External Influences on Spray Patterns (EPAS)

Report 14: Model study of the effect of a wind-breaking net

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ABSTRACT

It is a goal to establish a high speed testing procedure where the salt is spread at the same driving speed as on public roads. Such high speed tests are in principle possible at the test road at Bygholm. The main problem with outdoor testing is to get performance data for the salt spreading equipment that is not distorted by wind. For cross winds it is possible to use wind-breaking nets. This will reduce the wind velocities close to the road and thus increase periods suitable for testing.

A model study was performed for a wind breaking net with 40% opening area on a wind table at Engineering Center Bygholm. It revealed that the net was effective in reducing the wind velocity. Downstream of the net the velocity close to the net was reduced to 40 % of the undisturbed air speed. The wind speed fell to a minimum of 24% and then increased further away. The turbulence intensity was slightly reduced close to the net and then gradually increased further downstream from the net.

The results may be used as an indication of the effect to be anticipated from a wind net alongside the test road. Supplemental full scale experiments are however needed to validate the model results.

INTRODUCTION

Testing of salt spreaders is traditionally performed at low driving speeds in the spreading hall at Bygholm. For future tests of salt spreaders it is a goal to establish a high speed testing procedure where the salt is spread at the same driving speed as on public roads. Such high speed tests are in principle possible at the test road at Bygholm.

The main problem is to get performance data for the salt spreading equipment that is not distorted by wind. For cross winds it is possible to use wind-breaking nets. This will reduce the wind velocities close to the road and thus increase periods suitable for testing.

A laboratory study was performed to get information of how effective a wind breaking net may be. The study was performed with a 50 x 100 cm specimen of a net with 40% opening area on a wind table in a wind tunnel at Engineering Center Bygholm.

EXPERIMENTAL FACILITY

The wind tunnel's working cross-section was 2.8m by 2.8 m. The length from inlet to a fan bank in the outlet was 10.7m. The fan bank consisted of 4 Skov A/S type DB 1400 axial fans frequency controlled by a Danfoss VLT micro drive providing a maximum average air velocity slightly in excess of 5 m/s.

A wind table was installed in the wind tunnel. The purpose was to study the airflow around primarily scale models of salt spreader trucks and the effect of associated equipment.

The advantage of the wind table compared to a smaller wind tunnel is that larger models can be studied without serious blocking effects; there is easy access for sensors to be placed in the right position and it is easy to take pictures or videos of local airflow patterns.

The wind table was 1.2 m wide and 3.0 m long created from available materials. This included wooden pallets placed on two office tables for easy working access to the table surface. The front edge was placed 4m downstream from the tunnel inlet to stabilize the air flow before reaching the wind table. An aerodynamically shaped nose was added to the table front edge to smooth the airflow's entry onto the table and create constant flow conditions along the length of the table.

The pallets were covered with a black rubber mat to provide an even surface. Visualization of air movements by illuminated smoke was facilitated by the black color of the rubber mat and flat black paper on the wall. The center line of the wind table, i.e. 0.6 m from the sidewall and distances from the front edge was marked with white lines to facilitate placement of models and velocity censors. A picture of the tunnel with wind table is shown in figure 1.

Figure 1. Wind tunnel with wind table.

Power to the fans was adjusted to 20 Hz during the experiments resulting in an average air velocity of ca. 3 m/s in the wind tunnel.

Air velocity and turbulence intensity was measured 20 cm above the table surface with a hot wire anemometer type Air Velocity Meter model 9555 Series from TSI. Position along the centerline of the wind table was defined by the distance from the front edge of the table, i.e. where the nose ended and the flat table started, figure 2.

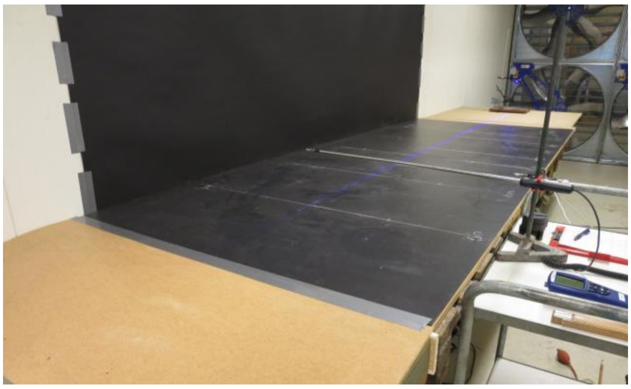

Figure 2. Measurement set-up for calibration of the wind table

REFERENCE AIRFLOW

The resulting variation in air velocity with no net on the table is shown in figure 3. It was 2.8 m/s in a reference point 50 cm from the front edge and increased nearly linearly to 3.0 m/s at the downstream end. The velocity in the reference point is used throughout this report as basis for determining the effect of a wind net.

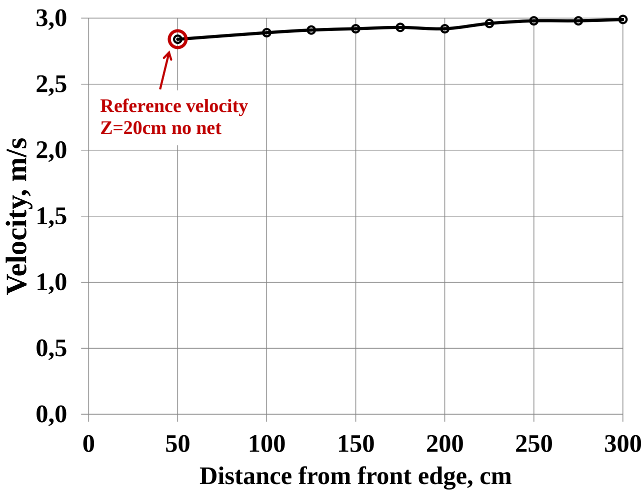

Figure 3. Air velocities 20 cm above the center line of the empty wind table

The variation in turbulence intensity is shown in figure 4. It was highest with 6,6% in the reference point and varied slightly between 4.8% and 6.1% with an average of 5.3% for the rest of the table.

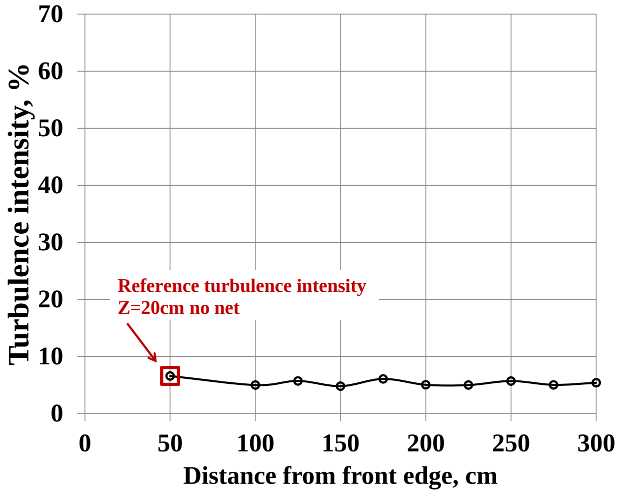

Figure 4. Turbulence intensity 20 cm above the center line of the empty wind table

EFFECT OF WIND BREAKING NET

A number of wind breaking nets are commercially available, made of different materials and with different shape and size of openings. The one selected for the study was made of green polyethylene and was marketed by Expo-net Denmark A/S for outside use in agriculture. The opening width of the holes was given as 5 mm, but as seen in figure 5 the opening shape is oval and of varying size. The openings in average were 72 mm^2 per 180 mm^2 of net equal to an opening area of ca. 40%.

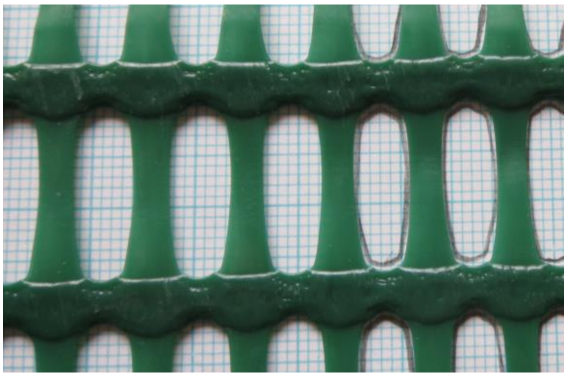

Figure 5. Close-up of wind breaking net

A sample of the wind net was attached to a wooden frame being 100 cm wide and 50 cm high. It was placed centralized and perpendicular to the centerline of the wind table 100 cm downstream from the front edge as shown in figure 6. The air velocity was measured in the reference point upstream of the wind net and at different distances downstream.

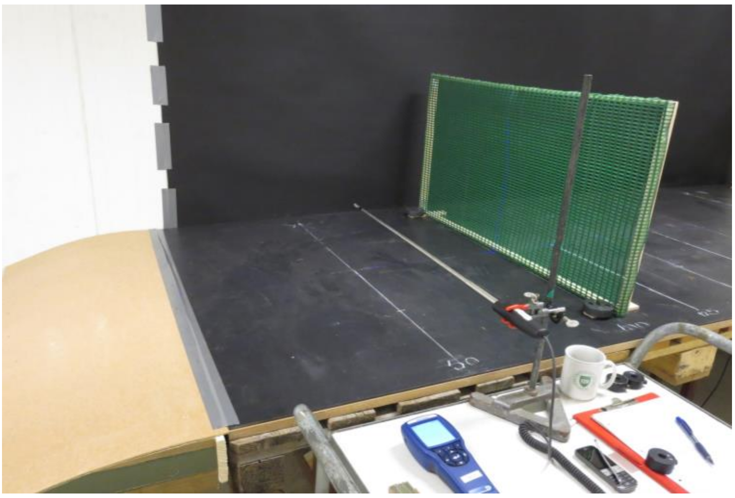

Figure 6. Wind breaking net on the wind table with anemometer in the reference point.

The measured air velocities are shown in figure 7. It is seen that the net reduced the air velocity upstream in the reference point from 2.8 m/s to 2.4 m/s. The velocity was reduced from 1.1 m/s at 25 cm to the net to a minimum of 0.7 m/s at 125 cm downstream from the net. The velocity then increased further downstream from the net.

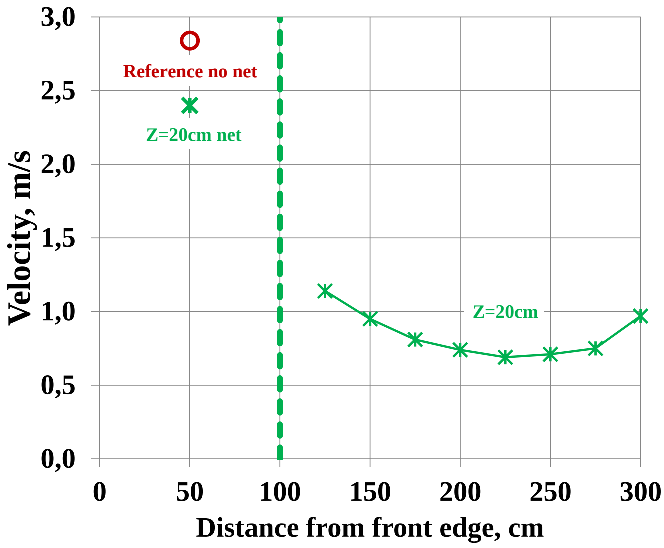

Figure 7. Air velocities 20 cm above the center line of the wind table with wind breaking net

The measured air velocities are converted to % of the reference velocity in figure 8. It is seen that the net reduced the air velocity upstream to 85% of the no net velocity. Downstream of the net the velocity close to the net was only 40 % of the no net velocity falling to a minimum of 24% 125 cm from the net and then increased further away.

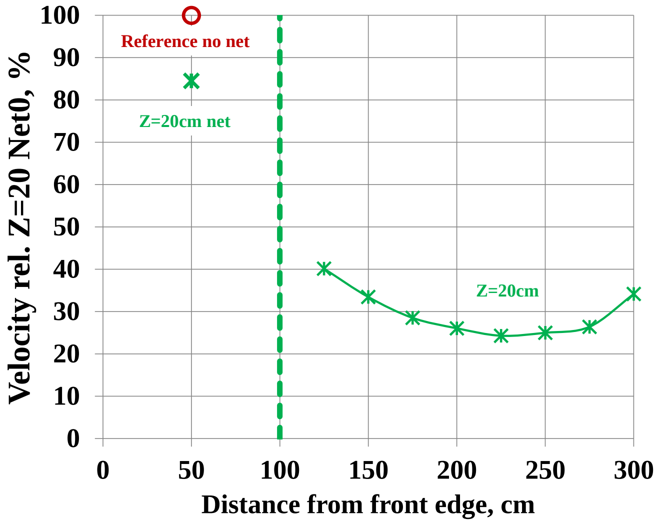

Figure 8. Effect of wind breaking net on the air velocities 20 cm above the center line of the wind table in % of the no net velocity.

The measured turbulence intensities are shown in figure 9. It is seen that the net had no effect on the upstream turbulence. The turbulence intensity was slightly reduced from 6.6% upstream to 5.9% 25 cm downstream of the net. The turbulence intensity then gradually increased further away from the net.

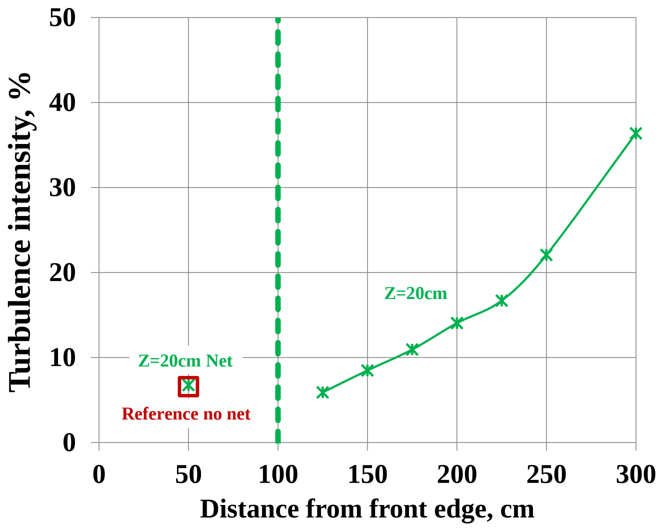

Figure 9. The effect of wind breaking net on the turbulence intensities.

DISCUSSION

The results from the model tests on the wind table may be used as an indication of the effect to be anticipated from a wind net alongside the test road. It is expected the effect may be scaled up to the full scale height. Assuming the full scale is selected at 5 m height is a scaling up factor of 10 relative to the model net's height. The maximum reduction in air velocity downstream of the model net was found at distance 125 cm which would be equivalent to 12.5 m at full scale. The net could thus be placed 2.5 m from the test road side to achieve the best effect at the middle of the road.

This reasoning may be a first best guess, but a number of factors may modify the result. First of all the effect was measured with a 100cm wide model net placed centrally on the 120 cm table. The airflow was only measured in the central plane and 3 dimensional flows near the wall and at the side edge of the table was not included in the study. In full scale the net would be longer than two times the height of the net to provide a sufficient long test section of the road protected behind the net.

The airflow direction on the wind table was perpendicular to the net. In real wind the wind direction is continuously changing. Furthermore initial measurements of the real wind have indicated much higher turbulence intensity than measured on the wind table. Finally no effort has been taken to get a specific vertical wind profile on the wind table. Supplemental full scale experiments are needed to validate the model results.

CONCLUSIONS

The model study of a wind net with 40% opening area revealed that the net was effective in reducing the wind velocity. Downstream of the net the velocity close to the net was reduced to 40 %. The wind speed fell to a minimum of 24% and then increased further away.

The turbulence intensity was slightly reduced from 6.6% upstream to 5.9% closely downstream of the net. The turbulence intensity then gradually increased further downstream of the net.

The results from the model tests on the wind table may be used as an indication of the effect to be anticipated from a wind net alongside the test road. Supplemental full scale experiments are however needed to validate the model results.