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EXTREME WIND CONDITIONS IN THE VATS- AND YRKEFJORD: UPDATED NOVEMBER 1985 FOR POSITIONS C, D and E

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The design wind criteria for positions C, D and E in Vats- and Yrkefjorden are checked and partly revised on basis of directional analysis of extreme winds on Utsira and Digernessundet, and of wind measurements on the island Kattrauv in the fjord.

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1. INTRODUCTION

The last evaluations of the extreme wind conditions in the Vats area were performed in November 1983 [1], and was mainly based on wind tunnel tests on a topographical model of the area [2]. During the last 2 years both other extreme value analysis are performed and an automatic weather station (aws) has been operating in the area. This has legitimated an updating og the wind speeds in the Vats- and Yrkefjord.

2. RECENT DATA AND ANALYSIS

2.1. Wind measurements in Vats.

The automatic weather station on the island Kattrauv in the mouth of the Vatsfjord has been in operation since May 1983. There are some lacks in the data due to different causes, the most serious is a failure in the wind direction sensor. A separate report is under preparation for this station. The data are mainly used to check the wind tunnel results. Unfortunately, the local wind conditions on this island are highly variable and strongly influenced by the steep hillsides in both fjords. Thus, the standard deviations are high in the results from this point. However, the reduction factor from the 850 mb wind to the 10 m wind on Kattrauv is found to be 0.44 for 75 cases with strong upper air wind, (all direction) while the wind tunnel gave 0.53, 0.38, 0.35 and 0.47 for 90^{o}, 165^{o}, 180^{o} and 260^{o} respectively for the same location. These values must be said to be of the same order of magnitude, and therefore supports the wind tunnel measurements as long as the gradient wind are correct for the directions 165^{o}, 180^{o} and 260^{o}.

2.2. Extreme value analysis for Sola and Utsira.

Extremes of 10 minutes mean wind speeds are calculated for Stavanger Airport, Sola, and Utsira lighthouse based on respectively 26 and 23 years of recorded extremes. The values with 10 and 100 years return period (winter) are given in table 1.

Table 1. Extreme 10 minutes wind speeds (m/s) for Sola, Utsira and the "approach" flow (165^{o}, 180^{o} and 210^{o}) for the wind tunnel tests.
Reference height: 10 m.

Return period:	10	100 years
Sola	25	31
Utsira	33	38
"Approach flow"	26	34

Table 1 also gives the estimated 10 masl values for the "approach flow" in the wind tunnel tests. Based on analyses of the wind in the 850 mb level above Sola (1200-1400 masl), the gradient wind was chosen to 45 and 60 m/s respectively for return periods 10 and 100 years. From [2] it can be found that the corresponding 10 m values are 26 and 34 m/s ($\alpha = 0.13$ in the "power law", and the depth of the boundary layer of 800 m). These values are between the Sola and Utsira values as should be expected from the exposition of the two sites. Thus, the "all direction" extremes for the actual area are confirmed.

2.3. Directional analysis for Utsira and Digernessundet.

A directional analyses is performed on 23 years of recorded wind speeds from Utsira. Seasonal (September - April and May - August) extremes are found for the eight main sectors and the preliminary results are presented in [3]. The values

for return periods 2, 10 and 100 years are given in table 2.

Table 2. Extremes of 10 min. mean wind speeds (m/s) for Utsira for 8 sectors.
Season: September - April.

Return period Years	Direction N	NE	E	SE	S	SW	W	NW
2	24	17	18	25	25	23	26	27
10	31	21	23	31	28	28	31	33
100	36	24	27	36	33	32	36	38

It is seen from table 2 that the strongest winds are expected from the sector W-N and around SE.

The main purpose of [3] was to estimate the directional extremes for Digernessundet, Stord. Based on nearly 2 years of wind records near Digernessundet, many cases with strong winds from all main sectors were compared with the wind records from Utsira and the synoptic weather patterns were studied as well. It was then possible to transfer the Utsira extremes to the inshore area. This study will be presented more detailed in the final report, but the conclusions seem to be relatively clear at this stage.

The analyses showed a pronounced anticlockwise veering of the wind direction of about 20-40^{o} from Utsira to Stord with the measured reduction of northerly winds due to the topography, this has led to a significant reduction of the northerly extremes in that area.

Due to anemometer records from the shipyard area, it has also been possible to give more reliable estimates of the

extremes from east. The weather map study showed that winds from east normally are weaker in the Stord area due to medium and large scale topographical effects. The pressure gradients and wind field are strengthened towards SE and E of Stord, and Vats is close to the area where stronger easterly and southeasterly winds are expected.

The 1 minute mean winds for Digernessundet with return periods 2, 10 and 100 years are given in table 3.

Table 3. Extremes of 1 min mean wind (m/s) in Digernessundet, Stord.

Sector (degrees)	Return period (years) 2	10	100
355-025	13	16	17
025-060	17	21	25
060-160	24	28	32
160-190	21	27	30
190-260	26	32	37
260-320	21	27	31
320-355	14	17	19

3. DISCUSSION OF THE VATS- AND YRKEFJORD

A brief comparison is performed on the wind data from the aws Kattrauv and Utsira based on 9 cases with easterly and 10 cases with westerly wind greater than 10 m/s. Due to the short period (the direction sensor was aut of function for a long period last winter) and the special local conditions on the aws, the results cannot be conclusive. It indicats

however, that winds from west are of the same magnitude in Yrkefjorden as on Utsira, probably because of the open channel formed by Yrkefjorden in this direction.

This means that the 100 year 1 min. mean wind from 260^{o} should be about 33 m/s on positions C and E instead of 30 m/s. On the other hand, the direction analysis of Utsira shows somewhat weaker extremes from SW-W than the "all-direction" extremes used for the wind tunnel tests, and as pointed out earlier, the "approach flow" fits well with the latter extremes which should give reason for a slight reduction in the values measured in the wind tunnel for this direction. All together, there seems to be no conclusive evidence for changing the values from the westerly sector.

For easterly winds the comparison indicates unrealistic values (47 m/s for 1 min 100 year r.p.). As stated before, the data are few and therefore not conclusive, but the wind from east is probably strongly inforced on the aws, and stronger than indicated in the wind tunnel for the positions C, D and E since the flow from this direction is more stable than the wind conditions in the wind tunnel.

As mentioned in the previous chapter, the weather map analyses has shown that SE and E-winds probably are stronger in the Vats area than near Stord. This result together with the aws-data indicates that the given wind speeds from this sector should be increased. However, due to the uncertainties it would be better to get more representative data for easterly winds in the fjord. If possible, we propose to move the aws from Kattrauv to one of the locations A, C or E if a representative installation can be found.

The weather map analyses has also shown that winds between

SE and S are expected to be of about the same magnitude as for Sola. The 1 min. value of 35 m/s for position D (150^{o}-180^{o}) it then supported by the extreme value analyses. Positions C and E have 10-15 m/s lower speeds from these directions according to the wind tunnel tests.

For the northern sector a substantial reduction seems to be justified by the data for Digernessundet. Due to the uncertainties with respect to the extreme cases it has been chosen earlier to maintain the extremes for the coast line also to some extent further inside the country.

For Digernessundet there is a rapid decrease of wind speeds north of 310-320^{o} as shown in table 3. Because of the longer distance from the coastline, the veering and reduction of northerly winds should be more pronounced in Vats. The values 35 and 25 m/s now valid for position D around N (350^{o}) are too high compared with the 19 and 17 m/s, respectively for Digernessundet, even if the differences in local topography is taken into account. Due to Vatsfjorden, position D is open to the NNW-NNE, while Digernessundet is sheltered by the island Stord. It is not possible to quantify these effects exactly, and it is not possible to decide which one is the stronger. Probably, no less than 20 m/s must be expected from the sector 320-090^{o} due to the channel of Vatsfjorden.

Consequently, the wind is reduces for position C from 25 to 15 m/s in the sector 310-040^{o} and from 30 to 25 m/s in the sector 040-090^{o}. the reduction relative to position D in the sector 360-040^{o} is justified by the reduced distance to the southern shore of Yrkefjorden.

For position E 15 m/s can be used for the sector 320-030^{o}.

4. SUMMARY

The revised 1 min mean wind speeds for return periods 2, 10 and 100 years are given in tables 4-6 for the positions C, D and E, respectively.

The return periods of 2 and 10 years are calculated from the data for Digernessundet.

If should be stressed that the eastern sector is the most uncertain due to the lack of representative data.

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Table 4. 1 MINUTE WIND SPEEDS (m/s).
POSITION C.
Reference height: 10 m.

Sector (degrees)	Return period (years) 2	10	100
310-040	11	13	15
040-090	18	21	25
090-150	15	18	20
150-310	21	27	30

Table 5. 1 MINUTE WIND SPEEDS (m/s).
POSITION D.
Reference height: 10 m.

Sector (degrees)	Return period (years) 2	10	100
320-090	15	18	20
090-150	23	26	30
150-180	25	32	35
180-220	21	26	30
220-270	14	18	20
270-320	21	27	30

Table 6. 1 MINUTE WIND SPEEDS (m/s).
POSITION E.
Reference height: 10 m.

Sector (degrees)	Return period (years) 2	10	100
320-030	11	13	15
030-120	23	26	30
120-190	15	18	20
190-320	21	27	30