risk of drying failure.

## 16 Primary natural drying



*Vertical primary drying*



*Horizontal primary drying*

The bricks coming straight from the extruder are transferred to a drying shed and piled together for a period of 3-5 days depending on the weather conditions.

The bricks are piled by rows in case of horizontal drying, otherwise, they are laid on wooden boards and stacked on shelves after being cut, according to the capabilities of the production facility.

## 17 Secondary natural drying



*Circular piling during secondary drying*



*Rectangular piling during secondary drying*

Bricks from the primary drying phase are now piled in 6-10 layers high. The bricks are now more resistant and can withstand the load of more bricks stacked on top of each other. This may be done in rectangular or circular shapes. This operation allows the bricks to be exposed to air circulation, facilitating the moisture evaporation and speed up the drying process.

## 18 Sorting and recording green products



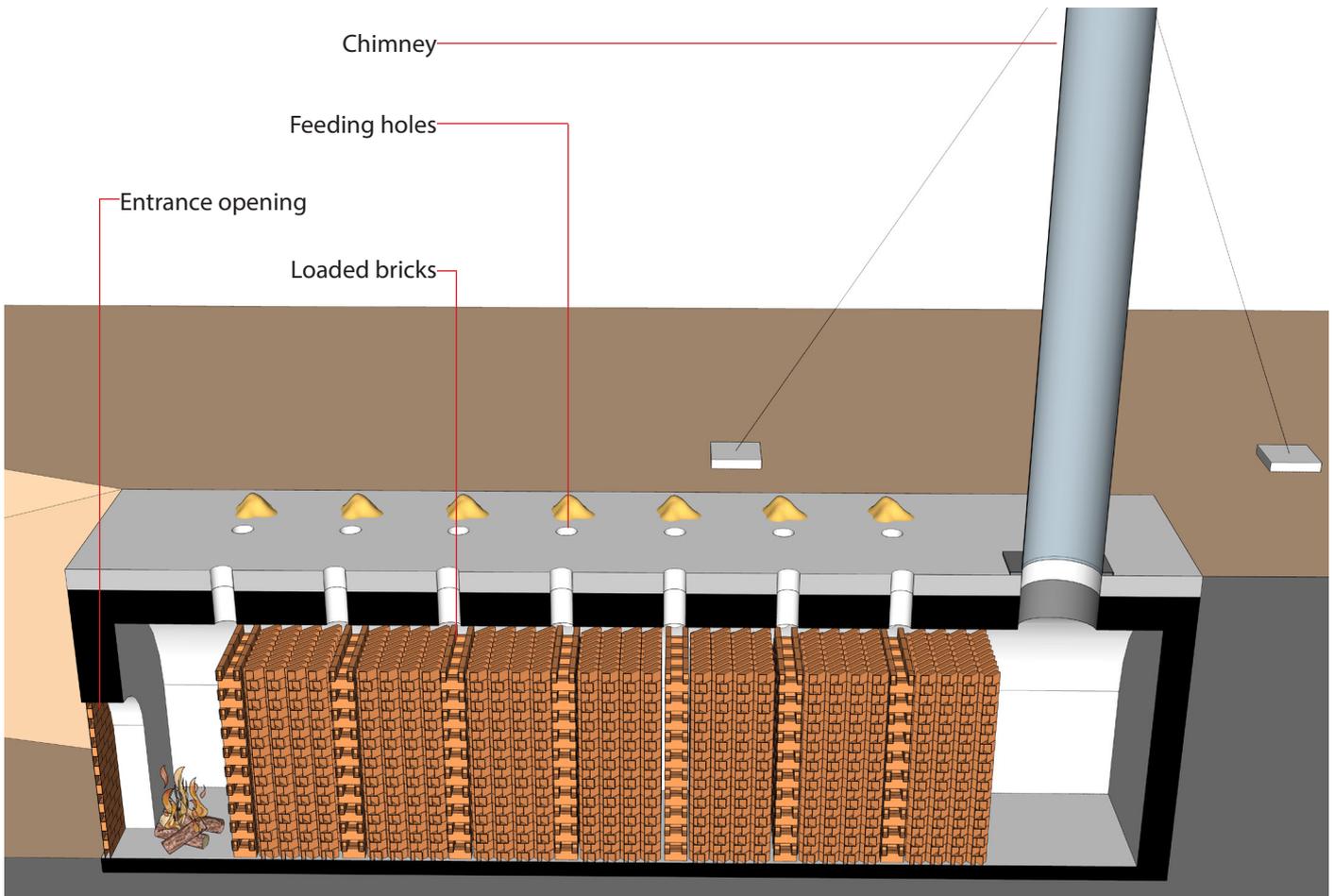
*Drying loss*



*Counting, sorting, and recording*

The Kiln Loading form is filled with the recorded quantities of products loaded as well as with the non-conformities, which at this stage are referred to as drying breakages. These are counted and sent back to the clay silo for recycling.

## 19 Kiln firing toolbox



Kiln firing process diagram

### TOOLBOX

- Thermometer gun
- Moisture content tool
- Thermo couple
- First-aid kit



## 20 Kiln loading



*Fish bone pattern loading*

The bricks are loaded manually into the kiln in stacks, with very small gaps (finger width) left in between each product to allow heat to circulate evenly throughout the firing chamber. Bricks placed face-to-face will have a more uniform colour than brick that are cross-set or placed face-to-back.

Note: the capacity of each kiln is as indicated in the loading work instruction.

## 21 Kiln fuel



*Fuel stock at the site*

The TMT Foreman shall inform the Production Operations Manager to buy stocks of fuel by raising a purchase request. At reception, the fuel shall be inspected by a team of two people (TMT foreman and his/her superior). These will make sure that the quality and quantity of fuel are met.

The TMT Foreman has to constantly monitor the fuel stock levels, and when the stock goes low a report shall be filed and a new purchase request issued.

The Production Operations Manager shall then follow the procedure to acquire more stock.

## 22 Kiln firing program and temperature control



*Kiln fuel top feeding*



*Kiln fuel top feeding*

In case of an Intermittent Kiln, the firing is done in 24-30 hours cycle (cold – hot – cold) with continuous feeding, after a preheating of 6-10 hours. In order to achieve the required product quality, the dried bricks are fired in three stages:

- Pre-heating
- Firing
- Cooling

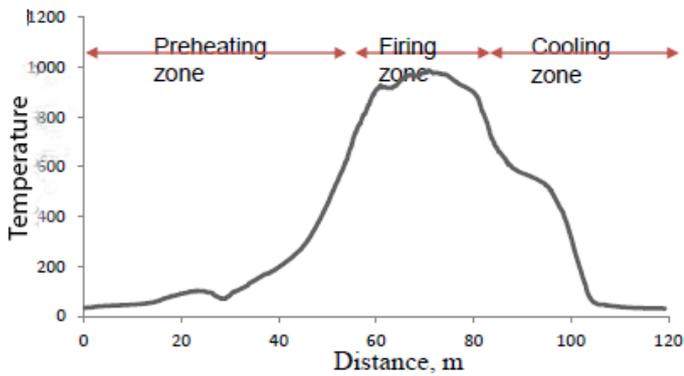
The heat conditions in each zone of the kiln are carefully monitored and the kiln is continuously operated once the fire is started.

The firing process may be divided into five general stages:

- Final drying (evaporating free water); 100 to 200 °C
- Dehydration; 200 °C to 600 °C
- Oxidation; 600 °C to 920 °C
- Maturing; 900 °C to 950 °C
- Gradual cooling

The key to the firing process is to control the temperature in the kiln in order to conform to the firing schedule. Temperature records are taken every one hour at all zones in the kiln.

# FIRING



Kiln firing diagram



Firing temperature record

color	approximate temperature °C
faint red	500
blood red	580
dark cherry	635
medium cherry	0690
cherry	0745
bright cherry	0790
salmon	0845
dark orange	0890
orange	0940
lemon	1000
light yellow	1080
white	1205

Kiln firing color chart



Firing temperature monitoring using a temperature gun

The temperature control during firing is a requirement in order to produce good quality products. This is done using a digital aid/or a manual thermometer or temperature gun, kiln firing thermocouples and a digital displayer. It is recommended to record the temperature variations at every hour; this enables proper monitoring of any defect related to firing temperature instability.

## 23 Kiln unloading



*Kiln unloading*

### STANDARD GRADE PRODUCTS:

The fired products are off-loaded in the sequence of first in - first out (tunnel kiln) and in reverse for the intermittent kiln. The offloaded bricks that present all the physical characteristic of a quality product are put on a safe area and shall be categorized under Standard grade.

## 24 Sorting/storage at the finished goods yard



*Broken fired products*



*Commercial products*

### **BROKEN FIRED PRODUCTS:**

These are piled out of the loading area to enable the wheel barrow to carry them to the grinding area. It is this scrap that is turned into grog and later recycled to be used in making other products such as fire cement and refractory materials. Excess scrap is heaped at the dumping ground from where it awaits to be re-purposed for example as sublayer for quarry roads.

### **COMMERCIAL PRODUCTS :**

Although these products have defects and may show signs of warping, breakage, etc., they are still useful in some aspect of construction. These products are arranged in the yard in the area reserved for commercial grade products, to avoid being mixed with Standard grade products.



*Overfired bricks piled outside the kiln*

## OVER FIRED PRODUCTS :

These are products that have been exposed to very high temperatures during firing and have changed to a very dark colour and have shrunk extra-ordinarily. These products are stocked in the yard in the section that is clearly demarcated "Over fired products" to avoid being mixed with Standard and Commercial grade products.



*Offloading bricks from the kiln*

## UNDER FIRED PRODUCTS:

These are products that have been exposed to low temperatures during firing. Since these products are not well fired, they are taken back for re-firing. These products are returned to the kiln loading area and are stocked in the section that is clearly demarcated "Under fired products" to avoid being mistaken with other grades products.

The product quantities are recorded in the various grades listed above in Kiln Offloading Register.

## 25 Kiln maintenance



*Kiln before maintenance*



*Kiln after maintenance*

After offloading the kiln, it shall be swept clean of any debris from damaged products by the firing team before being inspected by the Firemaster.

A kiln inspection consists of checking for and repairing any cracks that may have appeared during the firing cycle. Repairs are made using fire-resistant material like chamotte or kaolin.

## 26 Machine maintenance



*Screw shaft worn out to be replaced*



*Screw shaft with new full pitch distance*

Maintenance is a work that is carried out to preserve an asset (a machine etc.), in order to enable its continued use and function above a minimum acceptable level of performance, over its design or service life without unforeseen renewal or major repair activities.

It helps in maintaining and increasing the operational efficiency of brickyard facilities.

This maintenance activities may be carried out before the breakdown (preventive maintenance) or after breakdown (curative maintenance).

## 27 Work safety issues



*Workers in personal protective equipments and available clean water at the site*



*Operation carried out in hangars to protect from weather*

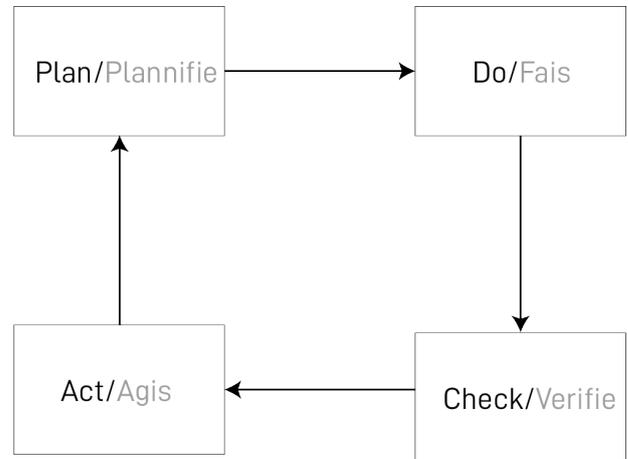
As per ministerial order number 2 of 17/05/2012, determining the conditions for occupational health and safety, the following measures are the minimum requirements to ensure the safety and wellbeing of the personnel at work:

1. Reasonable duty hours (8 hours shifts)
2. Provision of clean drinking water
3. Food facilities at the work place
4. Medical insurance scheme (mutuelle de sante)
5. Presence of aid kits in the work place
6. Uses of personal protective equipment (PPE)

## 28 Quality plan



Quality planning parameters



Quality planning cycle

During each production cycle, there are quality control activities that must be carried out. These activities are done as per a pre-planned schedule.

Quality Planning and Quality Management are the fundamental processes put in place to oversee all activities and tasks needed to maintain a desired level of excellence, with the goal of delivering a quality product as per customer's requirements and market demand.

The complete quality control process consists of:

**Plan** - the stage where the quality control processes are planned.

**Do** - use a defined parameter to develop the quality

**Check** - the stage to verify if the quality parameters are met

**Act** - take corrective action if needed and repeat the work.

Quality control characteristics: process adopted to deliver a quality product to the clients at best cost. The goal is to learn from other organizations so that the quality can be improved over time.

## 29 Process quality assurance and monitoring

The soil suitable for perforated bricks production should meet the requirement of adequate mixture of its components which are clay, silt and sand.

Apart from clay soil mixture proportion the production of bricks requires to take into consideration the following parameters :

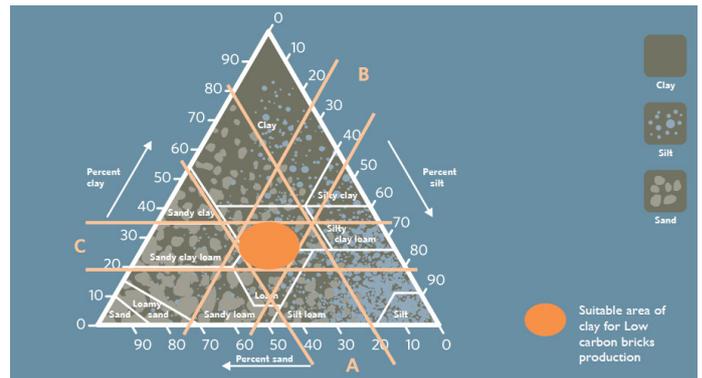
### 1. Raw Materials Mixture

Dry Shrinkage: 4-5%

Total Shrinkage: 6-7%

Sand Content: 20%-35%

	Elements	Size	Recommended value
1.	Sand	2mm-0.063mm	20-45%
2.	Silt	0.063mm-0.002mm	25-45%
3.	Clay	<0.002mm	20-35%



Ideal distribution of grain size for low carbon bricks

Suitable soil for perforated bricks

### 2. Clay Bank at Brickwork

Moisture Content (Clay bank) : 12% - 18%

Moisture Content in the Silos (Kaolin bank) :4% - 8%

Roller gap (Crushed particle size from High Speed Rollers):< 1 mm



Watering of clay silo

### 3. Extrusion

Moisture Content of column at Extruder exit: 20% - 21% which enables proper handling straight from the cutting table.



Regulated moisture in the clay column during extrusion for proper handling



Regulated moisture in the clay column during extrusion for proper handling

## 4. Drying

Moisture Content of dried product should be  $< 2\%$



*Bricks under drying process*



*Bricks ready for firing with moisture  $< 2\%$*

## 5. Firing

The firing schedule to follow pre-established norms. Moisture content of Kiln Fuel to do not exceed  $8\%$ .



*Fuel stock*

# QUALITY ASSURANCE AND QUALITY CONTROL

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## 6. Sorting

Fired products are sorted as defined by Rwanda Bureau of Standards (RBS), RS359:2009.

Under-Fired Products are those that have not matured fully during the course of kiln firing. Such products will be sent back to kiln for re-firing.

Breakages: Products that are totally broken in more than one piece are classified as broken. Such products are kept separately and sold to customer on weight basis.



*Green bricks sorting*



*Bricks sorting after firing*



*Bricks sorting after firing*

## 30 Soil and finished product quality control

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring of quarrying activities	Routine inspection of clay and kaolin quarries  Identify areas in the respective quarries to excavate for clay and kaolin	Nominated person at the production site.	Monthly once
2	Monitoring routine testing of raw materials	Routine checks of clay and kaolin received at Brickwork: <ul style="list-style-type: none"> <li>• L.O.I.</li> <li>• Granulometry</li> <li>• Shrinkage of clay</li> <li>• Sand content in kaolin</li> </ul>	Sample of clay and Kaolin to be sent to SKAT-BMC	Quarterly once

Quality Control Activities: QUARRY

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring of clay mix, clay being blended kaolin in a pre-determined ratio	Routine monitoring of clay & kaolin Mix	Nominated person at the production site.	Initially daily. Later, as the worker gains confidence the system, the testing could be scaled down to once weekly

Quality Control Activities: Clay mix

## ANNEX

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the Roller Mill operation.	<ul style="list-style-type: none"> <li>• Check the clay-Mix fall onto the Roller shells</li> <li>• If fall is not spread across the roller shell face, then ensure that it falls across the entire face by developing a suitable jig.</li> <li>• Check for gap between the two rolls, which ideally should be less than 1.00mm</li> </ul>	Nominated person at the production site.	Daily. Once systems are in place, this check could be done weekly.

*Quality Control Activities: Roller mill*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the moisture content of the clay mix at the Extruder Mouth	<ul style="list-style-type: none"> <li>• The moisture contents should be in the range of 18-21%</li> <li>• Initially the test will need to be done through a laboratory dryer and using weighing scales</li> <li>• Later on, once confidence built up, the test could be done by "feel" method</li> </ul>	Nominated person at the production site.	Hourly during extrusion operations

*Quality Control Activities: Moisture content at extruder*

S.No	Activity Activité	Process / Processus	Person Responsible Personne responsable	Frequency Fréquence
1	Monitoring the clay Mix column existing from the Extruder Die Mouth	<ul style="list-style-type: none"> <li>The clay mix column existing from the Extruder Die Mouth should conform to the Exit Regulation test, i.e. the column should be existing uniformly across the die mouth face.</li> <li>The Die cores are not out of position.</li> </ul>	Nominated person at the production site.	During extrusion operations to be recorded hourly

*Quality Control Activities: Extruder mouth*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the extruded green bricks/blocks being set for drying at drying station	<p>The freshly extruded green bricks are laid out on the drying floor as per set parameters, to allow ambient air to facilitate quick drying.</p> <ul style="list-style-type: none"> <li>Checking for the quality of drying</li> <li>Check for drying problems/deformities such as warpage, cracking</li> <li>Change stacking style as bricks get dry</li> <li>Bricks before being sent to kiln should have moisture content of &lt;2%</li> </ul>	Nominated person at the production site.	During drying operations, to be checked every shift

*Quality Control Activities: Drying*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the fuel for kiln firing	<ul style="list-style-type: none"> <li>Checking for the quality of the fuel for kiln firing</li> <li>Check for moisture content</li> <li>Check for granulometry of the kiln fuel</li> </ul>	Nominated person at the production site.	<ul style="list-style-type: none"> <li>During kiln firing operations, to be checked every shift.</li> <li>Granulometry to be checked with every receipt of kiln fuel</li> </ul>

*Quality Control Activities: Kiln fuel*

## ANNEX

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the kiln firing	<ul style="list-style-type: none"> <li>• Checking for the quality of the products being sent to the kiln for firing, no cracked, broken or deformed product enters the kiln.</li> <li>• Product stacking in the kiln chamber follows stacking norm</li> <li>• Pyrometer readings are recommended</li> <li>• Damper positions are maintained as per set norms</li> </ul>	Nominated person at the production site.	During kiln firing operations, to be checked every hour

### Quality Control Activities: Kiln

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the quality of the fired products exiting the kiln	Checking for the quality of the products exiting the kiln: <ul style="list-style-type: none"> <li>• Checking for fired dimensions</li> <li>• Checking for fired weight</li> <li>• Checking for squareness</li> <li>• Checking for surface quality</li> <li>• Checking for warpage</li> <li>• Checking for under-fired products</li> <li>• Checking for over-fired products</li> <li>• Checking for water absorption</li> <li>• Checking for strength</li> </ul>	Nominated person at the production site.	The fired products exiting from kiln chamber to be checked for bottom, middle and top rows for parameters mentioned under "process".

### Quality Control Activities: Fired products

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the quality of the fired products kept in the finished goods yard	Checking for the quality of the products exiting the kiln: <ul style="list-style-type: none"> <li>• Checking that each product type is kept together</li> <li>• For the same product type, the first and second quality types to be stacked differently</li> </ul>	Nominated person at the production site.	The fired products in the stockyard are to be analysed for quality and inspection done with every entry of fresh goods to the yard

### Quality Control Activities: Fired products in stockyard

## 31 Maintenance

Who	HOW	WHERE	WHEN	PROCEDURE
TRAINED MACHINE OPERATOR UNDER FOREMAN/ PRODUCTION MANAGER SUPERVISION	FOLLOW PROCEDURE	AT OPERATION SITE	BEFORE CRUSHER OPERATIONALIZATION	PREPARE SPARE PARTS (GEARS, BEARINGS, BOLTS AND NUTS) AND TOOLS (SPANNERS, GREASE PUMP ETC.
			DAILY AFTER OPERATION	WITH HELP A SOFT CLOTH WIPE DRY THE MACHINE
				WITH HELP OF A PLASTIC SHEETING COVER THE HOPPER TO KEEP MOISTURE AND EASY THE NEXT OPERATION
				IN THE RECORD BOOK;RECORD BREAKDOWNS AND THE MAINTENANCE ACTIVITIES DONE
			WEEKLY	DO A GENERAL MAINTENANCE OF THE MACHINE (CLEANING, LEVELLING, LUBRICATION OF MOVING ELEMENTS (GEARS,BEARINGS, ETC.)
			AFTER 100HRS OF OPERATION	CHANGE ENGINE OIL

*Crusher maintenance instructions*

Who	HOW	WHERE	WHEN	PROCEDURE
MACHINE OPERATORS	FOLLOW PROCEDURE/	AT OPERATION SITE	DAILY AFTER OPERATION	WIPE DRY THE MACHINE WITH A SOFT CLOTH
				COVER THE MOLD WITH A PLASTIC SHEETING TO KEEP MOISTURE AND EASY THE NEXT OPERATION
				IN THE RECORD BOOK;RECORD BREAKDOWNS AND THE MAINTENANCE ACTIVITIES DONE
			WEEKLY	WITH HELP OF A SCRAPER REMOVE CLAY IN THE CLAY BOX AND IN THE MOLD HOLDER
				GENERAL MAINTENANCE OF THE MACHINE (CLEANING, LEVELING, LUBRICATION OF MOVING ELEMENTS, SPECIFICALLY BEARINGS, ETC.)

*Manual extruder machine maintenance instructions*

32 Forms

MAINTENANCE CHECKLIST FOR A 30HP DIESEL ENGINE POWERED CRUSHER						
No	Machine part	Current status	Action taken	Involved staff	Schedule for next check	Comments
1.	Driving system	Motor (temperature during operation,sound,bearing,tightness				
		V belts,pulley and coupling status				
		Oil level				
		Oil quality(Viscosity)l				
		Availability of consumables(oil,grease,bearing,V belts,Diesel)				
2.	Double rollers	Distance between rollers				
		Status of bearings				
		Centricity of shafts				
3.	Coupling system	Status of the fan electricity and the pedals				
		Status of rubber for chock absorbtion				
		Coupling status on engine side and crusher side				
		Bearing stutus				
4.	Cooling system	Connection between the tank and the engine,and the filling of water				
		Air circulation status once the engine resist in switching on				

Checklist for the motorized crusher

MODERN BRICKS PRODUCTION MONITORING ...../...../20.....							
1.CLAY							
Activity	Date/Period	men	women	equipment used			
excavation							
transportation							
2.CLAY PREPARATION							
	period/date			men	women		
2.1.manual clay preparation	...../...../202.....						
2.2.mechanised clay preparation	...../...../202.....						
machine code	operation hours/day	QTY crushed (nbre of bricks)	diesel used (litters)	type of breakdown		change of engine oil	change of gears oil
RCM.....			.....			✓	✓
3.MOLDING AND PRIMARY DRYING							
machine code	MEE.....	MEE.....	MEE.....				
green brick dimensions Lxhxh(cm)							
green brick weight(kg)							
QTY of bricks mold/per machine							
labor	.....men and.....women	.....men and.....women	.....men and.....women				
change of smoothening material	✓						
change of cutting wires	✓						
mold adjustment	✓						
type of breakdown							
repair	✓						
replacement	✓						
4.SECONDARY DRYING							
total bricks dried= ..... bricks	time taken for drying		results(number of good bricks from the batch)	Labor			
	from(date)	to(date)		men	women		
primary drying			.....bricks				
Secondary drying			.....bricks				
<b>Note:</b>	1. In order to succed the daily production monitoring; brick batches labering is necessary						
	2.Please follow the instructions attached for a safe operation of the machines						
COMMENT							
<b>BRICKYARD MANAGER/FOREMAN NAMES &amp; SIGNATURE:</b>							

Modern bricks production monitoring

KILN FIRING MONITORING FORM 202.....												
type of the kiln:.....												
Bricks loaded												
	chamber/ zone1	chamber/ zone2	chamber/ zone3	chamber/ zone4	chamber/ zone5	chamber/ zone6	chamber/ zone7	chamber/ zone8	chamber/ zone9	chamber/ zone10	chamber/ zone11	chamber/ zone12
QTY of bricks loaded												
Bricks dimensions (LxHxh) (cm)												
temperature monitoring												
firing date time	chamber/ zone1	chamber/ zone2	chamber/ zone3	chamber/ zone4	chamber/ zone5	chamber/ zone6	chamber/ zone7	chamber/ zone8	chamber/ zone9	chamber/ zone10	chamber/ zone11	chamber/ zone12
...../.....h.....												
...../.....h.....												
...../.....h.....												
...../.....h.....												
<b>FUEL USED</b>	saw dusts(bags)										maize cobs(bags)	
<b>LABOR</b>	men											
QTY of well fired bricks												
QTY of underfired bricks												
QTY of overfired bricks												
Bricks dimensions (cm)												
<b>Note:</b> write a detailed observation at the back												
<b>BRICKYARD MANAGER/FOREMAN NAMES &amp; SIGNATURE:</b>												

Kiln firing monitoring form

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