HUE CITY HUONG RIVER FLOOD IN 1999

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ABSTRUCT

It is said that in 1999 flood of Huong River the water depth became about 2m in the downtown of Hue city and about 3000 people fell victims, and that a sudden rising of the water level at see side made damage serious. In 2006 we measured the maximum water level H of the flood and also 2006 flood along the river. The data suggest an odd behaviors of the flood caused the sudden rising, and a remedy is proposed.

KYEWORDS Flood, 1999, Hue City, Huong River

MEASUREMENTS OF H FOR 1999 AND 2006 FLOODS

We got H of the two floods from A to S points shown in Fig.1 from interviewing the local people. Since we used a simple measuring tape, we obtained the data only at such points as shown right-upper of the Fig.2, thus we could not get enough data where no relevant house locates. 1999 data at point B in the Fig.2 shows the height of the roof of the building located there, because the H became higher than the roof height. The tidal fluctuations during the observation(from 13^{th} to 17^{th} October 2006) were within 10cm at the pier near the point G. The range of their variations was so small and the flow was so weak, we regard the water heights as see level for A-S during the observational period.

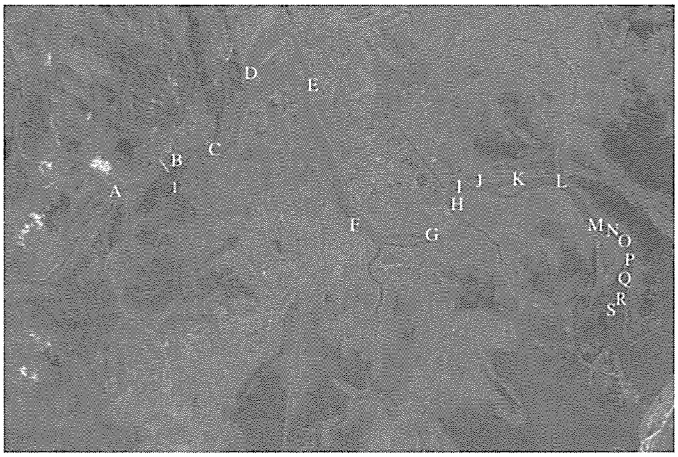

Fig.1 Measuring points of H

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i, the slope of H, for A-C is very steep. This may be caused by the narrow channel for the mountainous region, and at the point A, H may be raised due to the joining of Ta- and Hu-Trach rivers. The sudden decrease of i around the point C for both floods causes the sand-deposition due to the decrease of the tractive force; much sand is gathered there.

The following two singular surface variation are seen in the downstream reach:

a. In 1999 between G and I H are even and i between I and J becomes very steep.

b. Around the points M or N unusual humps were observed.

Tidal waves cannot explain such humps, because they are almost flat. As to 1999 flood the local people at point M said that a big swell came upstream from the see side, and the flood wave came

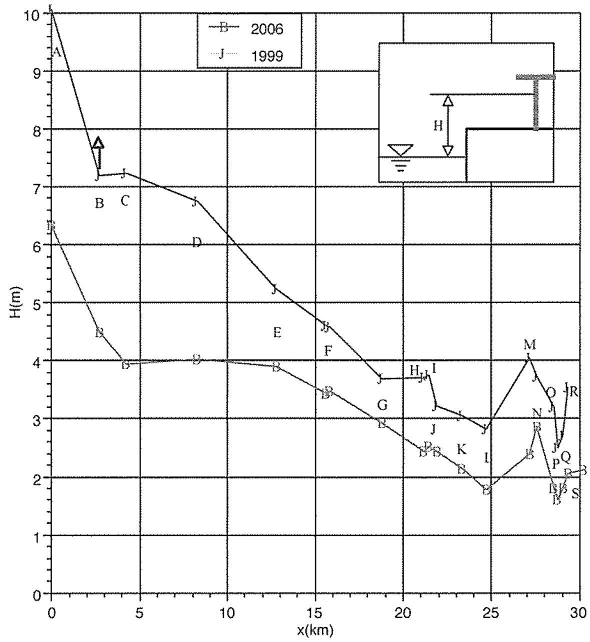

Fig.2 H observed

down from the upstream; they collided. They said that the wave speed was very first, suggesting the hump to be some kind of bore. In this report we will analyze this phenomena.

ESTIMATES OF DISCHARGE IN 1999 FLOOD

At the cross lines in Fig-1 and 3, the cross sections were observed using a GPS instrument and a depth meter. Using the area of the cross sections A and the width B in Fig.4, we define the mean depth h by $h = A/B$, and the total depth h_T by $h_T = h + H$. Since the channel in the reach A-B is rather narrow, assuming a simple rectangular cross section we will estimate the peak discharge

$Q_p$at the cross section No.1 located near the point B. It is not so good point to estimate i as mentioned above, so we simply take the difference of H between A and C, and we applied i=1/1430 for the cross section No.1.

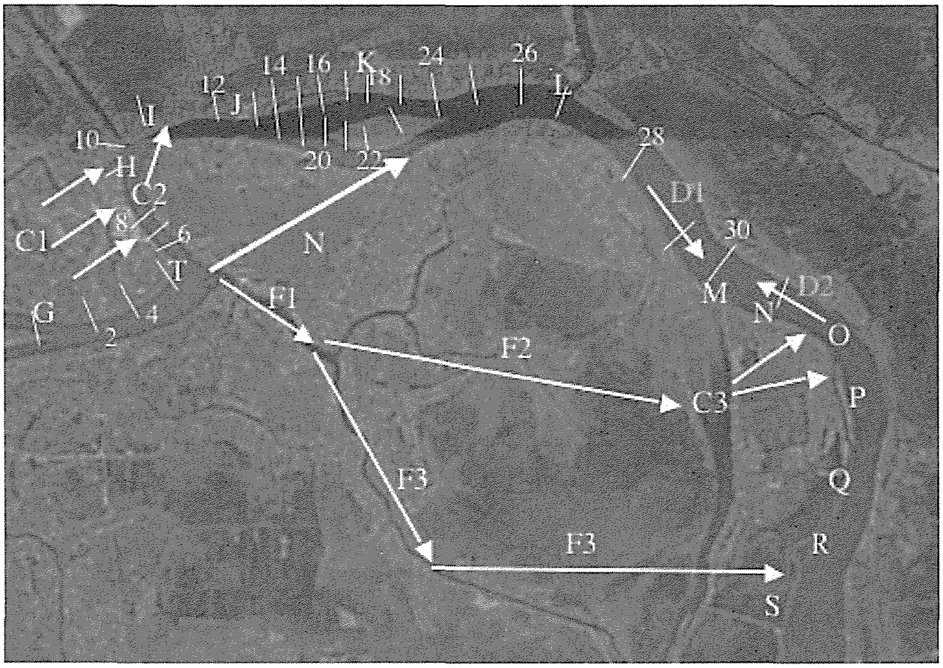

Fig.3 Cross sections observed

The roughness of the river beds strongly dependents on sand waves formed on the river beds. Among them the most probable ones are dunes and alternating bars. Kuroki-Kishi's theory(1) is frequently used to judge what kind of sand waves grow using parameter $\chi = B/h \cdot i^{0.2}$. In the case of Huong Rive if $\chi < 7$ dunes will grow; $\chi > 7$ alternating bars. From Fig.4 and 1, we obtain $A = 660m^3$, $B = 250m$ and $H = 8m$ then $h_T \approx 10.6m$, and $\chi \approx 5.5$. Hence dunes will occur, which are divided into 2 types(2).

$$\frac{i}{s} \leq 0.02\left(\frac{h}{d}\right)^{-1/2} \rightarrow \text{dune1}, \quad \frac{i}{s} > 0.02\left(\frac{h}{d}\right)^{-1/2} \rightarrow \text{dune2}.$$

Assuming specific weight of the sand $s = 1.65$ and the diameter $d = 0.3mm$, we obtain

$$\frac{i}{s} \approx 4.2 \cdot 10^{-4} \quad > \quad 1.7 \cdot 10^{-6} \approx 0.02\left(\frac{h}{d}\right)^{-1/2}.$$

This suggests to grow Dune 2, and $\varphi_0 = v/u_*$ (v:mean velocity, u_*:frictional velocity) becomes 8.9, which gives the following estimate: $v = 8.9u_*$, $u_* = \sqrt{ghi} =$ $0.27m/sec$ (g:acceleration of the gravity), $v = 2.4m/sec$, or

$$Q_p = vBh = 2.4 \times 250 \times 11 = 6600 m^3/sec.$$

Since we assumed a simple cross section, it may be $Q_p \geq 6600 m^3/sec$.

Next we estimate the discharge Q_{13} that of the cross section No.13. Applying $i \approx 1/8300$, $A = 1050m^2$, $B = 210m^2$, $\bar{h} = 5m$, $H = 2.6m$, $h_T = 7.6m$ from the data observed, we obtain $B/h \cdot i^{0.2} = 4.5$; sand wave may also be dunes. Then

$$\frac{i}{s} \approx 7.3 \cdot 10^{-5} \quad < \quad 1.3 \cdot 10^{-4} \approx 0.02\left(\frac{h}{d}\right)^{-1/2}$$

suggests dune1, and φ_0 is estimated as

$$\varphi_0 = 2.4\left(\frac{h_T}{d}\right)^{1/6} \tau_*^{-1/3} = 2.4\left(\frac{h_T}{d}\right)^{-1/6}\left(\frac{i}{s}\right)^{-1/3} \approx 11.$$

Thus we obtain $v = 11 \cdot \sqrt{9.8 \cdot 7.6/8300} = 1.0m/sec$;

$$Q_{13} = 1.0 \times 210 \times 7.6 = 1600 m^3/sec.$$

Now, we estimate the flood discharge as $Q_F \geq 5000 m^3/sec$.

ANALYSYS OF THE FLOOD

In the flood flows sometimes "cross flow effect(CFE)" takes place when flood flows return to the river in nearly normal angle to the channel. They decrease river flow speeds due to the inflow of the low momentum fluid of flood plane. In Rumoi river flood in Japan we observed that it took about 4 hours to flow down only 0.5km; usually it may be less than 10 minuits, see Fig.5. The geometry is very similar to the reach from G to J. High H due to the storage of the flood fluid at the upstream side caused the very high speed flow downstream side.

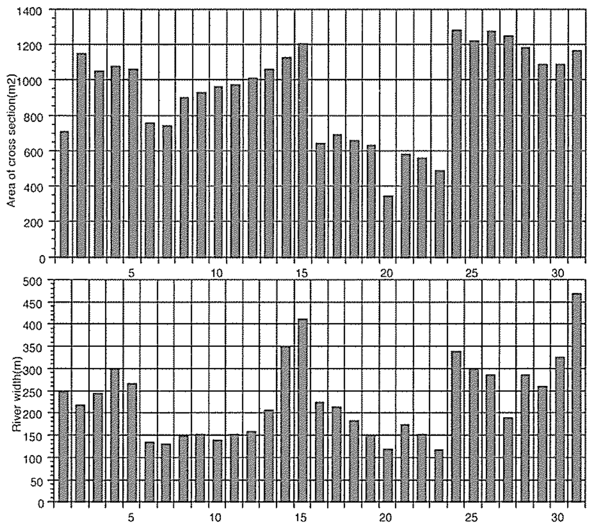

Fig.4 Area and width of the cross section

We consider three ECFs for both floods. The first CFE is C1, and the second is C2 in Fig.3. The local people near the point H said that the C2 flowed with very high velocity. For 2006 flood we observed the lean of grass at the right bank of the cross section 7, showing the occurrence of a similar flow with C2 also for 2006 flood. C1 will make the speed of flows between T—I low and C2 will works as a stopper for the flow between H—I. These effect are suggested from H-profiles between G and J (Fig.2). Such CFE may almost cease the flow between T-I for a while. The third CFE is supposed as the flow F1→F2→C3(the root F1→F3 is also possible). This flow must be very strong because of more than 3000 victims. An example of a simple calculation suggests a terrible flood flow has occurred there:

$$Q_F = \text{width } 2000\text{m} \times \text{depth } 1.6\text{m} \times \text{velocity } 1.6\text{m/sec.}$$

We think that at least the same order flood flow went into the downstream of the point M and caused the bore like flow. On the other hand the storage between G-I might reach a limit and release them to downstream, which caused the collision with high H observed by the local people.

To improve such situation it is effective to open the channel like N in Fig.3. As seen in Fig.4, the width B from the cross section 6 to 14 are narrow, but the depth h are not shallow. For such cross sections we suppose that full mixing will occur, and CFE of C1 and C2 are strengthen. Since along the both river side of this reach many people live, it is difficult to expand the channel width. Therefore, we think that the construction of such channel is effective.

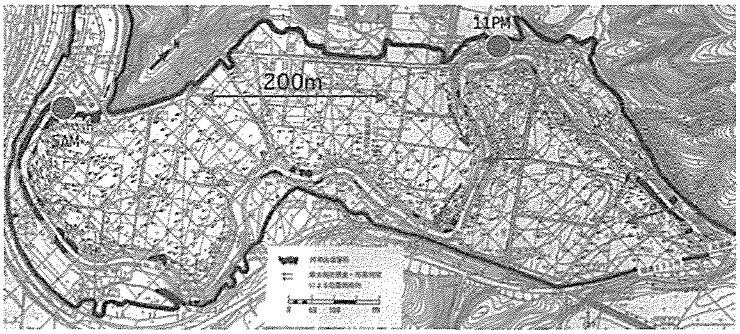

Fig.5 Rumoi Flood in 1988

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