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Ventilation of the Attic due to Wind Loads on Low-Rise Buildings.

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1. INTRODUCTION

The designs of eaves are important in wind-exposed areas. If the ventilation rate is too large, snow or rain can be driven into the attic and this can cause serious damages to the ceilings. Ventilation of roof is also important for preventing condensation of the humid indoor air. These two problems have opposite solutions since preventing snow and rain must reduce the ventilation rate, while preventing condensation must increase the ventilation rate. It is important to bear this in mind when a house is placed in the terrain.

The objective of this work is to investigate how the design of the eaves influences the ventilation rate of a cold attic. For a typical Nordic low-rise building, a two-dimensional simulation of the wind pressure around a detached house with gable roof of wood is performed. Both the inclined and horizontal cladding designs have been examined. The results presented here comes from: Wiik 1992.

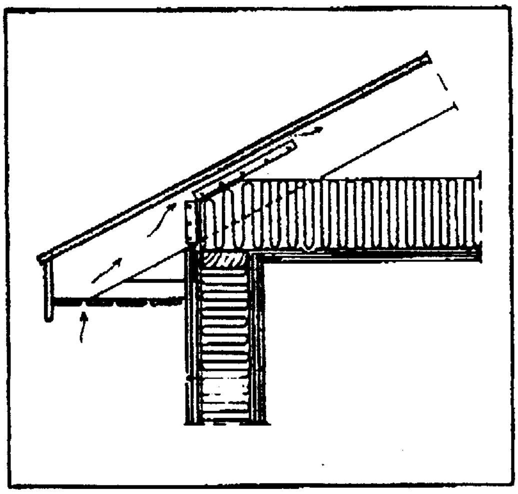

Figure 1 Detail of a typical Nordic eaves design , (Trehus 80, håndbok 34, NBI, 1982)

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The simulations have been performed with the software FLOW-3D (1991) on a HP-9000/720 computer at Narvik Institute of Technology (SIN). The calculation time of the different simulations took about 2.5 hours in CPU-time. This work is a preliminary part of a project called SNOW-SIM (Nielsen 1993) at SIN.

2. NUMERICAL MODEL

2.1 Numerical method. The program FLOW-3D is using finite difference and volume fraction method. By using volume fractions the program calculates how much of each cell that contains fluid and obstacle.

2.2 Boundary conditions. Figure 2 gives the boundary conditions. The inlet wind profile. is logarithmic. u-max 30 m/s (x-direction) at top boundary. At right side (outlet) is there Neumann condition, it means no acceleration over the border ($\partial u/\partial x = 0$ and $\partial w/\partial z = 0$). At top boundary is there Dirichlet condition, $u = 30$ m/s and $w = 0$ m/s, it means no outflow over the border. At the bottom boundary is there free-slip wall. That is not like the real world, but no friction at the "wall" allows faster calculations.

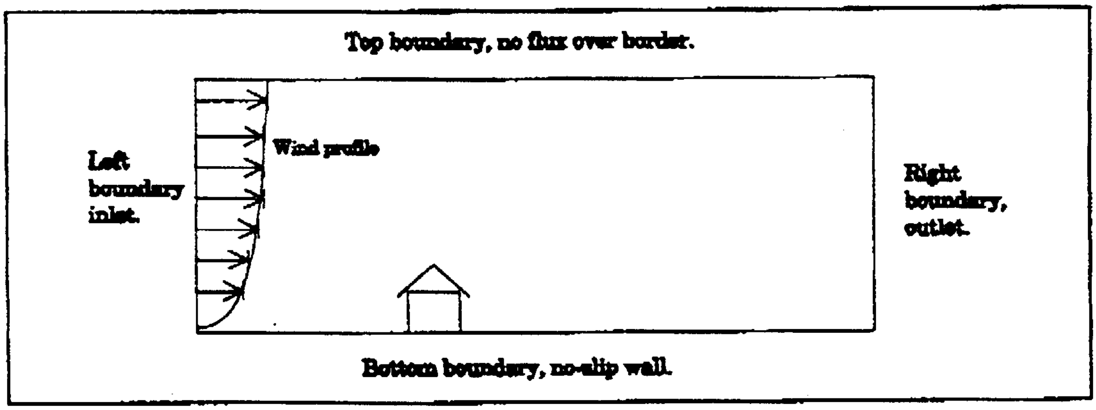
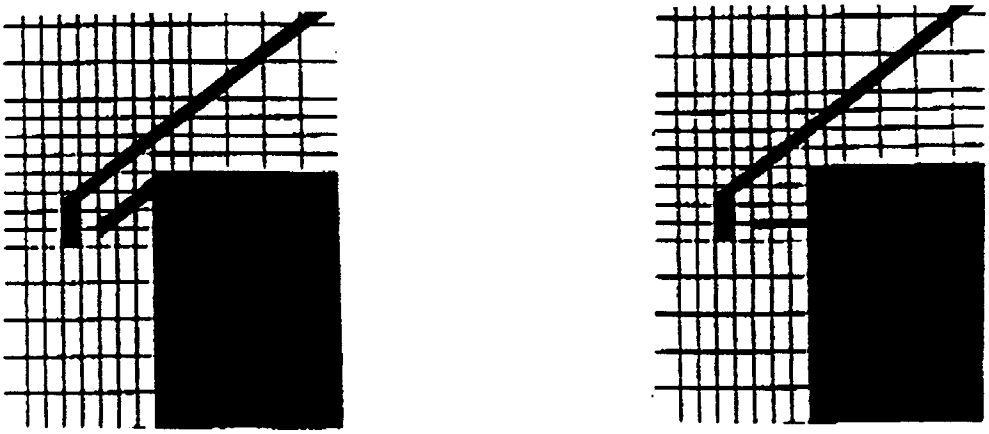


Figure 2 Boundary conditions.

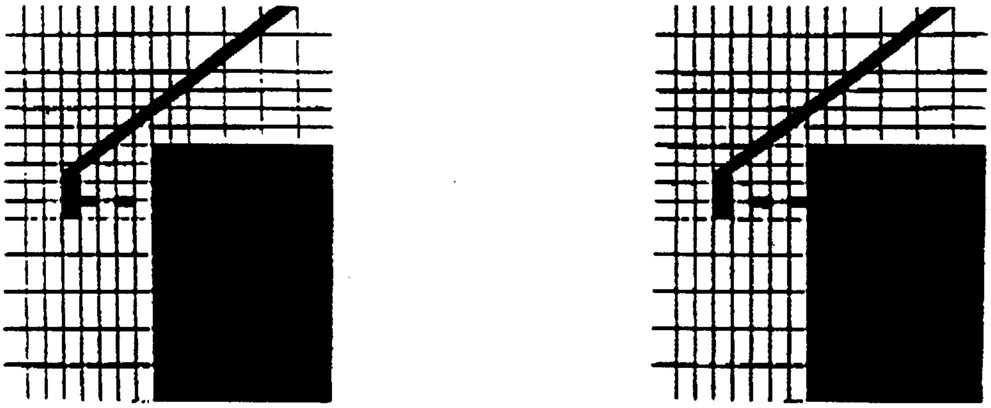
2.3 Domain size. Total number of nodes is 2412, 67 nodes in x-direction and 36 in z-direction. The distances in the x and z plane are 126 m and 30 m. Overall building model is 9,4 m high and 8 m width, upstream distance is 24 m. These distances are in accordance with recommendations from Baskaran and Stathopoulos 1991.

2.4 Design of the eave. Four different typical solutions on low-rise building eave designs have been considered. Figure 3 below, show the details of the simplified geometric solutions who have been choosen for the numerical simulations. The degree of accurancy of the geometric models depend on how fine grid sizes we choose. The smallest cell size is 0.25 m and the eaves extension in x-direction is 1 m., which is twice the extension for a normal eaves design.



Simulation 1

Simulation 2



Simulation 3

Simulation 4

Figure 3 Different eaves design used in the simulations.

3. RESULTS

First the inclined and horizontal cladding designs was investigated. To measure the wind speed I has choose two reference-cells (1, 2), see figure 4.

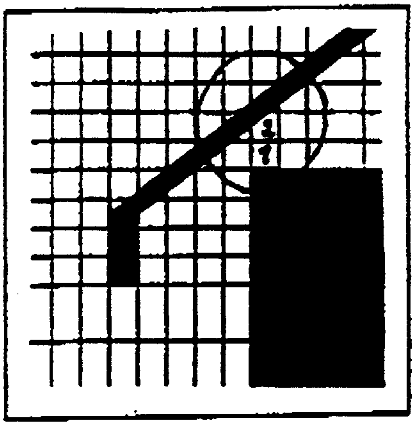
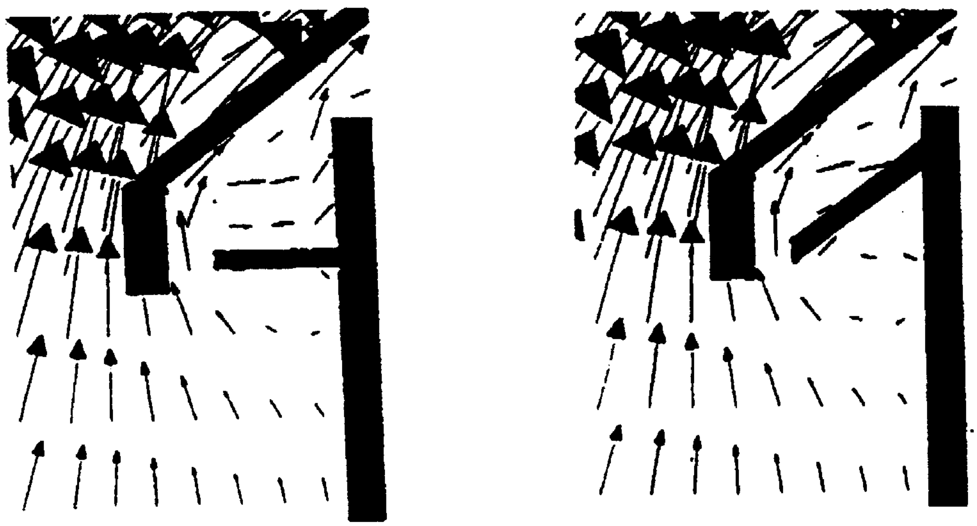


Figure 4 Reference cells for measuring of windspeed into the attic.

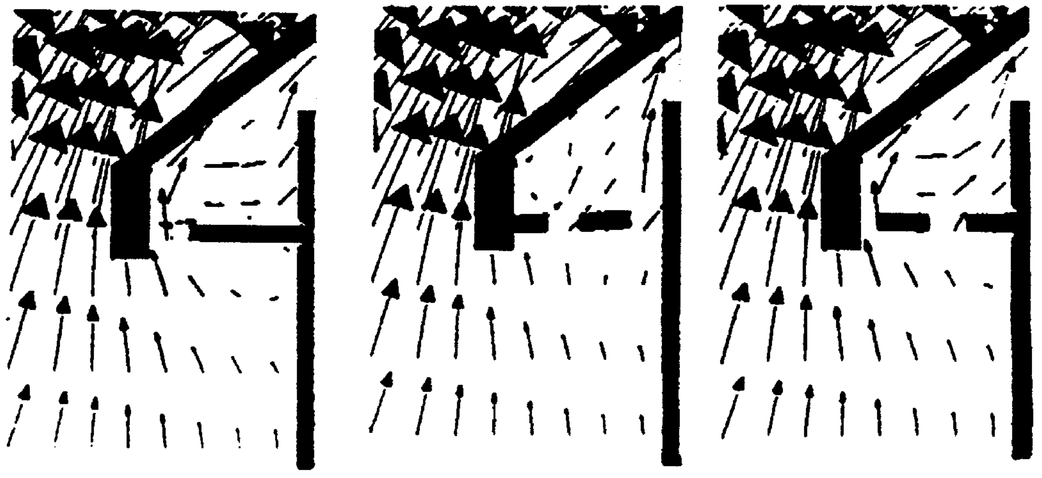
The results shows that the wind speed into the attic through the horizontal and inclined cladding at the references cell was 4.8 m/s and 4.3 m/s. This result indicate that horizontal cladding design gives 10 % higher ventilation rate than the inclined cladding (see figure 5).



Horizontal cladding, ref. speed is 4.8 m/s. Inclined cladding, ref. speed is 4.3 m/s.

Figure 5 Vector plots of wind speed and direction, for inclined and horizontal cladding

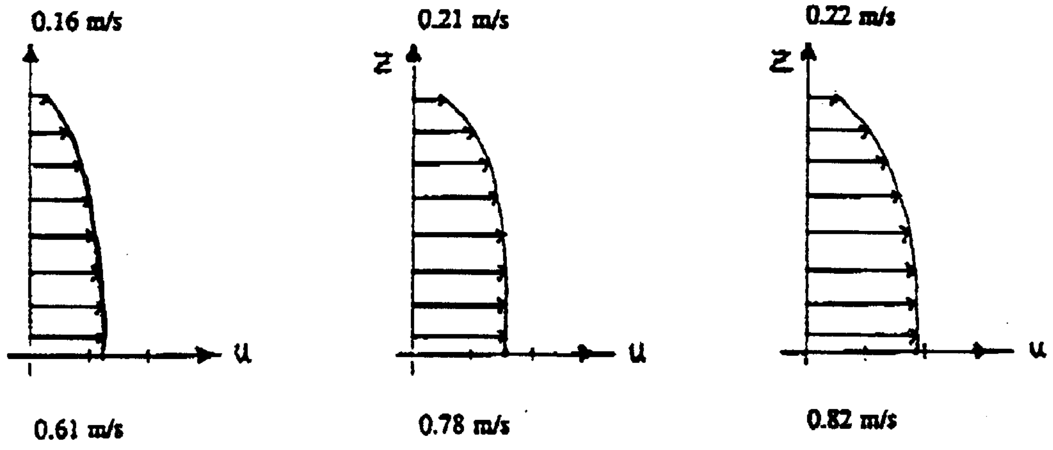
The next step was to examine different types of gaps to the horizontal cladding. Three different models were compared, simulation number 2, 3 and 4 (figure 6).



Simulation 2. Simulation 3. Simulation 4.

Figure 6 Vector plot of wind speed and direction for horisontal claddings with different placing of gaps.

The results show that the wind speeds (in x-direction) for the different models (2,3 and 4) were 4.8 m/s, 6.3 m/s and 6.6 m/s at the reference cells. In middle of the attic are velocity profile for the models shown in figure 7.



Simulation 2. Simulation 3. Simulation 4.

Figure 7 Velocity profiles in the the middle of the attic for the three simulations (2, 3 and 4).

5.0 CONCLUSION.

The simplified geometric models that are used in this report show that horizontal cladding causes larger ventilation of the attic than inclined cladding. With a horizontal cladding design it is obvious that the model with two gaps has larger ventilation effect than the model with only one gap. The results show also that the placing of the gaps have an effect of the ventilation rate. The model in simulation 4, with the gaps placed nearest to the fascia gives the largest ventilation of the attic. These results do not directly indicate the problems with snow driving into the attic, as this depend on several others parameters. Further investigations will be done at SIN into the studies of wind loads on building details.

The conclusion of the simulations is that Computational Fluid Dynamic (CFD) has a future, as a tool for predictions of flow field around buildings. Furthermore this report show that also details on building could be inspected by use of CFD. Since these 2-D simulations where done, we have got a better presentation program (FIELDVIEW) at SIN. With this program we are able to view the results from FLOW-3D in color plots in many ways. We have used this program to view the results of the last work done at this field in Narvik , which are 3-D simulations of flowfield around houses (Bang, Wiik 1993).

6.0 REFERENCES.

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