NARVIK UNIVERSITY COLLEGE

Implementing a 3D CFD Model to Study the Performance of Porous Fences under Harsh Climatic Conditions

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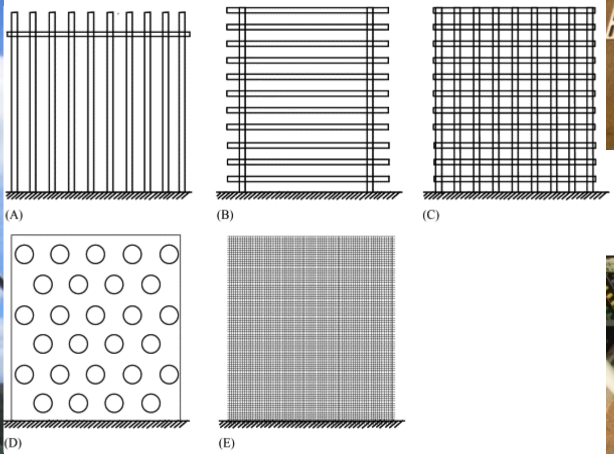
Introduction

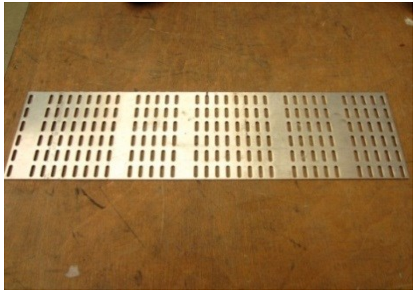
- *Using wind tunnel experimental and CFD approaches to identify the key factors influencing the performance of wind/snow fences, and to contribute novel knowledge to optimal fence design for offshore oil industry;*
- *Financed by the Norwegian Research Council under project number 195153 (ColdTech);*
- *To acknowledge the contribution of the industrial partner: IKM dsc AS, Norway.*

Applications of porous fences

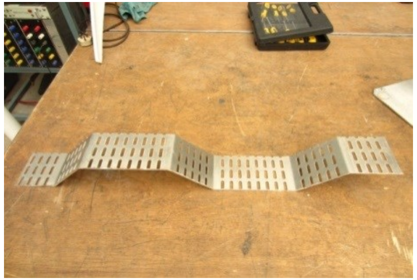
The Ekofisk Platform in Norway



Type of fences



Flat fence

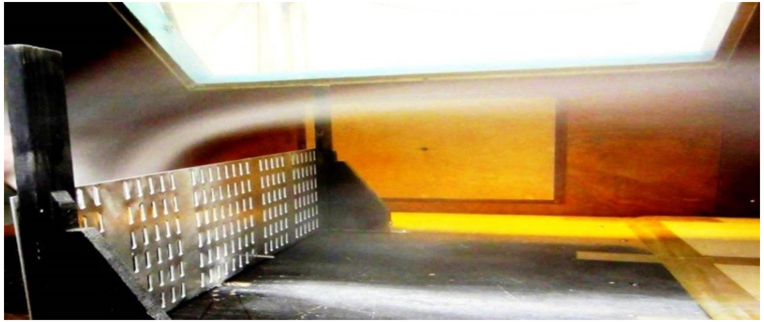


Corrugated fence

Wind Tunnel Experiments

Wind tunnel at NUC

Experimental set-up



Visualization

Limitations of WT Experiments

Limitied testing space
- *Difficulties in similitude requirements*

Extensive man power & time
- *Costs in sample & test preparations*

Elaborate equipment
- *Interference of wind field*

Data acquisitions
- *Difficulties in collecting data to reflect full structure of the wind field*

Advantages of CFD Application

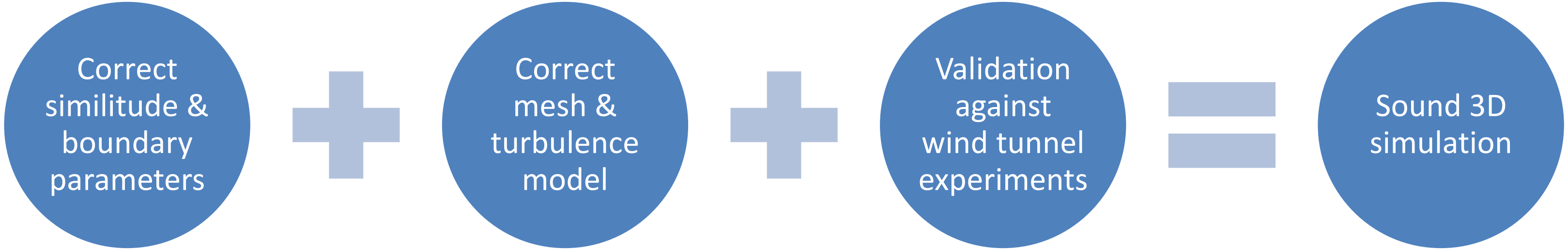
Flexible, efficient , less man power & more freedom in space creation

More advanced computer technology and rich research work in 2D simulation

Non-intrusion to wind field, easier data acquisiton & reflection of full structure of wind field

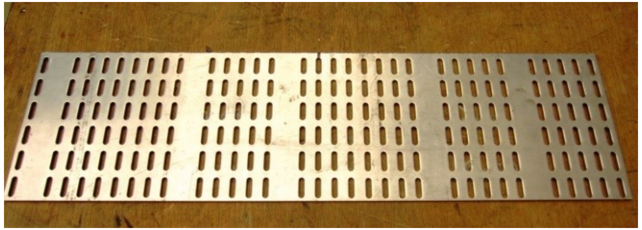
3D CFD

3D CFD Simulation

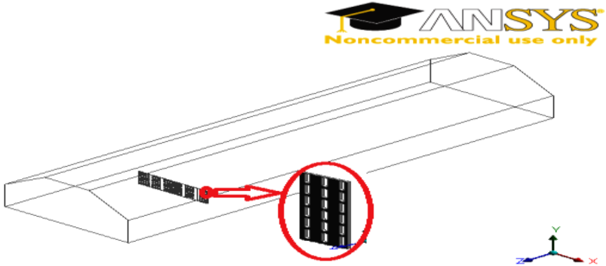


Physical & Numerical Domain

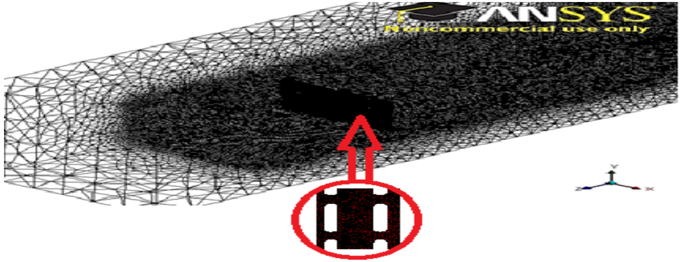
Cross view of test section of WT



Testing porous fence



Numerical domain

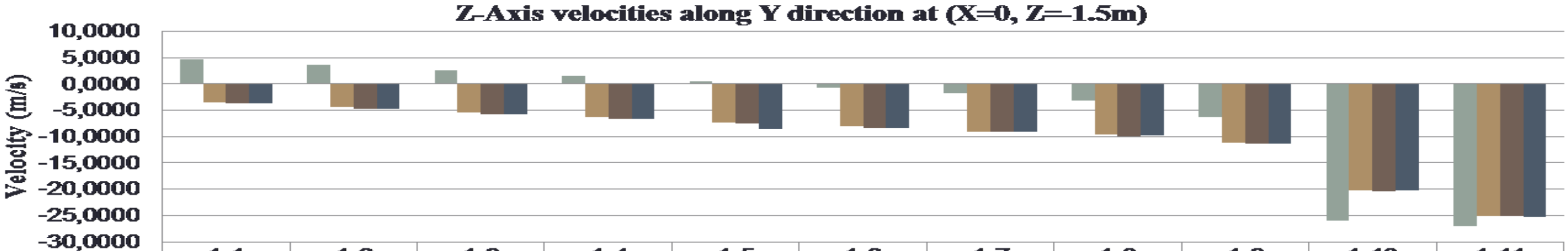


Meshed domain

Mesh sensitivity Analysis

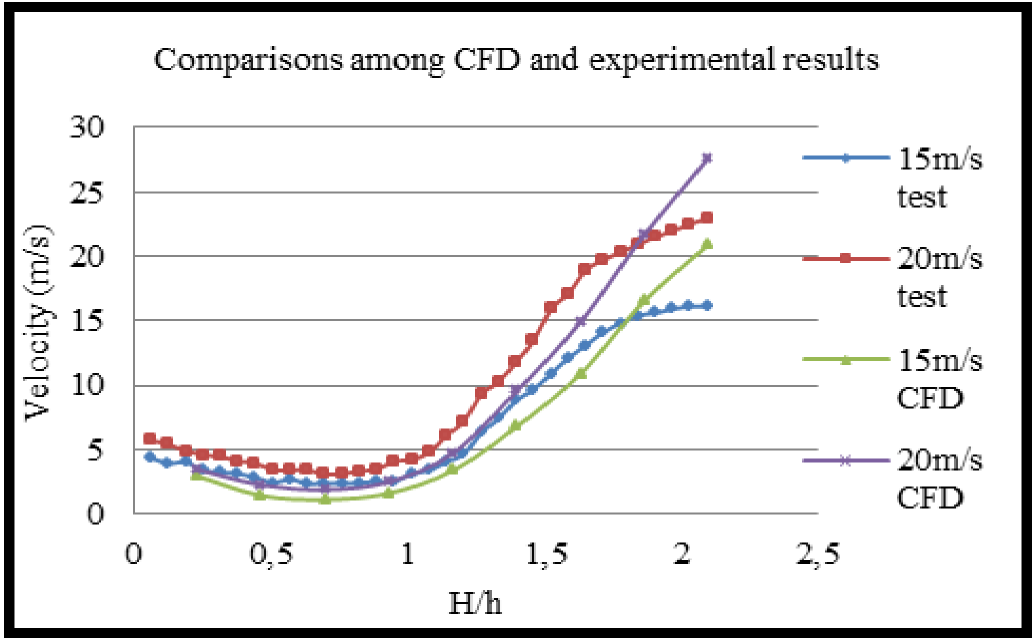
Meshing methods			
Meshing	Element	Elem. Type	Method
No.1	4073281	Tetrahedral	Body &edge sizing with face mapping
No.2	5322127	Tetrahedral	Body &edge sizing with face mapping
No.3	6280837	Tetrahedral	Body &edge sizing with face mapping
No.4	7209309	Tetrahedral	Body &edge sizing with face mapping

No. 3 is good mesh



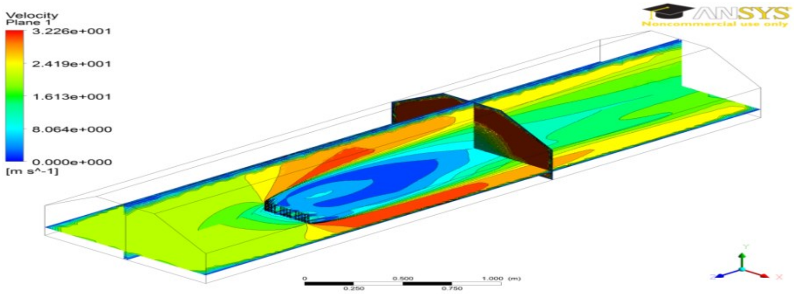
	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11
No.1	4,6620	3,7103	2,6619	1,6062	0,5122	-0,6485	-1,8401	-3,1290	-6,3445	-25,9932	-27,0551
No.2	-3,5294	-4,4315	-5,3738	-6,2910	-7,2630	-8,0763	-9,0389	-9,6799	-11,1412	-20,1726	-25,1409
No.3	-3,7415	-4,7664	-5,7250	-6,6482	-7,5405	-8,3553	-9,1296	-9,8705	-11,3225	-20,3179	-25,1750
No.4	-3,7601	-4,7850	-5,6979	-6,6160	-8,4742	-8,3167	-9,1105	-9,8440	-11,2862	-20,2721	-25,2403

Validation of CFD Model

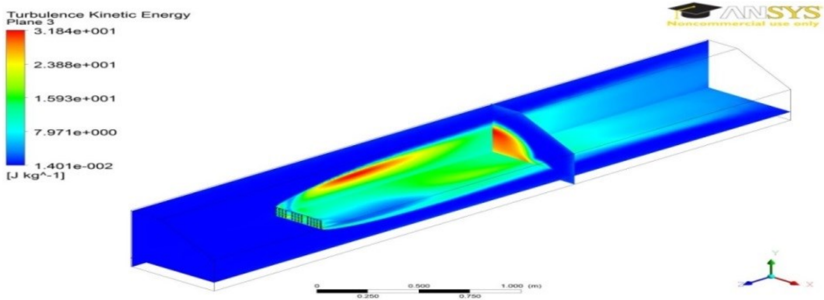


- *The CFD results are in good agreement with the experimental results in general;*
- *CFD simulations over-predicted the reduction of velocity when compared to the wind tunnel results. The discrepancy between them is around 20% in general;*
- *The 3D CFD is proved to be sound.*

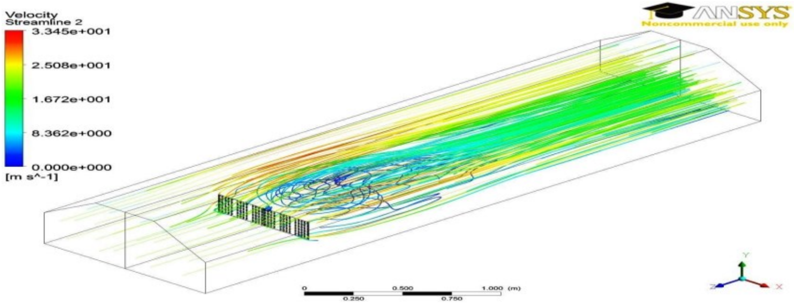
General Plots



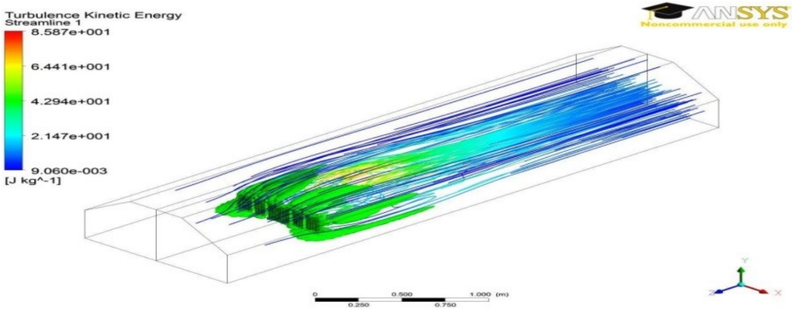
Velocity magnitude contours



TKE contours

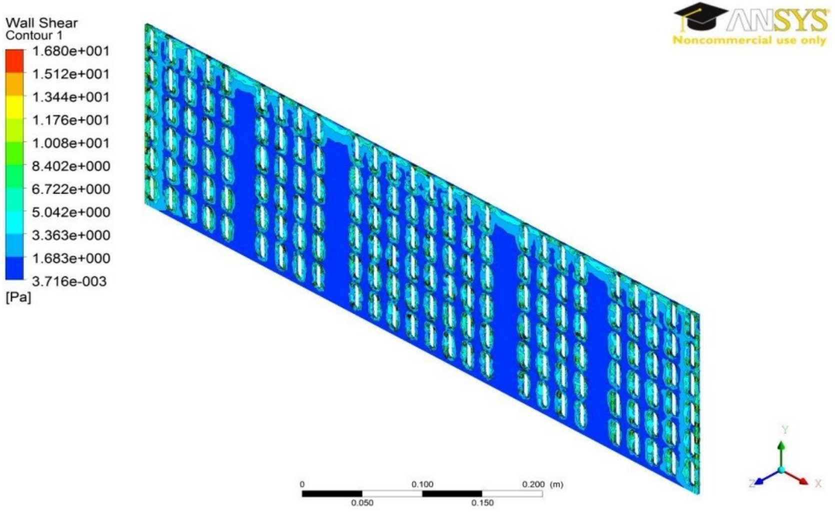


Velocity streamlines



Absolute Helicity vortex core region

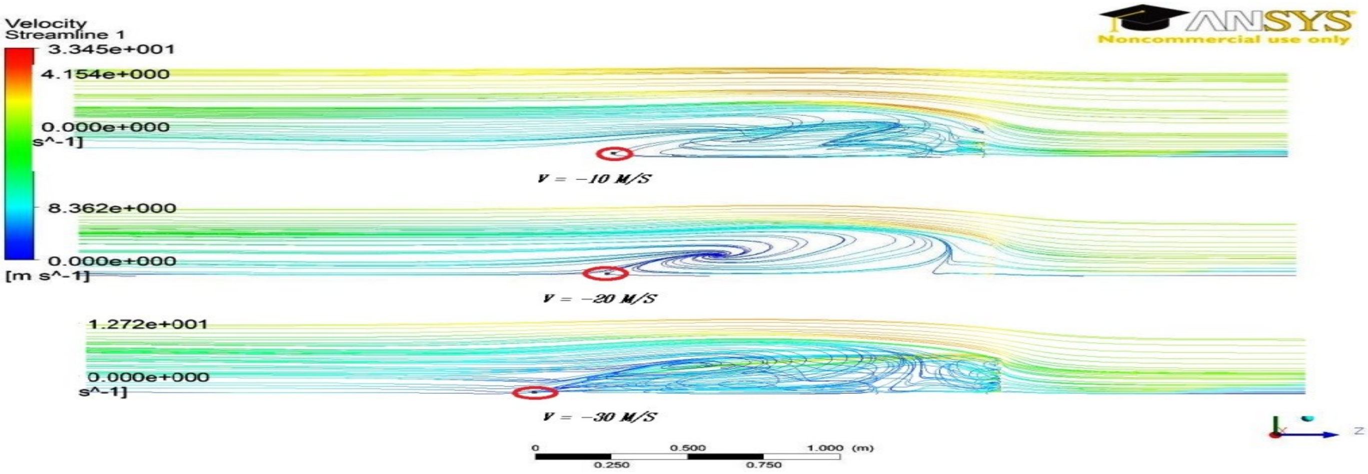
Shear Plot



Shear contours on the fence zone

- *2D model is not able to reflect it, that means that it requires stricter modifications of operating and boundary conditions, and varies almost in individual cases, which increases uncertainty of numerical results.*

Wind Field Analysis

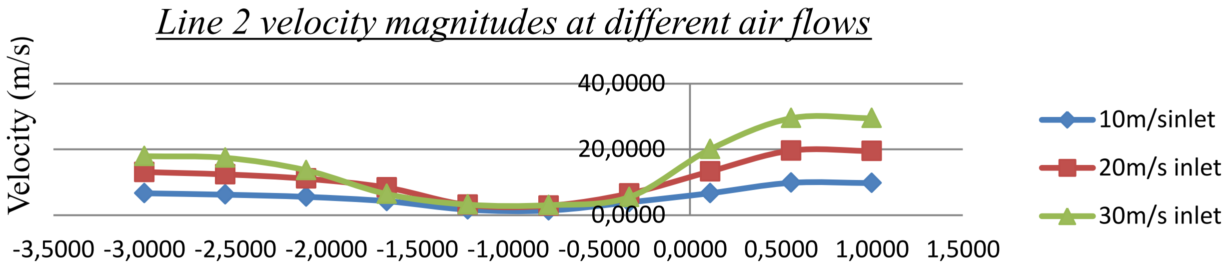


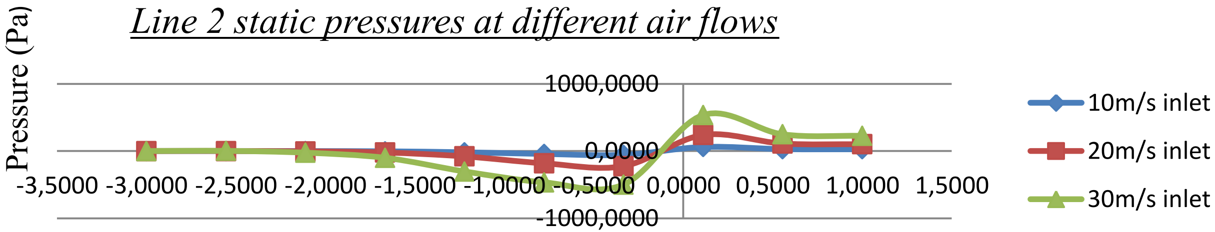
Velocity streamlines under different inlet velocities

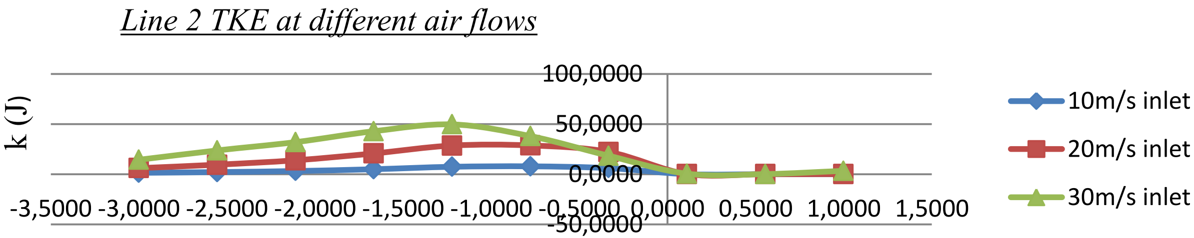
Reattachment length	
Air flow	length (m)
10 m/s inlet velocity	1,22276
20 m/s inlet velocity	1,26442
30 m/s inlet velocity	1,52961

Data Acquisition

- Line-2 by points (X=0, Y=0, Z= -3m) and (X=0, Y=0, Z=1m)







- Z Axial direction

Conclusions

- *The detailed set-up of the CFD model to investigate the wind flow behind a porous wind fence has been presented.*
- *A good agreement has been found between the CFD simulation and the experimental results. The CFD model has been proved to be sound.*
- *CFD simulations can overcome the limitations and weaknesses of wind tunnel experiments with flexibility, efficiency and low cost. Compared to 2D model, the 3D model is able to comprehensively reflect a full structure of air flow in the simulated domain.*
- *The 3D model is to be used for further studies of two-phase flow (with drifting snow).*

Thank you for your attention!