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EFFECTS OF HYDRAULIC STRUCTURE ON BED FORMATION

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1. INTRODUCTION:

Submersible groins in series are being used either to control or deflect the direction of flow that promote local scour, create new bank by trapping the sediment load, and may cause instability on the other part of the channel depending on groin length, shape and angle of facing to the direction of flow. The formation of non-similar sand waves in a channel bed is a random process up to a certain extent. We did the spectrum analysis by Fast Fourier Transform of the groin series bed. That showed instability of the sand waves depending on how much erosion and deposition occurred due to change of flow structure. In addition to the spectrum analysis, the variation of bed-form with the response to the arrangements of groin was also studied.

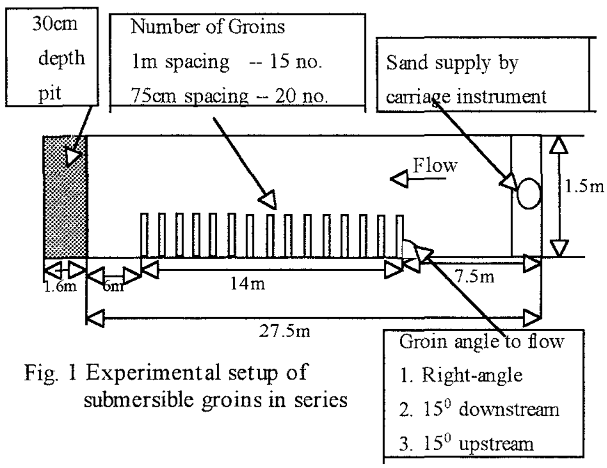

Fig. 1 Experimental setup of submersible groins in series

2. EXPERIMENTAL DESCRIPTION:

The laboratory flume of mobile bed was 27.5m long and 1.5 m width that had re-circulation of water and continuous sediment supply by an instrument carriage moving across the channel. Hydraulic conditions (Table 1) were same for all the experiments except changing the placement of the groins. We carried out one without any hydraulic structure and five groin series experiments with different angles facing the direction of flow and intervals between two groins. Angles were right angle to the longitudinal direction of flow, facing 15 degree downstream and upstream to the flow. The intervals were 1m and 75 cm. The submersible groins were 3cm above the initial bed, and their length and width were 50cm and 5cm respectively. The groins in each experiment had same interval and angle along the left bank that started at a distance of 6m from the downstream end to 20m. The bed consisting of non-cohesive granular sediment of 0.80mm size was initially flat having slope at the range of 0.0018 to 0.0016.

3. POWER SPECTRUM ANALYSIS:

The object of the spectrum analysis by FFT is to find impact of the groins on the mechanism of sedimentary bed-forms and longitudinal bed profiles. For the analysis, we measured the bed elevation Y, as a function of longitudinal distance X, by electro-magnetic velocity meter. The spectrum of no hydraulic structure bed (Fig.2) had similar slope of the 'minus three power law' but different proportionality. Fig 3 and Fig. 4 are the spectrum of groin facing downstream at 1m interval and groin right-angle at 75cm interval respectively along the longitudinal line 95cm from left bank. The difference between these three figures shows that groin beds experienced more non-equilibrium sediment transport than no hydraulic structure bed even very far from the groin head. No hydraulic structure bed spectrum had peak at lower wave-number and then gradually decreases with the increase of wave-number. The groin bed showed spectral peak at lower as well as higher wave-number. The spectrum along the longitudinal line near the head of the groins had two peaks at high wave-number in between the range of 0.1 to 0.3 cycle/cm (Fig.5).

Table 1. Experimental conditions

	No Hydraulic Structure	Groin in series				
		Downstream (interval 1m)	Downstream (interval 75cm)	Right-angle (interval 1m)	Right-angle (interval 75cm)	Upstream (interval 1m)
Water discharge(l/sec)	36.4	36.4	36.4	36.4	36.4	36.4
Sediment supply(ml/sec)	195	195	195	195	195	195
Water surface slope	0.0017	0.0021	0.0017	0.0018	0.0017	0.0017
Final bed slope	0.0014	0.0028	0.0021	0.0022	0.0019	0.0026

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Comparing all the spectrum figures (Fig. 2, 3, 4, 5) shows that rough turbulent flow caused groin beds much more disturbance than no hydraulic structure bed. The spectrums of all the five groin series experiments did not show similar characteristic meaning of every part of the channel bed. The groin bed spectrum showed peaks at lower as well as higher wave number that indicated non-equilibrium sediment transport near or far from groin head.

4. VARIATION IN BED-FORM:

Table 2 shows the comparative bed-form of the three experiments of without any hydraulic structure, groin facing downstream at 1m and 75cm interval. The bed elevations of the three experiments were plotted on large sheet. The bed-form wavelength was measured from the trough of a sand wave to the next downstream sand wave trough. The difference between the elevations of the sand wave peak and the next downstream trough was considered as bed-form height. The groin downstream 75cm bed had larger bed-form height than no structure bed but groin 1m bed had largest among the three beds. This clearly indicates that spacing between groins plays a major rule for bed formation and roughness. The groin bed converted into higher bed-form height with the increase of flow turbulence and bed shear stress. The average steepness and wavelength of groin 1m bed had 1/29 and 7h, and groin 75cm bed had steepness and bed-form wave-length of 1/43 and 9h respectively, where h is depth of water.

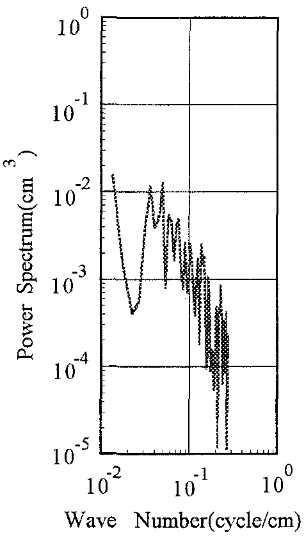

Fig. 2 Spectrum of no hydraulic structure bed

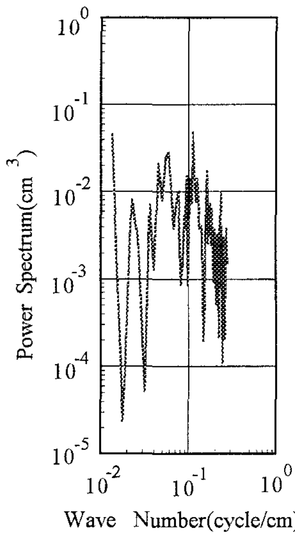

Fig. 3 Spectrum of groin facing downstream at 1m interval along long. line 95cm from left bank

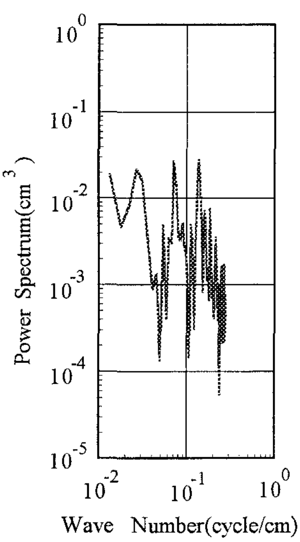

Fig. 4 Spectrum of groin right-angle to flow at 75cm interval along long. line 95cm from left bank.

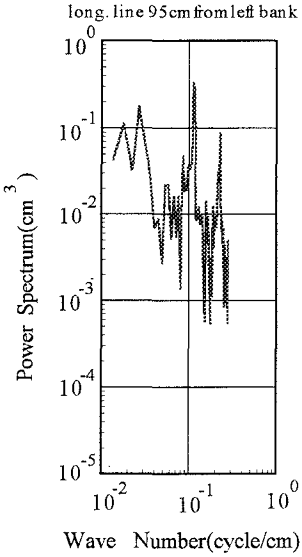

Fig. 5 Spectrum of groin facing downstream at 1m interval along long. line near groin head, 55cm from left bank.

5. CONCLUSION:

The spectral amplitude and bed-form height of groin bed were larger than those of no structure bed. The wide range of steepness of sand waves, the change of the spectral shape at higher wave-number and larger amplitude of spectral peak reflected the more instability of the groin bed.

Table 2. Bed-form variations of the three experiments

	No Hydraulic Structure	Groin in series Downstream (interval 1m)	Downstream (interval 75cm)
Average Water depth cm	6.5	10.3	8.04
Average shear velocity U* (cm/sec)	3.3	4.61	3.72
Average sand wave height cm	1.35	2.5	1.8
Average sand wavelength cm	98	73.6	78.8
Grain Reynolds number	20.3	34.1	20.9
Mobility number/Cr. mobility number	2.52	4.84	3.16