D316-2016a

UNHCR Circular Water Reservoir 30m³

Tools and Guidance for Refugee Settings

UNHCR
The UN Refugee Agency

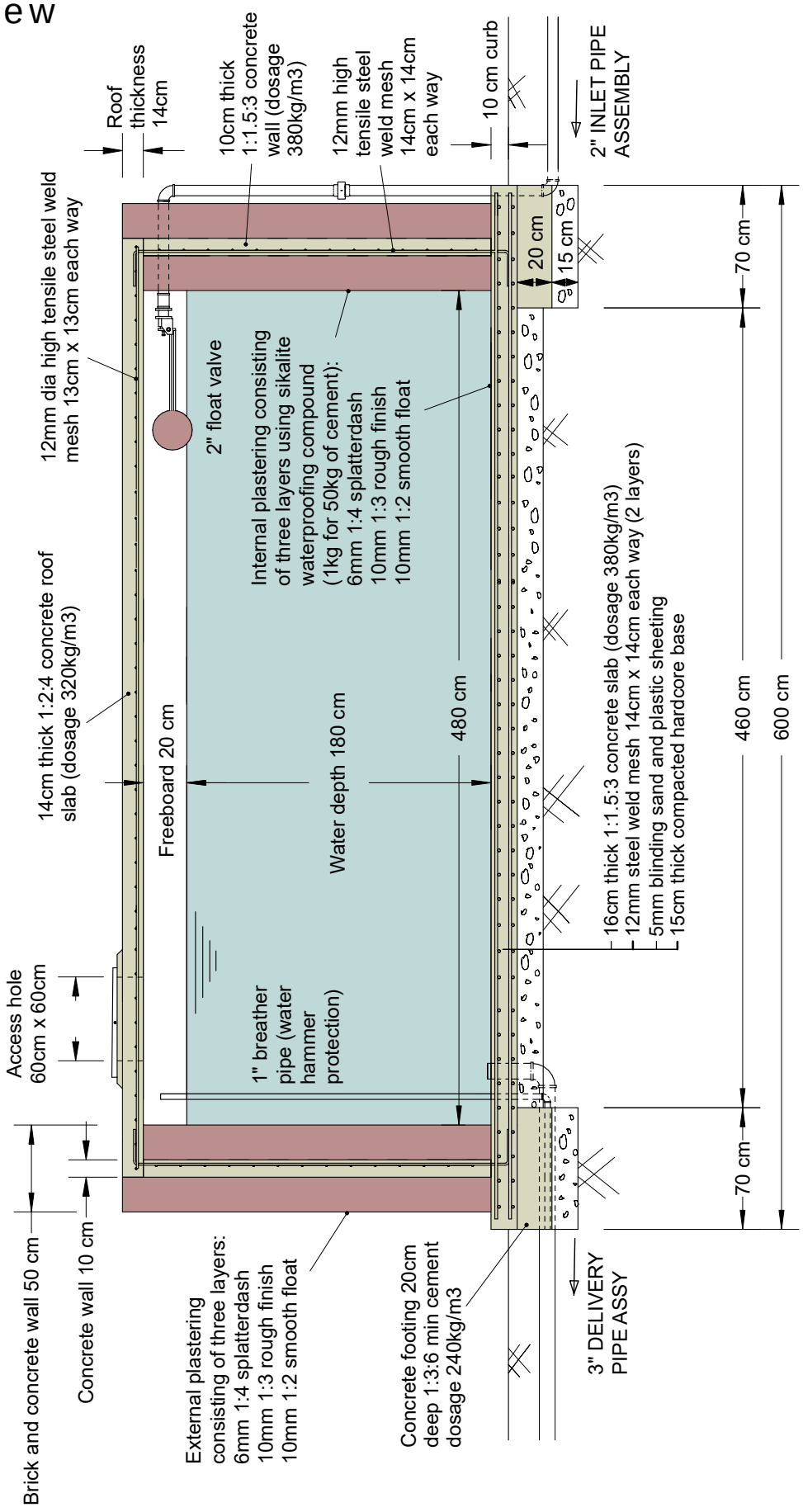
D-316/2016a

UNHCR Standardized Designs for Refugee Settings
Circular Reinforced Concrete Water Reservoir 30m^3

FOREWORD

These circular reinforced concrete water reservoir designs form part of UNHCR's series of Standardized WASH Design Guidelines for Refugee Settings which are the result of an extensive review process with WASH actors active in refugee settings. It is recognized that the Standardized WASH Designs will require continuous review and amendment in response to changes in engineering best-practice and feedback from the field. Therefore further review will be managed by a Technical Review Committee which will meet regularly to discuss issues related to the use of the design and an annual review will be reported back to the WASH community. More urgent amendments will be reported as, and when, required. Note that this reservoir is based on a design prepared by International Rescue Committee Ethiopia.

Sectional View



D-316

TITLE
30m^3 Round Water Reservoir
Sectional View

PROJECT
Project Name, Country

DRAWN BY
B. Harvey - 11/10/16

APPROVED BY
M. Burt - 15/11/16

SCALE
1:30

UNITS
metres

SHEET
1 of 3

DATE PUBLISHED
15/11/16

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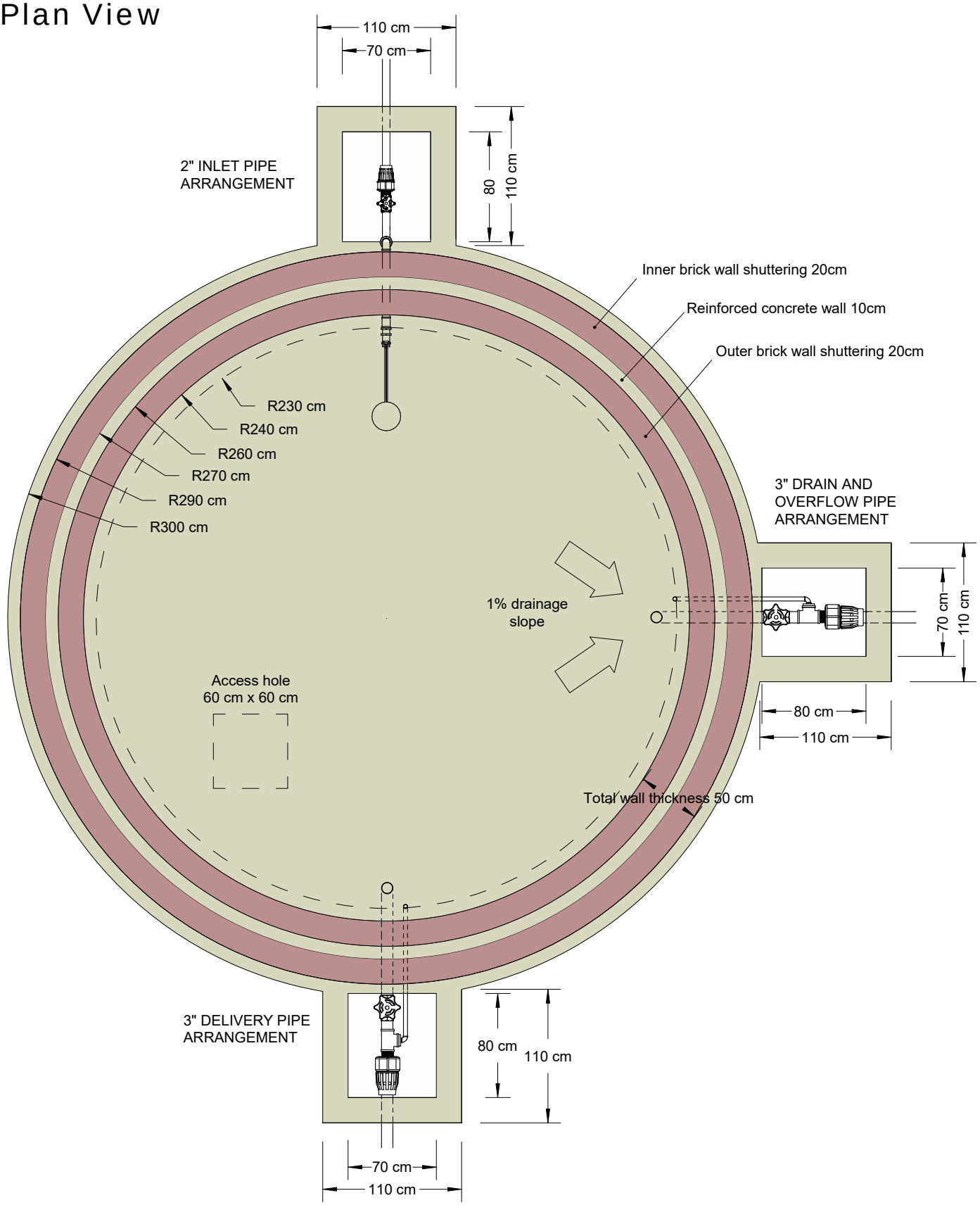
Plan View



NOTES

1. Ensure concrete is not over-watered = risk of cracking (no more than 1/4 height reduction during slump test).
2. Slabs to be cast in one continous operation. All concrete works to be well rodded (preferably vibrated).
3. Ensure all concrete works are kept damp and out of direct sunlight for at least 7 days while curing.

D-316

TITLE

30m^3 Round Water Reservoir

Plan View and General Layout

PROJECT

Project Name, Country

DRAWN BY
B. Harvey - 11/10/16

APPROVED BY
M. Burt - 15/11/16

SCALE
1:40

UNITS
metres

SHEET
2 of 3

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15/11/16

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D-316

TITLE
30m³ Round Water Reservoir
Pipe Assembly Detail

PROJECT
Project Name, Country

DRAWN BY
B. Harvey - 11/10/16

APPROVED BY
M. Burt - 15/11/16

SCALE
1:25

UNITS
metres

SHEET
3 of 3

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15/11/16

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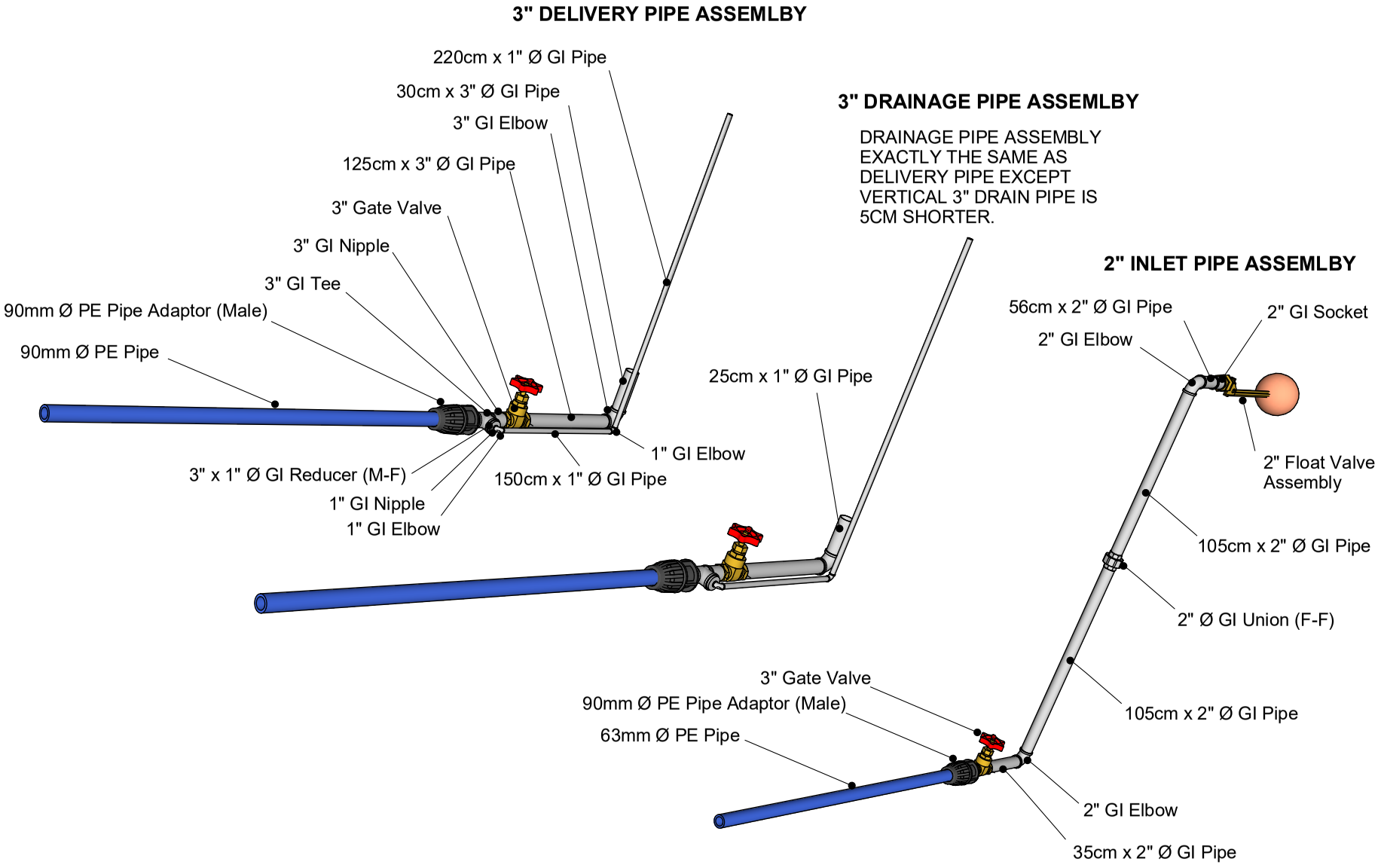
Pipe Assembly Detail

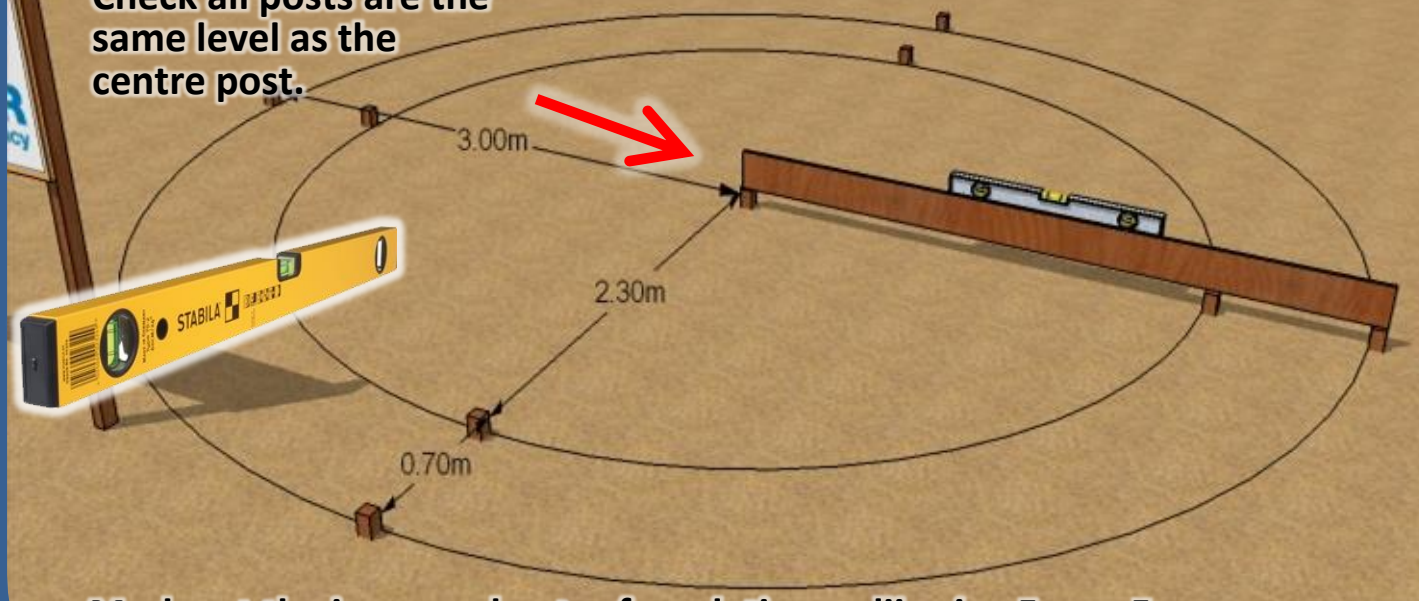


Notes
1. Alternative valve and pipe arrangements may be used if the inlet or outlet pipe diameters are different.
2. Valves to be positioned centrally. Valve box dimensions may be increased or reduced to match valve assembly arrangments.
3. The bottom of the valve box should be kept open (i.e. filled with compacted hardcore) to allow any excess water to drain.

1.

Area of 6m x 6m to be cleared and perfectly leveled.

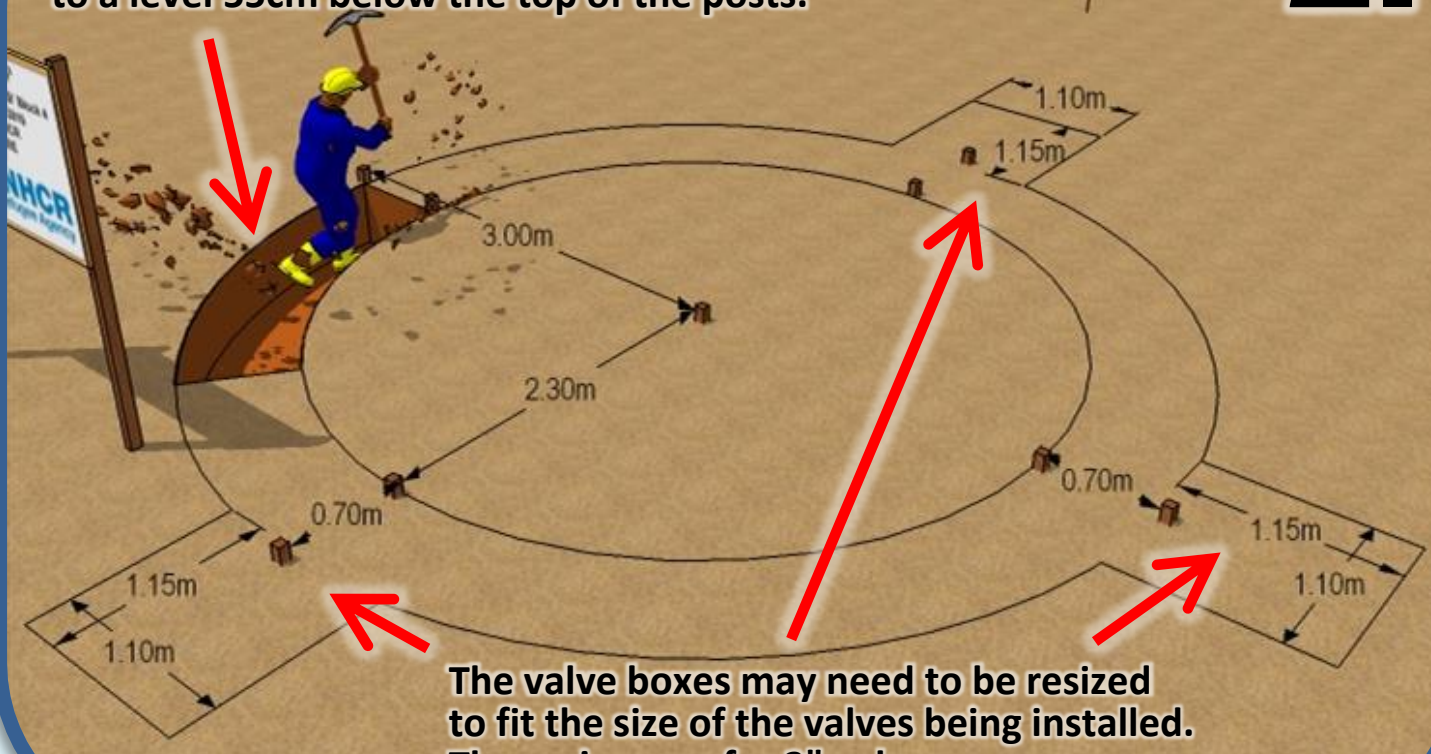
Check all posts are the same level as the centre post.



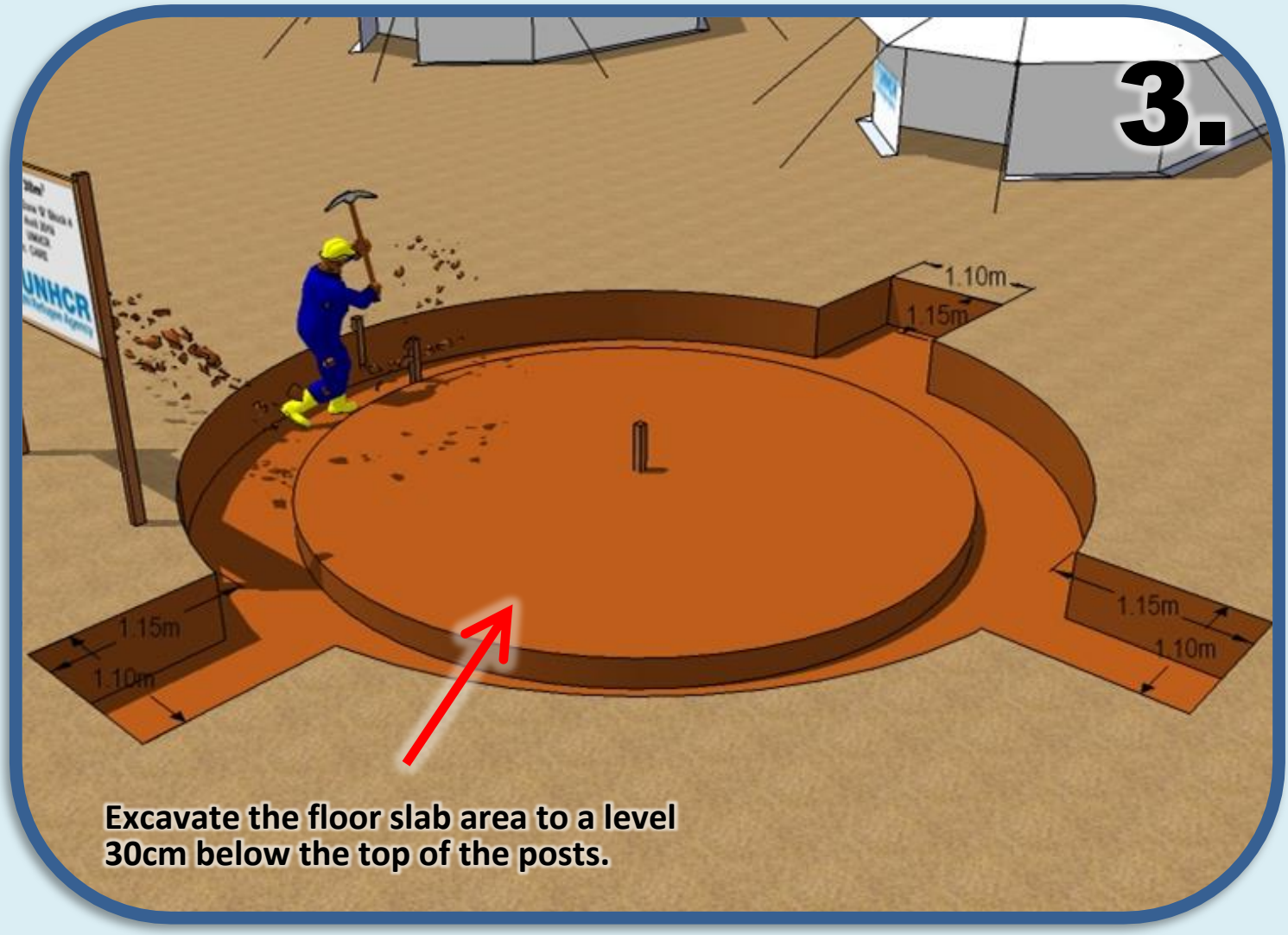
Mark out the inner and outer foundation radii using 5cm x 5cm wooden posts. All posts 10cm above ground and exactly the same level. This level will become the upper edge of the reservoir curb.

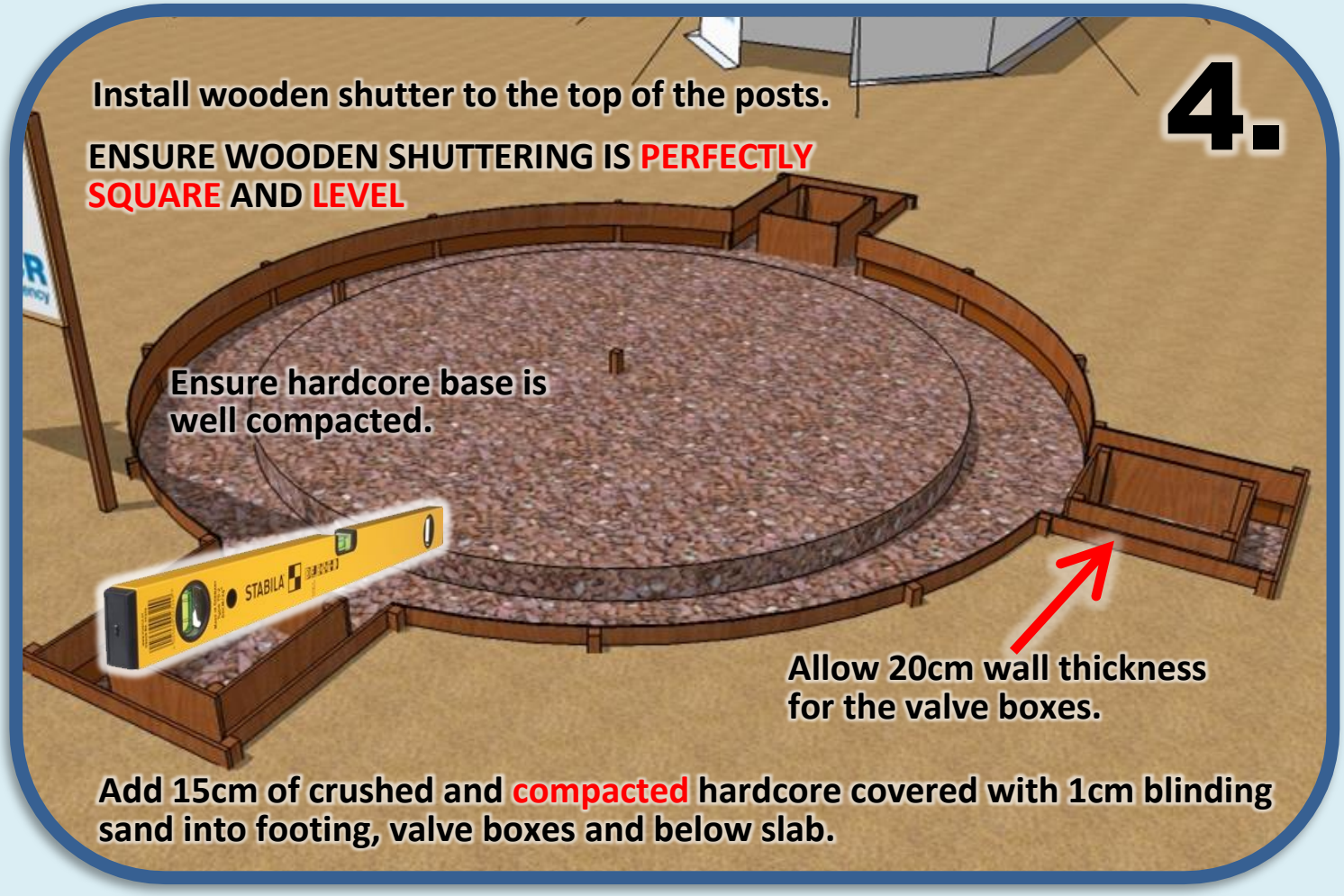
2.

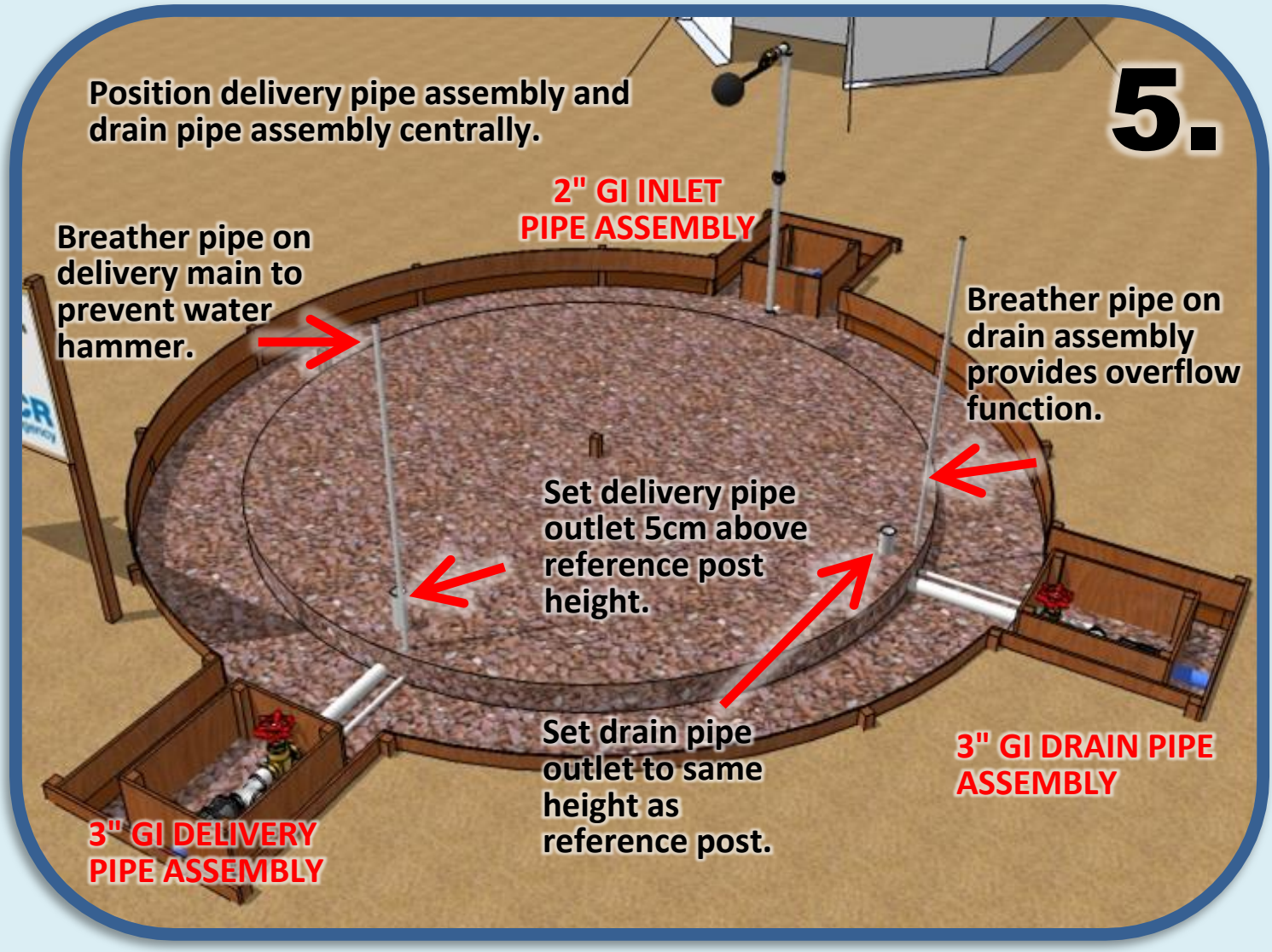
Excavate the 70cm wide footing and valve boxes to a level 55cm below the top of the posts.

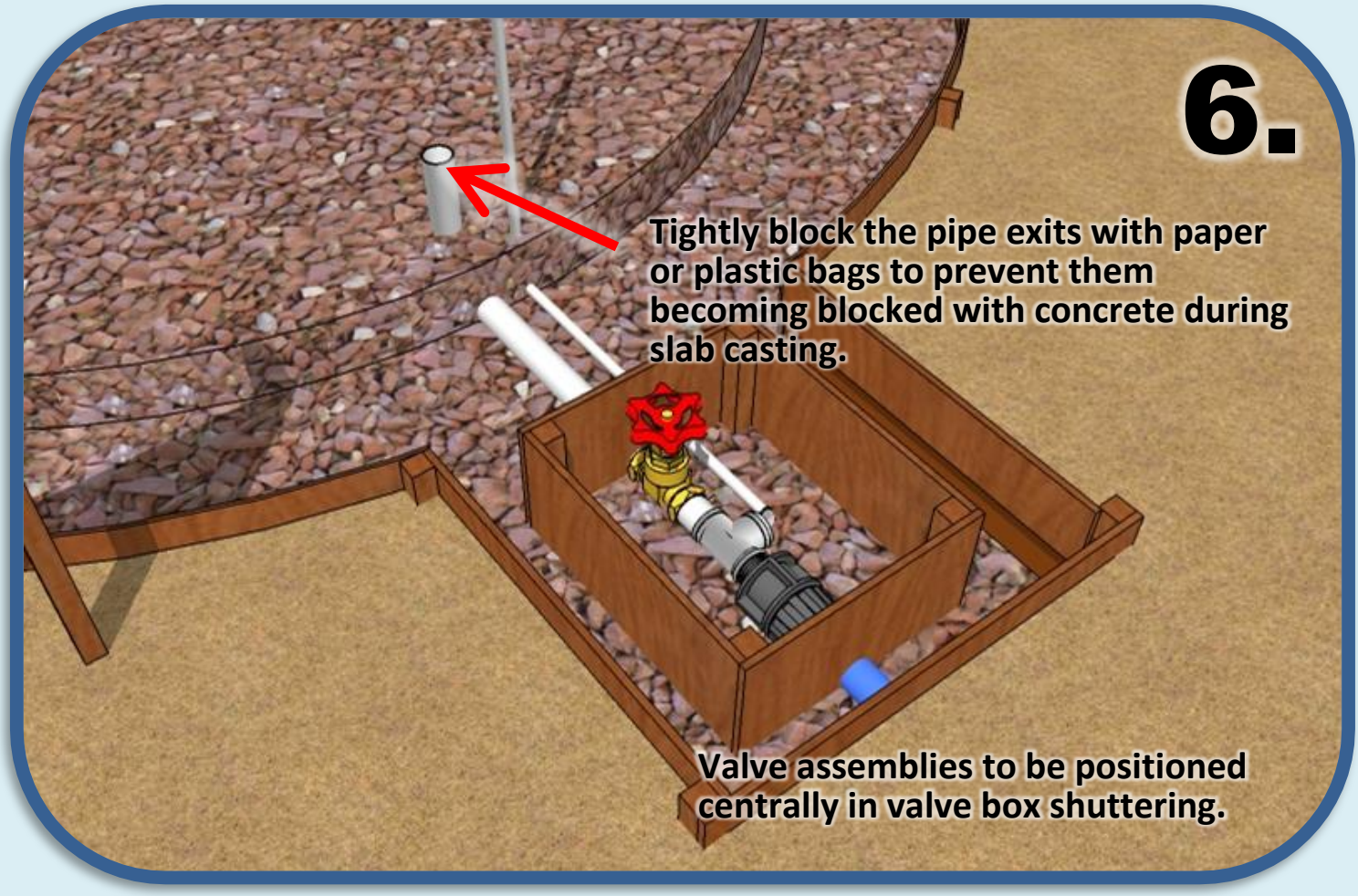


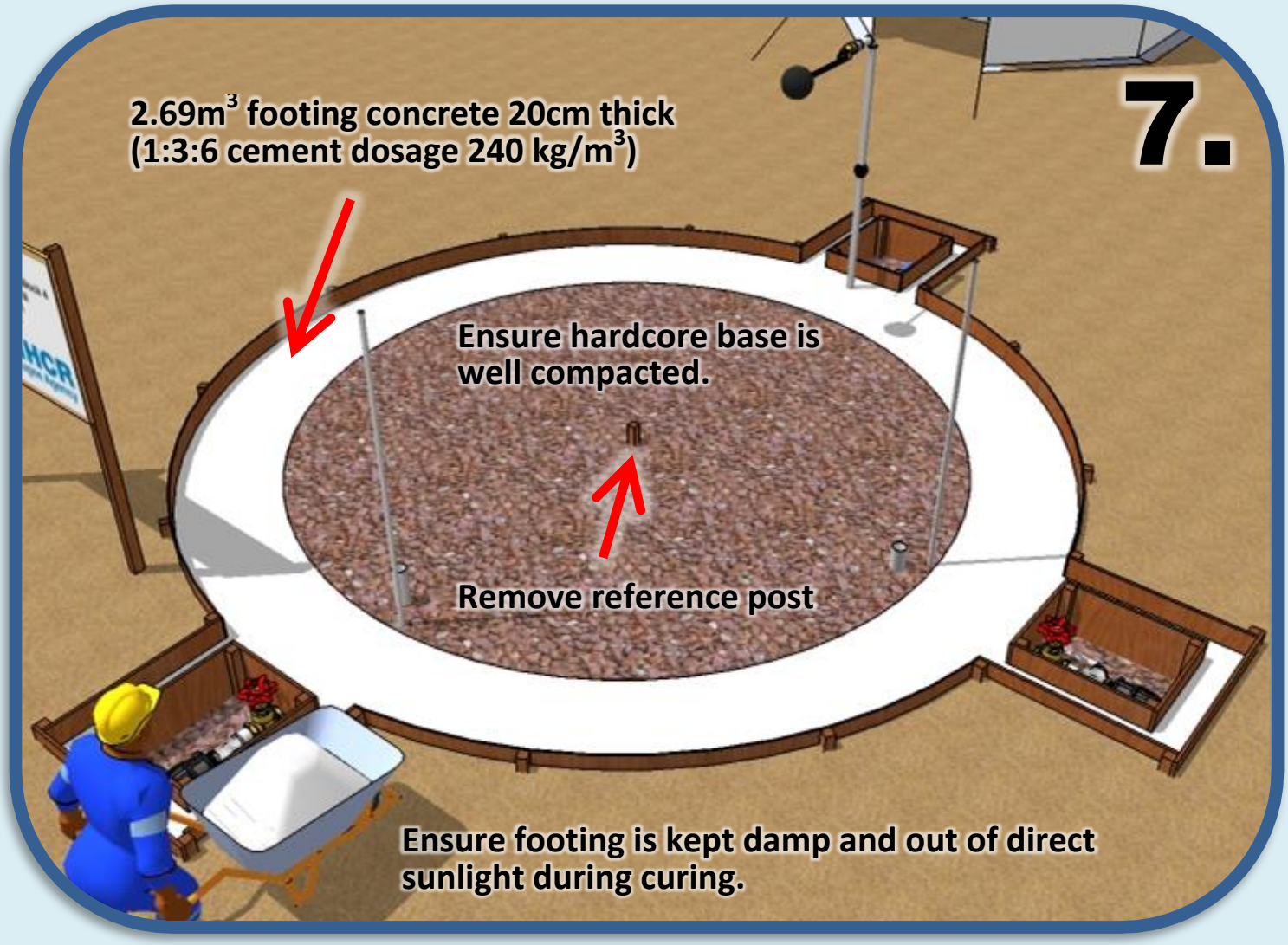
The valve boxes may need to be resized to fit the size of the valves being installed. These sizes are for 3" valves.

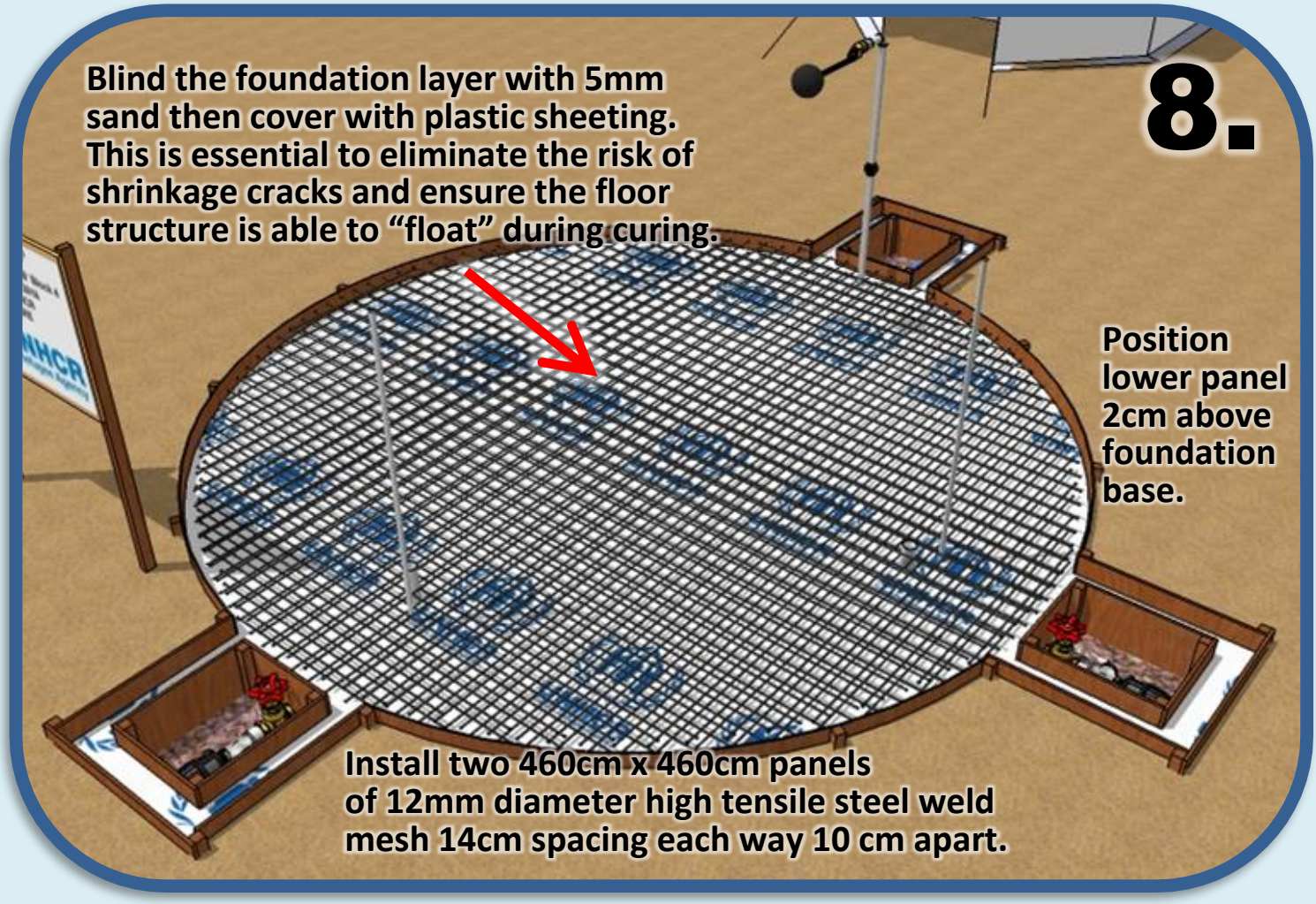

3.
1.10m
1.15m
1.15m
1.10m
1.15m
1.10m
Excavate the floor slab area to a level
30cm below the top of the posts.

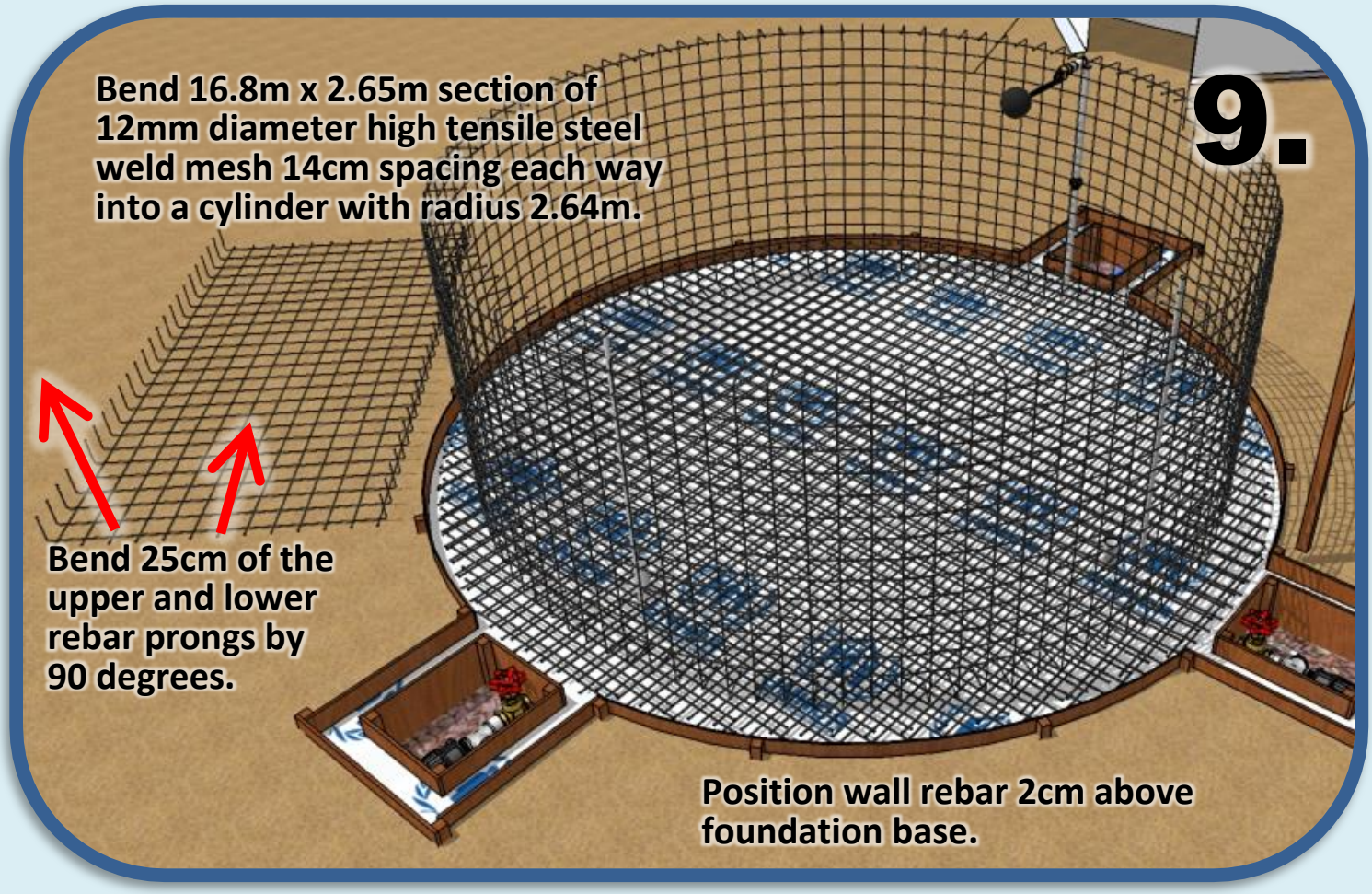

Install wooden shutter to the top of the posts.
4.
ENSURE WOODEN SHUTTERING IS PERFECTLY
SQUARE AND LEVEL
Ensure hardcore base is
well compacted.
STABILA
Allow 20cm wall thickness
for the valve boxes.
Add 15cm of crushed and compacted hardcore covered with 1cm blinding
sand into footing, valve boxes and below slab.

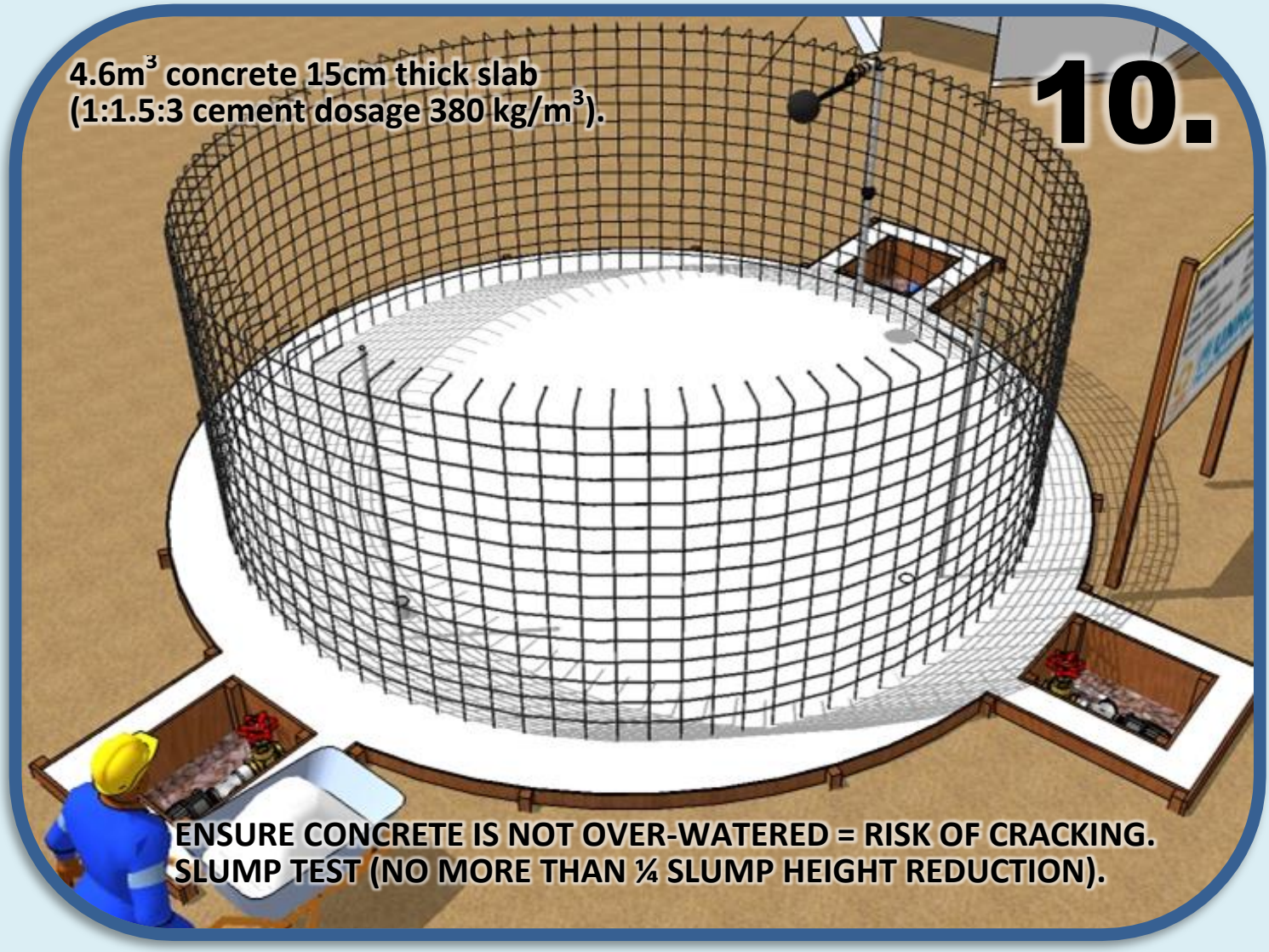

5.
Position delivery pipe assembly and drain pipe assembly centrally.
2" GI INLET PIPE ASSEMBLY
Breather pipe on delivery main to prevent water hammer.
Breather pipe on drain assembly provides overflow function.
Set delivery pipe outlet 5cm above reference post height.
Set drain pipe outlet to same height as reference post.
3" GI DRAIN PIPE ASSEMBLY
3" GI DELIVERY PIPE ASSEMBLY

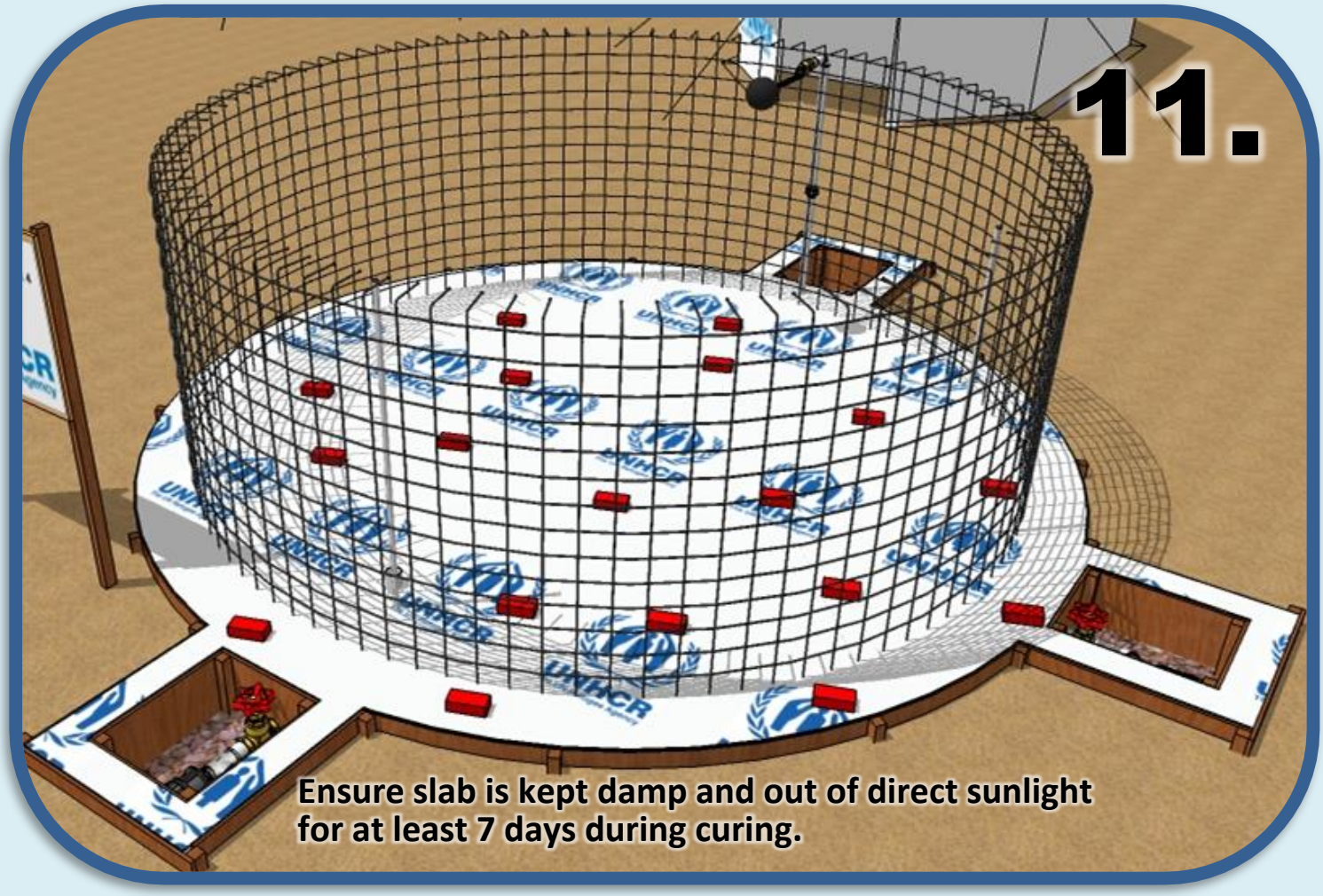

6.
Tightly block the pipe exits with paper or plastic bags to prevent them becoming blocked with concrete during slab casting.
Valve assemblies to be positioned centrally in valve box shuttering.

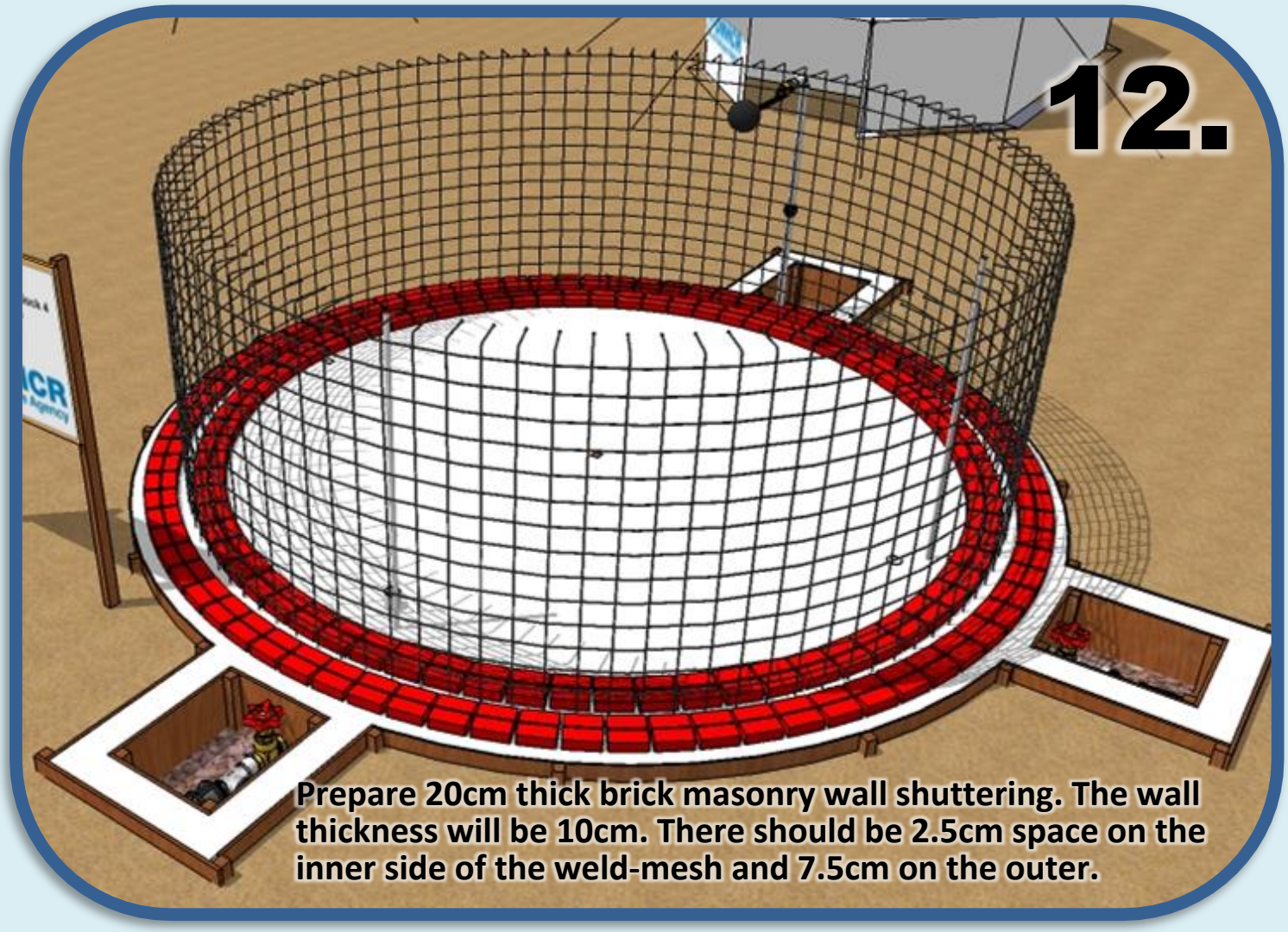

7.
2.69m³ footing concrete 20cm thick
(1:3:6 cement dosage 240 kg/m³)
Ensure hardcore base is
well compacted.
Remove reference post
Ensure footing is kept damp and out of direct
sunlight during curing.

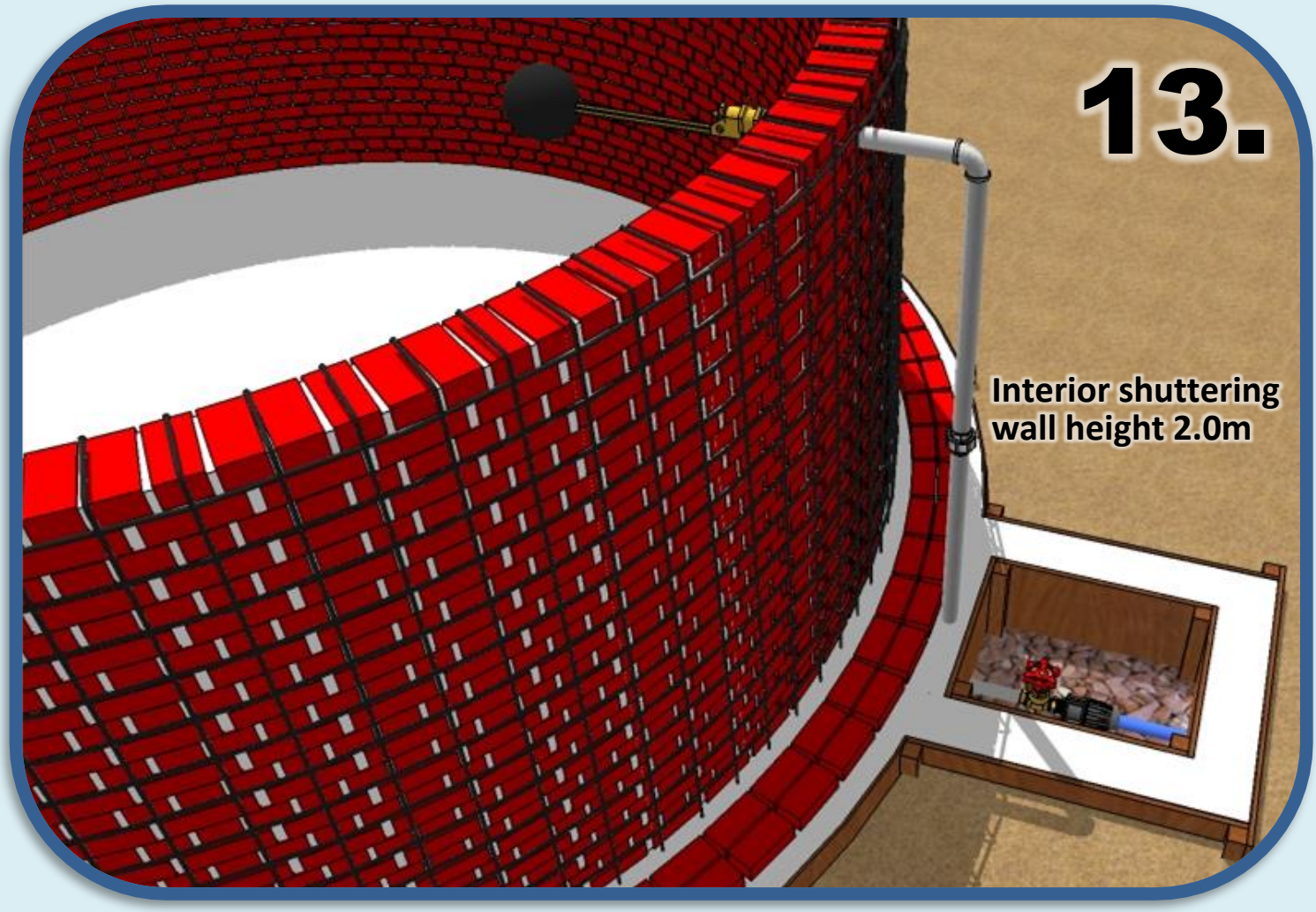

8.
Blind the foundation layer with 5mm
sand then cover with plastic sheeting.
This is essential to eliminate the risk of
shrinkage cracks and ensure the floor
structure is able to “float” during curing.
Position
lower panel
2cm above
foundation
base.
Install two 460cm x 460cm panels
of 12mm diameter high tensile steel weld
mesh 14cm spacing each way 10 cm apart.

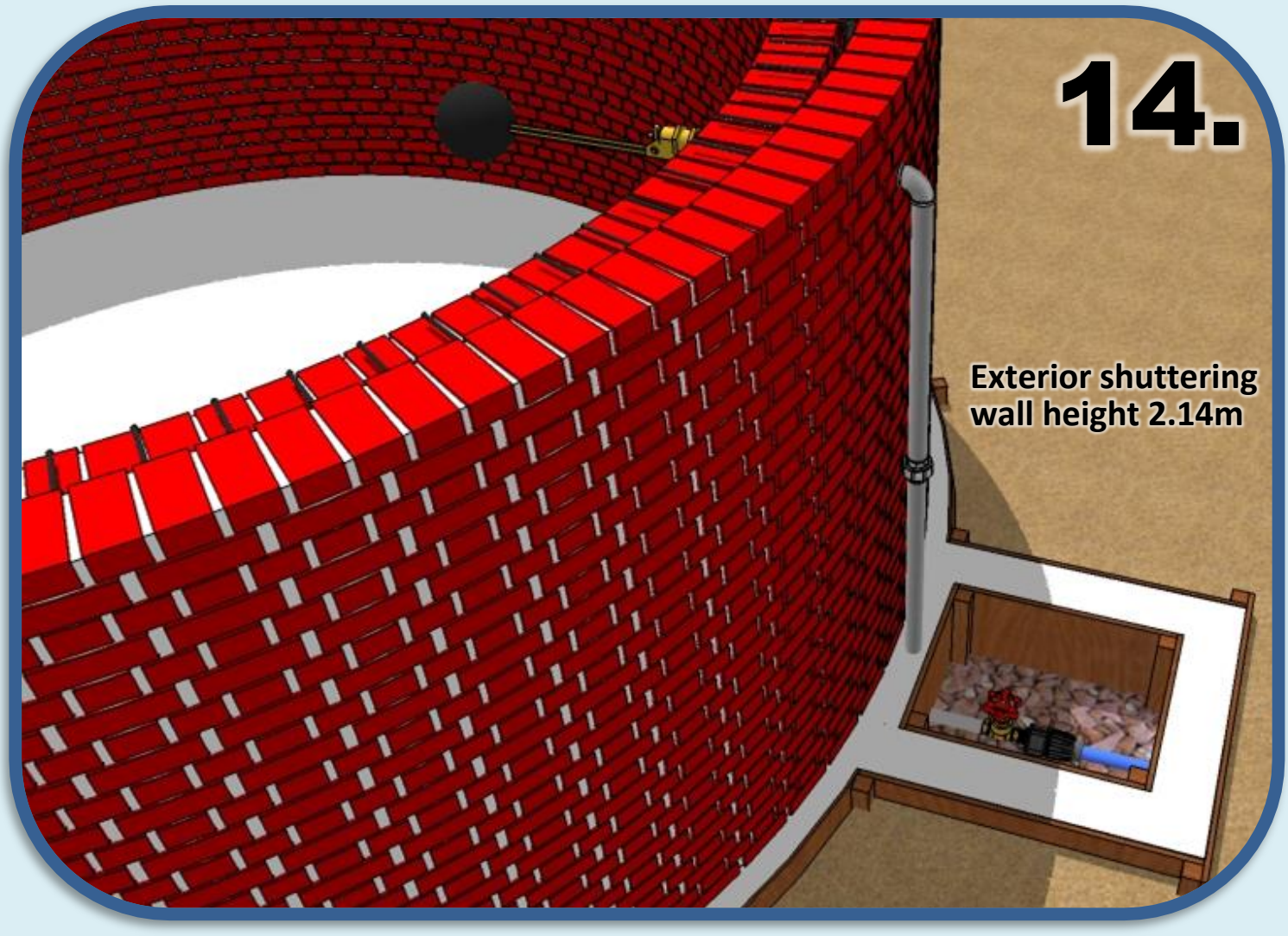

9.
Bend 16.8m x 2.65m section of 12mm diameter high tensile steel weld mesh 14cm spacing each way into a cylinder with radius 2.64m.
Bend 25cm of the upper and lower rebar prongs by 90 degrees.
Position wall rebar 2cm above foundation base.

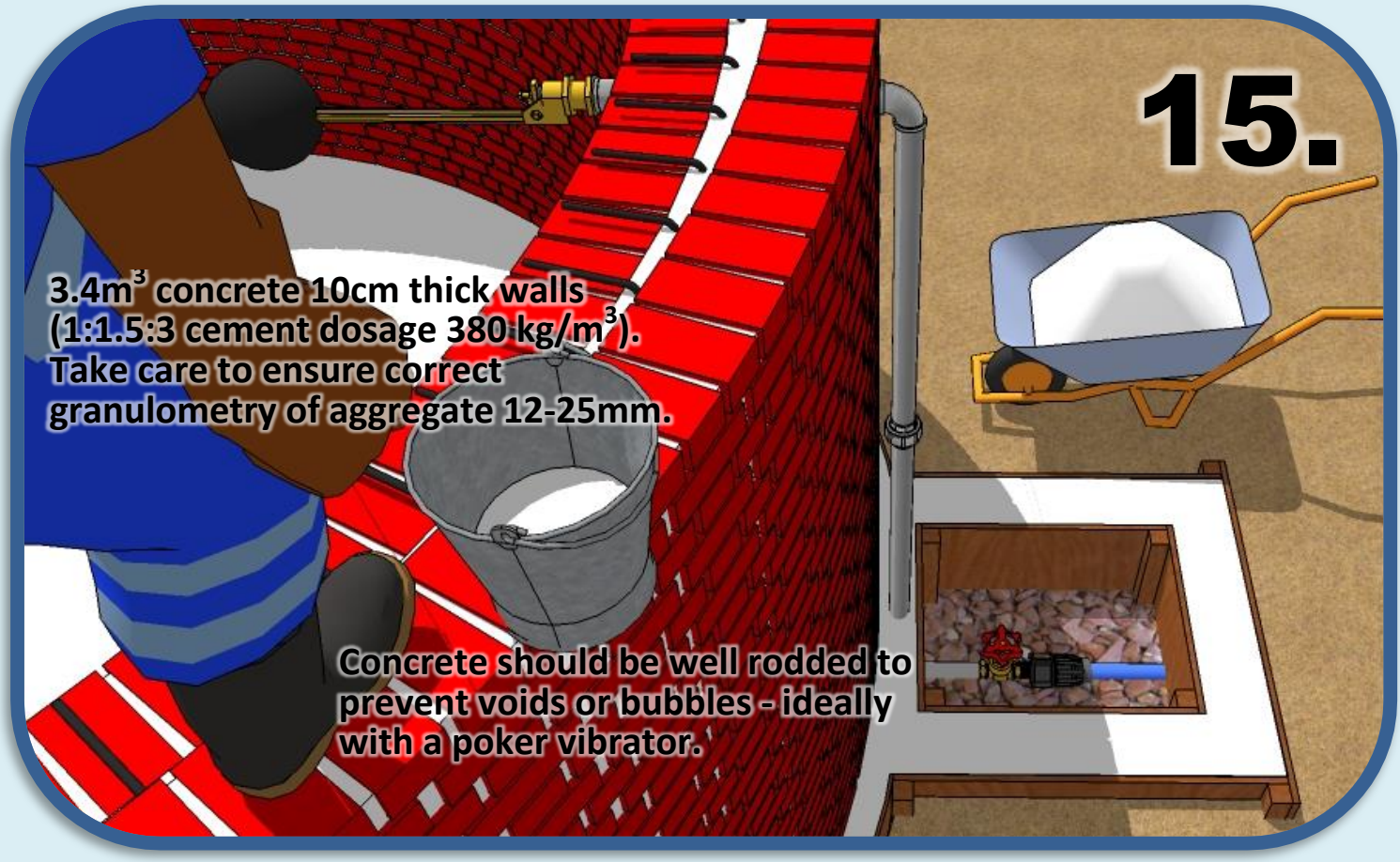

10.
4.6m³ concrete 15cm thick slab (1:1.5:3 cement dosage 380 kg/m³).
ENSURE CONCRETE IS NOT OVER-WATERED = RISK OF CRACKING.
SLUMP TEST (NO MORE THAN ¼ SLUMP HEIGHT REDUCTION).

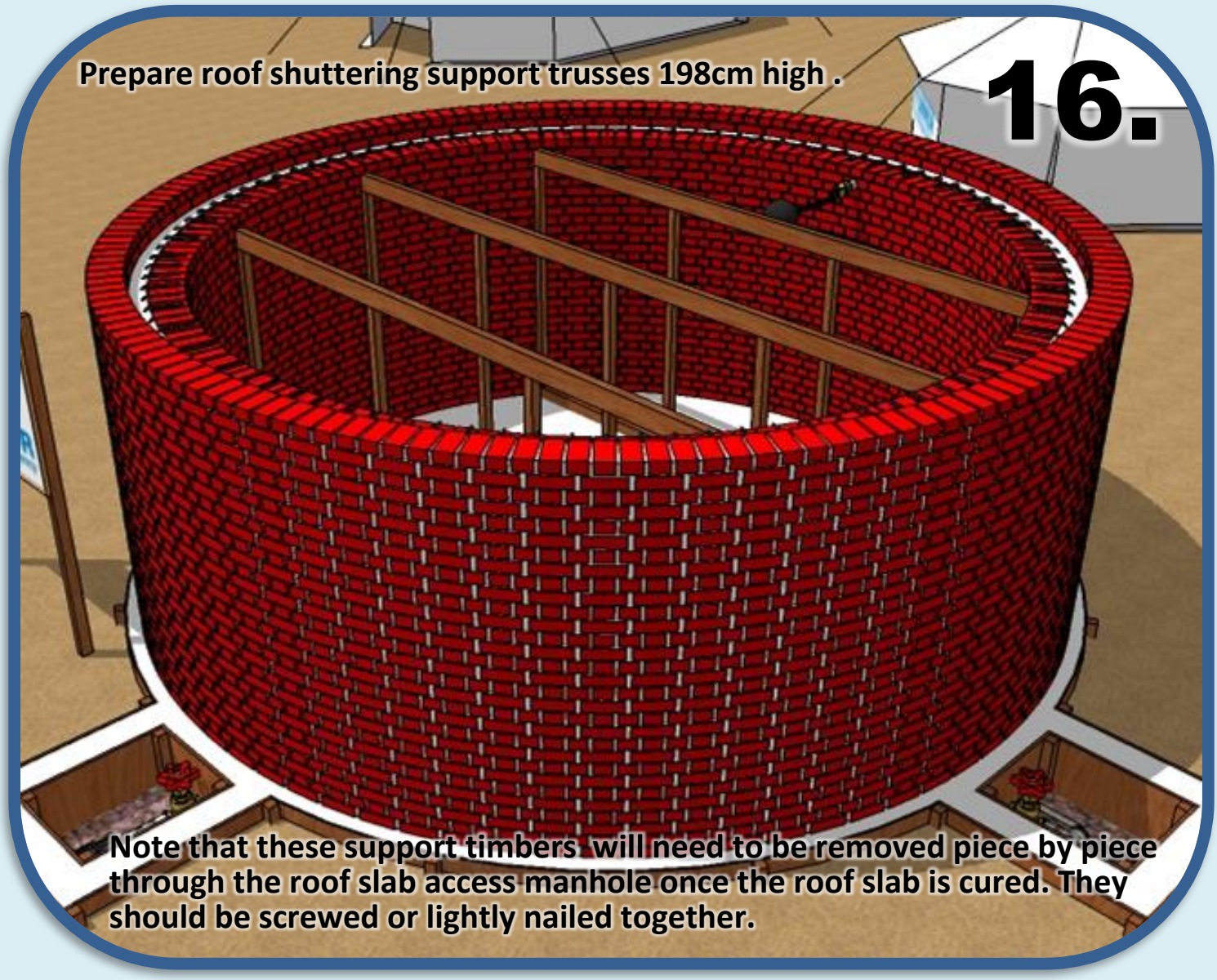

11.
Ensure slab is kept damp and out of direct sunlight for at least 7 days during curing.

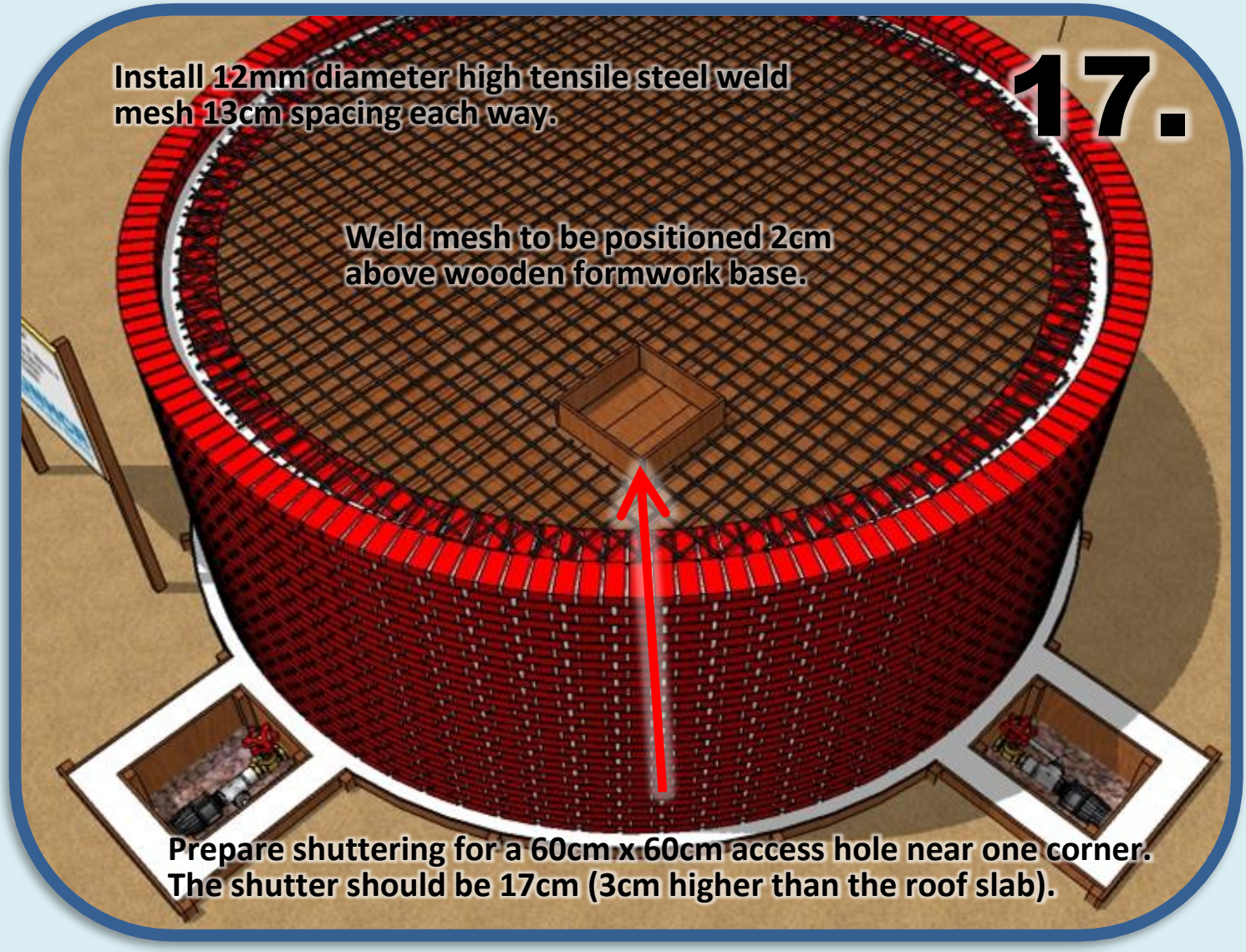

12.
Prepare 20cm thick brick masonry wall shuttering. The wall thickness will be 10cm. There should be 2.5cm space on the inner side of the weld-mesh and 7.5cm on the outer.

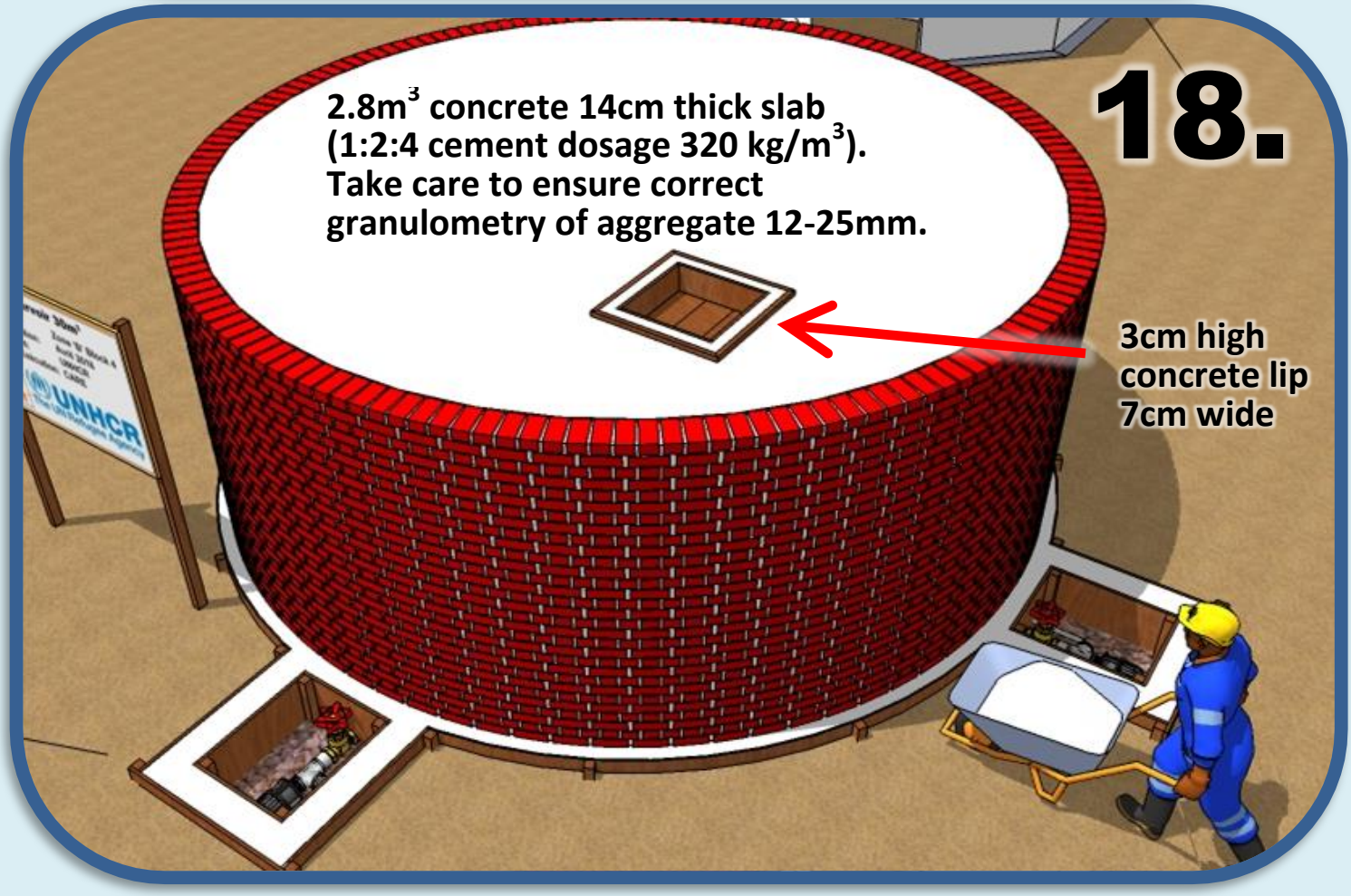

13.
Interior shuttering
wall height 2.0m

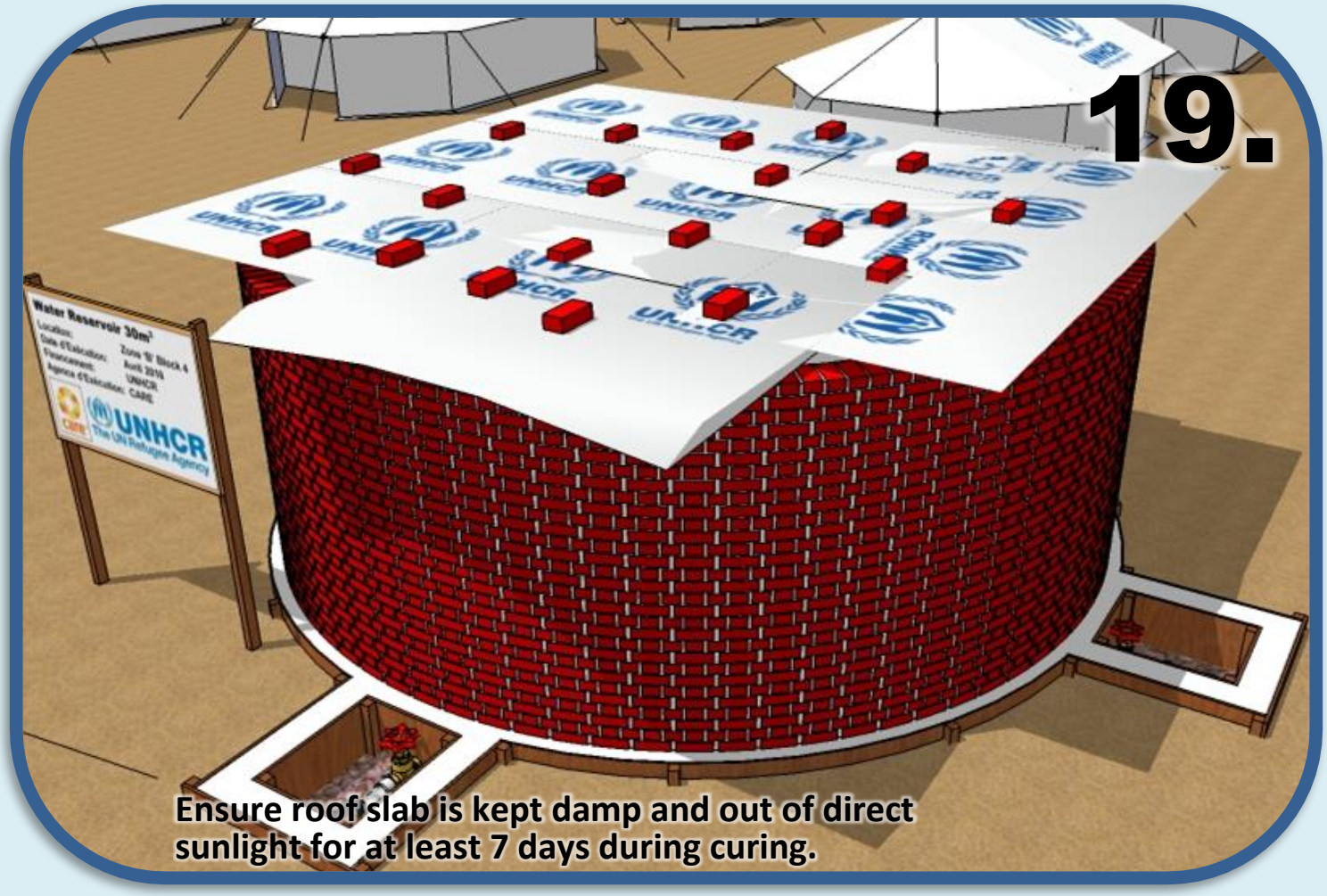

14.
Exterior shuttering
wall height 2.14m

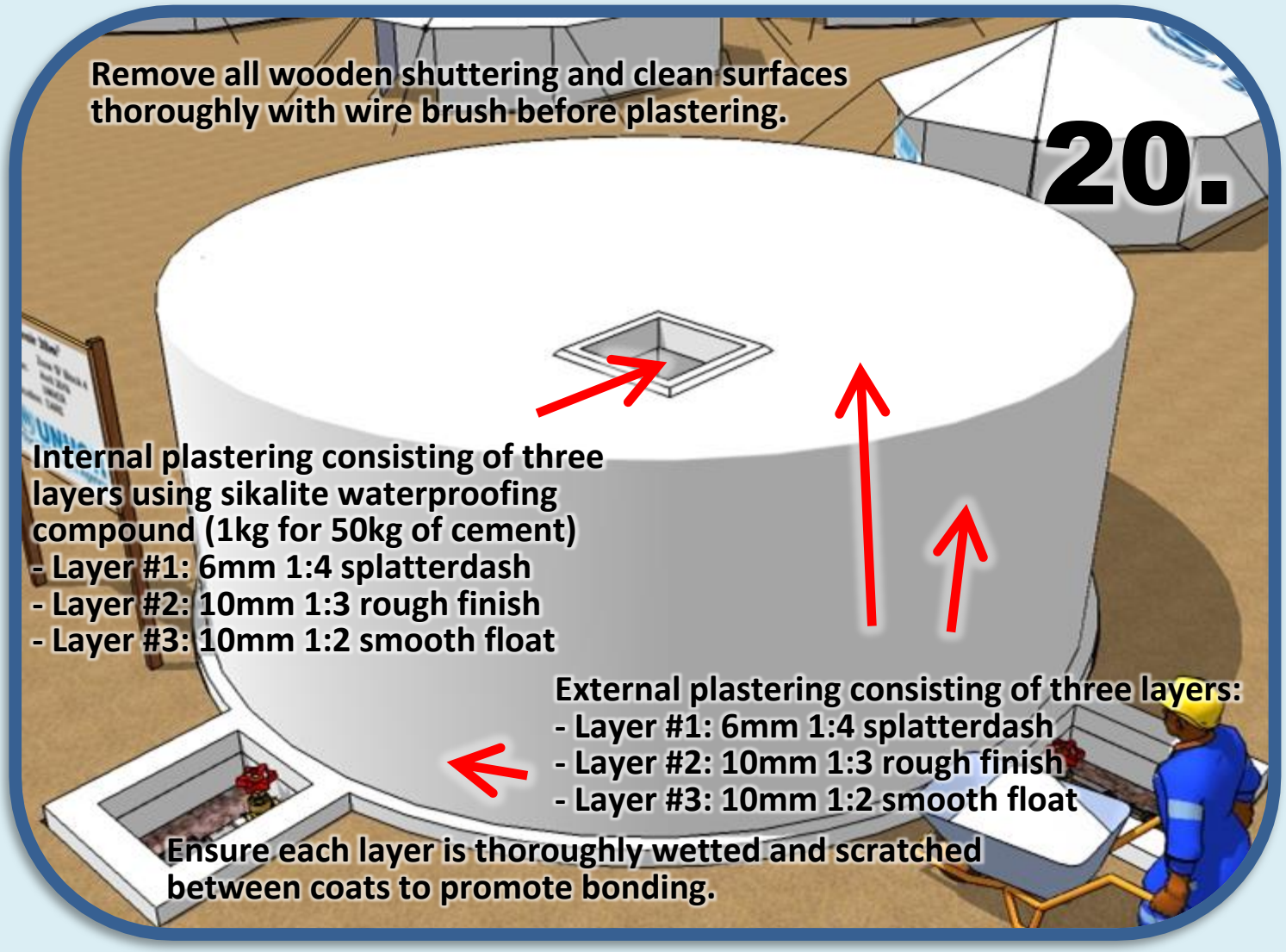

15.
3.4m³ concrete 10cm thick walls (1:1.5:3 cement dosage 380 kg/m³). Take care to ensure correct granulometry of aggregate 12-25mm.
Concrete should be well rodded to prevent voids or bubbles - ideally with a poker vibrator.

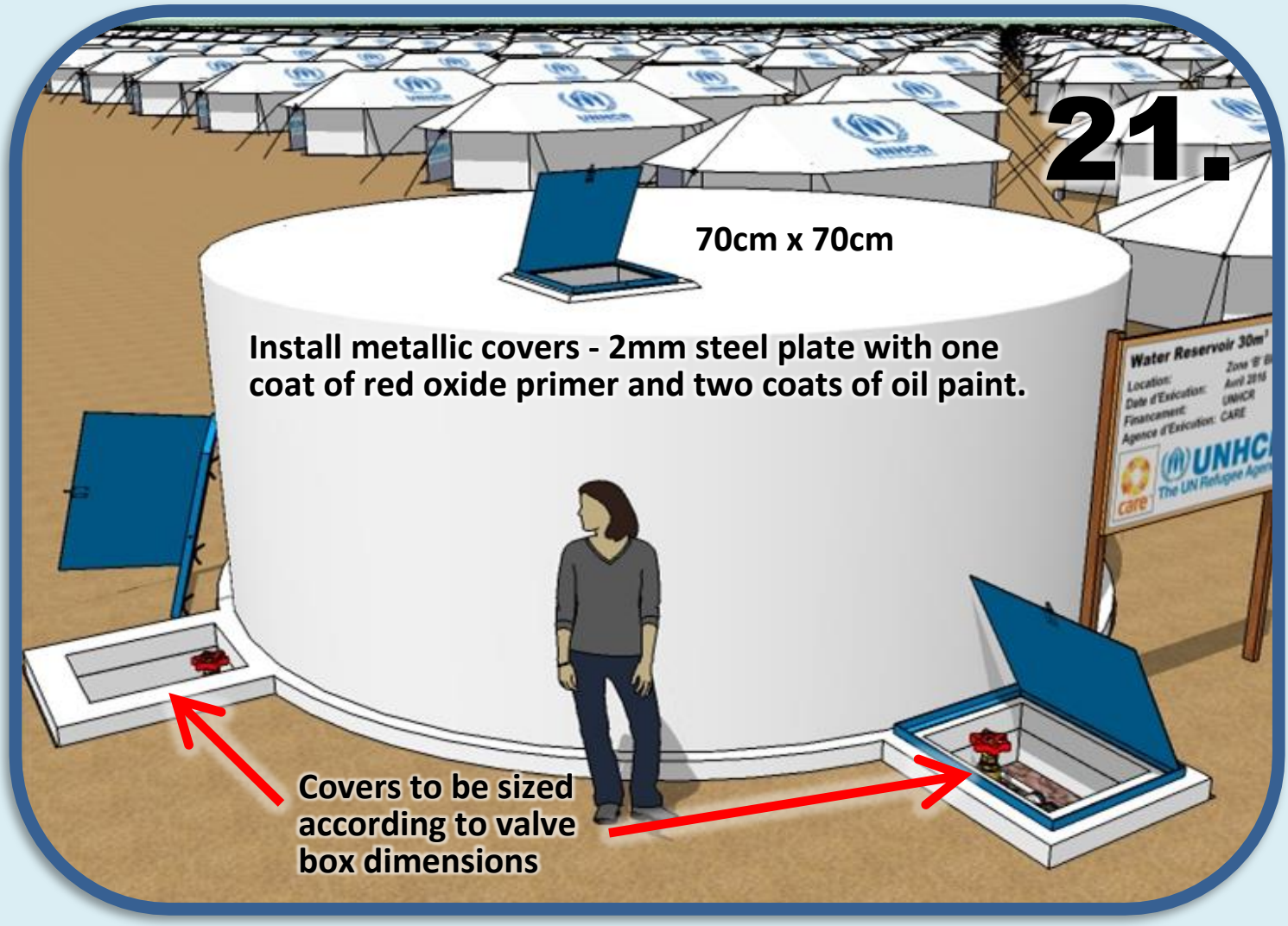

Prepare roof shuttering support trusses 198cm high .
16.
Note that these support timbers will need to be removed piece by piece through the roof slab access manhole once the roof slab is cured. They should be screwed or lightly nailed together.

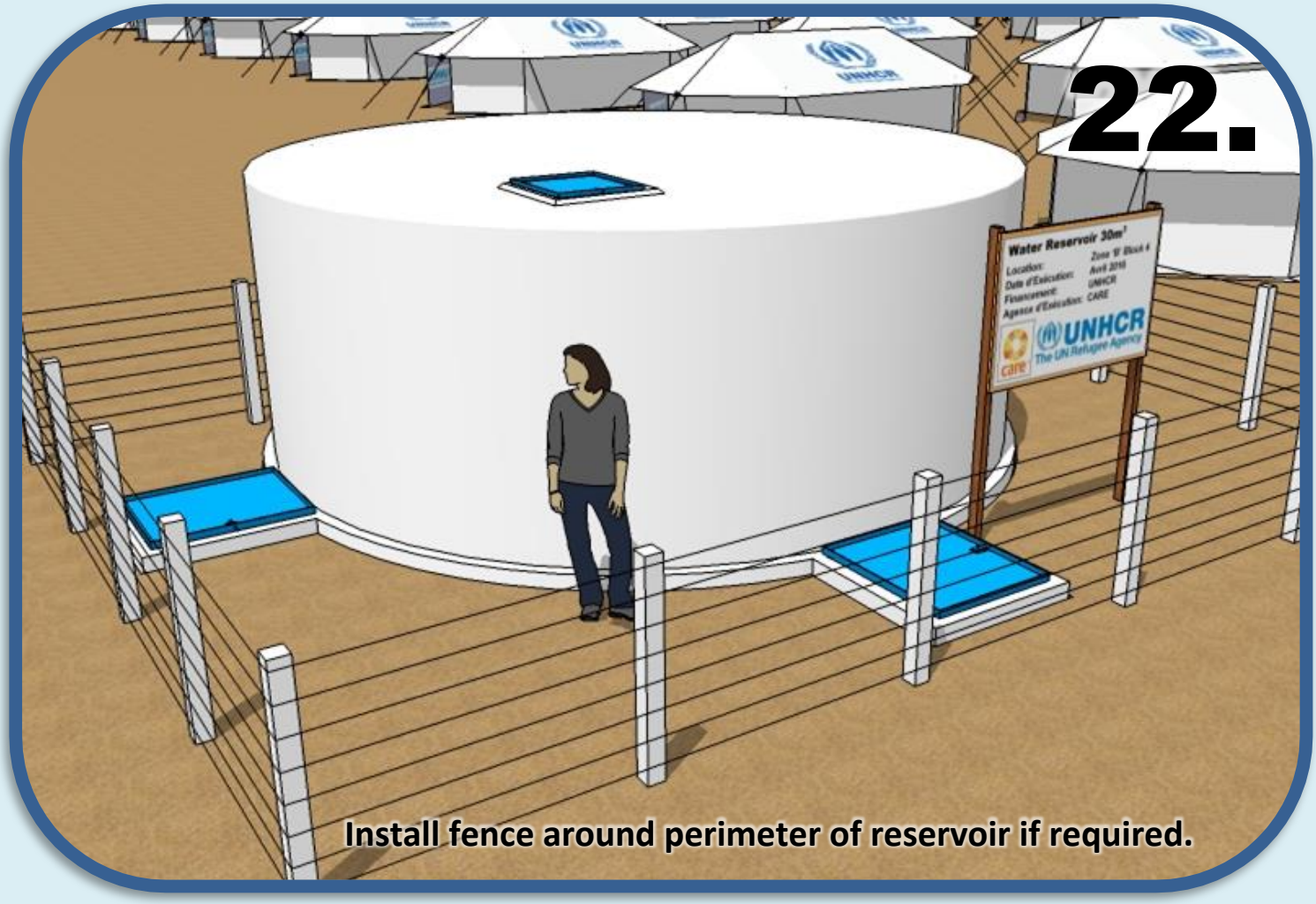

17.
Install 12mm diameter high tensile steel weld mesh 13cm spacing each way.
Weld mesh to be positioned 2cm above wooden formwork base.
Prepare shuttering for a 60cm x 60cm access hole near one corner. The shutter should be 17cm (3cm higher than the roof slab).


18.
2.8m³ concrete 14cm thick slab (1:2:4 cement dosage 320 kg/m³). Take care to ensure correct granulometry of aggregate 12-25mm.
3cm high concrete lip 7cm wide
UNHCR


19.
Water Reservoir 30m³
UNHCR
The UN Refugee Agency
Ensure roof slab is kept damp and out of direct sunlight for at least 7 days during curing.


Remove all wooden shuttering and clean surfaces thoroughly with wire brush before plastering.
20.
Internal plastering consisting of three layers using sikalite waterproofing compound (1kg for 50kg of cement)
- Layer #1: 6mm 1:4 splatterdash
- Layer #2: 10mm 1:3 rough finish
- Layer #3: 10mm 1:2 smooth float
External plastering consisting of three layers:
- Layer #1: 6mm 1:4 splatterdash
- Layer #2: 10mm 1:3 rough finish
- Layer #3: 10mm 1:2 smooth float
Ensure each layer is thoroughly wetted and scratched between coats to promote bonding.


21.
70cm x 70cm
Install metallic covers - 2mm steel plate with one coat of red oxide primer and two coats of oil paint.
Water Reservoir 30m³
Covers to be sized according to valve box dimensions

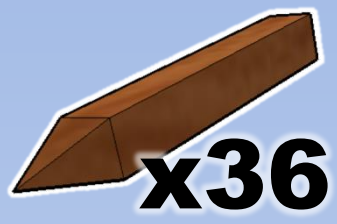

22.
Water Reservoir 30m³
UNHCR
Install fence around perimeter of reservoir if required.

BILL OF QUANTITIES

Description	QTY
Wooden Stakes (65cm x 5cm x 5cm)	36 pcs
Wooden Planks (4m x 20cm x 2.5cm)	37 pcs
Wooden Posts (4m x 5cm x 5cm)	7 pcs
Wooden Beams (4m x 5cm x 2.5cm)	7 pcs
Nails (6cm Galvanized)	1 kg
Nails (8cm Galvanized)	1 kg
High Tensile Steel Weld-Mesh Ø12mm 14cm x 14cm	112 m^2
High Tensile Steel Weld-Mesh Ø12mm 13cm x 13cm	28 m^2
Tying Wire Ø 1mm	0.5 kg
Plastic Sheeting	36 m^2
Inlet Pipe Assembly (2" Gate Valve, 2" GI Pipe x 35cm, 2" GI Elbow, 2" GI Pipe x 105cm, 2" GI Union, 2" GI Pipe x 105cm, 2" GI Elbow, 2" GI Pipe x 16cm, 2" GI Socket, 2" Float Valve)	1 pc
Outlet Pipe Assembly (3" GI Tee, 3" GI Nipple, 3" Gate Valve, 3" GI Pipe x 85cm, 3" GI Elbow, 3" GI Pipe x 105cm, 3" GI Pipe x 30cm, 3" – 1" GI Reducer (M-F), 1" GI Nipple, 2" GI Elbow, 1" GI Pipe x 110cm, 1" GI Pipe x 220cm)	1 pc
Drain Pipe Assembly (3" GI Tee, 3" GI Nipple, 3" Gate Valve, 3" GI Pipe x 85cm, 3" GI Elbow, 3" GI Pipe x 105cm, 3" GI Pipe x 25cm, 3" – 1" GI Reducer (M-F), 1" GI Nipple, 2" GI Elbow, 1" GI Pipe x 110cm, 1" GI Pipe x 220cm)	1 pc
Metallic Valve Box Covers (70cm x 70cm x 2mm)	4 pcs
Coarse Sand	14.1 m^3
Bricks 20cm x 9cm x 6cm	9,112 pcs
Coarse Gravel (12mm – 25mm)	11.4 m^3
Cement (50kg sacks)	112 sacks
Compacted Hardcore Sub-Base	4.6 m^3

Bill of Quantities

1. *Wooden Stakes (pc) 5cm x 5cm x 65cm*



x36

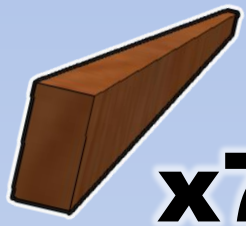
2. *Wooden Planks (pc) 2.5cm x 20 cm x 4m*

x37

3. *Wooden Posts (pc) 5cm x 5cm x 4m*

x7

4. *Wooden Beams (pc) 10cm x 5 cm x 4m*



x7

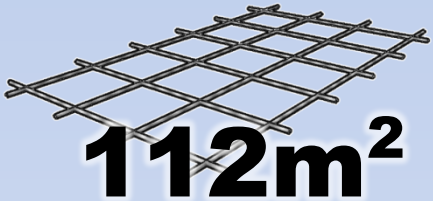
5. *Nails 6cm (kg)*

x1

6. *Nails 8cm (kg)*

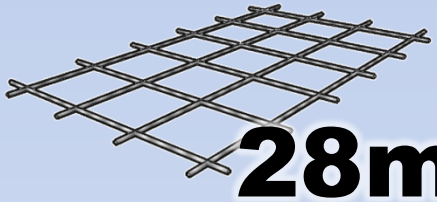
x1

7. *Steel Weld-Mesh 12mm Ø x 14cm x 14cm*



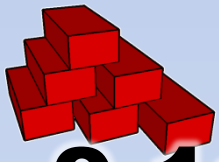
112m²

8. *Steel Weld-Mesh 12mm Ø x 13cm x 13cm*



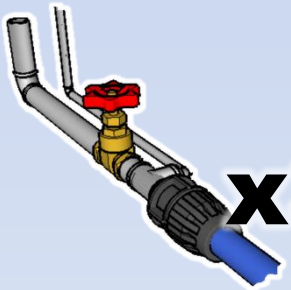
28m²

9. *Bricks 20cm x 9cm x 6cm*



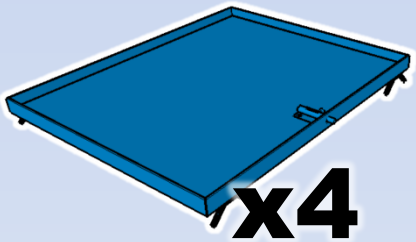
9,112

10. *Valve and Pipe Assemblies (pc)*



x3

11. *Metallic Covers 70cm x 70cm x 2mm*



x4

12. *Cement 50kg (sacks)*

x112

13. *Sand (m3)*

14.1m³

14. *Gravel (m3)*

11.4m³

15. *Cement 50kg (sacks)*

4.6m³

SPECIFICATIONS FOR CONSTRUCTION OF WATER SUPPLY RELATED INFRASTRUCTURE IN REFUGEE SETTINGS

300 SCOPE

300.1 These design guidelines specifically define the quality of materials and workmanship to be used when constructing water supply related infrastructure in refugee settings. A description of principles of water supply programmes in refugee settings, in addition to technical options and their advantages and disadvantages, can be found in the UNHCR WASH Manual.

301 SITE SELECTION

301.1 A basic requirement is that the site selected for water supply related infrastructure is free from the risk of high winds, flooding, subsidence, or erosion.

302 PREVENTION OF SURFACE OR GROUNDWATER CONTAMINATION

302.1 UNHCR and WASH actors must ensure that all water supply related infrastructure including treatment systems and soakaway systems do not contaminate surface water or shallow groundwater sources. Risks are generally low and related to contamination from water treatment chemicals, water treatment by-products and sludges and contamination from wastewater.

302.2 All tapstands, or other water collection and usage points, should be equipped with adequately designed soakage systems located at least 30 metres away from groundwater sources. The bottom of any pit or soak-away must be at least 1.5m above the highest average groundwater table level. These distances should be increased for fissured rocks and limestone.

302.3 In some situations temporary groundwater contamination from on-site soakage systems may not be of immediate concern if the groundwater is non-potable. An example of this can be found in areas where groundwater is heavily saline beyond drinking water health limits of 1,500µS/cm^2. In all cases, local legislation should be respected.

303 SPECIFICATIONS OF COMMON CONSTRUCTION MATERIALS

303.1 Gravel used for constructing concrete footings and slabs must be clean and free from mud, dust and plant material. Rounded aggregates are preferred. If crushed stone aggregates are used then additional cement should be added (see table below). UNHCR and WASH actors must ensure that only aggregates between 12mm and 25mm are be used to prevent inter granular crack propagation across load bearing concrete structures (e.g. tapstand floor slabs, water reservoir roof slabs, and columns used in reinforced concrete water towers) and to ensure an adequate covering of steel reinforcement bars.

303.2 Sand used for water supply related concrete works should be coarse (no fines), clean and free from mud, dust and plant material.

303.3 Water should be non-saline and free from organic matter.

303.4 Cement must be fresh (manufactured in the last three months) dry, and should be stored in a safe, dry, place at least 15cm off the ground.

303.5 Reinforcement bars should be free from rust and of the correct type and size for concrete construction work (typically a characteristic yield stress of at least 210 N/mm²). Steel reinforcement should be placed as per the designs (typically 7/8 of the slab or wall thickness) to ensure the bars function correctly in tension. All bars should have at least 12mm concrete covering under every bar. All laps should be a minimum of 25cm.

303.6 Concrete mix strengths Mass concrete footings should be cast with a 1:3:6 concrete mixture with a minimum cement dosage of 240 kg/m^3. Concrete slabs and drainage channels should be cast as single continuous structures using a 1:2:4 concrete mixture with a minimum cement dosage of 320kg/m^3. Water retaining structures (reservoir walls and bases) should be cast using a waterproof 1:1.5:3 concrete mixture (note that 1:2:4 is not waterproof) with a minimum cement dosage of 380kg/m^3. Additional cement should be added if hand mixing (see table below). Care should be taken to ensure that concrete mixtures are not over watered (bucket slump test should show no greater than ¼ reduction in the slump height). Cast concrete works should be immediately covered with plastic sheeting, straw, cement bags, sacking or leaves to keep the concrete moist and cool during the full curing period. All concrete should be well rodded (ideally vibrated) to remove air voids. The concrete should be cured with frequent watering at least twice daily for at least 10 days before use. The quantities of cement, sand and aggregate for 1m^3 of concrete can be found in the table below.

Concrete Mix	Quantity of Cement in Kg				Coarse Dry Sand (m^3)	Aggregate 12mm – 25mm (m^3)
	Machine Mixing		Hand Mixing			
	Gravel	Broken Stone	Gravel	Broken Stone		
1:1.5:3	370	390	380	400	0.42	0.84
1:2:4	290	310	300	320	0.45	0.90
1:3:6	190	210	200	220	0.46	0.92

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

303.7 Cement plasters Interior and exterior plasters should be applied as three layers as follows:

6mm 1:4 splatterdash
10mm 1:3 rough finish
10mm 1:2 smooth float

Each layer should preferably be applied when the previously layer is still 'green' (not fully cured). Each layer should be thoroughly wetted and the previously layer keyed (scratched) to ensure proper bonding. Interior

plasters of water retaining structures should be mixed with sikalite waterproofing compound (1kg per 50kg cement). The quantities of cement and sand for a 100m^2 of plaster can be found in the table below.

	100m^2 6mm thick		100m^2 12mm thick	
	Cement (kg)	Sand (m3)	Cement (kg)	Sand (m3)
1:4 splatterdash	274	0.766	- - -	- - -
1:3 rough finish	- - -	- - -	734	1.541
1:2 smooth float	- - -	- - -	979	1.371

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

303.8 Brick mortar strengths Above ground general purpose load bearing brick walls used in normal building construction, exposed to weather and heat, should be laid with a 1:6 mortar mixture with a minimum cement dosage of 250 kg/m^3. Below ground brick walls subject to soil pressure or seismic conditions should be laid with a 1:4 mortar mixture with a minimum cement dosage of 380 kg/m^3. Joint thickness should be 8mm - 12mm. The quantity of mortar required can be calculated as 0.23 to 0.25 of the brick wall volume. The quantities of cement and sand for 1m^3 of wet mortar can be found in the table below.

	1:4	1:5	1:6	1:7
Cement (kg)	380	312	250	220
Sand (m3)	1.1	1.1	1.1	1.1

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

304 SOAKAGE PIT SIZING BASED ON SOIL INFILTRATION RATES

304.1 The sizing of soakage pits, trenches and drain fields is dependent upon local site soil infiltration rates, the number of users and the quantity of waste water that is expected to be generated per person. Soakage pit dimensions should be determined by on-site soil infiltration tests (see Appendix 20 of Engineering in Emergencies. Alternatively refer to the table of typical soil infiltration rates on page 213 of the UNHCR WASH Manual). Soakage pits for wastewater from showers or septic tanks are likely to be much bigger than those for wastage from tapstands (see table below). In some cases communal shower blocks and septic tank installations may require drain fields rather than soakage pits.

	Clean Water (litres/m2/day)	Wastewater (Sewage and Sullage) (litres/m2/day)
Sand	720 – 2,400	33 - 50
Sandy Loam	480 – 720	24
Silt Loam	240 - 480	18
Clay Loam	120 - 240	8
Clay	24 - 120	Unsuitable

Source: Engineering in Emergencies (RedR, 2010)

305 SLOPES FOR WATER COLLECTION POINTS AND DRAINAGE CHANNELS

305.1 All water collection surfaces and drainage channels should be inclined to ensure that there is no standing water at water points. In general a slope of 1% should be sufficient to ensure that the water is gradually evacuated towards soakage pits.

306 SURFACE FINISHES AT PUBLIC WATER COLLECTION POINTS

306.1 All concrete surfaces at water collection points should be given a non-slip finish (the surfaces should be lightly brushed with a yard brush before the surface has cured) to ensure safe access by all users including the elderly, pregnant women, disabled users and small children. The surface should be sufficient to facilitate cleaning while also preventing slipping.

UNHCR STANDARD DESIGNS FOR WATER SUPPLY

UNHCR STANDARD DESIGNS FOR WATER SUPPLY

The following technical designs for water supply are available from UNHCR.

D-300/2015a	Emergency Tapstand (Wooden Pallets) with Drainage
D-301/2015a	Post Emergency Tapstand Design (Rectangular Concrete)
D-302/2015a	Post Emergency Handpump Apron Design (Rectangular Concrete)
D-303/2015a	Post Emergency Hand Dug Well Apron Design (Circular Concrete)
D-304/2015a	Borehole Design (Fractured Rock)
D-305/2015a	Borehole Design (Alluvial Aquifer)
D-306/2015a	Emergency Raised Water Platform (Sandbags)
D-307/2015a	Emergency Raised Water Platform (Concrete Rings)
D-308/2015a	Emergency Raised Water Platform (Corrugated Steel Rings)
D-309/2015a	Elevated 6m Water Tower with $20m^3$, $25m^3$, $50m^3$ $60m^3$ and $75m^3$ Water Reservoir (Reinforced Concrete)
D-310/2015a	Elevated Water Tower 15m high with $109m^3$ Reservoir (Steel)
D-311/2015a	Post Emergency Elevated Water Tower 4m (Steel)
D-312/2015a	Square Water Reservoir $10m^3$ (Reinforced Concrete)
D-313/2015a	Square Water Reservoir $30m^3$ (Reinforced Concrete)
D-314/2015a	Square Water Reservoir $50m^3$ (Reinforced Concrete)
D-315/2015a	Circular Water Reservoir $10m^3$ (Reinforced Concrete)
D-316/2015a	Circular Water Reservoir $30m^3$ (Reinforced Concrete)
D-317/2015a	Circular Water Reservoir $50m^3$ (Reinforced Concrete)
D-318/2015a	Circular Water Reservoir $45m^3$ (Ferrocement)
D-319/2015a	Circular Water Reservoir $75m^3$ (Ferrocement)
D-320/2015a	Circular Water Reservoir $90m^3$ (Ferrocement)

These designs may be found at http://wash.unhcr.org/wash-technical-designs/.

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