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Wall Building
Technical Brief
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Preparation of Clay for Brickmaking

Introduction

This is the first of four Technical Briefs. The other three will deal with "Moulding", "Drying", and "Firing of Bricks and Tiles".

Clay for brickmaking is prepared differently in a rural environment - manually in small brick yards - and near towns and urban areas mostly in large-scale factories employing heavy-duty machinery and equipment. Since modern clay works quite often cannot satisfy the demand for bricks and tiles, rural brickmakers are increasingly playing an important role as suppliers and thus, are confronted with the demand for good quality fired clay products.

Clay as a raw material must be prepared to guarantee a high quality end product. Its transformation makes it suitable for the ongoing manufacturing process. Clay preparation follows after winning and extracting the raw material and is done prior to moulding and shaping. It is often regarded as a burden by the rural brickmaker and as an energy-consuming factor by larger brick factories. In addition, the preparation process takes its time, if it is done correctly. But neglecting a proper preparation of the clay raw material results in cracks during drying, visible defects of the fired bricks and tiles and therefore in low quality of the end product. Preparation is the second stage in the long process of brick and tile production and is done in three stages.

Stage 1: Clay Disintegration

Concept

Clay disintegration as an important aspect of clay preparation was already known long ago, especially in China. There potters knew that excavated clay had to be "weathered" (exposed to rain, wind, sun) for several months, even years, in order to achieve the required plasticity for turning it into a product. The clay has to "open", and soften to become plastic for moulding. A potter will never begin to form a pot or shape a sculpture unless the clay has sufficiently weathered, is well mixed, and he has tested its workability.

Clay is a conglomerate of different minerals (Fig.1). Disintegration of clay is achieved when the fine-sized pores of clay lumps (which are blocked) are opened up. Clay minerals are bound together by nature and need to be "unlocked". All clay lumps should be crushed before the clay is exposed to weathering. Thorough mixing is needed afterwards before moulding can take place.

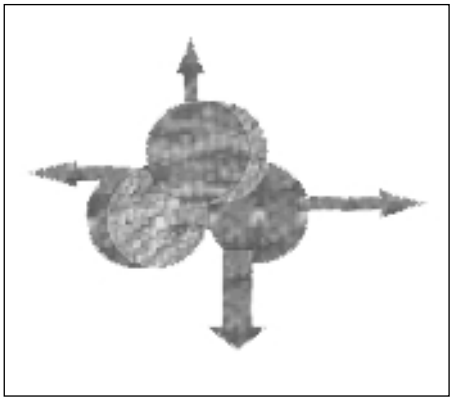

Fig.1: Conglomerate of different minerals

Practice

Today the old methods for weathering clay are no longer practised in large brick factories. They are compensated with heavy-duty equipment and a short-time tempering ("fermenting"). Rural brickmaker, however, should follow the potter's way of practicing "weathering" for achieving higher quality bricks and a larger production volume: The moist clay is dug from the pit and left to dry exposed to the sun. In the following dehydration process clay lumps will shrink and consequently crack. The clay minerals bound together are forced to open up. This slow process will continue over the days. Dew and rain will set on the lumps' surface and start softening up the top layers. The process is repeated until the clay material is soft thoughout.

Stage 2: Clay Crushing

Concept

During clay disintegration particle sizes of the clay material may not yet be small enough for the ongoing production process and the final product. For the production of ordinary bricks (24cm x 11,5cm x 7,5cm) weathered material containing tiny clay lumps which have not disintegrated during the weathering process are acceptable when they are mixed with the soft clay and will not cause any problems during moulding and firing. In tile production (floor and roof tiles of 2,5cm thickness) such clay lumps will cause problems during moulding and firing and should therefore not be accepted. As a general rule a brickmaker should not use clay particle sizes which exceed 10 to 20% of the product thickness. A potter will never accept prepared clay which is not homogeneous.

Practice

Already during the winning process of the raw material and additionally during preparation of the clay any roots, stones, limestone, etc. should be removed. Especially any limestone parts left will lead to defects of the clay product during firing. Soluable salts, inherent in the clay, can

unfortunately not easily be detected. They can later cause efflorescence.

Crushing is required where dry clay lumps are not tolerated (Fig. 2). A rural brickmaker will manually pound clay lumps with hoes and tampers. Horse-drawn rollers can also be employed. Simple, low-cost equipment has been developed for this purpose, such as pendulum crushers (see *"References"*). In large factories crushing is done mechanically with motor-driven machinery.

Stage 3: Clay Mixing

Concept

Extracted clay from a deposit is never homogeneous. After disintegrating and crushing the raw material it has also to be mixed to achieve a uniform distribution of all components inherent in the clay as well as those added during preparation, such as water, sand and other types of clays and also fuels (Fig.3). "Kneading" the clay is already achieving "mixing". Soft clay particles are forcefully mixed to form a homogeneous mass.

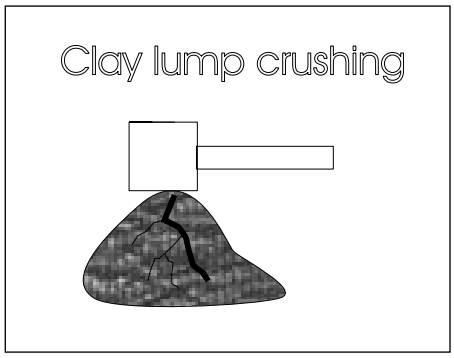

Fig. 2: Breaking up clay lumps for perfect preparation

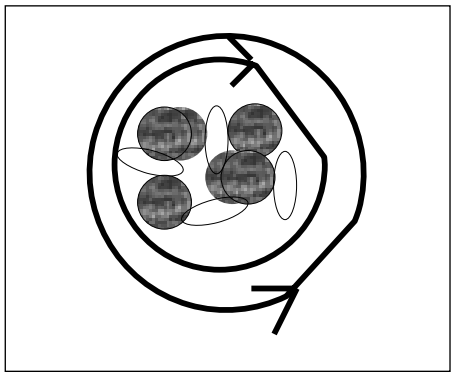

Fig. 3: Homogeneous mixing guarantees good quality products

Clay ready for production has two characteristics: The correct plasticity and bonding strength required for the final products, e.g. a clay with high plasticitiy and bonding strength is necessary for the production of thin-walled hollow bricks, perforated bricks, drain pipes and tiles.

Practice

Rural brickmakers and potters mix the clay material by treading the clay with their feet. For small-scale brickmaking and pottery enterprises this is sufficient. Commercial clay works employ homogenizing machinery for managing larger amounts of raw clay every day.

Clay Preparation Boxes

A well-known practice is the preparation of clay in so-called "preparation boxes" (Fig.4 and 5). These boxes, six in a row for each working day of the week, are built with burnt bricks. They should each be large enough to contain sufficient clay material for the production of about 1000 standard bricks. The boxes are 14 courses of bricks in height and 12 to 14 bricks in length deep.

Clay lumps are crushed after drying to the size of a fist and then spread out equally into each box, starting with the "Monday" box. Layers after layers in all boxes (each layer to the height of a brick layer) are watered with a watering can. The clay must not become too wet (such as mud). The water content is right if a moulded brick, placed on an edge, does not loose its shape. This test must be performed after each box of clay lumps has been filled up and watered. The last course of watered dry clay lumps in each box is covered up with bricks laid flat. After one week of rest the clay has softened throughout.This clay preparation method is similar to the use of a potter's soaking pit.

The required plasticity of clay can now be achieved by kneading or foot-treading.
The "mixed" clay is collected and stored under cover for at least 12 hours for further tempering. Thereafter tests are carried out to check on the plasticity and homogeneity of the material. For checking the correct grain size distribution before moulding a potter will form a little ball in his hand from the clay material. He will press the ball onto the back of his hand and observe the imprint. The clay is considered well prepared if no moisture is seen when the ball is removed.

Clay Preparation Equipment and Plants

Animal Powered Pug Mills

For rural brickmakers who are producing bricks only seasonally a well-proven method of clay preparation is the use of animal-powered pug mills (Fig. 6 and 7). Such simple mills are manufactured from empty oil drums. Long ago they were also made from wooden barrels. An arrangement of paddles and knives is fixed to a central metal shaft. A horse or a donkey is tethered to a long beam and turns the shaft. The clay material is mixed and discharged at the bottom of the drum or barrel and then stored for under-cover tempering. This simple clay preparation

Fig. 4: Clay preparation box

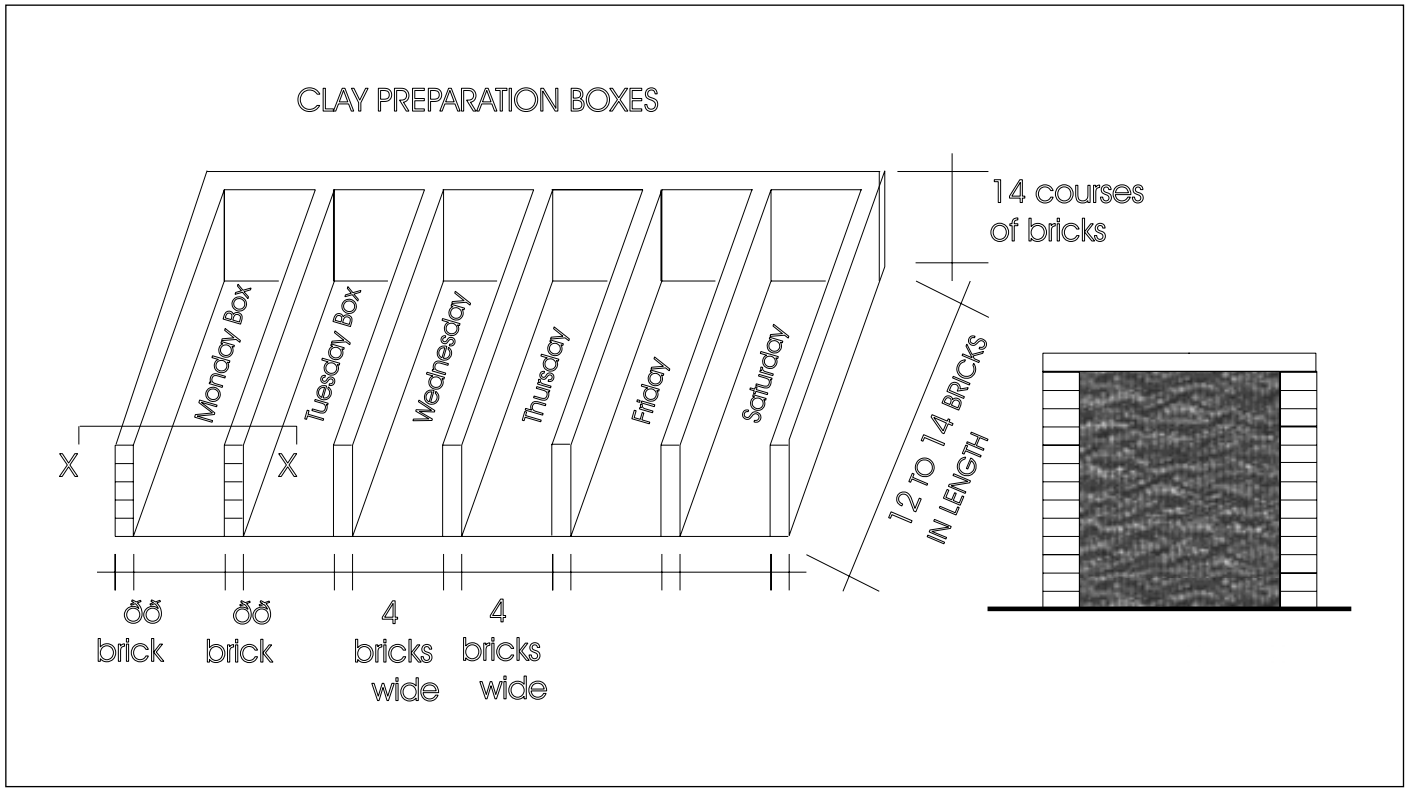

Fig. 5: One preparation box for each day - clay content for approximately 1000 bricks

method is appropriate for small-scale brick yards and can contribute very much to an improvement of the quality of burnt bricks and tiles.

From excavating the raw material onwards suitable mechanical equipment and motor-driven machinery can be used to ease the work for each further process. For example, bucket excavators can deliver larger amounts of clay lumps as manual labour who dig the clay with hoes and shovels and sort out stones and roots by hand. The six following plant arrangements are possible for medium-size to large brick yards (Fig. 8):

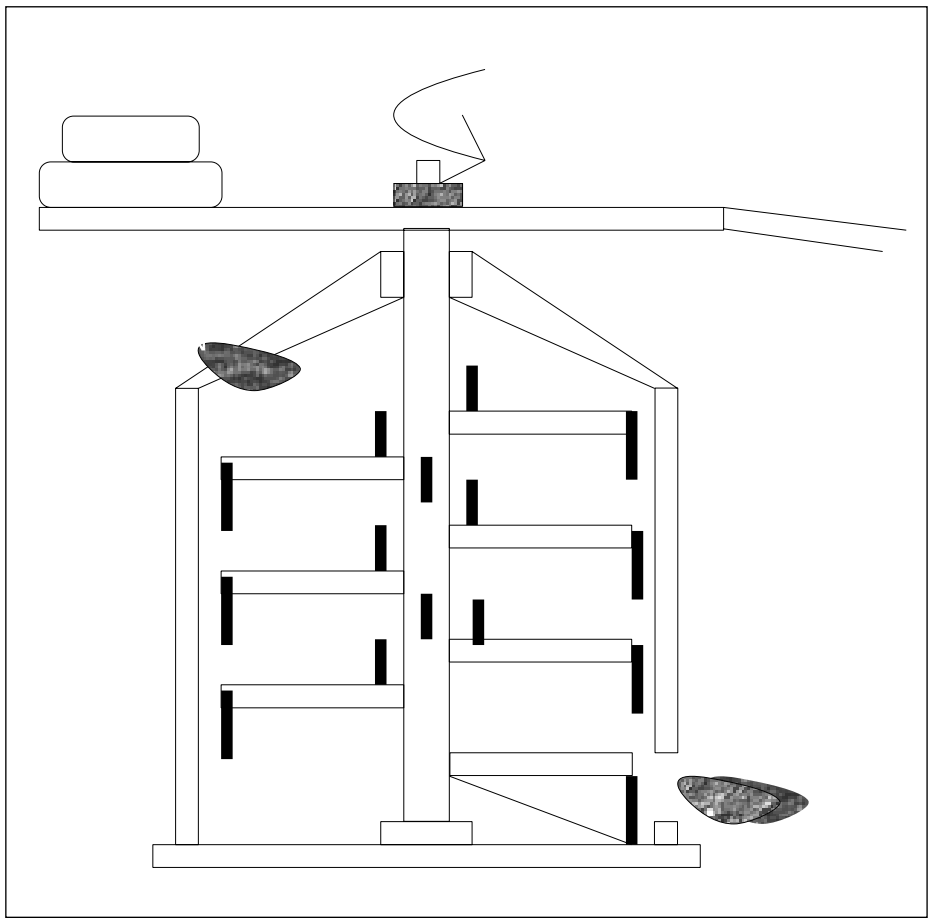

Fig. 6: Schematic drawing of an animal powered pug mill

Hopper - Belt Conveyor - Extruder:

This is a very simple plant arrangement with a minimum of machinery and still very labour intensive, since only very little clay mixing is done with the extruder.

Hopper - Belt Conveyor - Double Shaft Mixer - Belt Conveyor - Extruder:

The employment of a double shaft mixer aims at homogenizing the clay.

Box Feeder - Belt Conveyor - Double Shaft Mixer - Belt Conveyor - Extruder:

A box feeder is a useful equipment with regards to storage and constant supply of material. Already a certain amount of water can be added at the feeder to the material rather than only at the double shaft mixer.

Box Feeder - Belt Conveyor - Roller Mill - Belt Conveyor - Double Shaft Mixer - Belt Conveyor - Extruder:

The roller mill is integrated in this plant to assure that the final particle size of prepared material is less than 5mm.

Fig. 7: Layers of clay and coal dust ready for mixing in the pug mill

The design of a plant layout and selection of machinery arrangements will in each case depend on the condition of available raw materials and on the product requirements. It is generally advisable to have the clay already weathered and the material properly prepared before it is further processed by machinery.

Economics and Flexibility

In order to be less vulnerable if the market for products fluctuates, a clay preparation plant should be choosen or designed which is economic and flexible at the same time. Irregular electrical power supply has to be considered. A combination of motor-driven preparation machinery and of hand-operated tools and equipment is therefore feasible. Potential enterpreneurs should always be aware, however, that clay preparation is only one part of the brick and tile production process. Expert advice on the correct steps to be taken is available.

Box Feeder - Belt Coneyor - Roller Mill - Belt Conveyor - Double Shaft Mixer - Belt Conveyor - Vacuum Extruder (Fig. 9):

A vaccum extruder (or de-airing extruder) is integrated in the plant to achieve a higher densitiy of the material for moulding. This is especially required for thin-walled products.

Box Feeder - Belt Conveyor - Roller Mill- Belt Conveyor - Filter Mixer - Belt Conveyor - Vacuum Extruder (Fig. 10):

Integrated in this plant arrangement is a filter mixer which keeps back stones and roots. A filter mixer, however, needs a lots of spare parts and consumes a lot of energy.

Energy Requirements in Clay Preparation

Energy demand for clay preparation should be seen in relation to the product requirements. In most cases rural brickmakers and potters have only limited funds available or limited access to necessary financial provisions for investing

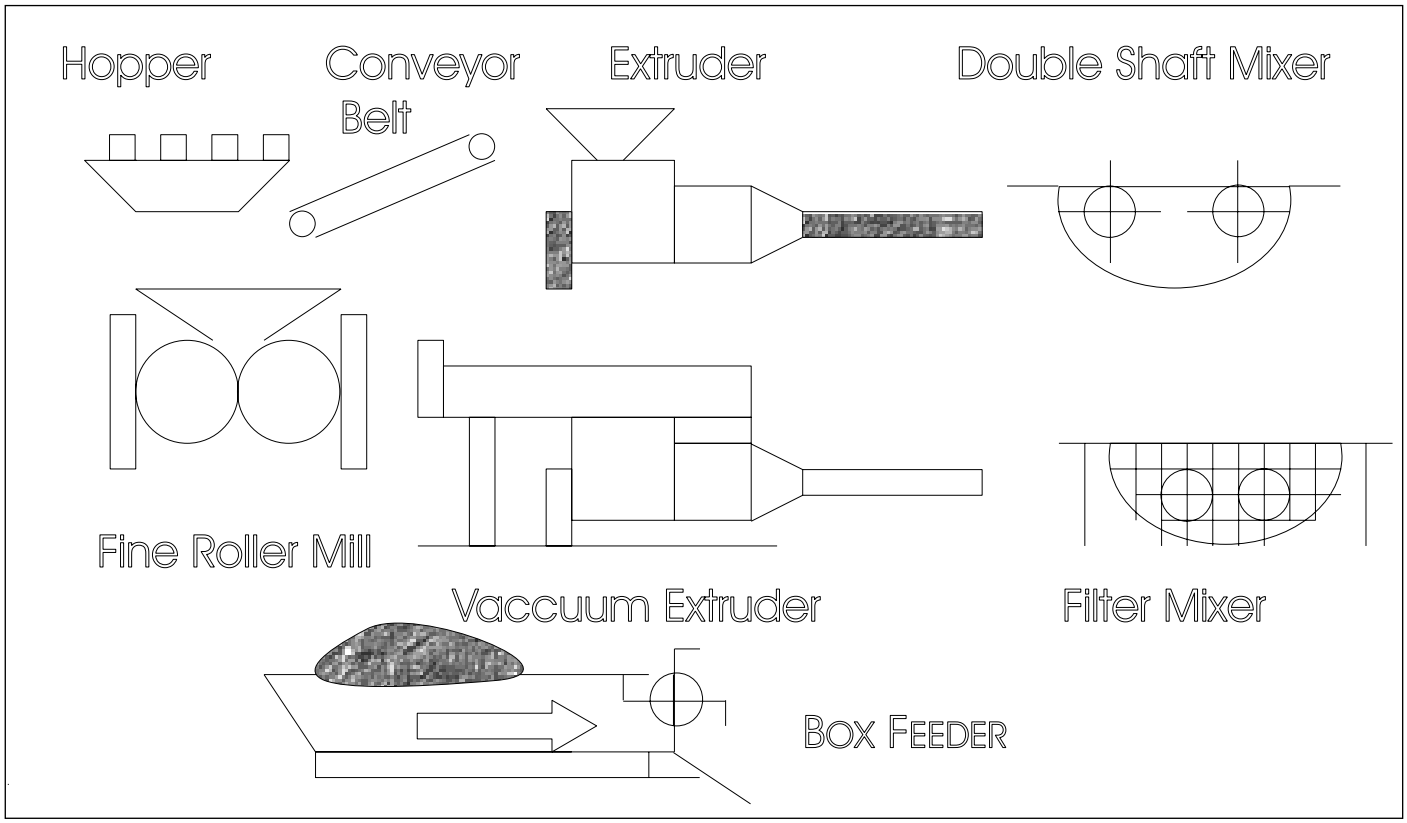

Fig. 8: Schematic drawing of clay preparation equipment

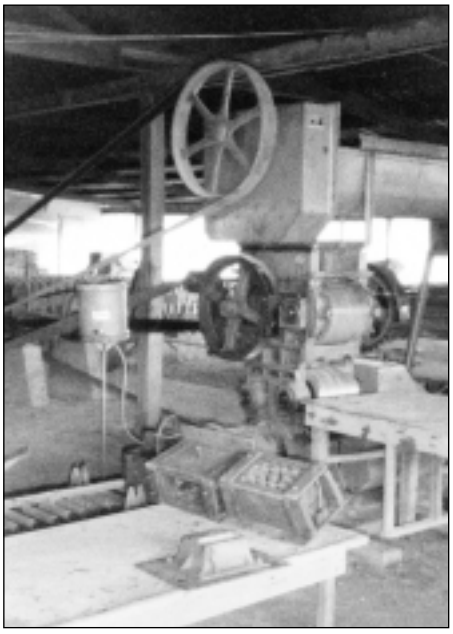

Fig. 9: Preparation plant suitable for clay without stones and roots

in mechanical clay preparation equipment. They mostly rely on manual production processes with hand tools and hand-operated equipment. Although this process requires little if no power-driven equipment it often results in low standard products. In addition rural brickmakers are faced with a lack of suitable fuel for firing their clay products. This is a serious problem especially in areas where firewood for firing bricks is scarce or no longer available.

Preparation of Clay and adding Fuel:

A considerable amount of firewood can be saved if suitable agricultural, forestry and industrial waste, such as coffee, rice and other husks, sawdust, and coal dust can be utilised as ad-mixture to the bricks during the clay preparation stage (Fig. 11 and 12).

For using about 10% (by weight) of saw dust or coal dust as ad-mixture, the clay used should have a high rate of shrinkage, or be very sticky or very fine. Before using saw dust it has to be soaked in water. The ratio of fuel to clay has to be found out by testing. Sand clays are absolutely unsuitable for being mixed with fuel waste materials, because the additional pores resulting in the firing process will reduce the compressive strength of burnt bricks and increase the rate of water absorption.

Experienced rural brickmakers will sometimes add fuel material to their clay for quite another reason: By just adding a little sawdust the tendency of cracking during the drying process will be reduced. A potter would in this case add crushed brick-dust or coarse sand to the clay material.

Fig. 10: A filter mixer for eliminating stones and roots

Fig. 11: Manual mixing of saw and coal dust with clay

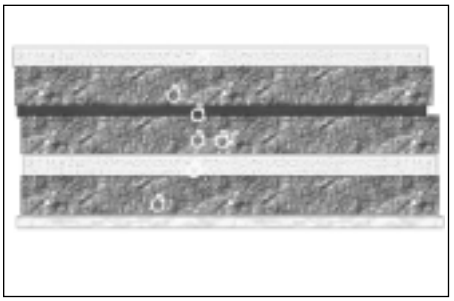

Fig. 12: Clay and solid fuels are mixed together

The Use of Anthill Soil

Anthill soil is very suitable for use as wall plaster and for pounded floors. It can also be used as a raw material for producing bricks of good quality. However, anthill soil can vary very much. The soil of huge, old anthills, for example, is not homogeneous. Also a lot of roots are often obstructing extraction of the soil. Many small stones are found in the outer layers of anthills. As they are covered with clay, they cannot easily be detected and are distributed irregularly in quantity and size. Some of these stones may also contain lime, which will cause cracking or even breaking of the bricks during the firing process. So anthill soil must be carefully examined before being used for brickmaking. Limestone found in anthills soil could be used for the production of slaked lime and as a binder and substitute for cement (for mortar and wall plaster).

Conclusion

Clays are part of the earth and of nature and are abundantly available. Earth and nature, however, differ from place to place. It is therefore not possible to offer "recipes" for clay preparation. Any clay raw material has its own "character". This should be considered when working with it. A brickmaker will gain experience in "reckognizing" the character of a clay material over the years by testing, experimenting and also by copying from other brick producers. Thus he will learn how to prepare the clay correctly.

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Table 1: Clay Preparation - inventory of effects

Qualities / **Characteristic**	disintegration	homogeneity	moulding	drying	risky production process	compressive strength	product quality	thin-walled products	flexibility
Clay with impurities/lumps		(-)	(-)	(-)	(0)	(-)	(-)		
Clay without impurities/lumps		(+)				(+)	(+)	(0)	
Clay analysed								(0)	(+)
Clay not analysed					(0)		(0)		
Clay is greasy			(+)	(-)	(0)	(+)	(+)	(0)	
Clay is sandy			(0)	(+)	(0)				
Prepared clay too wet/too dry			(0)					(0)	
Clay mixed with fuel		(0)		(+)		(0)	(0)		
Particle size below 5 mm	(+)		(+)				(+)	(+)	
Preparation by foot-treading	(0)	(+)					(0)	(0)	(+)
Employment of machines	(0)	(+)					(+)	(+)	(+)
Clay weathered		(0)	(+)						
Prepared clay tempered			(+)			(+)	(+)		
Anthill clay used					(0)				

(+) beneficial influence
(-) detrimental influence
(0) factor to be considered

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