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SOME EXPERIENCES OF PROVIDING WIND SHELTER

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Introduction

A wind tunnel study has been performed to evaluate the combined use of a windbreak fence and a porous roof to provide shelter from the wind inside the structure. A considerable reduction in wind speed was achieved on a flat open site, but the shelter system was much less effective on a hillside site.

Wind shelter method

The aim of the study was to achieve low wind speeds near to the ground on a windy site without requiring a fully enclosed building. The area to be sheltered was approximately circular.

The combinations which were tested included a circular fence with a nominal diameter of 50m at full scale of various fence heights and porosities. Inside the fence there was a flat porous roof, 3m above ground level, of 50% porosity. The porous structures were to be constructed using long lengths of steel roof cladding, with gaps between the parallel panels. The fences were constructed with the panels mounted vertically.

Two alternative sites were considered. One was in a flat, open field. The other site was on an exposed hillside, about 30m above the base of the hill, with a steep upwind slope of about 0.8. A flat area was excavated into the hillside to accommodate the site

Wind tunnel test procedure

The tests were performed at a scale of 1:200, using a terrain category 2 boundary layer simulation. Wind speeds were measured using a standard hot film anemometer. The hot film wire was mounted vertically with its centre at a scale height of 0.4m above ground level for all the measurements. Wind speeds were recorded for 2 minutes, sampled at 1000 Hz and low pass filtered at 450 Hz. For the flat site, the measured turbulence (Vrms/Vmean) at this height was 0.22. Relative wind conditions were compared by calculating on effective wind speed defined as Veff = Vmean + 2.Vrms. Veff for the flat site was given a nominal value of 100. All other speeds have been calculated relative to this value.

Results for the flat site

Figure 1 shows a plot of the wind speeds at the centre of the area enclosed by the windbreak fence, for a range of fence heights up to 4m. Results are shown for:

- a 35% porous fence, on its own without the roof
- a solid fence, on its own without the roof
- a 35% porous fence, with the 50% porous roof at 3m height
- a solid fence, with the 50% porous fence at 3m height.

As the fence is circular, these measurements are largely independent of wind direction. The only directional effect is due to the orientation of the roof panels relative to the wind direction. The results shown are for the wind at 45 degrees to the lengthwise orientation of the roof panels (the wind blows parallel to the roof panels at 0 degrees).

The two solid lines in Figure 1 show the performance of a fence without the roof. The 35% porous fence achieves a steady reduction in wind speed as the fence height is increased. For 3m fence height the measured wind speed was 46. This compares with a speed of about 55 which would be expected 25m downwind of a long straight fence of similar height and porosity, with the wind blowing normal to the line of the fence., Extensive data on the effectiveness of straight fences is available from studies such as those by Raine and Stevenson (1977), and Gandemer (1981).

The solid fence performs similarly to, but a little worse than, the porous fence up to a height of about 3m. However, for 4m height the wind speeds for the solid fence are significantly higher than for 3m height. The increase in Veff is mainly due to an increase in the mean speed.

The two dashed lines show the combined effect of a fence and the porous roof. We found that the wind speeds were reduced when there was a gap between the fence and the roof. The results shown are for a gap of 2m.

At 3m height, the porous fence with the porous roof achieves a very substantial reduction in wind speeds within the structure. There is no benefit from a further increase in the height of the fence to 4m.

The solid fence, with the porous roof, performed much worse than the porous fence. Again, the wind speed increased significantly when the fence height was increased to 4m.

Figure 2 shows the effect of fence porosity, for a fence height of 3m, with the porous roof. The optimum fence porosity is about 35%. The 3m high, 35% porous fence, in combination with the porous roof, was therefore selected as the configuration best able to achieve very low wind speeds on a flat, exposed, windy site.

The distribution of the effective wind speeds inside the fence was measured for this configuration, for wind directions 0, 45 and 90. The lowest effective wind speeds of 12 occur in the centre of the circle, and the highest speeds of 16 occur near the windward side. Overall these speeds are relatively uniform over the whole area inside the fence. There is very little effect due to the orientation of the roof panels, the average wind speeds being about 10% higher for wind direction 0 (wind blowing parallel to the roof panels), and 10% lower for wind direction 90.

The wind speed distribution is much less uniform if the 2m gap between the roof and the fence is omitted. In this case the wind speed at the centre increases a little to 16, but the speed at the windward side increases substantially to 30.

Results for the hill site

Figure 3 shows the effectiveness of the 35% porous fence, without the porous roof, for the hill site. The comparable results for the flat site are shown again for comparison.

Partly due to the natural contours of the hillside, there was a 4m high earth bank some 5m upwind of the fence line. This bank, and the steep slope of the hillside upwind, combined to cause the effective wind speed at the centre of the bare hill site (zero fence height) to be significantly lower than for a flat site. However, whereas the turbulence intensity for the flat site was 0.22, for the hill site the turbulence intensity was 0.48, with a substantial vertical component in the wind flow.

It can be seen that the fence has virtually no effect on the wind speed at the centre of the hill site.

Figure 4 shows the effectiveness of the 35% porous fence, with the porous roof in place for the hill site. In this case, results are shown for the hill site 1 and hill site 2, where hill site 2 was the same as hill site 1 but with the earth bank partially removed. This modification increases the wind speed on the site without the fence.

From these results we can see that:

For hill site 1, the fence again produces little reduction in wind speed.

The results for hill site 1 are virtually the same as those in Figure 3. Therefore the porous roof has little beneficial effect on the wind speeds.

For hill site 2, the fence does reduce the wind speed somewhat.

With the high level of turbulence on the hill sites we were unable to reduce the wind speeds to the very low levels achieved on the flat site, except by substantially increasing the solidity of the roof. This would therefore essentially result in the construction of a conventional building on the site.

Conclusions

Very low wind speeds were achieved on a flat site by enclosing the space with a structure with porous walls and roof. Wind speeds were reduced to about 15% of the speeds for the bare site.

On a hillside site, with very turbulent wind conditions, the same porous structure provided little reduction in the wind speeds.

The effectiveness of the porous structure, which is intended to reduce wind speeds in the enclosed space, is therefore highly dependent on the nature of the wind flow conditions at the site. This variation in the wind effects on a structure due to the site details is much greater than would normally be anticipated.

Acknowledgement

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References

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Gandemer, J. (1981) : "The aerodynamic characteristics of windbreaks, resulting in empirical design rules". Journal of Wind Engineering and Industrial Aerodynamics. Vol.7.

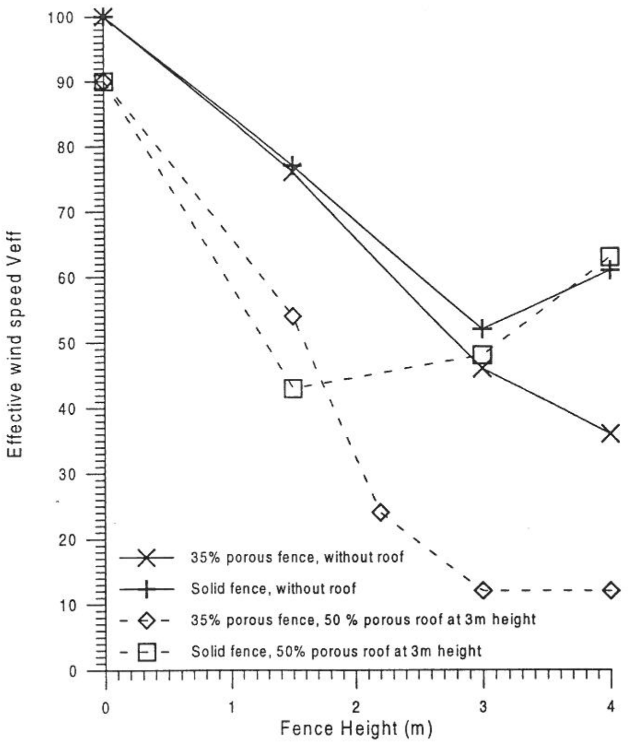

Figure 1. Variation of wind speed with fence height for a flat site

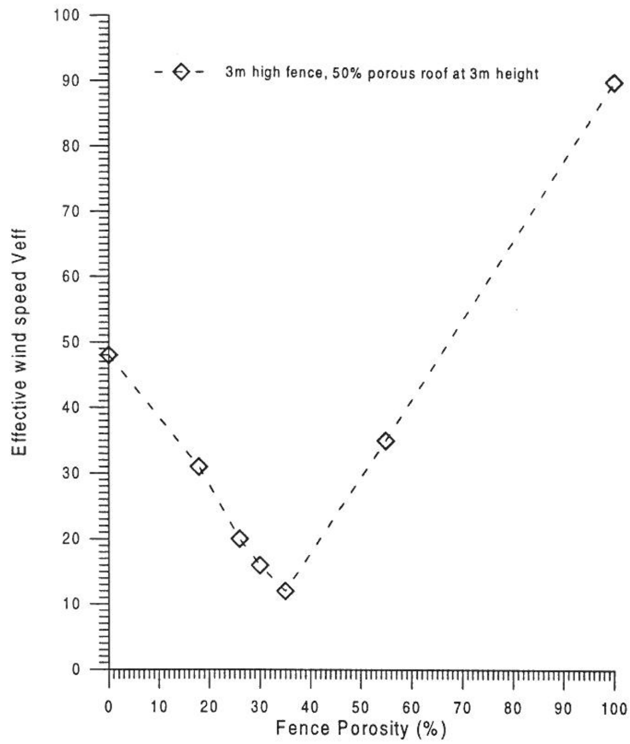

Figure 2. Variation of wind speed with fence porosity for 3m fence plus porous roof on flat site

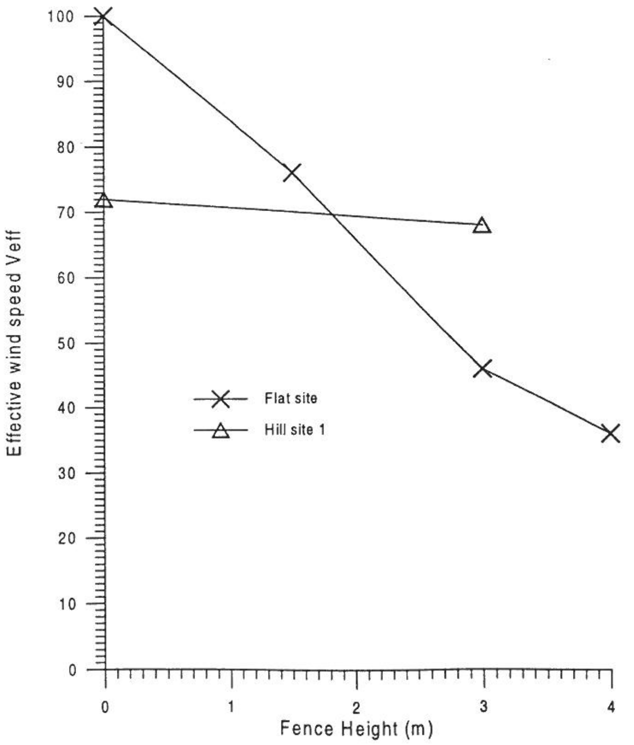

Figure 3. Variation of wind speed due to fence without roof on hill site

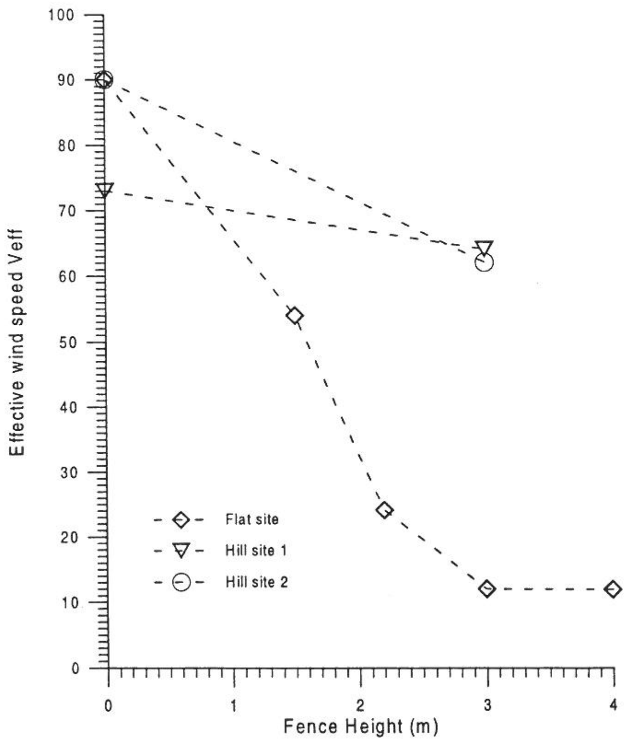

Figure 4. Variation of wind speed due to fence with porous roof on hill site