5. External Wall Construction

5.1. ERECTION OF EXTERNAL PRECAST WALLS

The erection of precast walls generally involves the following steps:

a) moving the precast wall panels from delivery truck or site storage yard to the designated locations for installation;

b) raising the precast panels to the required elevation (and rotating to correct orientation if necessary);

c) fixing the precast panels in position; and

d) casting the wet joints and/or grouting and applying sealant.

Figure 5.1: Erection of a precast wall

1. Remove precast wall from delivery truck

2. Raise the precast wall to required height and orientation

3. Position compressible waterproofing strip at joint

4. Apply non-shrink grout

5. Lower precast wall into position

6. Adjust position of precast wall

7. Install strutting

8. Verify plumb (and adjust if necessary)

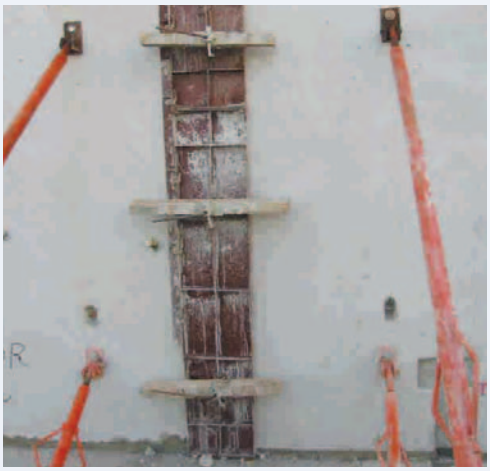
9. Remove excess grout infill after precast wall is erected

5.1.1 CASTING OF WET JOINTS

The use of wet joints is essential in minimising water seepage through the joint areas.

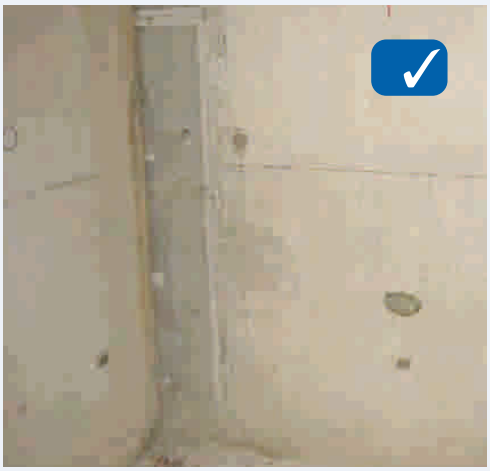
Figure 5.2: Casting of wet joint connections

1. Prepare continuity bars of wet joints



2. Set up formwork for casting

Figure 5.3: Wet joints



Good example of a wet joint

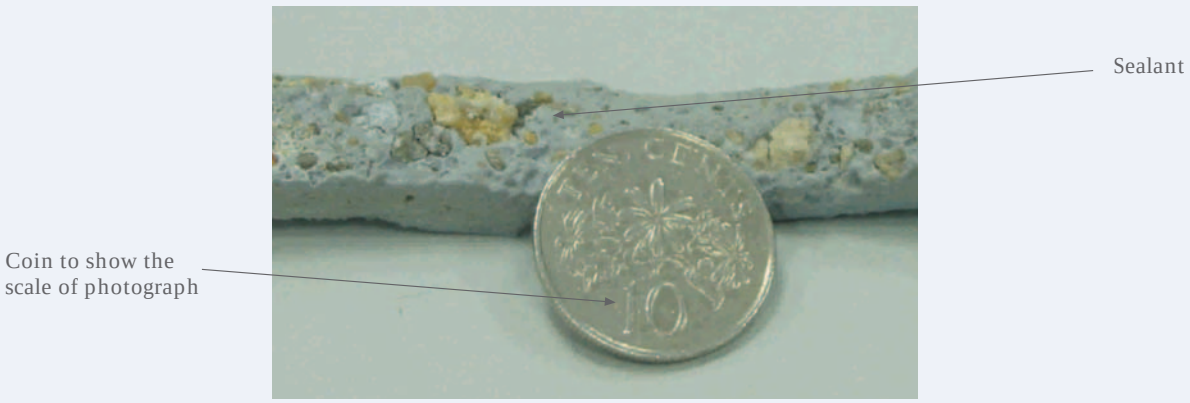
Bad example of a wet joint

5.1.2 SEALING OF JOINTS

Precast wall panels should be erected within the allowable construction tolerances, with emphasis placed on the gap size at the joints. This is important to facilitate proper installation of backer rod and application of sealant to ensure effective watertightness at these locations.

Concrete surfaces at the joint should be sound, smooth, clean and free from all mortar dust or other contaminants that may affect the adhesion of sealant to the surfaces. Some sealants may require a primer to improve the adhesion. In such cases, manufacturer's advice should be sought to ensure compatibility of the sealant and primer. As shown in Figure 5.4, poor surface preparation, resulting in loose particles and contaminants trapped in the sealant can lead to premature failure of the sealant system.

Figure 5.4: Premature failure of sealant due to contaminants

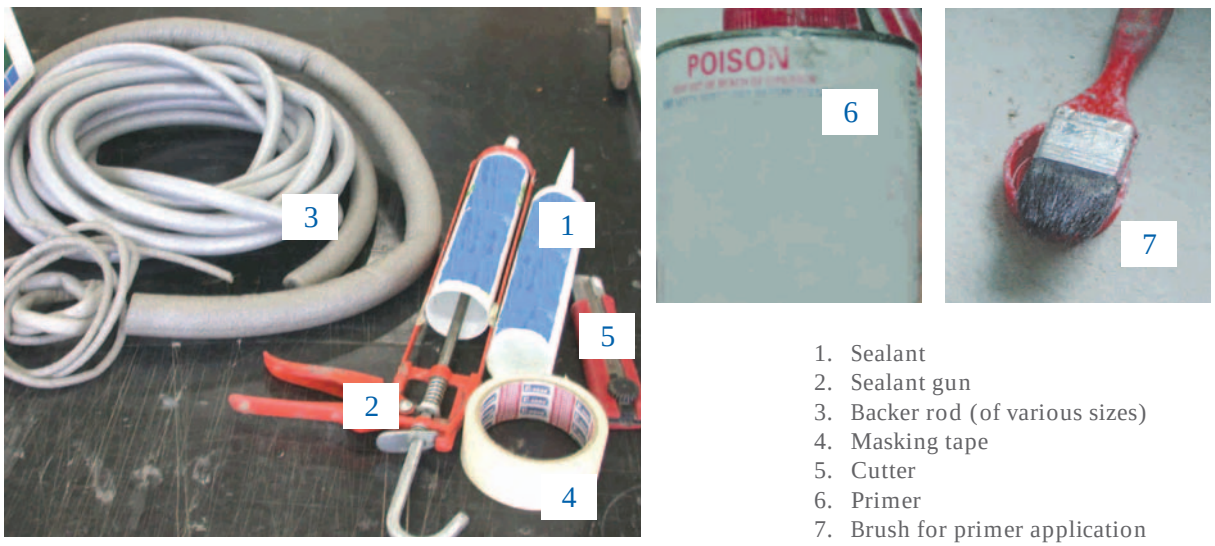


Where form release agents, form oils, or other surface coatings had been used, it is recommended that the joint surfaces be treated with a light sandblast, scarification or other approved methods in accordance with the manufacturer's advice to improve the adhesion of the sealant.

For effective sealing, the sealant should be extruded against a firm backing, such as a suitable backer rod, so that it is forced against the sides of the joint during application. The applied sealant should not adhere to the backing material because the induced restraint and resultant stresses from three-sided adhesion could lead to premature failure of the sealant system. A bond breaker such as polyethylene film could also be used, in place of a backer rod to prevent three-sided adhesion.

The applied sealant should be tooled to achieve a slightly concaved surface that is smooth, free of ridges, wrinkles, sags, air pockets and embedded impurities.

Figure 5.5: Tools for sealant application



1. Sealant
2. Sealant gun
3. Backer rod (of various sizes)
4. Masking tape
5. Cutter
6. Primer
7. Brush for primer application

5.2 CAST IN-SITU REINFORCED CONCRETE WALLS

Cast in-situ reinforced concrete (RC) walls are generally watertight, unless cracks are formed in the walls or at the joints between different elements. Cracks may be formed as a result of poor concrete quality, poor workmanship and/or unfavourable environmental factors.

To ensure watertightness at the joints between RC-RC members, the following preparatory work should be carried out before subsequent pour of concrete:

a) roughen the joint surface while the concrete is still green (eg. using a wire brush);

b) remove laitance at the joint surface;

c) rectify honeycombed areas with pressure grouting using approved material; and

d) apply a thin slurry coat of bonding agent at the joint surface, where watertightness is critical.

It is important to achieve the required alignment and verticality during casting so that there is minimal rectification work. The following should be observed:

a) formwork should be in good condition;

b) proper bracing and strutting; and

c) thorough checks on plumb and alignment before casting.

Form tie holes on external walls should be properly sealed to ensure watertightness of the building envelope. The following good practices should be adopted:

a) wall plugs of resilient material (non-biodegradable) and of appropriate sizes should be inserted into the form tie sleeve holes;

b) surrounding concrete surfaces should be cleaned to remove all loose particles and dampened;

c) a slurry coat of bonding agent, cement and water (refer to manufacturer's instructions on the mix ratio) should be applied to the dampened surface; and

d) non-shrink grout should be used to seal the holes. The slurry coat should still be fresh at time of application of mortar.

Figure 5.6: Joint surface roughened to improve bonding at RC-RC joint

Figure 5.7: Patching of form tie holes

1. Remove plastic cone

2. Insert wall plug into sleeve

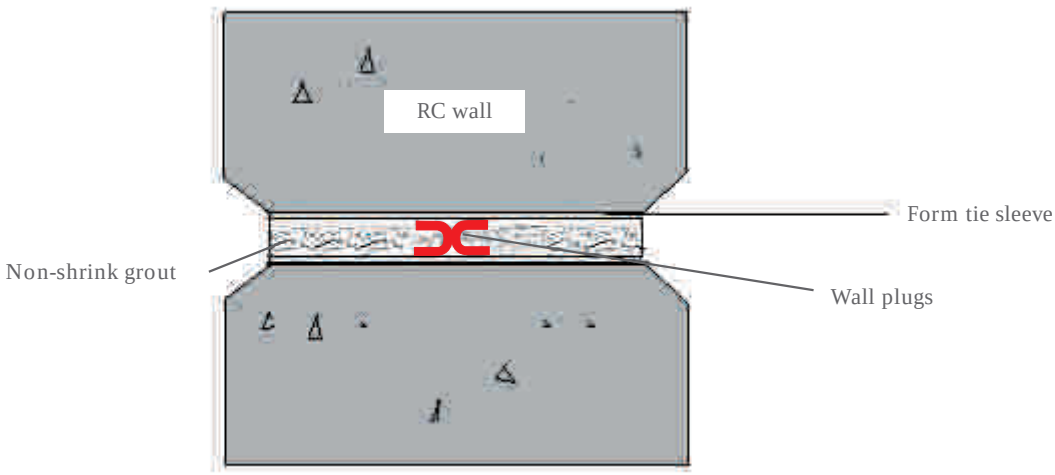
3. Clean concrete surface

4. Apply slurry of bonding agent, cement water

5. Mix non-shrink grout

6. Press grout mix into recess and finish by removing excess grout from concrete surface

Figure 5.8: Form tie sleeve hole (sectional view)



5.3 BRICKLAYING

5.3.1 GENERAL

Quality workmanship in bricklaying is essential in ensuring watertightness of brickwalls.

There should be proper co-ordination between external brickwork and other works. Setting out of all works, including openings, sills and lintels, should be coordinated. A copy of the approved brickwall setting out drawings could be displayed at appropriate location for easy reference.

There should be adequate scaffolding provided to enable workers to work from the outer side of external walls to achieve a high standard of laying and pointing works.

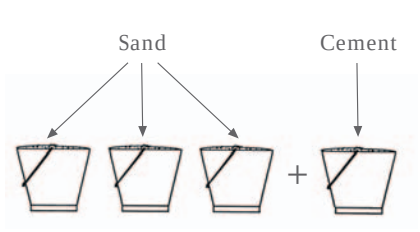
5.3.2 BATCHING, MIXING AND USE OF MORTAR

For enhanced performance, pre-packed mortar mix is recommended.

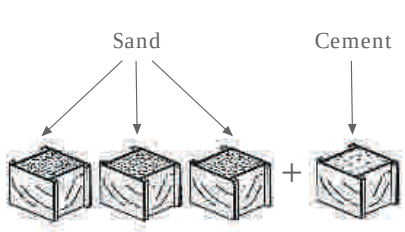
For site batching of mortar mix, standard size containers should be used to ensure correct proportion of materials. The use of shovels to gauge the amount of materials cannot be relied upon to give consistent performance. Additives should only be used upon the Designer's permission, and with the advice from the manufacturer. Machine mixing is recommended to achieve a thorough blend of mortar.

Wide variations in the mixing time should be avoided. Insufficient mixing may result in non-uniformity, poor workability and low water retention of the mortar. Excessive mixing, on the other hand, may adversely affect the strength and bonding of mortar due to air entrainment. It is a good practice to regulate the quantity of mortar being mixed, so that the mortar can be used up within the working time.

Figure 5.9: Measuring materials for mortar mix



Example of using bucket batching for a 1:3 mix



Example of using gauge box batching for a 1:3 mix

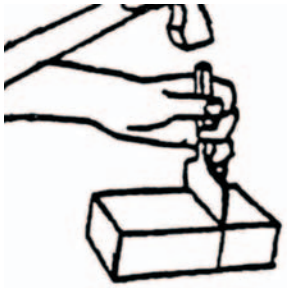
Gauging by shovels cannot be relied upon to give consistent mortar mix

5.3.3 CUTTING OF BRICKS

Proper setting out of the brickwork helps to reduce unnecessary cutting of brick units. Where cutting of brick units is needed, it is recommended that appropriate cutting machine be used to produce clean-cut edges. Alternatively, bricks could be cut using a bolster and a hammer. However, this method tends to produce less satisfactory results.

Figure 5.10: Cutting of bricks

Machine cut



Cutting with a bolster and hammer

5.3.4 LAYING OF BRICKS

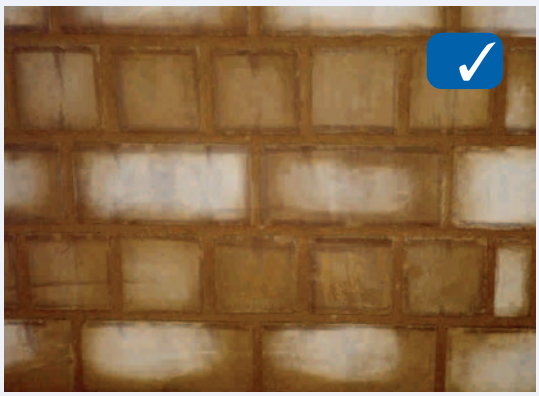
Brick units are generally porous and absorb moisture from the mortar during laying. This affects the adhesion between the brick units and the mortar. It is, hence, a good practice to dampen the brick units before laying, and to lay the mortar beds in shorter lengths to reduce rapid loss of water from the mortar through evaporation before the next course is being laid.

In addition, the top surface of the brick walls where the previous laying stopped, and the surfaces of abutting concrete slab/ beam/ column/ kerb should also be well wetted before commencement of laying. The bricks, however, should not be overly wetted (do not soak the bricks in water), as this may result in excessive efflorescence and staining of the brickwalls.

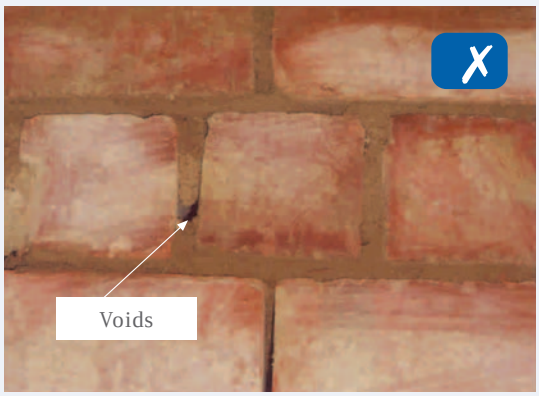
Brick units should be laid in full mortar bed with full head joints. Frogged bricks should be laid with the frog side facing up. The frogs should be completely filled with mortar to ensure no presence of voids between the bricks.

Watertightness would be adversely affected if voids are present in the cement mortar. Bricks should be laid in full and consistent mortar bed (Figure 5.10). The practice of furrowing the bed joints and buttering only the outer edges of the units should be avoided. As cement mortar joints are usually less watertight than the masonry units, average thickness of the mortar joints should not be thicker than 10mm.

Figure 5.11: Mortar joints

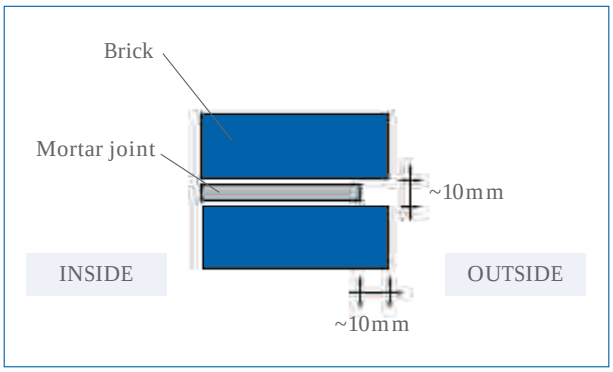


Brickwork without voids



Brickwork with voids

Figure 5.12: Raking of external mortar joints for plastered brickwalls



The joints should be raked out to a depth of about 10mm while the mortar is still green to form an adequate key for plaster (Figure 5.12).

As the brickwall is being erected, embed bonding bars and mesh reinforcement (exmet) in the mortar joints at every 4th course of brickwork. Where 2 pieces of reinforcement are joined, an overlapping of minimum 150mm should be provided. Lintels should be installed for doors and windows opening.

Figure 5.13: Installing bonding bars, brick reinforcement and lintels

Bonding bars fixed to a concrete column

Bonding bars embedded at every 4th course of brickwork

Mesh reinforcement embedded at every 4th course and tucked into the next course

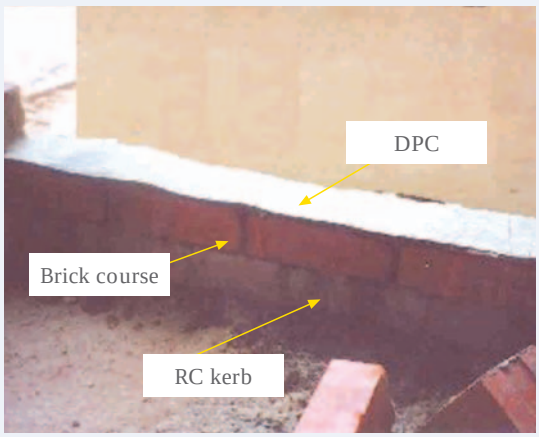
Steel lintel installed at window opening

5.3.5 INSTALLATION OF DAMP-PROOF COURSE (DPC)

DPCs should be laid on a smooth bed of fresh cement mortar. Care should be taken to ensure that the DPCs are not damaged, torn or punctured during the process of bricklaying. There should be minimum 150mm lapping at any joint between two sections of DPC.

The DPC laid should cover the entire width of the bricks. After laying the DPC, a fresh layer of mortar should be laid over the DPC as soon as possible, followed by the next course of brick. This creates good adhesion between the brick units, mortar and DPC.

Figure 5.14: Laying damp-proof course (DPC)



1. Lay DPC on fresh mortar bed

2. Lay fresh mortar over DPC

3. Lay at least one more course of brick over DPC

4. Damp-proof course laid with good adhesion

5.3.6 OTHER GOOD PRACTICES

As described in Section 2.4.3, a layer of metal lathing (mesh reinforcement) should be provided at the following locations to minimise the development of cracks:

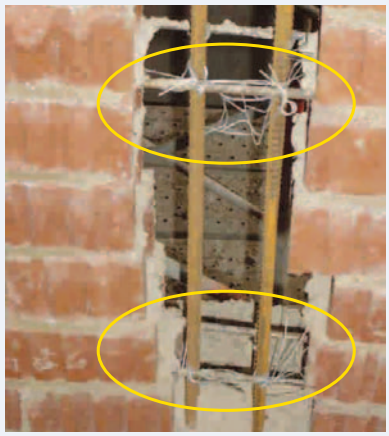
- interfaces between brick and RC elements;
- around door frames;
- around steel lintels; and
- around openings for electrical services.

Figure 5.15: Installing mesh reinforcement

Reinforcement installed around door frame

Reinforcement installed around lintel

Reinforcement installed around openings for electrical services



Reinforcement bars installed at every 4th course of brickwork for RC stiffeners

M&E services that penetrate the external walls should be housed in trunking boxes, with the surrounding gaps properly sealed to prevent any leakage, as illustrated in Figure 5.16 below.

Figure 5.16: Encasing M&E services in trunking boxes

1. Routing of pipes in the trunking box

2. Patching surrounding gaps using cement mortar

3. Connecting the trunking and finishing with paint

5.3.7 COMPLETING WORKS FOR BRICKLAYING

Mortar infill should be properly compacted between the last course of brickwork and the beam/ slab soffit. For better compactness, the use of a hand pump is recommended. Joints should be checked after excess mortar is removed from the brick face to ensure that the joints are properly filled. Any voids should be filled with grout. Where grout is used, avoid excessive water in the mix which may cause segregation and undue shrinkage.

Figure 5.17: Inject mortar between last course of brickwork and beam soffit

Gap between top course of brickwork and beam soffit

Hand pump for injection of mortar

Use hand pump to fill gap with grout

Completed grouting work

5.4 EXTERNAL PLASTERING AND SKIM COAT

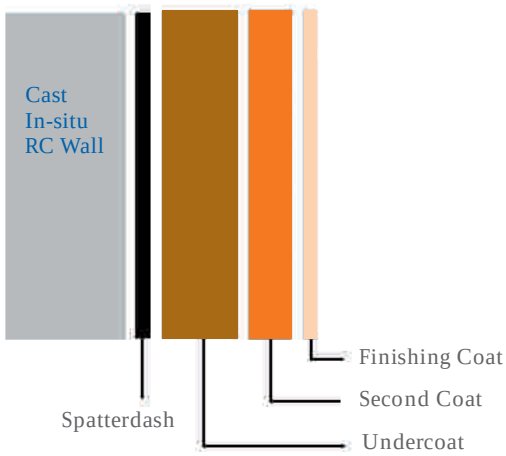
Typical cross sectional details of finishes for external wall are shown below:

Figure 5.18: Typical cross sectional details of external finishes

Typical cross section of a precast wall (or a cast in-situ RC wall) requiring skim coat only

External finishes for precast walls consisting:

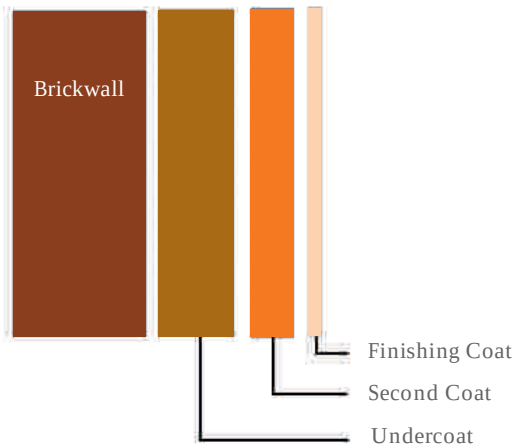
1. a thin layer of skim coat to fill out minor voids/ surface imperfections.



Typical cross section of a cast in-situ RC wall requiring plastering

External finishes for cast in-situ reinforced concrete (RC) walls consisting:

1. a spatterdash coat for better keying of the subsequent rendering coats;
2. an undercoat (scratched);
3. a second coat; and
4. a finishing coat.



Typical cross section of a plastered brickwall

External finishes for brickwalls consisting:

1. an undercoat (scratched);
2. a second coat; and
3. a finishing coat.

Figure 5.18 shows that external wall construction with precast walls involve the least work for external finishes. The process is, hence, less workmanship-dependent and more efficient.

5.4.1 PREPARATORY WORK

There should be proper co-ordination between external finishing works and works of other trades.

Gaps between the external walls and window/ door openings should be fully grouted with waterproofing mortar before the commencement of finishing work.

Figure 5.19: Sealing gap between window frame and external wall

Using hand pump to fill gap between frame and wall with waterproofing mortar before plastering

Gunning sealant into groove line after plastering is completed

External RC members with poor alignment and plumb, poor construction joint, honeycombed and badly formed surfaces should be rectified accordingly. All protrusions, fins, imperfections and blemishes should be removed from the RC surfaces.

Cleaning

All brick, concrete and other surfaces should be cleaned of dust, dirt, debris, grease, form release agents (for concrete surfaces), laitance and any other detrimental materials that may affect the bonding of plaster or skim coat.

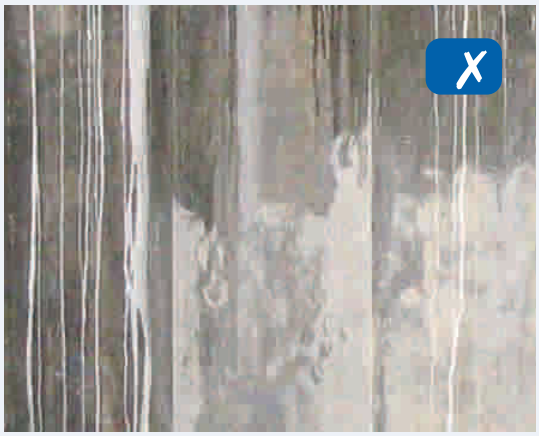
Active biological growth, such as algae, fungus and mould, should be removed as they may result in the formation of poorly laminated finishes, creating undesirable cavities or even cracks, thereby reducing the watertightness of the finishing coats. Appropriate cleaning solution can be used for this purpose.

Figure 5.20: General cleaning prior to application of finishes

Cleaning prior to application of finishes

Use of high pressure water jet

Figure 5.21: Use of appropriate cleaning solutions prior to application of finishes



Presence of form oils with efflorescence

Application of cleaning solution to remove residual form release agents on concrete surfaces

Treatment At Joints Between Dissimilar Materials

A layer of approved waterproofing compound should be applied at locations where there are potential risks of water seepage, for example, at brick-RC joints or around embedded M&E services.

A layer of render should be applied over the joint area prior to the application of the waterproofing membrane. The width of the applied waterproofing compound should be minimum 200mm (i.e. 100mm on each side of the joint). Once the waterproofing membrane has cured sufficiently, install a layer of metal lathing over the waterproofing membrane to prevent cracks at these interfaces.

Figure 5.22: Treatment at joints between dissimilar materials

1. Apply render to brick-RC joints

2. Apply waterproofing membrane

3. Install metal lath at brick-RC joints

Waterproofing Application along Perimeter Walls and Planters

There should be proper surface preparation before application of waterproofing membrane to the surrounding perimeter walls and planters as discussed in section 2.5.3. Refer to manufacturer's instructions on the surface preparation required, as well as coverage and number of coats to be applied. The membrane should be applied with a minimum 300mm upturn along the external wall (Figure 2.30 in Chapter 2).

Figure 5.23: Apply waterproofing membrane to perimeter walls with 300mm upturn

Application of Spatterdash Coat

For cast in-situ RC walls that require plastering, proper bonding and keying are important in ensuring good adhesion of the plaster to the RC substrate. The substrate surfaces should be dampened before commencing application of spatterdash coat. A spatterdash coat of 3-5mm thick should be applied to give effective keying action. For better performance, a thin layer of bonding agent can be applied on the RC surfaces before the application of the spatterdash coat. The application of the spatterdash coat should commence when the bonding agent is still damp.

Figure 5.24: Spatterdash coat on RC surfaces for better bonding with plaster

5.4.2 APPLICATION OF PLASTER

Plastering can substantially increase the rain resistance of external walls. However, cracks in the plaster may develop over time and reduce the level of protection against rain. Cracks in the plaster are usually caused by shrinkage of the plaster and/ or inadequate bonding between the plaster and the substrate.

For better performance, pre-packed plaster mixes are recommended. Approved waterproofing compound or bonding agent could be added to the plaster mix to improve its waterproofing ability.

Brick surfaces should be moistened prior to application of the undercoat to obtain good adhesion and prevent excessive absorption of water from the undercoat by the brickworks. Plastering on brick surfaces is usually applied in two coats (excluding the finishing coat). The thickness may vary depending on the evenness of the wall surface. Usually, the undercoat is between 8-10mm thick (scratched), and the second coat is 6-10mm thick. Some pre-packed plastering mortars may allow thinner layers of application. For such cases, refer to specifications of the manufacturer. The total thickness allowed for the plaster (including all coats) should generally be limited to 25mm.

For plastered RC surfaces, the thickness of plaster should be between 5-18mm. If the structural works are constructed with good alignment and surface condition, a thinner coat of plaster or skimming may be applied.

Each plaster coat should be sufficiently cured by mist spraying before applying the subsequent coat. Rapid drying of the plaster should be avoided to achieve better shrinkage control.

Where applicable, all plastering works should be terminated at groove lines, casing beads, corners, openings, or other acceptable intersection of surfaces to achieve a better finishing without any visible lines at the terminating plaster. To reduce the risks of water seepage at the joints between two adjacent groove lines, a suitable sealant should be applied to these joints, including the turning corners of the groove line after plastering.

Figure 5.25: Terminating plastering works at groove lines

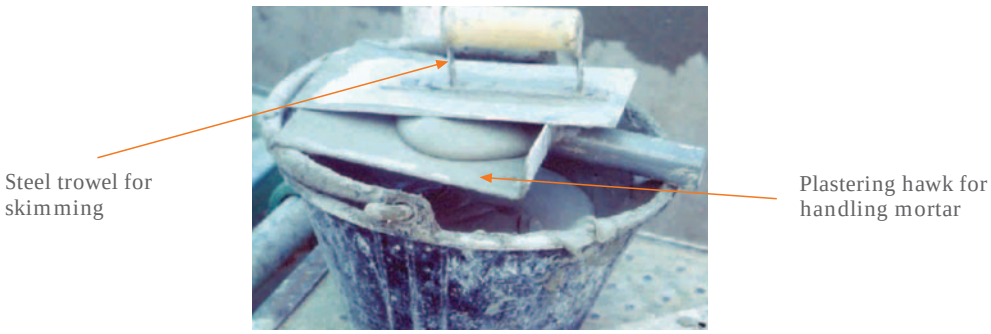
All defective plaster, including hairline cracks, pits, blisters, and other defects, should be rectified. When carrying out rectification works, a suitable bonding agent should be applied to the existing plaster edges or surfaces where the new plaster will be applied over.

5.4.3 APPLICATION OF SKIM COAT

The surface of RC members (including precast walls) should be constructed to good alignment and plumb so that plastering is not required. Where there are minor surface unevenness or blemishes, the RC surfaces could be skim coated with approved skimming materials. In such cases, the skimming can be applied in two coats, steel trowelled until a smooth and uniform surface is achieved. As a general guide, thickness of skim coat to RC walls should not exceed 5mm.

Skim coats should be cured for 48 hours by fog spraying to prevent rapid drying. For the first 12 hours, a very light fog spraying is recommended.

Figure 5.26: Application of skim coat



1. Prepare skimming tools

2. Scoop skimming mortar onto plastering hawk

3. Apply skim coat onto prepared RC surface, trowel until smooth and uniform

5.4.4 APPLICATION OF SEALER

Subsequent to the completion of plastering works or skim coating, it is recommended to apply a water repelling sealer, either film forming or impregnating in nature, over the external wall before commencing painting works. In particular, water-based impregnating sealers can form a hydrophobic zone which protects the substrate against water ingress. Prior to application of the sealer, the receiving surface should be dry, clean and free from dust, dirt, grease and any loose foreign matter. Refer to manufacturer's instructions on the selection and usage of the sealer.

Figure 5.27: Application of sealer prior to painting works

6. Testing

6.1. WATERTIGHTNESS TESTS

External Wall Panels

To verify the watertightness performance of the completed external walls, field watertightness test could be carried out on minimum 10% of the external walls. The conduct of field watertightness test is especially critical for external brickwalls where waterproofing performance is highly workmanship-dependent.

For conduct of the watertightness test, water should be sprayed on the wall surface at a distance of 1800 – 2000 mm from the wall, with the nozzle fixed at an inclined angle of 30 degree to the external wall. 300 litres of water should be delivered to the test wall panel for 2 hours.

The test wall panel is considered to have passed the test if no dampness or seepage appears on the internal surface of the wall panel or the adjacent areas during the test and within half an hour after the completion of test.

Joints Between External Wall and Window Frame

Field tests should be conducted to verify the watertightness performance of the joints between the external wall and window frame.

The following parameters are used in the CONQUAS 21 field watertightness test:

Water intensity	: 300mm/hr : 1 litre/min/m of joint
Wind Pressure	: 240 Pa
Nozzle inclination	: 90° to wall
Distance of nozzle from wall	: 200mm
Sample	: 1 sample = 2m length of joint
Spray duration	: 10mins

Figure 6.1: Conduct of field watertightness test for joints between external wall and window frame

No sign of seepage should be detected throughout the test.