# Wind comfort and solar access in a coastal development in Malmö, Sweden

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## 4C.3 WIND COMFORT AND SOLAR ACCESS IN A COASTAL DEVELOPMENT IN MALMÖ, SWEDEN

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### 1. INTRODUCTION

People in urban areas are exposed to a number of strains: noise, air pollution, thermal stress, etc. In stressful urban environments public spaces such as squares, waterfronts and parks and semi-private spaces such as courtyards provide important places for rest, leisure and commercial activities. (Szűcs, 2013)

Strong, cold winds constitute a problem in southern Scandinavia with its flat terrain. Although wind speeds are considerably lower in urban areas they are nevertheless problematic, especially for neighbourhoods situated in the outskirts of cities or along the coast. The lack of thermal comfort in this region is further aggravated due to poor solar access large parts of the year being the result of the high latitude and high amount of cloudiness.

Previous studies in cold and temperate climates with strong winds have concluded that both wind shelter and solar access is needed to encourage street life; a poor microclimate will result in lower frequentation of public spaces (e.g. Bosselmann et al., 1995; Lenzholzer, 2012; Szűcs, 2013; Westerberg, 2009). When the microclimatic conditions do not favour outdoor activities, optional activities (Gehl, 2001) tend to move from outdoors to indoors to e.g. shopping malls (Bosselmann et al., 1995; Westerberg, 2009).

Much of the current urban development in Swedish cities is in the form of densification, e.g. adding buildings to low density areas and transforming former and existing industrial areas to mixed development. In the southernmost region of Sweden, Scania, urban areas are surrounded by high quality farmland and therefore currently there is an aim to avoid horizontal expansion.

As in many parts of the world there is a trend in Sweden to build high-rise buildings, landmarks. Such buildings are well known to cause wind problems at street level and reduced solar access (e.g. Bosselmann et al., 1995;,ASCE, 2004; Reiter, 2010).

In the city of Malmö in the southernmost region of Sweden there are several new ongoing and planned large development projects, many of which are being constructed in wind exposed areas. These areas are situated at the outskirts of the city, either next to flat farmland or along the cost.

One of the planned areas is Nyhamnen (New Harbour), a former industrial harbour area in the north of the city. Although quite centrally located, it is exposed to strong winds, especially from southwest, west and northwest.

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This paper analyses a proposed design for the Nyhamnen district as regards wind control and solar access.

### 2. METHOD

The studied Nyhamnen area, which has a size of approximately 90 hectares, is very centrally located in the city of Malmö, just north and east of the main railway station, see Fig. 1. The area is exposed to strong winds from the Öresund strait to the west.

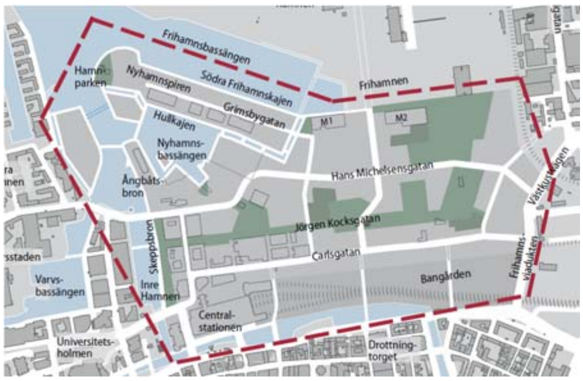


Fig. 1 The studied area Nyhamnen in Malmö (Malmö Municipality, 2018).

A master plan for the area has been developed by the municipality (Malmö Municipality, 2018). According to this the aim is a compact, green and mixed use neighbourhood with high building density. The urban structure will be based on traditional building blocks with building heights of 5 to 6 floors. However, the aim is to have variation in building heights including heights above 6 floors, especially near parks, waterfronts and wide streets.

Fig. 2. Preliminary urban design of the district Nyhamnen in Malmö. Buildings in the southwest corner constitute existing buildings. A more detailed analysis was made for the area within the red square.

A preliminary urban design of the district was provided by the municipality of Malmö, see Fig. 2. To a large extent the design follows the common design in the city with courtyard blocks. This is an urban design which has proven to create a good microclimate in this climate. Taleghani et al. (2014) assessed microclimate and thermal comfort for different urban forms in the Netherlands and found it to be the most favourable in summer. Also in winter courtyards work well as they create wind protected courtyards and are traditional in the region (Glaumann and Westerberg, 1988). If the height-to-width ratio of the courtyards are not too big, they also provide fairly good solar access. Moreover, the courtyards can be used as a semi-private area by the dwellers.

a)

b)

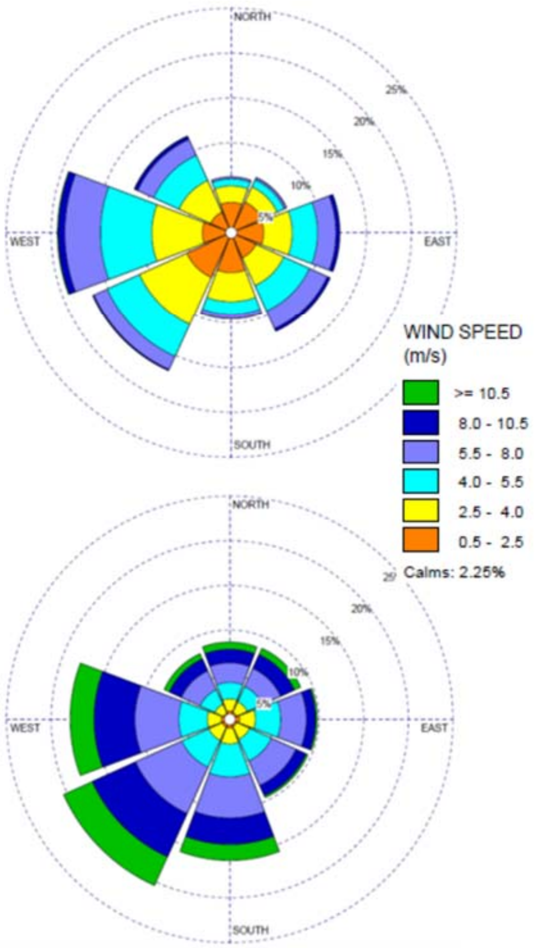


Fig. 3. Wind roses from two stations in Malmö, a) Jägersro 1996-2016 (Southeastern part of the city) and b) Oskarsgrundet 1985-99 (In the Öresund strait west of Nyhamnen)

## 2.1 The climate of Malmö

Malmö has a coastal climate with relatively mild winters for its latitude and not very warm summers. The winds in the region are mainly coming from the west and southwest. The wind roses of the official weather station situated in the southeast of the city and a temporary station in the Öresund strait west of Nyhamnen are shown in Fig. 3. Although the dominating wind directions are basically the same, the two stations show somewhat different patterns as regards wind directions; this could partly be due to different measurement periods. It is noticeable that the wind speeds are significantly lower for the suburban station compared to the off shore station.

The solar radiation varies greatly in Malmö depending on the season; in the summer it reaches almost 20 MJ/(m², day) whereas in winter it is as low as 1 MJ/(m², day), see Fig. 4.

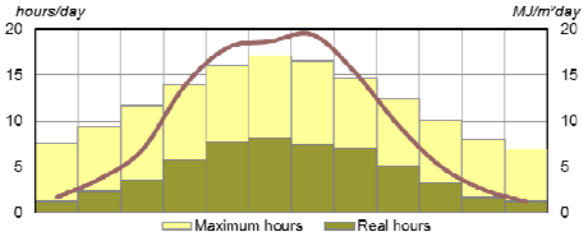


Fig. 4. Monthly variation of sunshine hours and solar radiation in Malmö.

Thermal comfort is poor most of the year as can be seen in Fig. 5 which shows how the Physiologically Equivalent Temperature (PET), which takes into account all the climate variables that affect thermal comfort, varies yearly and diurnally. For most parts of the year outdoor thermal comfort is poor due to low air temperature, strong winds and low solar radiation. Only during daytime in the months of July to August comfortable conditions (PET > 15°C) occur.

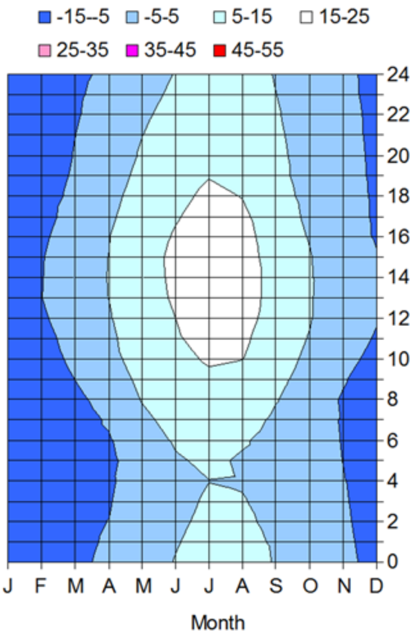


Fig. 5. Yearly variation of average PET in Malmö.

### 2.2 Wind Simulations

The wind conditions in the area according to the preliminary design was evaluated using Autodesk CFD. The advantage with this programme is that it is relatively user friendly and compatible with AutoCAD used by architects (Ebrahimabadi, 2015). The programme uses the k-ε turbulence model. The 3D model of the urban area should be enclosed by a computational domain which is considerably larger than the studied built-up area (Blocken et al., 2007), see Fig. 6.

Although there are some seasonal and diurnal variations in wind speed, average wind data for the whole year was used in this study. Simulations were performed for the wind directions west and southwest, each of which occur about 20% of the time, respectively.

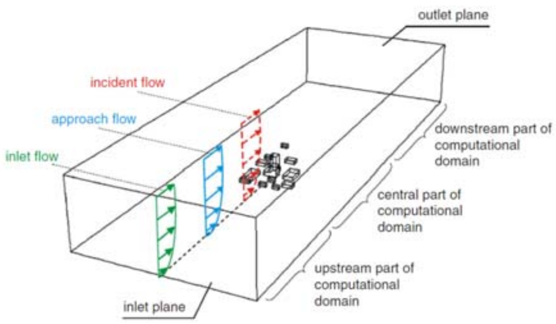


Fig. 6. Box surrounding the computational domain. (Blocken et al. 2007)

In general the Nyhamnen area is exposed to high wind speeds due to the proximity to the Öresund strait. However, the surrounding built-up areas have a decelerating effect on the wind speed. The reduction in wind speed is different from different wind directions. The effect of surface roughness on the wind speeds was assessed qualitatively for different wind directions. For westerly winds the wind speed is decelerated by the existing buildings just west of Nyhamnen. Consequently, the westerly wind speed (at 10 m height) was assumed to be 5.9 m/s, i.e. slightly lower than the off shore wind speed. The southwesterly wind speed was assumed to be 5.0 m/s; for this direction a larger urban area is decelerating the wind before reaching Nyhamnen.

Wind requirements developed in Sweden according to Glaumann and Westerberg (1988) are shown in Table 1.

### 2.3 Studies of solar access and shade

Solar access and shade in the area during different seasons – the equinoxes and the summer solstice – and different hours of the day were studied using SketchUp. A smaller area was chosen for a more detailed analysis as indicated in Fig. 2.

The criteria on solar access was that at least one street pavement should be exposed to solar radiation during part of the day and that the courtyards should be exposed to solar radiation at least a few hours per day.

Table 1. Wind criteria according to Glaumann and Westerberg (1988)

| Wind speed at 2 m (m/s) | Effect felt by humans | Planning measure |
|---|---|---|
| <2.5 | Not windy | Wind protection of places to sit might be necessary |
| 2.5–4.0 | Slightly windy | Places to sit and balconies need wind protection |
| 4.0–5.5 | Windy | Public space and footpaths need local wind shelter |
| > 5.5 | Very windy | Urban and landscape design need to consider wind control |

## 3. RESULTS

### 3.1 Wind simulations

Figs. 7 and 8 show that higher wind speeds occur around building corners, especially at the beginning of street canyons exposed to the wind and along streets and promenades oriented along the prevailing wind directions. Problematic places also include corners of high-rise buildings and larger public spaces. In these areas the average wind speed is in many places above the threshold value of 4.5 m/s according to Table 1.

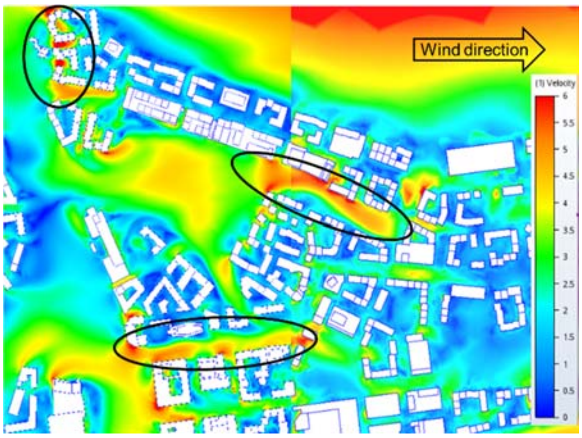


Fig. 7. Results of the wind simulations for winds from west.

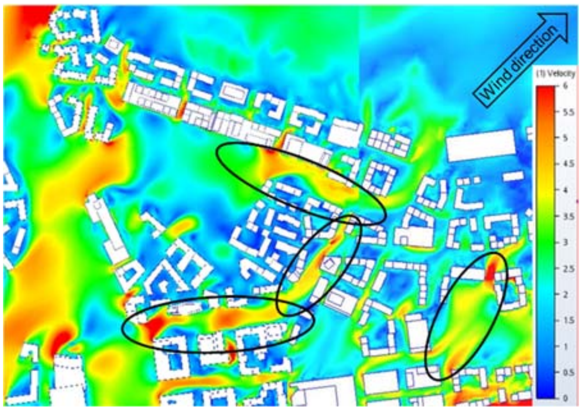


Fig. 8. Results of the wind simulations for winds from southwest.


Fig. 9. Shade patterns in central Nyhamnen on 21st March/September at 9 a.m., noon and 3 p.m.


Fig. 10. Shade patterns in central Nyhamnen on 21st June at 9 a.m., noon and 3 p.m

### 3.2 Shade analysis

The shade patterns at 09.00 a.m., noon and 03.00 p.m. for the equinoxes and the summer solstice are shown in Figs. 9 and 10. Whereas the waterfront promenade and most streets have acceptable solar access, all courtyards have too much shade due to the fact that the proposed building heights are too high in relation to the size of the courtyards. This is especially evident in March/September; at this time of the year the courtyards are basically completely in shade, even at noon, see Fig. 9. In June the situation is better but solar access in the afternoon is still poor, see Fig. 10.

The high height-to-width ratio of streets and courtyards will also have a negative effect on daylighting, especially for apartments and offices near the ground.

## 4. DISCUSSION

The wind conditions in the area are acceptable in the courtyards and most public spaces. However the waterfront promenade and some streets oriented along the prevailing wind directions are more problematic.

It is suggested to design the quayside in such a way that it deflects the wind over pedestrians along the waterfront promenade, see Fig. 11.

It is also suggested to plant trees along the wind exposed streets and promenades, especially at street entrances exposed to dominating winds and along streets oriented in the prevailing wind directions, West and Southwest, see Fig. 12.

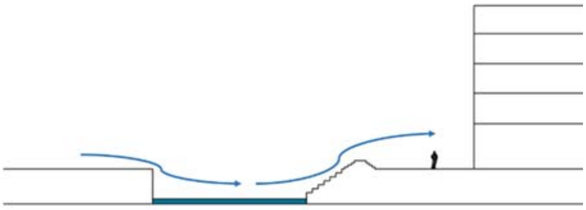

Fig. 11. Design of the quayside at the waterfront promenade in order to deflect the wind over the pedestrians.

Fig. 12. Planting of trees along the waterfront promenade and the main street in order to reduce wind speeds.

In order to improve solar access in the courtyards and along the streets, it is suggested that buildings to the south and west be maximized to 5 floors (except for a few higher buildings). This improves the solar access significantly, see Fig. 13.

The high-rise towers have not been lowered at this stage but it should be noted that they reduce the time of solar access on pavements and in some courtyards. Thus, it could be considered to lower the height of these landmarks as well. Moreover, for really narrow courtyards a solution may be to have a few even lower buildings – or even remove buildings – to achieve solar access at least some part of the day.

Public spaces like squares and streets have good solar access in general. In fact, to these places shade elements (trees, pergolas or shading devices) need to be added to offer shade during warm summer days. In public spaces it is important to create a variety of microclimates with the possibility to choose where to stay. In spring and autumn when the air is cold, spots with a combination of solar access and wind shelter are needed. On warm summer days places with shade and/or good ventilation are needed.

Future studies will include a more detailed analysis where the suggested measures to reduce wind speed and increase solar access will be validated. The aim is also to calculate a thermal comfort index to map spatial distribution of thermal comfort in the area to identify critical spots.

21 March, 9 a.m

21 June, 3 p.m

Fig. 13. Shade patterns in central Nyhamnen on 21st March/September at 9 a.m. and on 21 June at 3 p.m. The dark buildings have been lowered to 5 storeys to allow for more solar access in the courtyards and in the street.

**ACKNOWLEDGEMENTS**

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