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Experimental investigation of the suspended load deposition on the paddy field during the fluvial inundation

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Introduction

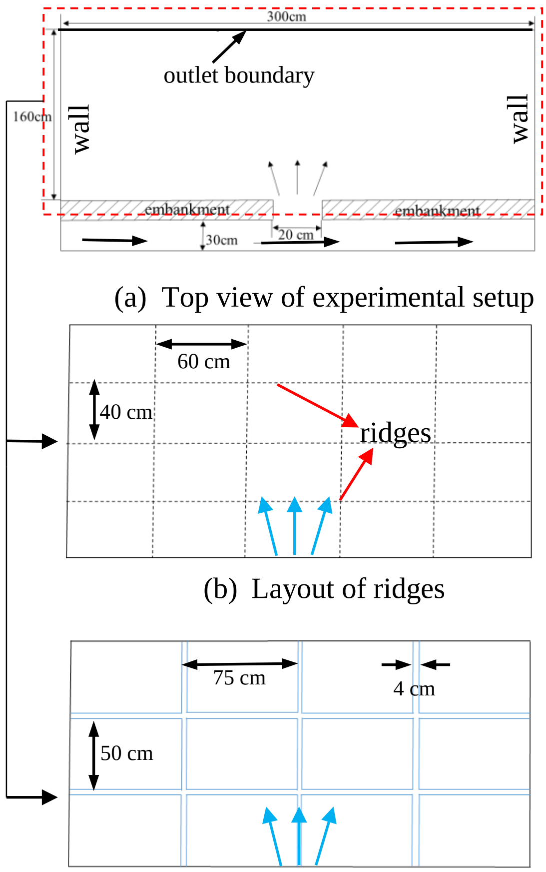
In the fluvial inundation, the huge quantity of sediment would be transported and deposited in the downstream area and cause serious problem to local people. The problem of sedimentation is especially critical for paddy field, on the one hand, if the sediment cannot be removed timely, the harvest in the few years would be influenced. On the other hand, the deposition occurred in the channel network would decrease the drainage capacity, it would make the inundation more serious. In this research, to better understand the mechanism of suspended deposition on the paddy field during the fluvial inundation and give appropriate countermeasures, a series of physical experiments were conducted. Besides, the collected data could be used for the numerical model verification.

Methodology

The experiments were conducted in the Ujigawa Open Laboratory, Kyoto University. The experimental setup consists of a channel (15 cm wide), embankment and an inundation platform (160 cm wide and 300 cm long), a breach of 20cm width was set on the embankment to connect the channel and inundation platform. There are 3 groups of experiments. In group 1 and 2, we investigated the influence of paddy ridges and channel network on the sedimentation, respectively. Through changing the downstream boundary condition and the channel outlets, 3 cases of experiment were conducted in each group. In group 3, paddy ridges and channels were jointly implemented. Besides, to save time, we decreased the scale of experimental setup in group 3. A constant water discharge of 2 L/s was given as the inlet boundary condition, a sediment feed over the inlet boundary supplied 1g of uniform sediment with a diameter of 0.01cm into the water per second. Fig.1 shows the layout of experimental setup.

Results

Fig.2 shows the results of 3 cases of group 1. The ridges were implemented in cases 2 and 3. The downstream boundary was a wall with 4.5cm height in cases 1 and 2, but it's open boundary in case 3. It's found that in both cases 1 and 2, most of sediment deposition was along the centerline and the downstream boundary of the platform. However, the deposition results were different in the vicinity of the ridges due to the three dimensional flow characteristics. From the figure we can see that the deposition didn't occur at the front side and downstream area of the ridges, but at the back side area. But for case 3, because of the open downstream boundary, the bed shear stress was very high near the inlet boundary, it caused most of sediment was transported downstream.



(a) Top view of experimental setup

(b) Layout of ridges

(c) Layout of channels

Fig.1 Plan view of the experimental setup

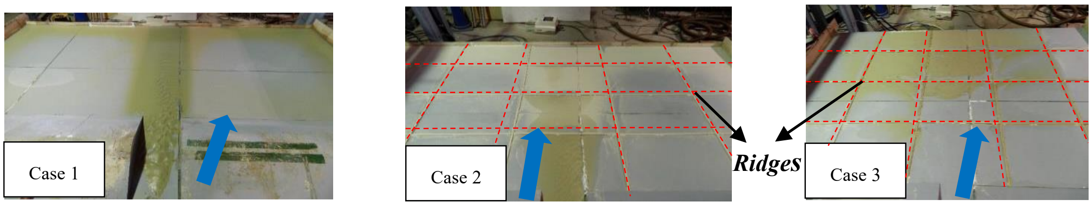


Fig.2 Deposition results of cases 1, 2 and 3

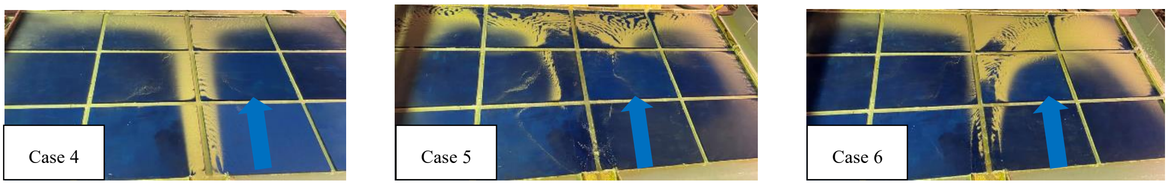


Fig.3 Deposition results of cases 4, 5 and 6

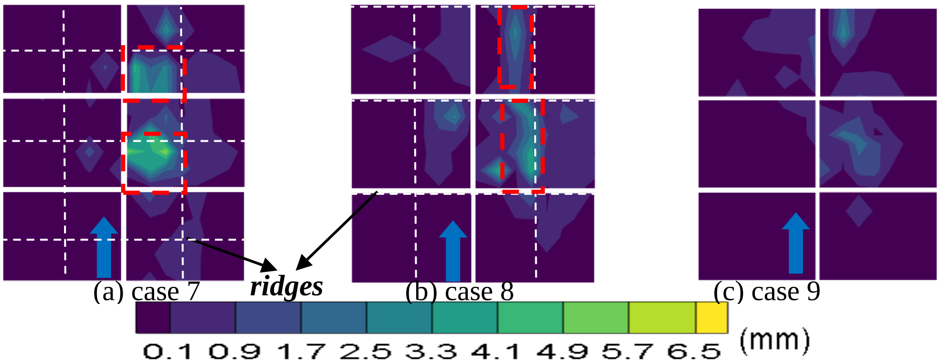


Fig.4 Deposition thickness distribution of cases 7, 8 and 9

Fig.3 shows the results of group 2. In case 4, all the outlets were closed, and in cases 5 and 6, the outlets on the downstream boundary and right side wall were open, respectively. From the figures, the operation of outlets could effectively change the flow direction and the deposition results. In case 4, because all the channel outlets were closed, the results presented similar patter with that in case 1; But in case 5 and 6, due to the outlets operation, the results were entirely different. It's obvious that the main flow direction diverse to the right side and the most of sediment deposited along the main flow path in case 6. In the experiment, serious deposition in the channels was observed. The results reflect that, in the channel, the highest deposition thickness occurred at the point that main flow pass.

Fig.4 shows the deposition thickness distribution on the land surface of each case of group 3. As the indication in the figure, the difference between cases 7, 8 and 9 is the location of ridges. From the figures, the paddy ridges could effectively change the sedimentation distribution on the land surface. In case 7, most of deposition occurred in the upstream area of the ridges, but the sedimentation in case 8 was along the ridges. However, the experimental data show that the total quantity of deposition of case 7 and 8 were similar (1.92kg of case 7 and 1.74kg of case 8, respectively), much larger than that of case 9 (0.91kg). Another phenomenon is that, in case 8, the maximum deposition thickness in channel significantly lower than that in cases 7 and 9 (7.56 mm of case 8 to 15.96 mm of case 7 and 12.19 mm of case 9). It because that the paddy ridges were located near the channels and decreased the bed load transportation from land surface to channels.

Conclusion

From the experiments, the sedimentation results are tightly related to the water depth and flow velocity field; Under high water depth scenario, the influence of ridges was only limited to its surrounding area, but in the small water depth cases, because bed load transportation plays an important role, the ridges could remarkably change the deposition results; The operation of channels outlets could effectively change the flow velocity and the deposition distribution; The blockage in the channels was mainly caused by bed load transportation, setting the ridges at the upstream side of channels could significantly relive it.