# CFD SIMULATIONS OF ASYMMETRIC KINOSHITA-GENERATED MEANDERING BENDS

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Most alluvial rivers have a tendency to meander as they flow downslope. To improve channel conveyance many streams have been channelized with detrimental consequences downstream. A good example is given by the Kankakee River that was straightened on the Indiana side and has exacerbated flooding problem as it flows though Illinois for more than a century. Nowadays there is a strong desire to restore streams to more natural conditions. However, not much is known about re-meandering of channelized streams and often times is not possible to go back to the original meandering pattern due to the development that has taken place along the river banks and its floodplain. So there is a great need to understand the mechanics of meandering streams if any further progress is to be made in restoring them to more natural conditions (Abad and García, 2005).

River planform evolution is described by a wide variety of key parameters such as flow conditions, sediment size distribution, vegetation, geological characteristics of the channel boundaries. The interactions of these key parameters result in a complex system, which can not be completely described yet even with the great advance of computational, experimental and field resources observed in the last decade. Scientists and engineers have had to incorporate assumptions and restrictions to their approaches in order to gain a better understanding of natural systems such as rivers. However several limitations have led the unsatisfactory prediction of the flow field and bed morphology interaction at high stages of river evolution. From an engineering perspective, prediction of time evolution of meandering rivers is indispensable for economic and social reasons such as development of urban areas near rivers, for prevention of damage in civil structures (e.g. bridges, water intakes, highways), for prevention of agricultural land losses, and for the maintenance of biological diversity in rivers. From a scientific perspective, a better understanding of the interaction of such key processes would made it possible to define under what conditions meander cut-offs, resonance between sediment bar migration and channel sinuosity, migrating and non-migrating alternate bars, can be observed in the field. This knowledge would facilitate the development and improvement mechanistic models for bed and bank erosion, thus making it possible to predict time evolution of rivers (García et al, 1996).

Several laboratory experiments have dealt with periodic symmetric channel configurations and have described the importance of high-amplitude and high-curvature bends in terms of flow structure and sediment redistribution. However, the effects of asymmetric configurations, commonly found in rivers on flow structure and sediment patterns are not completely understood. This study attempts to provide some insight into this topic regarding the hydrodynamic description of the flow. Four meandering channels are simulated for different sinuosities ($\theta = 20°$, $\theta = 50°$, $\theta = 90°$ and $\theta = 100°$) by using an asymmetric Kinoshita-type planform configuration. Sediment transport is not considered in this first stage of the study; thus, the meandering channels have been described topographically by using an empirical formulation based on local curvature and channel forming discharge. Thus, a state-of-the-art three-dimensional CFD model (FLOW3D) is applied herein for predicting the hydrodynamic flow structure. Fig. 1 shows the bed configuration and the near-bed boundary shear velocity responsible for sediment transport (bed-load) for $\theta = 20°$ and $\theta = 100°$ configurations. In a freely meandering condition, the time required to evolve from the 20° to 100° angular amplitude is 320 years approximately. Fig. 2 shows the velocity magnitude and turbulent kinetic energy at different cross sections at the middle bend. The results have reflected the importance of capturing the convective accelerations due to the presence of point bars, which redistribute the primary and secondary flows as well the near-bed shear velocity. Regions with high turbulent kinetic energy near the bed were found, which can in turn be related to the rate of bed and bank-toe erosion. Therefore, it was found in this initial attempt that coupling of the hydrodynamics and sediment transport for river-reach scales is essential in order to obtain better predictions on evolution of meandering rivers.

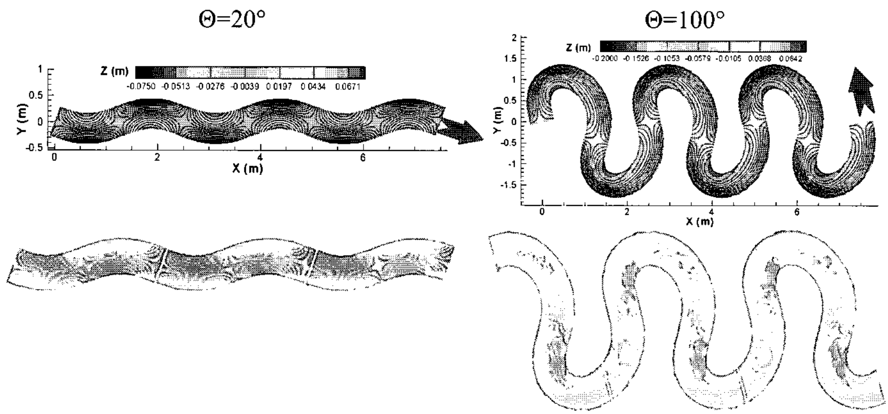
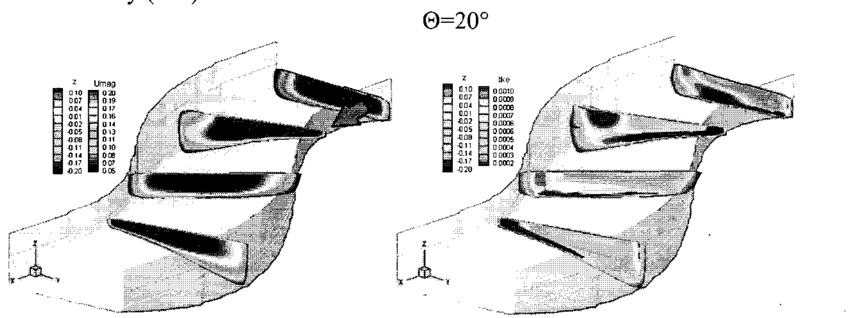



Fig. 1 [left] 20°, [right] 100°. Top figures: Bed elevation, bottom figures: near-bed shear velocity (m/s)



Θ=100°

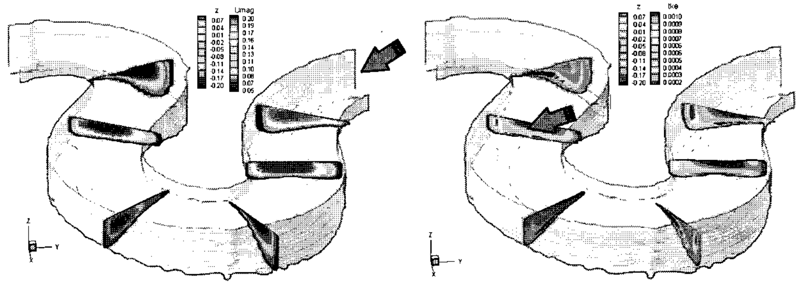


Fig. 2 [left] Velocity magnitude, [right] turbulent kinetic energy at different cross sections at middle bend Top figures: 20°, bottom figures: 100°

## REFERENCES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