# Modelling and validation of flow over a wall with large surface roughness

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Fluid flow over surfaces with large surface roughness is important in many applications such as hydropower tunnels and natural channels. When creating numerical models of such applications it is very impractical to include the wall roughness in the geometrical model both with regards to the geometric resolution required and the large computational cost of performing such simulations. Wall roughness is therefore typically estimated as a global parameter by some empirical relation and added mathematically into numerical simulations. It is here examined if combining partially resolved geometric wall roughness with partially modelled roughness can increase the quality of simulations in a quantitative manner.

A high-resolution laser scanning of an excavated tunnel was used to create a geometry for Computational Fluid Dynamics (CFD) simulations and a scale model of the geometry (1:10) was constructed for experimental validation. A section of the side wall from the tunnel with dimensions 40x2.5 m was selected for the numerical and experimental models. The height of the roughness elements for this wall segment varied between 0-0.8 m. This rough wall was then deployed as a side wall in a rectangular channel where the other walls were considered smooth.

Simulations were performed with the commercial software CFX13 from Ansys Inc. A $k - \epsilon$ turbulence model with standard wall functions was applied and the geometry of the rough surface was resolved to different degrees by numerical grids with varying element sizes. A numerical roughness is then added to the wall with partially resolved geometrical roughness to give a total roughness corresponding to the actual tunnel wall. Particle Image Velocimetry (PIV) measurements were made on the scale model to validate the simulations. By combining the partially resolved surface with a numerical wall roughness it is possible to obtain a model that is more accurate than a model with only numerical roughness but with a much lower computational cost than a model that fully resolves the discrete roughness elements of the surface.

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