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Alfjorden.
Extreme Wind Conditions

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Eksteremvind	1 min middel
Gullfaks B	10 min middel

Referat:

1 min. and 10 min. mean wind speeds with return period 10 and 100 years are evaluated for the "Gullfaks B"-inshore site in Alfjorden.

ALFJORDEN. EKSTREME WIND CONDITIONS

1. INTRODUCTION

The present report is made at the order of Haugesund Mekaniske Verksted A/S. For different wind directions 1 minute and 10 minute wind speeds should be given with return periods 10 and 100 years. It was agreed that this task should be solved within the existing service for climatic loadings for engineering purposes estabiliched as a cooperation between The Norwegian Meteorological Institute (DNMI) and The Norwegian Research Institute of Electricity Supply (EFI).

2. THE LOCATION

Alfjorden lies in Hordaland south of Stord, and the actual site is about 1 km south of Austre Vikebygd. see map in figure 1.

The fjord is mostly about 1.5 km wide and runs in the N-S direction. The terrain south (Tysvær) and west (Sveio) of the fjord is low, mostly below 200 m asl. On the eastern side (Ølen) there are heights above 500 m asl (Skredfjellet and Vikefjellet).

3. GENERAL WIND CONDITIONS

The general wind conditions in the costal areas can be represented by Slåtterøy lighthouse. Frequency distributions of wind-forces (F) and wind directions (DD) are given for the winter (January and February) in table 1 and for the whole year in table 2 (the period being 1971-84). See explanations on the page preceding table 1.

Looking at the strong winds (force 9 or more) we see that they occur in the sectors SSE-SW and W-N, the latter being the most frequent. Similar wind statistics for other weather stations in the area can be found in [1].

Investigation on extreme wind gusts [2] show that these have a relatively higher frequency in the SE-S sector. Because of the local topography and the orientation of the fjord, the actual site is relatively well exposed to both the SE-S and the NW-N sectors.

Winds from SW-NW will be somewhat reeduced due to the relatively high terrain on the leeward side. However, it is expected that in special weather conditions, strong SE-S winds may veer rather quickly towards SW-W and NW. This phenomenon may cause damages on buildings and structures on the west coast. Because of the rather short duration, the phenomenon is not very well represented in the wind statistics.

Winds from the sector N-E are both seldom and weak in the area. In the sector E-SE strong winds are frequent mostly in the inner parts of the fjord areas and on special locations where the topography favours a downward transportation of momentum. Such effects are not expected to be very pronounced in Alfjorden.

4. EVALUATION OF EXTREMES

Bergen airport, Flesland, is the most representative station with long series of wind recordings. A 16 years long series of annual extremes of wind gusts are analysed. The gust speed with return period 10 years is calculated to 37 m/s. Accoring to [3] the corresponding 1 minute mean for Flesland will be about 32 m/s. Flesland is more exposed for all wind directions than Alfjorden, but the difference in wind speed will be less than 5 m/s. Therefore the 1 min. mean wind speed in Alfjorden is set to 30 m/s regardless direction.

In the actual case the extremes have about equal probability to occur from each of the sectors SE-SW and NW-N. The "once in 10 years" wind above therefore represents the double return period for each of the sectors separately. The "once in 10 years" wind speed for each of the sectors is therefore represented by the 5 years return period regardless direction, or in this case, 28 m/s.

According to the Flesland extremes, we can multiply the 10 years value by 1.22 to get the 100 years values, and according to [3] the factor 0.88 is used to get 10 min. means.

Due to the general wind distributions and the local topography described above, the 1 min. mean wind with 10 years return period can be reduced to 25 m/s in the sector SW-NW and to 20 m/s in the N-SE sector.

The values for 10 and 100 years return period is listed in table 3. Due to the uncertainties in the estimates, the values are slightly rounded.

All wind speeds given above are valid for the height 10 m asl.

REFERENCES

[1] Andresen, L.: Monthly and Annual Frequences of Concurrent Wind Forces and Wind Directons in Western Norway and Trøndelag for the Period 1961-75. DNMI 1979.

[2] Fikke, S.M.: Vindkast. Ekstremer og kastfaktorer. DNMI internal note KLIMA 11 1983.

[3] Ghiocel, D. and D. Lungu : Wind Snow and Temperature Effects on Structures Based on probability. Abacus Press 1975.

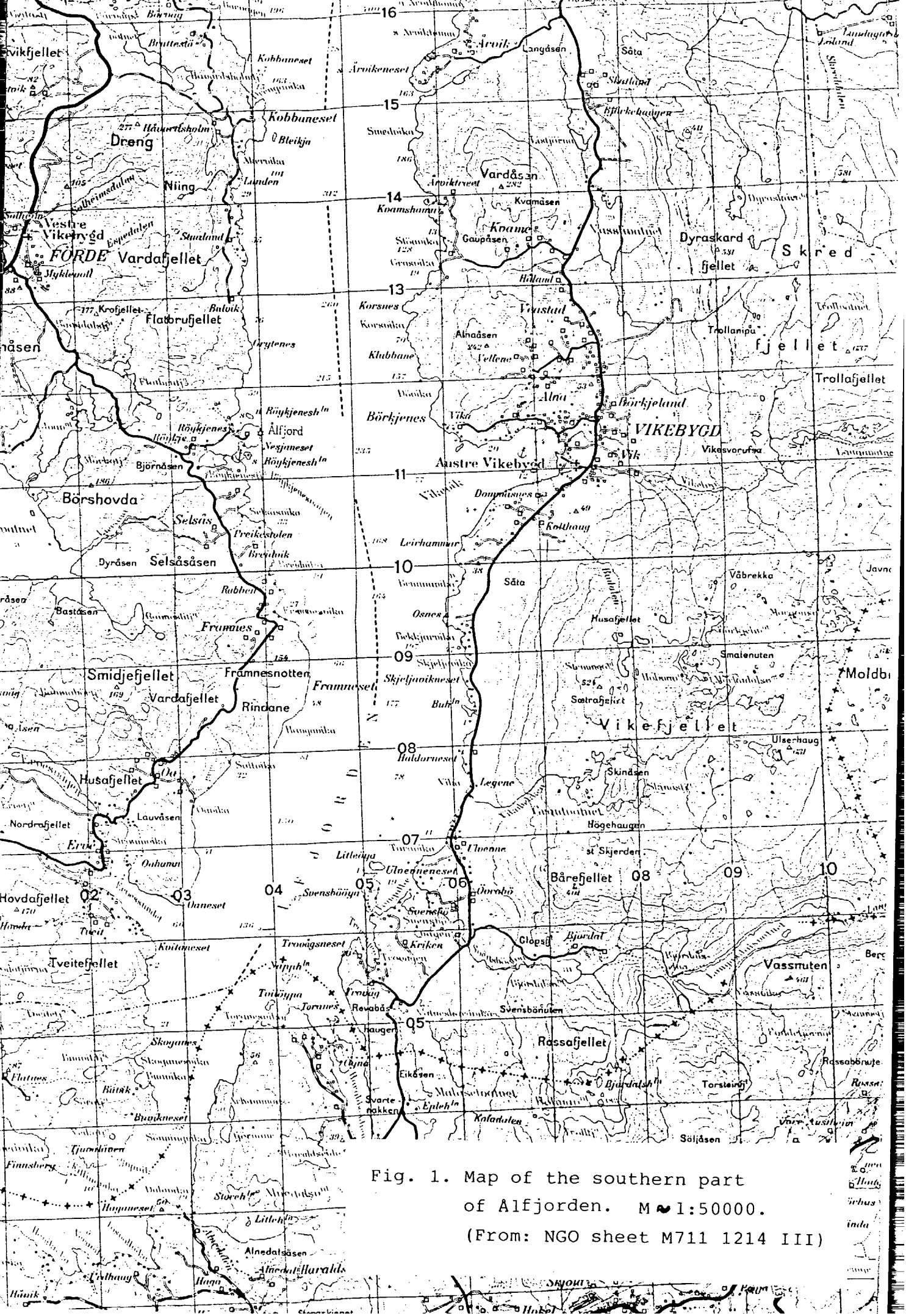

Fig. 1. Map of the southern part of Ålfjorden. M ≈ 1:50000. (From: NGO sheet M711 1214 III)

Explanation to tables 1-2

HRS	hours of observation in GMT
N	total number of observations
C	frequency of calm
VM	mean wind velocity in m/sec
FM	mean wind force in Beaufort
DD	wind direction in dekadegrees, rounded off to the nearest of 12 main directions: 35-01, 02-24 etc.
F	wind force in Beaufort
ND	frequency of each wind direction DD
FDM	mean wind force in Beaufort for each wind direction DD
NF	frequency of each wind force F

The formulas.

n_F	Number of observations with force F
n_D	- " - " - " - " - direction DD
$n_{F,D}$	- " - " - " - " - direction DD and force F
FDFREK	frequency of wind force F from direction DD
v'	central value in m/sec in each Beaufort interval (see below)

F	1	2	3	4	5	6	7	8	9	10	11	12
v'	0.90	2.44	4.41	6.72	9.30	12.30	15.47	18.96	22.59	26.40	30.58	35.04

$$N = \sum_{F=0}^{12} n_F$$

$$C = n_{F=0}/N$$

$$VM = 1/N \cdot \sum_{F=1}^{12} (n_F \cdot v')$$

$$FM = 1/N \cdot \sum_{F=1}^{12} (n_F \cdot F)$$

$$FDFREK = n_{F,D}/N$$

$$ND = n_D/N$$

$$FDM = 1/n_D \cdot \sum_{F_D=1}^{12} (n_{F,D} \cdot F)$$

$$NF = n_F/N$$

Table 1. Frequency distribution of surface winds in January and February. Slåtterøy lighthouse 1971-84. Explanation: see preceding page.

SLATTERØY FYR JANUARY 1971-1984

HRS. 06,12,18 GMT N= 1302 C= 2.2% VM= 7.7M/S FM=4.1 B

DD	F: 1	2	3	4	5	6	7	8	9	10	11	12	ND	FDM
36N	0.2	0.4	0.3	0.8	1.3	1.1	1.1	0.2	0.1				5.5	5.1
03	0.7	0.7	0.6	0.7	0.3	0.2	0.2						3.3	3.1
06	0.4	0.6	1.5	0.5	0.1								3.0	2.7
09E	0.9	0.9	1.2	0.5	0.2	0.2							3.8	2.6
12	1.5	0.9	0.9	0.6	0.3	0.2							4.5	2.5
15	3.3	5.0	6.9	4.9	4.3	3.5	2.1	0.2	0.2				30.3	3.7
18S	0.8	2.2	3.4	4.1	3.8	2.9	1.8	1.4	0.2				20.5	4.5
21	0.2	0.5	0.8	0.8	1.1	1.1	1.0	0.1					5.5	4.8
24	0.2	0.6	0.5	0.9	0.9	0.8	0.6	0.4	0.1				5.1	4.8
27W	0.1	1.0	0.6	1.2	1.2	1.2	0.5	0.7	0.3	0.1			6.9	5.0
30		0.1	0.4	0.4	0.8	0.2	0.5	0.2	0.2	0.1			3.0	5.6
33	0.2	0.6	0.5	0.5	1.0	1.2	1.4	0.4	0.5	0.1			6.4	5.5
NF	8.5	13.5	17.5	16.0	15.3	12.6	9.1	3.5	1.5	0.2				

FREQUENCY OF MAX WIND FORCE BETWEEN THE HOURS OF OBSERVATION

											C
19-07	1.2	4.8	15.7	14.7	17.3	15.4	16.1	9.0	4.8	0.9	
07-13	3.5	6.9	17.5	12.7	21.7	13.6	11.5	8.3	2.8	1.4	0.2
13-19	3.5	9.2	14.7	15.0	16.6	16.6	11.5	8.1	3.2	1.4	0.2

SLATTERØY FYR FEBRUARY 1971-1984

HRS. 06,12,18 GMT N= 1188 C= 6.2% VM= 5.5M/S FM=3.2 B

DD	F: 1	2	3	4	5	6	7	8	9	10	11	12	ND	FDM
36N	0.4	0.7	0.4	0.7	1.1	0.9	0.2						4.4	4.1
03	0.5	0.8	0.5	0.3	0.4								2.6	2.7
06	0.9	1.0	0.8	0.3	0.3		0.1	0.1					3.5	2.6
09E	2.0	1.5	1.6	0.8	0.2	0.2							6.2	2.4
12	1.6	0.9	1.0	0.2	0.1	0.2							4.0	2.2
15	4.7	6.4	5.9	4.6	3.0	1.9	1.0	0.2					27.7	3.2
18S	3.6	4.8	4.5	4.9	4.0	3.4	1.1	0.4	0.2				26.9	3.7
21	0.4	0.8	0.8	0.7	0.4	0.8	0.3						4.1	3.8
24	0.5	0.8	0.7	0.9	0.5	0.3	0.4	0.1					4.2	3.8
27W	0.3	0.3	1.1	0.8	0.7	0.6	0.4	0.1	0.1				4.3	4.3
30	0.2	0.5	0.5	0.3	0.3	0.5	0.3	0.1					2.5	4.1
33	0.5	0.5	0.8	0.5	0.3	0.3	0.3	0.3					3.5	3.9
NF	15.7	19.0	18.5	14.8	11.3	9.0	4.0	1.2	0.3					

FREQUENCY OF MAX WIND FORCE BETWEEN THE HOURS OF OBSERVATION

											C
19-07	3.0	11.6	20.2	20.7	16.4	13.9	9.6	3.0	0.8	0.8	
07-13	5.8	12.4	22.2	18.7	17.9	13.4	5.8	2.3	0.8	0.3	0.5
13-19	7.8	12.6	20.7	18.9	14.9	13.4	7.3	3.8	0.3		0.3

Table 2. Frequency distribution of surface winds for all observations. Slåtterøy lighthouse 1971-84. Explanation: page preceding table 1.

SLATTERØY FYR YEAR 1971-1984

HRS. 06,12,18 GMT N=15339 C= 4.7% VM= 6.2M/S FM=3.5 B

DD	F: 1	2	3	4	5	6	7	8	9	10	11	12	ND	FDM
36N	1.0	1.1	1.4	1.5	1.4	1.4	1.1	0.3	0.0	0.0			9.2	4.2
03	0.8	0.9	0.8	0.5	0.3	0.2	0.0	0.0					3.5	2.8
06	0.8	0.9	0.8	0.4	0.1	0.0	0.0	0.0					3.0	2.4
09E	1.2	1.0	0.9	0.5	0.2	0.1							3.8	2.4
12	0.6	0.7	0.6	0.3	0.2	0.1	0.0	0.0					2.5	2.7
15	2.1	3.1	4.0	3.1	1.8	1.4	0.6	0.2	0.1	0.0			16.3	3.5
18S	1.4	2.2	3.0	3.5	2.5	2.2	1.1	0.4	0.2	0.0			16.5	4.1
21	0.6	1.1	1.6	1.5	1.2	0.8	0.6	0.1	0.0	0.0			7.4	3.9
24	1.0	1.3	1.4	1.0	0.7	0.5	0.5	0.1	0.0				6.5	3.5
27W	1.0	1.1	1.0	1.1	1.0	0.9	0.6	0.2	0.1	0.0			7.1	4.0
30	0.6	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.0	0.0			4.1	3.7
33	1.7	2.5	2.8	2.6	2.1	1.9	1.3	0.3	0.2	0.0	0.0		15.3	4.0
NF	12.8	16.6	18.9	16.6	12.1	9.9	6.1	1.7	0.6	0.1	0.0			

FREQUENCY OF MAX WIND FORCE BETWEEN THE HOURS OF OBSERVATION

													C
19-07	2.8	9.2	18.8	20.1	17.4	13.8	11.5	4.3	1.5	0.5	0.0		0.0
07-13	4.8	12.5	20.0	18.2	17.2	12.5	9.0	4.2	1.1	0.4	0.0	0.0	0.1
13-19	3.6	10.8	19.7	19.4	16.4	13.5	10.2	4.5	1.2	0.5	0.0		0.1

CUMULATIVE DISTRIBUTION OF CASES WITHIN A PERIOD OF CONSECUTIVE DAYS WHEN MAX.WIND FORCE OF THE DAY IS LESS THAN OR EQUAL TO 3 B FOR THE PERIOD 1971-1984

DAYS	1	2	3	4	5	6	7	8	9	10	11	12	13
WINTER	189	65	24	13	8	6	2	2	1	1	1		
SPRING	275	87	37	20	10	4	3	2					
SUMMER	283	87	41	23	11	4	2	2	1	1	1		
AUTUMN	167	53	25	11	6	5	3	1	1	1	1	1	1
TOTAL	914	292	127	67	35	19	10	7	3	3	3	1	1

CUMULATIVE DISTRIBUTION OF CASES WITHIN A PERIOD OF CONSECUTIVE DAYS WHEN MAX.WIND FORCE OF THE DAY IS GREATER THAN OR EQUAL TO 6 B FOR THE PERIOD 1971-1984

DAYS	1	2	3	4	5	6	7	8	9	10	11	12	13
WINTER	663	291	164	105	73	47	39	31	25	19	16	13	11
SPRING	485	196	98	57	33	18	13	9	5	4	3	1	1
SUMMER	386	149	69	33	21	12	7	4	3	3			
AUTUMN	737	324	178	114	69	53	36	26	18	13	11	10	7
TOTAL	2271	960	509	309	196	130	95	70	51	39	30	24	19

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
NO. OF YEARS	14	14	14	14	14	14	14	14	14	14	15	13

Table 3. Extreme vind speeds 10 m asl
for the "Gullfaks B"- area in Ålfjorden.
The speeds are given in m/s.

Sector	Time average	10 years	100 years
SE-SW	1 min.	28	34
and NW-N	10 min.	25	30
SW-NW	1 min.	25	30
	10 min.	22	27
N-SE	1 min.	20	24
	10 min.	18	22