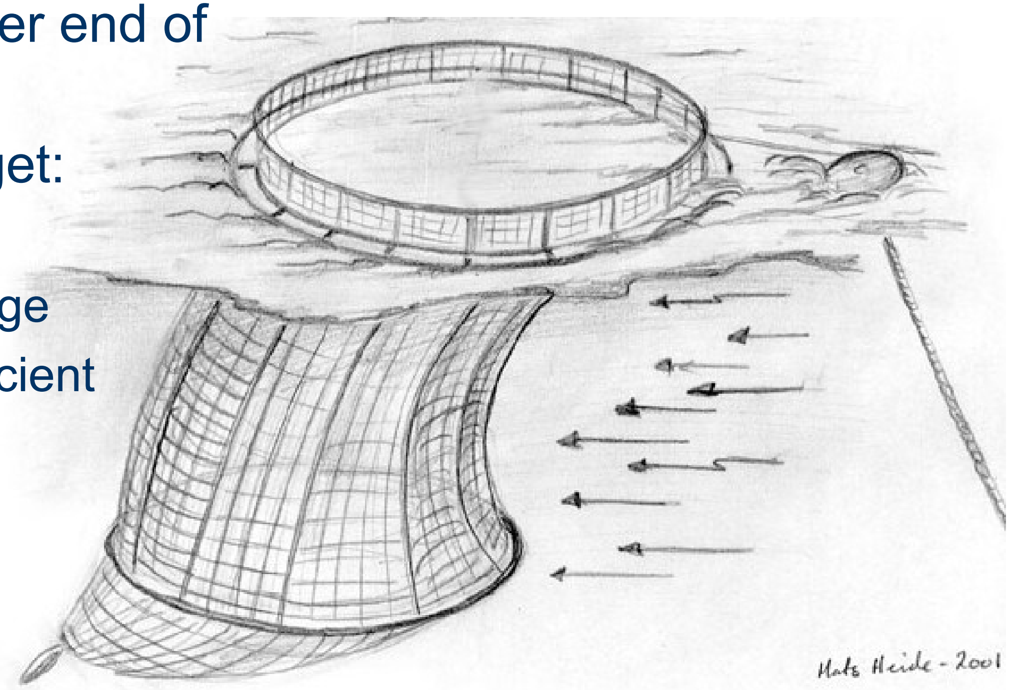
A non-dimensional weight-velocity parameter for estimating drag force and net deformation of gravity fish cages

by
Kyrre Vikestad & Egil Lien
SINTEF

A gravity fish cage

- The net is connected to buoyancy members (cage collar) at the top end
- The shape in current is kept by weights hanging down from the lower end of the cage walls
- For increasing current we get:
  - Larger deformations
  - Less volume inside the cage
  - Reduced drag force coefficient on the cage, due to the deformation



The weight-velocity parameter: What are the limitations / assumptions?

- The parameter is the reduced velocity: where:

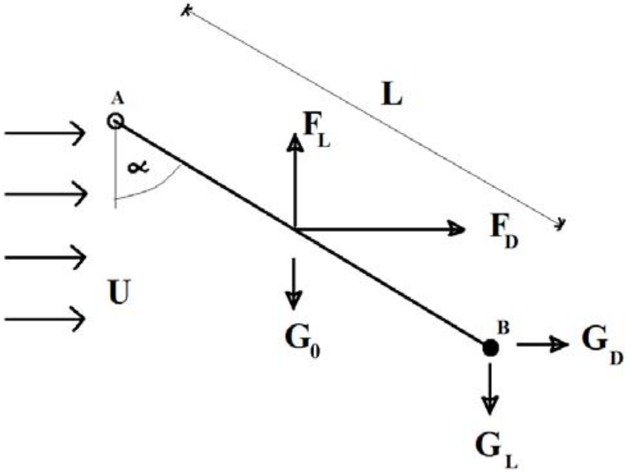
$$V_{red} = U\sqrt{\frac{\rho}{2G}}$$

  - U is the incoming flow velocity
  - ρ is water density
  - G is the **equivalent** weight per net area

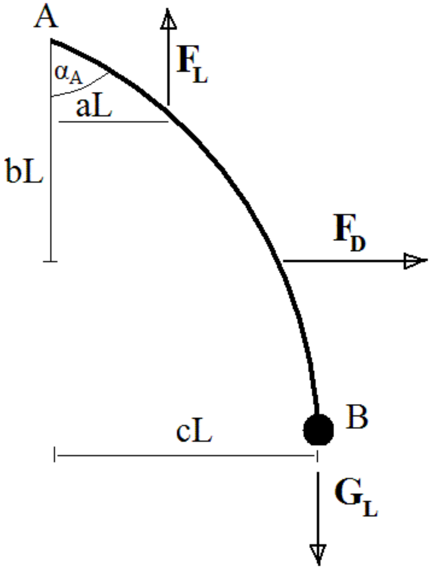
- The following is assumed:
  - The weights have no drag force
  - Cage modelled as vertical panels; the drag/lift forces on the bottom of the cage is neglected
  - Uniform current

How is the parameter found?

- By looking at the moment equilibrium of a (straight) panel with evenly distributed weight.

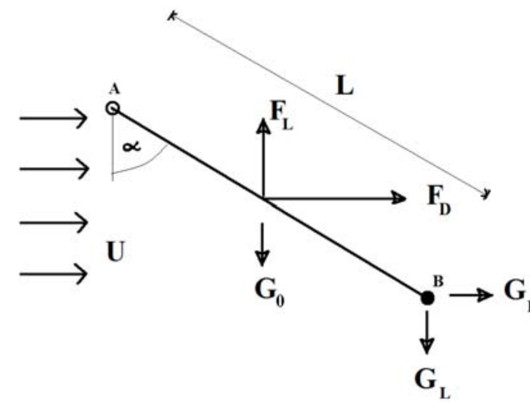


- Later extending the results using the moment equilibrium of a neutral panel with bottom weight.

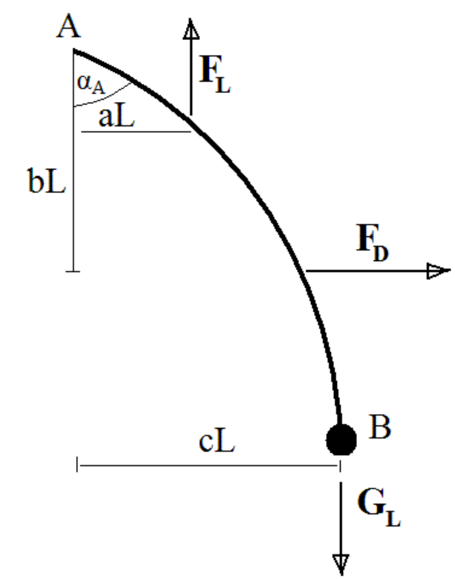


The difference between evenly distributed weight and panel with bottom weight:

- Evenly distributed weight:
  - The panel is straight when exposed to uniform current
  - The equivalent weight/area is G=weight of net in water/area of the net

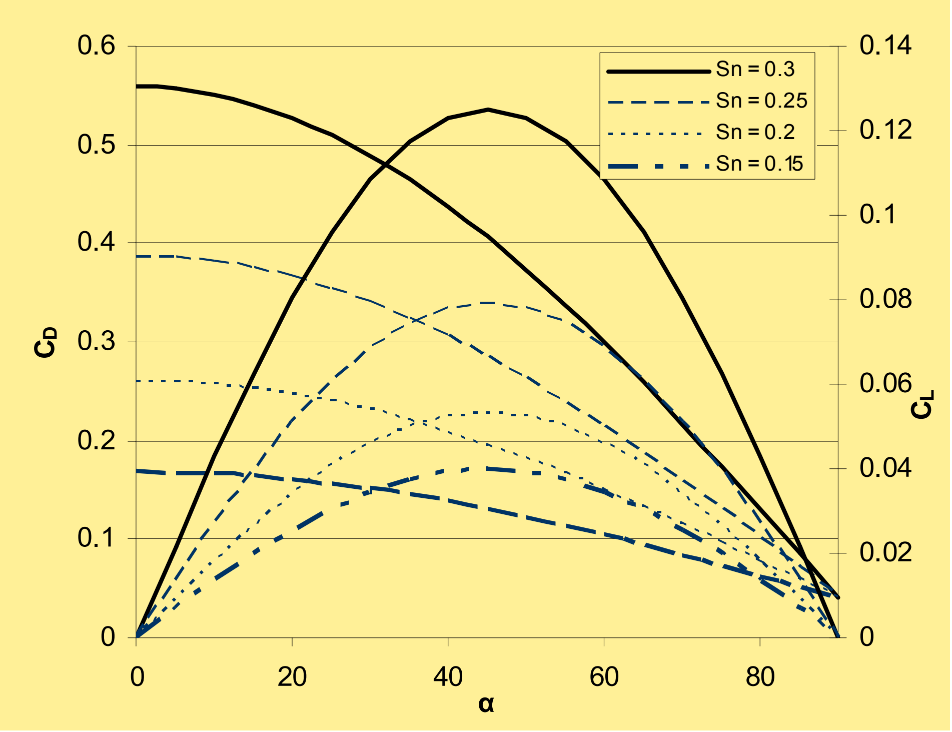


- Panel with bottom weight
  - Net is assumed neutral in water
  - The equivalent weight/area is $G=2G_L$/area of the net, where G_L is the bottom weight



Lift and drag given as functions of the solidity Sn and the incident angle α

- WE are using the formulations by Aarsnes et al (1990)
- Other formulations could have been used;
  - The results would have been different
  - The weight-velocity parameter would still be just as useful!



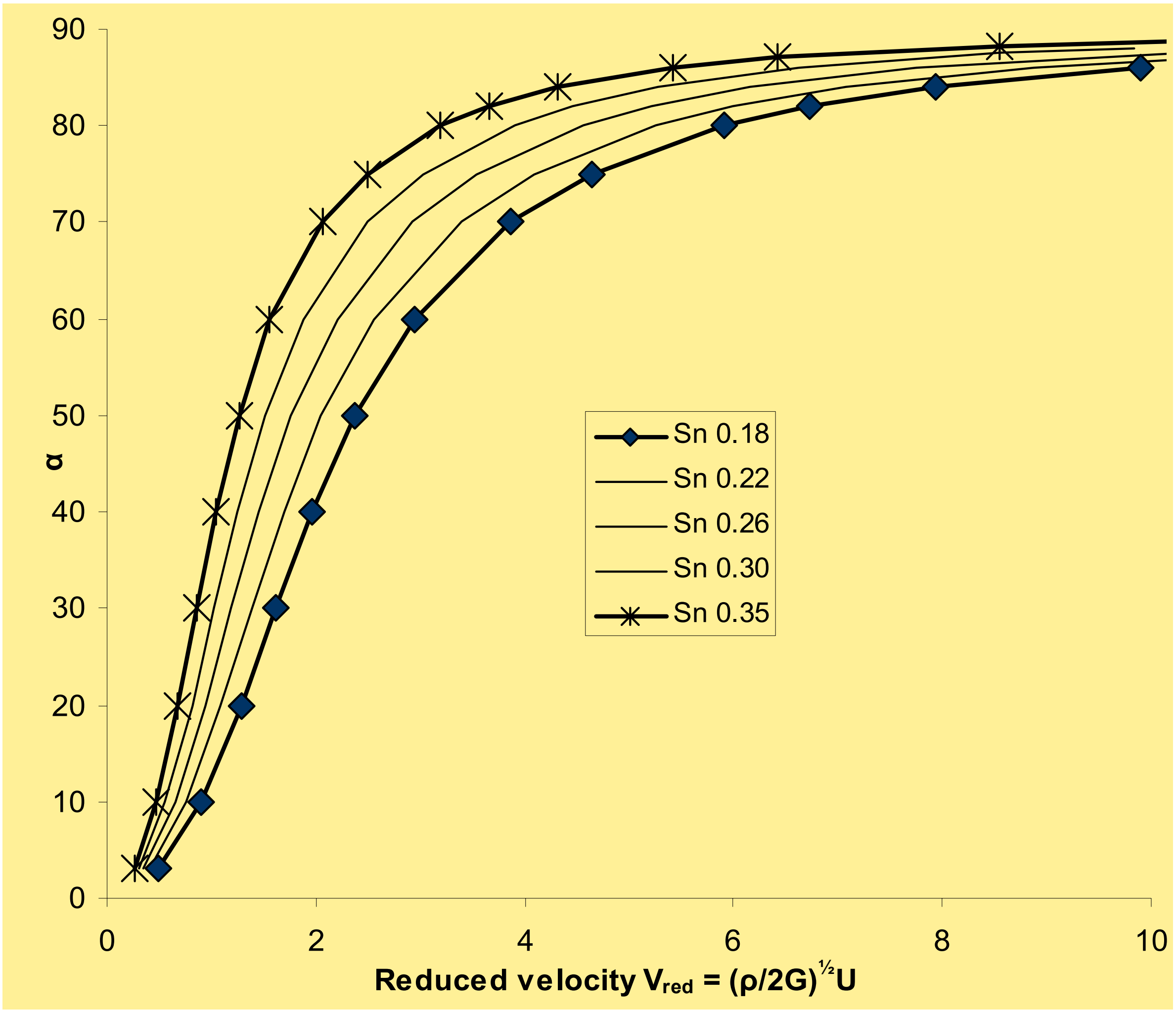
Evenly distributed weight, panel deformation (could be solved "analytically"):

Solution of:

$$V_{red}\, f(\alpha) = 1$$

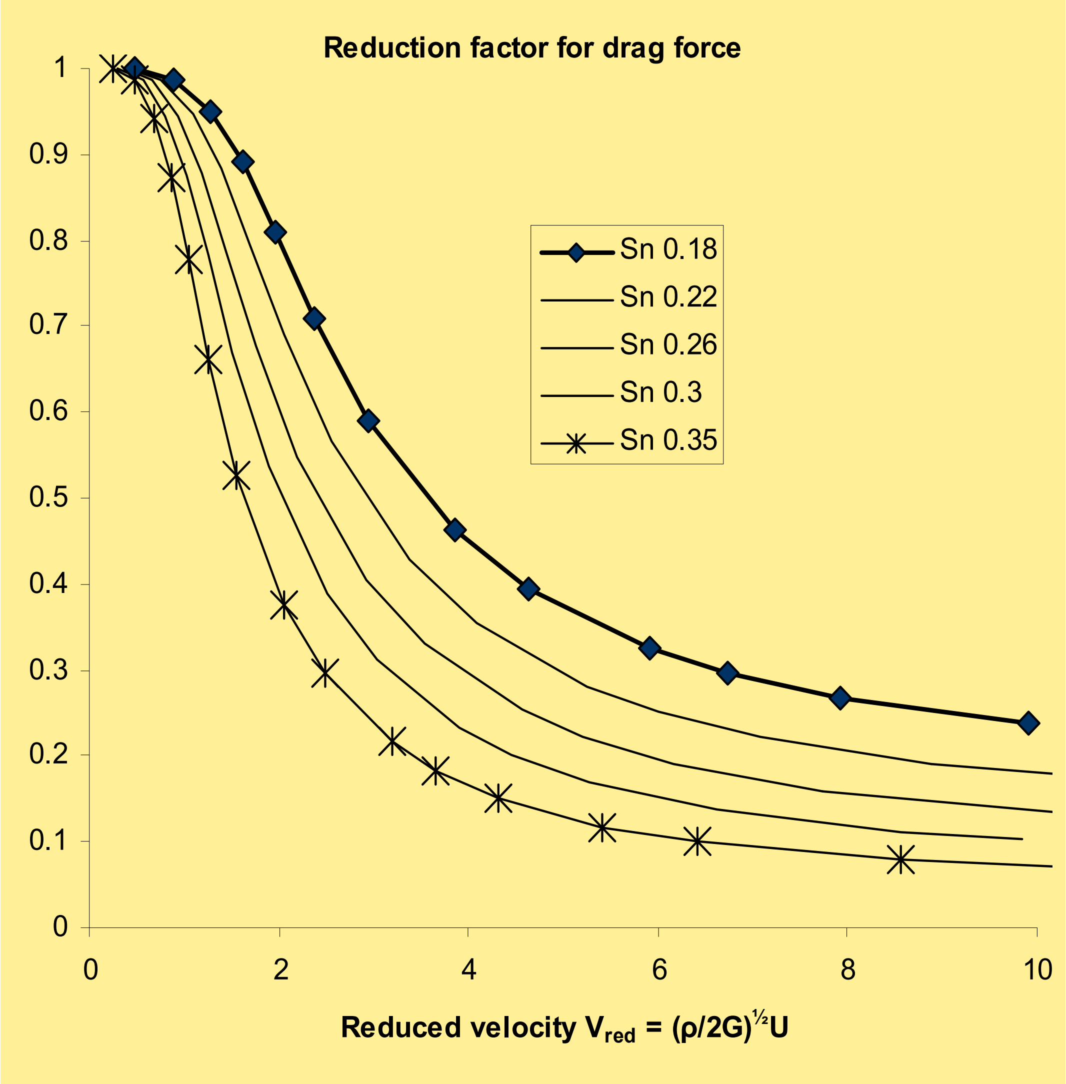
where

$$f(\alpha) = \sqrt{\frac{C_D(\alpha)}{\tan(\alpha)} + C_L(\alpha)}$$



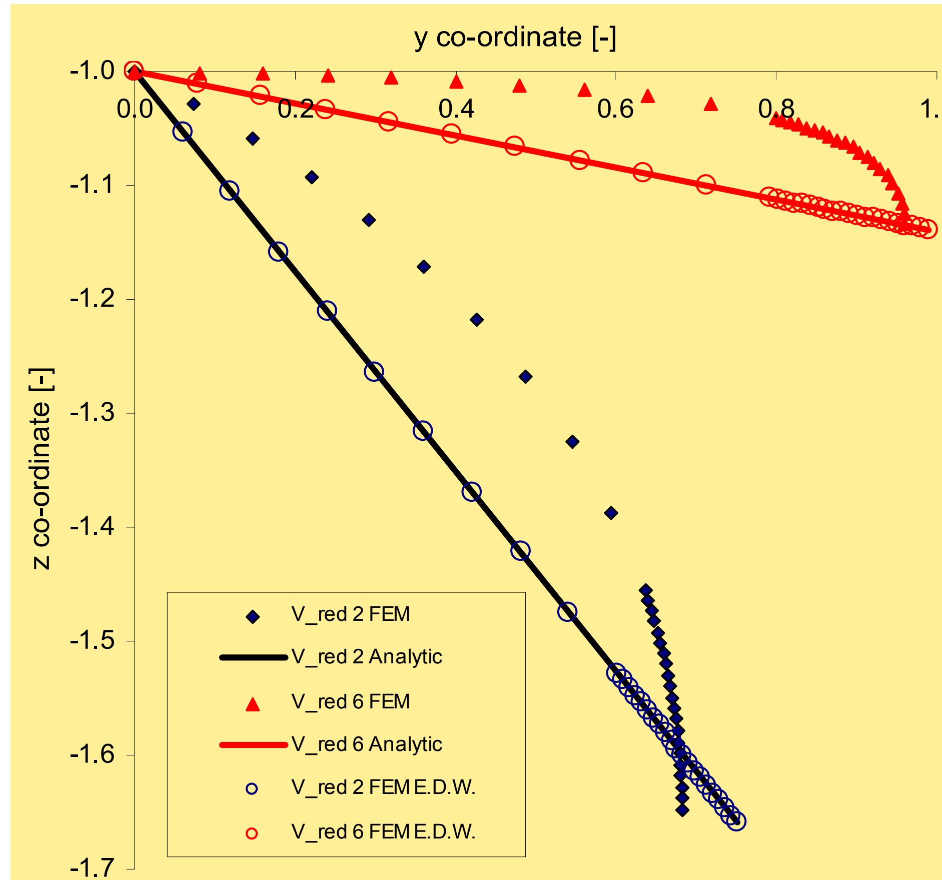
Evenly distributed weight, drag force reduction:

Found from the $C_D(\alpha)$ relationship;
$C_D(\alpha) / C_D(\alpha=0)$

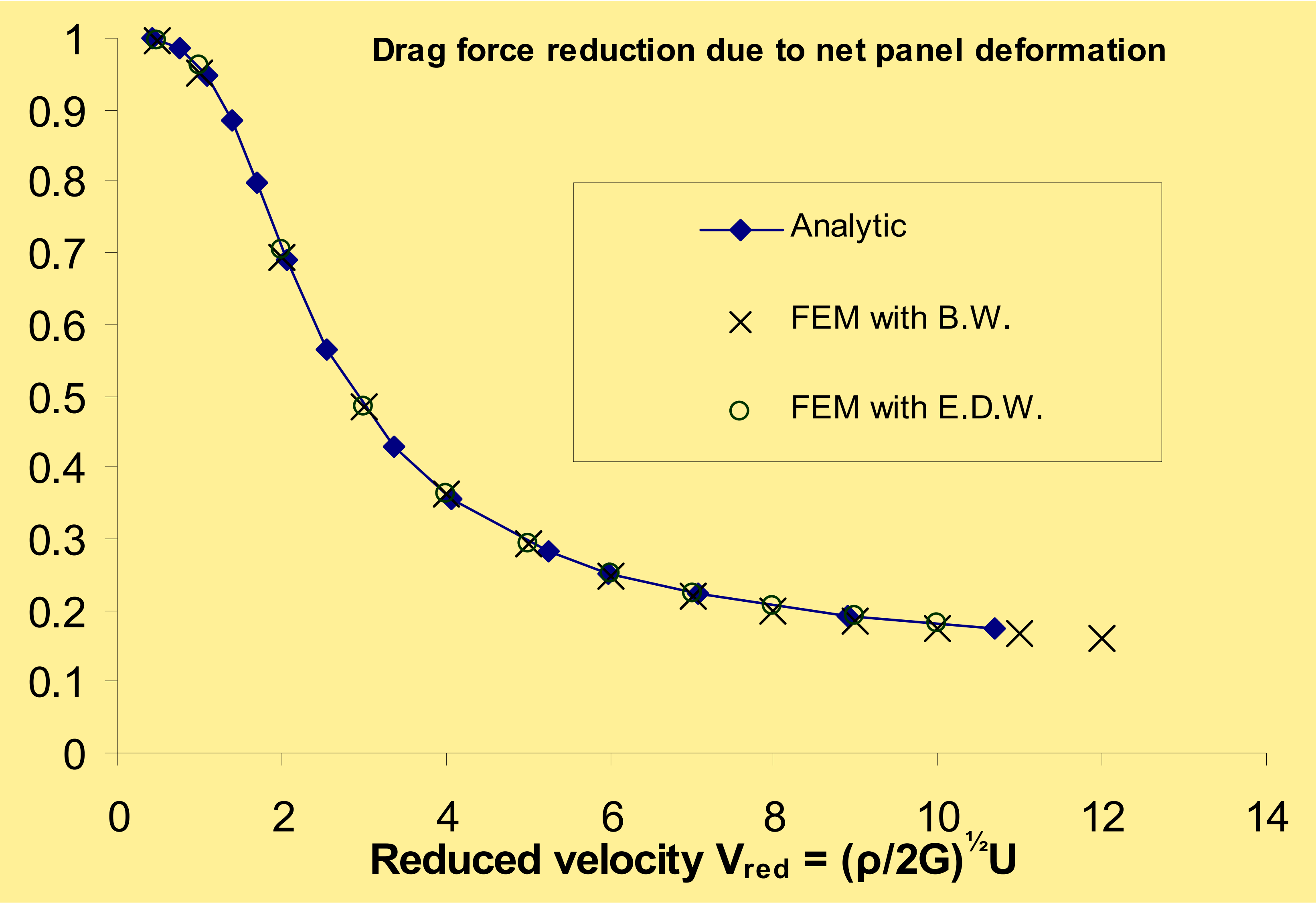


Comparing deformation for evenly distributed weight and bottom weight, V_{red} = 2 and 6

- For the force coefficients used, the maximum depth does not vary much



Drag force reduction as function of V_{red} :



Conclusion

- The weight-velocity parameter V_{red} can be used for:
  - Deciding the bottom weights needed for a given velocity and maximum deformation allowed
  - Finding the reduction in the static drag due to panel deformation

- For a given net, once the pre-calculations (finding the $f(V_{red})$ relationships) are done, the results can be used for all combinations of weight and depth
  - $C_L(\alpha)$ and $C_D(\alpha)$ must be known
  - Beware: Bio-fouling may change $C_L(\alpha)$ and $C_D(\alpha)$