TRAINING MANUAL

MANUFACTURING OF CONCRETE FLOOR / PAVEMENT TILES AND CONCRETE HOLLOW BLOCKS

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MANUFACTURING OF CONCRETE FLOOR OR PAVEMENT TILES AND CONCRETE HOLLOW BLOCKS

Objectives: At the end of this course, the trainees should:

- know what a concrete products manufacturer's job includes;
- be able to identify suitable materials used to manufacture concrete floor, pavement tiles and concrete building blocks;
- be able to test and identify good quality materials;
- be able to identify, describe, and maintain the necessary work tools and equipment;
- be able to sieve and clean materials before usage;
- know and be able to describe the mixing proportions of concrete and be able to mix concrete accordingly;
- be able to carry out and control the work related to manufacturing of concrete floor, pavement tiles and concrete building blocks in a qualitative proper way;
- be able to calculate the amount of material needed and the according cost of the products;
- know about safety and health measures in the workplace;
- know how to test the quality and be able to identify good quality concrete products as well as good quality clay bricks;
- know how to set up your own manufacturing site.

Duration of course: 7 days in total - 1 day in the class room, and 6 days practical work.

TABLE OF CONTENTS

1. Introduction

In other parts of the world, nowadays concrete blocks are very common and time proofed, earthquake resistant walling materials. Concrete blocks can be produced by hand and by machine. The specific use of a concrete block defines its size and the quality. One type of concrete blocks are Hollow Blocks. Hollow Blocks have better thermal properties than solid blocks of the same material and total thickness.

Hollow blocks have certain advantages over bricks, they are only about 1/3 of the weight of the same number of bricks. They can be laid about four times more rapidly and are of ample strength for all purposes for which ordinary bricks are used. They have the advantages of hollow walls as regards insulation against heat and sound. Moreover the production of concrete blocks is more environmentally friendly than the production of clay bricks because they do not have to be burned.

Looking at a different matter, the function of a house today is not only for shelter from rain and sun, but a simple house can be a clean, healthy and beautiful place. One way to create a clean and beautiful space inside the house, in the yard and parking area, is to use concrete paving blocks or concrete floor tiles.

Paving blocks and floor tiles can be used in and around houses and office buildings. The main function of this material is to cover the floor in a long lasting and clean way. Concrete pavement blocks and floor tiles can be laid without cement. This makes it a cheap and easy solution for water absorption and keeping the area mud free. Aesthetically, a simple building will be more beautiful with a nice yard floor and parking area. Different shapes, motives and patterns can be found in the market depending on the taste of the customers.

Many texts as well as pictures have been taken out of the “Basic Construction Training Manual for Trainers” written by Heini Müller (2004).

2. Job Description "Cement Products Manufacturer"

Cement Products Manufacturers mix, mould, compact, finish and cure concrete for various cement products such as pavement tiles, floor tiles, building blocks, wells, and decorative products, using hand tools, metal and wooden moulds, vibrators and mixing machines, if available.

2.1 Duties and Tasks

Cement Products Manufacturers may perform the following tasks:

- setting-up the workplace before starting to work;
- mixing cement, sand, aggregate, and water, to make concrete on site (mixing by hand, or using a mixing machine, if available);
- putting concrete into the according mould (usually temporary wood or metal moulds), making sure that the concrete is measured, spread and levelled, then compacted (using vibrators, if available);
- taking the moulded products out of the mould and placing it in the temporary storage;
- curing cement products for an appropriate time period;
- piling and storing cement products in a secure place;
- mixing and applying pigments when a coloured surface is required;
- maintaining the tools and equipment;
- cleaning the workplace in the end of the workday;
- marketing the cement products;
- informing and advising customers on specific products and quality of products;
- self-employed cement products manufacturers also need to manage their business (i.e. buying material, costing and pricing of products, book keeping, other financial related tasks…)

2.2 Personal Requirements

- Women, who enjoy working outdoors;
- Women, who are physically fit and strong as the work includes heavy lifting;
- Women, who enjoy practical work;
- Self-employed cement product manufacturers must also have a certain amount of business spirit, be potential business women.

2.3 Earnings

Generally, cement products manufacturers, who are employed as workers, are being paid per piece produced. At the time of writing this manual, the common piece rate for pavement or floor tiles as well as building blocks was Rp. 400 / piece. As two to three newly trained women working together are able to produce about 200 to 400 tiles or blocks per day, the daily earning of one cement products manufacturing worker is about Rp. 50.000 to Rp. 80.000. However, with time and practice the productivity rate for tiles or blocks per day will increase, and the daily wage will increase accordingly.

For self-employed cement product manufacturers, who have their own businesses, the earning depends on how successful they are in selling their products to their customers.

3. Materials / Consumables

For manufacturing concrete products the following materials are generally used:

- Cement
- Sand
- Aggregate
- Water

For using your mould, you will also need oil.

3.1 Cement – *(Additional reading – homework)*

Cement is a mixture of 60 to 67% lime, 17 to 25% silica and 3 to 8% alumina, which are intimately mixed together with water to form into a slurry, which is subsequently heated, dried, calcined and ground to a very fine powder. A small proportion of gypsum is added before grinding in order to control the rate of setting.

a) Setting/Hardening

The terms setting and hardening have different meanings. Setting is the process which changes a fluid concrete to a solid but weak state. Hardening is the process by which the weak set concrete attains strength.

b) Hydration of cement

When water is added to cement, the cement hydrates and during the chemical reactions, which take place while the cement is setting, an increase in temperature occurs and a considerable quantity of heat is generated.

c) Different types of cement

There are in total five different kinds of cements. Cements are classified by their properties and chemical composition. The names of these five kinds of cements are:

- Ordinary Portland Cement
- Rapid Hardening Cement
- Quick Setting Cement
- Blast – Furnace Slag Cement
- High Alumina Cement

d) Type and quality

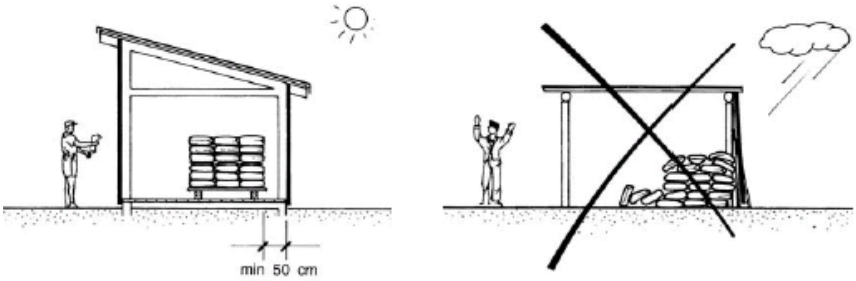
For concrete products such as building blocks and pavement / floor tiles it is recommended to use ordinary Portland cement. Brand names in Aceh are Andalas and Padang Cement. In general, and for concrete building blocks in particular, people prefer to use Padang Cement as the quality of this brand is perceived to be better and therefore can lead to increase the strength of the block immensely. For concrete pavement tiles Andalas Class 1 is also being used (there are three classes, one being the best, three being the lowest quality class).

In order to achieve good concrete products in strength and durability, it is essential that the following rules and regulations be followed:

- *Cement storage*

Cement can be safely stored in bags for a few months, if kept in a dry room. Paper bags are better for storing than jute bags because paper bags perform better in regard to quality deterioration due to moisture. During the rain season, the cement storage plays an even more important role, since the relatively higher humidity accelerates the deterioration process of the cement.

Cement bags should be stored on a raised wooden platform (e.g. timber pallets) about 15 to 20 cm above the floor level and about 30 to 50 cm away from walls. The cement stack should not be more than 10 bags high. The bags should be placed close together to reduce circulation of air. A cement bag should never be opened until its immediate use for mixing.



- *Use of fresh cement*

Ordinary Portland cement, which has been stored for over six months, should not be used for masonry work. The average reduction of strength in a 1:2:4 mix as a result of storage is:

- Fresh cement strength: 100%
- Cement after 3 months, strength reduced by 20%
- Cement after 6 months, strength reduced by 30%
- Cement after 12 months, strength reduced by 40%
- Cement after 24 months; strength reduced by 50%

e) Testing the cement quality

The indication of damaged cement is given by the presence of large lumps of set cement. These lumps of set cement should not be used, not even if screened again. The freshness of cement can be tested as per following description:

i) Lump test:

Check the cement for any small or large lumps. Remove them.

ii) Rubbing test:

When cement is rubbed between fingers and thumb it should feel like a smooth powder such as flour.

iii) Setting test:

If you are uncertain about your cement quality you can make a simple setting test. Make a stiff paste of neat cement and water and form it into a cake about 75 mm diameter and 12 to 15 mm thick. The cake should commence to set in about 30 to 60 minutes. In 18 to 24 hours the cake should have hardened sufficiently so that it does not effortlessly scratch the surface with a thumbnail.

f) Risks and dangers – Working with cement – Safety measures

Cement is widely used in construction. Anyone who uses cement (or anything containing cement, such as mortar, plaster and concrete) or is responsible for managing its use should be aware that, if not handled properly, it presents a danger for peoples' health.

- *Health effects*

If not properly handled, cement can cause ill health mainly by: skin contact, inhalation of dust, and manual handling.

Skin contact: Contact with wet cement can cause both dermatitis and burns.

Dermatitis

Skin affected by dermatitis feels itchy and sore, and looks red, scaly and cracked. Cement is capable of causing dermatitis by two mechanisms - irritancy and allergy. Irritant dermatitis is caused by the physical properties of cement that irritate the skin mechanically. The fine particles of cement, often mixed with sand or other aggregates to make mortar or concrete, can abrade the skin and cause irritation resulting in dermatitis. With treatment, irritant dermatitis will usually clear up. But if exposure continues over a longer period the condition will get worse and the individual is then more susceptible to allergic dermatitis.

Allergic dermatitis is caused by sensitisation to the hexavalent chromium (chromate) present in cement. The way this works is quite distinct from that of irritancy. Sensitisers penetrate the barrier layer of the skin and cause an allergic reaction. Hexavalent chromium is known to be the most common cause of allergic dermatitis in men. Research has shown that between 5% and 10% of construction workers may be sensitised to cement and that plasterers, concreters and bricklayers are particularly at risk. Once someone has become sensitised to hexavalent chromium, any future exposure may trigger dermatitis. Some skilled tradesmen have been forced to change their trade because of this.

The longer the duration of skin contact with a sensitiser, the more it will penetrate the skin, and the greater the risk of sensitisation will become. Therefore, if cement is left on the skin throughout the working day, rather than being washed off at intervals, the risk of contact sensitisation to hexavalent chromium will be increased. Both irritant and allergic dermatitis can affect a person at the same time.

- It is important for your health and safety that you apply control measures which minimise the contact of cement with your skin either directly or indirectly from contaminated surfaces in the working environment.

  An important way of controlling cement dermatitis is by washing the skin with warm water and soap, or other skin cleanser, and drying the skin afterwards. You should wash your forearms possibly with soap and both hot and cold (or warm) running water. Gloves also help to protect your skin from cement.

Cement burns

Wet cement can cause burns. The principal cause is thought to be the alkalinity of the wet cement. If wet cement becomes trapped against the skin, for example by kneeling in it or if cement falls into a boot or glove, a serious burn or ulcer can rapidly develop. These often take months to heal, and in extreme cases will need skin grafts or can even lead to amputation. Serious chemical burns to the eyes can also be caused following a splash of cement.

- It is important for your health and safety that you apply control measures which minimise the contact of cement with your skin either directly or indirectly from contaminated surfaces in the working environment.

Gloves will help to protect your skin from contact with cement. However, caution is advised when using gloves as cement trapped against the skin inside the glove can cause a cement burn. You should wear protective clothing, including clothes with long sleeves and long trousers.

Inhalation of dust

High levels of dust can be produced when cement is handled, for example when emptying or disposing of bags. In the short term, exposure to high levels of cement dust irritates the nose and throat. Scabbling or concrete cutting can also produce high levels of dust which may contain silica.

- Exposure to dust should be eliminated where possible, for example, by wearing a facial mask, which covers nose and mouth.

Manual handling

Working with cement also poses risks such as sprains and strains, particularly to the back, arms and shoulders from lifting and carrying cement bags, mixing mortar etc. More serious damage to the back can be caused in the long term if workers are continually lifting heavy weights.

- Manual handling of heavy loads should be avoided. In particular, cement should be supplied in 25 kg bags or ordered in bulk supply. Where manual handling does take place, you should be cautious to lift the bags in the correct way as described further below.

Health prevention and health surveillance

Employers should provide employees with information, instruction and training on the nature of the risk of contact with cement to health, and the precautions to be taken. This should include characteristic signs and symptoms of dermatitis.

Employees should be encouraged to examine their own skin for any such signs and take appropriate actions against them.

3.2 Sand and Aggregates – *(Additional reading – homework)*

Sand and aggregates are very essential building construction raw materials and deserve special attention.

a) Classification of sand and aggregates

Material retained on a 4,75 mm sieve is classified as coarse aggregate, and below that size as fine aggregate or sand. The material passing a 75-micron sieve is generally considered to be clay, fine silt or fine dust in an aggregate. Sand, which contains 90% of particles of size greater than 0.06 mm and less than 0.2 mm, is fine sand. Sand, which contains 90% of particles of size greater than 0.6 mm and less than 2 mm is coarse sand.

b) Coarse aggregate

There are mainly three sources from where coarse aggregates originate, namely:

- Natural deposits
- Crushed stones
- Brick aggregates

c) Sand

There are mainly four types of sand namely:

- Pit sand
- Sea sand
- River sand
- Crushed sand

d) Quality of sand and aggregates

The quality of the concrete is directly linked to the characteristics and condition of the sand. Sand and aggregates must be free from clay, loam, vegetables and any other organic material. Clay or dirt coating on aggregates prevents adhesion of cement to aggregate, slows down the setting and hardening process and reduces the strength of the concrete. Therefore, clay and silt content should not exceed 10%, otherwise the sand needs to be washed.

e) Sand storage

The sand should be stored preferably under a shade. The sand should be sufficiently protected, such that no impurity from animals, agricultural waste, children, trees, etc. is possible.

f) Testing the sand quality

There are two main sand quality-testing methods, namely:

1) Visible test

Check the sand for impurities such as organic materials (mud, leaves, roots etc.) Remove them before using the sand.

2) Clay and silt content test

The clay and silt content test can be undertaken in three ways:

i) Hand test

The sand sample is rubbed between your two damp hands. A clean sand will leave the hands only slightly stained. If the hands stay dirty, it indicates the presence of too much silt or clay.

ii) Bottle test

Take a bottle and fill in the sand until it is half full. Fill in clean water until the bottle is threequarters full. Shake up vigorously and leave it to settle for about one hour. Clean sand will settle immediately, silt and clay will settle slowly on top of the sand. The thickness of the clay and silt layer should not exceed one-tenth or 10% of the sand below. This test is also called decantation test. This test is not applicable to crushed stone sands!!

iii) Cloth test

Spread the sand on a clean surface. Rub a piece of white cloth over the sand. If the cloth is very dirty, the sand should not be used to make concrete.

Dirty sand should never be used for manufacturing of blocks or tiles because it will reduce the adhesive value of the concrete considerably.

g) Sea sand

Sea sand is unsuitable for mortar as it contains salts, which attract and retain moisture. In addition the salt content in the mortar will produce a whitish powder of efflorescence, which discolors the brickwork or masonry.

3.3 Water – *(Additional reading – homework)*

Not only the quality, but equally important the quantity of the water is important for producing good concrete products.

a. Type and quality

Almost any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water for making concrete products. Water suitable for making concrete, however, may not be fit for drinking.

b. Seawater

Seawater should not be used as mixing water for concrete.

c. Collected rainwater from roofs

Rainwater collected from roofs can be used for mixing concrete.

d. Oils

Various kinds of oil are occasionally present in mixing water. Water mixed with any kind of oil should not be used for mixing concrete.

e. Water storage

Water should be stored where no contamination is possible. Water stored in clean drums or covered tanks is preferred. The age of the water, or the storage time does not affect the concrete product quality in any way.

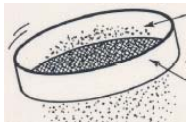
4) Tools and Equipment

Before starting to work, the appropriate hand tools and equipment have to be carefully selected. Tools should always only be used for their intended purpose.

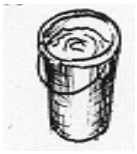
A tool which is regularly maintained, cleaned and kept in a dry place will last longer and will also be more pleasant to use.

Below a list of tools/equipment for manufacturing concrete products:

- building block moulds
- tiles moulds
- sand sieves (big and small) (pic. 1 and pic. 2)
- sand mixing boxes (pic. 3)
- trowels (pic. 4)
- shovels (pic. 5)
- hoes
- watering cans
- buckets (pic. 6)
- wooden plates (triplek for pavement/floor tiles only)
- plastic canvas (for covering your products in order to keep them moist)





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5) What is Concrete? – *(Additional reading – homework)*

In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of portland cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete. Within this process lies the key to a remarkable trait of concrete: it is plastic and workable when newly mixed, strong and durable when hardened. These qualities explain why one material, concrete, can build skyscrapers, bridges, sidewalks and superhighways, houses and dams.

The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. A concrete mixture that does not have enough paste to fill all the voids between the aggregates will be difficult to mould and will produce rough, honeycombed surfaces and porous concrete. A mixture with an excess of cement paste will be easy to mould and will produce a smooth surface; however, the resulting concrete is likely to shrink more and be uneconomical.

A properly designed concrete mixture will possess the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10 to 15 percent cement, 60 to 75 percent aggregate and 15 to 20 percent water. Entrained air in many concrete mixes may also take up another 5 to 8 percent. Portland cement's chemistry comes to life in the presence of water. Cement and water form a paste that coats each particle of stone and sand. Through a chemical reaction called hydration, the cement paste hardens and gains strength. The character of the concrete is determined by the quality of the paste. The strength of the paste, in turn, depends on the ratio of water to cement.

5.1 Hydration begins – *(Additional reading – homework)*

Soon after the aggregates, water, and the cement are combined, the mixture starts to harden. All portland cements are hydraulic cements that set and harden through a chemical reaction with water. During this reaction, called hydration, a node forms on the surface of each cement particle. The node grows and expands until it links up with nodes from other cement particles or adheres to adjacent aggregates. The building up process results in progressive stiffening, hardening, and strength development. Once the concrete is thoroughly mixed and workable it should be placed in forms before the mixture becomes too stiff. During placement, the concrete is consolidated to compact it within the forms and to eliminate potential flaws, such as honeycombs and air pockets.

Curing begins after the exposed surfaces of the concrete have hardened sufficiently to resist marring. Curing ensures the continued hydration of the cement and the strength gain of the concrete. Concrete surfaces are cured by sprinkling with water fog, or by using moisture-retaining fabrics such as burlap or cotton mats. Other curing methods prevent evaporation of the water by sealing the surface with plastic or special sprays (curing compounds). Special techniques are used for curing concrete during extremely cold or hot weather to protect the concrete. The longer the concrete is kept moist, the stronger and more durable it will become. The rate of hardening depends upon the composition and fineness of the cement, the mix proportions, and the moisture and temperature conditions. Most of the hydration and strength gain take place within the first month of concrete's life cycle, but hydration continues at a slower rate for many years. Concrete continues to get stronger as it gets older.

5.2 The forms of concrete – *(Additional reading – homework)*

Concrete is produced in four basic forms, each with unique applications and properties. Ready mixed concrete. It's batched at local plants for delivery in the familiar trucks with revolving drums. Precast concrete products are cast in a factory setting. These products benefit from tight quality control achievable at a production plant. Precast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding. Concrete masonry, another type of manufactured concrete, may be best known for its conventional 8 × 8 × 16 - inch block. Today's masonry units can be molded into a wealth of shapes, configurations, colors, and textures to serve an infinite spectrum of building applications and architectural needs. Cement-based materials represent products that defy the label of "concrete," yet share many of its qualities. Conventional materials in this category include mortar, grout, and terrazzo. Soil-cement and roller-compacted concrete - "cousins" of concrete - are used for pavements and dams. Other products in this category include flowable fill and cement-treated bases. A new generation of advanced products incorporates fibers and special aggregate to create roofing tiles, shake shingles, lap siding, and countertops. And an emerging market is the use of cement to treat and stabilize waste.

5.3 Functions and requirements of concrete ingredients – *(Additional reading – homework)*

a) <u>Functions of cement</u>

- It fills up the voids in the fine and coarse aggregates.
- Make the concrete impermeable.
- It provides strength to concrete on setting and hardening.
- It binds the aggregates into a solid mass by virtue of its setting.
- Hardens when mixed with water.

b) <u>Functions of sand</u>

- Sand fills the voids existing in the coarse aggregates.
- It reduces shrinkage of concrete
- Sand helps in hardening of cement by allowing the water through its voids.

c) Functions of coarse aggregate

- It makes solid and hard mass of concrete with cement and sand.
- It reduces the cost of concrete, since it occupies more volume.

d) Functions of water

- Water wets the surface of aggregates.
- It facilities the spreading of cement over the aggregates and makes the mix workable.
- It initiates the hydration process of the cement, subsequently starts the setting and hardening process.
- It controls the heat generated by the hydration process of the cement.

The strength of the concrete depends on mix proportions and should suit the work being done. Different applications require different strengths of concrete.

5.4 Requirements of concrete

a) Strength

The concrete must be strong enough to bear the imposed stresses safely in each with the required factor of safety. It will be uneconomical making the concrete stronger than desired, but at the same time its minimum strength must be ensured.

b) Workability

The concrete mix used should be such that it can be easily mixed, moulded, compacted and finished at the surface with minimum of effort i.e. the concrete should be workable.

5.5 Factors influencing concrete quality – *(Additional reading – homework)*

a) Cement

The cement quality is a very import factor that influences the basic requirement of the concrete. Cement must be fresh and free from any lumps. The grading of the cement is important, too. A high grade cement, e.g. Grade 53 is gaining more rapid strength than a Grade 33 cement. However, after 90 days, both types of cement will have approx. gained the same final strength. In Aceh Padang Cement is the best quality cement available and should be used in particular for concrete building blocks.

b) Water – Cement ratio

The ratio of minimum quantity of water to the weight of cement, required to obtain the desired consistency and workability of concrete mix is called: water cement ratio. Concrete strength decreases with the increases in water cement ratio. This is because the added water once evaporated leaves behind very very small voids. The more voids there are in a concrete, the weaker it becomes.

c) Raw materials

The sand and aggregate must be free of leaves, grass and other foreign matters. Sand should be fairly coarse with particle sizes ranging from fine dust up to about 5mm. Clean aggregate with sizes of 26,5 mm, 19 mm, 13,2 mm or 9,2 mm can be used for concrete. Aggregate size of 26.5 mm can be used for thick sections such as foundations, deep suspended slabs and industrial floors thicker than 120 mm. 19 mm aggregates can be used for floors, paths and driveways. Aggregates 13,2 mm or 9,5 mm can be used for thin concrete sections such as thin suspended slabs, precast items with sections' thickness ranging from 40 mm to 50 mm.

d) Fineness of fine aggregate

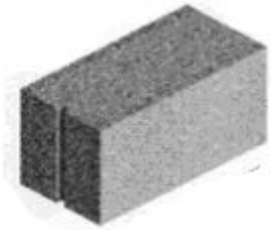
Concrete strength decreases with increases in fineness of fine aggregate. This is because the fines require a lot of cement for a total coverage, resulting into a leaner overall mix.

6) Different types of blocks and tiles:

Concrete blocks come in all shapes and sizes. The term building block properly refers to the rectangular units used for building solid walls.

- Concrete blocks are classified into two main groups:

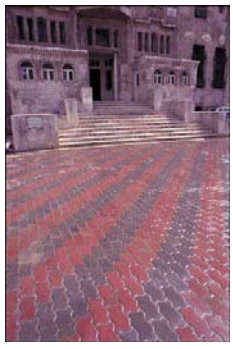
Solid Blocks



Hollow Blocks

Hollow blocks have better thermal properties than solid blocks of the same material and total thickness. Hollow blocks have certain advantages over bricks, they are only about one 3rd of the weight of the same number of bricks and they can be laid about four times more rapidly and are of ample strength for all purposes for which ordinary bricks are. They have the advantages of hollow walls as regards insulation against heat and sound.

- Pavement / Foor Tiles have different shapes, patterns, and colours



7) How to make pavement tiles/ building blocks?

7.1 Preparation

- Set up equipment, tools and material
- Sieve the sand, as a first step with 1 cm² sand sieve in order to separate bigger rocks. As a second step sieve with smaller mesh sieve (such as 4,5 mm²) in order to get fine sand. The sand must be clean from dirt, garbage, and mud.

7.2 Mixing of concrete

Mixing of concrete is usually done by hand for small quantities or by machine for big quantities.

a. Hand mixing

Hand mixing is adopted where in smaller quantities of aggregates is involved or the involvement or procuring of mixing machines is out of reach. Mixing shall always be done on a watertight platform in order to avoid cement water seepage.

Procedure for proper hand mixing:

- Spread the measured quantity of sand in a layer of about 10 cm on the mixing platform;
- Place the cement on top of the sand and mix the two thoroughly together until they form an even color;
- Pile the mixture into a heap and make a hollow in the middle;
- Pour in water slowly in small quantities and mix until a smooth paste is formed;
- If you choose to use aggregate, add now the correct amount of aggregate and mix until every aggregate is properly coated.
- Check your mix: take a handful of the mix and form a small ball. If the ball in your hand does not crack, and your hand is a little bit wet, the mix is ready to be moulded.

Flatten the dry mix with a trowel, if properly mixed a uniform gray color is visible.

Add water only once a uniform gray color is visible.

b. Machine mixing

Machine mixing is required for large quantities of concrete work and for good workability for placing the concrete in a short time and with no wastage. Concrete having coarse aggregates is mixed in concrete mixers.

Procedure for machine mixing:

- Measure the quantities of each ingredient;
- First add the aggregates and some amount of water, then the cement, then the sand;
- Mix and add more water until the right consistency is reached;
- Empty the mixer completely when discharging each batch;
- Clean the concrete mixer thoroughly on completion.

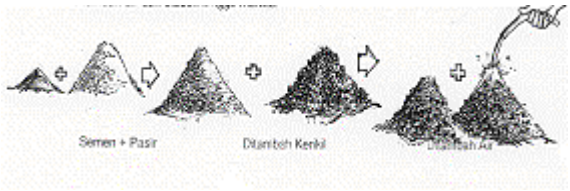
7.3 Different mix ratios

Based on your customers needs and different qualities of your products, the mix ratio for your concrete can be various. In general, the more cement you use in your mix the higher the quality you will achieve (but also the more expensive your product will be for the costumer).

a) Paving blocks / Floor tiles:

To make a **high quality paving block**, which can be used especially where continuously heavy loads occur (e.g. parking area), your mix ratio should be:

1 part good quality cement + 2 parts clean river sand + 3 parts fine aggregate + sufficient water

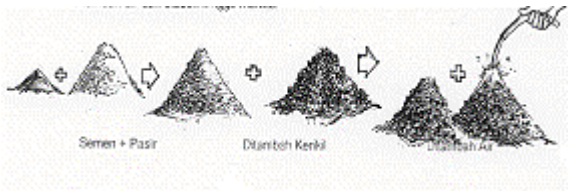


In order to produce a **lower quality of paving block**, you may use less cement and more clean river sand in your concrete mix (i.e. 1 part cement + 2 parts clean river sand + 4 parts fine aggregate sufficient water; 1 part cement + 4 parts clean river sand). This lower quality paving block may be used inside the house, in the front and back yard of a house, where no heavy loads are pressed onto the floor.

b) Concrete hollow blocks:

To make a **high quality concrete hollow block**, which can be used for walls of houses, your mix ratio should be:

1 part good quality cement + 2 parts clean river sand + 3 parts rough gravel + sufficient water



Keep in mind that for building houses **always** best quality blocks are to be used as the safety of families moving into the houses is at play. If you sell lower quality building blocks for building houses, risks are very high that the newly built walls will collapse and bury the occupants of the house underneath. If you sell these lower quality blocks without explaining the dangers and risks to your customers, you will be responsible for their grieve as a consequence of a collapsed house.

7.4 Moulding the concrete

The concrete after mixing must be placed in the defined position and compacted before the initial setting of cement starts. Before the moulding of concrete starts, it must be ensured that the moulds are rigidly braced, true to their position, oiled, cleaned and dried of any standing water. If concrete is moulded on the ground (e.g. for concrete building blocks), the soil should be level (flat), clean and thoroughly damp, but without any standing water when the concrete is moulded. A plastic canvas may be used to ensure that the soil is clean. Work the concrete right into the corners and along the edges of the moulds with a spade or a trowel.

a) Pavement / Floor Tiles

1) Fill the concrete mix into your measuring device (i.e. bucket with line for proper measurement);
2) Open the cover of the mould;
3) Set the mould into the filling position;
4) Pour the exact amount of measured concrete mix into the machine (every time use the exact same amount of concrete mix, so you will get the exact same tiles – same thickness, same strength, same quality);

5) Close the cover of the mould;
6) Set the handle into the compression position. Don't forget to use the hook;
7) Press the handle down until it does not move any further down;

8) Lift the handle back up to its initial position (upright), then unlock the hook;
9) Open the cover of the mould, press back down the handle until your tile is fully out of the mould;
10) Leave the handle carefully on the ground;
11) Carefully, lift the pavement tile together with metal plate off the mould, place a triplek on top of the ready moulded tile, then carefully turn the tile 180 degrees (top down);

12) Carefully place the product in your cool temporary storing space (no direct sunlight), and let it sit there for one day (after this one day it needs to be cured for at least one week→ procedure see explained below);
13) Clean your mould (including the metal plate) from the remains of the previous tile and dust. Sometimes you also need to oil your mould;
14) Put the metal plate back into original place within the mould;
15) Re-set the mould into filling position and follow steps 3-12 for making your next tile.

→ Once you are finished working for the day, cover up your tiles moulds with a dry plastic canvas or something similar, and store your tools and material in a save and dry place.

b) <u>Building Blocks</u>

1) Fill the concrete mix into your measuring device (i.e. bucket with line for proper measurement);
2) Put the bottom part of the block mould into its proper position (underneath a roof structure – shadowy place);
3) Oil the lower part of the block mould;
4) Pour the exact amount of measured concrete mix into the block mould (every time use the exact same amount of concrete mix, so you will get the exact same blocks – same size, same strength, same quality);

5) Put the compressive device of your block mould on top of the lower part of the mould;
6) Press the compressive device straight down until its “feet” touch the floor on both sides;
7) Step with your own feet onto the “feet” of the block moulds’ compressive device, bend over the mould, take the handles of the lower part of the block mould into your hands, and carefully lift the bottom part of the mould slightly up;
8) Carefully, set the bottom part of the mould back down onto the ground;
9) Take off the compressive device from the lower part of your mould, and set aside;
10) Carefully lift the lower part of the mould straight up, and place next to your ready moulded building block;
11) Leave your newly moulded building block, where it is for one day (do not move, but make sure it does not come in touch with direct sunlight);
12) After this one day, your blocks can be piled up, and need to be cured for at least one week (proper procedure see explained below)
13) Clean your mould from the remains of your previous block and dust;
14) Oil your mould;
15) Follow steps 2-14 for making your next block.

7.5 Cleaning up

At the end of a working session you should clean all tools and equipment thoroughly by washing and scrubbing them with a wire brush – stubborn patches of hardened concrete can be rubbed down with a piece of brick. If you have been using a concrete mixer, run the mixer for about fifteen minutes with a small load of aggregate and water to sour it, and clear any stubborn accumulation with a scraper and wire brush. Clean the outside of the mixer as well. Make sure nothing gets into drains.

→ Once you are finished cleaning your tools and equipment, store your block moulds as well as tools and material in a save and dry place.

8 Principles of curing – *(Additional reading – homework)*

Curing is the treatment or protection of concrete during its hardening period. Curing measures are necessary to maintain a satisfactory moisture and temperature condition in the concrete, because internal temperature and moisture directly influence early and ultimate concrete properties. Curing measures prevent water loss from the mixture and allow more thorough cement hydration. To maximize concrete quality it is necessary to apply curing measures as early as possible after moulding concrete. Curing is also critical to providing a durable pavement surface.

8.1 What is curing?

Curing must be made with every building material, construction part or product that is using cement as part of the raw material. This is because cement requires water to initiate the hydration process and to control the internal temperature generated by this process in order to obtain optimal hardening and strength of the cement. This internal temperature controlling with water is called curing. Uncontrolled hydration process initiated temperatures will lead to overheating of cement and a very substantial loss of hardness and final strength of the cement product such as concrete, mortar etc. Good curing means evaporation should be prevented or reduced.

8.2 Types of curing

There are generally 3 main type of curing used in the construction sector, namely:

a) Water curing
b) Vapor curing
c) Steam curing

a) Water curing

Water curing is the most commonly used practice. It is the system that is most appropriate for house construction and does not require any special infrastructure or skill. However, water curing requires a lot of water, which is not always easy at hand and might be even expensive.

In order to economize on water it is important that all measures are taken to prevent water evaporation of cement products. E.g. concrete must be protected from direct sunshine and winds to prevent rapid water evaporation. Methods such as covering the concrete with wet, earth, sand, sawdust, grass and leaves are inexpensive, still quite effective. Further, plastic, jute bags, hessian clothes too are common used material to prevent rapid water evaporation of cement products. Wood forms left in place also furnish good protection if they are loosened and flooded with water at frequent intervals.

It is of paramount importance that the entire cement product (concrete blocks, pavement tiles, stone masonry, brick masonry, plaster work, cement flooring work etc.) is kept wet and that it does never fully dry out, otherwise the final strength of the cement product will suffer. If the hydration process has prematurely ended due to overheating (no curing), sprinkling water onto the fully dried out cement product will not reactivate the hydration process, the loss in strength will be permanent. In water curing, the cement product must be kept fully wet (e.g. by covering the products with plastic canvas) for at least 7 days.

b) Vapor curing

Vapor curing is done where water is scare and cement based prefabricated elements such as toilet slabs, tiles, stairs, beams etc are mass-produced. Vapor curing reduces the curing time compared with simple water curing of about 50 to 60%. The principle of vapor curing is to keep the cement product in a humid and hot environment that allows the cement to gain strength in a much quicker way then with simple water curing. To create this humid and hot environment a simple chamber with water retaining walls and floor needs to be constructed which is covered with plastic to allow the sunshine to heat the chamber up and prevents the water from evaporating. A floor water level of about 5 to 7 cm is to be maintained all the times to keep the vapor system principle working.

c) Steam curing

Steam curing is normally used in only very sophisticated industrial plants that produce mass cement based produces. A steam curing system is expensive and requires a lot of energy to generate the required heat required for the steam. However, steam cured products can be used after approx. 24 to 36 hrs. after production, providing a distinctive advantage over all other curing systems.

Effect of aging

Basically if all rules and regulation for concrete manufacturing are properly followed, concrete gains strength by aging. However, the rate of increase in strength decreases with time.

9 Dos and don'ts – *(Additional reading – homework)*

Dos 1: Always calculate exactly how much finished concrete is required for the job to do and ascertain how much cement sand, coarse aggregate and water will be required

Why?
Even a good guess can go wrong. While guessing the amount of material required it can happen that you order to much, resulting into unnecessary expenses. It might also happen that you order too less and organizing immediately the remaining material might proof to be difficult or even impossible, resulting into unnecessary expenses and loss of quality.

Dos 2: Use always-clean sand and aggregates for concrete.

Why?
Contaminated sand and aggregate (e.g. roots, leaves, plastic parts, saw dust, animal and human excreta etc. will not bind with cement, hence is weakening the concrete. Also sand and aggregate with high percentage of clay or silt will weaken the concrete, because the clay or silt contains too many fines that needs to be covered by cement for proper binding, hence,
the concrete becomes weak.

Dos 3: Always use fresh and lump free cement for concrete

Why?
Old cement is loosing its strength property. E.g. cement that has been stored for about 6 months is gaining 30% less strength than fresh cement. For good concrete work, strength is important as it influences the overall building quality.

Dos 4: Always mix the dry ingredients (sand & cement) together before adding water.

Why?
Wet sand particles have the tendency to stick together and are therefore hindering that cement can cover them. This results in an un-uniform mix that is reducing the concrete quality, because each sand and aggregate particle should ideally be fully covered with cement. Further, adding water together with sand, aggregate and cement in one go makes mixing the concrete extremely difficult for the laborers.

Dos 5: Always protect the concrete-mixing place from wind, rain and sunshine.

Why?
Wind and sunshine is entraining the water from the concrete and is accelerating the hardening process before it is being used. This makes the concrete useless for any purpose. Rain is adding water and the concrete is becoming too wet, resulting in a weak final strength. Dogs will contaminate concrete raw material, therefore proper protection is required

Dos 6: Use the concrete mix within a maximum of 1 hr. after wet mixing and do never retempering by mixing in additional water.

Why?
In concrete that is older than 1 hr., the hydration process of the cement has started and remixing it is destroying the bond between cement and sand/aggregates. This bond cannot regain strength again by simply adding fresh water to the concrete.

Dos 7: Use always-proper quantity measuring boxes.

Why?
Using empty cement bags, or other means does not always ensure that the correct amount of raw material is being added. This inaccuracy could lead into a leaner or richer mix than designed, either reducing the concrete quality or adding extra costs.

Don'ts: Do not make concrete work if the outside temperature is crossing 40 degree Celsius.

Why?
The direct sunshine temperature at 40 degree Celsius is nearly 50 degree Celsius. Hence, the water evaporation of the freshly placed concrete will happen immediately, causing serious shrinkage cracks and hindering a proper and controlled hardening of the concrete. This will finally seriously weaken the concrete work quality. However, if it is unavoidable to stop concreting work, then the following precautions can be taken:

- Cooling down the aggregates by water sprinkling
- Providing a shade at the manufacturing side
- Placing immediately plastic on the moulded concrete product

SECTION THREE – QUALITY ISSUES AND TESTING

10 Quality of cement products

The basic quality requirement of concrete blocks and tiles are: strength, uniformity in size and to a certain degree water resistance. A good concrete block or concrete pavement tile is produced and stored under a sunshade, has an appropriate mix ratio, contains clean raw materials (sand, aggregates and water) and fresh cement, is properly cured for at least 7 days, and is handled with care up to the point of use for masonry work or tile laying.

11 Testing the quality of cement products in comparison to clay bricks – *(Additional reading – homework)*

In general, you can bring your cement products to the laboratory of the Technical Faculty of the Syiah Kuala University in Banda Aceh, if you need them to be tested and their quality / strength certified. This test takes a few days and costs Rp. 25.000 / block (at time of writing this manual). The same laboratory will also test clay bricks, if you would like to compare the quality of clay bricks to your own concrete building blocks. For clay bricks the university will charge Rp. 75.000 / brick (at time of writing this manual). However, there are also some short test that you can undertake at your own manufacturing site and will cost you nothing.

11.1 Testing concrete blocks as well as clay bricks at the manufacturing site

Clay bricks and concrete blocks must be of good quality and without visible cracks for a load-bearing wall. A hard ringing sound emitted when two clay bricks are struck together indicates that they have been burnt satisfactorily. Generally, the clay bricks as well as concrete blocks should be true to size and shape, with straight edges and even surface, so as to facilitate laying them into position without using too much mortar. Inferior clay bricks are generally under-burnt and as a consequence are easily broken and are very porous. Inferior concrete blocks are generally manufactured with bad quality cement, dirty sand, and are not cured properly. Inferior concrete blocks have cracks, are easily broken, and their surface is of sandy consistence. Inferior clay bricks as well as inferior concrete blocks are neither hard nor durable and are incapable of withstanding heavy loads.

a) Structure

Clay bricks and concrete blocks when broken should be homogeneous in structure, compact and free from holes, cracks, fissures, air bubbles, lumps, pebbles and stones and particles of lime etc. Concrete blocks may have small pebbles, stones or particles of lime, but these have to be distributed equally over the block, not be located only in one part of the concrete block.

b) Shape and size

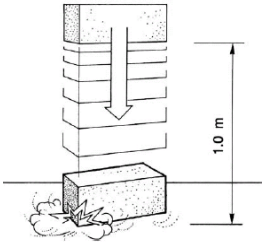
The clay brick as well as concrete block should be rectangular with straight and sharp edges. All bricks as well as all blocks should have the same dimensions and no broken corners or edges.

c) Soundness (only for clay bricks)

The quality of a clay brick is good, if there is a clear ringing sound when two bricks are struck together.

d) Fall test

A clay brick or concrete block should not break when dropped flat on hard ground from a height of about one meter.



e) Scratch test

A good burned clay brick has a surface so hard that the fingernail cannot scratch it. The same is true for a concrete block of good quality that was cured properly.

SECTION FOUR – HEALTH AND SAFETY

12 Health and Safety measures in the work place – *(Additional reading – homework)*

12.1 Introduction

"Accidents do not happen, accidents are made" .

The main reasons for construction / manufacturing related accidents are carelessness, technical faults, inappropriate use of tools, wrong reaction of workers, and most important no proper awareness about potential sources of accidents. A manufacturing site is a place where people come to work together mainly to earn money to support their families. A place where people come together for doing a living must be safe; no economical consideration justifies an accident. What a great tragedy for a family, if for the reason of a preventable working accident, no more income is available.

Knowing the sources of potential and predictable accidents means that we can prevent them. It is the duly of a business owner, but also the workers, to know the potential sources of accidents and to prevent them as far as possible.

These following incidents can also be called accidents:

- You slipped and fell
- A concrete block or a tool fell on your foot, now your foot hurts
- You fell from a chair or from a ladder
- You were splashed by hot water or burned yourself
- You sprained your back by lifting something heavy
- You broke something, but you yourself are not hurt

12.2 Rules to prevent accidents – *(Additional reading – homework)*

- Do not leave discarded timber with nails sticking out. Shuttering timber must always be collected and stored in one place.
- Always bend down or cover the ends of vertical steel bars that stick out of concrete (i.e. when setting up your business).
- Weights more than 30 kg should not be carried or lifted by one person alone.
- Prevent any material from falling down that could hurt people or could damage other materials or your products.
- Blocks and tiles shall not be piled up higher than 1 m at the storage as well at the construction site.
- The manufacturing site should be kept clean. A person could be made officially responsible for cleaning the manufacturing site.
- A toilet, should be provided for the manufacturing workers.
- An official resting-place protected from rain and sunshine could be established at the site. Clean drinking water should be provided at the resting-place as well as at the working place.
- A manufacturing site is not a playground for children. Absolutely no children should be allowed to run around or play in the workplace because this is very dangerous and may lead to harmful accidents. Mothers, who attend to their children should do so at the official resting place or at home only.
- Lifting blocks, cement and other heavy building materials must not be made with a bent back. Always lift the weight with a straight back.

Pavement tiles dangerously high piled up increase the risk of accidents.

12.3 Lifting heavy objects properly

Where manual handling is unavoidable, remember the following principles[1]:

Feet position
Place feet hip-breadth apart to give a large base. For better balance, put one foot forward and to the side of the object to be lifted.

Correct grip
Ensure that the grip is by the roots of the fingers and the palm of the hand. This keeps the load under control and permits the load to be better distributed over the body.

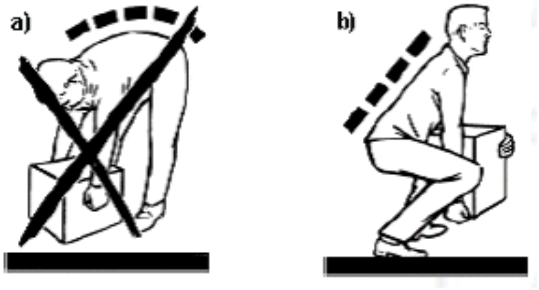
Arms close to body
Keep your arms close to your body to reduce the effort required to lift and minimise muscle fatigue in the arms and shoulders.

Flat back
Keep your back at an angle of about 15 degrees. This minimises pressure on your abdomen and ensures an even pressure on the vertebral discs. Your back will take the weight, but your legs do the work.

[1] Source: Health and Safety at Work in Ireland by Jeremy Stranks.

Chin in
It is just as easy to damage the spine at the top as it is at the bottom. To keep the spine straight at the top, elongate the neck and pull the chin in. Do not tuck the chin on to the chest as this bends the neck.

Body weight
Use your body weight to move the load into the lifting position and to correct movement of the load.



Pregnant women should not continuously lift anything heavier than 5 kg, and nothing at all which is heavier than 10 kg.

12.4 Safety equipment at work

- Gloves
- Masks
- Proper footwear (i.e. boots)

Always use safety equipment at work in order to keep working safely and secure.

SECTION FIVE – STARTING A BUSINESS

13 First steps in setting-up a batako business – *(Additional reading – homework)*

Plan your business well. You may want to join an ILO business management course, in which you will lear how one can start and run a business in a good way. Before starting your own concrete block business you may want to do a small market assessment.

- Find out, how many and what kind of businesses already selling the same or similar cement products as you wish to manufacture, are located in your neighbourhood.
- Go and talk to these manufacturers, find out what kind of cement products they are selling, at what price they are selling their products, how many workers they have employed, their method of manufacturing, how their business is going, and if they easily find customers?
- Decide what kind of products that are in demand you would like to manufacture and how you will market them.
- Find an appropriate business site, which is easily accessible and close to a main street (so trucks can access your site, and your potential customers will easily find your business).
- A good business site is big enough to store your products, has a sun shade under which you may manufacture and cure your products. It also has a small shelter with a lock in which you can store your tools and material in a secure way. You also need access to clean water (i.e. a well, or clean river close by).
- Set up your business site, so you have everything you need to get started working.
- Calculate how much the manufacturing of your product will cost in material and labour cost → calculate the total cost per piece and set a price at which you want to sell your product.
- Prepare a marketing strategy for your products.

14 Calculating the material and cost of your cement products

Estimating the material needed for manufacturing your products and calculating your production costs are important aspects of running a business. The calculation is necessary in order to set a profitable price for your concrete building blocks and pavement tiles.

14.1 Calculating example

The calculations below are examples only. Prices of material vary from geographic location to geographic location. The production cost will also depend highly on the quality you produce, i.e. how much sand, how much cement you decide to use. Therefore, never just take the examples below as your price. Always calculate your own cost and set your own price afterwards. Do this calculation from time to time as prices of materials do change, and you have to adapt your price to this change in order to still run a profitable business.

14.2 Concrete Building Blocks

The material mix ratio for the example below is: **1:4** (1 part of cement : 4 parts of sand)
For one bag of cement (40 kg weight), you will need 0,25 m³ of sand to produce 18 pieces of concrete building blocks, at a size of: 30cm x 15cm x 15cm.

Cost:

a) 1 bag cement	(in Banda Aceh)		Rp. 44.000,-
b) 0,25 m³ sand	(in Banda Aceh)		Rp. 25.000,-
c) 0,25 liter oil	(in Banda Aceh)		Rp. 5.000,-
d) Water	(in Banda Aceh)		Rp. 5.000,-
e) Labour cost	(in Banda Aceh)	Rp. 700 @ concrete block	Rp. 12.600,-
Total			**Rp. 91.600,-**
Production Cost per one concrete block			Rp. 5.088,-
+ 10% profit			Rp. 509,-
Price for one building block			**Rp. 5.597,-**

Explanation of Calculation

a) One bag of cement (in Banda Aceh) costs Rp. 44.000. You will need the whole bag to produce 18 concrete building blocks. Therefore, to calculate your cost for cement, you take the full amount.

   1 bag cement (40kg) = Rp. 44.000

b) 1 m³ sand (in Banda Aceh) costs Rp. 100.000. This is one truck load of sand. To produce 18 concrete building blocks, you need only ¼ m³ (or 0,25 m³). Therefore, to calculate your cost for sand, you divide the price for 1m³ by 4.

   1m³ sand: Rp. 100.000 / 4 = Rp. 25.000

c) 1 liter of oil (in Banda Aceh) costs Rp. 20.000. To produce 18 concrete building blocks, you need only ¼ liter (or 0,25 liter). Therefore, to calculate your cost for oil, you divide the price for one liter oil by 4.

   1 liter oil: Rp. 20.000 / 4 = Rp. 5.000

d) You need sufficient clean water to produce good quality building blocks. In Banda Aceh this will cost about Rp. 5.000. You may have water for free. If this is the case, you don't need to add a price for water in your calculation.

   Water for 18 building blocks = Rp. 5.000

e) Labour cost (in Banda Aceh) is calculated on a piece rate of Rp. 700 per building block produced. To calculate your labour cost for 18 building blocks, you need to multiply your piece rate of Rp. 700 by 18.

18 building blocks x Rp. 700 = Rp. 12.600

f) In order to calculate your production costs for 18 building blocks, you now add all costs a) to e).

Cement: Rp. 44.000 + Sand: Rp. 25.000 + Oil: Rp. 5.000 + Water: Rp. 5.000 + Labour cost: Rp. 12.600 = Rp. 91.600

To produce 18 building blocks will cost you: Rp. 91.600

g) If you now would like to know, how much it will cost you to produce 1 building block, you need to divide the amount for 18 building blocks by 18.

Cost for 18 building blocks: Rp. 91.600 / 18 = Rp. 5.088

To produce 1 building block will cost you Rp. 5.088

h) Now that you know your production cost per one building block, you will have to add a certain amount on top, which will be your profit. You could add 10%, and then you will have calculated the price for your block.

Cost of building block: Rp. 5.088 / 100 x 10 = Rp. 509

10% profit: Rp. 509 + cost of 1 building block: Rp. 5.088 = Rp. 5.597

The price you may sell your concrete building block at is therefore: Rp. 5.597

14.3 Concrete Paving Blocks

The material mix ratio for the example below is: 1:4 (1 part of cement : 4 parts of sand)

For one bag of cement (40 kg weight), you will need 0,25 m^3 (or ¼ m^3) of sand to produce 45 pieces of concrete paving blocks at a size of: 25cm x 25cm x 7cm.

Cost & Price

a) 1 bag cement	(in Banda Aceh)		Rp. 44.000,-
b) 0.25 m^3 sand	(in Banda Aceh)		Rp. 25.000,-
c) 0,10 liter oil	(in Banda Aceh)		Rp. 2.000,-
d) Water	(in Banda Aceh)		Rp. 5.000,-
e) Labour cost	(in Banda Aceh)	Rp. 500 @ paving block	Rp. 22.500,-
Total			**Rp. 98.500,-**
Production Cost per one paving block			Rp. 2.189,-
+ 10% profit			Rp. 219,-
Price for one paving block			**Rp. 2.408,-**
Price for one m^2 of paving blocks (~25 pieces)			**Rp. 60.200,-**

Explanation of Calculation:

a) One bag of cement (in Banda Aceh) costs Rp. 44.000. You will need the whole bag to produce 45 concrete paving blocks. Therefore, to calculate your cost for cement, you take the full amount.

   1 bag cement (40kg) = Rp. 44.000

b) 1 m³ sand (in Banda Aceh) costs Rp. 100.000. This is one truck load of sand. To produce 45 concrete paving blocks, you need only ¼ m³ (or 0,25 m³). Therefore, to calculate your cost for sand, you divide the price for 1m³ by 4.

   1m³ sand: Rp. 100.000 / 4 = Rp. 25.000

c) 1 liter of oil (in Banda Aceh) costs Rp. 20.000. To produce 45 concrete building blocks, you need about 0,10 liter. Therefore, to calculate your cost for oil, you divide the price for one liter oil by 10.

   1 liter oil: Rp. 20.000 / 10 = Rp. 2.000

d) You need sufficient clean water to produce good quality paving blocks. In Banda Aceh this will cost about Rp. 5.000. You may have water for free. If this is the case, you don't need to add a price for water in your calculation.

   Water for 45 paving blocks = Rp. 5.000

e) Labour cost (in Banda Aceh) is calculated on a piece rate of Rp. 500 per paving block produced. To calculate your labour cost for 45 paving blocks, you need to multiply your piece rate of Rp. 500 by 45.

   45 paving blocks x Rp. 500 = Rp. 22.500

f) In order to calculate your production costs for 45 paving blocks, you now add all costs a) to e).

   Cement: Rp. 44.000 + Sand: Rp. 25.000 + Oil: Rp. 2.000 + Water: Rp. 5.000 + Labour cost: Rp. 22.500 = Rp. 98.500

   To produce 45 paving blocks will cost you: Rp. 98.500

g) If you now would like to know, how much it will cost you to produce 1 paving block, you need to divide the amount for 45 paving blocks by 45.

   Cost for 45 building blocks: Rp. 98.500 / 45 = Rp. 2.189

   To produce 1 paving block will cost you Rp. 2.189

h) Now that you know your production cost per one paving block, you will have to add a certain amount on top, which will be your profit. You could add 10%, and then you will have calculated the price for your block.

   Cost of building block: Rp. 2.200 / 100 x 10 = Rp. 219

   10% profit: Rp. 220 + cost of 1 building block: Rp. 2.200 = Rp. 2.408

   The price you may sell your concrete building block at is: Rp. 2.408

i) Commonly paving blocks are being sold per m². If you have square paving blocks (size: 25cm x 25cm) one m² paving blocks consists of 25 pieces. To calculate the price of 1m² paving blocks, you multiply your price for one paving block with 25.

Price for 1 paving block: Rp. 2.408 x 25 = Rp. 60.200

The price for 1m² paving blocks is: Rp. 60.200

15 Alternative cement products

Besides building blocks and pavement / floor tiles, there are other cement products that can be manufactured in a similar way as described above. These include:

- Concrete pillars for balconies
- Concrete well rings
- Culvert pipes
- Air / ventilation windows made from concrete
- Other decorative elements for houses made from concrete