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A Dataset of Wave-Flume Experiments of the Threshold for Ripple Formation on Beds with Perturbations

Tomohiro SEKIGUCHI*

I Introduction

The purpose of this report is to present the total dataset of the wave-flume experiments conducted by Sekiguchi and Sunamura (2004, 2005), who examined the threshold for rippling on sand beds with different bottom perturbations.

II Laboratory experiment

The experiment was carried out using the wave flume (14 m long, 50 cm deep, and 25 cm wide) with a piston-type wave generator (Fig. 1). At the onshore end, a fixed slope of 1/20 was installed to reduce energy of waves reflected from the down-wave side of the flume. A sand bed (3 m long, 25 cm wide, and 3 cm thick) was constructed in the horizontal portion of the flume; both ends of the bed tapered off to reduce the local disturbance of flow. Three types of sand beds with different perturbations were prepared: (1) a horizontal flat bed, here referred to as "the flat bed," (2) a bed with a notch (Fig. 2a), described as "the notched bed," and (3) a bed with a notch and two mounds (Fig. 2b), called "the notch-mounded bed," with bed perturbation increasing in this order. The heights of disturbances on the bottom were 1.5 cm for the notched bed, and 2.3 cm for the notch-mounded bed.

Three kinds of well-sorted quartz sand were employed for the bed material; they have similar densities, 2.6–2.7 g/cm^3, but different median grain sizes, i.e., D = 0.021, 0.038, and 0.054 cm. The hydraulic parameters were: 20 cm ≤ h ≤ 30 cm, 1.0 sec ≤ T ≤ 3.5 sec, and 1.7 cm ≤ H ≤ 13.0 cm, where h is the water depth above the horizontal portion of the sand bed, T is the wave period, and H is the wave height over the sand bed. The hydraulic conditions were kept constant through each experiment run. By combining these experimental parameters, Sekiguchi and Sunamura (2004, 2005) carried out 47 runs for

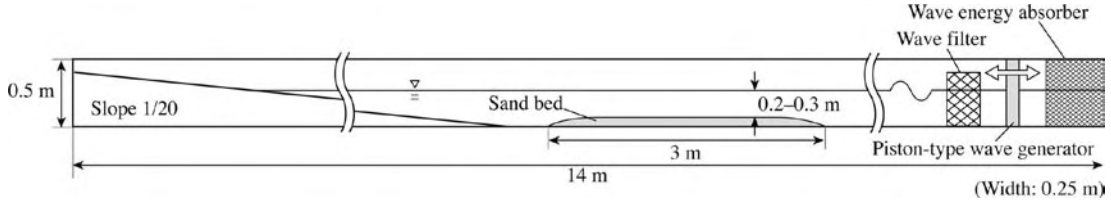

Fig. 1 Wave flume used in the present study

* Terrestrial Environment Research Center, University of Tsukuba

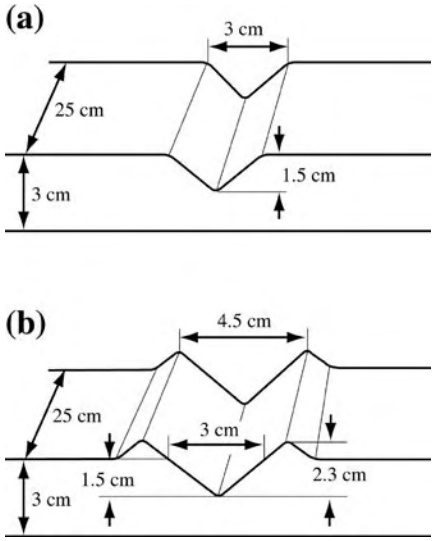

Fig. 2 Two types of topographic disturbances used in the experiments: a notch (a), and a notch and two mounds (b), both located in the central portion of the sand bed

the flat bed (Table 1), 113 runs for the notched bed (Table 2), and 82 runs for the notch-mounded bed (Table 3). Each run had 30-min wave action. Ripple formation was recorded using a digital video camera, and photographs were taken at a certain interval of time.

III The analysis of Sekiguchi and Sunamura (2005)

Three dimensionless parameters were employed in the analysis of Sekiguchi and Sunamura (2005): (1) the relative water depth to the wavelength, (2) the mobility number, and (3) the Reynolds number. The relative water depth to the wavelength can be described as kh ($k = 2\pi/L$; where L is the wavelength). According to linear wave theory (e.g., Komar, 1998, pp. 161–168), L is given by:

$$L = \frac{gT^2}{2\pi}\tanh kh \tag{1}$$

where g is the gravity acceleration.

The mobility number, M, is a simplified form, which neglects the frictional effect, of the Shields parameter that describes the relative magnitude of bed shear stress to the resisting force against the motion of sand grains, and is given by the following equation:

$$M = \frac{{u_b}^2}{(s-1)gD} \tag{2}$$

where u_b is the near-bottom orbital velocity, and s is the specific gravity of sediment. Sekiguchi and Sunamura (2005) employed $s = 2.65$. Linear wave theory gives u_b as:

$$u_b = \frac{\pi d_0}{T} = \frac{\pi H}{T \sinh kh} \tag{3}$$

where d_0 is the orbital diameter.

The value of the Reynolds number was used in order to describe flow disturbance due to the perturbation of the bottom surface. The Reynolds number is expressed by:

$$Re = \frac{u_b h_m}{\nu} \tag{4}$$

where h_m is the height of disturbances on the bottom, and ν is the kinematic viscosity of water. If the bottom is flat and smooth, h_m should be replaced by D:

$$Re = \frac{u_b D}{\nu} \tag{5}$$

which is often called the particle Reynolds number (e.g., Nielsen, 1992, p.165).

Their analysis showed that the threshold decreases with increase in bed roughness and

Table 1 Data of the ripple initiation from Flat bed

Run No.	D (cm)	h (cm)	T (sec)	L (cm)	H (cm)	u_b (cm/sec)	d_0 (cm)	kh	M	Re	Remarks
F20– 1	0.020	25	1.0	130	7.2	14.8	4.7	1.21	6.8	29	No Ripple
F20– 2					7.9	16.2	5.2	1.21	8.1	32	No Ripple
F20– 3					8.3	17.1	5.4	1.21	9.0	34	Ripple
F20– 4	0.020	25	1.5	217	6.2	16.5	7.9	0.72	8.4	33	No Ripple
F20– 5					8.1	21.4	10.2	0.72	14.2	43	Ripple
F20– 6	0.020	25	2.0	300	6.9	19.6	12.5	0.52	11.9	39	No Ripple
F20– 7					7.7	22.1	14.0	0.52	15.1	44	Ripple
F20– 8	0.020	25	2.5	381	7.4	21.9	17.4	0.41	14.9	44	No Ripple
F20– 9					8.3	24.6	19.6	0.41	18.7	49	Ripple
F20–10					9.8	29.0	23.1	0.41	26.1	58	Ripple
F20–11	0.020	25	3.0	461	7.3	22.0	21.0	0.34	15.0	44	No Ripple
F20–12					8.0	24.1	23.0	0.34	18.0	48	Ripple
F20–13	0.020	25	3.5	540	5.8	17.5	19.5	0.29	9.5	35	No Ripple
F20–14					7.3	22.1	24.6	0.29	15.1	44	No Ripple
F20–15					8.3	25.1	28.0	0.29	19.5	50	Ripple
F20–16					9.6	29.1	32.4	0.29	26.1	58	Ripple
F38– 1	0.038	25	1.0	130	8.4	17.4	5.5	1.21	4.9	66	No Ripple
F38– 2					8.9	18.4	5.9	1.21	5.5	70	No Ripple
F38– 3	0.038	25	1.2	166	9.4	22.5	8.6	0.95	8.2	85	No Ripple
F38– 4	0.038	25	1.5	217	8.3	22.1	10.5	0.72	7.9	84	No Ripple
F38– 5					9.8	26.0	12.4	0.72	11.0	99	No Ripple
F38– 6					11.0	29.1	13.9	0.72	13.8	110	Ripple
F38– 7	0.038	25	2.0	300	9.2	26.2	16.7	0.52	11.2	99	No Ripple
F38– 8					10.0	28.5	18.2	0.52	13.2	108	No Ripple
F38– 9	0.038	25	2.0	300	11.7	33.4	21.3	0.52	18.1	126	Ripple
F38–10	0.038	25	2.5	381	8.4	24.9	19.8	0.41	10.1	94	No Ripple
F38–11					10.3	30.4	24.2	0.41	15.0	115	No Ripple
F38–12					11.2	33.0	26.3	0.41	17.7	125	Ripple
F38–13					11.2	33.0	26.3	0.41	17.7	125	Ripple
F38–14					13.0	38.4	30.5	0.41	23.9	145	Ripple
F38–15	0.038	25	3.0	461	9.0	27.1	25.9	0.34	12.0	103	No Ripple
F38–16					10.3	31.0	29.6	0.34	15.7	117	Ripple
F38–17	0.038	25	3.5	540	7.5	22.7	25.3	0.29	8.4	86	No Ripple
F38–18					10.0	30.4	33.9	0.29	15.1	115	Ripple
F54– 1	0.054	25	1.0	130	9.0	18.5	5.9	1.21	3.9	100	No Ripple
F54– 2			1.5	217	11.0	29.1	13.9	0.72	9.7	157	No Ripple
F54– 3			2.0	300	12.1	34.7	22.1	0.52	13.8	187	No Ripple
F54– 4	0.054	25	2.5	381	10.3	30.5	24.3	0.41	10.7	164	No Ripple
F54– 5					11.0	32.6	25.9	0.41	12.2	175	Ripple
F54– 6					13.0	38.4	30.5	0.41	16.8	206	Ripple
F54– 7	0.054	25	3.0	461	7.3	21.8	20.9	0.34	5.5	118	No Ripple
F54– 8					9.8	29.4	28.1	0.34	9.9	158	No Ripple
F54– 9					11.8	35.4	33.8	0.34	14.4	190	Ripple
F54–10					13.0	39.2	37.4	0.34	17.6	211	Ripple
F54–11	0.054	25	3.5	540	7.8	23.6	26.3	0.29	6.4	127	No Ripple
F54–12					9.2	27.9	31.0	0.29	8.9	150	No Ripple
F54–13					11.2	34.1	38.0	0.29	13.3	183	Ripple

Table 2 Data of the ripple initiation from Notched bed

Run No.	D (cm)	h (cm)	T (sec)	L (cm)	H (cm)	u_b (cm/sec)	d_0 (cm)	kh	M	Re	Remarks
N20–1	0.020	25	1.0	130	3.6	7.4	2.4	1.21	1.7	1112	No Ripple
N20–2					5.1	10.4	3.3	1.21	3.4	1560	No Ripple
N20–3					5.4	11.1	3.5	1.21	3.8	1653	No Ripple
N20–4					5.6	11.6	3.7	1.21	4.1	1730	Ripple
N20–5					6.0	12.3	3.9	1.21	4.7	1838	Ripple
N20–6					6.8	14.0	4.4	1.21	6.0	2085	Ripple
N20–7					7.9	16.3	5.2	1.21	8.2	2440	Ripple
N20–8					8.5	17.5	5.6	1.21	9.4	2610	Ripple
N20–9	0.020	25	1.5	217	2.9	7.7	3.7	0.72	1.8	1152	No Ripple
N20–10					4.4	11.6	5.5	0.72	4.1	1728	No Ripple
N20–11					4.7	12.4	5.9	0.72	4.7	1847	Ripple
N20–12					4.9	13.0	6.2	0.72	5.2	1946	Ripple
N20–13					5.3	14.1	6.7	0.72	6.1	2105	Ripple
N20–14					6.9	18.2	8.7	0.72	10.3	2721	Ripple
N20–15					8.8	23.4	11.2	0.72	16.9	3495	Ripple
N20–16					9.7	25.6	12.2	0.72	20.3	3833	Ripple
N20–17	0.020	25	2.0	300	3.2	9.2	5.8	0.52	2.6	1370	No Ripple
N20–18					4.2	12.0	7.7	0.52	4.5	1799	No Ripple
N20–19					4.6	13.0	8.3	0.52	5.3	1949	No Ripple
N20–20					4.9	14.0	8.9	0.52	6.1	2098	Ripple
N20–21					5.3	15.2	9.7	0.52	7.1	2270	Ripple
N20–22	0.020	25	2.5	381	4.0	11.8	9.4	0.41	4.3	1770	No Ripple
N20–23					4.6	13.5	10.7	0.41	5.6	2014	Ripple
N20–24					4.7	13.9	11.1	0.41	6.0	2080	No Ripple
N20–25					5.1	15.0	11.9	0.41	6.9	2235	Ripple
N20–26	0.020	25	3.0	461	4.2	12.7	12.1	0.34	5.0	1891	No Ripple
N20–27					4.3	12.8	12.2	0.34	5.1	1914	No Ripple
N20–28					4.5	13.4	12.8	0.34	5.6	2004	Ripple
N20–29					4.5	13.6	12.9	0.34	5.7	2026	Ripple
N20–30	0.020	25	3.0	461	4.8	14.5	13.8	0.34	6.5	2161	Ripple
N20–31					5.0	14.9	14.2	0.34	6.9	2229	Ripple
N20–32	0.020	25	3.5	540	4.0	12.0	13.4	0.29	4.5	1797	No Ripple
N20–33					4.6	13.9	15.4	0.29	5.9	2070	Ripple
N20–34					4.8	14.5	16.1	0.29	6.5	2161	Ripple
N20–35					5.1	15.5	17.3	0.29	7.5	2320	Ripple
N38–1	0.038	25	1.0	130	3.5	7.1	2.3	1.21	0.8	1066	No Ripple
N38–2					3.6	7.4	2.4	1.21	0.9	1112	No Ripple
N38–3					4.0	8.3	2.6	1.21	1.1	1236	No Ripple
N38–4					4.7	9.7	3.1	1.21	1.5	1452	No Ripple
N38–5					5.3	10.9	3.5	1.21	1.9	1622	No Ripple
N38–6					6.6	13.5	4.3	1.21	3.0	2023	No Ripple
N38–7					7.0	14.5	4.6	1.21	3.4	2162	Ripple
N38–8					7.1	14.7	4.7	1.21	3.5	2193	Ripple
N38–9	0.038	25	1.2	166	9.0	21.5	8.2	0.95	7.5	3215	Ripple
N38–10	0.038	25	1.5	217	2.9	7.7	3.7	0.72	1.0	1152	No Ripple
N38–11					6.1	16.2	7.7	0.72	4.3	2423	No Ripple
N38–12					6.6	17.4	8.3	0.72	4.9	2602	No Ripple
N38–13					6.9	18.2	8.7	0.72	5.4	2721	Ripple
N38–14					7.3	19.3	9.2	0.72	6.0	2880	Ripple
N38–15					9.6	25.4	12.1	0.72	10.5	3793	Ripple
N38–16	0.038	25	2.0	300	3.2	9.2	5.8	0.52	1.4	1370	No Ripple
N38–17					5.8	16.5	10.5	0.52	4.4	2471	No Ripple
N38–18					6.1	17.5	11.1	0.52	5.0	2612	Ripple
N38–19					6.5	18.6	11.9	0.52	5.6	2784	Ripple
N38–20					8.0	22.9	14.6	0.52	8.6	3426	Ripple
N38–21					8.9	25.5	16.2	0.52	10.6	3811	Ripple
N38–22					12.4	35.4	22.5	0.52	20.4	5289	Ripple

Table 2 Continued

Run No.	D (cm)	h (cm)	T (sec)	L (cm)	H (cm)	u_b (cm/sec)	d_0 (cm)	kh	M	Re	Remarks
N38–23	0.038	25	2.5	381	5.6	16.6	13.2	0.41	4.5	2478	No Ripple
N38–24					5.9	17.5	13.9	0.41	5.0	2611	Ripple
N38–25					6.4	18.8	15.0	0.41	5.8	2810	Ripple
N38–26	0.038	25	3.0	461	5.0	14.9	14.2	0.34	3.6	2229	No Ripple
N38–27					5.4	16.1	15.4	0.34	4.2	2409	No Ripple
N38–28					5.5	16.6	15.8	0.34	4.5	2477	Ripple
N38–29					6.0	18.1	17.3	0.34	5.3	2702	Ripple
N38–30					12.2	36.6	35.0	0.34	21.8	5471	Ripple
N38–31	0.038	25	3.2	493	5.3	15.9	16.2	0.32	4.1	2375	No Ripple
N38–32					5.9	17.7	18.0	0.32	5.1	2647	Ripple
N38–33	0.038	25	3.5	540	4.4	13.2	14.8	0.29	2.9	1979	No Ripple
N38–34					4.6	14.0	15.6	0.29	3.2	2093	No Ripple
N38–35					4.9	14.9	16.6	0.29	3.6	2229	No Ripple
N38–36					5.4	16.4	18.3	0.29	4.4	2457	No Ripple
N38–37					6.0	18.1	20.2	0.29	5.3	2707	Ripple
N38–38					11.8	35.8	39.9	0.29	20.8	5346	Ripple
N54–1	0.054	25	1.0	130	3.6	7.4	2.4	1.21	0.6	1112	No Ripple
N54–2					7.9	16.3	5.2	1.21	3.1	2440	No Ripple
N54–3					8.1	16.6	5.3	1.21	3.2	2487	No Ripple
N54–4					8.4	17.4	5.5	1.21	3.5	2595	No Ripple
N54–5					8.6	17.8	5.7	1.21	3.6	2657	No Ripple
N54–6					10.3	21.2	6.7	1.21	5.1	3166	No Ripple
N54–7	0.054	25	1.2	166	6.3	14.9	5.7	0.95	2.6	2233	No Ripple
N54–8					7.9	18.9	7.2	0.95	4.1	2822	No Ripple
N54–9					8.9	21.2	8.1	0.95	5.1	3162	Ripple
N54–10	0.054	25	1.5	217	2.9	7.7	3.7	0.72	0.7	1152	No Ripple
N54–11					7.0	18.5	8.8	0.72	3.9	2760	No Ripple
N54–12	0.054	25	1.5	217	7.1	18.7	8.9	0.72	4.0	2800	No Ripple
N54–13					8.6	22.9	10.9	0.72	6.0	3416	Ripple
N54–14					8.6	22.9	10.9	0.72	6.0	3416	No Ripple
N54–15					11.3	30.0	14.3	0.72	10.3	4488	Ripple
N54–16					11.6	30.8	14.7	0.72	10.9	4607	Ripple
N54–17					11.8	31.2	14.9	0.72	11.2	4667	Ripple
N54–18	0.054	25	2.0	300	3.2	9.2	5.8	0.52	1.0	1370	No Ripple
N54–19					6.5	18.6	11.9	0.52	4.0	2784	No Ripple
N54–20					6.5	18.6	11.9	0.52	4.0	2784	No Ripple
N54–21					7.5	21.4	13.6	0.52	5.2	3190	Ripple
N54–22					7.7	21.9	14.0	0.52	5.5	3276	No Ripple
N54–23					8.9	25.4	16.1	0.52	7.4	3790	Ripple
N54–24					9.1	26.1	16.6	0.52	7.8	3897	Ripple
N54–25					10.3	29.4	18.7	0.52	9.9	4390	Ripple
N54–26					12.1	34.5	22.0	0.52	13.7	5160	Ripple
N54–27	0.054	25	2.5	381	5.5	16.3	13.0	0.41	3.0	2434	No Ripple
N54–28					5.5	16.3	13.0	0.41	3.0	2434	No Ripple
N54–29					6.8	20.1	16.0	0.41	4.6	3009	Ripple
N54–30					8.0	23.7	18.9	0.41	6.4	3540	Ripple
N54–31					8.0	23.7	18.9	0.41	6.4	3540	No Ripple
N54–32					10.0	29.6	23.6	0.41	10.0	4425	Ripple
N54–33	0.054	25	3.0	461	4.5	13.6	12.9	0.34	2.1	2026	No Ripple
N54–34					5.6	16.9	16.1	0.34	3.3	2522	No Ripple
N54–35					6.1	18.4	17.6	0.34	3.9	2747	Ripple
N54–36					8.0	24.1	23.0	0.34	6.7	3602	Ripple
N54–37	0.054	25	3.5	540	5.0	15.2	17.0	0.29	2.7	2275	No Ripple
N54–38					6.8	20.6	22.9	0.29	4.8	3071	Ripple
N54–39					6.8	20.6	22.9	0.29	4.8	3071	No Ripple
N54–40					8.3	25.1	28.0	0.29	7.2	3753	Ripple

Table 3 Data of the ripple initiation from Notch-mounded bed

Run No.	D (cm)	h (cm)	T (sec)	L (cm)	H (cm)	u_b (cm/sec)	d_0 (cm)	kh	M	Re	Remarks
M20–1	0.020	25	1.0	130	3.7	7.5	2.4	1.21	1.8	1729	No Ripple
M20–2					4.2	8.7	2.8	1.21	2.3	1989	No Ripple
M20–3					5.2	10.6	3.4	1.21	3.5	2439	Ripple
M20–4	0.020	25	1.5	217	2.9	7.6	3.6	0.72	1.8	1736	No Ripple
M20–5					3.8	10.0	4.8	0.72	3.1	2284	Ripple
M20–6					4.2	11.2	5.3	0.72	3.9	2558	Ripple
M20–7					5.5	14.6	7.0	0.72	6.6	3350	Ripple
M20–8	0.020	25	2.0	300	3.3	9.5	6.0	0.52	2.8	2167	No Ripple
M20–9					4.1	11.6	7.4	0.52	4.2	2659	Ripple
M20–10					4.3	12.3	7.8	0.52	4.7	2824	Ripple
M20–11					5.6	15.9	10.1	0.52	7.8	3644	Ripple
M20–12	0.020	25	2.5	381	1.7	5.0	4.0	0.41	0.8	1154	No Ripple
M20–13					3.0	8.7	7.0	0.41	2.4	2002	No Ripple
M20–14					4.1	12.0	9.5	0.41	4.4	2748	Ripple
M20–15					5.0	14.7	11.7	0.41	6.6	3359	Ripple
M20–16	0.020	25	3.0	461	2.4	7.1	6.8	0.34	1.6	1623	No Ripple
M20–17					2.8	8.3	7.9	0.34	2.1	1899	No Ripple
M20–18					3.6	10.7	10.2	0.34	3.5	2451	Ripple
M20–19	0.020	25	3.5	540	2.2	6.5	7.3	0.29	1.3	1500	No Ripple
M20–20					2.4	7.2	8.0	0.29	1.6	1639	No Ripple
M20–21					2.9	8.7	9.7	0.29	2.3	1988	No Ripple
M20–22					3.3	9.9	11.0	0.29	3.0	2267	Ripple
M20–23					3.8	11.4	12.7	0.29	4.0	2616	Ripple
M20–24	0.020	15	0.7	66	4.3	9.7	2.2	1.43	2.9	2229	Ripple
M20–25	0.020	20	0.8	89	4.4	8.9	2.3	1.42	2.5	2041	No Ripple
M20–26					4.9	9.9	2.5	1.42	3.0	2273	Ripple
M20–27					5.4	10.9	2.8	1.42	3.7	2505	Ripple
M20–28	0.020	30	0.9	117	6.0	8.6	2.5	1.61	2.3	1971	No Ripple
M20–29					6.7	9.7	2.8	1.61	2.9	2220	No Ripple
M20–30					7.0	10.0	2.9	1.61	3.1	2302	Ripple
M38–1	0.038	25	1.0	130	5.2	10.8	3.4	1.21	1.9	2463	No Ripple
M38–2					6.4	13.1	4.2	1.21	2.8	3008	No Ripple
M38–3					6.8	14.0	4.4	1.21	3.2	3197	Ripple
M38–4					8.3	17.1	5.4	1.21	4.7	3908	Ripple
M38–5					8.8	18.1	5.8	1.21	5.3	4145	Ripple
M38–6	0.038	25	1.5	217	2.9	7.6	3.6	0.72	0.9	1736	No Ripple
M38–7					4.0	10.6	5.1	0.72	1.8	2436	No Ripple
M38–8					5.0	13.2	6.3	0.72	2.8	3015	Ripple
M38–9					5.5	14.5	6.9	0.72	3.4	3319	Ripple
M38–10	0.038	25	2.0	300	3.4	9.7	6.2	0.52	1.5	2233	No Ripple
M38–11					3.9	11.2	7.1	0.52	2.0	2561	Ripple
M38–12					4.7	13.5	8.6	0.52	3.0	3086	Ripple
M38–13					5.9	16.9	10.8	0.52	4.7	3874	Ripple
M38–14					6.8	19.3	12.3	0.52	6.1	4432	Ripple
M38–15					8.1	23.2	14.8	0.52	8.8	5319	Ripple
M38–16	0.038	25	2.5	381	2.9	8.6	6.8	0.41	1.2	1968	No Ripple
M38–17					3.7	11.0	8.7	0.41	2.0	2511	No Ripple
M38–18					4.2	12.4	9.9	0.41	2.5	2850	No Ripple
M38–19					4.6	13.6	10.8	0.41	3.0	3121	Ripple
M38–20					5.7	16.9	13.4	0.41	4.6	3868	Ripple
M38–21	0.038	25	3.0	461	3.8	11.3	10.8	0.34	2.1	2589	No Ripple
M38–22					4.4	13.3	12.7	0.34	2.9	3038	Ripple
M38–23					5.0	15.1	14.4	0.34	3.7	3452	Ripple
M38–24					6.8	20.5	19.6	0.34	6.8	4695	Ripple
M38–25					7.6	22.9	21.9	0.34	8.5	5247	Ripple

Table 3 Continued

Run No.	D (cm)	h (cm)	T (sec)	L (cm)	H (cm)	u_b (cm/sec)	d_0 (cm)	kh	M	Re	Remarks
M38–26	0.038	25	3.0	461	8.4	25.2	24.0	0.34	10.3	5765	Ripple
M38–27	0.038	25	3.5	540	2.6	7.9	8.8	0.29	1.0	1814	No Ripple
M38–28					3.3	9.9	11.0	0.29	1.6	2267	No Ripple
M38–29					3.9	11.9	13.2	0.29	2.3	2721	No Ripple
M38–30					4.5	13.5	15.1	0.29	3.0	3104	Ripple
M54–1	0.054	25	1.2	166	6.5	15.5	5.9	0.95	2.8	3560	No Ripple
M54–2					7.8	18.5	7.1	0.95	3.9	4245	Ripple
M54–3	0.054	25	1.5	217	4.7	12.4	5.9	0.72	1.7	2832	No Ripple
M54–4					5.3	14.0	6.7	0.72	2.2	3197	No Ripple
M54–5					6.0	15.8	7.6	0.72	2.9	3624	Ripple
M54–6					7.3	19.3	9.2	0.72	4.3	4415	Ripple
M54–7	0.054	25	2.0	300	3.3	9.5	6.0	0.52	1.0	2167	No Ripple
M54–8					4.4	12.6	8.0	0.52	1.8	2889	No Ripple
M54–9	0.054	25	2.0	300	4.7	13.3	8.5	0.52	2.0	3053	Ripple
M54–10	0.054	25	2.5	381	3.3	9.6	7.7	0.41	1.1	2205	No Ripple
M54–11					4.0	11.8	9.4	0.41	1.6	2714	No Ripple
M54–12					5.3	15.7	12.5	0.41	2.8	3596	No Ripple
M54–13					6.0	17.6	14.0	0.41	3.6	4038	Ripple
M54–14	0.054	25	3.0	461	3.7	11.0	10.5	0.34	1.4	2520	No Ripple
M54–15					4.3	12.8	12.2	0.34	1.9	2934	No Ripple
M54–16					5.0	15.1	14.4	0.34	2.6	3452	Ripple
M54–17	0.054	25	3.5	540	1.8	5.5	6.1	0.29	0.3	1256	No Ripple
M54–18					2.8	8.4	9.3	0.29	0.8	1918	No Ripple
M54–19					3.3	10.0	11.2	0.29	1.2	2302	No Ripple
M54–20					4.5	13.7	15.3	0.29	2.1	3139	No Ripple
M54–21					5.0	15.2	17.0	0.29	2.7	3488	No Ripple
M54–22					5.7	17.2	19.2	0.29	3.4	3941	Ripple

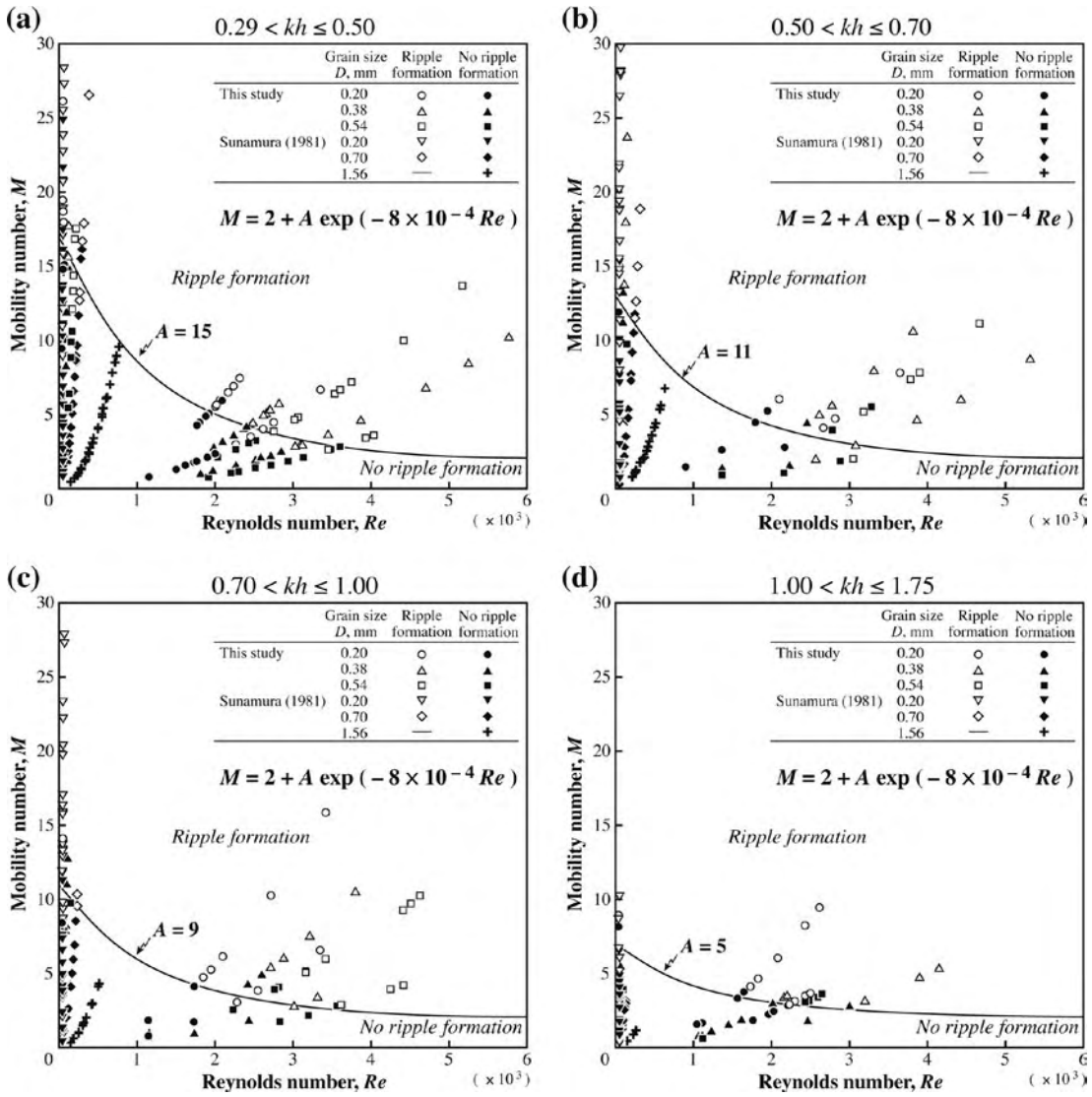

Fig. 3 Relationship between the Reynolds number, *Re*, and the mobility number, *M*, for ripple initiation with different ranges of the relative water depth, *kh* (after Sekiguchi and Sunamura, 2005). The solid curve in each graph denotes the threshold for ripple formation.

attains constant value with further increased bed roughness (Fig. 3). The threshold also decreases as *kh* increases. They proposed the following empirical model of the threshold for rippling considering the effect of bed perturbation:

$$M = 2 + A \exp B \tag{6}$$

where

$$A = 5.7\left(\frac{3.79}{kh - 0.65} - 1\right) \tag{7}$$

and

$$B = -8 \times 10^{-4} Re \tag{8}$$

References

Komar, P. D. (1998): *Beach Processes and Sedimentation*. Prentice Hall, Upper Saddle River, New Jersey, 544p.

Nielsen, P. (1992): *Coastal Bottom Boundary Layers and Sediment Transport*. World Scientific Publishing Corporation, Singapore, 324p.

Sekiguchi, T. and Sunamura, T. (2004): Effects of bed perturbation and velocity asymmetry on ripple initiation: wave-flume experiments. *Coastal Engineering*, **50**, 231–239.

Sekiguchi, T. and Sunamura, T. (2005): Threshold for ripple formation on artificially roughened beds: wave-flume experiments. *Journal of Coastal Research*, **21**, 323–330.

Sunamura, T. (1981): Bedforms generated in a laboratory wave tank. *Science Report A2*, University of Tsukuba, 31–43.

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