ICOLD & APG Symposium
on
Sustainable Development of Dams & River Basins

NUMERICAL MODEL SIMULATIONS FOR SEDIMENTATION IN RUN-OF-THE-RIVER PROJECTS

by

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INTRODUCTION

- Himalayan rivers has huge power potential owing to steep slope and perennial flow
- Main problem for developing the hydropower is huge amount of sediment carried by these river
- Flow velocity reduces upon construction of dam inducing sedimentation and reducing storage capacity of reservoirs
- Suspended sediment load entered into the water conductor system increases hydro-abrasive erosion of hydraulic turbines and thereby increasing the maintenance and operational cost of power generation

- To tackle problem of sediment, run-off-the-river projects are preferred over traditional storage dams in Himalayan reaches
- Spillway crest kept at lower level near the river bed
- Hydraulic and numerical model simulations are essential in planning stage to optimize the design and layout of the project

STUDY AREA

- River – Teesta (Flows through Sikkim and West Bengal)
- Reservoir length - 5.25 km
- Hydroelectric potential - 510 MW (170 x 3 units)
- Dam- Concrete gravity type (50 m)
- FRL -El. 579.00 m
- MDDL - El 568.00 m.
- Gross storage- 9.3 Mm^3
- Live storage- 5.57 Mm^3
- Average annual sediment load - 10.64 Mm^3

- **NUMERICAL MODEL**

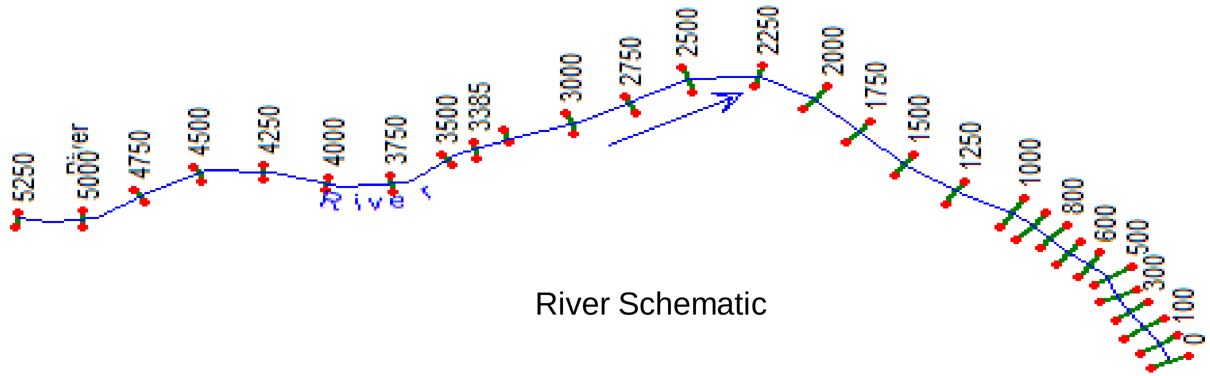
  HEC-RAS 5.0.7 developed by the U.S. Army Corps of Engineers

- ***Input data and boundary conditions***
  - Geometric data
  - Quasi-unsteady flow data
  - Sediment data

- ***Data availability***
  - Cross section (post monsoon bathymetric survey) data for the year 2010, 2011, 2014, 2016, 2017 and 2018
  - Bed gradation data at 6 locations ranging from 10 m to 200 m u/s of dam axis
  - Daily sediment data for the period June 2010 to December 2017

Geometric Data

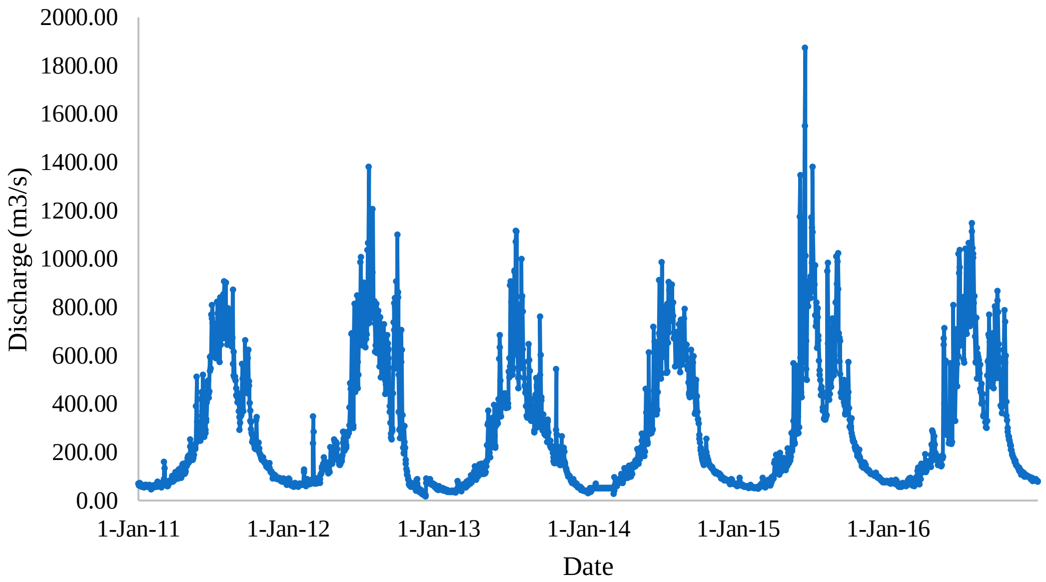
- The total reach reproduced was about 5.25 km upstream from the dam
- 29 cross sections
- The cross sections were at 100 m interval upto 1km upstream from the dam and 250 m interval for rest of the river reach



River Schematic

Flow Data

- The flow series for the period from 2011 to 2017 was used in the simulations
- The maximum observed discharge during monsoon was 1873 m^3/s for the year 2015.

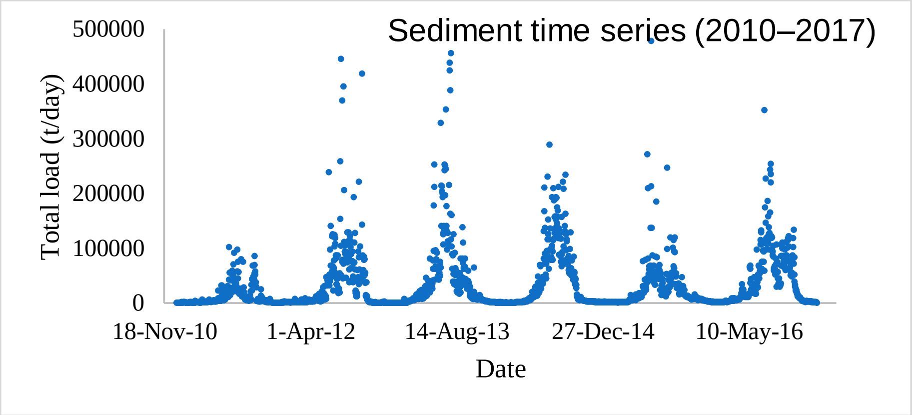


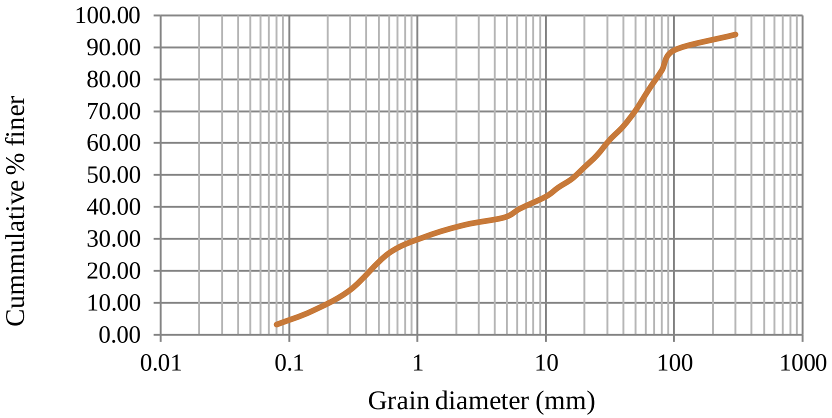
Flow series at Dam site (2011–2017)

Sediment Data

- The sediment data measured at the upstream end of the reservoir was available for the period 2010-2017.

- The bed gradation data was available at 6 locations upstream of the reservoir.
- The average bed gradation curve is used in the studies





Average bed material gradation curve

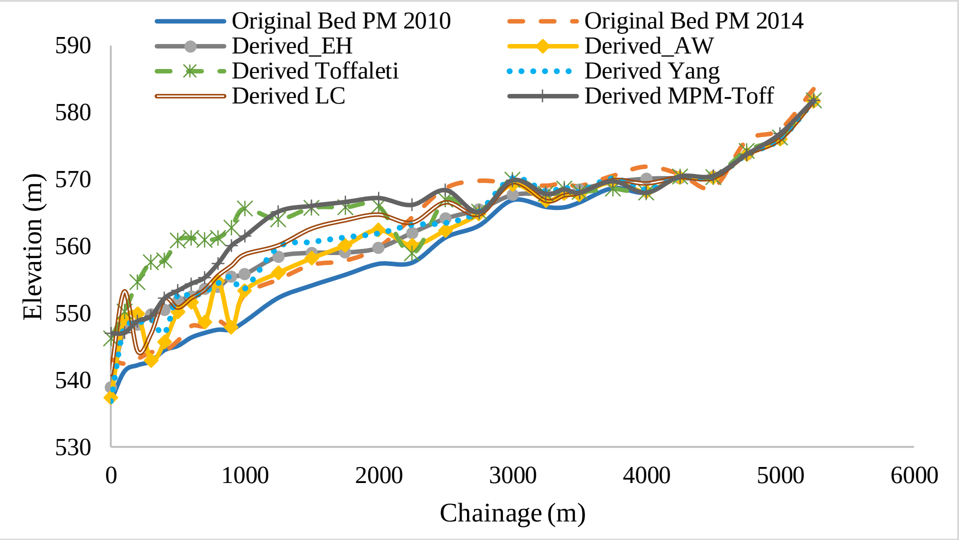
Boundary conditions

- The flow series and sediment series were used as the upstream boundary for the studies.
- The rule curve for reservoir operation was used for the downstream boundary

Calibration

- Steady state simulations were carried out for various discharges using different roughness values i.e. Manning's 'n'
- It was noted that the water surface profiles computed using n value of 0.045 fairly matches with the observed values.
- Hence, in further simulations, n value of 0.045 was used.
- The quasi-unsteady flow simulations were carried out by considering the post monsoon survey data of the river for the year 2011.
- The next post monsoon survey data was available or the year 2014.

- The resultant bed profiles were overlapped with the original bathymetric survey data of year 2014.
- The bed profiles for various combinations overlapped.
- Out of several combinations which were tried during simulation, Engelund-Hansen sediment transport equation with sorting method Exner 5 and fall velocity calculated using Ruby equation gave the best comparison

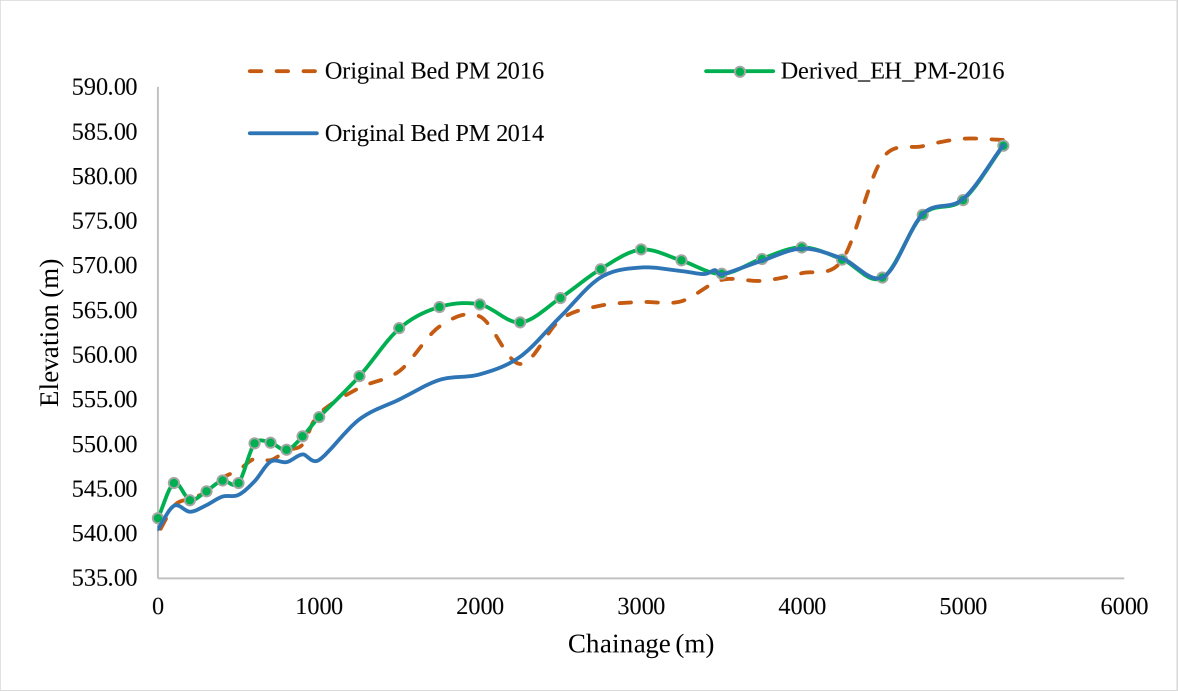


Bed profile comparison for different equations

Predictive simulations

- Further simulations were carried using post monsoon survey data of the year 2014 to predict the bed level for the year 2016 (Post Monsoon).
- Results indicated that in the upstream region of about 500 m, there is a deposition of about 10 m in the original measured bed of 2016.
- This deposition is not seen in the simulated bed, as there was landslide event on 14th august 2016. Sediment measurement was not done on 15th August 2016
- In addition to the comparison between the derived bed profile and the observed profile, the volumetric comparison between observed and computed volume was made.
- It was observed that the numerical model over-estimated the deposited volume in the reservoir by about 12%.

- The sedimention profile derived using Engelund-Hansen sediment transport equation (Post Monsoon 2016) fairly matches with the measured bed for the year 2016



Bed profile derived using Engelund-Hansen equation for the year 2016

CONCLUSIONS

The important observations made from the studies:

- The model computed longitudinal bed profile for the year 2016 fairly matches with the measured bathymetry.
- The volumetric comparison indicated that the numerical model over-estimated the deposited volume in the reservoir by about 12%.
- The studies indicate the suitability of the one-dimensional models in predicting the long-term deposition pattern, which in turn is required for finalizing the key levels of the projects viz., spillway crest, intake invert, MDDL, FRL and reservoir operation schedule.

THANK YOU