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Part 4: Code of practice for production and construction

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 514-4 was prepared by Technical Committee RSB/TC 9, *Civil engineering and building materials*.

In the preparation of this standard, reference was made to the following standard:

ARS 670-4-2014, Compressed earth blocks - Part 4: Code of practice for production and construction mortars

The assistance derived from the above source is hereby acknowledged with thanks.

DRS 514 consists of the following parts, under the general title *Compressed earth blocks*:

— *Part 1: Definitions, classifications, specifications*

— *Part 2 Earth mortars*

— *Part 3: Test methods*

— *Part 4: Code of practice for production and construction*

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and building materials* (RSB/TC 9) in the preparation of this standard.

A+ Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

Dutureheza Ltd

Enabel Rwanda

Greenpack Africa Ltd

Integrated Polytechnic Regional Centre (IPRC) - Musanze

Mass Design Group

NP Construction Construction Company (NPCC) Ltd

Road Transport Development Agency (RTDA)

Rwanda Housing Authority (RHA)

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

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Stonecraft Industries Ltd

University of Rwanda - College of Science and Technology (UR - CST)

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Compressed earth blocks — Part 4: Code of practice for production and construction

1 Scope

This Draft Rwanda Standard describes the processes relating to the production of compressed earth blocks (CEBs) and their use in design and construction of housing units. The draft standard is not applicable in areas subject to earthquakes, floods or cyclones to an extent that requires the application of appropriate rules in order to avoid major damage.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DRS 546, Clay products for building – Vocabulary

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in DRS 546 apply.

4 Production of compressed earth blocks (CEBs)

4.1 Recommendations on earth selection

Recommendations for earth selection, use of stabilization of additivities, manufacturing parameters, checking procedures, delivery of supplies and acceptability of compressed earth blocks (CEB) supplies can be found in Clause 8.5 of DRS 514-2.

5 Code of practice for the assembly of compressed earth block masonry

5.1 Laying out

5.1.1 General

It is on the quality of the layout of buildings that ease of assembly partly depends and as a result the quality of the construction, from both a technical and an aesthetic point of view, and this is particularly true for facing masonry.

If a detailed brickwork plan has been prepared, i.e. if the distances (horizontal and vertical) have been defined using the dimensions of the blocks used as well as the thickness of the joints, laying out should scrupulously respect the dimensions indicated on the plans.

If no detailed brickwork plan has been prepared or if the dimensions of the blocks and/or the thickness of the joints differ from what the designer had anticipated, the dimensions given should be modified. Agreement with the architect may be needed. Laying out should be done according to accepted practice using approved and reliable measuring instruments the measurements of which do not vary.

5.1.2 Horizontal laying out

Measuring instruments which enable one to measure directly the greatest lengths of the buildings should be used. Flexible tape measures should preferably be metallic. Right angles should be determined by triangulation (the 3-4-5 rule).

The best technique for laying out is to use site boards firmly fixed into the ground; these enable alignment strings to be stretched from nails or saw cuts. The site boards (at least their upper part) must be placed at the same level, and this should if possible correspond to the first course of CEBM (or to the upper part of the footing), which will enable this first course to be perfectly adjusted and therefore to serve as a reference.

5.1.3 Vertical laying out

The upper level of the site boards (horizontally adjusted) should preferably serve as a reference for the masonry work. Other points can, however, be used, provided they are firmly fixed.

To respect the vertical distances indicated by the brickwork plan, gauge rods should be used. These indicate the levels of courses and of important elements (window sills, lintels, ring beam, height of wall). Gauge rods can be mobile, but should preferably be fixed in strategic points of the building. When the gauge rods are sufficiently rectilinear and rigid, they can serve directly as a support for the strings possibly using strainers, nails or saw cuts. These marks are placed at regular intervals corresponding to the vertical brickwork measurements.

5.2 Scaffolding and safety

5.2.1 Safety on site

Scaffolding should be erected in such a way as to respect safety regulations. It is standard practice to use safety boots and site helmets.

5.2.2 Fixing scaffolding

With facing masonry, fixing scaffolding to the walls should be avoided as this means subsequent patching which is not easy. Scaffolding should therefore preferably be positioned sufficiently far away to avoid it banging against the wall and may be equipped with a system to prevent this occurring.

With rendered masonry, fixing scaffolding to the walls is not a problem. However, using the wall to support the scaffolding should be done only after its capacity to resist specific forces has been checked, and notably with regard to the stresses caused by scaffolding systems resting on the wall.

5.3 Deliveries and on-site stocks

5.3.1 General

Materials should be checked when they are delivered on site as a minimum by visual inspection. Simple field tests can also allow an overall assessment of whether the materials delivered conform.

It is recommended that the same types of check be carried out just before application, in order to separate out materials which might have deteriorated as a result of being badly stocked on site.

5.3.2 Compressed earth blocks

Compressed earth blocks should be unloaded with care. Transporting them on the site should be restricted and if possible done with suitable means of transport with a flat loading base.

Blocks intended for facing masonry should be handled with particular care, to avoid chipping them. One should therefore seek to restrict unnecessary handling by always stocking them as near as possible to where they are to be used. At the same time care should be taken not to overload recently completed scaffolding and floor slabs.

Stocks should be kept in stable piles and on ground which is sufficiently flat and firm and not liable to flooding.

5.3.3 Unstabilised compressed earth blocks

Stocks of unstabilised compressed earth blocks should be protected from rain in order to avoid surface erosion. If the blocks are stocked directly on the ground, good peripheral drainage should be used, to avoid rising damp which could affect the blocks. These measures should be taken only when a risk does exist (e.g. rainy season).

5.3.4 Cement and other binders

These should be stocked sheltered from humidity, or under cover, and raised off the ground on pallets or on any other support which allows good ventilation.

5.3.5 Earth and sand intended for preparing laying mortar

Earth and sand should be stocked on areas which are clean and above all cleared of any vegetation. Earth which is to be sieved should be protected from rain as wet earth is impossible to screen.

5.3.6 Earth intended for preparing stabilised earth mortar

In order to avoid lumps forming and to ensure the homogeneity of the mix, the earth should not be wet. It should therefore be protected from rain and capillary rise.

5.4 Composition, preparation and utilisation of the mortars

5.4.1 General

5.4.1.1 Bonding between compressed earth blocks is generally achieved using mortars prepared from the same materials as the CEBs, in order to achieve compatibility and similar strengths, i.e.:

(a) an earth mortar for unstabilised CEBs;

(b) a stabilised earth mortar for stabilised CEBs.

The earth used should preferably be of the same nature but can be different in origin.

5.4.1.2 Because no compression occurs, the strength of the mortar obtained is generally lower than that of the CEBs. Moreover, the significant water dosage (approximately 30%) required for the mortar to be easily workable, can result in cracking. The generally rapid drying out of mortar, despite the precautions which should be taken, can result in the stabilisation being less efficient, and this is particularly the case with low dosages.

For example, in the case of cement, correct practice is to adjust the dosage used for CEBs by:

(a) significantly increasing the proportion of sand to eliminate risks of cracking;

(b) significantly increasing the dosage of stabiliser, i.e. a proportion of approximately 1.5 to 2 times greater for low dosages (3 to 6%) and of 1.2 to 1.5 times greater for high dosages (7 to 10%).

5.4.1.3 Cement stabilised compressed earth blocks can also be bonded with sand-based mortars such as the following:

(a) sand and quicklime or slaked lime mortar (approx. 1 part lime to 4 parts sand);

(b) sand and hydraulic lime mortar with low dosages (200 to 250 kg/m^3);

(c) quarry sand and cement mortar (250 kg/m^3).

5.4.1.4 Carrying out preliminary tests, in real conditions on site, allows the most suitable composition to be determined.

5.4.1.5 In certain circumstances, it is acceptable to use unstabilised earth mortar for the masonry of stabilised earth blocks (e.g.: well protected walls subject to little stress).

5.4.2 Screening the earth

Earth screened using a 10 mm side square mesh is perfectly suitable. Other sizes, however, can also be suitable, bearing in mind that the maximum grain size passing through the mesh can be adjusted by tilting the mesh.

It is recommended that the screen should be fairly large in size. Dimensions in the order of 2m × 1m (h × w) are perfectly suitable.

5.4.3 Dosages

The materials making up the composition of the mortar should be measured out with precision. Dosage by weight is precise, but difficult to carry out on site without special equipment. Procedures for dosing by volume are therefore the most commonly used. Using spades to measure out is too imprecise, and not acceptable. One can, however, use buckets or wheelbarrows when their volume is known. These volumes should correspond to a whole number of recipients. Filling regularly, by levelling off and using the entire volume of the recipient are essential to obtain a regular dosage. Using gauge boxes is recommended. These are of predetermined volume and therefore enable the prescribed dosage to be matched with a high degree of precision.

Using the sack (of stabiliser) as a basic unit is valid only if the quantity contained is reliable.

5.4.4 Preparing unstabilised earth mortars

These are prepared by mixing water into the earth. The proportion of water is in the order of 30%, but varies according to the clay content of the earth. Mixing can be done by hand, in a cement-mixer, or even in a planetary or linear mixer.

Preparation can be done a long time ahead and in large quantities, whether in a dry or a wet state.

As earth absorbs water little by little, mixing is always carried out more liquid than is necessary to achieve the workability required for the assembly of compressed earth blocks.

If the earth has started to set through drying out, more water can be added, and as often as necessary, to recover the required workability.

5.4.5 Preparing earth mortars stabilised with cement or with hydraulic lime

The earth should be loose. If it is not naturally so, or loose on delivery, it should be screened or broken down, even if it contains no grains of too great a size. Loosening the earth is necessary to enable the mixing to take place quickly which ensures the homogeneity of the mix by spreading the stabiliser evenly throughout the mass.

5.4.5.1 Manual mixing

The various components are first mixed dry and then the water is added. To obtain good homogeneity, each mixing operation should not exceed 5 wheelbarrow loads, i.e. approximately 300 litres of mix.

Mixing with water should be carried out only for a quantity of mix which can be used within the following half hour in order to take advantage of the reaction of the cement with the other components of the mortar. To achieve this, mixing with water can be done gradually with small quantities taken from the initial dry mix.

Retempering a mortar which has already taken with water is not permissible as the stabilisation could not occur in good conditions and the strength of the ultimate mortar would be very low (in certain cases even lower than that of an unstabilised earth mortar).

5.4.5.2 Mechanical mixing

Mixing can be done using a planetary or linear mixer or even with a simple concrete-mixer.

With a planetary or linear mixer, mixing takes place as for manual mixing, i.e. first the dry mixing is done, and the water is added later. With a concrete-mixer, the filling process is reversed: the water is put in first, then the cement is added, followed by the sand (if any) and finally the earth. For the same reasons as stated for manual mixing, the quantities of mortar prepared must be capable of being used within the following half hour and any mortar which has already taken should be rejected.

5.4.6 Preparing earth mortars stabilised with non-hydraulic lime

The mix should be prepared in advance (at least 2 hours before, but preferably one day ahead) and if possible covered so that it stays moist until it is used. This gives the lime time to react properly with the clays, without hardening through carbonatation occurring, as this takes place only in the presence of air.

5.4.7 Preparing earth mortars stabilised with bitumen

Bitumen is used in liquid form (cut-back or emulsion). Mixing is carried out with earth which has already been mixed with water and is therefore in a liquid state (see preparing unstabilised earth mortars). These mortars can be prepared in advance. However, remixing them once they have dried out is not advisable.

5.5 Executing the masonry work

5.5.1 Bonding patterns

Compressed earth blocks should be used in masonry in accordance with the detailed brickwork plan already drawn up and following a bonding pattern which respects the rules that there should be no superimposed vertical joints and that at least 1/4 of the horizontal surface of the block should be covered. The most common bonding patterns are those used for traditional masonry work with small elements.

5.5.2 Thickness of the mortar

The most common thickness of mortar is 1.5 cm.

To be able to use all the classic bonding patterns, the dimensions of the block should follow the rule:

$l = 2 \times w + tm$ (l = length, w = width, tm = thickness of the joint).

For fill-in walls with no bonding pattern, it is not necessary to apply this rule.

5.5.3 Wetting the blocks

In order to allow the binder to take, the mortar must be prevented from drying out too quickly. It is therefore vital to wet the blocks and the course on which they will rest before laying them. This should be done by sprinkling

using a whitewash brush or by rapidly dipping them in water. Excessive wetting reduces the quality of the masonry work. When using unstabilised CEBs, they should not be wet too much to avoid damaging them. The water should be fully absorbed before laying. The water used should not contain any deleterious matter.

5.5.4 Cutting blocks

Cutting CEBs as they are being used should be carried out using any tool enabling one to obtain a precise cut and a flat surface, e.g. bolsters, saws, disks, etc.

5.5.5 Laying blocks for ordinary masonry intended to be rendered

The blocks should be laid on a full bed of mortar in order to ensure that they adhere well. It is recommended that the vertical joints should be filled at the same time as laying the CEBs, which is faster but above all more efficient than filling in from above after laying.

The joints can be lightly brushed or scratched after laying to allow the render to adhere well.

5.5.6 Laying blocks for facing masonry

The blocks should be laid on a full bed of mortar in order to ensure that they adhere well. It is recommended that the vertical joints should be filled at the same time as laying the CEBs, which is faster but above all more efficient than filling in from above after laying. Using this technique also enables one to obtain a good finish more easily. As the mortar oozes out slightly, one has only to scrape off the surplus holding the trowel at an angle to obtain a well filled and neat joint that can either be left as it stands or finished off later with a special tool.

As a result, the consistency of the mortar is very important. It should not be too liquid as it would drip down the wall during laying; nor should it be too dry as this would make it difficult to squeeze the mortar and thus to obtain a well filled and neat joint. The mortar should therefore not be laid too far in advance on the preceding course.

5.5.7 Laying the first two block courses

The first two courses will serve as a reference for aligning all the subsequent ones. They therefore have to be perfectly aligned (see chapter on laying out). Before proceeding with actually laying these courses, it is preferable to try them out dry in order to check that the dimensions and the bonding pattern correspond properly.

Adjusting the dimensions is acceptable if this allows simple and correct bonding pattern configurations to be used. The thickness of the joints can also be modified without however exceeding ± 5 mm of the thickness planned. Laying is then done one block at a time which allows the mortar thickness to be respected and avoids running the risk of gradually shifting the bonding pattern along. If the footing is seriously defective in terms of flatness, it will take several courses to retrieve horizontality in order to respect the tolerance of ± 5 mm. To obtain high strength masonry, it is recommended that the corner blocks should be laid using a plumb line and the others using a guide string.

5.5.8 Laying the remaining courses

Each course should be started off in the comers and at the level of wall junctions. Levelling, adjusting to plumb and adjusting the height of the course (see chapter on laying out) should be carried out for each of these blocks before going on to lay the whole course.

The use of vertical gauge rods is strongly recommended for facing masonry. Vertical gauge rods can be mobile or fixed. Laying several levels of blocks in the course before filling in the wall is possible if the mortar sets sufficiently quickly and enables the blocks to be adjusted without shifting the blocks on the lower courses and if the mortar has negligible shrinkage.

The maximum height of masonry work should not exceed 1m per day.

5.5.9 Jointing for facing masonry

Joints (including dry joints) can be simply scraped off with a trowel as described above. If necessary, jointing can be done using a pointing trowel.

Jointing should preferably be done as soon as the mortar starts to set, i.e. within 1/2 an hour to an hour of laying the blocks. The mortar, which has previously been scraped level with a trowel (after jointing if appropriate) is simply pressed in using a tool with a rounded shape (jointer) in such a way as to obtain a finish which is slightly hollow, but which does not retain water. More hollow joint finishes are possible inside or on walls which are well protected from bad weather, or with CEBs and EMs which are highly resistant to humidity.

5.5.10 Pointing for facing masonry

The laying mortar is scraped to a depth of at least 2 cm. The joint is moistened, and as soon as the water has been fully absorbed, it is refilled with fresh mortar treated in the same way as described above. This technique, which is especially useful for thick masonry, allows a water-resistant mortar to be used on the façade and a more weakly dosed mortar for the inside of the wall.

5.5.11 Protecting freshly erected masonry and cleaning

In hot, dry weather and if the walls are built with an earth mortar stabilised with a hydraulic binder, it is advisable to protect the walls from direct exposure to the sun and to spray them lightly and at regular intervals in order to prevent them from drying out too quickly, so that the binder can take correctly.

Walls erected using a non-hydraulic binder (lime) should not be moistened; on the contrary, for one month after laying, they should be protected from the direct effects of bad weather.

Drips or dirty marks should be cleaned off the masonry as soon as it is finished using nonabrasive tools (e.g. a sponge or a soft brush, etc.)

Subsequently, masonry should be protected from blows to avoid any risk of chipping or other damage.

5.6 Bonding with the other construction components

5.6.1 Water proofing from ground humidity

Footings are subject to capillary water rise from surrounding ground which is (even temporarily) wet, when the materials used for their construction are permeable. This phenomenon will be accentuated if the evaporation capacity of the footing is poor either because it is low or because it has a water proof render.

If this is the case, special technical measures should be used. There are several possible solutions:

(a) very good surface drainage around the building;

(b) the footing is built up sufficiently high and has a surface which encourages hydric exchanges, allowing water to evaporate before it reaches the CEB wall;

(c) the CEBs used have properties of sufficient wet compressive strength and are capable of resisting alternate dry-wet cycles;

(d) a capillary barrier (a layer of sufficiently dosed mortar, bituminous felt, etc.) is interposed between the footing and the wall;

(e) a cement slab is interposed between the footing and the wall. In this event, the slab itself should be protected from capillary rise.

5.6.2 Window sills

The use of window sills is highly recommended.

Window sills can be integrated into the fixed frame of the wood or metalwork, poured in situ or prefabricated. In the latter case, they should be laid on a bed of mortar.

Except where otherwise prescribed, window sills should jut out from the bare façade by at least 6 cm and should be fitted with a throat.

5.6.3 Fixing doors and windows

In the absence of technical specifications proper to the project, fixing doors and windows will be carried out according to the following prescriptions.

(1) Placing openings during wall construction
Wood or metalwork openings (or at least their pre-frame which will be made rigid) should be put into place and braced. If the prefabricated frames are made of wood, they must be perfectly dry so that they do not move once they are in position. The bond with the wall is achieved using fixing anchors (for metalwork) or 100 mm nails (for woodwork) spaced so that there is a fixing point approximately every 5 courses.

The spacing of the fixing anchors should be planned in such a way that they correspond to the location of a joint so that they are set into the mortar. Nails should be located between two courses of blocks, before the next course is laid. The mortar used at the level of the fixing points can be stronger than the usual mortar if the latter is considered to be too weak.

(2) Placing prefabricated elements after construction
Special elements should have dimensions corresponding either to whole blocks, or to half-blocks, so that they can be positioned in the walls. These blocks can be made of poured concrete in which a fixing anchor has been positioned, or alternatively they can be pre-treated wooden blocks.

(3) Placing openings after construction by fixing
There should be at least 4 fixing points for windows and 6 fixing points for doors.

In thick walls, the fixing is achieved by digging a hole shaped like a fish-tail and leaving a gap of at least 5 cm around the fixing anchor. It is recommended that the bond between the wall and the mortar be improved by hammering 100 mm nails in all around the hole. The fixing mortar should preferably be a sand-cement mortar dosed to 300 kg/m^3 and should be applied with a minimum of water in order to avoid shrinkage.

In thin walls, half-blocks located on either side of the metal or woodwork should be removed. The spaces thus liberated should then be dealt with in the same way as described in the previous point. Using a formwork is however necessary to ensure that the hole is well filled. In the case of metal or woodwork which is subject to little stress, as in the case of «Naco» louvre window systems, the same procedure can be used by digging only the thickness of the joint and therefore refilling it after the metal or woodwork is in position. This procedure however requires the fixing anchors to be well positioned at the height of the joints.

5.6.4 Beams and lintels

Wooden beams and lintels should be placed on a bed of mortar. The same applies to prefabricated concrete beams or lintels. Before putting them into position, one should check that these elements are dry and that their shrinkage is complete. In the case of concrete beams or lintels poured in situ, the pouring should be done as little liquid as possible in order to avoid to the maximum extent the tensions caused by shrinkage which could cause the walls to crack. In the case of buildings with facing masonry, using a fairly dry bed of mortar on the edges of the formwork is indispensable to fill in inevitable gaps and thus avoid dripping onto the masonry which would be very difficult to clean off subsequently.

5.6.5 Ring beams

Using wooden horizontal ring beams is possible, but the wood should be dry and pre-treated against fungi and insects. The bond between the wall and the ring beam is achieved by using 40 mm nails in all the joints. Wooden ring beams are placed on a bed of mortar.

Reinforced concrete can be used for ring beams. However, the section of concrete ring beams should be minimal so that the forces transmitted during the drying out of the concrete are not too great, thus avoiding the danger of cracking in the walls or even destabilising the structure.

The concrete used should be sufficiently firm in order to avoid too much shrinkage which could lead to cracking in the walls. For buildings with facing masonry, using a fairly dry bed of mortar on the edges of the formwork is indispensable to fill in inevitable gaps and thus avoid dripping onto the masonry which would be very difficult to clean off subsequently.

Using special compressed earth blocks is particularly recommended as this avoids all of the problems described above. Vertical reinforcement should preferably be replaced by simply using thicker masonry.

5.6.6 Tying down the roof

Common roofs should be built according the state of the art relative to building construction.

So-called light roofs should be anchored to the masonry in order to avoid the possibility of being ripped off by the wind. In medium risk circumstances, it is recommended that anchoring should be done over a height of blocks of at least 40 cm. If possible, the anchoring should be fixed on or under the ring beam.

5.7 Stabilised renders (earth-sand-cement/lime and sand-cement/lime)

Renders on compressed earth block walls should be applied following the usual rules, proper to each type of render. Nevertheless it is advisable to avoid renders which are too thick (maximum 2 cm) and single coat covering products in the case of sand-cement/lime renders. It is also appropriate to apply the following recommendations.

(1) Preparing the key
The key should be well prepared by lightly brushing the joints to hollow them out to a depth of no more than 2 cm, and by brushing the surface of the blocks if it is too smooth.

(2) Wetting the wall

The wall must be particularly well wet, and several times, before applying the render, especially if it is to be applied in dry weather.

(3) Sand-cement and sand-hydraulic lime renders

These often fairly rigid renders have a tendency to come away from the walls. To ensure that they stick well over time, it is appropriate to:

- carefully check the efficacy of the capillary barrier chosen;
- on stabilised CEB walls, not to use cement dosages which are too high: maximum 250 kg/m^3 or 300 kg/m^3;
- on non-stabilised CEB walls, to place a mesh of steel wire (if possible galvanised) stretched between nails regularly spaced over a square or triangular screen with 30 cm sides. One wire should always be stretched at the level of the edges in the corners of the wall and the window ledges.

This mesh will be fixed between the two (first) coats of render which should be applied at minimum one day's interval and if possible two days' interval.

5.8 Paints, washes and waterproofing products

Applying paints and washes should be carried out according to the known rules proper to each product. However, the following rules should be applied:

(1) Preparing the key
The walls should be dust-free. Any blocks which are too smooth should be brushed beforehand to obtain a rough surface providing a good key.

(2) Wetting
This is necessary only for cement based washes and should be done thoroughly, and several times.

(3) Thickness
The thickness of coats of paint and washes should be minimal. Preliminary tests should be carried out to determine the ideal mix enabling sufficient coverage with the minimal thickness.

(4) Preparing earth-cement washes
This type of wash is highly suitable for obtaining a finish which is neat, durable and reliable, at a very low cost. The use of white cement and colouring agents enables one to achieve very high quality finishings.

The earth should be mixed with water until a very liquid wash is obtained. This mix is left to rest for approximately 2 minutes so that the largest sand particles settle. The resulting wash is transferred into another container and mixed with half its volume in cement, if necessary with an added colouring agent. The resulting mix should be vigorously stirred from time to time and used within two hours.

Small colour differences may occur between different preparations. Sufficient quantities must therefore be prepared to cover complete wall panels.

(5) Waterproof paints or washes and waterproofing products

Products which form a waterproof coat can be efficient but are extremely dangerous as they prevent water from moving from the inside towards the outside of the wall. If such movement occurs, they can blister or fall off, but more seriously, they can cause problems due to stagnant humidity in the walls. As a result, such products are usable only if adequate measures are taken to avoid any water infiltration in the walls: capillary barriers, protecting the wall at plinth level, good ventilation in the rooms, especially rooms with water (bathroom, WC, kitchen, etc.) It is also recommended to use such products only on walls which behave well it the presence of moisture.

5.9 Checking procedures

5.9.1 Laying out

Check that the dimensions given on the plans have been respected.

Check the suitability of the proposed bonding pattern.

If necessary, modify the dimensions indicated on the plans to be able to use simple bonding patterns.

Check that the footing has been levelled.

Beforehand check the gauge rods used by the different builders.

5.9.2 Scaffolding

Check that safety standards are being respected.

Check that the scaffolding is not banging against the walls (only for facing masonry).

5.9.3 Deliveries and stocking CEBs on site

Monitor the care taken when unloading and transporting CEBs using suitable means (flat support bed).

Monitor stocking and identification procedures.

5.9.4 Storage of cement and/or lime

Check that the sacks are carefully stocked sheltered from humidity, or covered and raised off the ground on pallets or on any other support allowing good ventilation.

There must be visual verification with a fine mesh screen (1 mm) that the cement and/or lime contains no tiny lumps which would prove that it had already gone off when accidentally wet.

5.9.5 Storage of earth and sand for the preparation of the mortar

Check that the earth and the sand are stocked on clean areas, are free of organic matter, and are well protected (rainy season) from water and humidity.

5.9.6 Screening the earth

Check that the screening operation eliminates any particles larger than those tolerated.

Check that the screen is sufficiently large and is not damaged to avoid projecting larger particles.

5.9.7 Dosage

Check the accuracy of the dosage used after the mortar has dried out (if possible by conducting preliminary tests): cracking, resistance to brushing, resistance to water, or other laboratory tests.

Check the volume of the recipient used.

Verify the procedures for levelling off raw materials when filling measuring recipients.

Verify the daily consumption of materials per m^2 actually built. This means knowing the outputs obtained for each type of wall or block.

5.9.8 Preparing cement stabilised earth mortars

Verify the homogeneity of the mix. It should contain no foreign bodies. It should contain no lumps (due to poor screening).

Check that the water content is correct (plasticity).

Verify that the wet mix is used within maximum 1/2 hour and, if possible, within less than 1/4 hour.

5.9.9 Laying the blocks

Check the correct practice, wetting the course and the block before laying, using the mortar within the correct time limits, laying on a full bed of mortar. Verify that the quality of the mortar (presence and % of large particles) enables a good finish to be achieved.

Check the bonding pattern and the thickness of the joints; check that heights are being respected (use of gauge rods); check that the verticality and the horizontality of the courses and their rectitude (or curvature) are being respected, taking account of tolerances.

Check any cracking of the mortar.

Check that work is being carried out cleanly.

In dry periods, check that the walls are being regularly moistened for a week after construction.

5.9.10 Window sills and parapets

Check that they are correctly positioned and enable water run-off to occur correctly.

5.9.11 Ring beam and lintels

Verify the bed surface and the laying on a bed of mortar.

With regard to reinforced concrete, if pouring is done *in situ,* before this occurs check that the formwork is correctly positioned or that some measure has been taken to avoid the concrete running down the wall.

Verify the plasticity of the concrete (if it is too liquid, its shrinkage could pull on the masonry and cause cracking).

5.9.12 Typing down roofs

Verify the tension of the fixing points and that a very strong protection between the roof structure and the top of the wall has been used.

5.9.13 Fixing doors and windows

Check that the specifications have been followed.

Check that the number of fixing points conforms to the instructions and that it is sufficient.

5.9.14 Renders

Check that the key has been properly prepared: by brushing, wetting, and if necessary correct fixing of a mesh.

Check that execution has followed the prescriptions and that drying conditions are good.

5.9.15 Finishing

Check the final cleaning of the walls (gentle brushing, dusting off).

5.9.16 Washes

Check walls have been wet beforehand.

Check dosage and correct execution (thickness, homogeneity of colour).

Bibliography

[1] Compressed earth blocks. Vol. I. Manual of production. CRATerre-EAG: Rigassi V., Aus der Arbeit von GATE. Friedrich Vieweg & Sohn, Braunschweig/Wiesbaden, Germany, 1995;

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