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リップル変形に関する二次元造波水路実験データ

Dataset of a Wave-Flume Experiments of the Ripple Deformation

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Introduction

Wave-formed ripples abundantly develop in shallow-water environment, where sandy sediments are moved by wave-induced oscillatory flow. Development of ripples increases bed roughness, and affects bottom-boundary-layer hydraulics and sediment transport in coastal environments. Ripples acquire equilibrium form under steady oscillatory-flow conditions. The numerous laboratory studies have examined relationship among ripple geometry, and oscillatory-flow and bottom sediment conditions in order to predict bed roughness (e.g., Nielsen, 1979).

In the natural coastal environments, however, the near-bottom oscillatory-flow conditinos, i.e., wave conditions, continiously change, and thus size and shape of ripples are continually modified responding to the changes in the hydraulic conditions (e.g., Traykovski *et al.*, 1999). Some experimental studies have examined the ripple deformation prosesses responding to changes in hydraulic conditions in detail (Shulyak, 1963; Lofquist, 1978; Hansen *et al.*, 2001a,b; Sekiguchi, 2003, 2009; Bundgaard *et al.*, 2004; Davis *et al.*, 2004; Sekiguchi and Sunamura, 2004, 2005; Smith and Sleath, 2005; Testik *et al.*, 2005; Doucette and O'Donoghue, 2006). Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005) showed that some characteristic ripple patterns ephemerally occur during deformation into new equiriblium state depending on (1) ratio of orbital diameter' d_0' to preexisting ripples spacing' λ_i, (2) degree of asymmetry in oscillatory flow, and (3) sediment grain size. Recently, a brief review by Sekiguchi (2011) conceptually suggested a phasediagram of characteristic ripple due to ripple deformation using λ_e/λ_i in place of d_0/λ_i, where λ_e denotes spacing of equilibrium ripples under given hydrauric conditions.

The poupose of this report is to summarize the total dataset of the ripple-deformation experiments by Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005), and analyze the dataset based on Sekiguchi's (2011) concept.

Laboratory experiment

The wave-flume experiments by Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005) examined deformation processes of artificially made preexisting 2D ripples under

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wave-induced oscillatory flow. A wave flume used in the experiments was 14 m long, 25 cm wide, and 50 cm deep. A piston-type wave generator was fitted at one end of the flume, and a fixed slope of 1/20 was installed at the other end to decrease the energy of the reflected waves. A movable bed 3 m long, 25 cm wide, and 3 cm high and composed of mono-sized sand was placed in the horizontal portion of the flume. Well-sorted quartz sands of three different grain sizes were prepared as bed materials: the median diameters of the grains, D, were 0.10, 0.20, and 0.38 mm (Table 1). The density of sediments, ρ_s, was 2.65 g/cm^3. Almost mono-sized 2D ripples were formed manually on the bed and served as the initial boundary condition of the experiment; they were called the original ripples. The original ripple spacing, λ_i, and height, η_i, were in the range of 2.1

Table 1 The total experimental dataset of Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005).

Run No.	Grain diameter	Original ripple length	Original ripple height	Ripple index	Water depth	Wave period	Wave length	Wave height	Orbital diameter	Mobility number	Relative water depth	Final ripple length			Remarks
	D, mm	λ_i, cm	η_i, cm	λ_i/η_i	h, cm	T, sec	L, cm	H, cm	d_0, cm	ψ	kh	λ_e, cm	d_0/λ_i	λ_e/λ_i	
0.10-001	0.1	3.2	0.5	6.3	25	0.9	112	5.1	3.1	7.2	1.40	3.1	1.0	1.0	SSC
0.10-002	0.1	6.2	1.0	6.3	25	0.9	112	3.0	3.5	9.0	1.40	3.5	0.6	0.6	DSC
0.10-003	0.1	3.3	0.5	6.1	25	1.3	183	5.6	9.3	31.3	0.86	9.7	2.8	3.0	3D
0.10-004	0.1	2.1	0.4	5.5	25	1.3	183	7.5	9.6	33.4	0.86	10.1	4.6	4.8	3D
0.10-005	0.1	5.0	0.8	6.2	25	1.3	183	5.3	9.7	34.2	0.86	10.2	1.9	2.0	NSD
0.10-006	0.1	2.6	0.5	5.4	25	1.5	217	5.3	10.7	31.2	0.72	11.2	4.1	4.3	RR
0.10-007	0.1	3.2	0.6	5.8	25	1.5	217	5.8	13.2	47.3	0.72	13.9	4.1	4.3	RR
0.10-008	0.1	5.4	0.8	6.4	25	1.5	217	4.5	14.0	52.9	0.72	14.7	2.6	2.7	3D
0.10-009	0.1	3.2	0.5	6.2	25	2.0	300	5.9	7.8	9.2	0.52	7.9	2.4	2.5	3D
0.10-010	0.1	2.6	0.4	6.7	25	2.0	300	4.4	12.4	23.5	0.52	12.9	4.8	5.0	3D
0.10-011	0.1	5.0	0.8	6.2	25	2.0	300	6.6	12.5	23.8	0.52	13.0	2.5	2.6	3D
0.10-012	0.1	2.9	0.4	6.7	25	2.0	300	5.8	12.6	24.2	0.52	13.1	4.3	4.5	RR
0.10-013	0.1	3.4	0.5	6.3	25	2.0	300	4.3	17.1	44.9	0.52	18.1	5.0	5.3	RR
0.10-014	0.1	5.0	0.9	5.5	25	2.0	300	5.0	21.7	71.9	0.52	23.0	4.3	4.6	3D
0.10-015	0.1	3.3	0.5	6.5	25	2.0	300	5.0	22.1	74.4	0.52	23.4	6.7	7.1	RR
0.10-016	0.1	5.1	0.8	6.2	25	2.0	300	4.5	22.5	77.5	0.52	23.9	4.4	4.7	3D
0.10-017	0.1	2.8	0.4	6.4	25	2.0	300	5.9	23.3	82.6	0.52	24.7	8.3	8.8	RR
0.10-018	0.1	6.7	1.2	5.7	25	2.5	381	4.3	8.1	6.5	0.41	8.2	1.2	1.2	SSC
0.10-019	0.1	3.1	0.5	6.3	25	3.0	461	7.7	13.1	11.6	0.34	13.4	4.2	4.3	3D
0.10-020	0.1	3.4	0.5	6.2	25	3.0	461	7.9	18.1	22.3	0.34	18.9	5.3	5.5	RR
0.10-021	0.1	2.7	0.4	6.3	25	3.0	461	8.3	19.1	24.8	0.34	19.9	7.1	7.4	RR
0.10-022	0.1	5.2	0.8	6.5	25	3.0	461	9.2	21.9	32.4	0.34	22.9	4.2	4.4	RR
0.10-023	0.1	3.3	0.5	6.3	25	3.0	461	7.1	22.3	33.7	0.34	23.4	6.8	7.1	RR
0.10-024	0.1	2.6	0.4	6.4	25	3.0	461	11.1	23.3	36.8	0.34	24.5	9.0	9.4	3D
0.10-025	0.1	10.0	1.5	6.5	25	3.5	540	3.4	14.8	10.8	0.29	15.1	1.5	1.5	DSC
0.10-026	0.1	3.2	0.5	6.3	25	4.0	620	5.9	13.3	6.7	0.25	13.4	4.1	4.2	3D
0.10-027	0.1	2.6	0.4	6.1	25	4.0	620	9.1	17.2	11.2	0.25	17.6	6.6	6.8	3D
0.10-028	0.1	3.2	0.5	6.3	25	4.0	620	7.9	17.4	11.5	0.25	17.8	5.4	5.6	RR
0.10-029	0.1	5.5	0.9	6.3	25	4.0	620	11.1	17.6	11.8	0.25	18.0	3.2	3.3	RR
0.10-030	0.1	2.5	0.4	6.8	25	4.0	620	8.3	23.4	20.9	0.25	24.3	9.4	9.7	3D
0.10-031	0.1	3.4	0.4	8.5	25	4.0	620	8.3	23.4	20.9	0.25	24.3	6.9	7.2	RR
0.10-032	0.1	5.3	0.9	6.2	25	4.0	620	9.1	23.6	21.3	0.25	24.5	4.5	4.6	RR
0.10-033	0.1	3.7	0.4	8.4	25	4.0	620	7.7	27.9	29.7	0.25	29.2	7.5	7.9	RR
0.20-001	0.2	3.3	0.6	5.5	25	0.8	93	5.6	2.1	2.2	1.69	2.1	0.7	0.6	DSC
0.20-002	0.2	6.9	1.0	6.8	25	0.8	93	6.3	2.4	2.8	1.69	2.4	0.4	0.3	DSC
0.20-003	0.2	2.7	0.5	5.4	25	0.9	112	6.7	3.5	4.6	1.40	3.5	1.3	1.3	NSD

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.20-004	0.2	7.0	1.0	6.7	25	0.9	112	6.9	3.6	4.9	1.40	3.6	0.5	0.5	DSC
0.20-005	0.2	3.6	0.6	6.4	25	1.0	130	2.7	1.7	0.9	1.21	1.6	0.5	0.4	DSC
0.20-006	0.2	3.4	0.6	6.1	25	1.0	130	4.5	3.0	2.7	1.21	2.9	0.9	0.8	SSC
0.20-007	0.2	3.6	0.6	6.3	25	1.0	130	4.5	3.0	2.7	1.21	2.9	0.8	0.8	BP
0.20-008	0.2	3.6	0.6	6.4	25	1.0	130	4.5	3.0	2.7	1.21	2.9	0.8	0.8	SSC
0.20-009	0.2	3.5	0.5	6.7	25	1.0	130	4.7	3.1	2.9	1.21	3.0	0.9	0.9	BP
0.20-010	0.2	3.6	0.6	6.3	25	1.0	130	4.7	3.1	2.9	1.21	3.0	0.9	0.8	BP
0.20-011	0.2	3.4	0.5	6.3	25	1.0	130	4.9	3.2	3.2	1.21	3.2	0.9	0.9	BP
0.20-012	0.2	3.5	0.6	5.8	25	1.0	130	5.5	3.6	4.0	1.21	3.6	1.0	1.0	BP
0.20-013	0.2	3.5	0.6	6.2	25	1.0	130	5.5	3.6	4.0	1.21	3.6	1.0	1.0	SSC
0.20-014	0.2	3.5	0.6	6.3	25	1.0	130	5.5	3.6	4.0	1.21	3.6	1.0	1.0	BP
0.20-015	0.2	3.6	0.6	6.3	25	1.0	130	5.5	3.6	4.0	1.21	3.6	1.0	1.0	BP
0.20-016	0.2	3.5	0.6	6.1	25	1.0	130	7.6	5.0	7.5	1.21	5.0	1.4	1.4	NSD
0.20-017	0.2	3.7	0.6	6.5	25	1.0	130	7.8	5.1	8.0	1.21	5.2	1.4	1.4	NSD
0.20-018	0.2	3.5	0.6	6.3	25	1.0	130	8.1	5.3	8.6	1.21	5.4	1.5	1.5	NSD
0.20-019	0.2	3.6	0.6	6.3	25	1.0	130	8.1	5.3	8.6	1.21	5.4	1.5	1.5	NSD
0.20-020	0.2	5.0	0.8	6.2	25	1.0	130	4.5	3.0	2.7	1.21	2.9	0.6	0.6	DSC
0.20-021	0.2	4.8	0.6	8.5	25	1.0	130	8.8	5.8	10.1	1.21	5.9	1.2	1.2	NSD
0.20-022	0.2	4.7	0.6	8.4	25	1.0	130	11.9	7.8	18.7	1.21	8.1	1.6	1.7	NSD
0.20-023	0.2	7.0	1.2	5.7	25	1.0	130	5.8	3.8	4.4	1.21	3.8	0.5	0.5	DSC
0.20-024	0.2	7.6	1.2	6.3	25	1.0	130	6.7	4.4	5.9	1.21	4.4	0.6	0.6	DSC
0.20-025	0.2	7.4	1.1	6.6	25	1.0	130	6.9	4.5	6.2	1.21	4.5	0.6	0.6	DSC
0.20-026	0.2	7.5	1.2	6.3	25	1.0	130	6.9	4.5	6.2	1.21	4.5	0.6	0.6	DSC
0.20-027	0.2	6.7	1.2	5.9	25	1.0	130	8.4	5.5	9.3	1.21	5.6	0.8	0.8	DSC
0.20-028	0.2	8.5	1.3	6.5	25	1.0	130	5.0	3.3	3.2	1.21	3.2	0.4	0.4	DSC
0.20-029	0.2	8.4	1.3	6.4	25	1.0	130	5.0	3.3	3.3	1.21	3.2	0.4	0.4	DSC
0.20-030	0.2	8.4	1.5	5.5	25	1.0	130	6.8	4.5	6.1	1.21	4.5	0.5	0.5	DSC
0.20-031	0.2	8.4	1.4	5.9	25	1.0	130	8.1	5.3	8.7	1.21	5.4	0.6	0.6	DSC
0.20-032	0.2	8.4	1.3	6.5	25	1.0	130	12.2	8.0	19.5	1.21	8.3	1.0	1.0	SSC
0.20-033	0.2	8.7	1.4	6.2	25	1.0	130	12.2	8.0	19.5	1.21	8.3	0.9	1.0	SSC
0.20-034	0.2	8.8	1.4	6.3	25	1.0	130	12.2	8.0	19.5	1.21	8.3	0.9	0.9	SSC
0.20-035	0.2	15.0	2.3	6.5	25	1.0	130	6.3	4.1	5.2	1.21	4.1	0.3	0.3	DSC
0.20-036	0.2	15.0	2.3	6.5	25	1.0	130	7.9	5.2	8.2	1.21	5.3	0.3	0.4	DSC
0.20-037	0.2	3.5	0.6	6.2	25	1.2	166	10.9	9.9	20.8	0.95	10.3	2.8	2.9	3D
0.20-038	0.2	4.1	0.6	6.8	25	1.2	166	4.7	4.2	3.8	0.95	4.2	1.0	1.0	NSD
0.20-039	0.2	3.5	0.6	6.2	25	1.3	183	8.7	9.0	14.6	0.86	9.3	2.6	2.7	3D
0.20-040	0.2	3.5	0.6	6.2	25	1.3	183	10.0	10.3	19.1	0.86	10.7	2.9	3.0	3D
0.20-041	0.2	3.5	0.6	6.2	25	1.3	183	10.8	11.1	22.3	0.86	11.6	3.2	3.3	3D
0.20-042	0.2	6.5	1.2	5.5	25	1.3	183	10.6	10.9	21.5	0.86	11.3	1.7	1.7	NSD
0.20-043	0.2	3.5	0.6	6.2	25	1.5	217	4.4	5.5	4.1	0.72	5.5	1.6	1.6	3D
0.20-044	0.2	3.6	0.6	6.5	25	1.5	217	5.6	7.0	6.7	0.72	7.1	1.9	2.0	3D
0.20-045	0.2	3.3	0.5	6.2	25	1.5	217	5.8	7.4	7.3	0.72	7.5	2.2	2.3	3D
0.20-046	0.2	3.6	0.6	6.4	25	1.5	217	6.6	8.4	9.5	0.72	8.5	2.3	2.4	3D
0.20-047	0.2	3.5	0.6	6.3	25	1.5	217	7.6	9.6	12.5	0.72	9.8	2.7	2.8	3D
0.20-048	0.2	3.4	0.5	6.4	25	1.5	217	9.0	11.4	17.7	0.72	11.8	3.4	3.5	RR
0.20-049	0.2	3.4	0.6	6.0	25	1.5	217	9.4	11.9	19.1	0.72	12.3	3.5	3.6	RR
0.20-050	0.2	3.8	0.6	6.5	25	1.5	217	10.4	13.2	23.6	0.72	13.7	3.5	3.6	RR
0.20-051	0.2	3.8	0.6	6.1	25	1.5	217	11.8	15.0	30.4	0.72	15.7	3.9	4.1	RR
0.20-052	0.2	6.0	1.3	4.7	25	1.5	217	4.8	6.1	5.0	0.72	6.1	1.0	1.0	SSC
0.20-053	0.2	6.0	0.9	6.4	25	1.5	217	8.3	10.5	14.9	0.72	10.8	1.7	1.8	NSD
0.20-054	0.2	5.8	1.0	6.0	25	1.5	217	10.5	13.3	23.9	0.72	13.8	2.3	2.4	3D
0.20-055	0.2	7.2	1.1	6.8	25	1.5	217	5.4	6.8	6.3	0.72	6.8	0.9	1.0	SSC
0.20-056	0.2	7.2	1.1	6.4	25	1.5	217	7.5	9.5	12.3	0.72	9.8	1.3	1.4	SSC

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.20-057	0.2	8.2	1.4	5.7	25	1.5	217	3.9	4.9	3.2	0.72	4.8	0.6	0.6	DSC
0.20-058	0.2	7.8	1.1	7.0	25	1.5	217	4.0	5.1	3.5	0.72	5.0	0.7	0.6	RC
0.20-059	0.2	8.2	1.5	5.5	25	1.5	217	5.6	7.1	6.9	0.72	7.2	0.9	0.9	SSC
0.20-060	0.2	8.2	1.3	6.1	25	1.5	217	6.9	8.7	10.3	0.72	8.9	1.1	1.1	SSC
0.20-061	0.2	8.2	1.3	6.3	25	1.5	217	7.2	9.1	11.3	0.72	9.4	1.1	1.1	SSC
0.20-062	0.2	8.2	1.4	6.1	25	1.5	217	8.4	10.7	15.4	0.72	11.0	1.3	1.3	SSC
0.20-063	0.2	8.0	1.4	5.7	25	1.5	217	10.7	13.5	24.8	0.72	14.1	1.7	1.8	NSD
0.20-064	0.2	8.3	1.5	5.7	25	1.5	217	11.2	14.2	27.2	0.72	14.8	1.7	1.8	NSD
0.20-065	0.2	9.8	1.5	6.8	25	1.5	217	5.3	6.7	6.0	0.72	6.7	0.7	0.7	DSC
0.20-066	0.2	10.0	1.5	6.9	25	1.5	217	7.5	9.5	12.3	0.72	9.8	1.0	1.0	SSC
0.20-067	0.2	10.0	1.5	6.9	25	1.5	217	10.5	13.3	24.1	0.72	13.9	1.3	1.4	SSC
0.20-068	0.2	15.0	2.3	6.5	25	1.5	217	4.0	5.1	3.5	0.72	5.0	0.3	0.3	DSC
0.20-069	0.2	15.0	2.3	6.5	25	1.5	217	8.1	10.2	14.2	0.72	10.5	0.7	0.7	DSC
0.20-070	0.2	3.5	0.6	6.2	25	2.0	300	3.4	6.2	2.9	0.52	6.1	1.8	1.7	3D
0.20-071	0.2	3.6	0.6	6.4	25	2.0	300	3.7	6.7	3.4	0.52	6.6	1.8	1.8	NSD
0.20-072	0.2	3.9	0.6	6.5	25	2.0	300	3.7	6.7	3.4	0.52	6.6	1.7	1.7	3D
0.20-073	0.2	3.5	0.6	6.3	25	2.0	300	4.1	7.5	4.3	0.52	7.4	2.1	2.1	3D
0.20-074	0.2	3.9	0.6	6.5	25	2.0	300	5.5	9.9	7.5	0.52	10.1	2.5	2.6	3D
0.20-075	0.2	3.4	0.6	6.1	25	2.0	300	5.6	10.2	8.0	0.52	10.4	3.0	3.0	3D
0.20-076	0.2	3.5	0.6	6.2	25	2.0	300	6.6	12.0	11.1	0.52	12.3	3.4	3.5	RR
0.20-077	0.2	4.2	0.7	6.4	25	2.0	300	7.1	13.0	12.8	0.52	13.3	3.1	3.2	3D
0.20-078	0.2	3.5	0.6	6.2	25	2.0	300	7.6	13.8	14.5	0.52	14.2	3.9	4.0	RR
0.20-079	0.2	3.6	0.6	6.3	25	2.0	300	8.4	15.2	17.7	0.52	15.8	4.3	4.4	RR
0.20-080	0.2	3.8	0.6	6.1	25	2.0	300	8.4	15.3	17.9	0.52	15.9	4.0	4.2	RR
0.20-081	0.2	3.6	0.6	6.4	25	2.0	300	9.4	17.1	22.4	0.52	17.8	4.8	5.0	RR
0.20-082	0.2	3.6	0.6	6.4	25	2.0	300	9.4	17.1	22.4	0.52	17.8	4.8	4.9	RR
0.20-083	0.2	3.8	0.6	6.4	25	2.0	300	11.1	20.2	31.0	0.52	21.1	5.3	5.5	RR
0.20-084	0.2	5.0	0.8	6.3	25	2.0	300	3.7	6.7	3.4	0.52	6.6	1.3	1.3	NSD
0.20-085	0.2	6.0	0.9	6.9	25	2.0	300	4.3	7.8	4.6	0.52	7.7	1.3	1.3	RC
0.20-086	0.2	5.6	0.9	5.9	25	2.0	300	5.1	9.3	6.6	0.52	9.4	1.7	1.7	NSD
0.20-087	0.2	6.0	0.9	6.5	25	2.0	300	6.3	11.5	10.1	0.52	11.7	1.9	2.0	NSD
0.20-088	0.2	6.2	1.0	6.3	25	2.0	300	11.4	20.7	32.7	0.52	21.7	3.3	3.5	3D
0.20-089	0.2	6.1	1.0	6.4	25	2.0	300	11.9	21.7	36.0	0.52	22.8	3.6	3.7	RR
0.20-090	0.2	7.2	1.2	5.9	25	2.0	300	4.4	8.0	4.9	0.52	8.0	1.1	1.1	RC
0.20-091	0.2	6.6	1.0	6.7	25	2.0	300	4.8	8.8	5.9	0.52	8.8	1.3	1.3	RC
0.20-092	0.2	6.9	1.8	3.8	25	2.0	300	5.6	10.2	8.0	0.52	10.4	1.5	1.5	RC
0.20-093	0.2	7.1	1.1	6.4	25	2.0	300	5.7	10.4	8.3	0.52	10.6	1.5	1.5	RC
0.20-094	0.2	6.9	1.2	6.0	25	2.0	300	7.0	12.8	12.4	0.52	13.1	1.9	1.9	NSD
0.20-095	0.2	7.3	1.2	6.3	25	2.0	300	11.9	21.7	36.0	0.52	22.8	3.0	3.1	3D
0.20-096	0.2	8.2	1.3	6.3	25	2.0	300	3.4	6.2	2.9	0.52	6.1	0.8	0.7	RC
0.20-097	0.2	8.3	1.3	6.4	25	2.0	300	4.4	8.0	4.9	0.52	8.0	1.0	1.0	RC
0.20-098	0.2	8.5	1.3	6.7	25	2.0	300	5.3	9.7	7.1	0.52	9.8	1.1	1.1	RC
0.20-099	0.2	8.4	1.5	5.8	25	2.0	300	5.8	10.5	8.4	0.52	10.7	1.2	1.3	RC
0.20-100	0.2	8.5	1.3	6.4	25	2.0	300	6.7	12.2	11.4	0.52	12.5	1.4	1.5	RC
0.20-101	0.2	7.9	1.3	6.1	25	2.0	300	6.9	12.5	11.9	0.52	12.8	1.6	1.6	NSD
0.20-102	0.2	8.2	1.3	6.4	25	2.0	300	8.0	14.6	16.3	0.52	15.1	1.8	1.8	NSD
0.20-103	0.2	10.0	1.2	8.4	25	2.0	300	4.6	8.3	5.3	0.52	8.3	0.8	0.8	RC
0.20-104	0.2	9.9	1.5	6.7	25	2.0	300	6.5	11.9	10.7	0.52	12.1	1.2	1.2	RC
0.20-105	0.2	10.2	1.7	6.1	25	2.0	300	8.7	15.8	19.0	0.52	16.4	1.5	1.6	RC
0.20-106	0.2	15.0	2.1	7.1	25	2.0	300	4.2	7.7	4.5	0.52	7.6	0.5	0.5	RC
0.20-107	0.2	15.0	2.3	6.5	25	2.0	300	6.4	11.7	10.4	0.52	11.9	0.8	0.8	RC
0.20-108	0.2	15.0	2.3	6.5	25	2.0	300	6.5	11.9	10.7	0.52	12.1	0.8	0.8	RC
0.20-109	0.2	15.0	2.2	6.9	25	2.0	300	9.0	16.3	20.3	0.52	17.0	1.1	1.1	RC

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.20-110	0.2	5.2	0.8	6.5	25	2.5	381	9.8	23.1	26.0	0.41	24.1	4.4	4.6	RR
0.20-111	0.2	5.2	0.8	6.5	25	2.5	381	9.8	23.1	26.0	0.41	24.1	4.4	4.6	RR
0.20-112	0.2	8.2	0.6	14.5	25	2.5	381	9.8	23.1	26.0	0.41	24.1	2.8	2.9	NSD
0.20-113	0.2	3.7	0.6	6.4	25	3.0	461	3.2	9.1	2.8	0.34	8.9	2.4	2.4	3D
0.20-114	0.2	3.3	0.6	5.5	25	3.0	461	4.9	14.0	6.6	0.34	14.1	4.2	4.3	RR
0.20-115	0.2	3.5	0.6	6.2	25	3.0	461	6.9	19.7	13.2	0.34	20.3	5.6	5.8	RR
0.20-116	0.2	3.5	0.6	6.2	25	3.0	461	8.3	23.7	19.1	0.34	24.6	6.8	7.0	RR
0.20-117	0.2	6.2	1.0	6.5	25	3.0	461	6.6	19.0	12.2	0.34	19.5	3.1	3.1	3D
0.20-118	0.2	5.8	1.0	5.9	25	3.0	461	7.0	20.0	13.6	0.34	20.6	3.4	3.5	3D
0.20-119	0.2	6.2	1.1	5.9	25	3.0	461	8.5	24.5	20.3	0.34	25.4	3.9	4.1	3D
0.20-120	0.2	6.0	1.0	6.0	25	3.0	461	11.1	31.9	34.6	0.34	33.5	5.3	5.6	3D
0.20-121	0.2	6.6	1.2	5.8	25	3.0	461	6.9	19.7	13.2	0.34	20.3	3.0	3.1	3D
0.20-122	0.2	7.8	1.2	6.4	25	3.0	461	3.0	8.6	2.5	0.34	8.4	1.1	1.1	RC
0.20-123	0.2	8.0	1.3	6.2	25	3.0	461	4.5	12.9	5.7	0.34	13.0	1.6	1.6	RC
0.20-124	0.2	8.0	1.4	5.6	25	3.0	461	7.5	21.4	15.6	0.34	22.1	2.7	2.8	3D
0.20-125	0.2	7.8	1.2	6.3	25	3.0	461	8.4	24.0	19.6	0.34	24.9	3.1	3.2	3D
0.20-126	0.2	9.8	1.5	6.6	25	3.0	461	3.2	9.2	2.9	0.34	9.0	0.9	0.9	RC
0.20-127	0.2	10.2	1.3	7.6	25	3.0	461	4.7	13.5	6.2	0.34	13.6	1.3	1.3	RC
0.20-128	0.2	12.2	1.7	7.4	25	3.0	461	4.9	14.1	6.7	0.34	14.2	1.2	1.2	RC
0.20-129	0.2	9.8	1.5	6.8	25	3.0	461	6.8	19.6	13.0	0.34	20.1	2.0	2.1	RC
0.20-130	0.2	9.8	1.5	6.8	25	3.0	461	8.7	24.9	21.0	0.34	25.9	2.5	2.6	RC
0.20-131	0.2	15.0	2.3	6.5	25	3.0	461	8.1	23.3	18.4	0.34	24.1	1.6	1.6	RC
0.20-132	0.2	15.0	2.4	6.3	25	3.0	461	6.5	18.7	11.9	0.34	19.2	1.2	1.3	RC
0.20-133	0.2	15.0	2.3	6.5	25	3.0	461	4.7	13.4	6.1	0.34	13.5	0.9	0.9	RC
0.20-134	0.2	6.2	1.0	6.3	25	4.0	620	7.4	28.9	15.9	0.25	29.8	4.7	4.8	RR
0.20-135	0.2	6.0	1.0	6.3	30	1.0	137	5.3	2.9	2.5	1.37	2.8	0.5	0.5	DSC
0.20-136	0.2	6.0	1.0	6.3	30	1.0	137	8.6	4.7	6.6	1.37	4.7	0.8	0.8	SSC
0.20-137	0.2	6.0	1.0	6.3	30	1.5	234	5.9	6.5	5.8	0.81	6.6	1.1	1.1	SSC
0.20-138	0.2	6.0	1.0	6.3	30	1.5	234	8.6	9.6	12.5	0.81	9.9	1.6	1.6	NSD
0.20-139	0.2	6.0	1.0	6.3	30	2.0	326	4.2	6.9	3.6	0.58	6.8	1.1	1.1	RC
0.20-140	0.2	6.0	1.0	6.3	30	2.0	326	6.5	10.6	8.6	0.58	10.8	1.8	1.8	NSD
0.20-141	0.2	6.0	1.0	6.3	30	2.0	326	9.3	15.2	17.6	0.58	15.7	2.5	2.6	3D
0.20-142	0.2	6.0	1.0	6.3	30	3.0	503	5.3	13.8	6.5	0.37	13.9	2.3	2.3	NSD
0.20-143	0.2	6.0	1.0	6.3	30	3.0	503	7.0	18.2	11.3	0.37	18.7	3.0	3.1	3D
0.20-144	0.2	10.0	1.5	6.9	30	1.0	137	5.3	2.8	2.5	1.37	2.8	0.3	0.3	DSC
0.20-145	0.2	10.0	1.5	6.9	30	1.0	137	8.4	4.5	6.3	1.37	4.6	0.5	0.5	DSC
0.20-146	0.2	10.0	1.5	6.9	30	1.5	234	5.5	6.1	5.1	0.81	6.2	0.6	0.6	DSC
0.20-147	0.2	10.0	1.5	6.9	30	1.5	234	8.2	9.2	11.4	0.81	9.4	0.9	0.9	SSC
0.20-148	0.2	10.0	1.5	6.9	30	2.0	326	4.1	6.6	3.3	0.58	6.5	0.7	0.7	RC
0.20-149	0.2	10.0	1.5	6.9	30	2.0	326	6.7	10.9	9.0	0.58	11.1	1.1	1.1	RC
0.20-150	0.2	10.0	1.5	6.9	30	2.0	326	9.1	14.9	16.9	0.58	15.4	1.5	1.5	RC
0.20-151	0.2	10.0	1.5	6.9	30	3.0	503	5.0	13.0	5.8	0.37	13.1	1.3	1.3	SSC
0.20-152	0.2	10.0	1.5	6.9	30	3.0	503	6.9	18.0	11.0	0.37	18.4	1.8	1.8	RC
0.20-153	0.2	6.0	1.0	6.3	15	1.0	109	5.3	5.4	8.8	0.86	5.5	0.9	0.9	SSC
0.20-154	0.2	6.0	1.0	6.3	15	1.5	174	4.0	7.0	6.7	0.54	7.1	1.2	1.2	RC
0.20-155	0.2	6.0	1.0	6.3	15	1.5	174	6.2	10.8	15.8	0.54	11.1	1.8	1.9	NSD
0.20-156	0.2	6.0	1.0	6.3	15	2.0	236	3.6	8.7	5.7	0.40	8.7	1.4	1.5	NSD
0.20-157	0.2	6.0	1.0	6.3	15	2.0	236	5.7	13.8	14.5	0.40	14.2	2.3	2.4	3D
0.20-158	0.2	6.0	1.0	6.3	15	3.0	360	3.3	12.3	5.1	0.26	12.3	2.0	2.0	RC
0.20-159	0.2	6.0	1.0	6.3	15	3.0	360	4.0	15.1	7.7	0.26	15.3	2.5	2.6	NSD
0.20-160	0.2	6.0	1.0	6.3	15	3.0	360	5.7	21.5	15.7	0.26	22.2	3.6	3.7	3D
0.20-161	0.2	10.0	1.5	6.9	15	1.0	109	5.0	5.1	8.0	0.86	5.2	0.5	0.5	DSC
0.20-162	0.2	10.0	1.5	6.9	15	1.5	174	4.2	7.4	7.4	0.54	7.5	0.7	0.7	RC

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.20-163	0.2	10.0	1.5	6.9	15	1.5	174	6.3	11.1	16.6	0.54	11.4	1.1	1.1	RC
0.20-164	0.2	10.0	1.5	6.9	15	2.0	236	3.5	8.5	5.6	0.40	8.6	0.9	0.9	RC
0.20-165	0.2	10.0	1.5	6.9	15	2.0	236	5.8	14.0	15.1	0.40	14.5	1.4	1.4	RC
0.20-166	0.2	10.0	1.5	6.9	15	3.0	360	3.8	14.3	7.0	0.26	14.5	1.4	1.4	RC
0.20-167	0.2	10.0	1.5	6.9	15	3.0	360	6.0	22.6	17.4	0.26	23.4	2.3	2.3	RC
0.20-168	0.2	3.6	0.6	6.4	7	1.0	79	2.8	4.7	6.7	0.56	4.7	1.3	1.3	NSD
0.20-169	0.2	3.6	0.6	6.4	7	1.5	122	1.7	4.6	2.9	0.36	4.5	1.3	1.3	RC
0.20-170	0.2	3.6	0.6	6.4	7	1.5	122	2.7	7.2	7.0	0.36	7.2	2.0	2.0	RC
0.20-171	0.2	3.6	0.6	6.4	7	2.0	164	2.5	9.0	6.2	0.27	9.1	2.5	2.5	RC
0.20-172	0.2	6.0	1.0	6.3	7	1.0	79	3.0	5.1	8.0	0.56	5.2	0.9	0.9	SSC
0.20-173	0.2	6.0	1.0	6.3	7	1.5	122	1.6	4.3	2.5	0.36	4.2	0.7	0.7	RC
0.20-174	0.2	6.0	1.0	6.3	7	2.0	164	2.6	9.4	6.7	0.27	9.5	1.6	1.6	RC
0.20-175	0.2	6.0	1.0	6.3	7	3.0	247	2.1	11.5	4.5	0.18	11.4	1.9	1.9	RC
0.38-001	0.38	4.4	0.7	6.2	25	1.0	130	6.6	4.3	3.0	1.21	4.3	1.0	1.0	SSC
0.38-002	0.38	4.1	0.6	6.5	25	1.0	130	7.5	4.9	3.9	1.21	4.9	1.2	1.2	BP
0.38-003	0.38	4.1	0.7	6.2	25	1.0	130	8.7	5.7	5.3	1.21	5.7	1.4	1.4	NSD
0.38-004	0.38	6.5	1.0	6.3	25	1.0	130	6.6	4.3	3.0	1.21	4.2	0.7	0.7	NSD
0.38-005	0.38	6.6	0.8	8.4	25	1.0	130	8.1	5.3	4.6	1.21	5.3	0.8	0.8	DSC
0.38-006	0.38	6.5	1.0	6.3	25	1.0	130	8.6	5.7	5.1	1.21	5.7	0.9	0.9	DSC
0.38-007	0.38	5.9	0.9	6.4	25	1.0	130	8.2	5.4	4.7	1.21	5.4	0.9	0.9	BP
0.38-008	0.38	7.3	1.1	6.6	25	1.0	130	8.4	5.5	4.8	1.21	5.5	0.8	0.8	DSC
0.38-009	0.38	8.5	1.4	6.2	25	1.0	130	6.6	4.3	3.0	1.21	4.2	0.5	0.5	BP
0.38-010	0.38	9.1	1.5	6.2	25	1.0	130	8.1	5.3	4.6	1.21	5.3	0.6	0.6	DSC
0.38-011	0.38	10.0	1.6	6.1	25	1.0	130	8.5	5.6	5.0	1.21	5.6	0.6	0.6	DSC
0.38-012	0.38	10.0	1.6	6.3	25	1.0	130	6.8	4.5	3.2	1.21	4.4	0.4	0.4	DSC
0.38-013	0.38	12.7	1.5	8.5	25	1.0	130	8.7	5.7	5.3	1.21	5.7	0.5	0.5	DSC
0.38-014	0.38	15.0	2.3	6.6	25	1.0	130	8.4	5.5	4.9	1.21	5.5	0.4	0.4	DSC
0.38-015	0.38	6.1	1.0	6.2	25	1.2	166	9.1	8.3	7.7	0.95	8.4	1.4	1.4	NSD
0.38-016	0.38	6.8	1.1	6.3	25	1.2	166	9.4	8.6	8.2	0.95	8.7	1.3	1.3	NSD
0.38-017	0.38	8.2	1.3	6.5	25	1.2	166	9.4	8.6	8.2	0.95	8.7	1.0	1.1	SSC
0.38-018	0.38	11.4	1.7	6.5	25	1.2	166	9.3	8.4	8.0	0.95	8.6	0.7	0.8	DSC
0.38-019	0.38	4.3	0.7	6.3	25	1.3	183	10.2	10.5	10.5	0.86	10.7	2.4	2.5	3D
0.38-020	0.38	4.0	0.6	6.4	25	1.5	217	5.2	6.5	3.0	0.72	6.4	1.6	1.6	NSD
0.38-021	0.38	4.0	0.6	6.6	25	1.5	217	8.4	10.6	8.0	0.72	10.8	2.6	2.7	3D
0.38-022	0.38	4.1	0.7	5.9	25	1.5	217	9.4	11.9	10.2	0.72	12.2	2.9	3.0	3D
0.38-023	0.38	4.4	0.7	6.5	25	1.5	217	10.9	13.8	13.7	0.72	14.2	3.1	3.2	3D
0.38-024	0.38	6.3	1.0	6.3	25	1.5	217	5.8	7.3	3.8	0.72	7.2	1.2	1.2	RC
0.38-025	0.38	5.9	1.0	6.0	25	1.5	217	6.9	8.7	5.4	0.72	8.7	1.5	1.5	NSD
0.38-026	0.38	6.6	0.8	8.5	25	1.5	217	9.0	11.4	9.2	0.72	11.6	1.7	1.7	NSD
0.38-027	0.38	6.6	1.1	6.2	25	1.5	217	10.7	13.5	13.0	0.72	13.9	2.0	2.1	3D
0.38-028	0.38	8.5	1.6	5.5	25	1.5	217	5.8	7.3	3.8	0.72	7.2	0.9	0.9	SSC
0.38-029	0.38	8.3	1.3	6.2	25	1.5	217	7.3	9.3	6.1	0.72	9.3	1.1	1.1	SSC
0.38-030	0.38	7.8	1.3	6.2	25	1.5	217	7.3	9.2	6.0	0.72	9.3	1.2	1.2	SSC
0.38-031	0.38	8.3	1.3	6.2	25	1.5	217	9.0	11.4	9.2	0.72	11.6	1.4	1.4	SSC
0.38-032	0.38	7.8	1.2	6.3	25	1.5	217	8.7	11.0	8.6	0.72	11.2	1.4	1.4	SSC
0.38-033	0.38	7.5	1.4	5.5	25	1.5	217	9.6	12.1	10.5	0.72	12.4	1.6	1.7	NSD
0.38-034	0.38	10.0	1.7	5.9	25	1.5	217	5.5	6.9	3.4	0.72	6.8	0.7	0.7	RC
0.38-035	0.38	10.0	1.5	6.7	25	1.5	217	8.5	10.8	8.3	0.72	11.0	1.1	1.1	RC
0.38-036	0.38	10.0	1.6	6.3	25	1.5	217	10.8	13.6	13.3	0.72	14.0	1.4	1.4	NSD
0.38-037	0.38	11.1	1.8	6.1	25	1.5	217	11.8	14.9	15.9	0.72	15.4	1.3	1.4	NSD
0.38-038	0.38	12.4	2.0	6.3	25	1.5	217	6.8	8.6	5.3	0.72	8.6	0.7	0.7	RC
0.38-039	0.38	13.0	2.3	5.7	25	1.5	217	11.6	14.7	15.5	0.72	15.2	1.1	1.2	NSD
0.38-040	0.38	15.0	2.6	5.9	25	1.5	217	5.4	6.8	3.3	0.72	6.7	0.5	0.4	RC

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.38-041	0.38	15.0	2.3	6.5	25	1.5	217	8.1	10.2	7.5	0.72	10.3	0.7	0.7	RC
0.38-042	0.38	15.0	2.3	6.5	25	1.5	217	10.9	13.8	13.5	0.72	14.2	0.9	0.9	RC
0.38-043	0.38	7.3	1.2	5.9	25	1.8	267	4.7	7.5	2.8	0.59	7.4	1.0	1.0	RC
0.38-044	0.38	4.7	0.8	6.2	25	2.0	300	6.9	12.5	6.3	0.52	12.6	2.7	2.7	3D
0.38-045	0.38	4.0	0.6	6.3	25	2.0	300	9.5	17.2	11.9	0.52	17.7	4.3	4.4	3D
0.38-046	0.38	4.0	0.7	5.9	25	2.0	300	10.5	19.2	14.7	0.52	19.7	4.8	4.9	3D
0.38-047	0.38	4.0	0.6	6.5	25	2.0	300	12.3	22.3	20.1	0.52	23.2	5.6	5.8	3D
0.38-048	0.38	6.0	0.9	6.4	25	2.0	300	4.7	8.5	2.9	0.52	8.3	1.4	1.4	RC
0.38-049	0.38	6.3	1.0	6.1	25	2.0	300	9.5	17.2	11.9	0.52	17.7	2.7	2.8	3D
0.38-050	0.38	7.4	1.2	6.4	25	2.0	300	4.4	7.9	2.5	0.52	7.7	1.1	1.0	RC
0.38-051	0.38	7.4	1.1	6.5	25	2.0	300	4.4	8.0	2.6	0.52	7.8	1.1	1.1	RC
0.38-052	0.38	7.7	1.2	6.5	25	2.0	300	5.2	9.4	3.5	0.52	9.3	1.2	1.2	RC
0.38-053	0.38	7.7	1.3	5.9	25	2.0	300	6.6	12.0	5.8	0.52	12.1	1.6	1.6	RC
0.38-054	0.38	8.3	1.2	6.8	25	2.0	300	7.8	14.1	8.0	0.52	14.4	1.7	1.7	RC
0.38-055	0.38	8.2	1.3	6.5	25	2.0	300	9.0	16.4	10.8	0.52	16.8	2.0	2.0	NSD
0.38-056	0.38	8.2	1.3	6.2	25	2.0	300	9.0	16.4	10.8	0.52	16.8	2.0	2.0	NSD
0.38-057	0.38	8.6	1.3	6.5	25	2.0	300	4.4	7.9	2.5	0.52	7.7	0.9	0.9	RC
0.38-058	0.38	9.1	1.4	6.4	25	2.0	300	5.2	9.4	3.5	0.52	9.3	1.0	1.0	RC
0.38-059	0.38	9.2	1.5	6.0	25	2.0	300	8.2	14.9	8.9	0.52	15.1	1.6	1.6	NSD
0.38-060	0.38	9.1	1.4	6.4	25	2.0	300	12.4	22.5	20.4	0.52	23.4	2.5	2.6	NSD
0.38-061	0.38	10.0	1.6	6.3	25	2.0	300	4.1	7.5	2.2	0.52	7.2	0.7	0.7	RC
0.38-062	0.38	10.0	1.8	5.5	25	2.0	300	6.2	11.2	5.1	0.52	11.2	1.1	1.1	RC
0.38-063	0.38	9.9	1.6	6.1	25	2.0	300	8.9	16.2	10.6	0.52	16.6	1.6	1.7	NSD
0.38-064	0.38	10.0	1.9	5.4	25	2.0	300	9.1	16.6	11.1	0.52	17.0	1.7	1.7	RC
0.38-065	0.38	10.0	1.6	6.2	25	2.0	300	11.8	21.4	18.5	0.52	22.2	2.1	2.2	NSD
0.38-066	0.38	12.9	1.5	8.4	25	2.0	300	8.4	15.3	9.4	0.52	15.6	1.2	1.2	RC
0.38-067	0.38	13.4	2.1	6.3	25	2.0	300	5.6	10.1	4.1	0.52	10.1	0.8	0.8	RC
0.38-068	0.38	15.0	2.3	6.5	25	2.0	300	4.2	7.7	2.4	0.52	7.4	0.5	0.5	RC
0.38-069	0.38	15.0	2.4	6.2	25	2.0	300	6.4	11.7	5.5	0.52	11.7	0.8	0.8	RC
0.38-070	0.38	15.0	2.4	6.3	25	2.0	300	8.6	15.7	9.9	0.52	16.0	1.0	1.1	RC
0.38-071	0.38	15.0	2.4	6.4	25	2.0	300	11.3	20.5	16.9	0.52	21.2	1.4	1.4	RC
0.38-072	0.38	7.3	1.2	6.3	25	2.5	381	5.1	11.9	3.6	0.41	11.8	1.6	1.6	RC
0.38-073	0.38	9.1	1.5	6.3	25	2.5	381	5.1	11.9	3.6	0.41	11.8	1.3	1.3	RC
0.38-074	0.38	4.5	0.7	6.8	25	3.0	461	6.9	19.7	6.9	0.34	19.9	4.4	4.4	3D
0.38-075	0.38	4.4	0.7	6.5	25	3.0	461	7.0	20.0	7.1	0.34	20.2	4.5	4.6	3D
0.38-076	0.38	3.8	0.7	5.7	25	3.0	461	8.3	23.9	10.2	0.34	24.4	6.3	6.4	3D
0.38-077	0.38	4.0	0.7	5.5	25	3.0	461	10.6	30.5	16.6	0.34	31.5	7.6	7.9	3D
0.38-078	0.38	3.8	0.6	6.3	25	3.0	461	12.0	34.5	21.3	0.34	35.9	9.1	9.4	3D
0.38-079	0.38	6.4	1.0	6.5	25	3.0	461	5.0	14.4	3.7	0.34	14.2	2.2	2.2	RC
0.38-080	0.38	6.0	0.9	6.4	25	3.0	461	6.8	19.6	6.8	0.34	19.8	3.3	3.3	3D
0.38-081	0.38	6.0	1.1	5.5	25	3.0	461	9.8	28.1	14.0	0.34	28.9	4.7	4.8	3D
0.38-082	0.38	8.4	1.4	6.2	25	3.0	461	9.7	27.8	13.8	0.34	28.6	3.3	3.4	3D
0.38-083	0.38	9.6	1.5	6.5	25	3.0	461	6.9	19.7	6.9	0.34	19.9	2.1	2.1	RC
0.38-084	0.38	10.0	1.6	6.4	25	3.0	461	4.4	12.7	2.9	0.34	12.4	1.3	1.2	RC
0.38-085	0.38	10.9	1.7	6.3	25	3.0	461	4.9	14.1	3.5	0.34	13.9	1.3	1.3	RC
0.38-086	0.38	10.0	1.7	5.8	25	3.0	461	8.4	24.2	10.4	0.34	24.7	2.4	2.5	NSD
0.38-087	0.38	12.5	2.0	6.3	25	3.0	461	6.9	19.9	7.0	0.34	20.1	1.6	1.6	RC
0.38-088	0.38	12.5	2.0	6.2	25	3.0	461	12.2	35.0	21.8	0.34	36.3	2.8	2.9	NSD
0.38-089	0.38	15.0	2.7	5.5	25	3.0	461	4.9	14.1	3.5	0.34	13.9	0.9	0.9	RC
0.38-090	0.38	15.0	2.5	5.9	25	3.0	461	7.1	20.4	7.4	0.34	20.7	1.4	1.4	RC
0.38-091	0.38	15.0	2.3	6.5	25	3.0	461	8.5	24.3	10.6	0.34	24.9	1.6	1.7	RC
0.38-092	0.38	15.0	2.4	6.3	25	3.0	461	9.6	27.6	13.6	0.34	28.4	1.8	1.9	RC
0.38-093	0.38	6.0	1.1	5.4	15	1.0	109	5.0	5.1	4.1	0.86	5.0	0.8	0.8	DSC

Run No.	Grain diameter D, mm	Original ripple length λ_i, cm	Original ripple height η_i, cm	Ripple index λ_i/η_i	Water depth h, cm	Wave period T, sec	Wave length L, cm	Wave height H, cm	Orbital diameter d_0, cm	Mobility number ψ	Relative water depth kh	Final ripple length λ_e, cm	d_0/λ_i	λ_e/λ_i	Remarks
0.38-094	0.38	6.0	0.9	6.4	15	1.5	174	4.3	7.5	4.0	0.54	7.4	1.2	1.2	RC
0.38-095	0.38	6.0	0.9	6.5	15	1.5	174	6.2	10.8	8.3	0.54	11.0	1.8	1.8	3D
0.38-096	0.38	6.0	1.0	6.1	15	2.0	236	3.7	9.0	3.3	0.40	8.9	1.5	1.5	RC
0.38-097	0.38	6.0	0.9	6.7	15	2.0	236	6.0	14.7	8.6	0.40	14.9	2.4	2.5	NSD
0.38-098	0.38	6.0	1.0	6.3	15	3.0	360	4.1	15.5	4.3	0.26	15.4	2.6	2.6	NSD
0.38-099	0.38	10.0	1.5	6.5	15	1.0	109	4.1	4.2	2.8	0.86	4.1	0.4	0.4	DSC
0.38-100	0.38	10.0	1.5	6.5	15	1.0	109	4.8	4.9	3.8	0.86	4.8	0.5	0.5	DSC
0.38-101	0.38	10.0	1.7	5.9	15	1.5	174	4.3	7.5	4.0	0.54	7.4	0.7	0.7	RC
0.38-102	0.38	10.0	1.5	6.5	15	1.5	174	6.5	11.4	9.3	0.54	11.6	1.1	1.2	RC
0.38-103	0.38	10.0	1.5	6.5	15	2.0	236	3.5	8.5	2.9	0.40	8.4	0.9	0.8	RC
0.38-104	0.38	10.0	1.6	6.2	15	2.0	236	6.0	14.7	8.6	0.40	14.9	1.5	1.5	RC
0.38-105	0.38	10.0	1.6	6.1	15	3.0	360	4.5	17.0	5.1	0.26	17.0	1.7	1.7	RC
0.38-106	0.38	10.0	1.6	6.3	15	3.0	360	6.3	23.6	9.9	0.26	24.1	2.4	2.4	RC
0.38-107	0.38	6.0	0.9	6.7	30	1.0	137	8.9	4.8	3.7	1.37	4.7	0.8	0.8	DSC
0.38-108	0.38	6.0	0.9	6.8	30	1.5	234	5.8	6.4	2.9	0.81	6.3	1.1	1.0	SSC
0.38-109	0.38	6.0	0.9	6.3	30	1.5	234	9.0	10.1	7.2	0.81	10.2	1.7	1.7	NSD
0.38-110	0.38	6.0	1.0	6.3	30	2.0	326	4.5	7.4	2.2	0.58	7.1	1.2	1.2	RC
0.38-111	0.38	6.0	1.0	6.1	30	2.0	326	9.0	14.7	8.7	0.58	15.0	2.5	2.5	3D
0.38-112	0.38	6.0	1.0	5.8	30	3.0	503	4.9	12.8	2.9	0.37	12.5	2.1	2.1	NSD
0.38-113	0.38	6.0	1.3	4.7	30	3.0	503	6.7	17.3	5.4	0.37	17.4	2.9	2.9	3D
0.38-114	0.38	10.0	1.6	6.4	30	1.0	137	8.7	4.7	3.6	1.37	4.6	0.5	0.5	DSC
0.38-115	0.38	10.0	1.5	6.5	30	1.5	234	6.4	7.1	3.6	0.81	7.0	0.7	0.7	RC
0.38-116	0.38	10.0	1.5	6.5	30	1.5	234	8.6	9.6	6.6	0.81	9.7	1.0	1.0	RC
0.38-117	0.38	10.0	1.5	6.5	30	2.0	326	4.5	7.3	2.1	0.58	7.0	0.7	0.7	RC
0.38-118	0.38	10.0	1.5	6.8	30	2.0	326	7.0	11.4	5.3	0.58	11.5	1.1	1.1	RC
0.38-119	0.38	10.0	1.5	6.7	30	2.0	326	9.2	15.0	9.0	0.58	15.2	1.5	1.5	RC
0.38-120	0.38	10.0	1.6	6.3	30	3.0	503	4.9	12.8	2.9	0.37	12.5	1.3	1.3	RC
0.38-121	0.38	10.0	1.6	6.4	30	3.0	503	6.9	18.0	5.8	0.37	18.1	1.8	1.8	RC

BR: barrel-type ripples, DSC: ripples with double secondary crests, NSD: no significant deformation, RC: round-crested ripples, RR: rhombic-type ripples, SSC: ripples with a single secondary crest, and 3D: irregular three-dimensional ripples.

$\leq \lambda_i \leq 15.0$ cm and $0.3 \leq \eta_i \leq 2.4$ cm, and the ripple index, RI (= λ_i/η_i), was in the range $3.8 \leq RI \leq 8.5$ (Table 1). The ripple size was varied according to the experimental run.

The original ripples were deformed under the action of waves that had the following hydraulic conditions: $7 \leq h \leq 30$ cm, $0.8 \leq T \leq 4.0$ s, and $2.7 \leq H \leq 12.4$ cm, where h, T, and H denote the water depth, wave period, and wave height, respectively (Table 1). The direction of wave propagation was perpendicular to the crest of the original ripples. Through each run, the hydraulic conditions were kept constant. The ripple deformation process was examined in 329 experimental runs with different combinations of D, λ_i, h, T, and H. The top and oblique-top views of the process of ripple deformation were photographed with digital cameras at a certain interval of time.

Characteristic transitional ripple form during deformation

Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005) reported the following 4 types of dinsinctive transitional ripples, which ephemerally occur during ripple deformation: (1) ripples with secondary crests, (2) barrel-type ripples, (3) round-crested ripples, and (4) rhombic-type ripples. When the avobe charactaristic transient ripples did not occur, the original ripples show (5) no siginificant modification but slight increase in ripple spacing by "slide (Smith and Sleath, 2005)" or (6) deformation into larger 2D ripples through ephemeral occurrence of irregular 3D ripples (Sekiguchi, 2003; Sekiguchi and Sunamura, 2004, 2005).

1) Ripples with secondary crests (SSC, Fig. 1a; DSC, Fig. 1b)

This type of ripple has a single (SSC, Fig. 1a) or double (DSC, Fig. 1b) small crests, called as secondary crests in Evans (1943), in each trough. Ripples with secondary crsts occur during deformation from original ripples into those with smaller ripples under relatively symmetrical flow field. The number of secondary crest in a trough depends on the ratio of the horizontal scale of vortexes to the original ripple spacing the ratio of the horizontal scale of vortexes, d_v, to the original ripple length, λ_i: single for $0.35 \leqq d_v/\lambda_i \leqq 0.5$, and double for $d_v/\lambda_i \leqq 0.35$ (Sekiguchi, 2005).

2) Barrel-type ripples (BR, Fig. 1c)

BR was named for its barrel-like plan shape, and occur during deformation from the original ripples into smaller ones. Barrel-type ripples have short secondary crests in a staggered arrangement, and wide bridges connecting the original ripple crests form between short secondary crests. The ripple spacing in the non-bridge areas is larger than that in each bridge portion to form a bulge.

3) Round-crested ripples (RC, Figs. 1d and e)

The crest of this type of ripples is rounded, and their trough is rounded or angular. Their profile is generally asymmetical; but, it looks like symmetrical when their trough is angular. RC develop without significant changes in the initial ripple spacing. If a secondary crest occurs in their trough, they modified into angular-crested

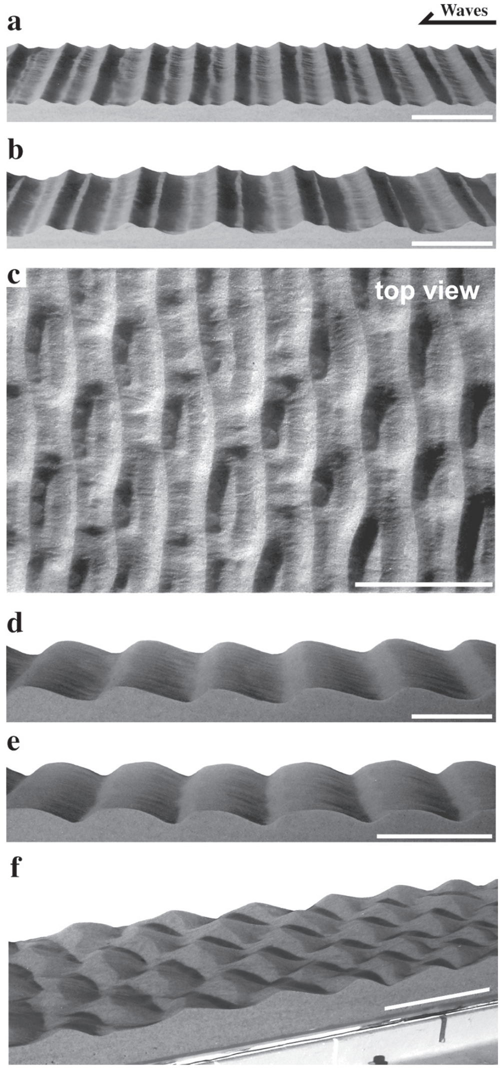

Fig. 1 Characteristic transient ripples, which ephemerally occur during ripple modification: (a) ripples with a single secondary crest (SSC), (b) those with double secondary crests (DSC), (c) barrel-type ripples (BR), (d, e) round-crested ripples (RC), and (f) rhombic-type ripples (RR). Scale bar shows 10 cm.

asymmetrical ripples whose spacing is smaller than that of the initial ripples.

4) Rhombic-type ripples (RR, Fig. 1f)

RR were characterized by similar-sized mounds arranged in a rhombic pattern. The rhombic ripples emerged during a process in which the original ripples developed into larger ones. After the occurrence of RR, the mounds merged each other and ripples with a sinuous or bifurcated crest line developed.

Physical basis of analysis

The present test analyze the conditions for occurrence of four types of transitional ripples considering: λ_e/λ_i, degree of asymmetry in oscillatory flow, and D based on Sekiguchi's (2011) consept. Because data of Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005) lack λ_e, the present report employs Nielsen's (1979) formula, which is widely used in wave ripple study, in order to predict λ_e from hydraulic and sediment properties. Nielsen's formula for regular waves is given as:

$$\frac{\lambda}{d_0/2} = 2.2 - 3.45\psi^{0.34}$$

where ψ is mobility number. Mobility number, a simplified Shield's parameter for oscillatory flow neglecting wave friction factor, is given by:

$$\psi = \frac{\rho u_s^2}{(\rho_s - \rho)gD}$$

where ub is maximum near-bed velocity of oscillatory flow, g is gravity acceralation, and ρ is dencity of fluid, i.e., ρ = 1 for water. Linear wave theory (Wiegel, 1964; Komar, 1998) gives:

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

where k is wave number (= $2\pi/L$; L is wavelength of surface wave). Again, linear wave theory gives:

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

The Nielsen's formula suggests that spacing of ripples, which strongly depend on orbital diameter, is also affected by the mobility of sediment grains.

Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005), which did not directry measure near-bed flow velocity, employed the relative water depth, kh, as an indicator of the degree of asymmetry in oscillatory flow. The degree of flow asymmetry increases as kh-value decreases.

Results and Discussion

Under relatively symmetrical oscillatory flow, i.e., for kh > 0.7, the original ripples were stable when $1 \leqq \lambda_e/\lambda_i \leqq 1.5$ and they were modified into smaller ripples through development of secondary crests when $\lambda_e/\lambda_i \leqq 1$ (Fig. 2). These results suggest that ripples are more sensitive to the decrease in λ_e/λ_i value than its increase. The slight decrease in λ_e/λ_i causes "split (Smith and Sleath, 2005)" trough formation of secondary crests and subsequent "merge (Smith and Sleath, 2005)," and thus original ripples are completely reconstructed into new equivalent ripples (Sekiguchi, 2011). On the other hand, the original ones are almost maintained with the slight increase in λ_e/λ_i value. As the flow field became more asymmetrical, i.e., with decreasing *kh* value, the heigher λ_e/λ_i value tends to be required to maintain the original ripples, and RC develop with the smaller λ_e/λ_i value (Figs. 2b and c); however, in the present report, it's not known exactly why.

It is found that the development of RC and RR depended on sediment grain diameter (Fig. 2); RC did not form in the series of experiment with the finer sediment (Fig. 2a), and the RR did not occur with the coarser sediment (Fig. 2c). This may attributed to the heigher respondency of finer suspended sediment grains to the slightest fluid motion. Sekiguchi and Sunamura (2005) showed that RC developed with the coarser sediment when the vortices over offshore-dipped flanks of ripples was weak and flattened under asymmetric flow field, and the vortices could not move sediment grains on and suspended over the offshore flank. When the sediment was finer, the weak offshore vortices could move the sediment grains and secondary crest could develop in place of RC. Sekiguchi (2009) suggested that the development of RR caused by the three dimensonality in fluid motion due to interaction between preexisting ripples and oscillatory flow. The coarser sediment grains may not sufficiently respond to the fluid motion perpendicular to wave propagetioin, and this would hinder the formation of regularly patterned RR.

Conclusions

The total dataset of Sekiguchi (2003, 2009) and Sekiguchi and Sunamura (2004, 2005) are summarized and analyzed based on Sekiguchi's (2011) concept. The analysis suggested that:

1. Ripples sensitively respond to the decrease in λ_e/λ_i value, but are relatively insensitive to its increase.
2. The respondency of sediment grains to

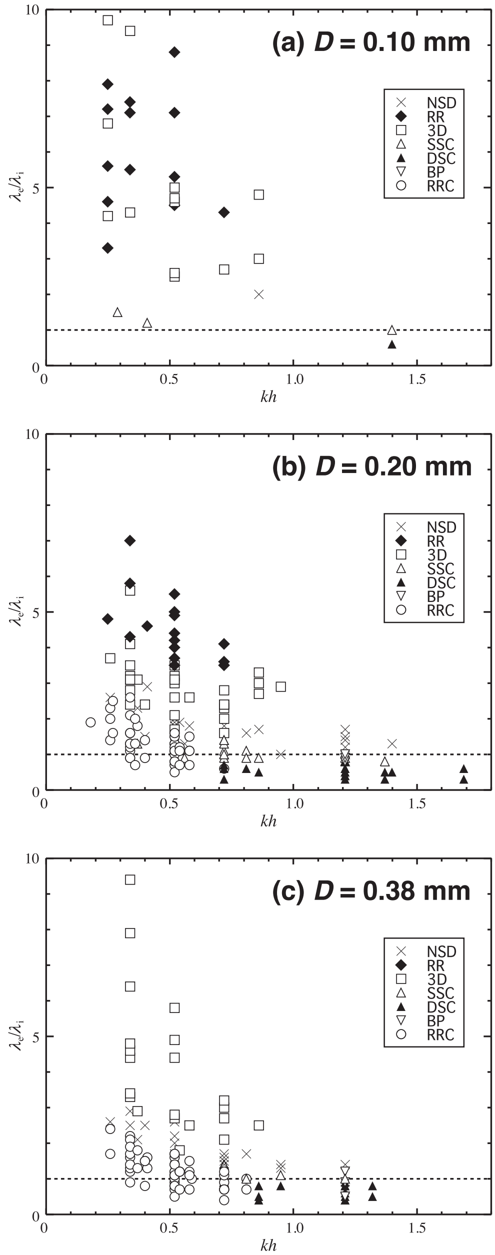

Fig. 2 The relationship between *kh* and λ_e/λ_i for the occurrence of distinctive transient ripples: (a) D = 0.10 mm, (b) D = 0.20 mm, and (c) D = 0.38 mm.

slight fluid motion may affect the formation of distinctive transient ripples.

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