Journal of Civil Engineering
The Institution of Engineers, Bangladesh
Vol. CE 27, No. 2, 1999

SPACING OF STRAIGHT SPURS IN SERIES

Syed Abdus Sobhan[1] and Swapan Kumar Das[1]

ABSTRACT : Spur is a bank protection and river training structure widely used in our country. The spacing between two spurs depends on the purpose, nature of the river flow, shape of the bank, economics etc. Spacing for a certain type of spur and for a specific problem could be efficiently found out conducting physical model study before actual construction. A typical spacing of 2 to 2.5 times the length is a general practice in our country for bank protection works. But higher spacing could be used for a series of spurs ensuring the effectiveness by physical model studies. In a model study carried out at the River Research Institute for the protection of bank erosion of the Ganges river at Chapai-Nawabgonj district, it was found that spacing of 4.5 to 5 times the length could protect the bank effectively.

KEYWORDS : Spurs, spur spacing, bank protection, model study.

INTRODUCTION

Spurs are stone, gravel, rock, earth or pile structures built at an angle to a river bank to deflect flowing water away from the critical zones, in to establish a more desirable channel for flood control, navigation and erosion control (Richardson, 1975).

A spur is an armoured projection into the stream. The cross sectional form as generally adopted in this country consists of an earthen bank with a face slope of 1:2. This slope with its lower end at nearly low water level, and the upper end about 5 ft above the highest flood level is covered by a layer of pitching stone of definite size. At the foot of the slope, an apron is provided (Ahmed, 1953).

Bank erosion is a recurring problem caused by the major rivers of Bangladesh. A large amount of money is spent in almost every year for bank protection and river training works of which spur is a widely used structure. Length, spacing orientation and location of a particular type of structure could be optimized through physical model studies before taking any construction work in the field where huge cost is involved. This paper presents the results of a physical model study on the spacing of straight spurs in series.

---

1. River Research Institute, Faridpur, Bangladesh

LITERATURE REVIEW

Spur length ranges from a few feet to hundreds of feets and depends on location, purpose, spacing and economy of construction. The length and spacing of spurs are related by economics, purpose, and the fact that the separation zone behind a spur is from 7 to 11 times the spur length. Spacing is often expressed as some multiplier times the projected length. If the spur length is short then spacing is close and construction costs may be prohibitive. If the spur length is too long, the spacing may be so large that a meander loop may form between spurs. Group of long spurs may contract the flow to the extent that general channel degration and opposite bank erosion occurs. The length of bank protected by each spur is at least 3 to 4 times its projected length perpendicular to the current. Spacing S is related to spur length, velocity of flow, angle θ and α, bank curvature and purpose. Recommended spacing is $1.5<L<6L$, where L is the upstream projected spur length into the flow. Spacing equal to 1.5 to 2L has been used to obtain a well defined deep channel for navigation. For bank protection S = 2 to 6L are used. For T- head spurs, spacing 3 to 4L are recommended for navigation channels. For bank protection, short spurs with spacing 10 to 100L have been used successfully and economically where the banks were protected with riprap jacks or vegetation (Richardson, 1975).

The spacing of the river spurs along a reach of river depends upon the length of the spurs and the degree of protection required. A wide range of recommendations is made by different authors with the preferred spacing ranging from 1 to 6 times the exposed length of the spurs. other sources recommended calculating spur spacing based on the velocity head of the flow in the river. However, this method can lead to very wide spur spacing in some cases. A number of recommendations are given in Table-1 (Seed, 1997).

Regarding the spacing between adjacent spurs, the general practice has been to adopt a certain portion of their lengths, varying with the width of the river. Spurs are usually spaced further apart (with respect to their lengths) in a wide river than in a narrow one, if their discharges are nearly equal. The location of spurs, i. e., whether at concave or a convex bank, or at a crossing, affects their spacing. A large spacing can be adopted for convex banks and a smaller one for concave banks, with intermediate spacings at the crossings. A spacing of 2 to 2.5 times the length of spur is the general practice. Sometimes, spurs are spaced far apart to lessen the cost of construction, or with a view to put more spurs in between at a latter time. As a result the either the flow is disturbed and the spurs out flanked, or their heavy maintenance cost exceeds the savings attempted (Jogleker, 1971).

Table 1. Recommended spurs spacing for bank protection (after Seed. 1997)

Reference	Type of Bank	Spacing	Comment
Grant	Concave	3 L	–
UNECAFE	Concave	1 L	General Practice
UNECAFE	Convex	2 to 2.5L	General Practice
Richardson and Simons, 1973	Concave	4 to 6 L	–
Neil, 1973	Either	2 to 4 L	–
Los Angles District, 1980	Straight	2 L	Bank may need riprap
Los Angles District 1980	Concave	1.5L	Bank may need riprap
Los Angles District, 1980	Convex	2.5L	Bank may need riprap
Garg et al. 1980	Either	3 to 4L	Upstream orientation
Maccaferi, 1980	Concave	4 L	Gabions
Maccaferi, 1980	Convex	6 L	Gabions
Copeland, 1983	Concave	upto 3 L	Bank may need riprap
Bognar and Hanco, 1987	Either	1.2L	Maximum siltation
Alvarez, 1989	Concave	2.5 to 4 L	–

In general, the practice is to relate the spacing of spurs to their length. The spacing depends not only on the length of the groyne, but also slightly on the orientation of the flow velocity, the bank curvature, and purpose of the spurs. General practice is a spacing of about 2 to 3 times the length of spurs. This rule includes some safety for the bank protection. In favourable conditions and without additional safety a single groyne can protect 4 to 5 times the length of the groyne. An Indian guideline suggests a spacing of the spurs by 0 .1 to 0.15 of the meander length of an out flanking channel. If the meander length is 15 to 30 times the channel width and length of the groyne is 30% of the channel width, then the spacing is 0.6 to 1.5 times the length of the groyne. For impermeable and permeable, non-submerged spurs along a straight bank, a spacing of 2.5 to 3 times the length of the groyne is recommended for bank protection. This recommendation includes some safety. On concave outer banks, groynes are to be placed closer together than on straight banks and the design ratio should be reduced to 2 to 2.5. On a convex bank the spacing between the groynes can be slightly more than the recommended spacing along a straight bank (BWDB, 1993).

As each spur can protect a certain length, the primary factor governing the spacing between two adjacent spurs is their length. The spacing is, therefore, taken as a certain proportion of their length. Larger spacing is required for locating spurs on convex banks, and a smaller one for concave banks with intermediate values at the crossings. A spacing of 2 to 2.5 times the length of the spur is generally adopted at convex banks, while a spacing equal to the length of the spur is mostly adopted for concave banks. For rivers of equal flood discharges, a larger spacing is prefered for wider rivers than for narrower rivers. A higher value of spacing may be used for permeable spurs as compared to that required for impermeable spurs (Garg, 1993).

DISCUSSION

The study area for this work is situated on the left bank of the Ganges river in the district of Chapai-Nawabganj, which was threatened due to severe bank erosion. A physical model study was carried out with a series of impermeable straight spurs for the protection of a 2 km length river bank. Shape of the bank of the study reach was more or less straight as shown in Fig. 1 and the type of soil was medium to fine sand with D_{50} and D_{90} of 0.16mm and 0.24 mm, respectively. Model sand was more or less similar to that of the prototype. The model was an undistorted sectional mobile bed model of geometric scale 1:75. The length of the study reach was 2 km. The average velocity of the river in the flood season was about 2.8 m/s. The model was designed with Froudian similarity and it was run until equilibrium scour was reached.

Some 12 nos. tests were conducted with the series of solid straight spurs as shown in Fig. 2. changing the length, spacing and location in each tests. The length of the spurs in different tests were varied from 30 m to 97 m and spacings were varied from 3 times to 12 times of the projected length of the spurs. It was observed during all the tests that with these straight spurs back flow velocity was always generated between the spurs and the magnitude of reverse flow velocity varied in the range of 0.75 m/s to 1.6 m/s from time to time and at different locations. Back velocity/reverse velocity was more than the erodible velocity. Various attempts were taken to eliminate the reverse velocity, but it was not possible to eliminate and even to reduce the velocity to the desirable limit. One of the limitations of this model study was that the length of the spurs had to be kept as short as possible for the convenience in construction in the deep channel and to reduce the cost. So, as the back velocity was not possible to eliminate, the spacing of the spurs were optimized reducing the direct velocity near the bank. Flow deflected by these spur spacing are shown in Fig. 1. After a long series of tests five spurs at the upstream of length 50 m and spacing 4.5 times the length and five spurs at the downstream of length 45 m and spacing 5 times the length were found to work effectively (Fig. 1.)

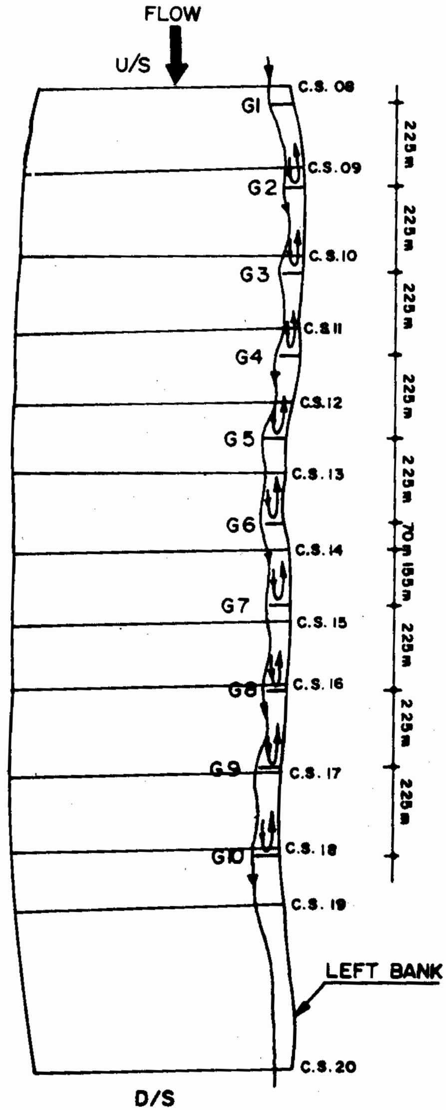

Fig 1. Location of the spures

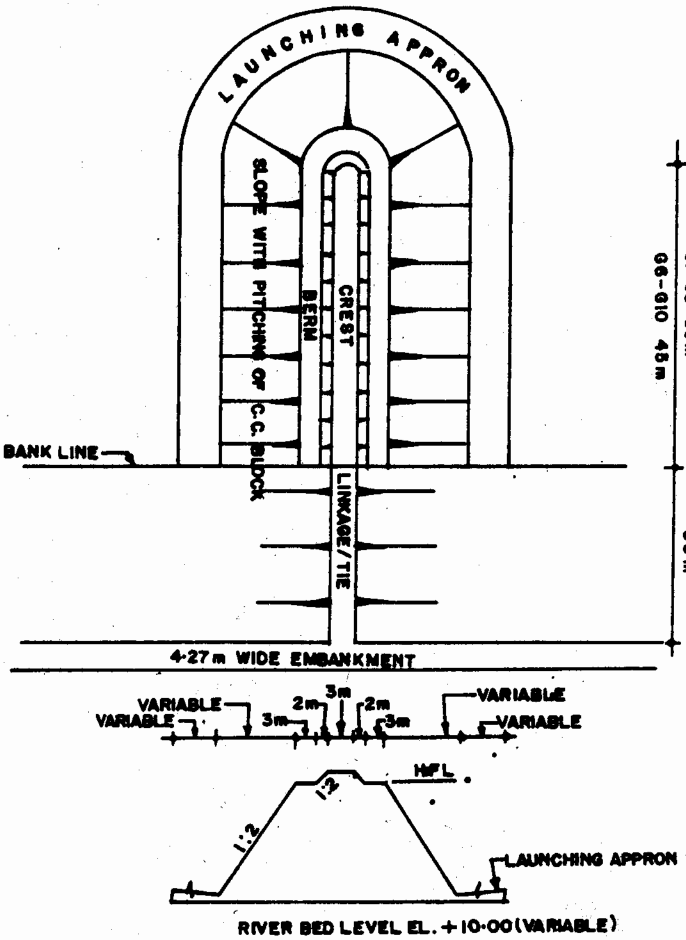

Fig 2. Plan and Section of the Spur

CONCLUSION

Spacing between the spurs is a very sensitive factor that influence the stability of the spur and also the river bank to be protected. This spacing could be optimized by physical model study. From the observation of extensive model study it is concluded that a spacing of 4.5 to 5 times the spur length with bank riprap/vegetation/tarfing could be used for the design of this type of spurs in series at a more or less straight bank. The designer can use these values for design purpose and could verify the effectiveness in the field. For any particular case, these values could be optimized through physical model investigation, which would ensure a technically feasible and economically viable design.

REFERENCES

Ahmed M. (1953), "Experiments on design and behaviour of spur dikes", Proc. IAHR, ASCE, Joint meeting, Univ. of Minn.

BWDB (1993), "Guide to planning and design of river training and bank protection works", BWDB, December '1993

Garg (1993), "Irrigation engineering and hydraulic structures", Khanna publishers, India.

Jogleker, D.V (1971), "Mannual on river behaviour control and training", publication no. 60 (revised), Central Board of Irrigation and power, New Delhi, India.

Richardson, E.V. etal (1975) "The design of spurs for river training", proceedings of IAHR, volume-2, pp. 382-388.

Seed D. J. (1997), "River training and channel protection", Report SR 480, HR Wallingford.