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Degradation in channel and its modelling- A Review

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Abstract - ***Degradation is process of lowering the fluvial surface of stream bed, through erosional processes. Any artificial or natural change, of a permanent nature, in the flow of water and/or sediment may affect the entire system. Such effects may prove detrimental to the proper functioning of the engineering works located in the river. The various parameters and methods as well as relations were proposed by previous researchers. The extensive study of research paper is carried out for a review paper which determine degradation in alluvial channel by different mathematical model.***

Keywords–Degradation, numerical modelling, Nonuniform sediment, River bed.

I. INTRODUCTION

Many rivers are so delicate that, any artificial or natural change, of a permanent nature, in the flow of water and/or sediment may affect the entire system. The rate at which the river will adjust its regime to artificial river works or the natural causes may be very slow or rapid depending on its nature.

An alluvial stream flowing under equilibrium condition is called a graded stream. No natural stream however is truly in equilibrium. The discharge of a natural stream varies continuously with time, with a ratio of high discharge to low discharge ranging from unity to several hundred or more. The temperature and the rate of sediment supply by tributaries and even the character of the sediment also vary. The result of continuous change is that the stream under in consideration be in true equilibrium.

A change in controlling factors, namely, slope, sediment size, water and sediment discharge, will necessitate changes in one or more factors to restore the equilibrium. The above situation can be explained quantitatively by well-known balance analogy by Lane (1955), where two controlling variables, sediment discharge and diameter of sediment are on one pan and the other two controlling variables, water discharge and slope area on the other pan. Thus, if the sediment equilibrium can again be restored only if the water discharge and/or slope are increased sufficiently.

II. LITERATURE REVIEW

Robert G. Bell, et al. (1983) examined The response of a gravel bed reach to imposed steady flows under nonequilibrium conditions, where the bedload inflow is zero. Experimental research to date and general mathematical models for nonequilibrium alluvial conditions are reviewed. An experimental program was designed to examine the transient bed response for different reach lengths. Also, measured nonequilibrium bedload transport rates were compared with comparable local equilibrium capacity rates at selected time intervals and distances for a common mean flow velocity. Differences occurred between nonequilibrium transport rates and comparable equilibrium capacity rates at a maximum near the beginning of the reach but diminishing towards the downstream end of the local scour hole. This spatial variation of the transport rate deficit exists because the flow requires a finite length of bed to erode sufficient bed material to satisfy its equilibrium transport capacity. Consequently, mathematical model performance will be poor in the local scour hole region

Wilson F. Jaramillo, et al. (1984) has worked on Aggradation and Degradation of alluvial channel beds using the nonlinear parabolic model for nonequilibrium processes. They derived analytical expressions for the characteristic parameters of relevant aggradation and degradation processes. The validity and limitations of the model are assessed by comparing the analytical results with the available experimental data. The nonlinear parabolic model introduced in their paper can be considered as an accurate tool for predicting one-dimensional non-equilibrium processes in alluvial channels. It is applicable to both aggradation and degradation processes in which the relative variation in sediment discharge, $\Delta G0/G0$, ranges between - 1 and 1. The agreement between the nonlinear analytical solution and the available experimental data is good.

Mohammad Akram Gill, et al. (1987) presented perturbation solution for the non-linear aggradation/degradation problem. The second order solution is believed to account for the non-linear character of the aggradation/degradation equation. The predicted profiles are compared with the experimental results. The agreement between theory and experimental observations is good. The limiting curve for the extreme nonlinear situation is within the usual scatter range of the linear solution indicating that in many situations, the linear solution by itself may provide reasonably accurate predictions. In situations where the ratio of the initial and final sediment supply rates is very small, a non-linear correction is needed.

Subhash C. Jain, et al. (1989) determined the rate and extent of riverbed degradation resulting from sediment interruption by means of computer-based numerical experiments. Momentum and continuity equations for water and sediment flows in a wide prismatic channel are solved numerically using a recently verified model for the bed armoring process. The bed profiles for different times are found to be similar and are coalesced to a single normalized curve. The changes in bed levels and mean sediment size, and the length of degradation, determined from the numerical experiments, are correlated by multiple regression analysis to the independent dimensionless variables.

Bhallamudi, et al. (1991) numerically solved the aggradation and degradation of channel bottom due to an imbalance between water flow and sediment discharge by using the Saint-Venant equations describing an unsteady flow in open channels and the continuity equation for the conservation of sediment mass. The MacCormack explicit finite-difference scheme was introduced in their paper for study the cases of Bed- level changes due to sediment overloading, development of longitudinal profile due to base-level lowering,bed- level changes associated with the migration of knickpoints, the computed results were compared with the available experimental data. The agreement between them was satisfactory. After surveying the above discussed literature, it is concluded that numerical models based on the finite difference scheme are also capable of producing satisfactory results for simulating the transient bed and water surface profiles for the process of aggradation and degradation in alluvial channels. Therefore, in a present study a numerical model based on an explicit finite difference scheme has been developed to simulate transient bed and water profiles for the processes of degradation in alluvial channels.

C.W.Lenau, et al. (1992) did their research work on the River Bed Degradation due to abrupt outfall lowering.In their paper, they conducted a study for the lower reaches of tributaries of the MissouriRiver which were straightened in the late 19th and early 20th century due to which thischannel degradation had progressed towards the upstream side. A diffusion model and a hyperbolic model, each describing channel degradation, were solved using a Laplace transform approach. In their paper they concluded that closed- form solution for the diffusion model, but numerical methods are necessary for evaluation of the inverse transform of the hyperbolic model. The asymptotic solution was compared with observed degradation of West Tarkio Creek, a small river in north-western Missouri and south-western Iowa, with good results.

Ajay K. Singh, et al. (2004) in present study a fully coupled one-dimensional alluvial river model is developed which is capable of simulating sharp hydraulic and bed transients in an alluvial river. These may result from a flash flood, dam break, dike break, etc. The physical processes governing the changes in river bed profiles are complex and varied both in spatial and temporal domains. In addition, the process of grain sorting, wash load transport and non-equilibrium sediment load transport are simulated by using the present model. Better results have been obtained when the present computational scheme was applied for simulating processes involving non-equilibrium transport and grain sorting A computational scheme based on the finite difference numerical modelling is presented here for simulation of sharp flow and bed transients in alluvial channels and it satisfactorily worked for a wide range of values of the computational parameters.

Md. Ataur Rahman, et al. (2010) used MacCormack explicit finite difference scheme and developed a mathematical model to predict the bed level changes of alluvial channel due to sediment over loading. To verify this numerical model, the laboratory experiments were carried out at the Hydraulics and River Engineering Laboratory of BUET. The numerical model was applied to simulate the bed level changes of alluvial channel due to sediment overloading. The computed results were compared with the experimental data and the agreement between them was satisfactory. But from their work they also gave future scope for predicting the degradation using the model they developed.

.Jeremie Gaucher, et al, (2010) were conducted A flume experiment to investigate the effect of compaction on the erodibility of three cohesionless soils. sediment erosion rates and incipient motion, as a function of shear stress, average velocity, and dry density, have been determined for three compacted sand and gravel mixtures. It was found that critical shear stresses and velocities shows that soils compacted at or near the Proctor optimum have a higher resistance to erosion than soils compacted at lower densities.

Umesh C. Kothyari , et al, (2010) Several experiments are conducted to study the channel bed degradation in cohesive sediments made up of clay mixed in varying proportions with uniform and nonuniform cohesionless sediments. Two types of sediment mixtures are used, in first one clay is mixed in varying proportions from 10% to 50% with fine gravel and in the other clay is mixed in various proportions from 10% to 50% with sand and fine gravel of equal proportions. The clay percentage in bed material and unconfined compressive strength of channel bed were found to be the main factors controlling the depth of degradation of channel bed of cohesive sediment mixtures, as degradation depth reduces considerably with an increase in clay percentage and unconfined compressive strength of sediment bed.

III. CONCLUSION

Many previous researchers have carried out experiments in laboratory channel to study degradation by varying parameters like different sediment size and proportions , discharge and slope. Various numerical models have been developed by many researchers under such as Linear Model, Nonlinear Parabolic Model, Diffusion Model, Regression Analysis, Finite Difference Schemes etc.

The MacCormack explicit finite-difference scheme is second-order accurate, handles shocks and discontinuities in the solution without any special treatment, and allows simultaneous solution of the water and sediment equations, thereby obviating the need for iterations. The agreement between the computed and experimental results is satisfactory.

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