Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(2) (2021) 175-176
DOI: 10.22060/ceej.2019.16646.6289

Optimal design of groynes with hydraulic, technical and economic criteria

Nasrin abouzari[1], Mahammad Reza Majdzadeh Tabatabai[2,*], Jafar Yazdi[2]

[1] Faculty of Civil Engineering, Water and Environment, Shahid Beheshti university, Tehran, Iran
[2] Assistant Professor, Department of Water Resources Engineering, Faculty of Civil Engineering, Water and Environment, Shahid Beheshti University

ABSTRACT: Groynes are one of the most important protective structures for river regulation and are constructed to prevent erosion in the river. A multi-objective optimization model has been used to provide a technically and economically optimal design. In the present study, the hydraulic design as well, as the design of the groyne structures, were formulated in the form of an optimization problem using the NSGA-II algorithm. The objective functions of the optimization model include simultaneously minimizing costs and maximizing sediment load transport. The first objective function is to economize the design and the second objective function is based on the definitions of river stability in to keep the river stable. Model calibration was performed using Zanjanrood River information of bedload and scour equation. The model was investigated for sensitivity to change inlet flow parameters and longitudinal slope and its effect on output parameters and model validation with case study structural information. The optimization problem pareto front was derived based on cost and bedload functions. By comparing the five optimal possible designs (5 different design scenarios) from the pareto front with the existing design and the ideal design, the results show that the design selected among the five scenarios has the closest approximation to the Utopia point. The selected design suggests that the length of the groynes and the distance between them are reduced compared to the existing design and the slope of the side of the groynes is also lower than the groyne's root. The selected design has 64.95% less cost and 39.96% more sediment transport than those of the current condition.

Review History:

Received: 6/25/2019
Revised: 11/26/2019
Accepted: 11/27/2019
Available Online: 12/2/2019

Keywords:

Groyne
River training
Optimization
NSGA-II
Cost

INTRODUCTION

River training is referred to as a set of operations that involves the construction and implementation of structures with special arrangements along the river course and is intended to meet specific objectives. River training requires the application of scientific, technical, economic, social, biological, and aesthetic knowledge in the natural and dynamic environment of the river. groynes are one of the structures that transverse to the river flow and are designed to direct the flow axis in a desirable direction and to trap sediment to create a new bank and other uses in the river. The method described in this study simultaneously designs the optimal dimensions of the structure by standard criteria by minimizing the design cost and maximizing cross-section stability. In this regard, a multi-objective optimization model with an NSGA-II optimization algorithm is developed. two objective functions considered in this model are the stable cross-section function and the construction cost function. The stable cross-section function is obtained by the theory of maximum deposition capacity (MSTC2). Despite numerous studies to optimize gutter components and the efficiency or inefficiencies of structures, such as depth scour assessment around the structure and sedimentation and erosion rate of the riverbank, so far the method has been able to simultaneously investigate design considerations, Economic and dynamic changes of the river have not been presented, so this study has focused on the necessity of constructing a river structure and besides, the necessity of simultaneously considering the stability of the river structure and minimizing the cost.

*Corresponding author's email: m_majdzadeh@sbu.ac.ir

METHODOLOGY

- Groyne design

generally, important factors in the design of the groynes are the shape and plan of the groynes, the angle of the groyne relative to the bank (θ), the groyne length (L), the groyne distance (S), the height of the crest (Hg), the cross-section shape, the building material and the expected depth of scouring[1]. In this study, the hydraulic and structural design of the groyne was performed.

a)hydraulic design of the groyne

Hydraulic design of groynes requires compliance with standards. In this research, the Manning flow Resistance Relation has been used [17]. The flow depth is calculated with n coefficient of manning roughness and s longitudinal slope.

- scour

The scour is the erosion caused by the movement of water fluid in the vicinity of the erodible bed or crusts. Total scour includes depth of local scour and depth of general scour. In this research, Gill's (1972) relationship is used to calculate calculating the depth of scouring.

- River bed load calculation

There are various equations for calculating the river bedload that all of these equations include a threshold of motion ie shear stress.

In this study, Van Rijn's (1984) bed load equation is used which is by the following equation [19].

$$q_b = \frac{0.053}{D_*^{0.3}}\left(\frac{\theta}{\theta_c}-1\right)^{2.1}$$

- External Hypothesis

Huang and Nanson (2000) the equilibrium or stable hydraulic geometry of regulated alluvial rivers are considered to be the condition where water and sediment flow pass without erosion and deposition. In their view, due to insufficient basic flow equations, including equations of continuity, flow, resistance and sediment transport to explain the equilibrium phenomenon (existence of three equations and four unknown widths, depths, velocities, and slopes), the use of the proposed limit theories That's right. In this study, the theory of maximum sediment transport capacity(MSTC) is used [21].

b)structural design of the groyne

The forces applied to the groyne are the driving forces (the forces are in units of groyne length).

- Optimization model formulation

The goal is to optimize the cost of dredging construction with Cost (x) and to maximize river sediment transport capacity represented by Qs (x). These goals are formulated as follows:

$$f_1 = Min\,Cost(\vec{x}) = \left(N_{groyne}\times UPRC_{groyne}\times(T+z\times H_g)\times H_g\times(L+root)\right)$$
$$+\left(N_{groyne}\times UPRC_{excavation}\times(2\times d_f^2 - z\times d_f^2)\times\frac{1}{3}\times L\right)$$
$$+\left(N_{groyne}\times UPRC_{earthfill}\times(2\times d_f^2 - z\times d_f^2)\times\frac{1}{3}\times L\right)$$
$$+\left(N_{groyne}\times UPRC_{excavation}\times length\times(2\times d_f^2 - z\times d_f^2)\right)$$
$$+\left(N_{groyne}\times UPRC_{earthfill}\times length\times(2\times d_f^2 - z\times d_f^2)\right)$$

$$f_2 = MaxQ_s(\vec{x}) = w\times q_b$$

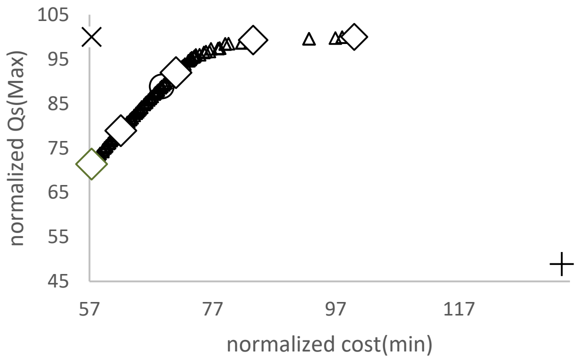

Fig. 1. Pareto front of the NSGA-II algorithm

- Optimization model

The optimization model consists of a combination of hydraulic sub-models and structural sub-models.

- Solution Algorithm

The NSGA-II multi-objective optimization algorithm is used to solve the optimization model.

- RESULTS AND DISCUSSION

- pareto front of NSGA-II algorithm

Fig. 1 shows the pareto front of the NSGA-II algorithm with the information that the model calibrated.

CONCLUSION

The model presented in the present study, in addition to optimizing the groyne dimensions, also considers the stability of the groyne structures as well as the stability of the river cross-section. The results and points on the pareto front indicate that the responses from the optimization model shown on the pareto front all have better results than the current design and this model has a good ability to optimize the economy and sedimentation at the same time considering the structural stability of the groynes.

REFERENCES

1. Supervision, V.P.o.S.P.a., *Deputy Director of Strategic Planning and Control, "Guide for Designing and Maintenance of River groynes"*. 2009.
17. CHOW, V.T., *OPEN-CHANNEL HYDRAULICS*. 1959.
19. Rijn, L.C., *Mathematical modelling of morphological processes in the case of suspended sediment transport*. 1987: Waterloopkundig Laboratorium.
21. Huang, H.Q. and G.C. Nanson, *Hydraulic geometry and maximum flow efficiency as products of the principle of least action*. Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group, 2000. **25**(1): p. 1-16.

HOW TO CITE THIS ARTICLE

N. abouzaria, M.R.M. Tabatabeib, J. yazdi, Optimal design of groynes with hydraulic, technical and economic criteria, Amirkabir J. Civil Eng., 53(2) (2021) 175-176.

DOI: 10.22060/ceej.2019.16646.6289