CLEARFORM

Clearform Wall System

BCA Compliance | Fire & Combustibility

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E-LAB Consulting

Where science and engineering inspire design.

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1 INTRODUCTION

Clearform wall system consists of reinforced concrete infill and cast in situ formwork. The formwork, being the Clearform material, is constructed from Polyvinyl Chloride (PVC). The figure below details a typical Clearform constructed wall.

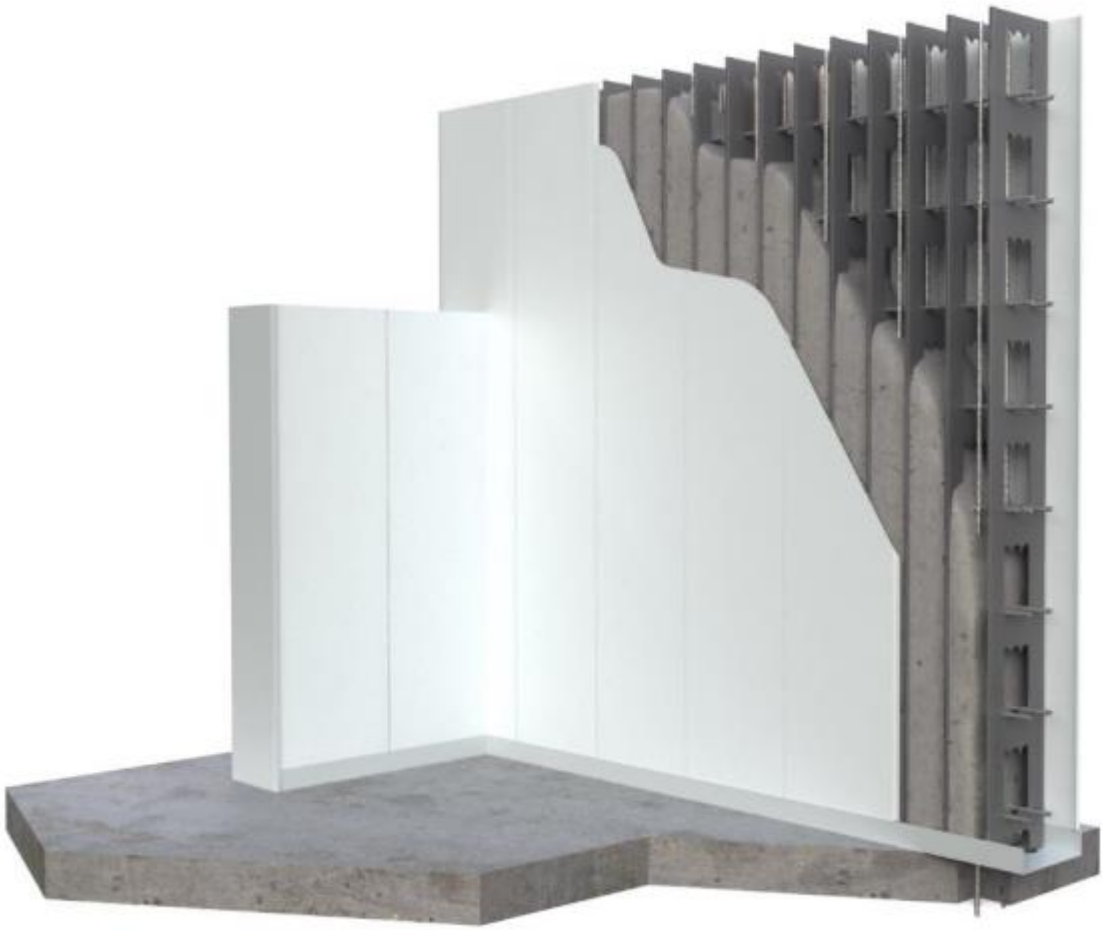


Figure 1: Clearform Wall System [25]

Clearform consists of two PVC outer layers joined together by PVC ribs. The outer layers of the PVC are designed to be exposed while the PVC ribs are to be embedded into the concrete. It is considered that if the outer layers were removed from the wall assembly then the wall and its components would be non-combustible despite the PVC ribs remaining embedded in the concrete. The ribs which are designed to be encased in concrete do not reduce the fire resistance of the wall. This is demonstrated as Clearform walls achieve an FRL of up to 240 minutes for a wall thicknesses of 200mm.

This document provides guidance on how the use of Clearform on projects, will achieve compliance with the Building Code of Australia (BCA).

2 BUILDING CLASSIFICATION

The BCA groups buildings by the purpose for which they are designed, assigning each type of building with a classification. The building classifications are labelled “Class 1” through to “Class 10” with some of the classifications having a sub-classification. The classifications are further detailed below. For further information regarding the classification of buildings, refer to Part A6 of the BCA.

CLASS 1

A Class 1 building includes one or more of the following sub-classifications:

(1) Class 1a is one or more buildings, which together form a single dwelling including the following:

(a) A detached house.

(b) One of a group of two or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit.

(2) Class 1b is one or more buildings which together constitute—

(a) a boarding house, guest house, hostel or the like that—

(i) would ordinarily accommodate not more than 12 people; and

(ii) have a total area of all floors not more than 300 m^2 (measured over the enclosing walls of the building or buildings); or

(b) four or more single dwellings located on one allotment and used for short-term holiday accommodation.

CLASS 2

(1) A Class 2 building is a building containing two or more sole-occupancy units.

(2) Each sole-occupancy unit in a Class 2 building is a separate dwelling.

CLASS 3

A Class 3 building is a residential building providing long-term or transient accommodation for a number of unrelated persons, including the following:

(1) A boarding house, guest house, hostel, lodging house or backpacker accommodation.

(2) A residential part of a hotel or motel.

(3) A residential part of a school.

(4) Accommodation for the aged, children, or people with disability.

(5) A residential part of a health-care building which accommodates members of staff.

(6) A residential part of a detention centre.

(7) A residential care building

CLASS 4

Class 4 is a dwelling in a Class 5, 6, 7, 8 or 9 building if it is the only dwelling in the building.

CLASS 5

A Class 5 building is an office building used for professional or commercial purposes.

CLASS 6

A Class 6 building is a shop or other building used for the sale of goods by retail or the supply of services direct to the public, including—

(1) an eating room, café, restaurant, milk or soft-drink bar; or

(2) a dining room, bar area that is not an assembly building, shop or kiosk part of a hotel or motel; or

(3) a hairdresser's or barber's shop, public laundry, or undertaker's establishment; or

(4) a market or sale room, showroom, or service station.

CLASS 7

A Class 7 building is a storage-type building that includes one or more of the following sub-classifications:

(1) Class 7a — a carpark.

(2) Class 7b — a building that is used for storage, or display of goods or produce for sale by wholesale.

CLASS 8

A Class 8 building is a process-type building that includes the following:

(1) A laboratory.

(2) A building in which the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce for sale takes place.

CLASS 9

A Class 9 building is a building of a public nature that includes one or more of the following sub-classifications:

(1) Class 9a — a health-care building including any parts of the building set aside as laboratories, and includes a health-care building used as a residential care building.

(2) Class 9b — an assembly building including a trade workshop or laboratory in a primary or secondary school.

(3) Class 9c — a residential care building.

CLASS 10

A Class 10 building includes one or more of the following sub-classifications:

(1) Class 10a is a non-habitable building including a private garage, carport, shed or the like.

(2) Class 10b is a structure that is a fence, mast, antenna, retaining wall or free-standing wall or swimming pool or the like.

(3) Class 10c is a private bushfire shelter.

3 BCA COMPLIANCE – CLASS 2-9

To achieve compliance with the BCA, the Performance Requirements of the BCA must be met. There are two ways to satisfy the Performance Requirements, a Deemed-to-Satisfy (DtS) Solution or a Performance Solution (Alternative Solution). To achieve a DtS solution, the prescriptive requirements of the BCA must be followed. Whereas a Performance Solution is any alternative solution that has been demonstrated to comply with the Performance Requirements of the BCA by a Fire Engineer.

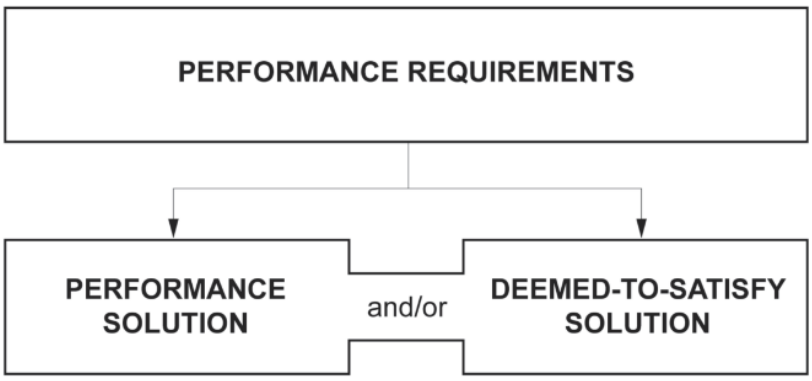


Figure 2: BCA Guidance on meeting Performance Requirements

The requirements vary depending on the particular application of the material (i.e. external wall, internal wall, shafts etc.). To address BCA compliance regarding the use of Clearform, the following methods of compliance could be adopted for each application.

Table 1: BCA Characteristics

APPLICATION	BCA DTS REQUIREMENTS	DTS SOLUTION OR PERFORMANCE SOLUTION	EVIDENCE OF SUITABILITY
External Walls Common Walls	**Clause C2D10** – External walls and common walls including any covering in Type A and B buildings must be non-combustible.	Performance Solution	Fire Engineering Report specific to the building which demonstrates compliance with the BCA.
Internal Walls Fire-isolated stairs and fire control rooms	**Clause C2D11, Clause S7C4 of Specification 7** – Internal wall linings must comply with the group numbers specified in Table S7C4 of Specification 7 and achieve an average specific extinction area less than 250 m^2/kg or a smoke growth rate index (SMOGRA) of less than 100.	DtS Solution	Warringtonfire Classification Report (RTF190201) for test carried out in accordance with AS5637.1:2015 using a full-scale room test. Clearform achieved a group number 1 and a smoke growth index (SMOGRA) of 4.7 which achieves DtS compliance.
Other materials (i.e. shafts and other elements not listed above)	**Clause C2D11, Clause S7C7 of Specification 7** – Other materials and assemblies must achieve a Spread-of-Flame Index of 9 and a Smoke-Developed Index of 8 or less.	DtS Solution	CSIRO Advisory Report (FCO-3489) and test carried out in accordance with AS1530.3-1999. Clearform achieved a Spread of Flame Index and Smoke Developed Index of 0 and 4 respectively, which achieves DtS compliance for the applications relevant to Clearform.

APPLICATION	BCA DTS REQUIREMENTS	DTS SOLUTION OR PERFORMANCE SOLUTION	EVIDENCE OF SUITABILITY
FRL of 240/240/240	**Clause S1C2, Specification 1** – The FRL of a wall is required to be tested in accordance with AS 1530.4 by an Accredited Testing Laboratory.	DtS Solution	SGS Fire Testing Report (AJFS2305003984RS) for test carried out in accordance with AS 1530.4:2014. A Clearform wall with a thickness of 200mm achieved an FRL of 240/240/240.

4 PERFORMANCE SOLUTIONS – CLASS 2-9

The BCA DtS requirements permit combustible materials to be applied as internal wall linings if the material achieves the required Group rating. Clearform has been fire tested and achieves a Group 1 material rating and an ASEA of 242.1 m^2/kg, meaning that Clearform will comply with the BCA DtS provisions for internal wall applications.

The BCA also permits combustible materials and assemblies in other locations internally such as the construction of a shaft as well as other elements not mentioned in the table above, provided they achieve a Spread-of-Flame Index of 9 or less and a Smoke-Developed Index of 8 or less. Clearform was fire tested and achieved Spread-of-Flame Index of 0 and a Smoke-Developed Index of 4, therefore will also comply with the DtS Provisions of the BCA in these other locations.

Clearform applied as an external wall or a common wall between buildings does not satisfy the BCA DtS provisions. Rather, BCA compliance will be demonstrated by providing a Performance Solution which aims to satisfy the BCA Performance Requirements.

The Performance Solution strategy includes:

- Demonstrating the outer PVC layers do not pose an undue risk of fire spread via the wall/façade/shaft (refer to fire behaviour of PVC)
- While Clearform is combustible, the BCA permits combustible material such as plasterboard to be used where non-combustible materials are required. The fire performance of Plasterboard will be compared to Clearform, the comparison aims to demonstrate a similar level of fire safety to determine BCA compliance using an equivalence approach.
- Fire testing was conducted in accordance with AS 1530.3:1999. The test confirmed a Spread-of-Flame Index of 0 and a Smoke-Developed Index of 4 for Clearform and as a result is better than or comparable to materials such as Plasterboard, which is considered a DtS compliant solution.
- Fire testing was conducted in accordance with AS 5113:2016. The test assessed Clearform PVC material propensity to spread fire via the façade. AS 5113 is a large-scale test that represents a building and measures fire spread via the façade. The test replicates a compartment fire and impinging on the cladding material.
- Large full-scale room testing was conducted in accordance with AS 5637.1:2015 to determine the group number and the smoke growth rate (SMOGRA) of the material. The intent of the test is to quantify how a material will perform in a compartment fire. Materials with a group number of 4 are considered the worst preforming material while Group 1 are the best preforming. The test determined that Clearform is a Group 1 material and has a SMOGRA of 4.7.

4.1 Fire Behaviour of PVC

When PVC is exposed to high temperatures it will decompose to provide an insulating layer of char that retards further degradation of the virgin PVC material below. The insulating properties of this char layer can provide built-in fire resistance. The rate of char is initially fast but as the char increases it slows as this insulating layer grows.

PVC will combust when exposed to a heat source, but when the source of heat is removed, PVC will typically char and self-extinguish. This makes it difficult to burn and to sustain a fire without another source of heat and therefore would not support rapid fire spread along the façade in which Clearform is present.

PVC is made from a mixture of carbon, hydrogen and chlorine. The chlorine not only gives PVC useful durability properties, but also improves the materials resistance to fire. As mentioned, PVC will not typically burn when a flame or heat is removed. This is due to the chlorine in the polymer, as chlorine improves the fire resistance of plastic polymers.

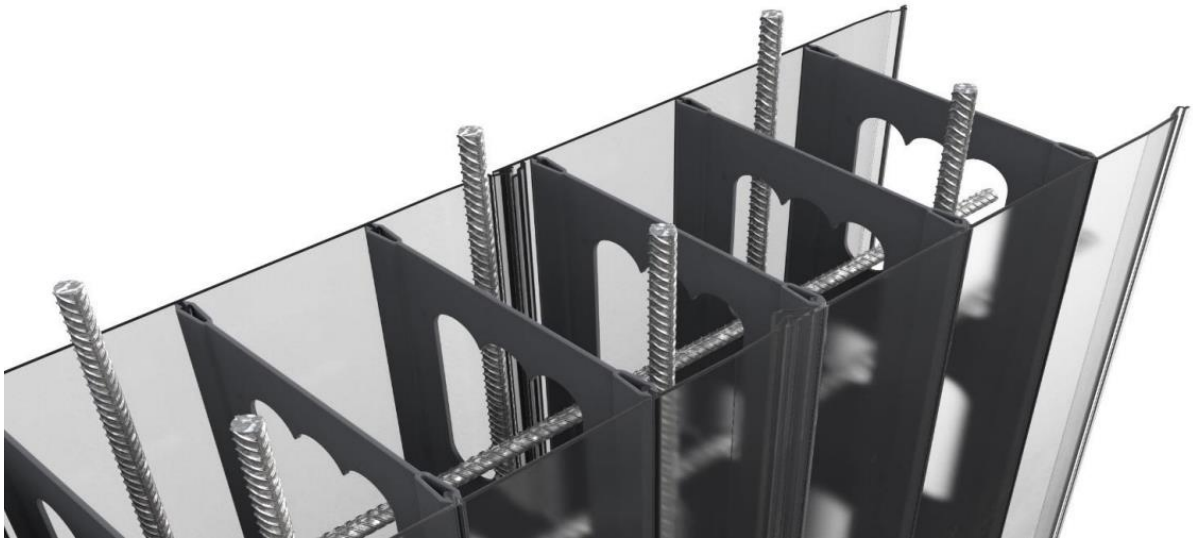


Figure 3: Clearform

While PVC is combustible by nature, it is considered to not be a highly flammable material. Flammability of a material can be characterised by the ignition temperature and ability to sustain a flame. Materials with a higher ignition temperature are considered to have a lower hazard to combustibility. Typically, PVC will ignite when temperatures exceed 435 °C, in comparison, paper made from cellulose typically has an ignition temperature of 233 °C. Furthermore, even though PVC is combustible, its high ignition temperature coupled with its capacity to char translates to a material that is not highly flammable; materials such as paper (i.e. plasterboards linings) are considered to be more flammable and more readily facilitate the spread of flames faster than PVC.

It should also be noted, the BCA provides a concession for combustible materials to be used where non-combustible materials are required; BCA clause C2D10 states that plasterboard can be used where non-combustible materials are required. Plasterboard contains a plaster core with two outer layers of paper, and as discussed, paper will ignite at lower temperatures than PVC.

Plasterboard when tested in accordance with ASTM E84, has a Flame Spread Index (FSI) of 10-20, while 3mm thick PVC sheet has an FSI of 5-10. The ASTM E84 test method measures flame growth across the material, the result, measured as a Flame Spread Index (FSI), which is a scale from 0 to 100; asbestos board has an FSI of 0 and red oak wood has a maximum value of 10. Considering this, it is apparent that even though PVC is combustible, its ability to spread flames via the façade or internally would be limited. This is demonstrated by the AS1530.3-1999 fire test, where Clearform achieved a Spread-of-Flame Index of 0, with 0 being the best and 10 being the worst.

There is a strong indication from the information presented above, that the Clearform outer PVC layer would not support significant flame spread and will likely self-extinguish when the source of heat is removed. The PVC ignition temperature suggests that the Clearform outer layers (PVC) could ignite when an external source of heat is applied (i.e. flames from a window impinging onto the facade), however, with PVC's ability to char coupled with a low Flame Spread Index suggests that the material away from the original flame source is unlikely to sustain flaming combustion that would result in significant fire spread.

Clearform has been subjected to the large-scale room test in accordance with AS ISO 9705:2003 and AS 5637.1:2015. The intent of this test is to observe the wall materials propensity to facilitate compartment flashover and to record the amount of smoke produced.

The test apparatus included a compartment measuring 2.4m wide by 3.6m long by 2.4m high. All walls were constructed from Clearform, with the PVC outer layers left exposed. A fire source was placed within the room, which exposed the PVC to elevated temperatures.

The results show that the Clearform did not cause flashover, and consequently achieved a Group 1 rating. Group 1 materials are considered to be a low fire hazard material. The test also demonstrates that the amount of thermal energy and smoke produced during combustion was low.

While the test assessed a compartment fire and is not directly relatable to a façade fire, the test demonstrates that Clearform is able to resist fire spread and minimally contribute to the severity of a fire; this provides further evidence that Clearform is not readily flammable and is unlikely to cause fire spread via the façade.

Clearform was subjected to a full facade test in accordance with AS 5113:2016, which is a full-scale test that replicates a real-life fire breaking through a façade opening (i.e. window) and impinging the façade.

The intent of AS 5113:2016 is to assess the behaviour of the external wall materials during a fire event. Materials that behave well in this fire test are characterised as not causing extensive fire to spread via the façade; while materials that behave poorly are characterised as causing rapid and extensive fire spread via the façade.

The Clearform wall system was subjected to the fire for 30 minutes, during that time the extent of flame spread via the Clearform was observed. Flames were seen to not reach the top of the façade, which indicates that the PVC material itself did not significantly contribute to fire spread beyond the original fire.

The test shows that the Clearform directly above the crib burnt due to being subjected to the crib fire, however, the Clearform material directly above this flaming zone did not propagate flame. This further demonstrates that the Clearform PVC material away from the original flame source is unlikely to sustain combustion that is capable of causing significant fire spread.

It is clear from the test that the portions of PVC that burnt were either in direct contact of the flame or exposed to extreme radiant heat from the original fire source. PVC material above the fire source are shown to have not burnt but appeared to have charred or were blackened by smoke damage and resisted the spread of fire. A material that facilitates fire spread would have shown flames continually spreading upwards and would have resulted in extensive fire damage to the full vertical extent of the specimen. It is clear that fire damage to the Clearform specimen is limited and does not extend to the full height of the specimen.

Moreover, the fire test results presented indicate that the Clearform PVC material is unlikely to facilitate the spread of fire via a façade. The PVC is expected to char and self-extinguish beyond the original fire source and result in limited vertical flame spread.

The fire behaviour of Clearform during this test can be used to provide additional support to any Performance Solution in order to achieve BCA compliance.

5 BCA COMPLIANCE – CLASS 1 AND 10

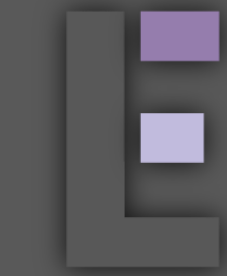
To address BCA compliance regarding the use of Clearform, the following methods of compliance could be adopted for each application.

Table 2: Clearform Applications and DtS Requirements for Class 1 and Class 10 buildings

APPLICATION	BCA DTS REQUIREMENTS	DTS SOLUTION OR PERFORMANCE SOLUTION	EVIDENCE OF SUITABILITY
External Walls	**Clause H3D3** – Any external walls (including gables) required to be fire resisting needs to be fire rated with an FRL of no less than 60/60/60 or to be no less than 90 mm thick. The BCA Volume 2 puts no restriction on the combustibility of external walls for Class 1 buildings. Based on the above it is considered that an FRL of 60/60/60 is required for load bearing walls and an FRL of -/60/60 is required for non-load bearing walls.	DtS Solution	SGS Fire Testing Report (AJFS2305003984RS) for test carried out in accordance with AS 1530.4:2014. A Clearform wall with a thickness of 200mm achieved an FRL of 240/240/240.
Common Walls	**Clause H3D4 -** A separating wall between Class 1 buildings, or a wall that separates Class 1 and for an unassociated Class 10a building needs to be fire rated with an FRL of no less than 60/60/60 or to be no less than 90 mm thick when of masonry construction. Non-combustible vertical lining is to separate eaves, verandas and similar spaces that are open to the roof space and is common between more than one Class 1 building.	DtS Solution	SGS Fire Testing Report (AJFS2305003984RS) for test carried out in accordance with AS 1530.4:2014. A Clearform wall with a thickness of 200mm achieved an FRL of 240/240/240.
Separation of Garage top dwellings	**Clause H3D5 –** Where parts of a Class 1a dwelling located above a Class 10a private that is not associated with the Class 1a dwelling that separates parts of the Class 1a dwelling from the private garage not associated with the dwelling must have an FRL not less than 60/60/60 or to be no less than 90 mm thick. Based on the above it is considered that an FRL of 60/60/60 is required for load bearing walls and an FRL of -/60/60 is required for non-load bearing walls.	DtS Solution	SGS Fire Testing Report (AJFS2305003984RS) for test carried out in accordance with AS 1530.4:2014. A Clearform wall with a thickness of 200mm achieved an FRL of 240/240/240.

6 CONCLUSION

Based on the supporting test data and the inherent performance of PVC lined concrete, Clearform is considered to be capable of complying with the BCA via a combination of DtS Solutions and Performance Solutions as discussed within this document.



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