REPORT

Wind Plug Analysis

MELBOURNE | VICTORIA
WIND UPLIFT ASSESSMENT

PREPARED FOR:

MULTIPOD INTERNATIONAL

EXECUTIVE SUMMARY

has been commissioned by MultiPod International Pty Ltd to perform an uplift wind loading assessment on a proposed wind plug design.

The maximum resistance to uplift force provided by manufactured **wind plugs** acting on a group of loose-laid pavers was investigated. Data collected from mechanical testing was used to interpret the behaviour of the wind plug and pedestal system during high wind speed events.

Additionally, Computational Fluid Dynamics (CFD) was used to visualize the flow field over the tiles and between the small apertures. The 3D model was constructed in accordance with the drawings supplied by A list of the drawings used to construct the model and the surrounding buildings is provided in Appendix A of this report.

All testing was carried out in the warehouse facility of MultiPod International during November, 2018.

The findings of this study are:

- Forces corresponding to the uplift/failure of the test configurations are:
    - Configuration 1: 294 N
    - Configuration 2: 785 N
- The wind plug increased the strength of the tiles by 491 N.
- Without the wind plug the force dependence on the weight of the tile

1. INTRODUCTION

1.1 Geometry of MultiPod

The pods are shown as below. There are three different types of pods manufactured by Multipod. The only pod tested in this paper is pod 3 as further defined below. The MultiPod is made up of 80% PP and 20% Glass Fibre.

Figure 1: Top plan view of MultiPod 003

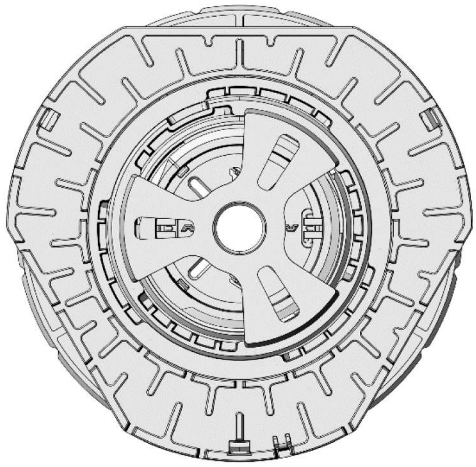

Figure 3: Bottom plan view of MultiPod 003

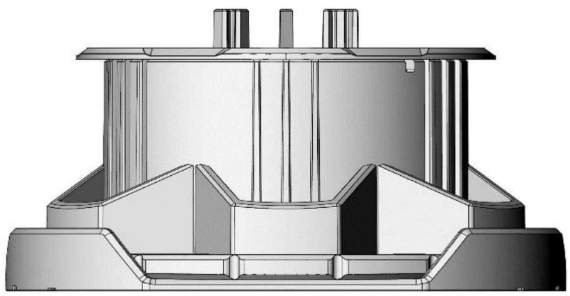

Figure 2: Elevation of MultiPod 003

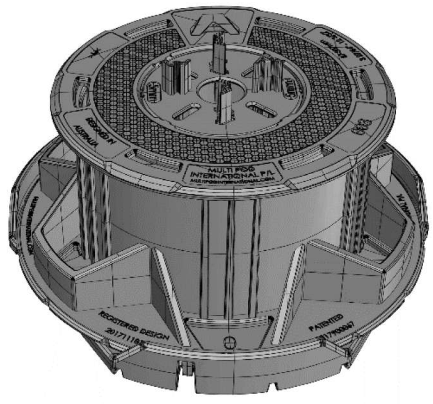

Figure 4: 3D view of MultiPod 003

1.2 Geometry of Wind Plug

The wind plugs are shown as below. They are made up of Nylon PA66, an extruded form of polyamide, with high rigidity, strength and wear resistance properties. They are fitted with straight and diagonal locking mechanisms that are inserted and secured within the MultiPod. Figure 5 to Figure 7 illustrate the geography of the wind plugs.

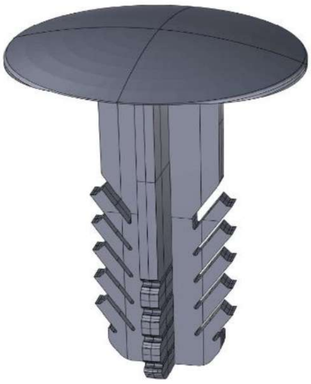

Figure 5: 3D view of wind plug

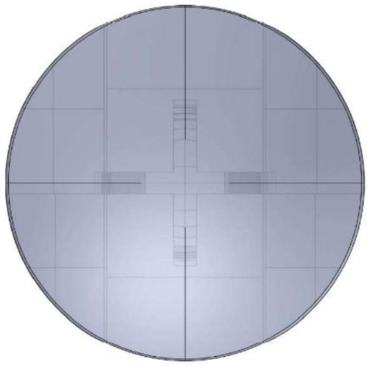

Figure 7: Top plan view of wind plug

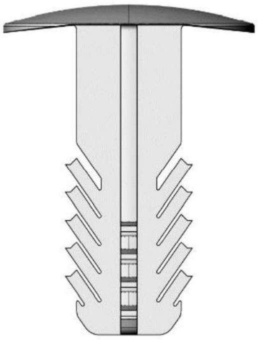

Figure 6: Elevation 1 of wind plug

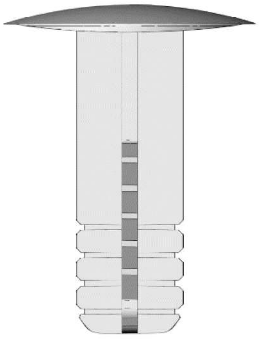

Figure 8: Elevation 2 of wind plug

The mechanical properties of this material are as follows:

Mechanical Properties	Metric	Reference
Tensile strength	82.7 MPa	ASTM D638
Elongation at break	50%	ASTM D638
Tensile modulus	2.93 GPa	ASTM D638
Flexural Yield Strength	103 MPa	ASTM D790
Flexural Modulus	3.10 GPa	ASTM D790
Compressive Strength	86.2 MPa	ASTM D695
Compressive Modulus	2.90 GPa	ASTM D695
Shear Strength	68.9 MPa	ASTM D732

2. TEST PROCEDURE

2.1 Test Configurations

The predicted uplift wind force at which the MultiPod - wind plug systems fail was analysed for three configurations. Configuration 1 consisted of four porcelain tiles (600 x 600 x 20 mm) laid loosely upon nine MultiPods. Spacing between each tile was 3mm. Configuration 2 maintained the same set-up as Configuration 1, however, the central MultiPod was fixed and three screws and a wind plug were added to the central pedestal. Configuration 3 consisted of 8 tiles, fifteen MultiPods and three wind plugs, as illustrated in Figure 11 below. As with Configuration 2, only the central pedestal was fixed for Configuration 3.

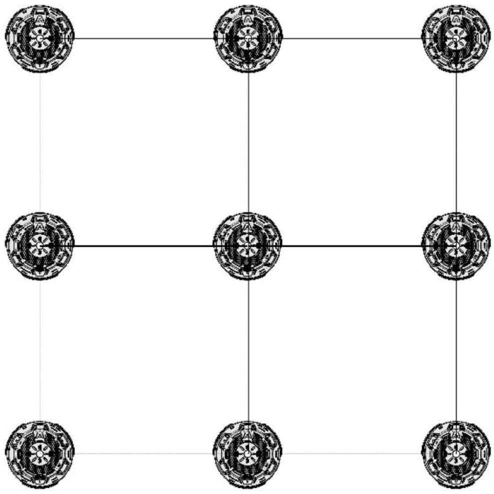

Figure 9: Plan view of configuration 1

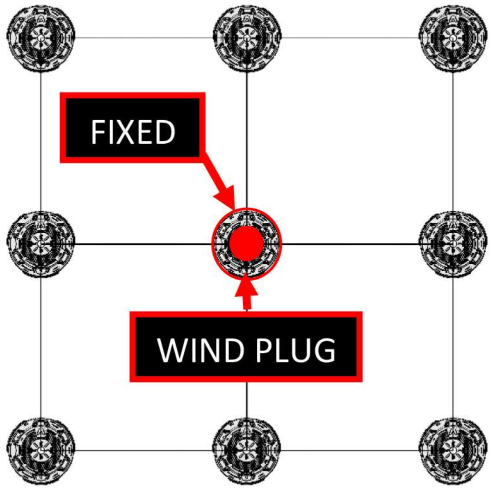

Figure 10: Plan view of configuration 2

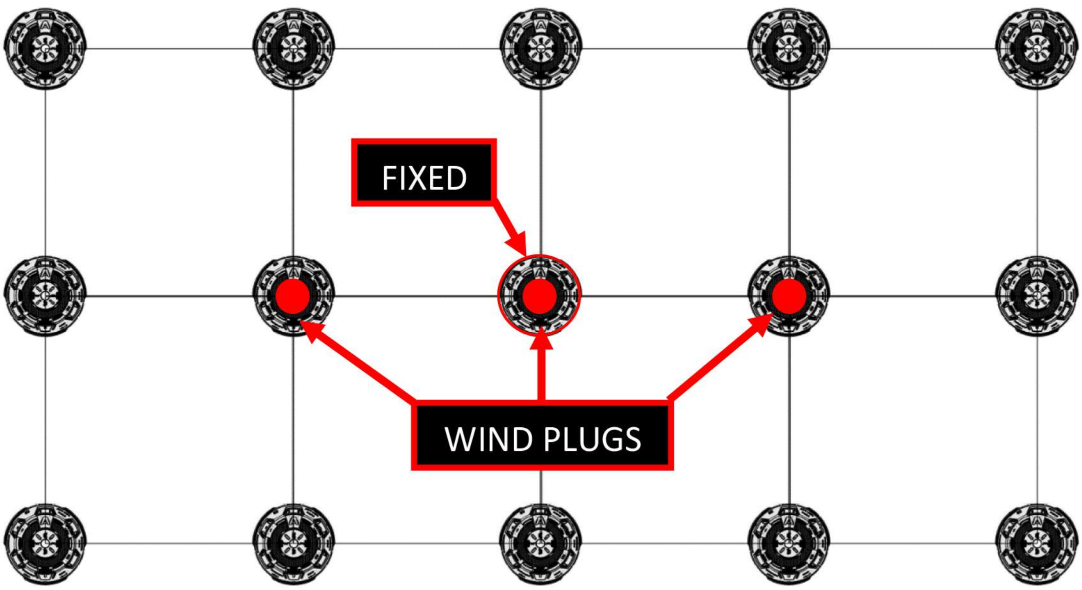

Figure 11: Plan view of configuration 3

2.2 Test Methods

2.2.1 Configurations 1, 2 and 3

A pulling/suction force was applied to Configurations 1 and 2 using four high-tensile ropes with washers resting on the underside of the tiles. Figure 12 and Figure 13 illustrate the rope assembly for tests 1 and 2, both with and without the central wind plug.

Figure 12: Applied force on configuration 1

Figure 13: Applied force on configuration 2

Figure 14: Applied force on configuration 3

Figure 14 illustrates the crossbar used to evenly apply and uplift force across Configuration 3. A lifting force was equally applied by using a forklift to gradually increase tension in the ropes. Force was applied until the tiles were lifted from their horizontal position and the corresponding force was recorded using load cell.

3. TEST RESULTS

3.1 Predicted Wind Speed Values

Pressure is determined by:

$$P = \frac{1}{2}\rho v^2 C_p$$

Thus,

$$F = PA = \frac{1}{2}\rho v^2 C_p$$

$$\frac{F}{A} = P = \frac{1}{2}\rho v^2 C_p$$

$$\frac{2F}{\rho A C_p} = v^2$$

$$v = \sqrt{\frac{2F}{\rho A C_p}}$$

Where P = pressure
ρ = density of air
v = wind velocity
C_p = pressure coefficient

Using the above method, wind speeds for various pressure coefficients are predicted for testing with and without the wind plug, as shown in Table 1 and Table 2.

Table 1: Predicted wind speeds with the wind plug

Applied Mass (kg)	Applied Force (N)	Area of Applied Force (m^2)	Pressure (Pa)	Pressure Coefficient (C_P)	Wind Speed	
					(m/s)	(km/h)
80	784.8	0.6 x 0.6 = 0.36	2180	-1	60.3	217.0
80	784.8	0.6 x 0.6 = 0.36	2180	-2	42.6	153.4
80	784.8	0.6 x 0.6 = 0.36	2180	-3	34.8	125.3

Table 2: Predicted wind speeds without the wind plug

Applied Mass (kg)	Applied Force (N)	Area of Applied Force (m^2)	Pressure (Pa)	Pressure Coefficient (C_P)	Wind Speed	
					(m/s)	(km/h)
30	294.3	0.6 x 0.6 = 0.36	817.5	-1	36.9	132.9
30	294.3	0.6 x 0.6 = 0.36	817.5	-2	26.1	94.0
30	294.3	817.5	817.5	-3	21.3	76.7

4. CFD SIMULATION

The Computational Fluid Dynamics (CFD) simulation was carried out on 6 by 4 tiles with pedestals and wind plugs. The aim of the CFD study is to understand the flow over the tiles and the gap between the tiles. The tiles of 600 mm by 600 mm with 5mm gap arranged as shown in Figure 15. The outer edge of the tiles is covered by skirt as in a general construction.

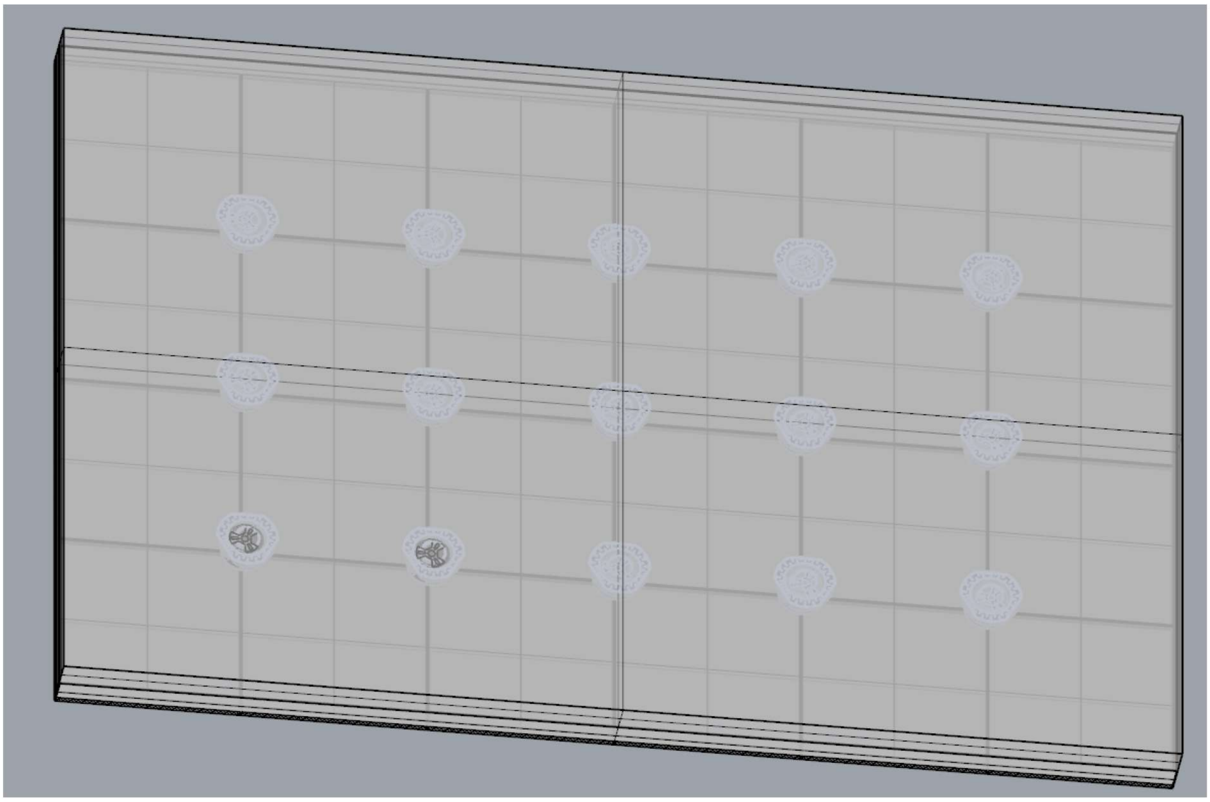

Figure 15: Geometry and arrangement of tiles and pedestals used for CFD study

A constant wind speed of 10m/s specified as inlet boundary conditions. The result of the CFD simulation shows that the wind distribution as the pressure distribution changed in the gaps between the tiles. The flow distribution show separation at the leading edge and uniform distribution after the leading edge. Figure 16 to Figure 18 shows velocity contour and vector plots for wind blowing over the tiles.

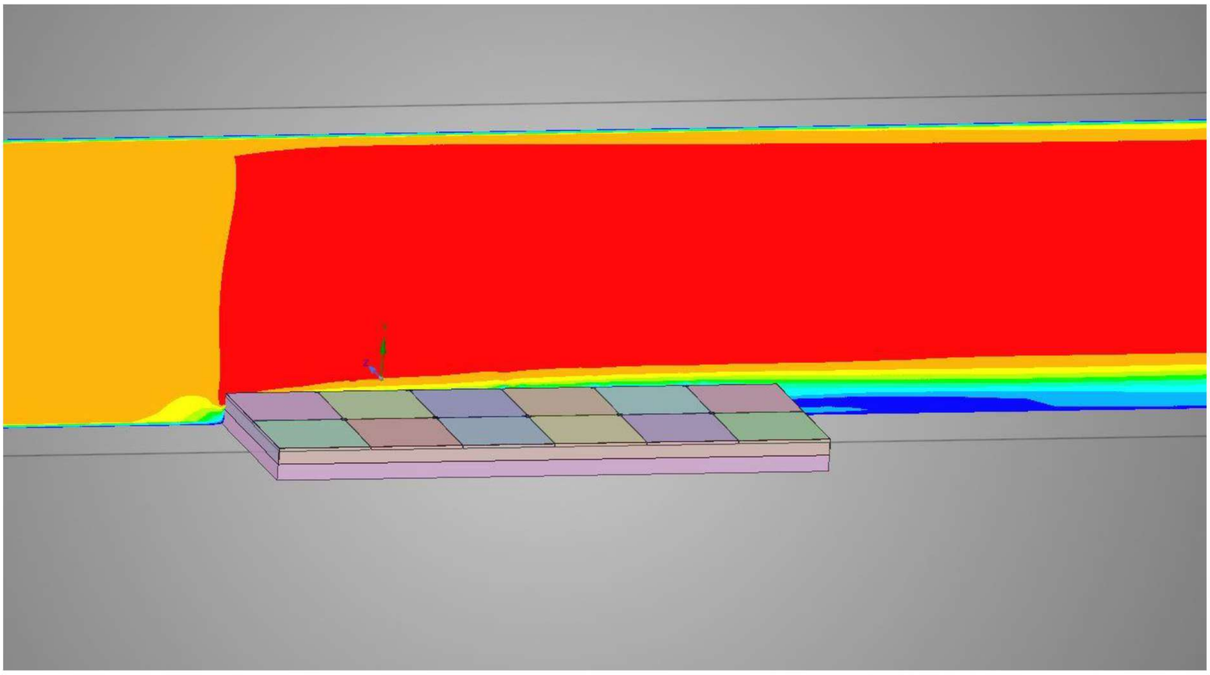

Figure 16: Velocity contour plot along the flow direction

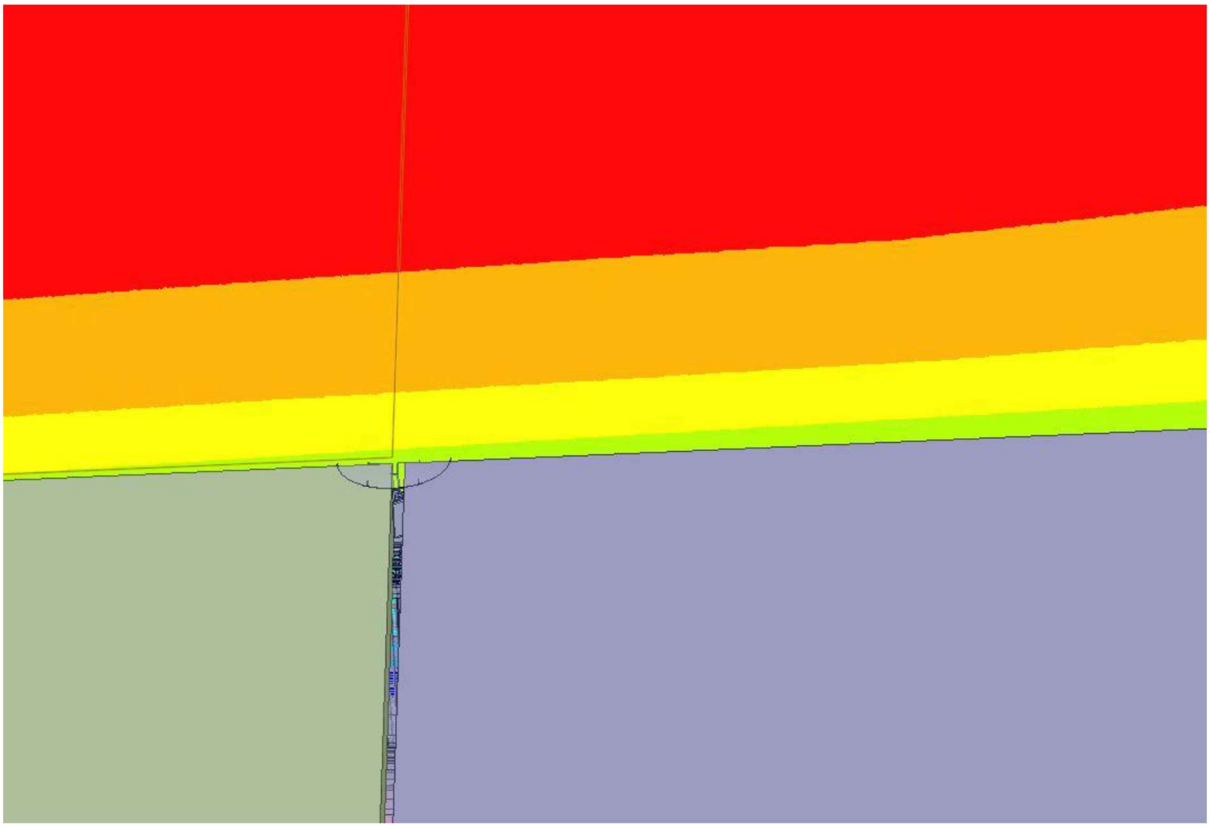

Figure 17: A closeup view of velocity contour plot along the flow direction

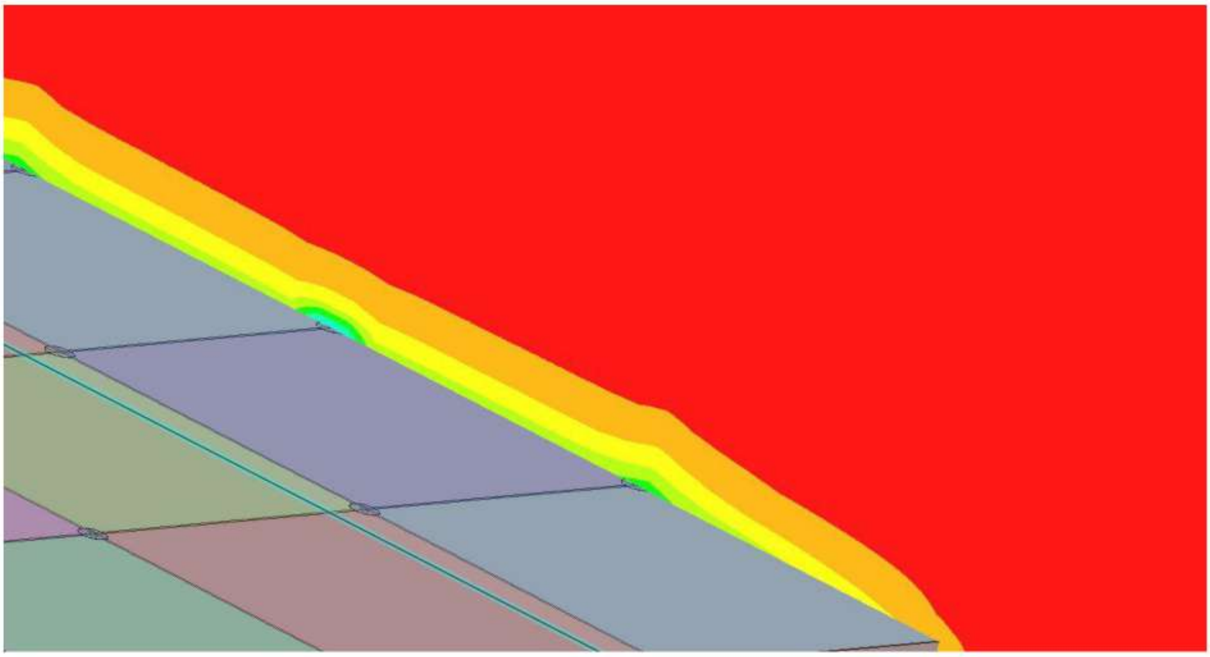

Figure 17: Velocity contour plot across the flow direction

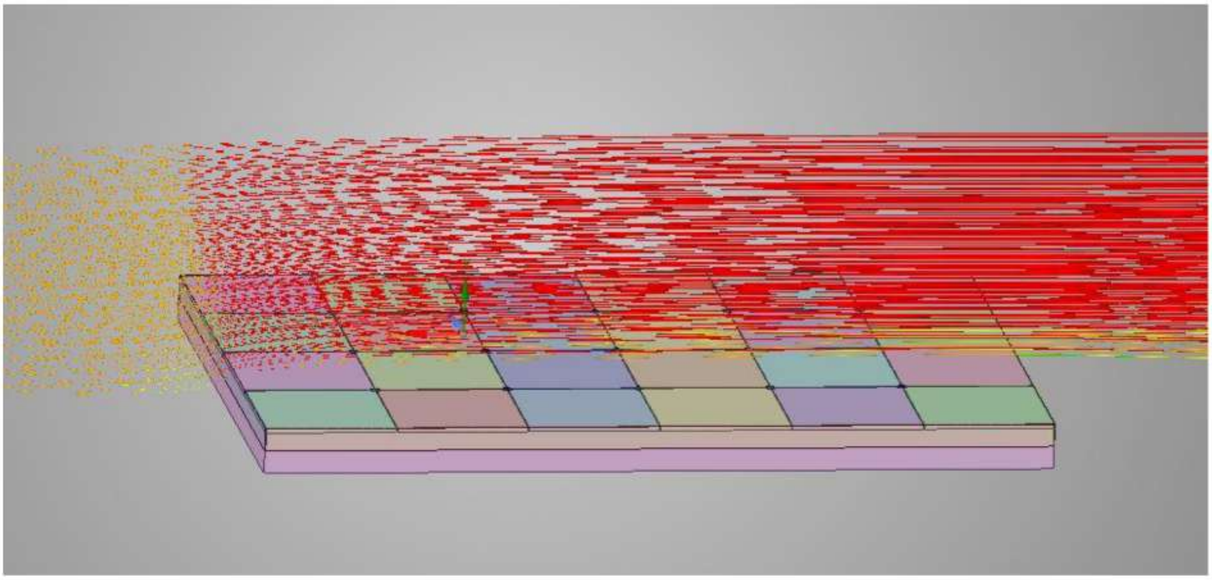

Figure 18: Velocity vector plot along the flow direction

5. CONCLUSION

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6. REFERENCES

1) Australian Standard 1170.2:1989, Wind actions
2) Australian Wind Engineering Society, "Cladding Pressure and Environmental Wind Studies" Quality Assurance Manual, 2001
3) AS/NZS 1170.2 Supplement 1: 2011