TECHNICAL SPECIFICATION

ISO/TS 17870-3

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Ceramic tiles — Installation —

Part 3: Installation of large format porcelain tiles and panels by mechanical means onto a supporting structure

Carreaux et dalles céramiques - Installation —

Partie 3: Installation des carreaux et panneaux céramiques grand format par des moyens mécaniques sur une structure de support

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 189, *Ceramic tile*.

A list of all parts in the ISO 17870 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Ceramic tiles — Installation —

Part 3: Installation of large format porcelain tiles and panels by mechanical means onto a supporting structure

1 Scope

Classes A1a and B1a porcelain (as defined in ISO 13006) are now manufactured in much larger formats than previously available and are increasingly being used as an external cladding material for buildings.

Classes A1b, A11a, and AIIb extruded ceramics (as defined in ISO 13006) are not covered by the scope of this document. These materials, when specifically developed for external façade applications, have been used extensively for many years and established methodologies already exist.

Large format porcelain tiles or panels are generally considered to be too large to be used externally on high buildings when installed by conventional adhesive fixing methods (ISO/TR 17870-1 and ISO/TR 17870-2); therefore, mechanical fixings are used.

As there are currently no published standards or guidelines for these products to be installed in this way, this document provides generic information on some typical types of mechanical fixing systems in use together with positive and negative wind load factors and typical testing procedures that can be used for evaluating anchor pull-out or edge fracture resistance. Also, because the current impact resistance test method for ceramics tiles (ISO 10545-5) relates only to traditional (bedded) installed tiling – which measures the coefficient of restitution – it is not an appropriate test for unbedded (unsupported) tiles, so alternative test methods (ISO 7892) are referred to for measuring hard-body and soft-body impact resistance.

Guidance is provided regarding typical impact zones of vulnerability to hard and soft body impact and reference is made to anti-shatter mesh backings, which are sometimes applied to porcelain cladding tiles and panels.

Installation systems which rely upon the chemical adhesion of metal brackets, straps or framing, etc. onto or into large format porcelain tiles or panels in conjunction with, or instead of, mechanical attachment, are not included in this document.

The detailed principles for the design and construction of the substructure of ventilated façades, also known as rain screens, used on the outside of buildings, are well documented in other national and international standards and are not therefore, included in this document, other than in general reference.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
arris
sharp edge formed by the intersection of two surfaces such as the corner of a masonry unit text of the definition

3.2
porcelain
ceramic with water absorption ≤ 0,5 % (Class A1a or B1a according to ISO 13006)

3.3
large format porcelain tile
surface area >3 600 cm^2 and no tile edge >1 200 mm

3.4
porcelain panel
surface area >1 m^2 and any tile edge > 1 200 mm

3.5
ventilated façade
system for cladding the exterior of a building that provides for the formation of a cavity between the building structure and the cladding to allow for the installation of a thermal/acoustic insulation layer and an air cavity between the *insulation layer* (3.8) and the *large format porcelain tiles* (3.3) or panel

Note 1 to entry: Air cavity has a minimum of a 20 mm wide continuous air flow cavity.

3.6
drift
unintended sideways movement of *large format porcelain tiles* (3.3) or panels across a support structure due to differential thermal expansion/contraction of components and/or gusting wind pressures

3.7
primary support
subframe or substructure, usually metal, onto which the *large format porcelain tiles* (3.3) or panels are mounted

3.8
insulation layer
layer included to obtain sound or thermal insulation

3.9
movement joint
joint (3.10) in *large format porcelain tiles* (3.3) or panels, backgrounds or substrates, designed to accommodate movement

3.10
joint
space between adjacent *large format porcelain tiles* (3.3) or panels

3.11
undercut anchor
special type of stress-free mechanical anchorage system used to secure brackets or straps onto *large format porcelain tiles* (3.3) or panels

3.12
support system
metal brackets and rails used to form the subframe

3.13
vapour membrane
impervious layer to resist the passage of water but which will allow vapour from the building structure to escape

3.14
slotted edge system
kerf edge system
slots formed into the edges of *large format porcelain tiles* (3.3) or panels to receive clips which are secured to the façade subframe

3.15
overlapping clip
visible clips which overlap the edges of *large format porcelain tiles* (3.3) or panels and secured to the façade subframe

3.16
hard-body impact
impact by hard projectiles that may be thrown, blown or otherwise caused to impact the façade

3.17
soft-body impact
impact from persons or other significantly heavy soft objects falling or pushing against the façade

3.18
negative wind load
negative load (suction) imposed onto the façade by strong or gusting wind

3.19
positive wind load
load imposed onto a façade by strong or gusting wind

3.20
workshop drawing
project-specific detailed installation drawing

4 Exchange of information

In order for the correct large format porcelain tiles or panels ventilated façade system to be installed in appropriate conditions, at the right time, etc., it is essential that all parties have a clear understanding of the requirements of the project. To ensure that this is achieved, it is essential that there is wide consultation between all the parties involved in the project, including client, façade installer and materials suppliers.

As each project will be unique, it is impossible to give a definitive list of the information to be exchanged, but the following are common examples:

a) specification: the information required;

b) special attendances: access, unloading, hoisting and storage facilities, heat, light and power, and any additional items considered necessary to expedite the work;

c) large format porcelain tiles or panels mechanical fixing system: technical specification and instructions for transport, storage, use;

d) backgrounds: type of façade subframe construction; location on the building and any need for movement joints;

e) associated work: services in or passing through the façade substructure and junctions with other adjacent finishes;

f) finishes: type, size, and colour of large format porcelain, tiles or panels and layout requirements;

g) installation: type and technique;

h) workshop drawing;

i) wind load: engineering calculations;

j) programme: a time schedule for the progress of the work.

5 Workmanship

The installation of large format porcelain tiles or panels requires efficient supervision and the employment of skilled operatives properly trained to install large format porcelain tiles or panels façade systems to an appropriate level of competence.

The large format porcelain tiles or panels façade installers should be properly trained to work safely from a scaffold or when using access equipment to work at height, including the use of a safety harness and other equipment where necessary.

6 Ventilated façades

6.1 General

Ventilated façade systems vary in design, depending upon the performance criteria required by the specifier, e.g. drained and ventilated, pressure equalised, compartmented.

The various requirements and recommendations contained in this document relate only to the installation of mechanically fixed large format porcelain tiles or panels onto an appropriately designed, drained and ventilated façade system subframe.

Usually a ventilated façade subframe will consist of primary support brackets that attach a metallic subframe to the structure of the building, which may be masonry or concrete/steel frame, etc.

Primary support brackets, which are usually available in a range of sizes depending upon the façade cavity dimension required, are securely fixed to the building structure and normally provide for some adjustment of the subframe, which is appropriately attached to the primary support brackets after first aligning it to the required planarity and perpendicularity.

A thermal/acoustic insulation layer may be installed and covered by a waterproof vapour membrane if recommended by the façade designer or required in accordance with national regulations.

Purpose-designed horizontal rails are then attached to the subframe in accordance with the specification at the correct levels and spacing to suit the setting out module of the large format porcelain tiles or panels to be mechanically attached to them (see Figure 1).

Some ventilated façade primary support systems are suitable for the mechanical attachment of large format porcelain tiles or panels directly onto the vertical support rails (See Figure 4, Figure 5 and Figure 6).

In some countries ventilated façade systems are classified as ‘construction kits’ consisting of all the components necessary to construct the façade and tested to appropriate standards.

7 Methods of mechanical fixing for porcelain

7.1 General

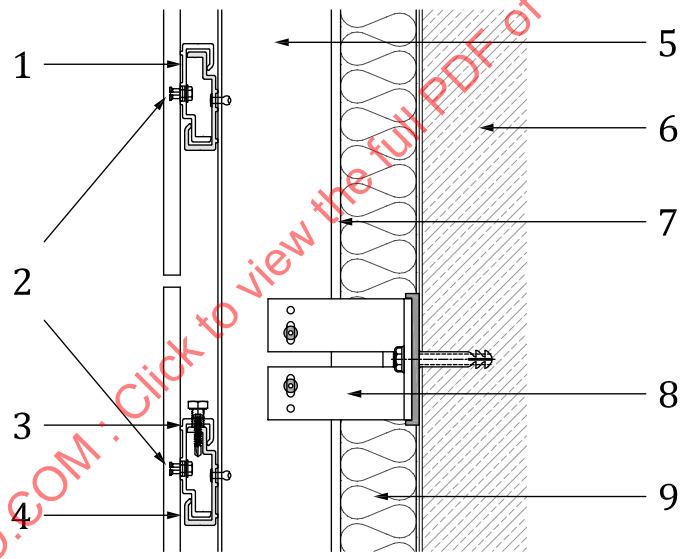
There are various methods of mechanically fixing large format porcelain tiles or panels. This clause sets out details of some of the most popular types of mechanical fixing systems currently in use. It is important that whichever mechanical fixing system is used, the fixing shall be able to sustain the specified design load, without causing stresses within the large format porcelain tiles or panels.

7.2 Anchored systems

7.2.1 General

Whilst the precise design of undercut anchoring systems may vary between different manufacturers, the general intent is to achieve invisible and stress-free fixing of appropriately designed brackets or clips, to the rear sides of large format porcelain tiles or panels, for their attachment to a supporting façade framework.

Undercut anchor details provided in this clause are, therefore, for general information purposes rather than being design-specific.



Key

1 façade system brackets
2 undercut anchors
3 compression pads
4 façade system horizontal rail
5 subframe
6 building structure
7 vapour membrane
8 primary support bracket
9 insulation

Figure 1 — Typical anchored support brackets

The minimum thickness of large format porcelain tiles or panels to receive undercut anchors will be determined by the façade system designer according to the size of the panel and the spacings between the undercut anchors.

7.2.2 Bracket and strap attachment

Bracket or strap attachment to the backs of large format porcelain tiles or panels is usually by means of specially designed anchors which, when tightened, expand at their base into undercut recesses at the bottom of holes, drilled to precise depths into the porcelain using specially designed drilling apparatus (see Figure 2 and Figure 3).

When the anchors are fully tightened to a predetermined torque value, they should not exert any pressure between the porcelain and the anchor but should fit precisely into the undercut hole in order to be able to satisfactorily secure the brackets or straps to the large format porcelain tiles or panels.

Some large format porcelain tiles or panels façade systems include compression pads which are fitted between the large format porcelain tiles or panels and the bracket or strap attachment.

Undercut anchors should be made of austenitic stainless steel.

The diameter and depth of the anchor will depend upon the thickness and weight of the large format porcelain tiles or panels, the anticipated wind loads and the frequency at which the anchor fixings are spaced.

Where large format porcelain tiles or panels façade systems employ brackets which attach to horizontal carrier rails, the top brackets should have adjustable bolts on them for final levelling adjustment.

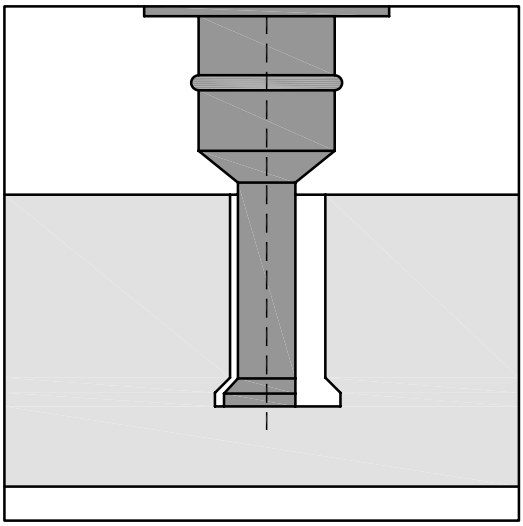
One of the top brackets should be secured to the horizontal carrier rail by a suitable screw to prevent any lateral drift of the large format porcelain tiles or panels.

Small cut porcelain returns/reveals are sometimes bracketed and undercut anchored to large format porcelain tiles or panels. The large format porcelain tiles or panels and their fixings must be able to support the additional loads created by the attachment of the return, taking into consideration also that wind loads may increase at external corners of the building.

Undercut drilling, anchoring and fabrication of these units should only be carried out at quality-controlled and appropriately accredited facilities in strict accordance with the façade designer's recommendations.

Final anchor tightness checks should be carried out on site by the façade installer immediately prior to the installation of large format porcelain tiles or panels using a torque testing hand tool designed for the purpose

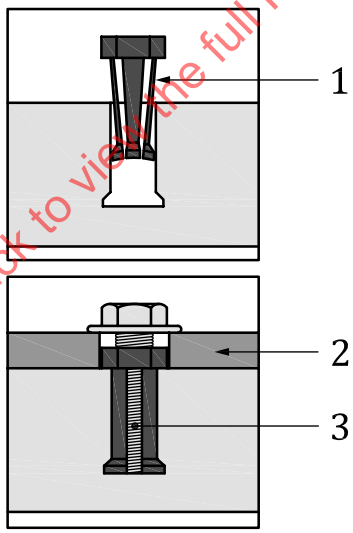
7.2.3 Undercut drilling



a

a Eccentric undercut drilling facility employed creates undercut recesses at base of drill holes.

Figure 2 — Example of undercut drill hole



Key

1 anchor
2 bracket or strap
3 anchor bolt

Figure 3 — Typical undercut anchor and bolt assembly

7.2.4 Anchorage – pull-out testing of undercut anchors and edge fracture testing of slotted edge systems

There can sometimes be significant variations in the pull-out value of undercut anchors or slotted edge wall strengths of some large format porcelain tiles and panels due to differences in tile or panel manufacturing processes.

It is important to evaluate anchor pull-out or slot edged strength to ensure that the values exceed the minimum design requirements necessary for resistance to wind load.

— Pull out resistance values – worked example:

  Based on a 140 mph (max.) (225,3 kph) wind speed which produces a force of 2,4 kN/m^2 and taking into account a safety factor of 3:

  Assume a 1 200 x 600 mm (0,72 m^2) tile is used with four fixings.

  NOTE Additional undercut anchors can be installed to the façade designer's specification in order to meet the required safety factor.

— Wind load calculation example

  — With a force of 2,4 kN/m^2 and a safety factor of 3, the system shall resist:

    2,4 kN/m^2 x 3 = 7,2 kN/m^2

  — For the tile size 1 200 x 600 mm (0,72 m^2):

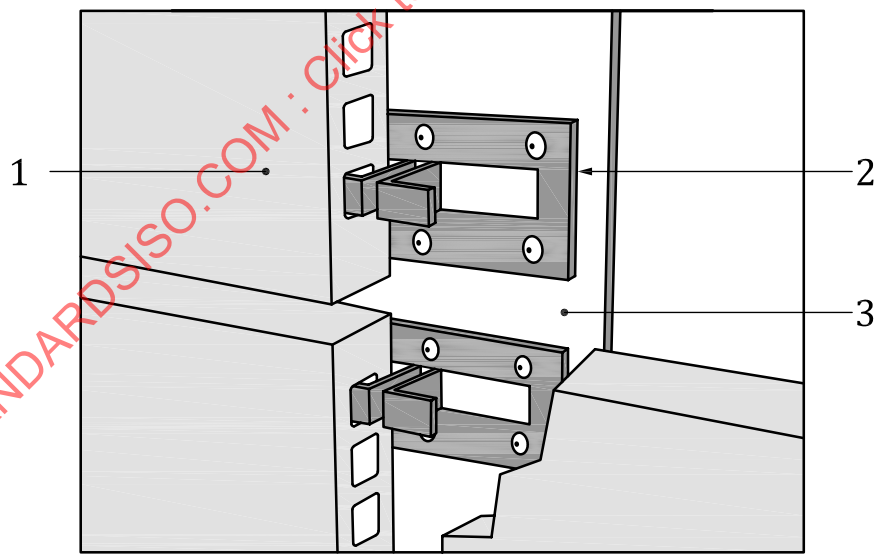
    7,2 kN/m^2 x 0,72 m^2 = 5,19 kN

  — Using four fixings per tile, each fixing shall achieve a minimum pull out or slotted edge wall fracture value of :

    5,19 k ÷ 4 = 1,3 kN (each)

  Calculations for the proposed design should be provided by a qualified façade designer.

7.3 Apertured tile systems



Key

1 porcelain panel with apertures through body
2 clip/fixing
3 façade support subframe

Figure 4 — Typical aperture and clip fixing

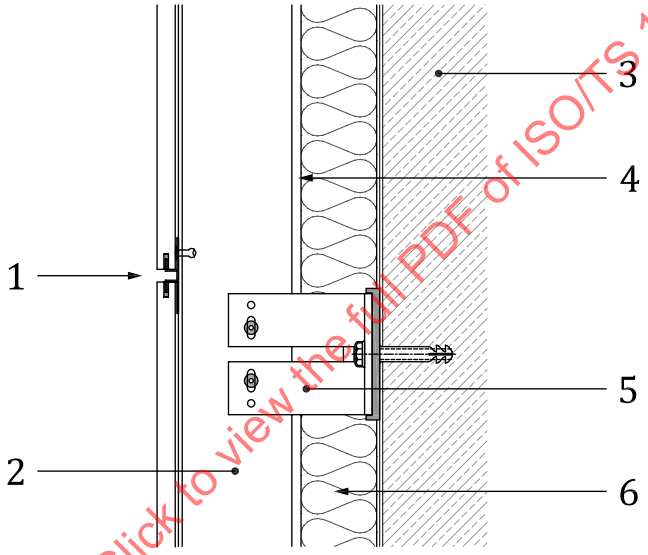
Some porcelain tile manufacturers produce large format porcelain tiles or panels, usually by extrusion, which have apertures formed through their body, which are designed to receive mechanical end fixing devices in order to facilitate attachment to a façade substructure.

Where mechanical fixings are fitted into apertures formed through the body of large format porcelain tiles or panels, the fixings should not fit so tightly into the apertures, so as to prevent anticipated differential thermal expansion/contraction movement between the large format porcelain tiles or panels and the fixings or metal support structure to which the clips are attached taking place, as this may result in the development of stresses within the façade system.

The large format porcelain tiles or panels manufacturer's advice should be followed.

7.4 Edge slotted systems

7.4.1 General



Key

1 fixing clips fitted into slots cut into the edges of porcelain
2 subframe
3 building structure
4 vapour membrane
5 primary support bracket
6 insulation

Figure 5 — Typical horizontal edge slotted fixings

The minimum thickness of large format porcelain tiles or panels suitable for this type of fixing will be determined by the façade designer taking into account the size of the large format porcelain tiles or panels and the anticipated performance requirements of the façade. After slots have been formed, the remaining front and rear edges of the slot walls should preferably be minimum 5 mm thick, subject to the large format porcelain tiles or panels façade system manufacturer's recommendations.

This type of fixing may not be appropriate for very large porcelain panels where the spans between perimeter fixing points may be too great to achieve adequate restraint against negative wind loading.

Clips should not fit tightly into slots that are formed into the edges of the large format porcelain tiles or panels, to prevent anticipated differential thermal expansion/contraction movement between the large format porcelain tiles or panels and the metal support structure to which the clips are attached, as this may result in the development of stresses within the façade system.

Due to climatic conditions, in some countries, the façade designer may consider that the slots formed in the top edge of large format porcelain tiles or panels should be filled with silicone or other appropriate substance to prevent water from reservoiring in the slot which may freeze and cause damage to the large format porcelain tiles or panels.

7.4.2 Horizontal drift

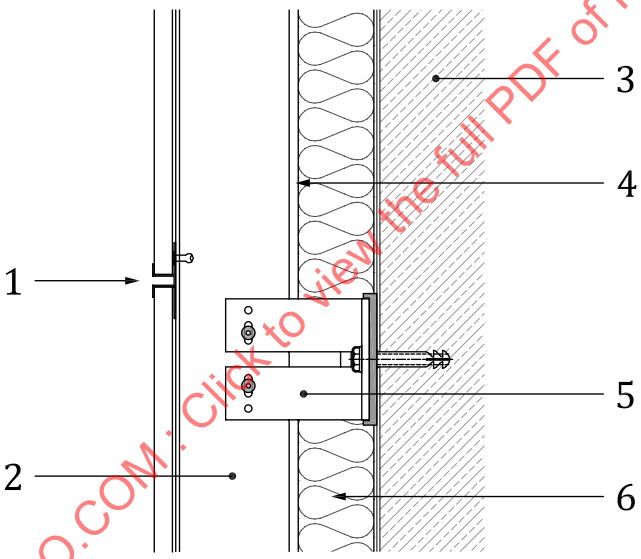
Edge slotted clip systems should provide means for preventing large format porcelain tiles or panels sideways movement, known as 'drift', along their horizontal support rails or clips.

The large format porcelain tiles or panels manufacturer's advice should be followed.

7.4.3 Effect of frost

Due to climatic conditions in some countries where freezing temperatures are to be anticipated, water should not become trapped in joints or slots in the top edges of large format porcelain tiles or panels, as subsequent freezing can cause damage that may adversely affect performance of the material and the integrity of the façade system.

7.5 Visible overlapping clip systems



Key

1 visible clips
2 sub frame
3 building structure
4 vapour membrane
5 primary support bracket
6 insulation

Figure 6 — Typical overlapping clip fixing

Visible clips overlap the large format porcelain tiles or panels at positions around their perimeter where the clips can be fixed to the façade support structure.

This type of fixing may not be appropriate for some very large porcelain panels where the spans between perimeter fixing points may be too great to achieve adequate restraint against negative wind loading, but this will be determined by the façade designer taking into account the size of the large format porcelain tiles or panels and the anticipated performance requirements of the façade.

The minimum thickness of large format porcelain tiles or panels for façades installed using overlapping clips is determined by the span between clips without deflection or deformation of the large format porcelain tiles or panels, when subjected to maximum wind load.

The large format porcelain tiles or panels manufacturer's advice should be followed.

7.6 Off-site prefabrication

Undercut drilling of large format tiles or panels to accommodate fixing anchors for the attachment of brackets or straps, etc. should be carried out off-site at a quality-controlled and appropriately accredited facility.

The brackets or straps should also be attached to the large format porcelain tiles or panels at a quality-controlled accredited facility where the necessary quality control procedures can be monitored and recorded.

Some large format porcelain tiles or panels façade system manufacturers can also attach porcelain reveals, soffits and cill pieces, by means of undercut anchored special bracketing onto the main large format porcelain tiles or panels face units.

When slots or grooves are required to be formed in the edges of large format porcelain tiles or panels to receive edge fixing clips, this should be carried out in a quality controlled accredited facility strictly in accordance with the large format porcelain tiles or panels manufacturers' recommendations as any irregularity in the thickness of the remaining side walls of the slots and grooves can adversely affect resistance to wind load pressures and impact.

7.7 Cutting large format porcelain tiles or panels

7.7.1 Wet cutting

The recommended method for cutting large format porcelain tiles or panels for open jointed ventilated façades is by wet cutting using appropriate diamond encrusted cutting blades.

Dry machine cutting of large format porcelain tiles or panels is not recommend due to the release of potentially hazardous dust particles that this cutting method can cause.

7.7.2 Scribe and break

Scribe and break is an appropriate technique for cutting some types of large format porcelain tiles or panels, but it should be taken into account that for open jointed ventilated façades, the cut/broken edges of the large format porcelain tiles or panels will be visible through the open joints.

8 Erection sequence

The project façade designer will normally be responsible for estimating the best time to install large format porcelain tiles or panels. On low-rise buildings (up to five storeys), it is generally desirable to wait until the main structure is complete before installation but on high-rise buildings enclosure of lower storeys may sometimes be started before the structure is completed. This will enable lower storeys to be weatherproofed and fitting-out of interior spaces to be started, but it does expose the enclosure to the risk of damage from the hoisting of large structural items or from splashing by concrete.

If installation of the large format porcelain tiles or panels is delayed until the structure is complete, there may be a choice of installing from the bottom up, or from the top down. If scaffolding is used, there are advantages in installing from the top down. The enclosure may be fully weatherproofed and finished, and scaffolding struck, as installation proceeds.

NOTE Some installation systems are non-sequential and allow large format porcelain tiles or panels to be removed and replaced without damaging or interference with surrounding adjacent tiles or panels thus allowing closure of the façade as scaffold is struck and scaffold ties to the building structure are removed.

9 Setting out

9.1 General

A benchmark or datum should be provided at each floor level for setting out the façade. Before installation of large format porcelain tiles or panels is commenced, a survey of the building shell or façade primary support framework should be made to ensure that it is within specified tolerances. If any specified tolerances have been exceeded, the designer, manufacturer and enclosure subcontractor should be immediately informed, and steps taken to remedy the deficiencies before installation of the large format porcelain tiles or panels begins, by either remedial work on site, adjustment of the design, or both.

Setting out of the large format porcelain tiles or panels will normally be predetermined by the project architect/designer in order to align certain horizontal and vertical joints between large format porcelain tiles or panels with other features e.g. windows, doors, columns, etc.

The façade designer will normally specify that the joints between large format porcelain tiles should not be less than 6 mm wide in order to provide sufficient space to allow for thermal expansion/contraction movement of the large format porcelain tiles and the metallic support rails to which they are attached. Joints between porcelain panels may need to be wider than 6 mm as specified by the façade designer.

9.2 Plumb and planarity

The plumb and planarity of large format porcelain tiles or panels are determined by the plumb and planarity of the subframe.

The large format porcelain tiles or panels systems are usually fixed directly to the subframe or to horizontal carrier rails (usually aluminium) which are part of the large format porcelain tiles or panels façade system and should be secured to the subframe strictly in accordance with the large format porcelain tiles or panels façade manufacturer's recommendations using stainless-steel rivets or screws, with appropriate shear and pull-out resistance.

Screws should be fitted by a specially designed power screwdriver with torque and speed control in accordance with the screw manufacturer's instructions. If drill speed and screw tightness torque are not within the manufacturer's recommended parameters, the pull-out resistance of the stainless-steel screw from aluminium components can be adversely affected.

Screws should be cyclic tested and certified to confirm their long-term durability.

10 Fixings

Close supervision should be exercised to ensure that the type and number of fixings are in accordance with the job specification, and that fixings are properly made, especially where they are hidden and cannot be checked at a later date. Where insulating bushes and washers have been specified to separate dissimilar metals or to allow for sliding movement, a check should be made that they have been positioned correctly.

Overtightening and bending of fixings to accommodate inaccuracies is not permitted.

11 Wind loads

11.1 Wind-load calculations

Project specific wind load should be calculated by the façade designer.

11.2 Wind-load testing

Aero engine-driven propellers are normally used to replicate wind load and driven rain when testing large format porcelain tiles or panels façade systems.

Some testing facilities use inflatable air bags placed within the cavity of the façade system to replicate the effect of negative wind load in order to evaluate any deflection of the large format porcelain tiles or panels.

Positive wind load and negative wind-load testing of the large format porcelain tiles or panels façade system should be carried out by an accredited testing authority.

11.3 Components - wind-load resistance

The façade designer should specify project specific maximum wind loads that the large format porcelain tiles or panels and their fixing components shall be able to resist.

11.4 Operational forces

The size and position of operational forces acting on the façade depends on expected conditions of use and position. The large format porcelain tiles or panels should be capable of accepting the likely horizontal load applied on them without damage.

Loads resulting from the operation of cleaning cradles should be obtained from the cradle manufacturer and taken into account by the façade designer.

Some cleaning cradles have deformable rollers attached to them in order to minimize the load that the cradle may apply.

12 Impact criteria and performance testing

12.1 General

Impact criteria and performance testing is regulated in many countries. Some countries where extreme climatic conditions are to be expected, for example, hurricanes in Florida USA, may require special testing of large format porcelain tiles or panels façade systems to be carried out in accordance with their own national standard test requirements by an accredited testing facility.

Some countries where seismic activity is to be expected, for example, Japan, may require special seismic testing of large format porcelain tiles or panels façade systems to be carried out in accordance with their own national standard test requirements by an accredited testing facility.

In countries where façade impact criteria and performance test requirements are not defined in a national standard, the following impact criteria and performance testing (see 12.2 – 12.5) shall be used.

12.2 Performance category

The vulnerability of large format porcelain tiles or panels to impacts varies considerably with location, both location on an individual building and the use of the building itself.

Larger and more frequent impacts will tend to occur on lower level vertical surfaces adjacent to public areas where accidental pedestrian, trolley or perambulator impact may occur, or from thrown objects, as compared with privately used areas. For those with access to a vertical surface, the degree of incentive to exercise care will also be an important factor in determining the likely impact loads. This provides a wide spectrum of use which the façade designer should consider when specifying the size and/or thickness of the large format porcelain tiles or panels, but for practical purposes four categories may usefully be considered for vertical surfaces up to 1,5 m above pedestrian level (A to D in Table 1).

Above this level the vulnerability to damage is reduced giving two possible further categories (E and F in Table 1).

In addition, special consideration is given to façades adjacent to areas used by vehicular traffic. The use of guardrails is often appropriate in this situation.

12.3 Impact resistance

Minimum test impact values for large format porcelain tiles or panels, as described in Table 1 should be as suggested in Table 2 and Table 3. The intention is for the large format porcelain tiles or panels, to provide resistance to all of the impacts shown for the relevant category. Some large format porcelain tiles and panels may have a lower resistance than those values indicated in Table 2 if they are easily replaceable.

Table 1 — Categories associated with impacts on surfaces of the vertical enclosure to buildings

Category	Description	Examples	
A	Readily accessible to public and others with little incentive to exercise care. Prone to vandalism and abnormally rough use.	External wall of housing and public buildings in vandal prone areas	Zone of wall up to 1,5 m above pedestrian level
B	Readily accessible to public and others with little incentive to exercise care. Chance of accident occurring and of misuse.	Walls adjacent to pedestrian thoroughfares on playing fields when not in category A	
C	Accessible primarily to those with some incentive to exercise care. Some chance of accident occurring and of misuse.	Walls adjacent to private open gardens, back walls of balconies	
D	Only accessible, but not near a common route, to those with high incentive to exercise care. Small chance of accident occurring and of misuse.	Walls adjacent to small fenced decorative garden with no through paths	
E	Above zone of normal impacts from people but liable to impacts from thrown or kicked objects.	1,5 m to 6 m above pedestrian or floor level at location categories A and B	
F	Above zone of normal impacts from people and not liable to impacts from thrown or kicked objects.	Wall surfaces at higher position than those defined by category E	

Table 2 — Test impacts

Wall category (See Table 1)	Test impact energy for impactor shown		
	H1 [Nm]	**H2** [Nm]	**S1** [Nm]
A	[a]		
B		10	120
C	6		120
D	[b]		
E	6		
F	3		

[a] No test impact values are given for category A walls. In each case the type and severity of vandalism needs to be carefully assessed and appropriate impact values determined.

[b] With category D walls the risk of impact is minimal and impact test values are therefore not appropriate.

If large format porcelain tiles or panels become damaged when subject to impacts in Table 2, but remain attached to their mesh reinforcement/backing and to the supporting structure and no fragments that are of a size that may cause serious damage or injury fall from the supporting structure (see 12.6) and the large format porcelain tiles or panels are easily replaceable, the test result may be recorded as – failure (aesthetic only).

The results of tests should be defined as follows:

— failure;

— failure (aesthetic only);

— no damage.

Where the damage is a chipped edge or corner, this should be quantified although the criterion for failure may be an aesthetic one only. The size of a chipped corner or edge which is acceptable visually depends on the characteristics of the material, its finish and location.

Table 3 — Test impacts to ensure safety to persons

Wall category (see Table 1)	Test impact energy for impactor shown	
	H2 [Nm]	**S1** [Nm]
A	[a]	
B and C external and indoor surface	10	500
D	[b]	
E external and indoor surface	10	
E and F external surface if access is required for regular cleaning and maintenance		350

[a] No test impact values are given for category A walls. In each case the type and severity of vandalism needs to be carefully assessed and appropriate impact values determined.

[b] With category D walls the risk of impact is minimal and impact test values are therefore not appropriate.

12.4 Hard body impact testing

12.4.1 General

The test procedure described below is based on ISO 7892.

12.4.2 Equipment

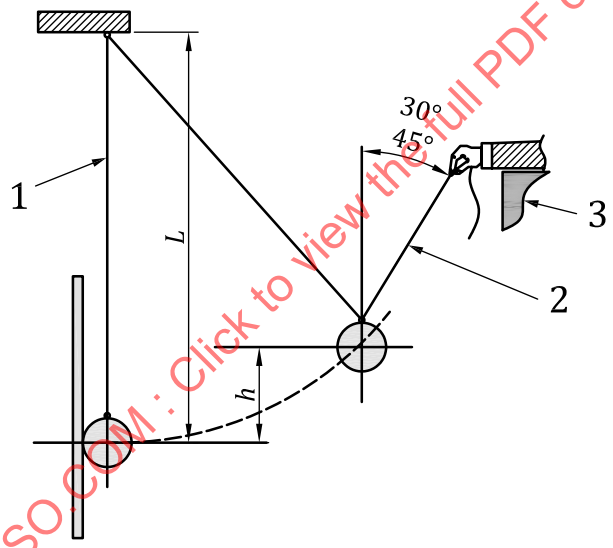
Hard body tests are carried out with a steel ball of 50 mm diameter with an approximate mass of 0,5 kg or 62,5 mm diameter with an approximate mass of 1 kg. The ball is suspended from a cord at least 3 m long. An eyebolt may be used to provide a connection between the steel ball and the suspension cord. The mass of the impactor shall be taken as the total mass of the ball and any connection rigidly fixed to it.

12.4.3 Procedure

The ball is placed at the impact point in such a way that, when it is suspended from the cord, it just touches the surface of the panel. The ball shall then be drawn away from the panel surface such that the maximum angle to the vertical subtended by the movement of the rope shall be not greater than 65°. The ball shall be raised to the required height of drop *h* measured vertically from the impact point. The ball is then released and allowed to swing freely in an arc onto the face of the panel.

Three standard levels of impact energy are 3 J, 6 J and 10 J. 3 J and 6 J impacts are carried out with the 50 mm diameter impactor and 10 J impacts are carried out with the 62,5 mm diameter impactor. The drop height should be calculated based on the actual mass of the impactor including any hooks rigidly attached to it to allow connection to the suspension cord (See Figure 7).

Hard body impact testing should be carried out at an appropriately accredited testing facility.



Key

1 cable
2 rope
3 support
L length
h drop height

Figure 7 — Example of test apparatus using a small hard impact body

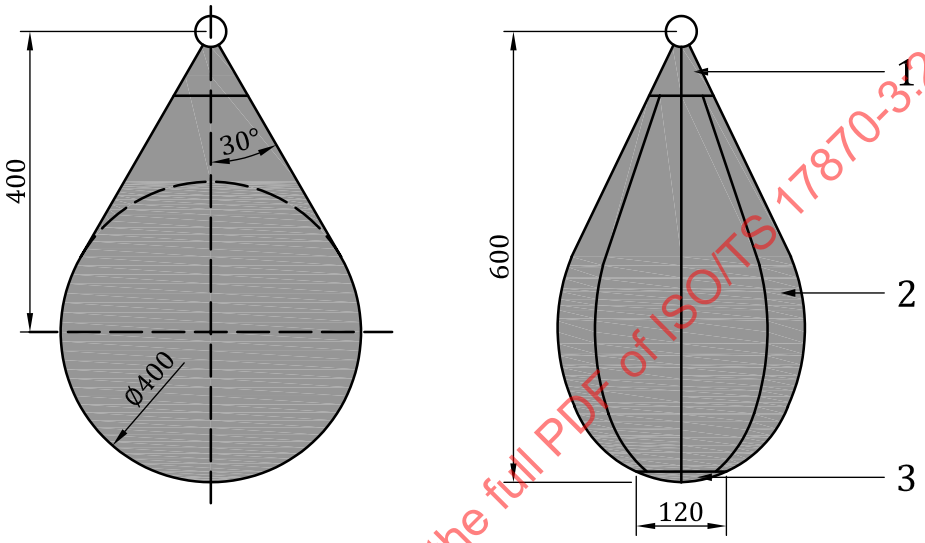
12.5 Soft body impact testing

12.5.1 General

The test procedure described below is based on ISO 7892.

12.5.2 Equipment

The equipment is shown in Figures 8 and 9. The impactor is a coarse canvas bag containing a thin polyethylene bag of the same size which, when filled with hardened solid glass spheres each having a diameter of (3 ± 0,5) mm shall have a mass m of (50 ± 02) kg. The dimensions of the bag when filled are those of a volume composed of a sphere of 400 mm diameter inscribed in a cone, the top of which is located at a distance of 400 mm from the centre of the sphere. The bottom of the bag is strengthened by a circular piece of leather of 120 mm diameter sewn into it. The top of the bag is slightly truncated in order to make an opening of 80 mm diameter. This opening is strengthened by a leather strip sewn onto the bag, to which are fixed four equidistant rings held together by a suspension ring.

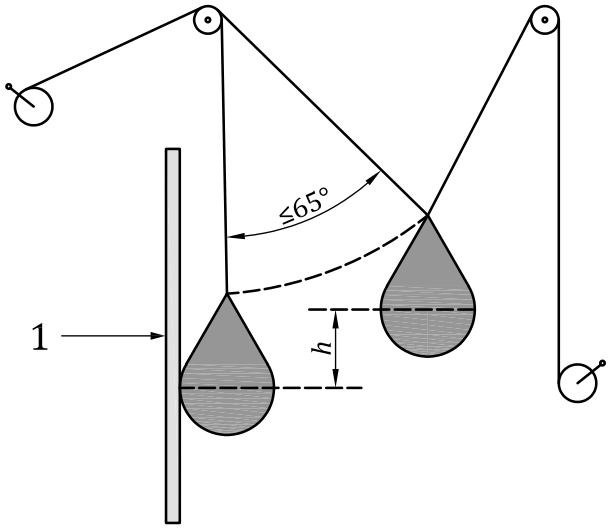


Key

1 leather straps
2 eight sections
3 leather bottom

Figure 8 — Spheroconical bag

The bag is suspended by a rope at least 3 m long in such a way that, while vertically at rest, the bag is just touching the panel surface at the point of impact. The suspension point needs to be moveable to allow tests to be carried out at different locations on the sample.



Key

1 specimen

h drop height

Figure 9 — Soft body test arrangement

Devices are required for:

— hoisting the impactor to give the required drop height; and

— instantaneously releasing the bag.

To ensure that the drop height can be consistently maintained a mechanical means of holding the impactor before release is required. The method of holding the impactor immediately before release should be such that the centre of gravity of the bag is vertically below its connection to the suspension rope and with the suspension rope taut.

12.5.3 Procedure

Before an impact load is applied, the bag shall be rolled to loosen the spheres. The bag is placed at the impact point in such a way that, when it is suspended from the rope, it just touches the surface of the panel. The bag shall then be drawn away from the panel surface such that the maximum angle to the vertical subtended by the movement of the rope shall be not greater than 65°.

The bag shall be raised to the prescribed height of drop, h, measured vertically from the impact point. The bag is then released and allowed to swing freely in an arc onto the face of the panel.

Three standard levels of impact energy are 120 J, 350 J and 500 J which require the following drop heights (see Table 4).

Table 4 — Impact energy and drop height

Impact energy [J]	**Drop height** [mm]
120	245
350	715
500	1 020

The effect of the impact shall be described.

Soft body impact testing should be carried out at a testing facility meeting the requirements of ISO/IEC17025.

12.6 Mesh backing

Whilst having exceptional surface hardness, some large format porcelain tiles and panels may, depending upon their thickness, prove to be rather brittle when subjected to heavy impact. Therefore, the façade designer should consider specifying an appropriate mesh, e.g. fibre glass or other adequate protective layer is sometimes bonded to the backs of large format porcelain tiles and panels so that in the event of impact damage/fracturing, the tiles or panels should remain largely intact and in position until replacement which should be carried out without delay.

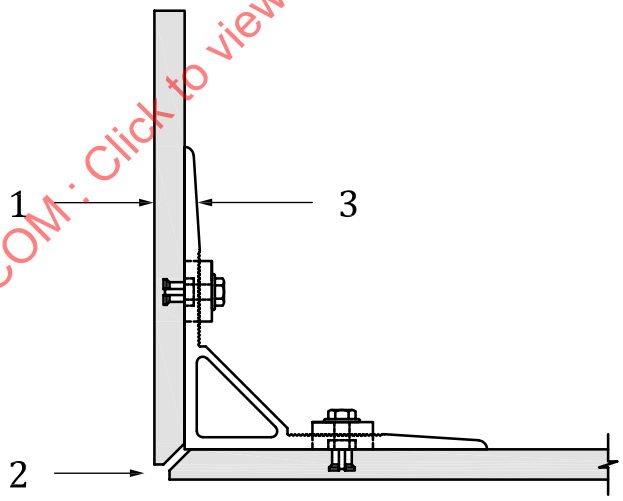
NOTE Some façade installation systems allow large format porcelain tiles or panels to be removed and replaced without damage or interference with surrounding adjacent tiles or panels.

13 External corners and edge treatment

Some large format porcelain tiles or panels are through-body coloured, therefore exposed edges at external corners are usually aesthetically acceptable. Edges can also be mechanically polished, if necessary, to match the polished face surface of the porcelain tiles or panels.

Any reinforcement mesh applied to the back of the large format porcelain tiles or panels should be appropriately dressed back from their edges for use at lapped external corners or where aesthetically appropriate.

When large format porcelain tiles or panels are colour decorated on their face surface only, the edges of the porcelain may be a noticeably different colour. In these circumstances, it may be necessary to mitre the edges of the porcelain tiles or panels, to form external corners (see Figure 10).



Key

1 return panel

2 6 mm birds mouth mitre

3 prefabricated with a special bracket (if required)

Figure 10 — Birds mouth mitre detail

14 Thermal moisture and structural movement

14.1 General

All components forming the exterior walling are subject to movement owing to the action of heat, moisture, imposed loading or vibration. Some of these movements, such as those resulting from temperature changes or sudden imposed loading (e.g. by wind) may reach their maximum in minutes. Others, such as settlement or creep in concrete, may take years to reach their maximum. Some movements may be cyclic in that there is continuous oscillating movement between maximum and minimum, while others may be a steadily progressive increase or decrease.

14.2 Movement

14.2.1 General

Failure to provide for movement leads to stressing of components and this may produce one or more of the following results.

a) The component will fracture.

b) The component will remain stressed and therefore be unable to accept the normal design load it would otherwise withstand. For example, a component may become over-stressed owing to thermal movement and fail under wind load.

To prevent such failures, the large format porcelain tiles or panels façade system and supporting subframe should be designed so that components can move relative to their fixings and so that space is available at joints to take up movement.

The recommended minimum width of joints, other than movement joints, between large format porcelain tiles is 6 mm.

Joints between porcelain panels may need to be wider than 6 mm, as specified by the façade designer.

Additionally, suitably wide movement joints in large format porcelain tiles or panels should be specified by the façade designer to coincide with movement joints in the façade's supporting subframe and the background structure.

14.2.2 Thermal movement

The temperatures causing movement of components is related to, but not the same as, air temperature. The maximum design surface temperature depends on the exposed material and its colour. The maximum variation of surface temperature is generally not less than 65 °C or more than 110 °C in countries with moderate climates, for example, countries in northern Europe, but wider variations should be anticipated for countries where greater extremes of temperature are to be expected.

The amount of movement calculated using extreme surface temperatures is the difference between extreme sizes of the component and does not represent the change of size from installed position, as installation will usually take place at a temperature between the extremes. The amount of thermal movement to be accommodated should, therefore, be calculated in two parts, a positive movement between installed temperature and highest surface temperature and a negative movement between installed temperature and lowest surface temperature. There may also be movement between similar materials if the mass of each varies to any extent.

Where large format porcelain tiles or panels façade systems include metallic vertical or horizontal support rails, the rails should not be longer than 6 m per rail and there should be a minimum 8 mm wide gap between each rail.

Where movement joints are to be installed, the project architect/designer should specify the width of the movement joint and its design.

14.2.3 Moisture movement of a masonry structure to which a façade supporting metal framework is to be attached

Two types of moisture movements should be considered:

a) the initial change in dimension that occurs when the moisture content of the component adjusts to become in equilibrium with its climatic conditions in use; and

b) reversible movement due to fluctuating moisture content in use.

Moisture movement of the structural shell of the building to which the primary support brackets and façade framework are attached, can adversely affect the stability of the façade system, if it is not taken into consideration by the façade designer.

In concrete structures, especially those cast in situ, the drying shrinkage of the structure is likely to have the most serious effect on the façade especially if this is accompanied by thermal or moisture expansion of the façade components. In particular, it should be noted that clay brickwork has a long-term irreversible moisture expansion and special care should be taken when these two materials are combined. The attachment or building-in of walling to concrete structures should be delayed as long as possible to allow as much drying shrinkage as possible to take place.

14.2.4 Permeability to water

The overall performance of the large format porcelain tiles or panels should not be adversely affected by water vapour which is allowed to penetrate to the interior of the façade or by condensation resulting from the presence of vapour. If water vapour or condensate is allowed into the interior of the façade, the components should be so designed as to allow it to disperse harmlessly.

Materials most seriously at risk due to build-up of moisture vapour within the fabric of the façade are thermal-insulating materials, which are usually not only able to absorb water but whose performance is thereby, seriously affected. This may result in a decrease of internal surface temperature and the consequent surface condensation which, in turn, may cause damage.

The method of avoiding damage due to water vapour may vary from excluding vapour entirely from the wall to allowing it to escape through the external surface.

15 Durability and design life

15.1 General

The durability and design life of large format tiles or panels, when used for façades, should be related to, but not necessarily the same as, the design life of the completed building.

The façade may be independent of structure and it may be possible, therefore, to replace the whole or part during the life of the building. The designer should, nevertheless, assess as precisely as possible the required minimum life of the large format porcelain tiles or panels façade as a whole (with maintenance considered), during which period it should, subject to routine maintenance, repair and replacement, meet the criteria given in this section. This information should be made known to the building owner in order that the façade is properly maintained.

Some large format porcelain tiles or panels installation systems allow large format porcelain tiles or panels to be removed in order to facilitate inspection of services and to be replaced without damaging or interfering with surrounding adjacent tiles or panels.

15.2 Durability

All fixing components should be able to retain their properties with little or no maintenance and should, therefore, possess a high degree of resistance to corrosion.