WATER FLOW PRESSURE CHANGES ON CIRCULAR AND SQUARE BRIDGE PIERS UNDER INCREASING VELOCITY FLOODS

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RESISTANCE TO FLOOD IS A CRITICAL PARAMETER AFFECTING THE DESIGN OF THE BRIDGES. TYPICAL DESIGN PROCESS WOULD CONVERT THE FLOOD LOADING IN TO A STATIC FORCE WHICH CAN NOT REFLECT THE FULL EFFECT OF FLOOD ON DIFFERENT SHAPED PIERS. THEREFORE IT IS IMPORTANT TO INVESTIGATE THE EFFECT OF FLOOD LOADING ON PIERS OF DIFFERENT SHAPE. THIS WORK SIMULATES THE FLOODING EFFECT ON THE PIERS USING A FINITE VOLUME METHOD IN ANSYS FLUENT. THE PIER IS MODELLED AS A COLUMN WITH A SQUARE CROSS SECTION OR A CIRCULAR CROSS SECTION.

INTRODUCTION

Floods have the greatest damage potential of all natural disaster worldwide and effect the greatest number of people. Over the last 30 years, many bridges were damaged under the impacts of flooding, The damages to these bridges are completely or partially attributed to, the damages to piers. Generally, a great majority of bridges are built across rivers, and routinely the water flow force on the pier is calculated using the methods specified in the design codes.

- Previous studies on the effect of the flood are mainly focused on the fluid loadings. Basically, the simulations based on Computational Fluid Dynamic (CFD) are reliable and they have a definite advantage over simplified calculation of pressure as a function of velocity of flood, CFD can also assist in assessment of lift and drag loading on flooded decks, the shape optimization of piers with the aim of minimizing the scour and pier erosion, the analysis of sediment transport and its influence on scour and evaluation of active or passive countermeasures for damage mitigation.
- The research scope is to calculate the flood hydro-dynamic forces applied to the bridge pier, using CFD method, as the flood forces needs more investigation due to increasing the flood intensity during last decades. In this study, a Finite Volume Method (FVM) method is used to determine the distribution of pressure on the piers in cuboid and cylindrical shapes in a wide range of flood velocities.

METHODOLOGY

- The complex fluid/solid interactions under the effect of flood are governed by the Navier–Stokes equations in which the conservation of mass, momentum and energy are taken into account. Numerical methods such as finite-volume method (FVM), finite-difference method (FDM) and Finite Element Analysis (FEA) have been developed to effectively discretise and solve these equations.
- Depending on the flow conditions, hydrostatic and hydrodynamic loads are generally applied to the bridges. These loads depend on the flow velocity and hydrodynamic load can be transferred to hydrostatic one for simplification when the velocity is less than 10 m/s according to the standard of ASCE. However, AS 5100 does not have such a restriction. The hydrodynamic load can be split into the drag and lift forces.
- The setup conditions for both models of the square and circular pier are the same and the velocity of the fluid domain is varied to derive the pressure variation. As the behaviour of the structure in this step is not considerable, the piers have been modelled as an unstructured model. The nonslip walls are assumed as boundary conditions and also for unstructured piers.

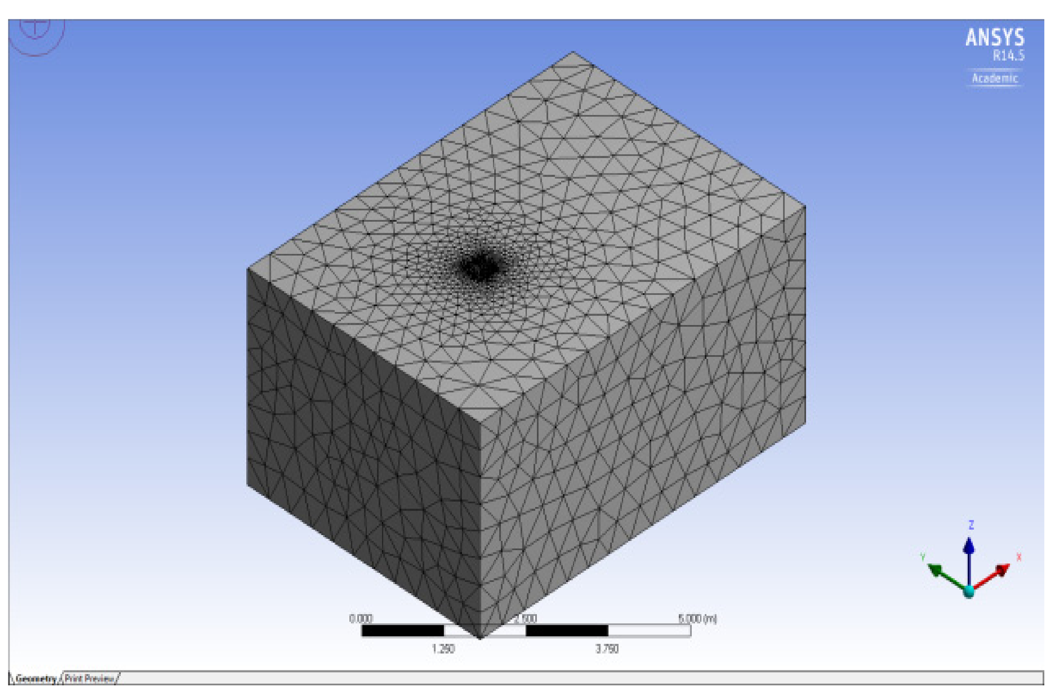

Fig 1: The model is discretised in adoptive mesh

RESULTS AND DISCUSSION

The flood depth is 3.5 m height as it is suggested by AS5100.2 as a critical flood height. Various velocities have been applied to the domain in the range of 0.5-10 m/s with 0.5 m/s increments.

Based on the analysis results the positive and negative pressure distribution is given as the pressure vs. pier height. Pressure-derived by the CFD analysis for different velocities are demonstrated in figure 2 and figure 3.

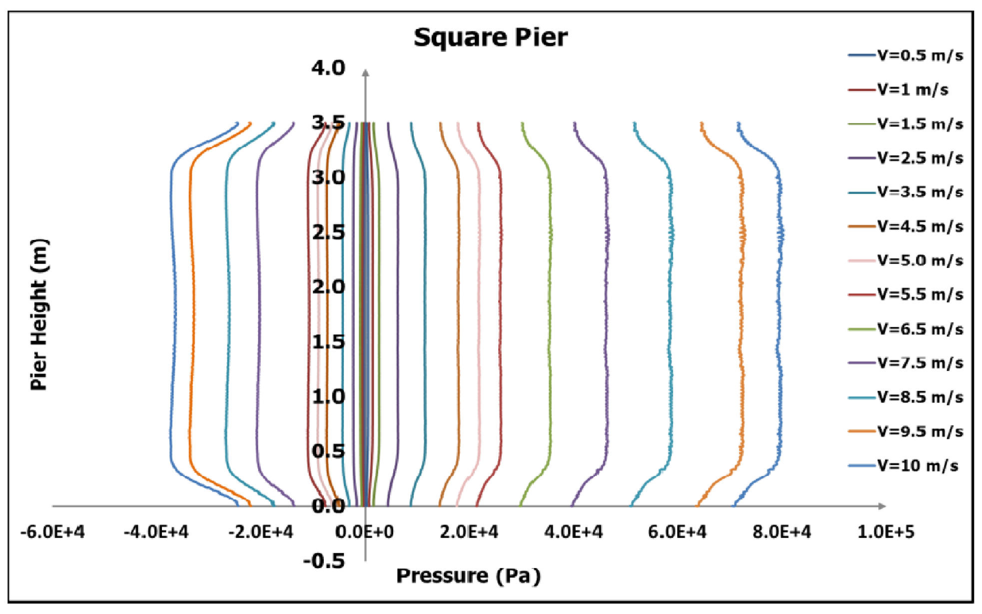

Fig2: Pressure distribution along the square pier height

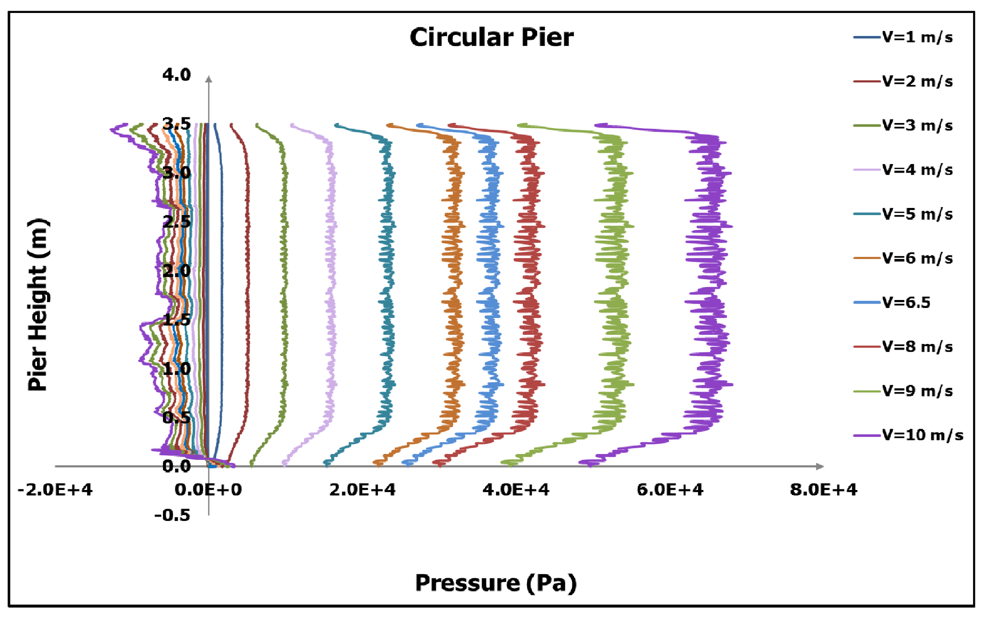

Fig3: Pressure distribution along the circular pier height

The pressure distribution on the square pier along the pier height shows a smooth curve with constant value while in the circular pier the pressure distribution fluctuates. The values in the circular pier show the same consistency as well as the square pier. There is a very significant difference in negative pressure on the other side of the pier.

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