Turbulent Wind Flow over a High Speed Train

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Cross wind effects on trains

Low mass passenger vehicles may be blown over.

- Wind tunnel tests used to give force and moment data
- Probability of overturning may be evaluated

Wind tunnel data shows large variability

- Effect of turbulence?
- Effect of embankment?
- Effect of train motion?

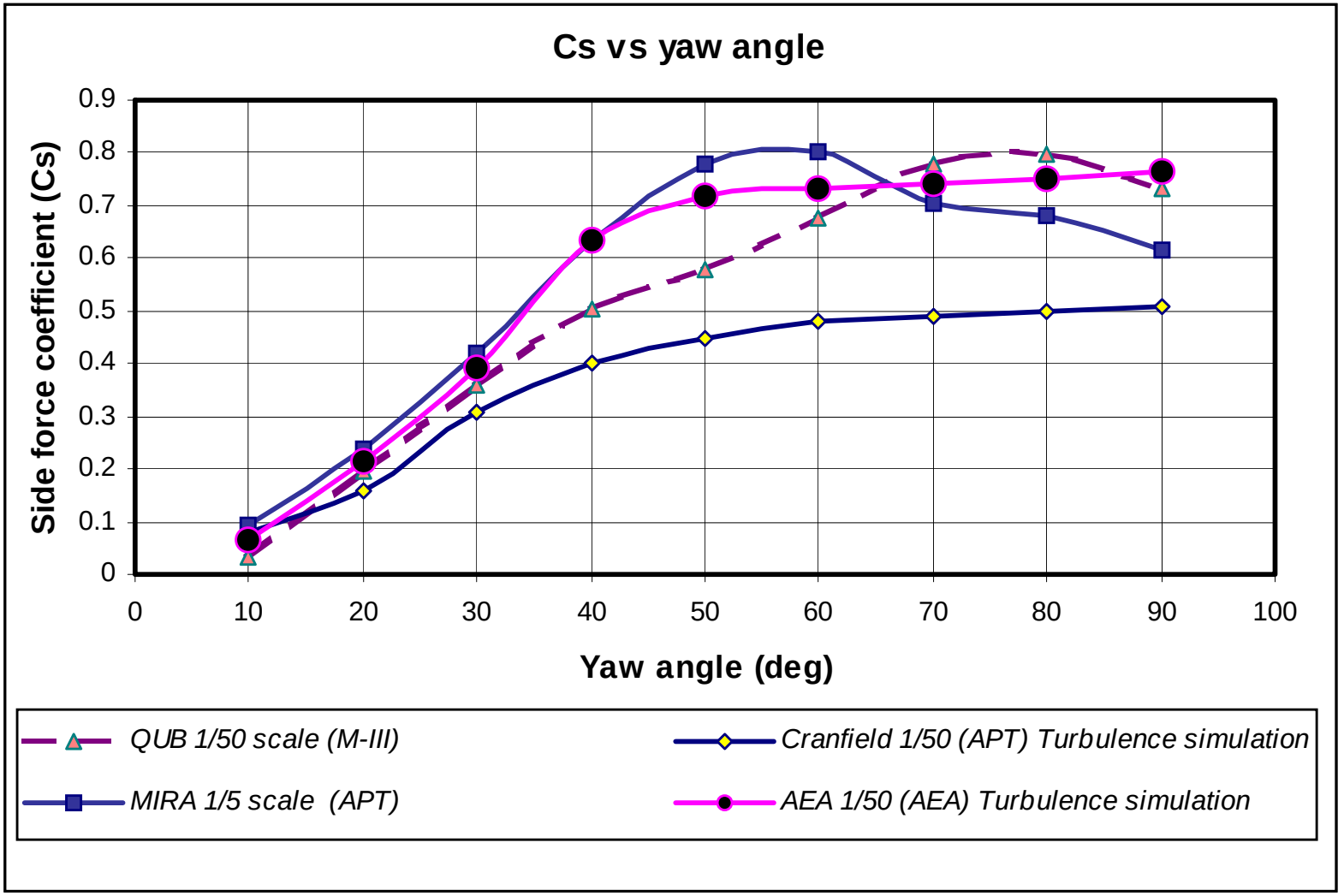
Moving model experiments

- Expensive and difficult
- May create more problems than they solve

Will CFD give the answer?

Coefficient of side force vs. yaw angle

- significant variation between wind tunnel tests
- depends on turbulence intensity and scale



Trains with Mark 3 passenger coaches

Class 87 electric loco.
+ Mark3 coaches

Prototype for wind tunnel models

High Speed Train
Diesel-electric loco.
+ Mark3 coaches

Prototype for CFD model

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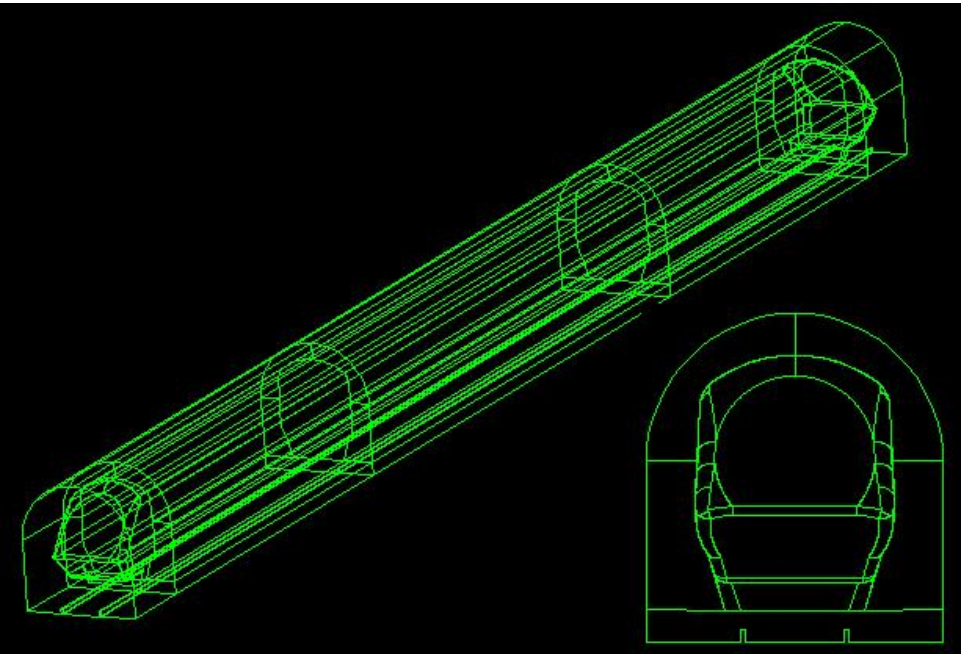
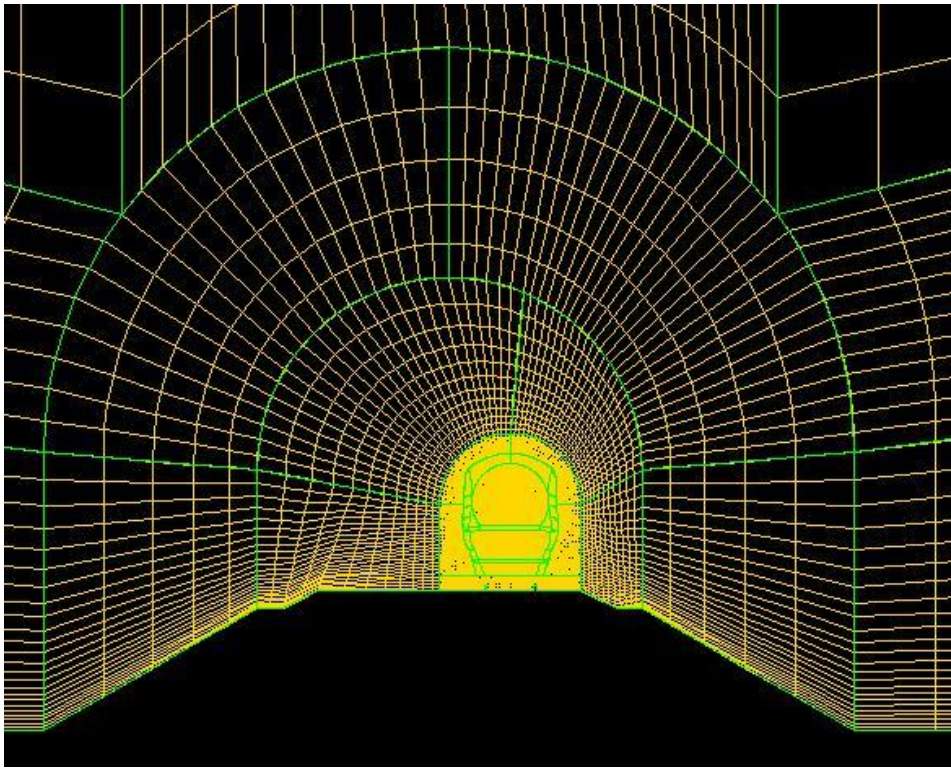
BMT Fluid Mechanics Wind tunnel (4.8m *2.4m)
Atmospheric Boundary Layer simulation
Class 87 + Mark 3 coaches (1/30 scale)

Fluent 6

Hybrid grid

- Unstructured around nose and tail
- Relative wind inflow profile specified
- Moving ground simulation possible





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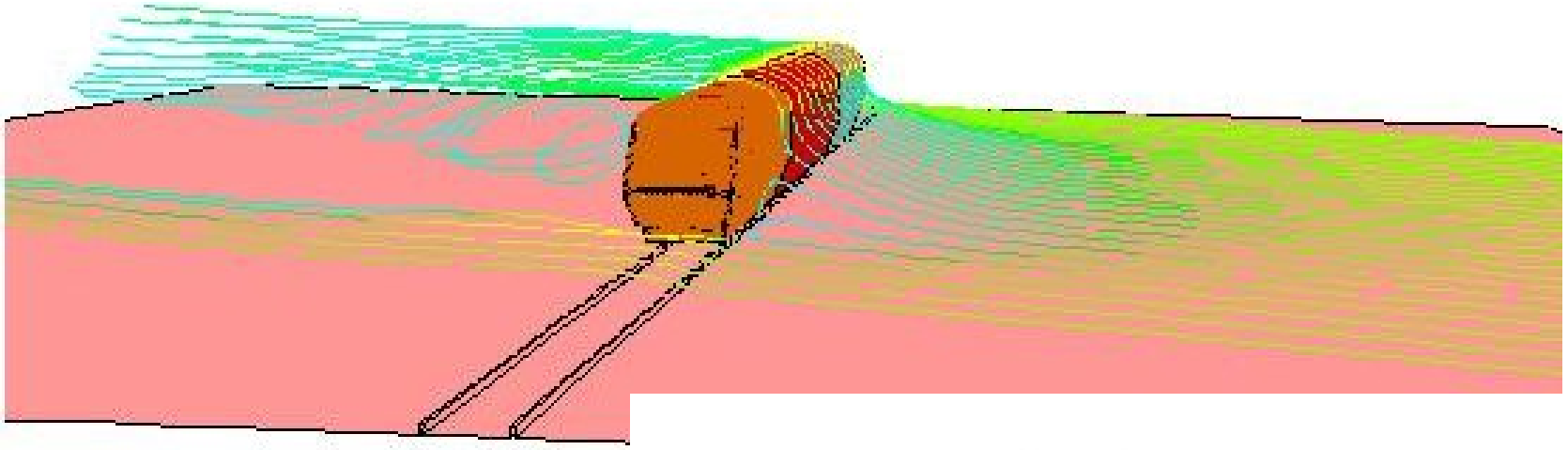
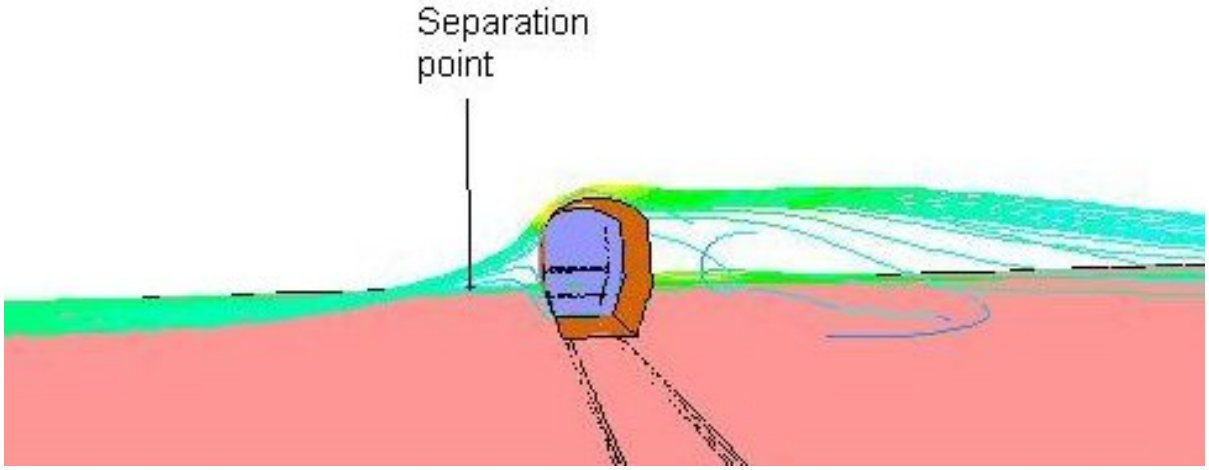
CFD

- Reynolds number 1.5*10^5
- Turbulence intensity 3%
- Length scale 3m
- Yaw angle 60 deg.



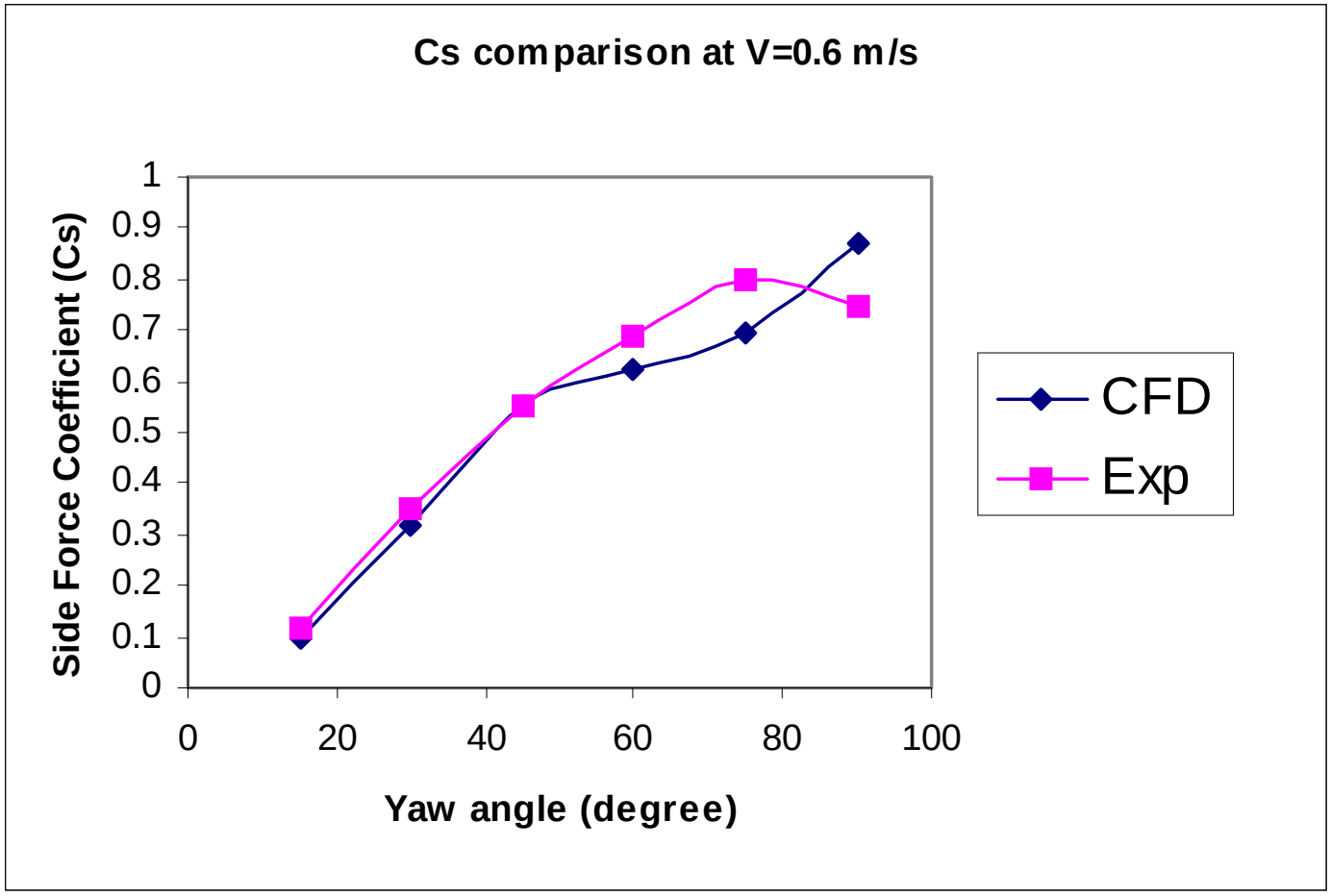
Note

- Lee side vortex
- Separation on ground



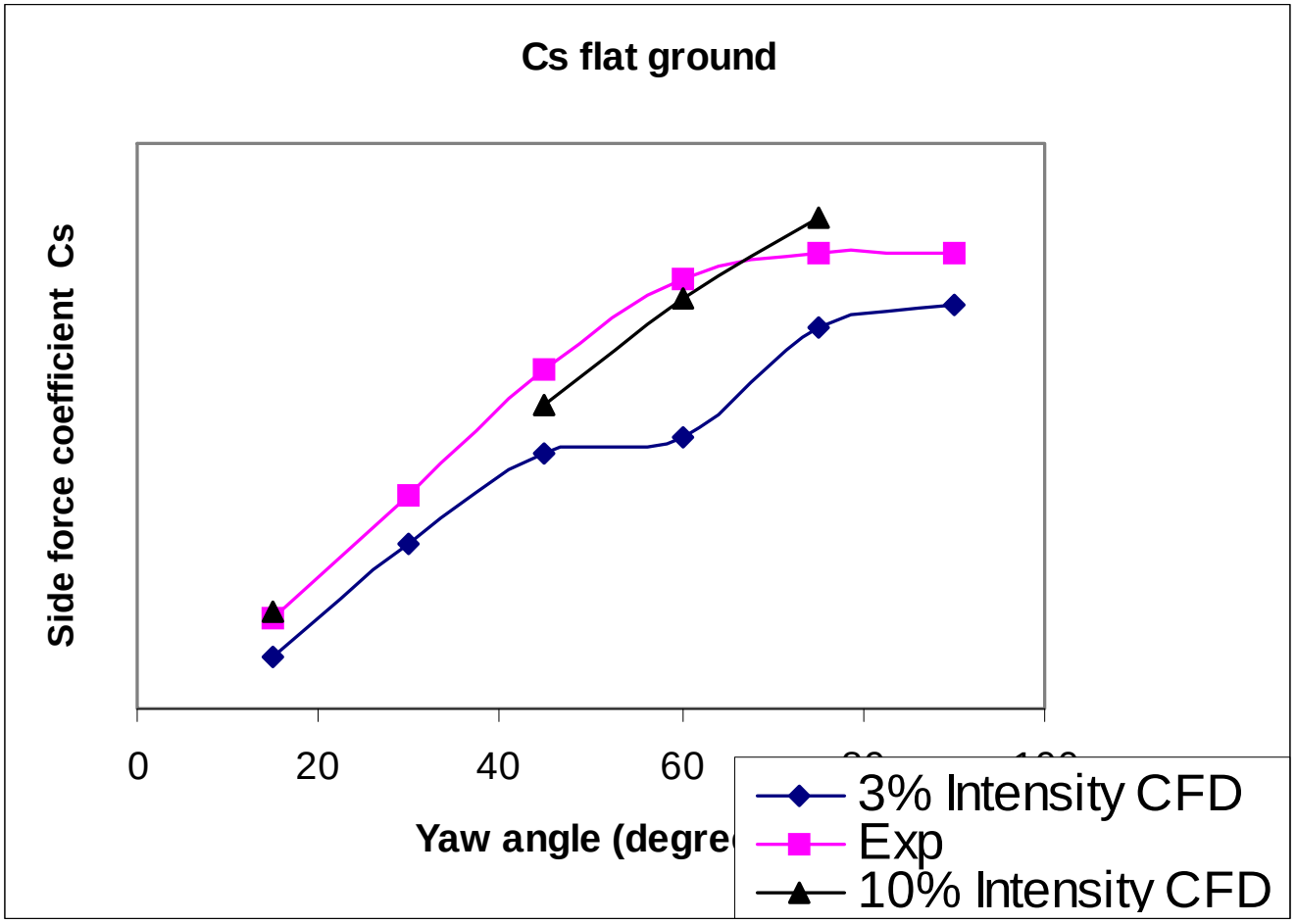
QUB wind tunnel experiment

- 1/50 scale Mark 3 coach & loco.
- Flat ground
- Turbulence intensity <1%
- Reynolds number 1.6*10^5



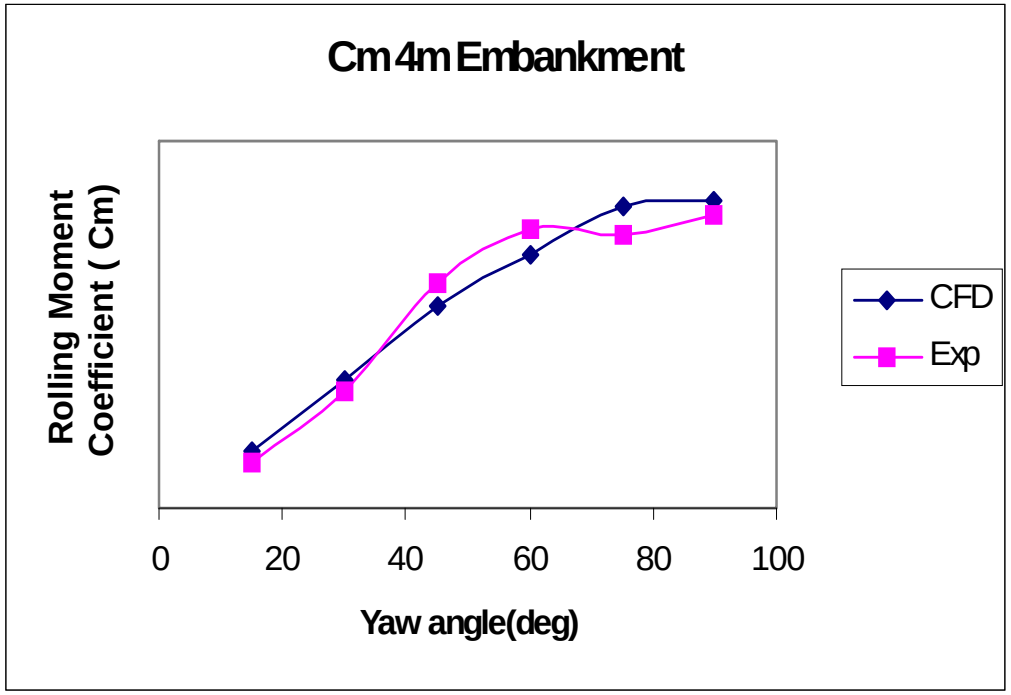
BMT ABL wind tunnel experiment

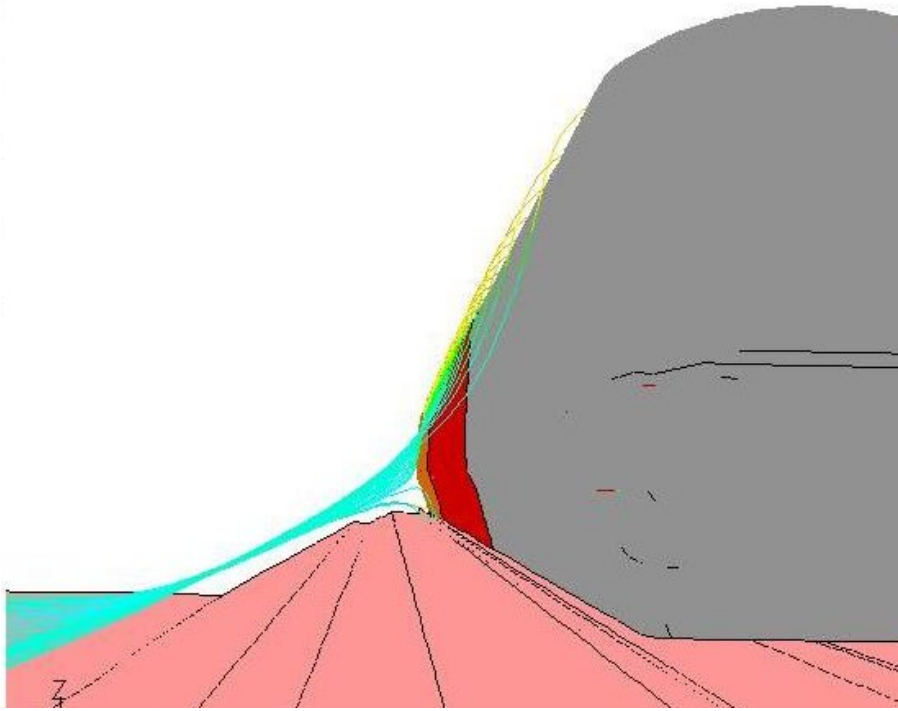
- 1/30 scale Mark 3 coaches & loco.
- Reynolds number 2.5*10^5
- Turbulence intensity 22% at 3m (full scale)
- Turbulence length scale 24m (full scale)



Train on 4m embankment

- CFD 3% turbulence
- Flow attached to embankment slope
- Less sensitive to turbulence?





Conclusions

CFD shows promise for accurate simulation of

- Flow over train on embankment
- Forces and moments
- Train motion over ground

Problems

- Turbulence intensity and length scale important
- Ground roughness should be adjusted for correct wind profile

CFD may extend the range of wind tunnel data

- Train motion over ground
- Unsteady flow, e.g. gust simulation