**EFFECT OF GRAIN SHAPE ON BEDLOAD TRANSPORT OF CORAL GRAVELS UNDER TURBULENT FLOW**

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INTRODUCTION

Coral islands with low-lying accumulations of wave-deposited carbonate bioclasts are suffering significant erosion and flooding threats due to sea level rise and wave climate changes. Properties of coral gravels are distinct from natural quartz sands in its larger skeletal porosity and more irregular shape (de Kruijf et al., 2021). This study aims to investigate how the particle shape affects bedload transport process of coral gravels under turbulent flow by means of laboratory experiments, which can provide insights for better predictive skills of morphology change of coral islands.

METHODOLOGY

Particle shape measurements and settling velocity experiments were conducted, respectively, using coral gravel samples collected from Okinawa Prefecture, Japan. Morphological parameters and settling velocity of studied particles were obtained by digital image processing algorithms.

Bedload transport experiments of coral gravels under steady turbulent flow were performed in an oscillatory flow tunnel, which consisted of a loop-shape closed conduit. A 10 cm thick coral gravel bed with grain size of 3.93 mm in median diameter and a density of 2.37 g/cm3 was situated along the test section. Net bedload transport rate was obtained by the following procedures. A separator was placed at the middle of the test section, and the total weight of dry coral gravels were measured respectively on both sides of the separator. Steady flow was generated after the removal of the separator. After each test, the separator was placed again and the wet coral gravels on both sides were separately collected. At last, the wet coral gravels on both sides were separately dried in the oven for at least 12 hours, and the net bedload transport rate can be determined as the mass difference between the two parts before and after each test.

RESULTS AND DISCUSSION

Various shape parameters of coral gravels were obtained. It was found that the ratio of long and short diameters of the coral grain was clearly larger than that of natural quartz sand grains. Based on the drag coefficient of smooth spheres $C\_{d, s},$ a correlation law between the dimensionless particle diameter $d\_{\*}$, defined as $d\_{\*}=(∆g/ν^{2})^{1/3}d$, and $αC\_{d, s }^{1/3}Re\_{p}^{β}Ψ^{γ}$ for coral gravel particles was established (Figure 1) by introducing a particle shape parameter $Ψ$, defined as the ratio of sphericity and circularity, where $∆$ is the sediment relative density, $g$ is the gravitational acceleration, $ν$ is kinematic viscosity of fluid, $d$ is particle diameter, $Re\_{p}$ is the particle Reynolds number,$ α$ , $β$ and $γ$ are fitting parameters. The correlation among $d\_{\*}$, drag coefficient, and $Re\_{p}$ was significantly improved by introducing the shape factor.

Based on the correlation law shown in Figure 1, the drag coefficient of coral gravels was modified. The modified drag coefficient was then applied to a newly developed bedload transport formula for coral gravels with various shapes (Figure 2). Besides drag coefficient, here the modified static friction coefficient obtained by the angle of repose experiments, were also used. The developed formula showed more accurate predictions of bedload transport of coral gravels than other common bedload transport formulae.



Figure 1 – Correlation law plot between $αC\_{d, sphere}^{1/3}Re\_{p}^{β}Ψ^{γ}$ and $d\_{\*}$ for coral gravels.



Figure 2 – Development of a new bedload transport equation considering shape effects ($θ$: Shields parameter, $θ\_{cr}$: critical Shields parameter, $C\_{\*}$ and $μ\_{\*}$ are dimensionless shape-dependent drag and static friction coefficient, respectively).

REFERENCES

de Kruijf, M., Slootman, A., de Boer, R.A. and Reijmer, J.J. (2021): On the settling of marine carbonate grains: Review and challenges. Earth-Science Reviews, 217, p.103532.