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Evaluation of River Meander Geometry Using Uniform Excess Energy Theory and Effects of Climate Change on River Meandering

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Abstract : Since ancient history rivers have been the fostering and favorite place for people and civilizations to live and exist along river banks. However, due to floods and droughts, especially sever conditions due to global warming and climate change, river channels are completely evolving and moving in the lateral direction changing their plan form either through straightening of curved reaches (meander cut-off) or increasing meandering curvature. The lateral shift or shrink of a river channel affects severely the river banks and the flood plain with tremendous impact on the surrounding environment. Therefore, understanding the formation and the continual processes of river channel meandering is of paramount importance. So far, in spite of the huge number of publications about river-meandering, there has not been a satisfactory theory or approach that provides a clear explanation of the formation of river meanders and the mechanics of their associated geometries. In particular two parameters are often needed to describe meander geometry. The first one is a scale parameter such as the meander arc length. The second is a shape parameter such as the maximum angle a meander path makes with the channel mean down path direction. These two parameters, if known, can determine the meander path and geometry as for example when they are incorporated in the well known sine-generated curve. In this study, a uniform excess energy theory is used to illustrate the origin and mechanics of formation of river meandering. This theory advocates that the longitudinal imbalance between the valley and channel slopes (with the former is greater than the second) leads to formation of curved meander channel in order to reduce the excess energy through its expenditure as transverse energy loss. Two relations are developed based on this theory; one for the determination of river channel radius of curvature at the bend apex (shape parameter) and the other for the determination of river channel sinuosity. The sinuosity equation tested very well when applied to existing available field data. In addition, existing model data were used to develop a relation between the meander arc length and the Darcy-Weisback friction factor. Then, the meander wave length was determined from the equations of the arc length and the sinuosity. The developed equation compared well with available field data. Effects of the transverse bed slope and grain size on river channel sinuosity are addressed. In addition, the concept of maximum channel sinuosity is introduced in order to explain the changes of river channel plan form due to changes in flow discharges and sediment loads induced by global warming and climate changes.

Keywords : river channel meandering, sinuosity, radius of curvature, meander arc length, uniform excess energy theory, transverse energy loss, transverse bed slope, flow discharges, sediment loads, grain size, climate change, global warming
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