Estimating knickpoint migration in the Deep Loess Region of western Iowa

Filippo Bressan; Christopher G. Wilson; A. N. Thanos Papanicolaou
IIHR – Hydroscience & Engineering, University of Iowa

From continuous field monitoring...

Knickpoints: water moves down, they move up

...to numerical modeling

Knickpoint evolution over time occurs due to two main mechanisms depending on the soil type.

PARALLEL RETREAT

INCLINATION

which can be simulated numerically using the Advection-Diffusion Equation (ADE):

\[
f_T = A \frac{\partial h}{\partial t} + D \frac{\partial^2 h}{\partial x^2}
\]

The Advection (A) and Diffusion (D) coefficients depend on the flow conditions and the soil properties.

Bed geometry: \( A = q \)

Cohesive sediment: \( A = k_s (\tau - \tau_c) \)

Sediment continuity: \( D = k_p k_s R \)

Our objectives were:

1) Use the field surveys to estimate the model parameters
2) Use the numerical model to predict knickpoint evolution

Knickpoint Evolution simulated with the ADE

Results: capturing the knickpoint upstream migration

The knickpoint migrated ~25 ft or 7.5 m during the above study period. It exhibited a parallel retreat during moderately high flows, but experienced inclination during extreme floods (e.g. June 2008).

CONCLUSIONS & FURTHER RESEARCH

1) The advection-diffusion model was able to predict knickpoint migration and can be used to determine a stable slope for the design of GCS.
2) The knickpoint inclination was overestimated due to an inaccurate estimation of the diffusion coefficient.
3) The downstream scour hole and the knickpoint steepening were not captured by the model. These probably require a non-linear equation.

Acknowledgements

This study was funded at various stages by the Iowa Highway Research Board (IHRB), Hungry Cayon Alliance (HCA), and Mid America Transportation Center (MATC).

Bibliography


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