TECHNICAL BULLETIN

MECHANICAL FIXING OF STACK STONE AND OTHER CLADDING TILES TO WALL SUBSTRATES

INTRODUCTION & SCOPE

The Technical Bulletin DTB001 "Installation of Large Format and Heavy Stone Tiles" discusses the concerns associated with fixing heavy cladding tiles to wall substrates using adhesives only. The main issue is the capability of the wall substrate to support the weight of the tile finish and any associated applied surface preparation material (e.g. cement render). A table showing the maximum weight carrying capacity of various wall substrates was included in Technical Bulletin DTB001 and recommends additional mechanical fixing devices be used where these limits are exceeded and/or where the tiles are to be installed 3 metre (or higher) above ground level.

This bulletin provides some guidelines regarding the suitability of substrates to accept mechanical fixing devices and a mechanical support system is discussed.

TILE FINISHES

The types of cladding finishes being applied to wall surfaces internally include ceramic and natural stone tiles in square and rectangular shapes. The majority of these tiles are uniform in thickness and may have weight per square metre less than the maximum given in DTB001. However, the popular stack stone tiles, which are composed of narrow rectangular pieces of natural stone held together by a resin based (e.g. epoxy) adhesive, may have considerable variations in thickness. These stack stones use the variations in thickness as part of the attractiveness of the completed installation, and frequently weigh in the order of 50 to 80kg per m^2. The most common stack stone nominal sizes are 600 x 150 x (25)mm and 400 x 100 x (20) mm and unlike ceramic tiles, they are usually installed with butt joints, i.e., no grout is used between the tiles. In addition, excess resin binder (usually an epoxy) may prevent the tile adhesive from achieving full contact with the stone pieces leading to weaker than normal bond strength when adhesive fixed to the wall substrate.

WALL SUBSTRATES

There is considerable variety in the nature of the substrates to which these cladding tiles are fixed. Substrates include concrete, concrete block, brick and fibre cement sheeting and even with these substrates, there can be issues when fixing external cladding systems.

Concrete

Concrete walls may be of cast construction (off-form) or tilt panel construction. These may have the residues of mould release agents remaining in the surface in addition to laitance and/or efflorescence deposits that will impair the adhesive fixing of the cladding tiles. Off-form concrete may also have an uneven surface where the formwork has not been fixed correctly and rendering may be required to achieve a flat surface suitable for the fixing of the tiles. Surface preparation such as grinding, abrasive blasting or high pressure water blasting may be required to achieve an open pored textured substrate suitable for adhesive fixing of the cladding tiles.

Concrete block and brick

Concrete block and brick should be rendered prior to the adhesive fixing of cladding tiles in accordance with the recommendations of AS3958. In addition, the concrete block should be reinforced and core filled, particularly when mechanical fixing is to be used in conjunction with the tile adhesives. This recommendation is to ensure that all fixing bolts are able to grip to solid concrete and not just the thin block wall. This applies to rendered brick walls also, as too heavy a loading (or too shallow fixing into the block/brick), may cause localised failure of the block/brick and lead to tiles falling. Some manufacturers supply masonry anchors for block-work, but these have limited load carrying capacity and so core filling is the preferred method.

Fibre Cement Sheeting

Fibre cement sheeting includes the compressed sheeting and the standard wall sheeting that may, or may not have been primed at the factory prior to sale. The standard (uncompressed) fibre cement sheeting is mostly used on internal walls (except specific external products) and it is fixed to a variety of framing systems such as timber or metal. We recommend that the fibre cement sheet manufacturer be consulted regarding each installation to ensure the frame spacing, sheet type, sheet thickness and fasteners are appropriate for the job. For example, DTB001 notes that the weight carrying capacity of 6mm fibre cement wallboard sheet fixed at 200mm centres is only 20 kg/m^2 compared to 32 kg/m^2 for sheet fixed at 100mm centres.

We note that the James Hardies Villaboard Lining Installation Guidel (Jan. 2012) page 17, table 9, has listed maximum tile thicknesses for different thicknesses of Villaboard sheeting fixed at two different stud intervals (600mm & 450mm centres). Tile thickness (together with density) is a guide to the weight per square metre regardless of the individual tile size. Support angles are recommended and a maximum height limit to the tiling of 3 metres.

DUNLOP will not offer recommendations for adhesive fixing tiles in disagreement with sheet suppliers published practices, and so no adhesive recommendation is offered for non-compliant sheets (e.g. Harditex, Exotec). At the time of writing in 2016 the only fibre-cement sheets intended to take external tiles are BGC Inova

Stonesheet and James Hardie 'Easy Lap'.

Crucial to the carrying capacity, is the framing that supports the fibre cement sheet wall linings as the mechanical fixing devices must be fixed (screwed or bolted) through the sheet lining into the framing. Fixing to the sheet lining is unacceptable as the fixing screws/ bolts may simply pull due to the weight of the tile finish. The framing must therefore be strong enough to support the weight of the sheet lining and the tile finish. Lightweight metal framing may not be suitable when heavy and large tiles are to be installed, and conversely, fibre-cement sheeting is not recommended for direct fastening to heavy steel sections designed to carry loads.

MECHANICAL FIXING

Mechanical fixing systems commonly used for thick stone panels are considered unsuitable for these thinner types of cladding tiles. This is because these fixing systems are frequently designed to be concealed and the stone panels are usually sufficiently thick to be strong enough to not break around the fixing device.

Consideration of the thinner cladding tiles has led to the use of metal angles that are fixed horizontally across the face of the wall and at regular intervals up the wall. It is recommended these angles are made from stainless (304 or 316 grade) steel thick enough (2mm minimum) to support the weight of the stack stone tiles without distorting. Unprotected aluminium angles are not recommended as the aluminium may react with the cement in the tile adhesives and deteriorate over time. The angles are to be mechanically fixed into the wall substrate using suitable screws or bolts at frequent intervals. Care must be taken to ensure the fixing screws/ bolts are into the framework of sheeted walls and that the heads of the screws/bolts do not protrude to such an extent as to prevent the tiles from being correctly set in position.

Examples of suitable masonry anchoring bolts are provided in specification manuals such as provided by Powers Fasteners or Ramset. The anchors best suited for use with the stone cladding support angles are the drilled-in types and are available in a range of sizes for fixing into holes from 10mm to 32mm diameter. As a guide, the hole should be drilled to 125% of the anchor length and set at intervals corresponding to 10 times the anchor diameter for maximum load capacity. Refer to manufacturer's literature for full details.

Where the construction is framed, the interval between anchor locations will be decided by the framing locations which can alter the actual load capacity of the tile supports.

These anchors are available with corrosion resistant coatings as well as being made from stainless steel. Anchors are available with Hex heads, countersunk heads, and mushroom heads. It is important that the size of the anchor head is large enough not to pull through the metal angle under load, a large washer may be required under the anchor head to prevent this happening. The clamping (toggle) type anchors are not recommend for use when fixing the stack stone cladding as the substrates such as hollow masonry block or fibre cement sheeting, for which these types of anchor are suited, are not suitable for the heavy stack stone cladding tiles. Fixing the support angles to these substrates may result in the anchor pulling through the substrate and we recommend hollow masonry block or brick be core filled prior to fixing the stack stone cladding tiles.

The vertical spacing of the angle will be influenced by the size and weight of the cladding tiles. Heavier, larger stack stone pieces will have the angles at closer intervals than lighter pieces. For example, stack stone weighing approximately 65 kg/m^2 may have the angles placed at every third row first, and then at every second row above two metres above ground level. Lighter, smaller tiles weighing only 35 kg/m^2 may have the angles at every fifth row first and then at every third or fourth above two metres.

The angle should be of sufficient width to support a minimum of three-quarters of the tile thickness (measured on the thickest stack stone) so that the metal edge is not showing in the tile finish. We noted previously that the stack stone tiles are normally fixed with no grout joints between the pieces. To install these stones, a rebate may need to be cut into the edge of tile to allow the tile to sit on the angle without the metal showing, otherwise the angle edge may be covered with a suitable flexible sealant used to fill the gap between the upper and lower rows of stack stone.

Installation of the stack stone tiles onto overhanging wall substrates with no supporting base to the stone cladding, is generally not recommended. In this application the total weight of the stone cladding will be upon the wall. Framed wall construction may not be strong enough to support this loading and we recommend suitably qualified engineers be consulted prior to proceeding with this installation.

The stack stone cladding may use a variety of stone types, which have variable strengths and weather-ability, and these points need to be taken into consideration as well as mechanical load issues.

DUNLOP recommends that appropriately qualified and certified engineers determine the suitability of the subwall for tiling, the most appropriate metal angle supporting system including dimensions and materials of construction, and the anchor type, locations and centres. It is particularly important that engineering and design issues are resolved where it is intended to fix these stones to high walls.

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TILE ADHESIVES

Tile adhesives recommended for fixing the stack stone to the prepared substrates are generally the polymer fortified, C2 cement based types (DUNLOP UNIVERSAL & DUNLOP TILE ALL) or R1 reaction resin epoxies. These have high bond strength with high resistance to all climatic conditions, including high temperatures and moisture penetration. Substrate preparation includes ensuring the surfaces are dry and free of all contaminants such as concrete curing agents, formwork release agents, paint over-spray, excess laitance and/or efflorescence, waxy or oily residues and loose particles. Porous substrates such as cement renders and fibre cement sheeting, should always be primed with a compatible primer (e.g. DUNLOP MULTIPURPOSE PRIMER for DUNLOP cement based adhesives) and allowed to dry prior to adhesive fixing the stack stone.

Where greater performance is required the recommended adhesives are the R class epoxy construction types adhesives.

For recommendations regarding specific adhesives, please consult DUNLOP's technical advice hotline. The range of DUNLOP adhesives for this application is limited and so the inquiry may result in an ARDEX recommendation instead.

ENVIRONMENTAL ISSUES

This engineering process must also include considerations regarding the effects of seismic activity, wind loading and weathering on the stack stone wall finishes.

Where an installation is subject to seismic forces, the high ground accelerations create significant loads on the cladding (commonly exceeding their design capabilities) which may result in the cladding de-bonding or tiles breaking free. Areas known to show seismic activity with recorded damaging earthquakes include:

NSW – Newcastle and the Southern Highlands around Canberra-Gunning,

Tasmania – North Eastern areas, the Bass Straight Islands and areas in the central-west,

SA – Adelaide city and the Adelaide Hills,

WA – East of Perth centred on Meckering/Calingiri and also the Kimberley-Pilbara regions.

Areas in the north-west of WA and NT can receive seismic effects from strong southern Indonesian earthquakes. Outside Australia, most of New-Zealand can be subject to strong seismic activity.

Large areas of the Australia coastal zone, and especially north from Brisbane round the top of Australia to north of Perth are subject to cyclones and thus have strict wind load codes applied to construction. Where large areas of these heavy stone claddings are installed, this will increase the dead load on the construction, change the air flow characteristics, and may alter the wind load capacity of the wall.

External walls, especially east-north-west facing walls in Australia are subject to strong weathering due to heat and rain exposure. The thermal changes during a day, and particularly in summer, can created differential stress and strains between the cladding and the substrate, and these need to be allowed for in the construction. Heavy tiles without mechanical fixing, are more likely to be subject to movement related bonding issues. Cladding made from inferior grades of dimension stone can also suffer from premature ageing and failure of the stone itself due to weathering. Rock types that are suspect include schists and mudstone-argillites.

DESIGN CONSIDERATIONS

We have encountered numerous situations where the wall design aesthetics have not taken into account the mechanical and technical properties of the system or the construction. In this situation, it may be necessary to re-design the cladding system to be appropriate for the type of tile that has been selected.

Another point which needs consideration is what water proofing is required for the light weight cladding systems to prevent moisture penetrating the sheet joints.

The following schematic diagrams give some guidance with relation to mechanical fixing.

They are not design diagrams and are not intended to be used engineering purposes.

All engineering and design drawings must be professionally drafted.

Notes

Always refer to the product data sheets for specific usage details.

The information contained herein is to the best of our knowledge true and accurate.

No warranty is implied or given as to its completeness or accuracy in describing the performance or suitability of the product application.

Users are asked to check that the literature in their possession is the latest issue.

ARDEX AUSTRALIA PTY LTD,

ABN 82 000 550 005

7/20 Powers Road, Seven Hills, NSW. 2147.

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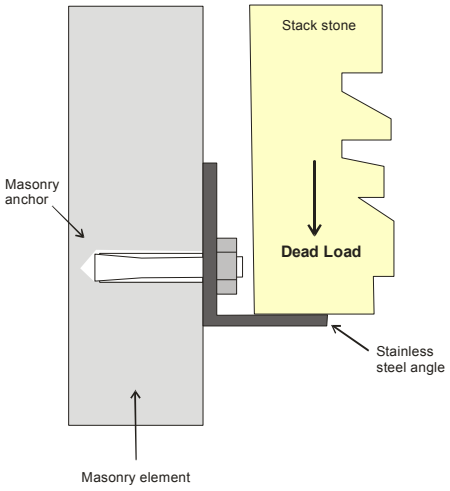
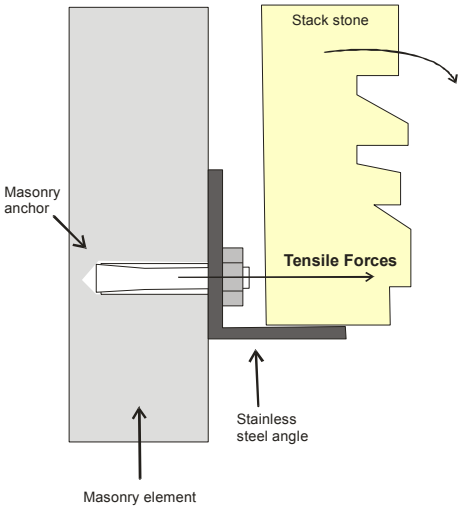


1a) Dead load from the cladding's weight.



1c) Tensile loads on the fastener (pull out load on the fastener). Well anchored fasteners can remove a cone shaped piece of the substrate which fails before the fastener pulls out.

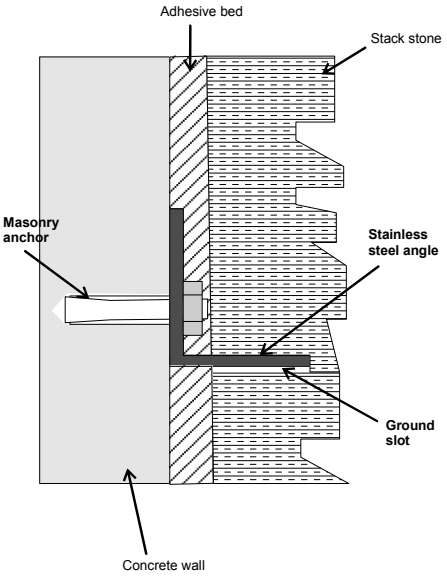
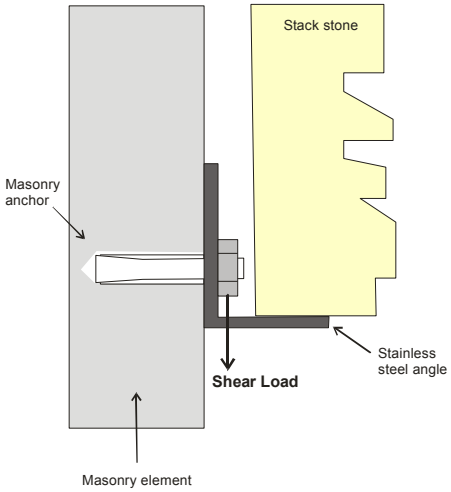
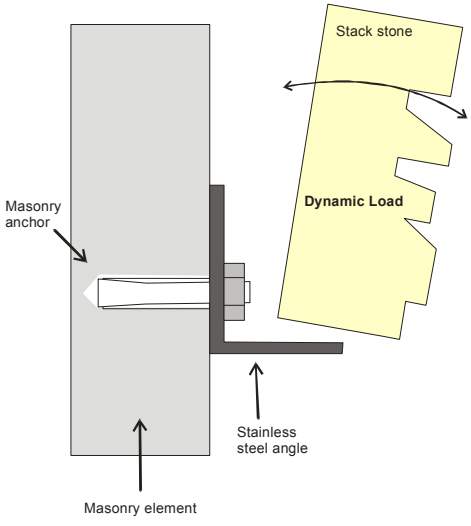


Diagram 2.
Suggested method of using L brackets and mechanical anchors for fixing to solid concrete walls.



1b) Shear load exerted on the fastener by the cladding. Fasteners with too low a load rating may bend or shear off.



1d) Dynamic loads created by movements in the cladding (i.e. seismic, wind loading, differential movement or simple impacts)

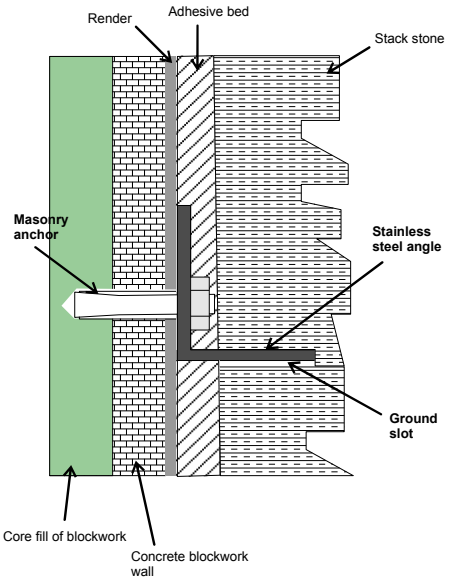


Diagram 3.
Suggested method of using L brackets and mechanical anchors for fixing to rendered filled block work and rendered brick walls.

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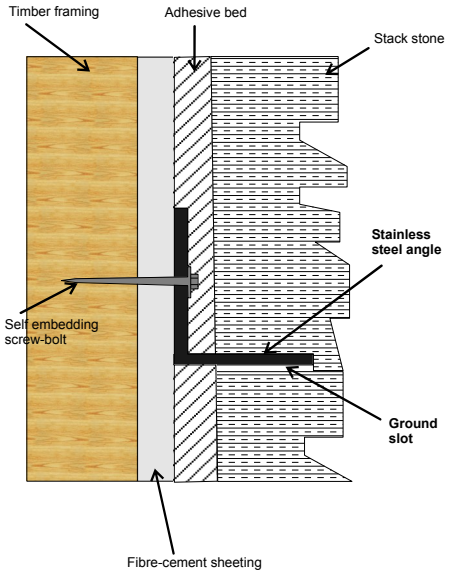


Diagram 4.
Suggested method of using L brackets and screws bolts for fixing to timber framed walls.

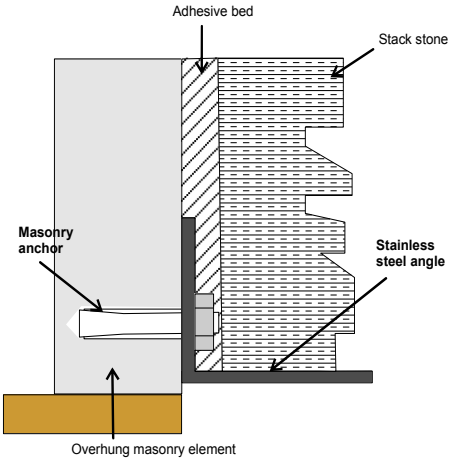


Diagram 5

Detail for bracketing at the base of a wall or overhung area. The bracket must extend past the maximum thickness of the cladding stone.

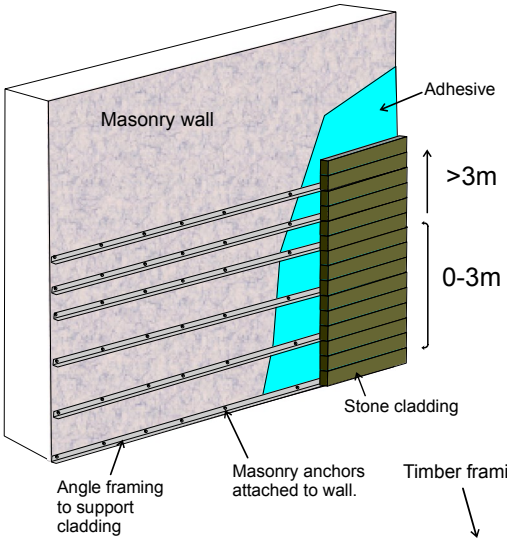
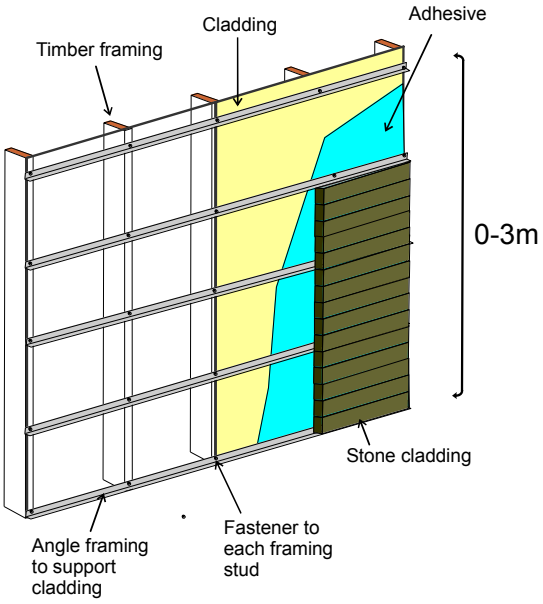


Diagram 6

Typical layout for mechanical fixing system on a masonry wall. In this example the closer bracket spacing is shown for the heavier weight range.

Diagram 7

Typical layout for mechanical fixing system on a timber framed internal wall. In this example the closer bracket spacing is shown for the lighter weight range.



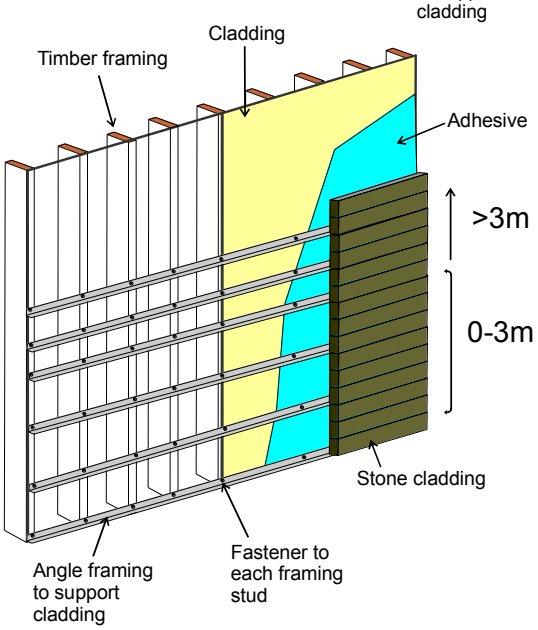


Diagram 8

Typical layout for mechanical fixing system on a timber framed internal wall. In this example the closer bracket spacing is shown for the heavier weight range.

References

-Ardex Australia – DUNLOP DTB001 Installation of Large Format and Heavy Stone Tiles

-Ardex Australia – DUNLOP DTB099 Differential Movement and Tiling Finishes

-ASTM C1242-05 Standard Guide for Selection and Installation of Dimension Stone Anchoring Systems.

-Power Fasteners 2012 – Specification guide. October 2011.
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http://www.powers.com.au/downloads/PDF_docs/Updated%202011%20Handbooks/Volume%20Eleven/Vol11_Brick_Facade_Stone_V3indd/fscommand/Vol11_Brick_Facade_Stone_V3_WEB.pdf

-Ramset Specifiers Resources Book-
http://www.ramset.com.au/Document/Resources/231/Search
(online PDF docs, requires login).

-Ramset undated – Anchoring principles. Mechanical anchoring. http://www.ramset.com.au/Document/Resources

GLOSSARY

C2 adhesive-Improved cement based adhesive. A definition from ISO13007 for cement based adhesives with tensile strengths exceeding 1.0MPa in all the relevant test conditions. Typically C2 adhesives are highgly polymer modified and can be powder/liquid combinations.

Core filled—Refers to hollow concrete blocks that have been filled with concrete down the hollows. Re-bar rod and cross bars are placed in the blocks before filling.

Dead load-Effectively the dead load is the weight of the tiles applied, but for the purposes of the structure load includes the adhesives and any brackets.

Exotec, Harditex, Villaboard are all forms of fibre-cement sheeting and registered tradenames of James Hardie Australia.

Seismic-A term relating to earthquake forces. Seismic zones are areas of known earthquake activity.

Stainless steel-A steel allow that contains chromium and nickel to provide chemical and corrosion resistance. Typical alloys are 304 (18% chromium / 8% nickel) and 316 “marine grade stainless’.

Live load– Also called dynamic load. The forces applied to the structure by factors such as wind, seismic activity, vibrations of other dynamic forces.

Mechanical brackets—There are a range of brackets, and other fixings that can be used as supports. L-shaped brackets are one type, but there are also specialised commercial brackets, pins and other slotted devices.

R Class adhesives– Normal resin reaction adhesives. These are two part polymer resins and nearly all based on epoxy. They have higher tensile strength than c class adhesives.

Stack stone-A type of stone cladding made by bonding together of thin stone strips with resin adhesives (usually epoxy). A panel is commonly 400-600mm long, 150mm wide and 10-30mm thick.

Wind loading-Forces exerted on a structure by the movement of air in a wind. The force is proportional to the speed / velocity of the wind.