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THE EFFECTS OF DYNAMIC MESH METHODS ON BRIDGE DECK VIBRATIONS

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INTRODUCTION

Literature is rife with the effects of Vortex-Induced Vibrations (VIV) on bridge decks [1]. However, extant analysis is mainly confined to analytical, experimental and semi-empirical approaches. Numerical approaches can be effective, although they are computationally expensive. Also, the errors and instabilities associated with these approaches increase with the use of a dynamic mesh. In the case of Large-Eddy-Simulation, this mesh distortion can have a significant influence on the surrounding velocity field. The aim of this research therefore is to investigate the effects of various dynamic mesh approaches on the VIV of bridge decks. The calculations were performed using the open-source code OpenFOAM.

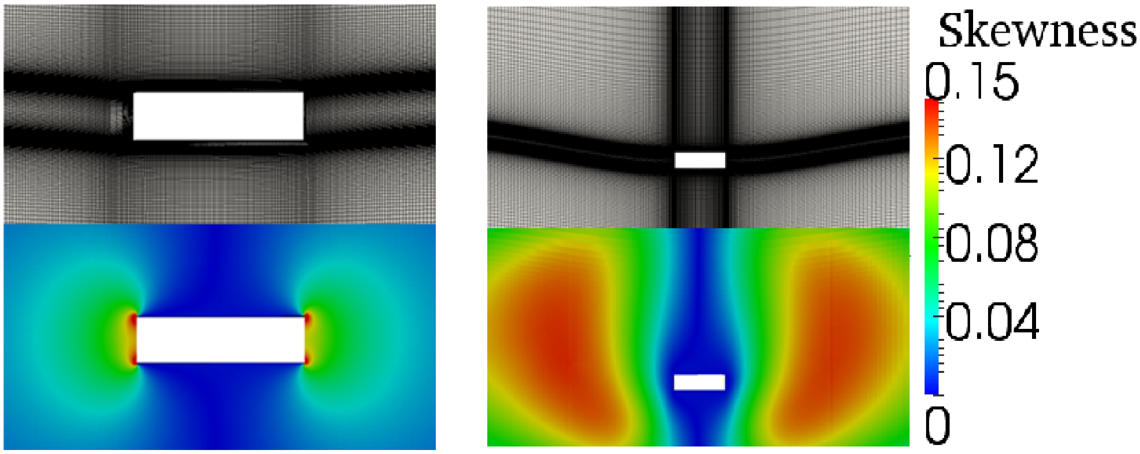
METHODOLOGY

The term *dynamic mesh* refers to the relative distances among grid points changing in time to adjust to an unsteady motion of a body through squeezing and stretching the surrounding cells and their associated vertices. To govern the vertex motion, OpenFOAM's distance-based diffusive models adopt a Laplacian operator

$$\nabla \cdot (\gamma \nabla u_p) = 0 \tag{1}$$

where u_p is the point velocity, which is imposed at each vertex of the control volume. The boundary conditions for this are enforced from the known boundary motion, e.g. a moving wall. The diffusivity, γ, has a significant influence on the mesh deformation [2]. The various types of diffusive models include: constant $\gamma = constant$, linear $\gamma = 1/l$, quadratic $\gamma = 1/l^2$, and exponential $\gamma = e^{-l}$. l is the cell centre distance to the nearest selected boundary. Comparison of these models for the VIV of a rectangular bridge deck (height-width ratio 1:4) was undertaken. The fluid flow, using Large-Eddy Simulation was considered to be smooth with Reynolds number Re = 40,000. PimpleDyMFoam was used for the calculation of the dynamic mesh, while the sixDoFRigidBodyMotion [3] solver was utilised to determine the response of the structure.

RESULTS



(a) $\gamma = constant$ (b) $\gamma = \frac{1}{l^2}$

Figure 1: The effect of diffusivity model on the mesh skewness around the bridge deck.

The mesh distributions around the bridge deck using two of the aforementioned diffusion models are presented here. It is clear from the differences of figures 1(a) and 1(b), that the quadratic diffusion model is favourable as the mesh skewness is focused further from the bridge deck thus resulting in a more stable calculation; as opposed to the constant diffusion model.

CONCLUSIONS AND FUTURE RESEARCH

The influence of the diffusion models on the dynamic mesh calculations for bridge deck vibrations is the focus of this paper. The quadratic diffusion model has shown to present a more stable calculation than that of the constant model. Further research into non-distance based models such as the quality-based diffusion models are to be considered; applying these for both heaving and torsional motions.

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