

Minimize placard's drag force

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Project statement

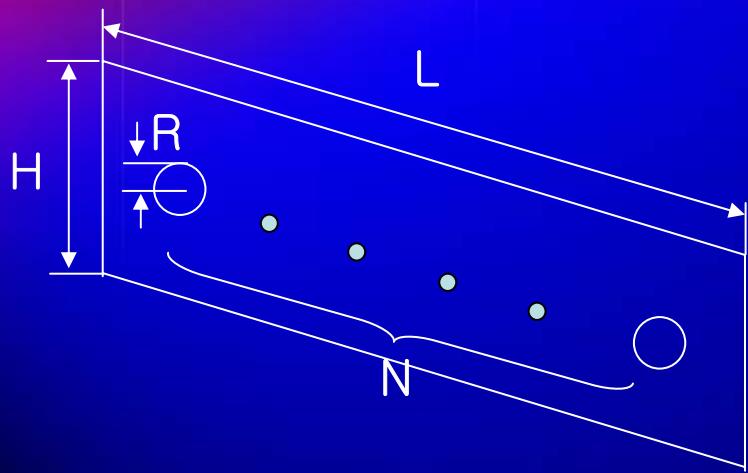
❖ Problem of placard

- ✓. Tare in Placard
- ✓. Wire snapped
- ✓. Column broken

*Minimize
Drag force*



Information collection and Identification of variable



❖ Data for project

	Data
L(m)	8
H(m)	0.6
V(m/s)	2.41

❖ Design variables

x_1 : Number of hole (N)
 x_2 : Radius (R)

Identification of a objective function

- ❖ Make a Objective Function

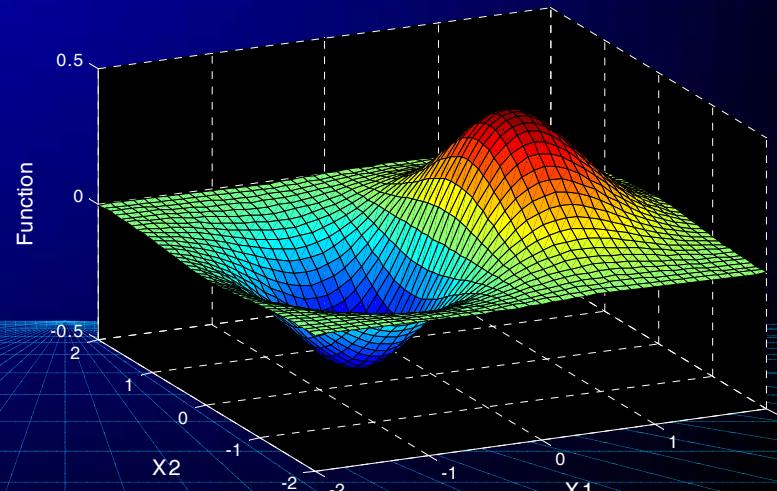
Calculate Drag force using Simulation

Create Drag force Function by Curve Fitting

- ❖ Minimize $f(x_1, x_2)$

Graphical method

Numerical method



Identification of constraints

- ❖ Area of Holes less than 5% placard's Area

Constraint. 1 $A_h \leq 0.05 \times A_p$

$$A_h = x_1 \times \pi x_2^2, \quad A_p = L \times H$$

- ❖ Length of between holes more than 1.5 times radius

Constraint. 2 $2x_2(5x_1 + 3) \leq L$

$$x_1 \times 2x_2 + (x_1 + 1) \times 3x_2 \leq L$$

Constraint. 3 $0 \leq x_1(\text{int}) \leq 30, \quad 0.05 \leq x_2 \leq 0.1$

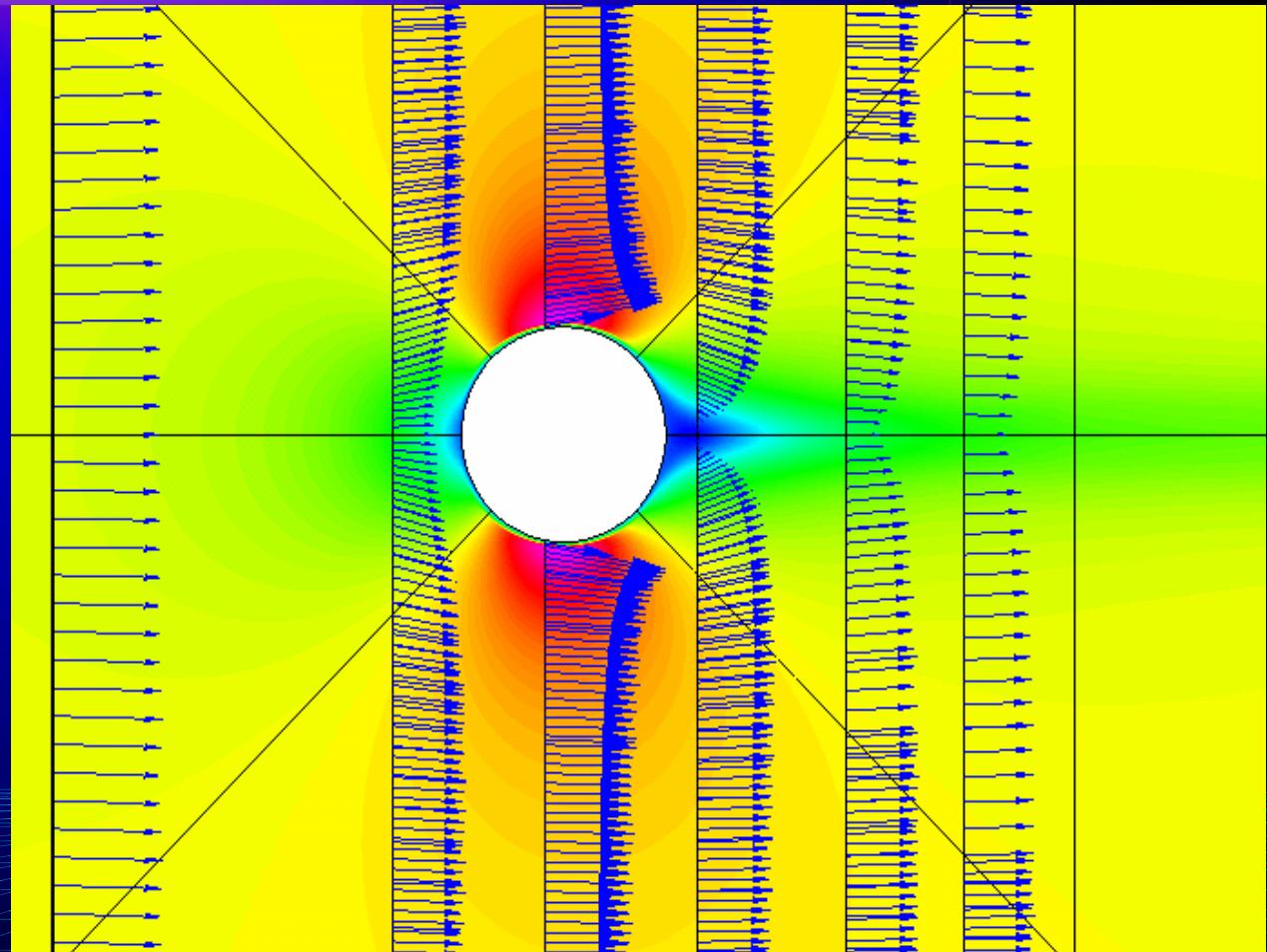
Verification

$C_d(\text{ref})=0.71$

$C_d=0.65$

$\text{Re}=1.4\text{E}5$

error=8.4%



Reference: Turbulence models and boundary conditions for bluff body flow.

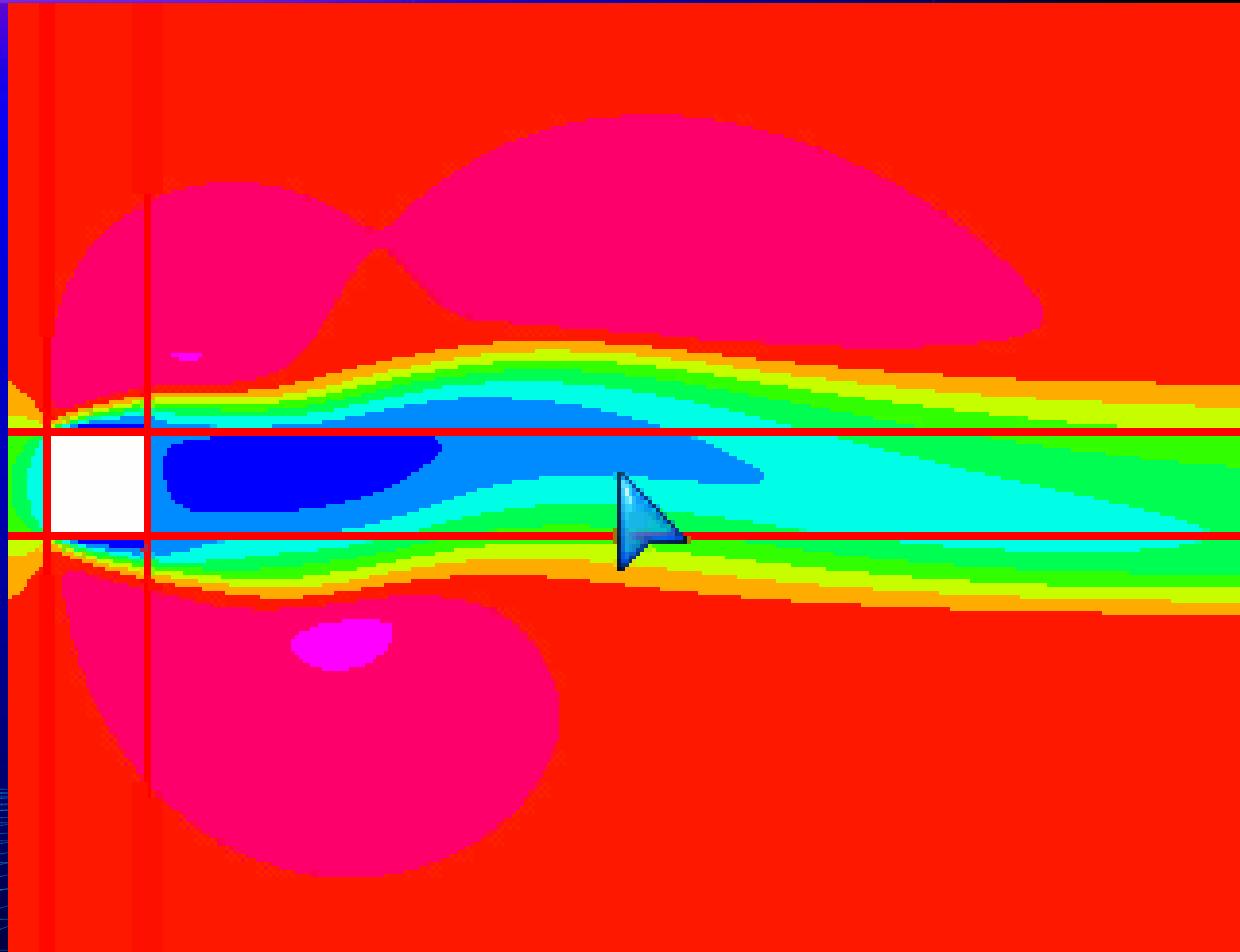
Verification

$C_d(\text{ref})=1.618$

$C_d=1.62$

$\text{Re}=2.2\text{E}4$

Error=0.1%

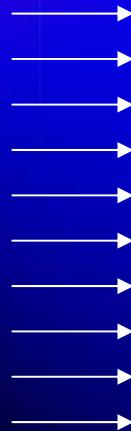


Reference : simulation of vortex shedding past a square cylinder with different turbulence models

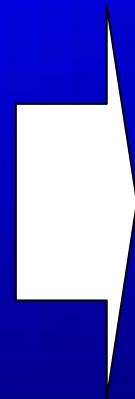
Assumption

❖ Geometry of placard

$V_0=2.41\text{m/s}$



$V_0=0.54\text{m/s}$



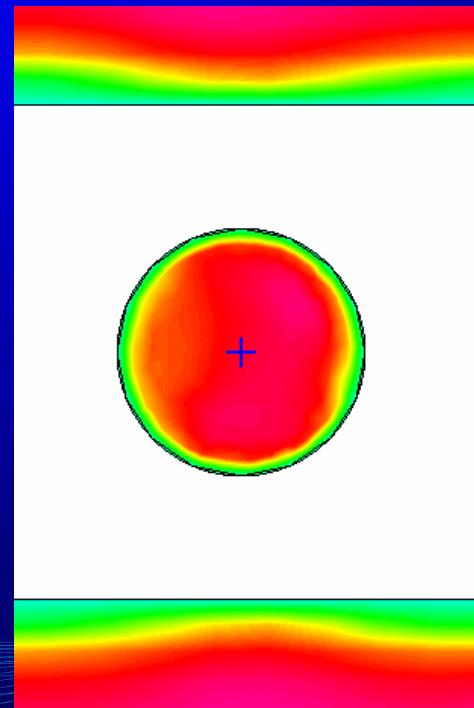
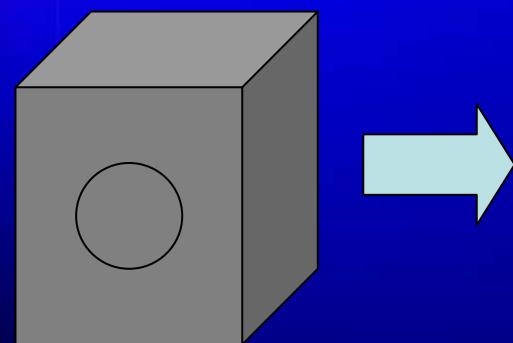
Shear force=0

Shear force=0

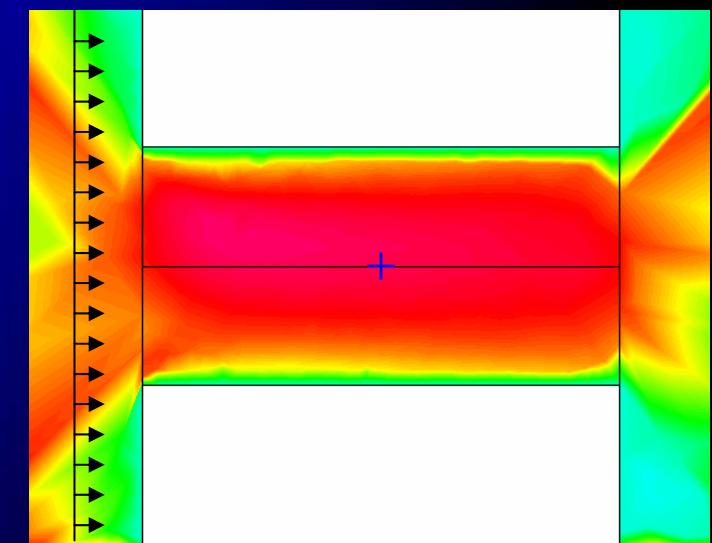
Pressure force= $1.89E-1\text{ N}$ Shear force= $1.99E-4\text{ N}$

Result (CFD–ace)

❖ Velocity profile of placard



<Front view>



<Side view>

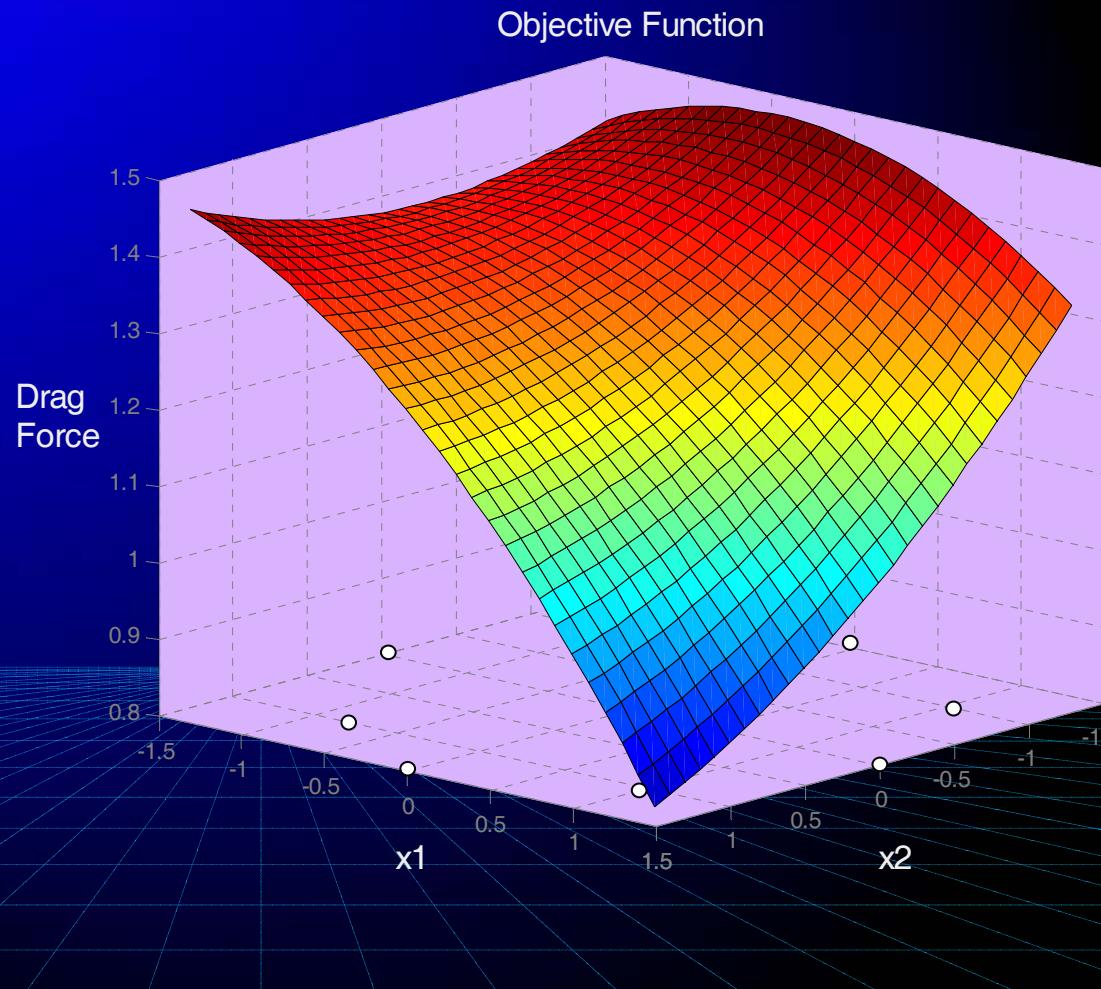
Result (RSM)

❖ Velocity Objective function

Minimize

$$f(x) = 1.298 - 8.42E^{-2}x_1 - 1.37E^{-1}x_2 + 2.98E^{-2}x_1^2 - 5.25E^{-2}x_2^2 - 6.85E^{-2}x_1x_2$$

$\langle R^2 = 95\% \rangle$



Result (Excel)

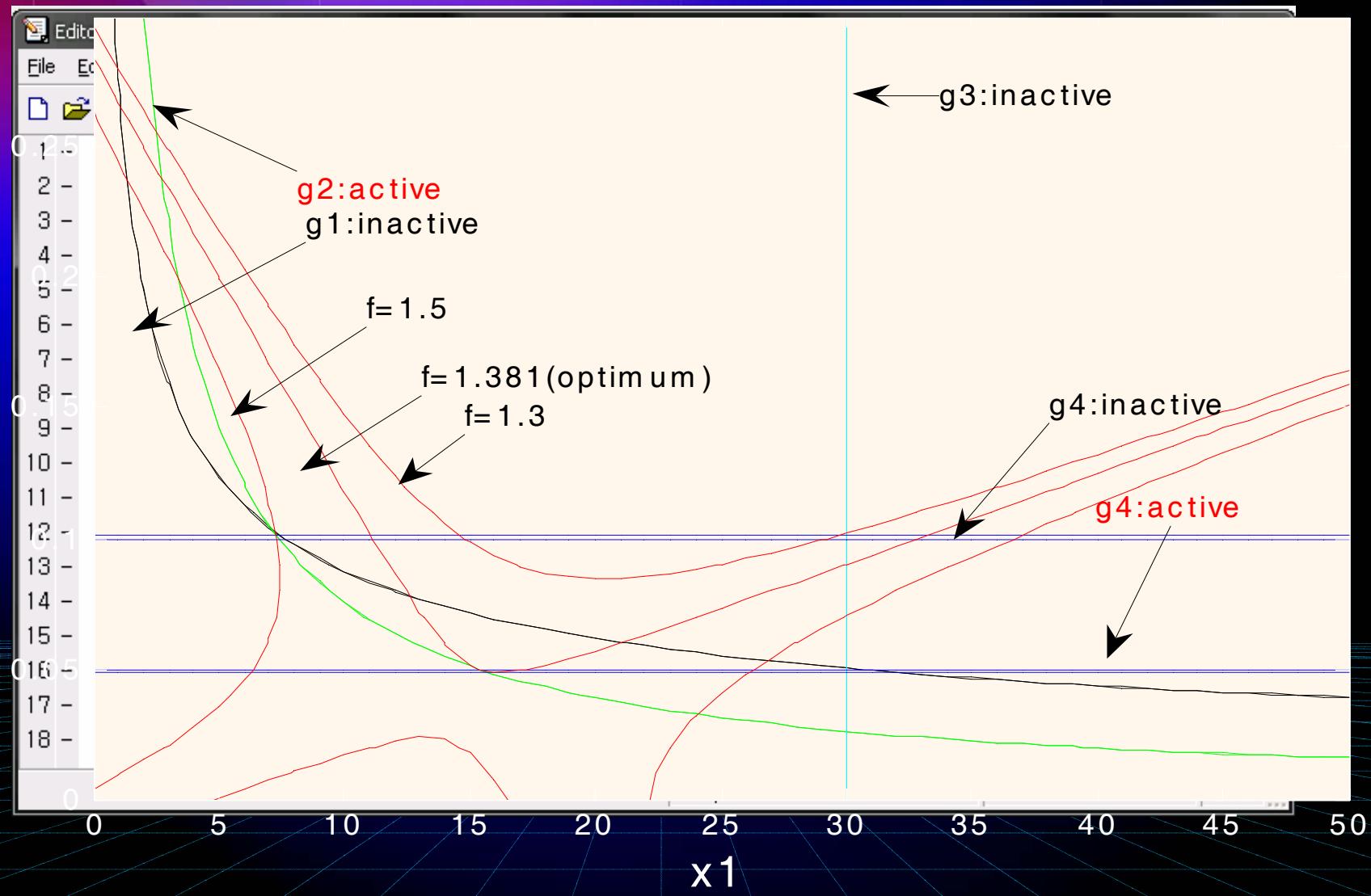
Placard 제원

length	8	[m]	Re	2.20E+04	
height	0.6	[m]	wind V	0.54	[m/s]

variable	x1	length between circle
	x2	radius
objective	minimize f	=1.297-8.42E-2xx1-1.37E-1xx2 +2.98E-2xx1^2-5.25E-2xx2^2-6.85E-2xx1xx2
subject to	g1	=pi()*x1*x2^2-0.05*8*0.6=0
	g2	=2*x2(5*x1+3)-8<=0
	g3	0<x1<30
	g4	0<x2<0.1

x1	15		
x2	0.051282		
f	1.380501		
g1	-0.11607	0	
g2	0	0	
g3	15	0	30
g4	0.051282	0.05	0.1

Result (Matlab-graphical)



Result (Matlab-fmincon)

The image shows a Matlab environment with two open editor windows and one command window.

Editor - D:\matlab\work\fun.m

```
1 function f=fun(x)
2 - f=1.297-8.42E-2*x(1).^4/7*(x(1)-15)-1.37E-1*x(1).^4/0.071*(x(2)-0.1)+2.98E-2*(1.414/7*(x(1)-15)).^2-5.
3
4
```

Editor - D:\matlab\work\confun.m

```
1 function [c,ceq]=confun(x)
2 - c(1)=pi*x(1).*x(2).^2-0.05*8*0.6
3 - c(2)=2*x(2)*(5*x(1)+3)-8
4 - c(3)=-x(1)
5 - c(4)=-x(2)+0.05
6 - c(5)=x(1)-30
7 - c(6)=x(2)-0.1
8 - ceq=[]
```

Command Window Output:

```
<command>
X0=[15,0.05];
[x,fval]=fmincon('fun',x0,
[],[],[],[],[],[],'confun')
x =
    15.3690    0.0501
fval =
    1.3803
```

Conclusion

- ❖ Drage force reduction
($1.477N \Rightarrow 1.38N$)
- ❖ Three method express same result
- ❖ Too many assumptions
- ❖ Uncertainty 3D CFD modeling