WOOD & GRIEVE ENGINEERS

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Permaform Walling System

BCA Compliance – Fire and Combustibility Report

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Revision

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1. Introduction

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

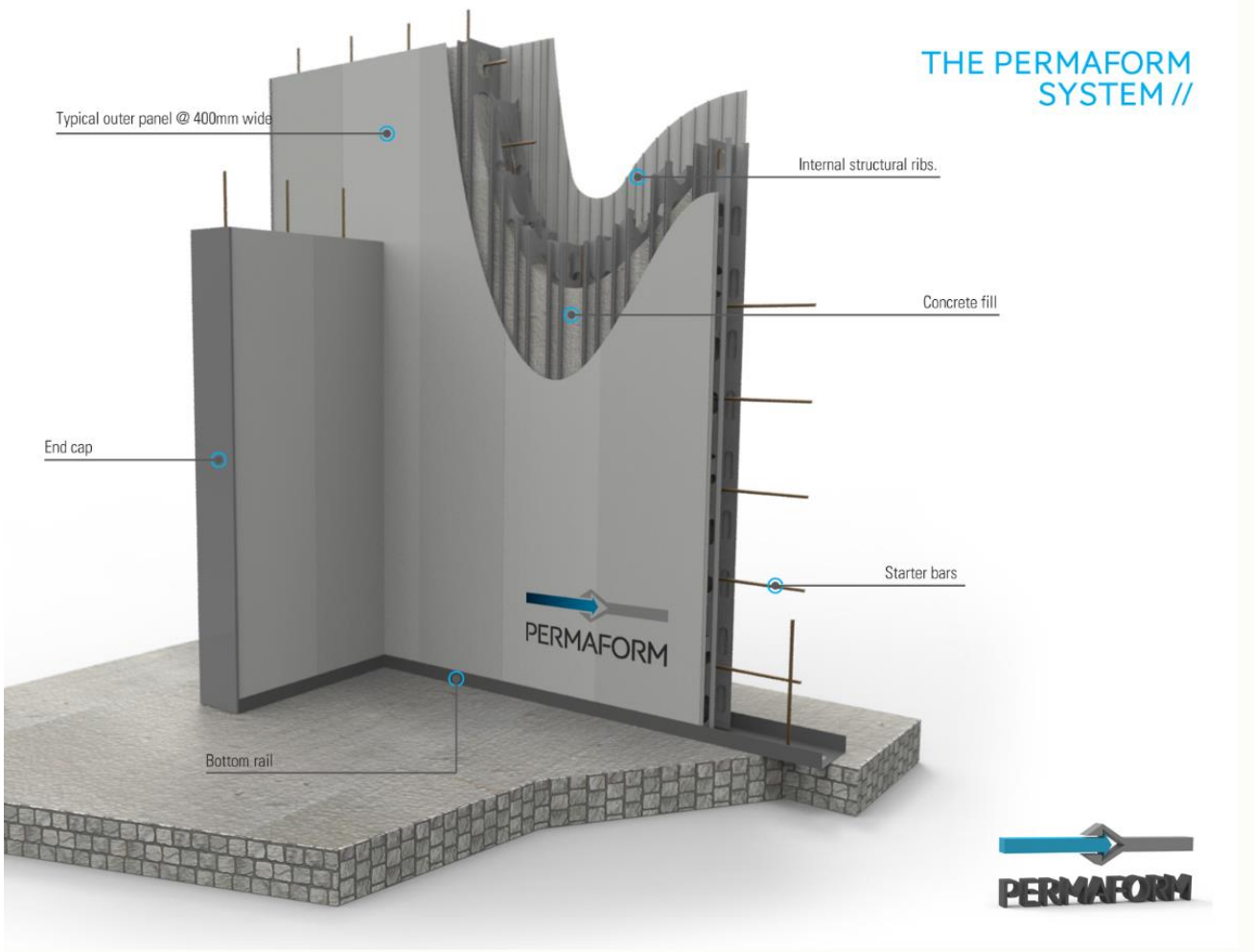


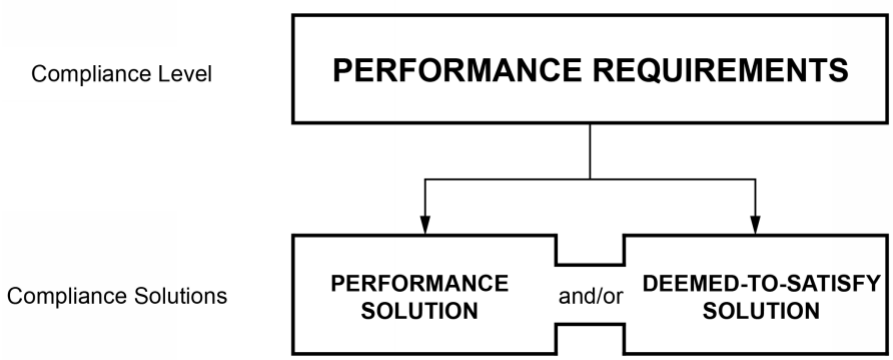
Figure 1: Typical Permaform wall [25]

Permaform 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 Permaform walls achieve an FRL of 95 minutes and 120 minutes for wall thicknesses of 110mm and 150mm respectively.

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

2. BCA Compliance

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.



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 Permaform, the following methods of compliance could be adopted for each application.

Table 1: Permaform Applications and DtS Requirements

Application	BCA DtS Requirements	DtS Solution or Performance Solution	Evidence of Suitability
External Walls **Common Walls**	**Clause C1.9(a)** – 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 C1.10, Clause 4 of Specification C1.10** – Internal wall linings must comply with the group numbers specified in Table 3 of Specification C1.10 and achieve an average specific extinction area less than 250 m^2/kg.	DtS Solution	CSIRO Fire Testing Report and Certificate of Assessment for test carried out in accordance with AS/NZS 3837-1998. Permaform achieved a group number 1 and an average specific extinction area of 236.8 m^2/kg which achieves DtS compliance. Refer to the appended testing report.
Other materials (i.e. shafts and other elements not listed above)	**Clause C1.10, Clause 7 of Specification C1.10** – 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 Fire Testing Report and Certificate of Assessment for test carried out in accordance with AS1530.3-1999. Permaform achieved a Spread of Flame Index and Smoke Developed Index of 0 and 4 respectively, which achieves DtS compliance for the applications relevant to Permaform. Refer to the appended testing report.

Application	BCA DtS Requirements	DtS Solution or Performance Solution	Evidence of Suitability
FRL of -/60/60 (non-load-bearing)	**Clause A2.3, Specification A2.3** – 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 for test carried out in accordance with AS 1530.42014. A Permaform wall with a thickness of 110mm achieved an FRL of -/60/60. Refer to the appended testing report.
FRL of -/120/120 (non-load-bearing)	**Clause A2.3, Specification A2.3** – 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 for test carried out in accordance with AS 1530.42014. A Permaform wall with a thickness of 150mm achieved an FRL of -/120/120. Refer to the appended testing report.

3. Performance Solutions

The BCA DtS requirements permits combustible materials to be applied as internal wall linings if the material achieves the required Group rating. Permaform has been fire tested and achieves a Group 1 material rating and an ASEA of 236.8m^2/kg, meaning that Permaform 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. Permaform 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.

Permaform 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 undue risk of fire spread via the wall/façade/shaft (refer to fire behaviour of PVC)
- While Permaform 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 Permaform, 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 Permaform and as a result is better than or comparable to materials such as Plasterboard, which is considered a DtS compliant solution.

3.1 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 Permaform 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 atoms in the polymer, as chlorine improves the fire resistance of plastic polymers. [26]

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 flame. Materials with a higher ignition temperature are considered to have lower hazard to combustibility. Typically, PVC will ignite when temperatures exceed 435°C [27], in comparison, paper made from cellulose typically has an ignition temperature of 233°C [28]. 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 are considered to be more flammable and more readily facilitate spread of fire 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 C1.9 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 a FSI of 5-10. [26] The ASTM E84 test method measures flame growth across material, the result, measured as a Flame Spread Index (FSI), which is a scale from 0 to 100; asbestos board has a FSI of 0 and red oak wood has a maximum value of 100. 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 Permaform 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 Permaform outer layers 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 Permaform 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 it suggests that the material away from the original flame source would unlikely be able to sustain flaming combustion that would result in significant fire spread

4. Conclusion

Based on the supporting test data and the inherent performance of PVC lined concrete, Permaform 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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