3D PRINTING SET TO REVOLUTIONISE THE CONSTRUCTION INDUSTRY!

Advances in 3D printing technology are seamlessly linking the digital and physical worlds. As a result, demand is surging across all spheres: from consumer applications in the home, to different sectors such as retail, healthcare and aviation.

Most construction project costs can be split into three categories: finance, materials and labour. 3D printing could potentially erase significant amounts of money in bringing construction projects to market, through shorter project times and fewer wasted resources.

This technology could replace certain parts of a number of labour intensive trades, including builders, electricians and plumbers. Overall, there are one million people employed in construction in Australia. Using 3D printers to create prototypes of early products, and fulfil small manufacturing orders could significantly impact a number of these workers.

Smaller companies with access to 3D printing services will be able to create their own prototype products and bypass parts of the manufacturing process, putting more power into the hands of start-ups.

However, there are indications 3D printing could create many more jobs. A technique known as Contour Crafting has already been developed which enables builders to create large projects using 3D printers – such as entire homes. Meanwhile, as 3D printers become more accessible they will start entering the home, allowing consumers to create their own products. The distribution of ‘blueprints’ for these products will inevitably become more valuable.

This is already starting. A Kickstarter campaign in 2014 to fund a small, consumer-focused 3D printer blew past its $50,000 goal within hours, and raised more than $3 million.

The demand is clearly here for 3D printing – and its popularity is set to transform the construction industry forever.

THE CARPET INDUSTRY’S APPROACH TO BCA COMPLIANCE FOR SLIP RESISTANCE

The Carpet Institute of Australia Limited (CIAL), the peak industry body for Australia’s $1.6 billion carpet industry, in conjunction with CSIRO has developed a report to demonstrate compliance with the Building Code of Australia’s slip resistance provisions, as amended in 2014. This approach utilises the assessment method A2.2 evidence of suitability of the National Construction Code.

CAN THE NCC ACCOMMODATE THE OUTPUTS FROM 3D PRINTING?

NATIONAL CONSTRUCTION CODE (NCC)

The NCC is a performance based code, meaning a building will comply with the NCC if it satisfies the Performance Requirements, which are the NCC legal requirements. The Performance Requirements of the NCC can be met using either a Performance Solution (an ‘Alternative Solution’) and/or a Prescriptive Solution (complying with the Deemed-to-Satisfy (DtS) Provisions).

Although it is highly unlikely that outputs from 3D printing technology would meet the current DtS provisions, a Performance Solution could be developed to satisfy the Performance Requirements.

Table 1 Slip resistance classifications based on slip resistance values

<table>
<thead>
<tr>
<th>Classification</th>
<th>Pendulum Slip Resistance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5</td>
<td>&gt;54</td>
</tr>
<tr>
<td>P4</td>
<td>45-54</td>
</tr>
<tr>
<td>P3</td>
<td>35-44</td>
</tr>
<tr>
<td>P2</td>
<td>25-34</td>
</tr>
<tr>
<td>P1</td>
<td>12-24</td>
</tr>
<tr>
<td>P0</td>
<td>&lt;12</td>
</tr>
</tbody>
</table>

Note: For full details, refer to AS 4586 Table 2 and normative Appendix A.

For dry surfaces, the majority of carpet installations, excluding ramps steeper than 1:14, the minimum required slip resistance classification is P3 for new carpet or the stair nosings/landing edge strip. The corresponding ‘Deemed-to-Satisfy’ requirement for ramps steeper than 1:14 is a minimum P4 classification.

THE CARPET INDUSTRY’S APPROACH TO BCA COMPLIANCE FOR SLIP RESISTANCE

BCA 2014 introduced new slip resistance ‘Deemed-to-Satisfy’ requirements for:

- stair treads and nosing strip (all building classes); and
- pedestrian ramps, landings and edge strip (Class 2 – 9 buildings).


The BCA 2014 slip resistance requirement is set to transform the construction industry in Australia. Using 3D printers to create entire homes and export new products, the BCA 2014 requirement may significantly impact a number of these workers.

The database is a good cross section of the huge range of carpet qualities sold in Australia and New Zealand. The database is a good cross section of the huge range of carpet qualities sold in Australia and New Zealand.

The Carpet Institute of Australia Limited compiled a database of 153 tests for a very diverse range of carpets, all of which were tested in accordance with the requirements of the AS 4586 Appendix A Pendulum Test.

The tested carpets include:

- machine made ‘wall to wall’ carpet, carpet tiles and a few artificial turf products.
- tufted, woven and electro-statically flocked carpets.
- cut pile carpets, loop pile carpets and a few cut/loop combinations.
- fibre type of wool; wool/synthetic blends; goat hair; nylon; polyester; polypropylene and triexta.
- total pile weight of 410 to 2,588 grams/m².
- pile thickness of 0.88mm to 15.2mm.

The database is a good cross section of the huge range of carpet qualities sold in Australia and New Zealand.

Of the 153 carpets tested, 129 (84%) achieved a P5 Classification and the remainder a P4 Classification. All the test results passed the minimum mandatory slip resistance requirement (P3 Classification).
These results support our view that carpet is an inherently slip resistant product because of the pile use-surface. Millions of square metres of carpeting in a wide range of end uses have been shown to perform satisfactorily over many years by providing a safe non-slip surface and cushioning should slips and falls occur, as well as other positive attributes and benefits. To comply with the Code’s Deemed-to-Satisfy requirements, carpet manufacturers and distributors must demonstrate their product achieves the minimum slip resistance classification. One way of doing this is to have their products independently tested. Laboratories charge about $260 per carpet quality for the Pendulum Test. The full cost taking into account the cost of the test specimen; couriers and staff time would be at least $700 per test. On this estimate, testing 153 carpet qualities cost about $76,000 to show that all the products comfortably passed the Code’s Deemed-to-Satisfy criteria.

There is a problem here. There are literally thousands of individual carpet qualities and it is not possible to test all of them. The value of testing is also questionable when the available evidence suggests that machine made carpets and carpet tiles are highly likely to pass the Code’s slip resistance requirements.

**ANOTHER WAY OF DEMONSTRATING CODE COMPLIANCE**

In November 2014 CIAL commissioned CSIRO to perform a statistical risk analysis on our data base of AS 4586 test reports to assess the likelihood of Code compliance for new carpet to be installed in dry areas. At the time we had approximately 100 valid AS 4586 test reports and the fact that a large majority of the test results achieved a P5 Classification gave us confidence to go ahead with the study.


The study included a statistical risk analysis on 200 AS ISO 9239-1 test reports for 100% wool carpets and certain wool/nylon blend carpets to show that these carpets pass the code’s Deemed-to-Satisfy fire resistance requirements with 99.9% confidence. The study produced a Report and Certificate of Assessment that is accepted by building regulators as evidence of compliance to the BCA, hence avoiding the necessity of testing each and every carpet of the types covered by the CSIRO study. In other words, a contribution to an Alternative Solution that is still valid today.

The study investigated whether, with 99.9% confidence, samples of various carpets can be expected to exceed the Code’s Deemed-to-Satisfy criterion (P3 Classification).

Based on the CSIRO analysis and modelling, the range of carpets shown in the following table will achieve a Classification not less than P3 and hence which can be considered to conform without testing for stair treads, landings and ramps not steeper than 1:14.

Carpeting conforming to the above description and manufactured by Beaulieu Australia, Brintons, Cavalier Bremworth, Feltex Carpets, Godfrey Hirst Carpets, Interface, Norman Ellison Carpets, Ontera, Quest Carpets, Supertuft, Tuftmaster Carpets and Victoria Carpets, are covered by this assessment.

<table>
<thead>
<tr>
<th>Fibre Type ('face fibre' or 'wear surface')</th>
<th>Cut Pile Carpet</th>
<th>Loop Pile Carpet</th>
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<tbody>
<tr>
<td>Wool and wool rich (≥80%)</td>
<td>OK for 4.1mm sPT ≤ 6.2mm</td>
<td>OK for 5.5mm sPT ≤ 6.6mm</td>
</tr>
<tr>
<td>Nylon</td>
<td>OK for 3.8mm sPT ≤ 6.0mm</td>
<td>OK for 7.0mm sPT ≤ 8.0mm</td>
</tr>
<tr>
<td>Other</td>
<td>OK for 3.8mm sPT ≤ 6.0mm</td>
<td>insufficient data</td>
</tr>
</tbody>
</table>

Notes:
- sPT is measured pile thickness, defined as the difference in the thickness of the carpet before and after the pile above the substrate has been short wave measured under standard pressure.
- Wool and wool rich carpets must not be less than 80% wool pile content.
- Nylon carpets have 100% nylon pile content.
- Other carpets have 100% pile fibre content that is polyester or polypropylene or triexta.
- Carpets must be either 100% cut pile or 100% loop pile.
These results support our view that carpet is an inherently slip resistant product because of the pile use-surface. Millions of square metres of carpeting in a wide range of end uses have been shown to perform satisfactorily over many years by providing a safe non-slip surface and cushioning should slips and falls occur, as well as other positive attributes and benefits.

To comply with the Code’s Deemed-to-Satisfy requirements, carpet manufacturers and distributors must demonstrate their product achieves the minimum slip resistance classification. One way of doing this is to have their products independently tested. Laboratoires charge about $260 per carpet quality for the Pendulum Test. The full test taking into account the cost of the test specimen; couriers and staff time would be at least $500 per test.

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Table 2 Analysis and modelling results for different carpets tested to the P3 Classification

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- PT is measured pile thickness, defined as the difference in the thickness of the carpet before and after the pile above the substrate has been shaved away, measured under standard pressure.
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CIAL undertook a similar exercise in 2009 with CSIRO. This involved a statistical risk analysis on 200 AS ISO 9239-1 test reports for 100% wool carpets and certain wool/nylon blend carpets to show that these carpets pass the code's Deemed-to-Satisfy fire resistance requirements with 99.9% confidence. The study produced a Report and Certificate of Assessment that is accepted by building regulators as evidence of compliance to the BCA, hence avoiding the necessity of testing each and every carpet of the types covered by the CSIRO analysis. In other words, a contribution to an Alternative Solution that is still valid today.

Like the fire risk assessment of wool and wool rich carpets, we determined that the CSIRO analysis of slip resistance test results should be conducted using the 99.9% confidence interval (i.e. only 1 chance in 1,000 of a non-complying test result). In our view, a very tough but responsible test.

It is important to note that, unlike fire resistance testing in accordance with the requirements of Specification C1.10 using AS ISO 9239-1, the standard for slip testing AS 4586 does not require carpet products to be tested as ‘installed’. As a result, laboratories commonly test new carpet without underlay. AS 4586 Appendix A at Clause A9 Report, states that a description of the test sample shall include the presence of any underlay, condition of the surface and whether the surface was tested wet or dry.

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Based on the CSIRO analysis and modelling, the range of carpets shown in the following table will achieve a Classification not less than P3 and hence which can be considered to conform without testing for stair treads, landings and ramps not steeper than 1:14.

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The report and testing will inform the development of Alternative Solutions and may also be used to inform a proposal to change the Code’s slip resistance provisions to the specific carpet installation, CIAL has prepared a Carpet Details Pro-forma which is filled out by the carpet manufacturer/distributor and the building permit applicant. This document is intended to assist the regulatory authority when deciding whether to accept the CSIRO Report and Certificate of Assessment as a valid assessment method.

It is important to note that CSIRO has placed specific restrictions on the use of the study Report and Certificate of Assessment. These include:

- the documents can only be used for internal business purposes; to demonstrate conformity to a standard published by a recognised standards body; and as part of a building approval process for submission to an approval authority.

The Pro-forma together with a copy of the CSIRO Report and Certificate of Assessment should then be submitted to the regulatory authority in the normal manner in place of the Test Report that would normally have been submitted.

For further information, or to obtain a copy of the CSIRO Report and Certificate of Assessment, please contact Allan Firth, Executive Director, Carpet Institute of Australia Limited (email: allan@carpetoz.com.au or phone: 0409 406 920). For enquiries relating to the slip resistance analysis and modelling, please contact Alex Webb, email alex.webb@csiro.au.