External wall cladding systems

Scope

This commentary applies to the specification and appraisal of external cladding systems, including those of expanded polystyrene, for domestic housing in Australia. It should be read in the context of the Building Code of Australia, and may form the basis of Alternative Solutions.

Corrosion Resistance

Specifications should state the acceptable proximity to sources of corrosion, such as breaking surf and polluting industries. BCA Volume 2 Tables3.3.3.2 and 3.4.4.2 provide suitable alternative systems of designating the environment. Various Australian Standards, including AS 3600, AS 3700 and AS 4100, provide suitable alternative systems of designating environment.

Wind, loads and deflections

Specifications should state the permissible Wind Classifications, as defined in AS 4055. They should also state the permissible in-plane (racking) forces and out-of-plane pressures and suctions.

As a general rule, cladding systems are not designed to resist racking forces due to wind, earthquake, foundation movement or differential heating and cooling. In order to prevent rupture of cladding systems in these circumstances,

- The structure should incorporate adequate bracing (or the like), with sufficient stiffness to minimise deflections; and
- The fixing should be such that local failure occurs at the fixing before panel rupture occurs.

AS/NZS 1170.0 Table C1 provides guidance on deflection limits for various building components. In the absence of more specific criteria, the deflection of the supporting structures should be limited as follows:

Mid height out-of-plane deflection	Height/200
Mid height in-plane deflection	Height/300

The deflection limits, acceptable bracing and fixing details should be included in the specification.

Fixings

Specifications should state the requirements for fixings and washers, giving consideration to the wind pressures in AS 4055. Additional fixings to cater for local suction at the corners of building should be provided in accordance with AS 4055.

Washers must be flexible but strong enough not to crack – too flexible will allow them to pull though the cladding.

The capacity of fixings and washers to fix the cladding without pulling through, may be determined from published engineering data and known material properties, or by tests in accordance with AS/NZS 1170.0 Appendix B. (See Appendix).

Guidance on the suitability of fixings to hardwood, softwood and light gauge steel structural elements may be obtained from AS 1684 and AS/NZS 4600. For less common structural members, tests may be performed in accordance with AS/NZS 1170.0 Appendix B. (See Appendix)

Specifications should state the overall length, diameter and type of fixing, and the required structural support material and length of penetration.

Battens

Battens may be used to provide additional support and/or provide physical separation for movement and drainage between the cladding and structural wall frame. Battens must be rigid enough to properly support the cladding, and this may require lapping.

Specifications should state the batten dimensions, material, permissible span, fixings to the structure, drips (if required), location and laps (if required).

Moisture Control at Battens and Bottom of Wall

If horizontal battens are used, there should be provision for the removal of condensation and other moisture from the wall. Acceptable systems include the use of cladding with vertical ribs or striations; or spacers between the battens and cladding. Battens incorporating drips may be acceptable, depending on the detail.

There should be provision for the removal of moisture from the bottom of the wall. Acceptable systems include a combination of flashing and weepholes. Systems similar to those given in AS 4773.2 for masonry veneer are considered acceptable.

Joins

Panels should be joined in a way that reduces relative movement when they are subjected to structure movement or face loading (perhaps due to a person or object leaning against the panel). Some methods include tongue and groove, back blocking, mesh and adhesive. Materials should be alkali resistant. Meshes should be sufficiently coarse to enable render or adhesive to penetrate and fully bind the strands.

Specifications should state how cladding panels are to be joined. When renders, adhesives, and meshes are used, full specification of the components should be included.

Articulation and Control Joints

All houses deflect, and the cladding system should incorporate articulation joints and control joints to cater for building movements caused by reactive foundations (such as clay soils); and expansion or shrinkage in the cladding and supports. The method of determining Site Classifications (accounting for reactivity of foundation soils) is set out in AS 2870.

Specifications should state how often and where articulation joints and control joints should be placed. This is influenced by the type of building support (masonry, mega anchors, concrete slab, timber pole, structural steel etc.), and such limitations should be included. Specifications should state any limitations in respect of the Site Classifications of AS 2870. They should also state the coefficient of expansion of the cladding materials and the framing materials.

Specifications should provide joints details, including the width of gap, the tolerance on the gap width, the type of jointing material, the type of backer rod and the type of bond-breaker tape (if required).

Specifications should also provide typical details covering:

- Situations panels are fixed across wall frames and onto other framing systems, such as a trussed gable roof;
- Precautions to be taken in regard to shrinkage of a timber frame particularly over a two or more storey building;
- Horizontal control joints at the base and frame interface;

In the absence of material-specific test data or engineering analysis, the following specification (developed from AS 4773.2) is considered suitable for most cladding materials.

The position of expansion and/or contraction joints should limit differential movement to 5 mm. Articulation joints may also serve as expansion and/or contraction joints. Articulation joints shall be vertical, full-height of the cladding, and free of obstructions. Where articulation joints are required, they shall be provided at the following locations:

(a) In straight, continuous walls having no openings, at centres not more than the values given in the Table below.

(b) Where the height of the cladding changes abruptly by more than 20% of its lesser height, at the position of change in height.

(c) Where openings more than 900 × 900 mm occur, at not more than 5000 mm centres.

(d) Where cladding changes thickness.

(e) At control or construction joints in footings or slabs.

(f) Within 4500 mm of all corners.

SPACING OF ARTICULATION JOINTS FOR CLADDING			
Site Class	Maximum Articulation Joint Spacing, m		
	Up to 4 m high for 10 mm joints	4 m to 8.5 m high for 10 mm joints	4 m to 8.5 m high for 10 mm joints
A, S	Not required	Not required	Not required
M, M-D	6.0	4.2	6.0
H1, H1-D	5.5	3.9	5.5
H2, H2-D	5.0	3.5	5.0
Note Site class is defined in AS 2870. For Class P sites, joints spacing shall be determined by consideration of the specific site conditions.			

Ground Contact

In many locations, saline groundwater can damage some cladding systems. The groundwater may be drawn up the cladding and render by capillary action, and the salts may attack the materials, leading to deterioration or discolouration. Splash back of rain can also contribute.

Specifications should state any limitations in respect of contact with paving, ground or ground-water. In such circumstances, a damp-proof course (DPC) should be included.

Weather-proofing

In some circumstances, moisture may collect on the inside surface of the cladding. This may originate in:

- Temperature differentials, causing condensation to form;
- Residual moisture in the cladding material; or
- Rainwater penetration due to breakdown of control joints, penetrations and flashings or exposed parapets.

The effectiveness of weather-proofing measures depends on the flashings, degree of protection by eaves and other overhangs, exposure to wind driven rain, wind speeds, joint sealing, corner mouldings, drips on sill, resistance to ultraviolet radiation, and the ability to withstand shock from doors slamming.

Specifications should provide:

- Details of flashings and sealing around windows and doors, other claddings, balconies, plumbing and electrical penetrations;
- Details of weep holes;
- Details of corner mouldings;
- Details of sills, including drip moulds if required;

- Compatibility and flexibility of joint sealants;
- Compatibility and flexibility renders and coatings;
- Whether the materials are suitable for use with aluminium or timber framework, cladding and the textured finish;
- The limiting Wind Classification (as per AS 4055) and corresponding velocity;
- Whether measures are required to protect from of rain splashes and bounces behind laps and over flashings;
- Whether it is necessary for the cladding system to "breathe".
- Whether flexible fixings (or other measures) are required What is the long term effect of sliding doors, air conditioning units and other vibrations on seals – what system of isolation is used?

The weather resistance of most cladding systems can be assessed by careful consideration of the details and specifications. The following specification, based on AS 4773.2 for masonry veneer, is suitable for most claddings. For uncommon systems, a weather tightness test, developed by BRANZ (based on AS/NZS 4284) may be appropriate.

> ***Flashings and damp-proof course materials***
> *Flashings and damp-proof courses shall comply with the following:*
>
> *For non-exposed condition (within the structure and not exposed directly to the weather:*
>
> *a) Embossed/quilted polyethylene sheet of high impact resistance and low slip, with an average thickness prior to embossing of not less than 0.5 mm and not less than 0.75 mm after embossing*
>
> *(b) Polyethylene-coated aluminium with 0.3 mm min. base thickness (aluminium core thickness of not less than 0.1 mm coated with bitumen adhesive on both sides, enclosed in polyethylene film with a minimum thickness of 0.1 mm on both faces) and overall min. thickness of 0.5 mm prior to coating*
>
> *(c) Bitumen-coated aluminium with 0.3 mm min. base thickness and overall min. thickness of 0.56 mm after coating*
>
> *(d) Bitumen-coated copper with 0.15 mm min. base thickness and overall min. thickness of 0.41 mm after coating*
>
> *(e) Uncovered copper having a mass of not less than 2.8 kg/m2 and having a thickness of 0.5 mm*
>
> *(f) Galvanized zinc-coated steel with a thickness of not less than 0.6 mm*
>
> *(g) Uncovered annealed lead having a mass of not less than 10 kg/m^2 in lengths not exceeding 1.5 m or 1.5 m^2 in area*

For exposed condition (continuously open to the weather)

(a) Bitumen-coated aluminium with 0.55 mm min. base thickness and overall min. thickness of 0.81 mm after coating

(b) Bitumen-coated copper with 0.15 mm min. base thickness and overall min. thickness of 0.41 mm after coating

(c) Uncovered copper having a mass of not less than 2.8 kg/m^2 and having a thickness of 0.5 mm

(d) Galvanized zinc-coated steel with a thickness of not less than 0.6 mm

(e) Uncovered annealed lead having a mass of not less than 20 kg/m2 in lengths not exceeding 1.5 m or 1.5 m^2 in area

For areas with saline ground salt

(a) Embossed/quilted polyethylene sheet of high impact resistance and low slip, with an average thickness prior to embossing of not less than 0.5 mm and not less than 0.75 mm after embossing

(b) Polyethylene-coated aluminium with 0.3 mm min. base thickness (aluminium core thickness of not less than 0.1 mm coated with bitumen adhesive on both sides, enclosed in polyethylene film with a minimum thickness of 0.1 mm on both faces) and overall min. thickness of 0.5 mm prior to coating

(c) Bitumen-coated aluminium with 0.55 mm min. base thickness and overall min. thickness of 0.81 mm after coating

For Class A or S sites with sandy or limestone free draining soils

(a) Proprietary polymer emulsion DPC parged to the slab

When flashings are expected to hold a particular shape, a rigid flashing material shall be used. To avoid galvanic corrosion, metal flashings shall be compatible with other metals with which they are in contact or spill water onto, or from which they receive water. Lead flashings shall not be used on any roof that is part of a potable water catchment roof. The combination of lead with zinc aluminium alloy shall not be used. Flashing that extends through the cladding may also serve the purpose of DPCs.

Membrane damp-proof course shall consist of—

(a) a material that complies with AS/NZS 2904; or

(b) sheet metal termite shields in accordance with AS 3660.1 (with any penetrations sealed) continuous through the cladding.

Damp-proof-courses

Damp-proof-courses (DPCs) shall be installed where the cladding is in direct contact with the ground, pavement, concrete footing or a concrete slab-on-ground. If a DPC is required, it shall be—

(a) installed in the cladding, where required to form a continuous damp-proofing barrier around the building;

(b) of sufficient width to extend through the cladding; and

(c) visible at the face of the cladding, including after rendering or any other applied coatings.

The height of the DPC shall be not less than—

(i) 150 mm above the adjacent finished ground level;

(ii) 75 mm above the finished paved, concrete or landscaped areas that slope away from the wall; or

(iii) 50 mm above finished paved, concrete or landscaped areas that slope away from the wall and protected from the direct effect of the weather by a carport, veranda or the like.

DPCs may be stepped such that continuity is maintained where a change in floor or ground level occurs.

Where lap joints in a DPC occur, they shall not be less than—

(A) 150 mm in a straight run; and

(B) the width of the DPC at corners.

A flashing that extends through the entire width of the cladding may also be used as a DPC.

Where there is a slab on ground that is Class A or S in accordance with AS 2870 on a sandy or limestone soil, a proprietary polymer emulsion DPC may be used, in accordance with the manufacturer's instructions.

NOTE: In addition to the provisions of this Clause, termite management provisions in AS 3660.1 need to be considered when determining the appropriate DPC location.

Cavity flashings

Where it is supported on a concrete slab, cavity flashing shall be located at the base of the cavity and at all points where the cavity is interrupted by a structural element, an opening or the like.
A cavity flashing shall be—

(a) turned up a minimum of 150 mm at the inner frame;

(b) fixed to the inner frame at 600 mm maximum centres;

(c) lapped at joints in a straight run by a minimum of 150 mm;

(d) lapped at corners by the width of the leaf and cavity or fanned; and

(e) embedded not less than 25 mm into the outer leaf.

A cavity flashing that is also a DPC shall extend across the full width of the flashing. Flashing that protrudes past the face of the cladding shall be either cut off or turned down. Cavities shall be drained by weepholes at 1200 mm maximum centres.

Where cavity flashings are penetrated, the flashing shall be punched through or cut from the inside of the wall, and be fitted around the penetration and sealed.

In areas where termite management systems are required, all penetrations within the cavity shall be treated in accordance with AS 3660.1.

Workmanship

Specifications should clearly state the workmanship and construction requirements, including:

- The required level of skill of the applicator;
- Required training of the tradesperson in the technical specifications and their scope and limitations;
- How long has the cladding may be left prior to rendering, ginving consideration to water entrapment has occurred, surface oxidisation, deterioration and UV exposure (will depend on time of year);
- Compatibility of render to cladding;
- Residual chemicals, and the possible need for their removal (Cladding & beading may have residual films from the manufacturing process);
- Effectiveness of sprayed on applications;
- Render shrinkage, and the use mesh and render control joints to control it;
- Misalignment of sheets, affecting the thickness of render;
- Whether the render mixed on site or premixed, and the level of quality control;
- Whether over-screwing results in increased thickness of render at the washers and uneven stresses;
- Whether over-screwing on thin cladding sheets reduces the strength and performance of cladding;
- The best number of render coats - one thick coat is more prone to cracking – two or more coats may result in delaminating;
- Increased reinforcement at the corners of openings;
- The effect of temperature on the material being applied;

- The effect of dew, rain or frost on the cladding when render is being applied;
- Detailing around parapets, box gutters, windows etc, and the skills of the roof plumber in fitting effective flashing systems.
- Roof plumber's knowledge of the compatibility of sealant systems?

Polystyrene panels, accessories, sealants, renders and paints

Polystyrene is available in a variety of grades, each with different densities, strengths, moisture content and thermal resistance. AS 1366.3 includes specifications for various grades of expanded polystyrene and AS 1366.4 includes specifications for various grades of extruded polystyrene.

Flexible paint systems will bridge small cracks that may form in the panels and at the joints. Paint systems that "breathe" will reduce the tendency for condensation to form on the inside surface of the cladding. Textured paint systems may be more flexible, but also may hold dirt, containments and acids. Paint systems should be UV resistant, and prevent UV breakdown of the cladding system.

Specifications should state:

- The grade of polystyrene; including compliance with AS 1366.3 for expanded polystyrene and AS 1366.4 for extruded polystyrene;
- Whether the panels are to be pre-coated;
- Compatible adhesives;
- The ability has the material to resist insect, vermin and mould attack;
- Fire hazard properties.
- The following paint requirements:
    - Flexibility;
    - Porosity;
    - Texture;
    - UV resistance.

The following specification is considered suitable for most domestic residential applications (subject to compliance with the other points noted in this document, including supports, fixings and the like). Other specifications may be used, subject to verification.

Extruded Polystyrene (EPS) Board

Extruded Polystyrene (EPS) board shall be M Grade, fire retarded, vermin retarded, termite resistant, in accordance with AS 1366.3, with the following properties:

- *Thermal resistance at a mean temperature of 23^{o} of a 50 mm sample in accordance with AS/NZS 4859.1 not less than1.2 m^{2}.K/W.*

- *Compressive strength in accordance with AS 2498.3 Method 3 not less than 105 kPa.*
- *Cross breaking strength in accordance with AS 2498.4 Method 4 not less than 200 kPa.*
- *Water Vapour Transmission in accordance with AS 2498.5 Method 5 not more than 520 mg/m^2.*
- *Dimensional stability in accordance with AS 2498.6 Method 6 not more than 1%.*
- *Flame Propagation Surface Ignition of Vertically Oriented Specimens in accordance with AS 2122.1 Method 6*
- *Residue for 2 second Ignition Median Percent not less than 30%, Standard Deviation not less than 27%,*
- *Flame duration 5 second Median Percent not more than 2 seconds, Standard Deviation not more than 3 seconds.*

PVC Beading and Mouldings
PVC Beading and Mouldings shall be polyvinyl chloride virgin material, mesh reinforced, UV stabilised, marine grade extruded to the specified shapes.

Screws
Screws shall be self-drilling steel, teflon-coated, counter-sunk ribbed head with coarse thread, Class 3 - Sizes STS55 & MS 65 (10-8 x 65 for 40 mm board), TS90 & MS100 (10-8 x 100 for 75 mm board), TS125 & MS125 (10-8 x 125 for 100 mm board).
The system (as detailed herein) is suitable for use up to 1 km of breaking surf. For applications closer to breaking surf than 1 km, Grade 304 or 316 stainless steel screws shall be used.

Washers
Washers shall be minimum 40 mm diameter, PVC.

Fibreglass Mesh
Factory-installed fibreglass - 5 x 5 mm mesh, 130 g/m^2 mesh, shall be alkali resistant
Site-installed fibreglass - 5 x 5 mm mesh, 160 g/m^2 mesh, shall be alkali resistant

Construction Adhesive
Construction adhesive shall be:
- *Synthetic rubber-based thixotropic gunable heavy paste, of*
- *Viscosity approximately 110,000 cps at 25^{o}C, Low odour,*
- *Colour beige (unless specified otherwise),*
- *Solids content 77% +,- 5%,*
- *Specific gravity 1.16 +,- 0.05 ,*
- *Flammability flashpoint approximately -20^{o}C,*
- *Service temperature -30^{o}C to +80^{o}C, with*
- *High green strength,*

- *High initial grab,*
- *High flexibility,*
- *Temperature resistant,*
- *Slump resistant,*
- *Water resistant,*
- *Styrene safe,*
- *Working time 5 to 10 minutes depending on temperature,*
- *Open time 20 to 30 minutes depending on temperature,*
- *Maximum bond achieved within 12 to 72 hours depending on temperature and thickness.*

Sealant
Sealant shall be an acrylic based texture coating suitable for external application over cement rendered surfaces.

Render
Render shall be pre-blended polymer modified cement render, suitable for mixing with mortar immediately before use to provide a smooth trowelable paste.

Membrane Coating
Coating shall consist of an acrylic sand based membrane product.

Joint Material
Backing rod for control joints, expansion joints and articulation joints shall be expanded polystyrene tube or bead. Joint sealant shall be gun grade multi-purpose polyurethane sealant.

Steel Brackets
Steel brackets shall consist of steel fabricated in accordance with AS 4100 and shall be galvanized in accordance with the following specification. All painting and galvanising shall comply with AS/NZS 2312. For surface preparation, refer to AS 1627.4 and AS 1627.5. When galvanising is specified, it shall consist of hot dip galvanising to AS 4680 to a minimum of 300 g/m^2.

Notes

1. The total thermal resistance, R, of thermal wall systems comprising insulation board, fixings and high-build multi-layered weatherproof coating shall be not less than the following.

- *The value specified in the Building Regulations for the particular application. Where total thermal resistance is specified, an allowance shall be made for internal air film of 0.12, external air film of 0.03, and appropriate values for render, plasterboard, reflective or non-reflective cavities and other wall components, if incorporated into the construction.*
- *Any value specified for purposes of enhanced comfort or energy saving.*

2. *The stated thermal resistances are the minimum values for compliance with AS 1366.3 Class M expanded polystyrene.*

Thickness of Expanded Polystyrene, mm	*Thermal Resistance R m^2K/W*
40	*0.96*
75	*1.80*
100	*2.40*

3. *These values may be used, in conjunction with the thermal properties of other components, to satisfy:*

    - *Performance requirement BCA Volume 2 P2.6.1 using verification method V2.6.2.2.*
    - *Deemed-to-Satisfy provision BCA Volume 2 3.12.1.4, using Table 3.12.1.3.*

Acknowledgement

This paper draws, in part, on work developed by Peter Nassau, Consultant Regulatory Development, Building Commission, Victoria (October 2010), which, in turn, is based on a paper by: Mick Galloway, *GRIFFITHS AND GALLOWAY BUILDING SURVEYORS*, *TASMANIA* 2007

It also includes specifications based, in part, on Australian Standard, AS 4773.2.