

LOW COST HOUSE Construction Manual

**INZU YUBATSWE KU BURYO
BUCIRIRITSE
Igitabo cy'Imyubakire**



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Kigali City
RISD (Rwanda Initiative for Sustainable Development)
DED (German Development Service)
EWB-USA (Engineers without Borders – USA)
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Introduction / Iriburiro

Using simple materials and simple construction techniques with compressed earth block technology, people in Rwanda can construct a simple, efficient, cost-effective house. This house will have all the advantages of a concrete block construction without the costs. To achieve good results, however, some new construction techniques must be learned, and this manual will teach you how to do them.

In the Kigarama sector the City of Kigali has constructed a model house at low cost and achievable price of less than 2 Million Rwandan francs. The model house proves that a high quality, legal, low cost house can be built by everyone.

Hakoreshejwe ibikoresho byoroheje ndetse n'ubuhanga buciriritse muby'ubwubatsi bw'amatafari adatwitse akorwa n'imashini, abaturarwanda bashobora kwiubakira inzu nziza kandi ijyanye n'amikoro yabo. Iyo nzu kandi yaba ikomeye nk'iyubatswe n'amatafari akozwe mu isima, kandi idahenze. Kugira ngo ibi bigerweho ariko, hagomba kwigwa tekinike nshya zo kubakalki gitabo kiragufasha kongera no kugera k'ubumenyi mu myubakire ihamye y'iyi nzu.

Umujyi wa KIGALI wubatse inzu- ntangarugero mu murenge wa KIGARAMA, ku giciro gito kitageze ku amafaranga y'u Rwanda miliyoni ebyiri (2.000.000). Iyo nzu igaragaza ko ikomeye, yemewe n'amategeko kandi ko buri wese yashobora kuyiyubakira.

The marker "A" shows **alternative methods** to complete construction. The advantages or disadvantages of the alternative construction technique will be described.

Ikimenyetso "A" kirerekana uburyo bunyuranye bukoreshwa mu irangizwa ry'inubako. Ibyiza n'ibibi bya bumwe mu buryo bw'imyubakire biragaragazwa hanyuma.

The Model House near completion / Iyi ni inzu –ntangarugero iri hafi yo kuzura.

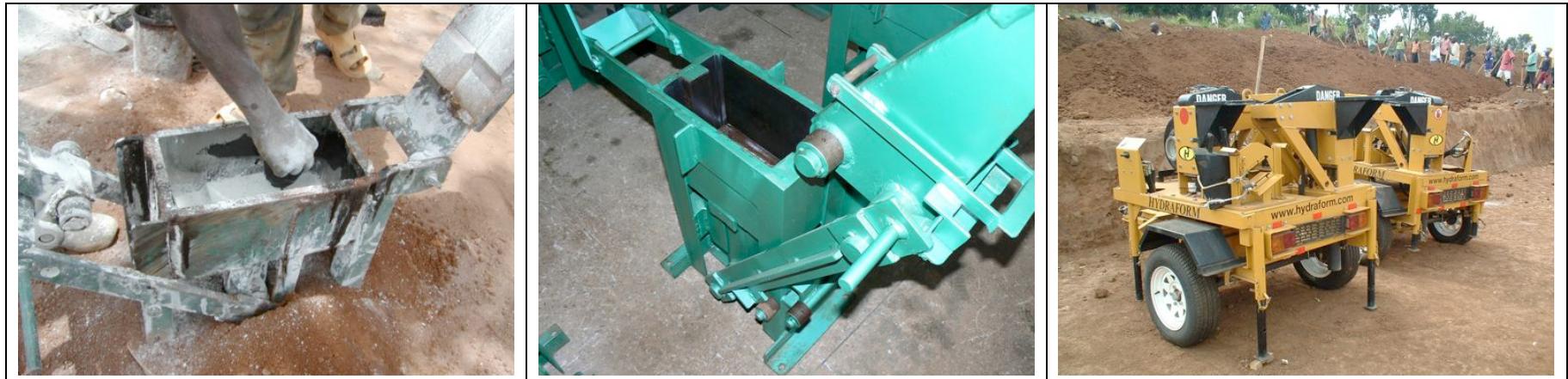


Tools / Ibikoresho



| | | | |
|--|---|--|---|
| <ul style="list-style-type: none"> • Shovels • Picks • Watering can • Oil • Sieve | <ul style="list-style-type: none"> • Wire • Pliers • Rubber gloves • Metal saw • String | <ul style="list-style-type: none"> • Wheelbarrow • Calculator • Chisels • Trowels • Surveyors level | <ul style="list-style-type: none"> • Eye protection • Carpenter square • Measuring tape • Wood Saw • Block press • Hammers |
| <ul style="list-style-type: none"> • Ibitiyo • Amapiki • I bivomesho • Amavuta • Akayunguruzo | <ul style="list-style-type: none"> • insinga • Makorewa/ipensi • Riba y`ubwubatsi • Urukero rw`ibyuma • ikamba | <ul style="list-style-type: none"> • Ingorofani • Akamashini kabara • Umukasi • Imyiko • icyuma gipima uburinganire | <ul style="list-style-type: none"> • ikilinda ijisho • Ekeli • Metero-bushumi • Urukero rw`ibiti • Iforomo ibumba • Inyundo |

Block Presses / Amamashini abumba amatafari adatwitse



There are many different types of block presses. Some are manually operated on some are powered with electricity or petroleum. Manual presses can be operated by semi-skilled workers, whereas powered machines need more skilled operators and are more expensive to run. Bricks may be square and flat faced, or they may interlock. Interlocking blocks have the advantage of requiring less (or no) mortar between the blocks. Square blocks are more versatile for making curves or intersection walls, as are conventional bricks.

Hari uburyo bwinshi bw'imashini zikora amatafari adatwitse. Zimwe zikoresha amaboko, hali izikoresha n'amashanyarazi cyangwa se peterori. Iz'amaboko zishobora gukoreshwa n'abakozi basanzwe naho izikoresha amashanyarazi zikoresha n'abakozi babifitiye ubuhanga n'ubushobozi, bityo kuzikoresha bikaba bihenze. Amatafari adatwitse ashobora gukorwa afite ishusho ya kare kandi ahashe. Ashobora kandi gukorwa ku buryo afungana. Iyiza by'amatafari afungana ni uko adasaba gukoresha ishwaraga n'umucanga byinshi (hagati y'amajuwe) cyangwa se akubakwa yonyine. Amatafari afite ishusho ya kare akoresha cyane mu kubaka inkuta zifite ishusho y'uruziga cyangwa se inkuta zinyuranamo nk'uko ayandi asanzwe abikora.

In case no machine is available, a simple compressed earth block can be produced with the help of a mold and a tool to ram the earth into the mold. If a proper mix is used and the bricks are well mixed and uniformly compressed, better strength can be achieved than with traditional molding techniques. However this technique is not consistent and does not achieve the same results as a machine press. Also, this method is very slow, and only flat faced bricks can be reliably produced.



Iyo nta mashini ibumba ibonetse, amatafari adatwitse ashobora kubumbwa hakoreshejwe iforomo n'intiku (Igikoresho cyo gutsindagira ubutaka bwavanzwe neza n'ishwagara). Iyo iyo mvange y'ubutaka n'ishwagara yakozwe neza ndetse no gutsindagira bigakorwa ku buryo bungana mu iforomo yose, aya matafari adatwitse agira ubukomere burenze ubw'inkarakara. Gusa, ubu buryo ntabwo bwihuta kandi bukoreshwa ahanini mu gutanga amatafari ahashe.



Example Blocks / Ingero z` amatafari



There are also different types of block shapes. The most common shape is the rectangular flat faced block, similar to a large brick, as *Rukarakara*. Interlocking blocks are recommended in this manual, as illustrated above, and there are many different shapes available. They can help structural stability while saving on mortar.

Hari kandi ubwoko butandukanye bw` amatafari adatwitse hakurikijwe foromo zakoreshejwe. Azwi cyane ni amatafari y` urukiramende, ahashe kandi manini: mbese atubutse nka Rukarakara. Amatafari afungana niyo yibanzweho muri iki gitabo kandi nayo afite amoko menshi atandukanye nk`uko bigaragazwa n`iki gishushanyo kiri hejuru. Aya matafari atuma inzu ikomera kandi ntihakoreshwa umucanga n`ishwagara byinshi mu kuyubaka.

Getting Started: Organizational topics / Gutangira

Preparation with the District office:

- Ask for registration of your plot.
- Think about the placement of the house on the plot and ask for options if you need help. There are floor plan alternatives in the appendix of this manual.
- Consider site drainage, water collection, sewage, and access. Determine whether city services such as water and electricity are available.
- Prepare a cost estimate for construction and finishing:
 - Choose or adapt the floor plan to your family needs and your capacities. A bigger house is more expensive. A small house can be extended later if you plan for the placement of the extension at the beginning.
 - Plan the materials for the floor, doors, and windows according to your financial capacities. If you are unsure of costs, always choose the cheaper option; it can be upgraded later.
- Hand in all documents for building permission at the district office.

Gutangira:urutonde rw'ibikorwa

Ibijyanye n'ubuyobozi bw'Akarere:

- Gusaba ko ikibanza cyawe cyandikwa mu bitabo bya bigenewe
- Gutekereza uko inzu izicara mu kibanza ndetse byaba ngombwa ukagisha inama. Mu migereka y'iki gitabo harimo uburyo butandukanye bwo gutegura ikibanza.
- Kwita kubijyanye no kuyobora amazi y'imvura ava mu kibanza ,amazi y'imvura , amazi ava mu rwiuhagiro no mu misarane,kureba niba ahazubakwa hagera umuhanda,amazi n'imuriro.
- Gutegura ibijyanye n'agaciro k'inzu no kuyikorera amasuku:
 - Guhitamo ugereraniye n' ibyo umuryango wawe ukenera kandi witaye k'ubushobozi ufite.Inzu nini iba ihenze mu gihe kubaka into wateganyije kuzayagura byaguhendukira.
 - Guteganya ibikoresho bikenewe muri pavoma, inzugi n'amadirishya bijyanye n'ubushobozi ufite. Biba byiza iyo uhisemo ibikoresho bihendutse kuko ushobora kuzabisimbura igihe kigiyeyo cyane iyo ushidikanya kubiciro.
- Kwaka impapuro zose ziguha uburenganzira bwo kubaka.

Before block making and construction:

- A soil test is necessary before you make blocks. A gradation test is recommended at minimum. You must dig below the top layer and test the soil underneath. Ask for assistance from the district office.
- Determine the right mix for the bricks and ask for assistance. Some information is included here, but also see the Block Making Manual.

Ibikorwa mbere yo kubumba no kubaka.

- Gupima ubutaka mbere yo kubumba ni ngombwa. Kumenya nibura uko ubutaka uzakoresha bwitwa ni ngombwa cyane. Ubutaka upima ni ubwo ucukura nibura muri metero imwe y'ubujyakuzimu. Waka ubufasha ku karere.
- Kugaragaza uburyo bwiza bwivangwa ry'ubutaka n'ibindi byongerwamo ukanasaba inama. Zimwe muri izo Nama zatanzwe muri iki gitabo ariko bitabujije ko warebamo n'ibirebana n'ibumbwa ry'amatafari.



Good Maurram soil (laterite clay) for block making. Ubu ni ubutaka bwiza bwavamo amatafari (inombe).



Digging a test pit to analyze soil on site. Uburyo bacukura mu kibanza ngo hapimwe ubwiza bw'ubutaka.

Soil Mix / Ivangwa ry` ubutaka

Stabilization means modifying a soil to achieve improvements such as compressive strength, impermeability, strength when saturated with water, or resistance to erosion. Stabilization can be achieved mechanically through compaction, physically through controlling grain size and distribution, and chemically through the addition of materials such as lime or cement.

Soil in Rwanda is typically comprised of **laterite clay** (also called Maurram soil), although montmorillonite ('black cotton soil') might be encountered in the north near the basalt volcano areas. Lateritic clay is generally red in color, is formed from weathered granite, and is composed of large quantities of iron oxide and aluminum. It is generally a good soil for compressed earth block construction, but montmorillonite is not due to excessive shrinkage and swelling characteristics from water exposure. Topsoil, comprised of organic materials mixed with soil, should never be used.

A well-graded (also called “poorly sorted”) soil has relatively equal amounts of particles that range from fines to gravel, as opposed to a poorly-graded soil that consists of primarily one particle size. For Stabilized Earth Blocks, it is important to have a well-graded soil in order to reduce the volume of air voids within the soil matrix.

The following table defines particle type according to size:

| | | |
|---------|------|------------------|
| Gravel | | 60 mm to 2 mm |
| Sand | | 2 mm to .06 mm |
| 'Fines' | Silt | .06mm to .002 mm |
| | Clay | Less than .002mm |

Soil should be sieved to eliminate all particles greater than 5mm diameter. Such particles will not bind well with the lime or cement. For more information concerning soil types and definitions, consult a soils text.

Uko ubutaka buvangwa

Aha “guhindura ubutaka” ni uburyo bukoreshwa kugira ngo ubutaka bwongere ubukomere, ntibwinjirwemo n’amazi, bukomere n’igihe buri mu mazi kandi ntibutwarwe n’isuri. Ibi byagerwaho hakoreshejwe kubutsindagira, kubuvangira neza ku buryo ibice byabwo byose bigaragaramo no kubwongeramo ishwanaga cyangwa isima.

Mu Rwanda dusangamo ubutaka ahanini bw’inombe ndetse n’ubutaka bufite ibara ry’umukara buboneka mu mujyaruguru (hafi y’ibirunga). Ubusanzwe ubutaka bw’inombe buba butukura, imunda y’isi asaza agacikagurika. Bugizwe n’utundi duce duta cyane (Ubutare: Fer na Aluminium). Ni ubutaka bwiza buberanye no kuvamo amatafari adatwitse. Naho ubutaka twavuze buboneka mu Karere k’ibirunga ntabwo butumba iyo buri mu mazi. Ubutaka bwo hejuru ya metero imwe y’ubujyakuzimu ndetse n’ubutaka buhingwaho ntibugomba gukoreshwa mu gukora amatafari adatwitse.

Ubutaka bwiza buba bufite ingano nyinshi z’inyangiro (uduce tugize ubwo butaka) kandi zinganya ubwinshi bwazo uhereye ku buto cyane ukagera kubw’amabuye (igaraviye), ububi buba bufite ingano imwe gusa. Kugirango rero amatafari y’itaka adatwitse abe akomeye/arambye, ni ngombwa gukorseha ubutaka bufite ingano nyinshi, ibi bikaba bituma nta myenge myinshi iboneka hagati yabwo.

Iyi mbonerahamwe irerekana ubwoko bw’uduce tw’ubutaka n’ibipimo:

| | | |
|-------------------|---------------------|---------------------------|
| Igaraviye | | 60 mm kugeza kuri 2 mm |
| Umucanga/umusenyi | | 2 mm kugeza kuri .06 mm |
| ubwiza | Ubushobora guhingwa | .06mm kugeza kuri .002 mm |
| | Ibumba | Munsi ya .002mm |

Ubutaka bugomba kuyungururwa ngo havemo utubumbe turengeje umurambararo wa 5cm kuko utwo duce tutakwivanga neza na sima cyangwa ishwanaga. Ibisobanuro bihagije kubirebana n’ubwoko bw’ubutaka, reba ibijyanye n’ipimwa ry’ubutaka muri iki gitabo.

Lime vs. Cement

Generally, cement binds better with sand and lime binds better with clay; depending on the ratios of sand and clay in the mixture, the amount of cement and/or lime should be adjusted accordingly. This will best be determined by making test blocks before construction that can be tested for strength and water resistance.

With soils of less than 30% clay, **cement** should be used as the stabilizer. The quantity should be between 3% and 10% by weight, although higher cement ratios will always produce higher compressive strength. Cement should be added immediately before block making.

If clays in the soil are greater than approximately 50%, **lime** should be used for stabilization. The quantity should be between 6% and 15% by weight, although at some point the percentage of lime is optimized, beyond which the compressive strength will decrease; this amount has not been determined in Rwanda. Preliminary tests indicate that at least 10% lime produces a significantly stronger block than lower ratios (see graph below). Lime should be added a day before block making to allow the lime to break up soil lumps and increase compaction.

Lime quality and type in Rwanda is not distinguished when purchased outside the factory. For compressed earth block production, one should use non-hydraulic lime: 'quick lime' (CaO) or 'slaked lime' [(CaOH)₂], formed by hydrating quicklime. Hydraulic limes and agricultural limes should not be used.

For soils between estimated 30% and 50% clay, it is likely that the best compressive strength will be achieved with a mixture of **cement and lime** with the soil base. However, this amount should be determined by field and laboratory testing before any construction is proposed with this gradation. Note that if cement and lime are added, the lime should be added a day before and the cement immediately before block production.

Ishwagara ugereranyije n'isima

Muri rusange, sima ivangwa n'umucanga /umusenyi, naho ishwagara ikavangwa n'ibumba hakurikijwe ingano yakimwe muri ibyo. Ingano ya sima cyangwa ishwagara yongerwamo ku gipimo. Ibi biterwa n'icyo isuzuma ry'amatafari ryatanze. Hapimwa kandi ubukomere n'ubudahangarwa n'amazi byayo.

Kubutaka butarengeje 30% by'ibumba, hakoreshwa sima ngo bikomere. Ingano yayo iba iri hagati ya 3% na 10% by'uburemere: sima nyinshi itanga ubukomere bwinshi, ishyirwamo kandi mbere y'uko amatafari ubumbwa.

Naho iyo ubutaka burengeje 50%, ni ishwagara ikoreshwa. Ingano yayo iba ari 6% kugera kuri 15% by'uburemere. Akenshi ishwagara irizerwa ariko iyo ibayemo nyinshi igabanya ubukomere bw'amatafari n'ubwo ibi bitaragaragazwa mu Rwanda. Igeragezwa ryambere ryagaragaje ko nibura 10% by'ishwagara bitanga amatafari akomeye. Ishwagara ishyirwamo umunsi umwe mbere y'ibumbwa ry'amatafari, ibyo bituma ibinonko bishwanyagurika maze ubukomere bw'amatafari bukiyongera.

Ntawabasha gutandukanya ubwiza bw'ishwagara zo mu Rwanda iyo zitaguriwe mu nganda. Hagakoreshejwe ubwoko budaseye (igiheri) bwitwa CaO cyangwa se indi iheretuye yitwa CaOH₂. Ishwagara inoze ndetse n'ikoreshwa mu buhinzi ntizikoreshwa mu kubumba.

Ubutaka bufite hagati ya 30% na 50% by'ibumba, bibabyiza iyohongewemo sima ndetse n'ishwagara icyarimwe ngo hongere ubukomere bwa'matafari. Ingano iterwa n'ubutaka ubwo ari bwo ndetse n'ipimwa ryabwo muri loborawari mbere y'uko hagira igikorwa kuri uru rwego. Ibuka ko ishwagara ishyirwamo mbere ho umunsi umwe, naho sima yo ishyirwamo ako kanya.

Water Content

The amount of water necessary for block making will vary, but it should be approximately 1:10 water: soil. The optimum content is that which allows the greatest compaction of the soil (highest density). This amount should be determined through laboratory testing, although field experience will also indicate a good ratio. A ball of soil with the proper water content is dropped from 1m onto hard ground, it should break into a few pieces and not shatter into small pieces or remain in one big lump.

Ingano y'amazi

Mu kubumba amatafari, ingano y'amazi irahindagurika, ariko yakabaye 1:10(amazi: ubutaka)..Ingano y'amazi nyayo ni ituma ubutaka bufatana bya nyabyo.Ikaba rero imenyekana nyuma y'igerageza muri laboratwari.Uburambe mu kazi ko gupima ubutaka nabwo ariko bushobora gukorsehwa.Akabumbe k'ubutaka bwavanzwe n'amazi nyayo karekurwa mu buhagarike bwa meteroimwe kakagwa hasi.Ingano iba nziza iyo gashwanyutsemo uduce duto tudakabije cyangwa kadashwanyutse na busa.



Compaction

The compaction of the soil bricks results in a higher strength. There are different ways to compact but the manual earth block press will give you the better result compared to the hand compaction, as illustrated in the picture.

Gutsindagira

Ubukomere bw'amatafari y'igitaka buterwa n'uko atsindagiye. N'ubwo hari uburyo bunyuranye bwo gutsindagira amatafari, usanga imashini arizo nziza iyo ugereranyije n'amaboko. Byagaragajwe ku gishushanyo.

**Strength**

Soil blocks should achieve at least 0.7 MPa (Mega Pascals) compressive strength when dry. A good field test is to place a block between two adjacent blocks as shown in the photo, and then stand on the center of the middle block. If the block breaks, its strength may not be sufficient.

Ubukomere

Ubukomere bw'amadafari bwakabaye bugera kuri 0.7 mu ngero za Mega Pascals (0.7 MPa) iyo yumye. Igerageza riboneye rikorewe ahabumbiwe ni ugufata amatafari abiri ntuyegeranye, maze hejuru yayo ugatambikaho irindi; noneho ugahagararaho hagati nk'uko igishushanyo kibikwerekako.



| | |
|---|---|
| <p>Soil mix recommendation</p> <p><i>Lime</i> 10% lime should be added to a soil mixture by volume, i.e. 9 buckets soil and 1 bucket lime. 5% lime appears to lessen soil strength in the short term and lime over 15% does not increase strength. Mixing the materials and letting it sit for a day or more appears to increase strength, as suggested by the literature. Most lime in Rwanda has many lumps. Screening the lime with a fine mesh before use appears to heighten strength.</p> <p><i>Cement</i> Cement in any quantity appears to strengthen the mixture tremendously. At the time of construction of the Model House, cement was more than 3 times as expensive as lime. Currently, it is even slightly less expensive than lime. However, unlike lime, cement must be used immediately to achieve this strength (within 30 minutes). This is difficult in the field for mass production with hand tools, and unlikely in unsupervised conditions.</p> <p><i>Sand</i> A mix of approximately 50% sand and 50% silt/clay is optimal when soil is stabilized with cement.</p> | <p>Uko igitaka kivantwa</p> <p><i>Ishwagara</i> Mu gitaka cyateguwe hajyamo 10% by`ishwagara ni ukuvuga inshuro 9 z`ubutaka n`inshuro imwe y`ishwagara.5% by`ishwagara bitanga ubukomere buke, naho hejuru ya15% nabyo ni uko. Ubukomere bwiyongera iyo urwo ruvange kozwe umunsi umwe mbere. Ishwagara nyinshi mu Rwanda ifite utubumbe.Kuyiyungurura rero mbere bituma ubukomere bwiyongera.</p> <p><i>Sima</i> Sima uko yaba ingana kose itanga ubukomere.Hubakwa iyo nzu –ntangarugero,sima yahendaga kurusha ishwaraga inshuro 3 zose . Ubu nabwo iracyahenda kurenza ishwaraga.Ntishyirwamo ako kanya si nk`ishwaraga (iminota 30 irahagije)Ibi ariko biragorana iyo ari ahakenerwa nyishi icyarimwe kandi bavangisha ibikoresho by` amaboko nta n`ubagenzura.</p> <p><i>Umucanga/umusenyi</i> Iyo mu ruvange harimo sima singombwa kurenza cyangwa ugeza kuri 50% by`umucanga/umusenyi cyangwa ibumba.</p> |
|---|---|

Testing

Generally, a test regimen will require five (5) similar shaped and sized blocks of each particular lime: soil ratio or mixture.

Testing should follow normal international standards. These tests include:

- 2003 IBC 2109.8.1.2.1 Modulus of Rupture Test
- ASTM C67 - Sampling and Testing Brick and Structural Clay Tile
- ASTM D1632 - Making and Curing Soil-Cement Compression and Flexure Test Specimens
- ASTM D1633 - Compression Strength of Molded Soil Cement Cylinders
- ASTM D558 - Moisture-Density Relations of Soil Cement
- ASTM D559-03 Wetting and Drying Soil-Cement Mixtures
- NZS 4298:1998 Appendix D Pressure Spray Method Erosion Test

The details of these tests are familiar to soils laboratory personnel and are beyond the scope of this document. They should be referred to in their original form for accuracy. In the event that some testing methods are not practical (such as the NZS Pressure Spray Method Erosion Test), an alternative, similar method should be selected from available resources in Rwanda. The selected alternative should be as close to the original standard as possible to maintain continuity with previous methods and research in other countries.



Igeragezwa/ isuzuma

Muri rusange igerageza –ntangarugero rikorerwa ku madafari 5 ameze kandi ateye kimwe kuri buri bwoko bw` ingano y`ubutaka n`ishwagara .




Igeragezwa rigomba kwitabaza aya amategeko-mpuzamahanga:



- 2003 IBC 2109.8.1.2 Modulus of Rupture Test (ikusanya ku igeregeza ry`ishwanyaguza)
- ASTM C67 - Sampling and Testing Brick and Structural Clay Tile
- ASTM D1632 - Making and Curing Soil-Cement Compression and Flexure Test Specimens
- ASTM D1633 Standard Test Methods for Compressive Strength of Molded Soil-Cement cylinders (igeragezwa ryemewe mu kongera ubukomere n`imatana by`uruvange rwa sima n`ubutaka)
- ASTM D559-03 Standard Test Methods of Wetting and Drying Soil-Cement Mixture (uburyo bwemewe bwo kumutsa no kumisha amadafari y`uruvange rw`igitaka n`isima)
- NZS 4298:1998 Appendix D Pressure Spray Method Erosion Test (igerageza mu buryo bw`irwanyasuri)



Amakuru arambuye azwi neza n`abakozi ba laboratwari kandi ahanini ntajyanye cyane n`iki gitabo.By`imvaho, ni ugusoma igitabo cy`ayo mategeko.Hari n`ubwo amwe mu mageragezwa adakunda: nka NZS Pressure Spray Method Erosion Test. Kubw`ibyho, uburyo bwagakwiye guhitwamo, mu Rwanda. Hakurikijwe ibikoresho biboneka.Ubuhiswemo bukaba bujyanye nayo kugirango habeho uruhererekane hagati y`uburyo bwa mbere n`ubushakashatsi bw`ibindi bihugu.

Block Production / Kubumba amatafari

The following procedure is recommended for soil block production/ Uburyo bukurikira nibwo bukoreshwa mu kubumba amadafari mu gitaka:

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| <p>Excavate soil below the topsoil layer. Often, deeper soil is harder to excavate, but it will produce a strong block.</p> | <p>Higizwayo ubutaka bwo hejuru. N`ubwo gucukura ubutaka bwo hasi bivuna, akenshi nibwo butanga amadafari akomeye.</p> |  |
| <p>Arrange for a laboratory tests on soil to determine properties: gradation and optimum water content. Ask for assistance at your District office.</p> | <p>Hategurwa kandi igeragezwa kiri bwa butaka ngo hamenyekane ubwiza n`ingano z`amazi yashyirwamo. Saba ubufasha ku karere.</p> |  |
| <p>Sieve soil to remove all particles >5mm. Crush larger particles and resieve or discard. Add silt or sand if necessary, according to the results from the gradation test and the availability of cement or lime. In Rwanda you will most likely choose lime as a stabilizer due to its lower cost and wider availability, as well as its suitability for stabilizing clay (Maurram) soils.</p> | <p>Hayungururwa ubutaka ngo havemo itubumbe turenze 5mm, noneho ibisigaye bikamenwa. Iyo bibaye ngombwa honger-wamo umusenyi/ umucanga hakurikijwe ibyavuye mu igerageza. Iyo habonetse sima cyangwa ishwagara bishyirwamo. Mu Rwanda wakoresha ishwagara kuko ariyo iboneka hose kandi inahendutse. Inaberana n`ibumba.</p> |  |

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| <p>Add lime to soil, thoroughly mix, and allow to sit for one day. This allows the lime to break apart clay lumps and create a better mix.</p> <p>Remix soil and lime, add cement if desired, add water and produce blocks immediately. Cement should not contact moisture in the mix for more than 20 minutes before producing the block. A trained operator will know the best water content for the soil.</p> | <p>Hongerwa ishwaraga mu gitaka maze bikavangavanga. Bikorwa mbere ho umunsi umwe. Akamaro k'iyi shwaraga ni ugushwanyaguza rya bumba/igitaka ngo habeho kwivanga kubereye. Hakomezwa kuvangavanga ubutaka n'ishwaraga, hakongerwamo sima iyo ubyifuje; hagashyirwamo amazi, bigapondwa byanoga bikabumbwa. Isima ntirenza iminota 20 kugirango igumane ubudahangarwa bwayo. Impuguke zimanya amazi ajyamo.</p> |  |
| <p>The soil block press should be operated as described in the instruction manual; different machines require different soil amounts and maintenance requirements. Operators of the machine should be trained before use to insure high quality block production. Blocks are delicate for the first several days after production.</p> | <p>Aya matafari ugomba kubumbwa hakurikije amabwiriza yatanzwe muri iki gitabo. Kimwe n'uko imashini zitandukanye mukwakira ubunini runaka bw'urwondo/ibumba, zisaba no kwitabwaho gutandukanye. Abakoresha imashini bagomba kubitozwa ngo bazabumbe amatafari yizewe. Nyuma y'iminsi mike hatangira kugaragara ubwiza bwa yamatafari.</p> |  |

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| <p>Arrange blocks in rows and place under a plastic tarp. Sprinkle water on blocks in morning and evening for seven days, keeping covered. The process is called curing. The longer the blocks are cured, the higher the final strength of the wall will be.</p> | <p>Tondekanya amafari unayatwikirize ihema/shitingi. Ayo mafari avomererwa mu gitondo na nimugoroba: bigakorwa iminsi myinshi kandi akaguma atwikiriwe: ubwo ni uburyo bwo kuyitaho. Uko yitaweho avomererwa niko akomera.</p> |  |
| <p>After the first seven days, stack blocks up to five rows high and allow further curing for at least one month for lime bricks and seven days for cement bricks. Keep them covered with the plastic tarp.</p> | <p>Amafari atondwa mu mirongo 5 uzamuka: nyuma y'icyumweru. Akomeza kuvomererwa ukwezi kose ku mafari arimo ishwagara, n'icyumweru kuyarimo sima. Aba agitwikiriye.</p> |  |

House Design / Inyigo y' inzu

Structural House Design /Inyigo y'ubukomere bw'inzu

The following considerations are important in designing a structurally adequate and durable house:

- Interlocking blocks are recommended, although they may take more experience to use properly
- No vertical joint should be positioned above another vertical joint.
- A bond beam around the entire perimeter of the structure at the windows or at the roof. This may be of bamboo or steel reinforcing, in a concrete matrix. Sliced bamboo pieces are sufficient for a one-story construction.
- Additional reinforcement in and around corners within the bond beam.
- A lightweight roof relative to the entire structure.
- Relatively small and evenly spaced openings such as windows and doors that are not more than 1/3 the wall length. Windows and doors should not be near corners if not necessary.
- No openings should be greater than 1.2m width.
- At least 1.2m of wall should exist between all doors or windows to maintain vertical wall strength.
- Good quality materials and workmanship, including plumb walls.
- Uniform thickness of mortar between joints.
- Uniform bricks, both in height and length.
- Interior walls in both directions which are load-bearing and similar in design and construction to exterior walls.
- Square or nearly square floor plan (not 'L' shaped or other irregular shapes).
- Strong lintels above all windows and doors which will prevent collapse at these locations.
- Well made foundation, which is densely packed with as few voids as possible.

Good protection of the wall against water by constructing a big overhang, good drainage and splash protection on the base of the wall.

Inyigo y'ubukomere bw'inzu

Amabwiriza akurikira ni ingenzi mu gukora inyigo y'inzu ikomeye kandi izamara igihe:

- Amatafari afungana niyo yakagombye gukoreshwa n'ubwo bisaba uburambe mu kuyubaka.
- Nta juwe ihagaze yakagombye kurebana n'indi ihagaze.
- Hejuru y'amadirishya n'inzugi hashyirwaho lento. Ishobora kuba na beto ikozwe n'umucanga, isima na garaviye ndetse n'ibyuma cyangwa imigano. Imigano ikaba ishobora gukoreshwa ku nzu isanzwe.
- mu nguni hongerwamo ferabeto, kugira ngo lento irusheho gukomera.
- Igisenge kitaremereye kandi kijyanye n'imiterere y'inzu.
- Amadirishya n'inzugi biba bigereranyije: bitarenze 1/3 cy'uburebure bw'urukuta. Ntibishyirwa hafi y'inguni.
- Ubugari bw'inzugi n'amadirishya ntiburenga metero 1.2.
- Nibura hagati y'amadirishya n'inzugi hakenewe metero 1.2m z'ubutambike kugira ngo inkuta zibe zikomeye.
- Ibikoresho byiza, n'imikorere myiza.
- Amajuwe hagati y'amatafari angana hagati .
- Amatafari angina ari uburebure n'ubugari .
- Mu nzu imbere hubakwamo inkuta zinyuze mu mpande zose, zakira uburemere bw'inzu kandi zisa n'izo hanze haba mu myubakire no mu nyigo(uko ziteye).
- Hasi hagira ishusho ya kare cyangwa iyenda kuba kare (si imeze nka 'L' n'izindi zibonetse zose).
- Lento ikomeye ishyirwa hejuru y'inzugi n'amadirishya, zigatuma inyubako yo hejuru y'inzugi n'amadirishya itangirika.
- Fondasiyo ikomeye ku buryo haboneka imyanya hagati y'amabuye muke ishoboka.
- Inkuta zirindwa amazi hakoreshejwe urubaraza rugari, imigende iyobora amazi, n'umukandara wo hasi (urugarika) wo kurinda amazi atarukira ku rukuta.

House Architectural Design

In addition, you have to consider some aspects concerning the architectural design:

- How many bedrooms do you need?
- How big should the house be? A small initial size with a plan for future possible extensions? There are some floor plan examples in the Appendix.
- Do you need a corridor or can you do without it and save some money this way?
- Do you want to construct a separated annex with toilet, shower and kitchen or would you like these in the main house?
- Where do you want to place the annex in the plot in relation to your house?
- Do you want to share a biogas digester with your neighbors to create a clean waste water solution and in addition to gain some gas for cooking?
- Where do you install the rain water tank? It should be placed near the annex but you need some roof surface from which you collect the water.
- Which shape of roof do you choose? A shed roof is the best choice if you plan to harvest rain-water with one tank. It is also the cheapest.
- Which type of doors and windows are you going to buy or build? Metal doors and windows are expensive and are not safer than wooden doors if placed in an earth construction. Do you need glass in the windows? You can always plan for window glasses but cover the opening with screen and upgrade it later when you have money.
- Which type of floor and finishing do you choose? The manual will tell you about alternatives in the respective section.

While making the choice, never forget that 'more', 'bigger' or 'stronger' means 'more expensive' but not necessarily 'better'.




Inyigo y'igishushanyo cy'inzu




Mugutegura ishusho y'inzu, hari ibyitabwaho:

- Umubare w'ibyumba wifuza.
- Uko inzu izaba ingana: niba ishobora kuzagurwa nyuma. Urasanga hari ingero zatanzwe mu mugereka w'igitabo.
- Esa haba hakenewe korodori cyangwa ushobora kuyireka mu buryo bwo kugabanya amafaranga azatangwa?
- Wifuza kubaka izindi nzu ku ruhande nk'umusarani, bwogero n'igikoni? Cyangwa icyifuzo ni uko byaba mu nzu nini?
- Urashaka gushyira izindi nzu hehe mu kibanza ugereranyije n'aho inzu nini yubatse?
- Waba uzafatanye Biyogazi n'abaturanyi ngo mukemure ikibazo k'imyanda n'amazi ndetse no kubona gazi yo guteka.
- Ni he wifuza gushyira itanki y'amazi? Ahanini ishyirwa hafi y'inzu zindi(annexe) ariko hagakenywa igisenge giteye neza.
- Igisenge kizaba giteye gite? icya gitwekimwe ni cyiza iyo ushaka gutega amazi yose mu itanki imwe, dore ko ari nacyo gihendutse.
- Ni ubuhe bwoko bw'amadirishya n'inzugi uteganya kugura cyangwa kubakishya? Ibya metalike birahenda kandi ntabwo biba byiza kurusha iby'ibiti iyo bikinze ku nzu y'amatafari y'igitaka. Uzakoresha ibirahure mu madirishya? Wategura ay'ibirahure ariko ukaba ushizemo amabati wazabona amafranga nyuma ukaba washiramo ibirahure .
- Hasi hazaba hameze gute? Amasuku yo ni ayahe? Igitabo kirimo ibyerekeranye n'ibi.

Mu guhitamo ibi byose ntiwibagirwe ko uko inzu iba nini cyangwa ikomera niko ihenda ariko ntibivuga ko iba ari nziza.

Site Preparation / Gusiza

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| <p>The site should be graded below the topsoil layer to have good foundation support. The grade should be flat if possible, as stepped foundations are more likely to settle unevenly and result in cracks in the building later.</p> | <p>Mu gutegura ikibanza, habanza hakurwaho itaka ryo hejuru ngo haboneke ahakomeye inzu yicara. Hagomba kuba haringaniye bihagije kuko fondasiyo zitaringaniye zikunze kwika bityo bigatuma inzu isatagurika nyuma.</p> |  |
| <p>A surveyor's level can be used to make the foundation grade level within 2cm. If a surveyor's level is not available, a water level can be used instead.</p> | <p>Hakoreshwa kandi inivo ireberwamo ngo hapimwe umusingi ku gipimo cya santimetero 2.. Iyo itabonetse hakoreshwa imbaho y'amazi.</p> |  |
| <p>The corners should be laid out with a measuring tape and marked with stakes. Measure the diagonal distance between corners to insure that the foundation is square.</p> | <p>Inguni zigomba gupimwa hakoreshwejwe metero kandi zigaterwaho imambo. Hapimwa kandi ko zidafunganye ngo hamenyekane ko ari kare.</p> |  |

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| <p>Mark the edges of the foundation excavation with lime to allow easier excavation. If the wall is 15cm wide, then the foundation should be at least 30cm wide, and the excavation a bit wider than this.</p> | <p>Umusingi ushushanyishwa ishwaragara /ingwa ngo byorohere abacukura. Iyo urukuta rufite 15cm z'ubugari, umusingi ungana na 30cm; ahazacukurwa harenzwaho gake.</p> |  |
| <p>Excavate the soil along the marked lines. The minimum foundation depth equals the width, although deeper is better.</p> | <p>Mu gucukura hakurikizwa iyo mirongo. Ubujoyakuzimu bw'umusingi bungana n'ubugari bwawo ariko ibyiza ni uko warezaho.</p> |  |
| <p>When the foundation excavation is complete, place a layer of gravel approximately 3cm deep in the bottom of the foundation area. This will allow drainage if water enters the foundation later.</p> | <p>Iyo gucukura umusingi birangiye, hasaswamo igaraviye mu bujoyakuzimu bwa 3cm mo hasi; bituma amazi aramutse agiyemo yamanuka.</p> |  |

Check the level of the foundation again, and check during the placement of rocks to keep the layers even.

Nyuma, hasuzumwa ingano y`umusingi mbere n`igihe hashyirwamo amabuye ngo za ngero zidatakara.








Foundation / Umusingi

Large rocks should be placed in the foundation first. These will distribute the load from the walls more evenly into the soil below. Rocks should be placed flat so that they are more stable and will not tilt if they settle later.


Amabuye mmanini niyo abanzwa hasi. Ibi bikaba rero bituma yakira uburemere bwose bw'inkuta bujya hasi mu butaka. Amabuye ashwirwamo hakurikijwe uko ateye (inda yayo) ngo nyuma ataba yahirima ageretsweho inyubako.







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| <p>After placing the large rocks, insert medium sized and smaller rocks. Smash these with a hammer to make them dense and well packed. Stabilized soil may be added also to fill all voids in the foundation. This may also be dampened to allow the soil to fill the matrix, but the soil should not be wetted too much.</p> | <p>Nyuma y`ayo mabuye manini, hongerwaho agereranyije n`amato maze agatsindagirishwa inyundo. Nyuma umusingi uratabwa hakoreshejwe ubutaka buvanze n'ishwagara kugira ngo imyanya yose isibwe. Iryo taka naryo rigatsindagirwa. Iryo taka ntirigomba gutoswa cyane.</p> |  |
| <p>Mix a mortar for the foundation. The mix should be similar to that used for block production.</p> | <p>Vanga ubutaka n'ishwagara ushyiremo n'amazi nk'uko wabivanze hakorwa amatafari.</p> |  |
| <p>At the top layer of the foundation, again place large, flat rocks. This layer is very important, as it will form the base for the walls. You should start with laying out the corners. Use large, stable stones in the corners.</p> | <p>Hejuru y`ibyo byose hagerekwaho andi mabuye manini azaba intebe y`urukuta. Ushobora guhera mu nguni kandi ukibanda ku mabuye manini cyane kuko niyo akomeza inguni.</p> |  |

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| <p>A layer of soil can be used to make the foundation level (within 1cm) at the top.</p> | <p>Hejuru y`ayo mabuye hashobora kongerwaho ibitaka kugira ngo fondasiyo iringanire(ntiburenza cm 1 hejuru y'amabuye).</p> |  |
| <p>A If materials are available, the foundation can be raised above the grade level to allow better drainage and provide some splash protection for the walls. This should be done such that the stones are stable, however.</p> | <p>Iyo ibikoresho bihari ari byinshi, umusingi urenga indara y`ubutaka ngo birwanye iyinjira ry`amazi mu nkuta ndetse bigatuma n'imigende y'amazi ikorwa neza..Ibi bikorwa ya mabuye yicazwa neza ku buryo nta cyayahungabanya.</p> |  |

Plumbing / Iby` amazi


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| <p>In some cases, a biogas digester or other water or waste treatment system may be installed on the house. If so, this system should be considered while building the foundation so that excavation is not required later.</p> | <p>Akenshi ku nzu hashyirwaho biyogazi cyangwa se ikindi cyose gitunganya imyanda. Iyo bizakorwa, ni byiza ko byubakanwa n`umusingi ngo nabyo bicukurirwe.</p> |  |
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| <p>In this example, the drain from the toilet passes through the foundation in this area of the house. The foundation should be widened slightly at this interruption to make it more stable and durable.</p> | <p>Kuri uru rugero rwatanzwe, imiyoboro y`umusarane yambukiranya urukuta.Ningombwa ko mu musingi hasigaramo umwanya wabiteganyirijwe ngo umusingi utazononwa.</p> |  |
| <p>Rain water from the roof for the toilet, kitchen and small bath-room can be installed at low cost. Think of the location of the tank and the plumbing during the construction of the foundation if you want to place the pipes in the bottom of the house. The tank should be placed as high as possible to achieve water pressure for the taps, but also placed below the lowest point of the gutter.</p> | <p>Amazi y`imvura aturuka ku gikoni, n`urwiyuhagiriro ashobora kubikwa ku giciro gito.Teganya aho itanki izajya ndetse n`aho amazi azanyura hose mu gihe cy`iyubakwa ry`umusingi niba ushaka ko imiyoboro y`amazi yanyuzwa mu nsi y'inzu. Itanki igomba kwigizwa hejuru hashoboka ngo amazi abashe kugera muri robine, ariko na none itarenze ubutumburuke bw`umureko.</p> |  |
| <p>For plumbing, PVC pipes and fittings are easiest to install at the site. The joints will be fixed with a specific PVC glue. Steel taps will require adaptors to work with the PVC.</p> | <p>Mugushyira amazi mu nzu, amatiyo ya PVC, niyo yoroshye gukoreshwa.Afatanywa n`umuti wabugenewe.Hari udukoresho twabugenewe duhuza ayo matiyo na robine dore ko zo ziba zikozwe mu byuma.</p> |  |

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| <p>Piping can be run either above the doors or underneath the floor. Below is easier, but it requires planning during foundation construction. Consult a trained plumber for this system to insure proper installation.</p> | <p>Amatiyo ashobora guca hejuru y'imiryango cyangwa mu nsi y'inzu. Ibi ni nabyo byiza uretse ko bigomba guteganywa mu gihe cyo kubaka fondasiyo. Hitabazwa impuguke mu by'amazi kugirango ibi bikorwe neza.</p> |  |
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Walls / Inkuta

Layout, Door Openings, and 1st Course / Ishusho y'inzu igitangira kubakwa, kugaragaza imiryango na ranje ya mbere




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| <p>Place a plastic sheet above the foundation to prevent water and termites from entering the walls. The entire house should be laid out on the first course, including door openings. This will insure that the blocks line up above the door lintels. This is not necessary in block shapes such as the 'Hydraform,' where the individual block length may vary.</p> | <p>Hejuru y'umusingi hashyirwa ishashi cyangwa ikindi kintu gikoze muri parasitiki ngo kirinde inkuta imiswa n'amazi. Inzu yose igomba kuzengurutswa umurongo wa mbere harimo n'ah'imiryango, bituma umurongo w'amatafari ukurikira ugira ifatizo rihamye. Ibi ariko ntaho bihuriye n'imiterere y'amatafari nk'aya Hydraform, aho uburebure bwayo bushobora guhinduka.</p> |  |
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| <p>Special consideration should be given to corners and intersections to prevent locating vertical joints above each other. Here is one example of how this can be accomplished using interlocking blocks.</p> | <p>Hitabwa cyane ku mfuruka n'aho fondasiyo zihurira mu kwirinda kubaka ibirebane. Ibi bishobora kugerwaho hakoreshejwe amatafari afungana.</p> |  |
| <p>Before continuing with the second course, check again that the base course is level and that the corners are square.</p> | <p>Mbere yo gukomerezaho ranje ya kabiri hagenzurwa wa murongo fatizo, kandi niba n'imfuruka zigororotse [ari kare]</p> |  |
| <p>Once this is completed, the blocks of the door areas may be removed and the next courses continued. Remember that the doors should be located away from corners for better wall stability. Recommended is a distance of 1,20m from corners.</p> | <p>Ibi birangiye uca imiryango ukuyemo amatafari yari ahubatse maze ugakomerezaho. Ibuka ko amadirishya n'imiryango bijya kure y'imfuruka muri 1.2m kugira ngo inzu ikomere.</p> |  |




Lower Courses and Corners / Ranje zibanza n'inyubako z'inguni


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| <p>Wall construction will not require much mortar between courses if the blocks are high quality and the same height. Every five courses, though, a layer of mortar approximately 3cm thick should be used to lock the blocks together and maintain the same vertical height in the course if necessary.</p> | <p>Kubaka inkuta ntibisaba urwondo rwinshi cyane hagati y'amajwe iyo bloke zabumbwe neza kandi zingana zose .Nyuma ya buri mirongo itanu hajyaho urwondo rwa 3cm kugira ngo bloke zifungwe neza kandi ntihabeho ubusumbane mu buhagarike.</p> |  |
| <p>Wall construction proceeds from the corners to the middle of the wall. If the layout on the first course was correct, the blocks should fit into the wall without later adjustments such as trimming. Experienced masons should be used for this procedure.</p> | <p>Inyubako y'urukuta itangirira/ iherwa mu mfuruka ugaruka hagati mu rukuta. Iyo umurongo ubanza ugoroye ukurikiyeho urihuta nta mananiza nko gukata bloke. Ni byiza gukoresha abafundi b`inzobere muri izi nyubako</p> |  |
| <p>Check the corners periodically for square and vertical alignment. The wall can also be sighted along its length to make sure it is straight.</p> | <p>Hakorwa igenzurwa ry` inguni buri gihe kugira ngo harebwe niba zigororotse .Inkuta kandi zishobora kugorama ni byiza ko zigenda zigenzurwa ngo zikomeze zihagarare zemye.</p> |  |

Walls at Windows / Inkuta ku madirishya



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| <p>Wall construction should proceed in an organized fashion with all walls constructed at the same time to maintain the stability of the structure.</p> | <p>Iyubakwa ry`inkuta rigomba kwitonderwa.Zigomba kubakwa icyarimwe kugira ngo inzu ikomere.</p> |  |
| <p>Window openings should also be located in the middle of the wall, away from corners, to make the structure more stable.</p> | <p>Amadirishya ashirwa hagati mu rukuta, witaruye imfuruka ngo bidahungabanya ubukomere bw`inyubako</p> |  |
| <p>Checking vertical alignment is more important as the walls gain height and the window openings create breaks in the structure.</p> | <p>Uko inkuta zizamuka hasuzumwa niba ubuhagarike bwazo bugororotse Kandi amadirishya akaba atuma haboneka ubusate mu nyubako.</p> |  |




Bond Beam / Kuri rento



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| <p>The bond beam is an important part of the structure, as it ties the walls together at the weak openings. The bond beam should be made of high quality 1:2:4 (cement: sand: gravel) concrete with either bamboo or steel reinforcement.</p> | <p>Lento (imitambiko ku madirishya n`inzugi) ni ngombwa cyane mu bigize inzu kuko iba iyibumbiye hamwe. Ikorwa hakoreshejwe 1:2:4 bya Sima, umucanga n`igaraviye kandi byiza. Ibyo byunganirwa n`ibyuma cyangwa imigano.</p> |  |
| <p>Reinforcement should be well tied to make sure it remains in location when the concrete is applied. All reinforcement should have at least 3cm of concrete around it to create a good bond on all surfaces.</p> | <p>Ibyuma cyangwa imigano bigomba kuba bihambiriye cyane kugirango bigume mu mwanya wabyo igihe beto ishyirwaho. Beto ntirenza cm 3 z'umubyimba.</p> |  |
| <p>The concrete can be smoothed with a 1:4 (cement: sand) mortar mix on the outside to make the beam flush with the wall.</p> | <p>Nyuma horoswaho igipande (1:4 sima: umucanga) kuigira ngo biringanire n`urukuta.</p> |  |

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| <p>The bond beam should also be made level with the surveyor's level or a water level.</p> | <p>Lento ipimwa /iringanizwa hakoreshejwe impaho y'amazi cyangwa ikindi cyuma nivo.</p> |  |
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Roof / Igisenge



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| <p>Roof framing will vary depending on the type of roofing material to be used. If galvanized sheet metal roofing is installed, the framing can be smaller dimensioned lumber. The use of pine wood is recommended compared to eucalyptus, because it will not bend when sliced into pieces.</p> | <p>Imiterere y`igisenge iterwa n`ibikoresho bihari.Nk`iyo hazasakazwa amabati, igisenge gikorwa mu buryo kigira uburemere buke.Gukoresha imbaho nziza zitari iz'inturusu kuko imbaho zikozwe mu nturusu zihengama cyane.</p> |  |
| <p>Plan for a possibly wide overhang as this will protect your earth block wall from rains.</p> | <p>Guteganya urubaraza ruhagije birinda urukuta kunyagirwa.</p> |  |



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| <p>Whatever the quality of your construction wood is, try to join the pieces accurately and tight. The length of construction wood in Rwanda is 4m which will make it necessary to join pieces.</p> | <p>Uko imbaho zaba zimeze kose, ni ngombwa ko ziteranywa neza kandi zikazirikwa. Mu Rwanda, uburebure bw`urubaho usanga ari 4m .Biba rero ngombwa ko zungwa.</p> |  |
| <p>Steel bands can be used to splice together shorter members. These bands should be well nailed with short nails.</p> | <p>Impurumpuru / imikenja niyo ikorehwa mu kunga ibice by`impaho.Hagomba kuzirikwa neza kandi hagaterwamo udusumari.</p> |  |
| <p>If you use iron sheets as a roof cover, you would tie the wood construction to the wall with wire. You tie the wire under the bond beam respectively under the door and window lintels. The reason is the low pressure carried out by the iron sheets which could make your roof blown off by a storm.</p> | <p>Niba hazasakazwa amabati, hazirikwa igisenge hakoreshejwe imikwege cyangwa insinga binyuze mu rukuta cyane kuri za lento.Ibi birinda igisenge kuba cyatwarwa n`inkubi y`umuyaga.</p> |  |

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| <p>Cover the top of the walls in case you construct in the rainy season and in case of delays putting up the roof structure. Remember, the wall is made from soil blocks, which need to be protected as much as possible.</p> | <p>Niba ari mugihe cy`imvura cyangwa igihe igisenge kizatinda kurangira, inkuta zitwikirwa neza kuko ayo amazi yakwangiza inkuta z`amatafari y`icyondo.</p> |  |
| <p>When you place the iron sheets, you should first lay out one row and make sure that all sheets will be mounted straightly. The crosswise overlap would be two wave lengths of the sheet and the longitudinal overlap is about 10cm.</p> | <p>Mugusakara amabati bikorwa mu mironko.Ubanza gusakara umurongo umwe hakarebwa ko uringaniye, maze bigakomezwa gutyo.Amabati kandi aryamanaho imigongo 2, hagasigara 10cm zitwikiriye imbaho.</p> |  |

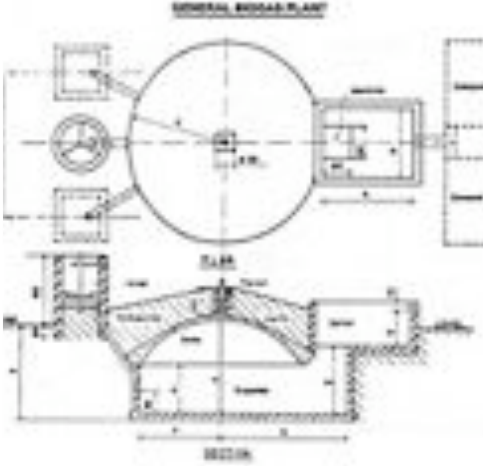

Gutters and rain water harvesting / Imireko no kureka amazi y`imvura

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| <p>Gutters are important to protect your house from water, and they can also collect this water and direct it to a storage tank. This is recommended because you will gain a lot of water to be used in the household. It may also lessen erosion on the plot.</p> | <p>Imireko ni ingirakamaro mu kurinda ko amazi yangiza inzu.Ishobora gutega no kuyobora amazi mu itanki. Ibi ni ngombwa kuko bituma haboneka amazi ahagije agakoreshwa murugo kandi bikarwanya n`isuri mu kibanza.a~</p> |  |
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| <p>Construct a stable base for the rain water tank. It should be elevated to use gravity to conduct the water into kitchen, shower and toilet. Make sure that the elevation is as high as possible but low enough to fit the water tank under the gutter with a slightly descending water pipe. The base needs a foundation which can be constructed in the same manner as the foundation of the house.</p> | <p>Hubakwa kandi icyicaro gikomeye giterekwaho itanki..Cyigizwa hejuru kugira ngo amazi asohokemo afitte ingufu n`umuvuduko ajya aho akenewe.</p> <p>Itangki yigizwa hejuru bihagije, ariko ntirenge umureko.Icyo cyicaro kigomba umusingi nk`uw`inzu.</p> |  |
| <p>The gutter is installed with a slight slope towards the collection point. You can create the slope by using U-shaped gutter support pieces welded from metal, which would be prepared with an ascending hanger-length.</p> <p>You also need to prepare a gutter piece with an outlet to be connected to a rainwater descend to the tank.</p> | <p>Umureko umanura amazi mu kigega ugomba kuba uhengetse gato kugira ngo amazi ashobore kumanuka.Ibi bigerwaho iyo ukozwe ushashe nka ' U'. Uba ufunze uruhande rumwe naho urundi hagateganywaho ahazacomekwa undi.Hakorwa n` akazafatanya iyo mireko,ndetse n'aho amazi asohokera ari naho afatirwa ajwanwa mu itanki.</p> |  |
| <p>You can either use the rain water from the tank, which is cheaper, or install plumbing and serve the kitchen, shower and toilet with the rainwater. In case you are in-stalling a biogas digester, it is recommended to lead the rain water at least into the toilet because in order to</p> | <p>Amazi ashobora gukoreshwa avanywe mu itankii, ari nabyo bihendutse cyangwa hagakoreshwa imiyoboro iyajyana mu gikoni,mu bwogero no mu musarani.Iyo uteganya kubaka biyogazi, ugomba kuyobora amazi mu musarani mu kuhasukura nibura rimwe ku</p> | |

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| <p>flush the toilet once a day. However, it could also be flushed using a simple bucket.</p> | <p>munsi.Hanakoreshwa kandi indobo mu gusukamo ayo mazi.</p> |  |
| <p>There is the option of installing a “first flush system”, which enables the user to separate the first water enriched with dirt from the roof and to lead the cleaner water into the tank after the first flush. There are different first flush systems but the simplest way is to just disconnect the pipe from the tank when the first rain after a long dry period comes and to reconnect, when the dust is flushed off your roof.</p> | <p>Hari uburyo bwinshi bukoreshwa kugira ngo amazi aturuka ku gisenge bwa mbere (yanduye) atandukanwe n'andi aza nyuma ari nayo meza. Uburyo bworoshye ni u gucomora itiyo yajyanaga amazi mu kigega iyo ubonye imvura yambere, nyuma y`impeshyi, igiye kugwa. Isubizwaho iyo ivumbi ryashize ku gisenge.</p> |  |

Biogas harvesting / Biyogazi n’umusaruro wayo



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| <p>Installing a biogas system has two advantages: You deal with your toilet and kitchen waste in an environmentally sustainable manner and you gain energy in the form of gas for cooking. The biogas system consists of an inlet, the digester, an outlet and possibly an expansion chamber. For the evacuation of the affluent, you can plan a pit or a composter. The main component is the digester and it can be constructed with burned bricks or stones. You need to get professional assistance for the construction of such system but it is affordable especially if you share one with your neighbors.</p> | <p>Gukora biyogazi bifite inyungu ebyiri: uba wirinze imyanda mu yo mu musarani no mu gikoni ku buryo burengera ibidukikije kandi buhoraho ndetse ukanunguka gazi ikoreshwa mu gikoni. Biyogazi igizwe n'umwobo muto winjirizwamo imyanda, umwobo munini utunganyirizwamo imyanda, umwobo usohokeramo imyanda ndetse n'icyobo imyanda yasohotse ijyamo. Umwobo utunganyirizwamo imyanda nicyo gice cy'ingenzi cya biyogazi. Ushobora kubakishwa amatafari ahiye cyangwa amabuye. cyangwa amabuye. Hitabaza inzobere mu kuyubaka kandi birahendutse cyane iyo uyifananyije n'abaturanyi.</p> |  |
| <p>It is advantageous if you can use the dung of a cow for harvesting more gas. Otherwise it cannot be assured that all your needs for cooking gas can be met and the biogas harvesting might have to be topped up with other means of gaining energy.</p> | <p>Bitanga umusaruro uhagije iyo hakoreshejewe amase y’inka. Kuko imyanda yo mu musarani no mu gikoni idahagije yonyine.</p> |  |

Landscaping and storm water drainage / Gutunganya ubutaka n'imigende y'amazi

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| <p>It is important that all storm water gets drained away from the house- i.e. from the walls and foundation. This means that the top of the foundations must be made impermeable. The big roof overhang helps also but there is splash water, the reason of which you plaster the façade. There might also occur strong storm water runoff, which should be canalized away from the house, too.</p> | <p>Ni ngombwa ko amazi yose y'imvura (uretse ajya mu itanki)agira imigende iyayobora kure y'inzu ni ukuvuga kure y'inkuta na fondasiyo. Ni ukuvuga ko hejuru ya fondasiyo hagomba gukorwa ku buryo nta mazi ahinjirira. N'ubwo ibaraza ifasha mu kurinda ayo mazi ajya ku nkuta,hari n'andi agenda azitarukuraho ari nayo mpamvu inzu iterwa igipande. Hashobora no kunyura umuvu w'amazi hafi y'inzu,bigasaba rero kuhaca umugende ariko utayegereye.</p> |  |
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Floors / Pavoma




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| <p>There are different options of finishing the floor. The simplest and by far the cheapest is compressed earth floor which can be stabilized with lime. You would mix the top layer of 5-10cm with lime to stabilize it. Use about 6% lime by volume.</p> | <p>Hari uburyo bwinshi bwogutunganya hasi munzu: Ubworoshye ni ugusasamo amatafari y'igitaka arimo ishwagara. Ukoresha ubutaka bwo hejuru(buri hagati ya 5-10cm)mu rwego rwo kongera ubukomere ukoresha nka 6% by'ishwagara .</p> | |
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| A | <p>Another alternative is a stone floor. The stones need to be dressed as in common stone masonry. The joints would be filled with a soil mortar, which can be stabilized with lime. Make sure that you compact the mortar in the joints for that the floor resists future pressure over time. Finish the joints with a “paint” of cement, which does really not need to be thick.</p> | <p>Ubundi buryo ni ugusasa amabuye. Amabuye اساسwa nk'uko bisanzwe bikorwa mu kuyubaka. Amajuwe agomba kuzuzwamo icyondo cy'ubutaka n'ishwagara. Icyo cyondo kigomba gutsindagirwa. Suzuma niba hatsindagiye bihagije kandi ko amajuwe yose zose yuzuye ngo hatazika uko igihe kigirayo. Ubundi ugakotera amajuwe na sima itagomba kuba ifite umubyimba munini.</p> |  |
| A | <p>An alternative is also a floor constructed of a crushed stone layer which would be covered by a cement layer. However, both alternatives will raise the construction costs remarkably.</p> | <p>Ikindi ni ugusasa amabuye amenaguye maze ukarenzaho sima hose. Ubu buryo bwombi, ariko butuma inzu ihenda cyane.</p> |  |

Doors and Windows / Imiryango n'amadirishya

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| <p>If the door and window frames are not installed during wall construction, some difficulty may be encountered with installing them later.</p> | <p>Iyo amadirishya n'inzugi bitateganyirijwe uko bizafungwa mbere, bitera ikibazo mu kubishyira mu nyubako, kuko bisaba rimwe na rimwe gusenya kugira ngo haboneke aho amadogi azajya.</p> |  |
| <p>Installing doors requires nails on the side of the frame. This method works, but it requires a large amount of cement compared with installing the frames during construction. It also causes destruction of the walls when the doors and windows get inserted into the wall. This adds time to the finishing due to required fixing necessities.</p> | <p>Gutera inzugi bisaba gukora amadogi y'imisumari. Ubu buryo burakoreshwa ariko busaba isima nyinshi kandi bugasaba gusenya urukuta igihe inzugi n'amadirishya birimo gufungwa. Binongera igihe cyo gukora amasuku. Ibyiza rero ni ugufunga inzugi n'amadirishya mu gihe inkuta zubakwa.</p> |  |
| <p>The space surrounding the windows and doors should be well plastered with cement mortar or stabilized earth after installation.</p> | <p>Ku muzenguruko w'amadirishya n'inzugi haterwaho igipande cya sima cyangwa se icyondo cy'ibitaka bivanze n'ishwagara.</p> |  |

Finishing / Amasuku

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| <p>For the interior plaster, there are different options, too. There is the conventional cement: sand plaster. But if you have built with earth blocks and lime stabilization, you should decide for a lime plaster. This is not only much cheaper; it will have better cohesion to the blocks.</p> | <p>Hari uburyo butandukanye bwo guhoma imbere mu nzu.hari ugutera igishahuro cy`umucanga na sima, ariko mu gihe hubakishijwe amatafari y'ibitaka arimo ishwagara, wahitamo kuhatera igishahuro cy'ishwagara dore ko ari nabyo bihendutse kandi binajyanye n`amatafari.</p> |  |
| <p>For the interior, you can mix paint from latex, sand and lime. Latex alone is possible but expensive. You will need to apply several layers.</p> | <p>Mwo imbere kandi, ushobora kuvanga irangi ry`amazi mu mucanga n`ishwagara ukabiteramo.Irangi ryonyine rirahenda, kandi risaba kurisiga inshuro nyinshi (layer).</p> |  |
| <p>For outer finishing you can use “karabasasa”, which you apply manually with a cheaply available sprinkling device. It is a thin layer functioning as a wall protection. Make a mix of sand: lime: cement 10:2:1.Add color if you like.</p> | <p>Inyuma kunzu ho, washyiraho karabasasi.Itereshwa icyuma gikoreshwa n'amaboko,kigahenze kandi kiboneka. Iba ifi umbyimba muto (kushe) kandi ikomeza inkuta.Hakaba havangwa umucanga, ishwagara, n`isima (10:2:1) Iyo ubishatse wongeramo irange.</p> |  |

Appendix / Umugereka

Building Permit Documents / Ibyangombwa bitanga uburenganzira bwo kubaka

- Drawings / Ibishushanyo-mbonera
 - 2-Bedroom Model House /Inzu-ntangarugero y`ibyumba 2.
 - 3-Bedroom House (Model House type with extension) /Inzu y`ibyumba 3 (urugero rwo kwagura)
 - 3-Bedroom House /Inzu y`ibyumba 3
- Form sheet project description /imbanzirizamushinga

Bibliography / Ibyo twifashishije

The following books and web sites will give the reader more information about earth construction and building methods:

Ibi bitabo ndetse n'imirongo ya interineti bitanga amakuru afatika mu myubakire hakoreshejwe amatafari y'igitaka.

- "2003 New Mexico Earthen Building Materials Code"
<http://www.nmcpr.state.nm.us/nmac/parts/title14/14.007.0004.htm>
- Affordable, Quake-proof Adobe Housing in Peru http://www.idrc.ca/en/ev-2689-201-1-DO_TOPIC.html
- AC162: Acceptance Criteria for Structural Bamboo http://www.icc-es.org/criteria/pdf_files/ac162.pdf
- ASTM 1633-00 "Standard Test Method for Compressive Strength of Molded Soil Cement Cylinders"
- ASTM D-559-03 "Standard Test Methods for Wetting and Drying Compacted Soil Cement Mixtures"
- ASTM E-2302-95 "Standard Guide for Design of Earthen Wall Building Systems"
- Bamboo testing methods <http://www.bwk.tue.nl/bko/research/Bamboo/iso.htm>
- Catholic University of Peru (Pontificia Universidad Catolica del Peru) "Earthquake Resistant Construction of Adobe Buildings: A Tutorial"
- Compressed Earth Block lab testing <http://www.asceditor.usm.edu/archives/2004/Arumala04.htm>
- Earth materials guidelines <http://www.greenbuilder.com/sourcebook/EarthGuidelines.html>
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- General list of adobe sites <http://www.adobebuilder.com/index.html>
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