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# Some flume experiments on large grains but little denser than the transporting fluid, and their implications †

by

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## Correspondence

**Mr T. H. F. Nevins** of the Soil Conservation and Rivers Control Council, New Zealand, stated that the Paper carried the Author's investigations into the transportation of solids by fluids over the full range of density differences. Starting with desert sands in air, and proceeding to quartz grains in water, he had now reached the other end of the scale where the specific gravity of the solids approached that of the transporting fluid. The next phase was to apply that fundamental research to practical problems.

There was a copious literature on the behaviour of rivers flowing in silt but little was known of what happened to the beds of shingle rivers during floods. Velocities of about 10 to 20 ft/sec, and the size of the material forming the bed load, made observations at such times extremely difficult. Conditions probably lay between the Author's two sets of experiments on which he had presented Papers.[9, 10] During floods a suspended load of silt and sand was carried by water flowing on top of a denser fluid composed of shingle and water. It was the study of the behaviour of the denser fluid to which the present Paper gave a clue. The whole bed of a shingle river could move as a high density fluid, but the movement was over limited lengths at any one time, and little was known of the mechanics of the phenomenon.

The problem was of considerable interest in New Zealand where, because of the hardness of the rocks forming the mountain backbones of both islands and the short lengths of the rivers, the shingle phase occupied a position of greater economic importance than in Continental countries.

† Proc. Instn Civ. Engrs, Part III, vol. 4, p. 174 (Apr. 1955).

[9] The Paper under consideration, Proc. Instn Civ. Engrs, Pt III, vol. 4, p. 174 (Apr. 1955).

[10] R. A. Bagnold, " Beach Formation by Waves : Some Model Experiments in a Wave Tank." J. Instn Civ. Engrs, vol. 15, p. 27 (Nov. 1940).

A gauging had recently been made in the Waimakariri Gorge during a moderate flood. A propeller-type meter was used with a 100-lb. weight, suspended by a gauging crane from a high single-span bridge. Maximum velocity of the silt-charged water was 15·8 ft/sec but the bottom 6 ft of flow was a very different fluid. In the upper layer of turbid water the gauging proceeded normally but, as the meter was lowered through the high-density fluid, it gradually lost weight until, near the bottom, the only sensation was the drag of the current. Maximum velocity in that fluid was 12·0 ft/sec. On raising the meter the pull of gravity progressively increased and the surface of the dense liquid was clearly indicated by a sudden snatch. That was more apparent when raising the meter than when lowering it. Observations were made at a number of verticals all of which showed corresponding phenomena. Discharge at time of gauging was 23,600 cusecs, but flows from 1,220 to 150,000 cusecs had occurred.

That was the first observation it had been possible to make of the condition in New Zealand, and no sediment samples were taken. It was intended to make more and fuller observations in future. As a matter of interest, the edges of the propeller blades after the gauging had a slightly hammered appearance but the surfaces of the blades and of the streamlined weight were unmarked.

**The Author,** in reply, said it was possible that an answer to Mr Nevins's interesting problem was to be found at the end of one of the Author's previous Papers.[4] Therein, under the heading "Flowing gravel," the Author quoted a first-hand description given to him by Professor K. Terzaghi of a river of gravel without any overlying liquid at all which had flowed at near walking pace and at a slope of only a few degrees. The Author then showed how such a flow was possible and how its details could be calculated from the new experimental information reported in the Paper.[4] The data needed were the size and density of the gravel or shingle grains, and the density and viscosity of the intergranular fluid (supposed to be mud or water-dispersed silt).

The necessary assumption had to be made that the concentration of the shingle grains was constant with depth. That appeared to be true if the flow of the grains was maintained mostly by gravity components acting directly on the grains and on their intergranular fluid. If, on the other hand, the grain flow was maintained mostly by a shear stress applied from above, as was the usual case in rivers of gentle gradient, the grains became dispersed upwards and their concentration dwindled progressively with height above the final bed.

The water depth above the flowing shingle was not stated. From the evidence of a sharply defined interface it seemed likely that the shear stress applied by the water to the top of the shingle layer below did not much exceed that applied by the shingle layer and its contained fluid to the final bed. If so, the flow of the shingle could be calculated approximately by introducing the effect of the overlying water as a constant additive shear stress.

Observations under the conditions Mr Nevins described must obviously be very difficult. But it seemed important to get samples of the bed material which were sufficiently intact to enable not only the densities to be found but also the viscosity of the intergranular fluid as it existed when the shingle was flowing.