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40. *The Roughness Coefficient in a Town Area Observed in the Case of the Kanto Flood of Sept. 1947.*

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At midnight on Sept. 15, 1947, the Kanto and Tohoku districts of Japan were attacked by a destructive typhoon which was accompanied by heavy rainfall. As a result of this typhoon, several banks of the Tone and Arakawa rivers were damaged. At 2 h 20 m, Sept. 19, 1947, the Sakura Bank of the Edogawa river was damaged and Katsushika-ku and Edogawa-ku, the eastern part of Tokyo, were washed away by a flood as shown in Fig. 1.

Soon after the occurrence of the flood damage, the Geographical Survey Institute of the Ministry of Construction[1] surveyed in detail this area of inundation.

Based on the provisional report of the investigation, the water velocity and roughness coefficient of the flooded area were calculated in the present paper. In particular, a contrast of the roughness coefficients between the town area and the open field are discussed.

The flood is treated as a non-uniform flow in an open channel. As shown in Fig. 1, the flooded area was cut at every 1 km along the main flow and the vertical sections of the floods perpendicular to the flow direction were sought as shown in Fig. 2.

Fig. 3 shows a profile along the main flow of the flood, in which the mean inclination of the water surface i becomes approximately 2.6×10^{-4}. The hydraulic formulas of Chézy and Forchheimer are usually employed for the estimation of the velocity of water. According to Chézy, the velocity of water is given by a formula as follows:

$$v=C\sqrt{Ri}\ ,$$

where $R=A/S$ (A is the sectional area of the water channel and S the length of the wet periphery) which, in this case, approximately corresponds to the inundation height h above the ground. Making use of

1) GEOGRAPHICAL SURVEY INSTITUTE, "Report of the Floods along the Tone and Arakawa Rivers of Sept. 1947," *Provisional Rep.*, Dec. 1947, (in Japanese).

the observed arrival time of the flood front and the time variation of the inundation height as shown in Fig. 3, the water velocity in each section along the main flow can be obtained with the aid of the continuity condition, and then Chézy factor C can be decided.

Next, according to Forchheimer

$$C=\frac{1}{n}R^{0.2}, \quad \text{(Unit: } m, \text{sec.)}$$

so we can obtain a variable coefficient for roughness n of the bottom

Table 1. The values at each vertical section.

Section No.	Area A (m)	The mean height h (m)	Velocity v (m/sec)	C	n
1	6800	1.53	0.44	22.1	0.049
2	2500	1.19	1.20	68.3	0.015
3	3000	1.45	1.00	51.5	0.021
4	1780	0.97	1.69	106	0.009
5	2480	1.06	1.21	73	0.015
6	2260	0.91	1.33	86.5	0.011
7	4850	1.07	0.62	37.2	0.023
8	5200	0.93	0.58	37.4	0.026
9	3900	0.76	0.77	54.5	0.017
10	2900	0.65	1.03	86	0.011
11	2660	0.67	1.13	85.5	0.011
12	2660	0.96	1.13	71.6	0.014

of the flood area as shown in Table 1. From Table 1, it may be deduced that the mean velocity of the flood along the main flow is about 1 m/sec. The velocity of water flowing through the town area is slower than that on the open field. Also the roughness coefficient on these places may be deduced as follows:

The town area: $n=0.023$,
The open field: $n=0.012$.

The roughness coefficient on the town area corresponds to a full water level at a natural river that Ganguillet-Kutter has decided.

The phenomenon of sea water overflowing the land as in case of a tsunami may be considered similar to a river flood in many respects. The roughness coefficient obtained in this paper may be used with advantage when the velocity of water overflowing the land at the time of a tsunami invasion is considered.

Fig. 1. The area of the flood and the main flow.

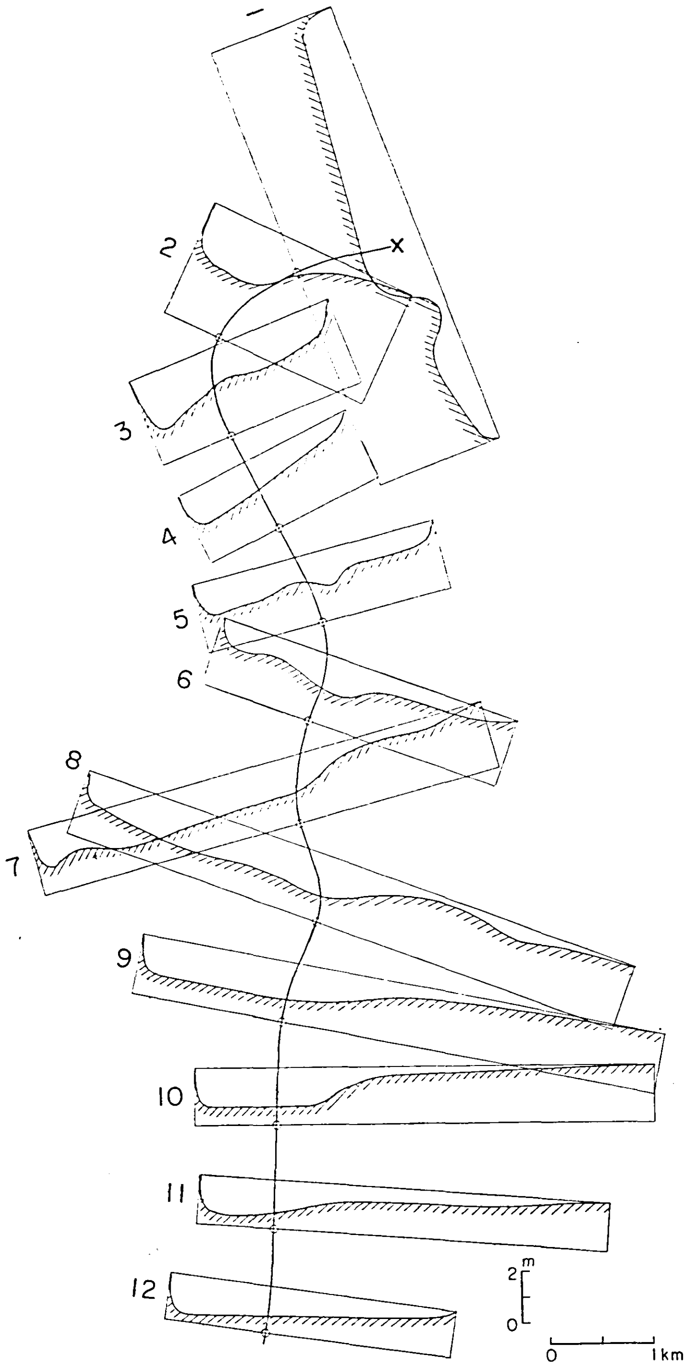

Fig. 2. Vertical sections in each 1 km along the main flow.

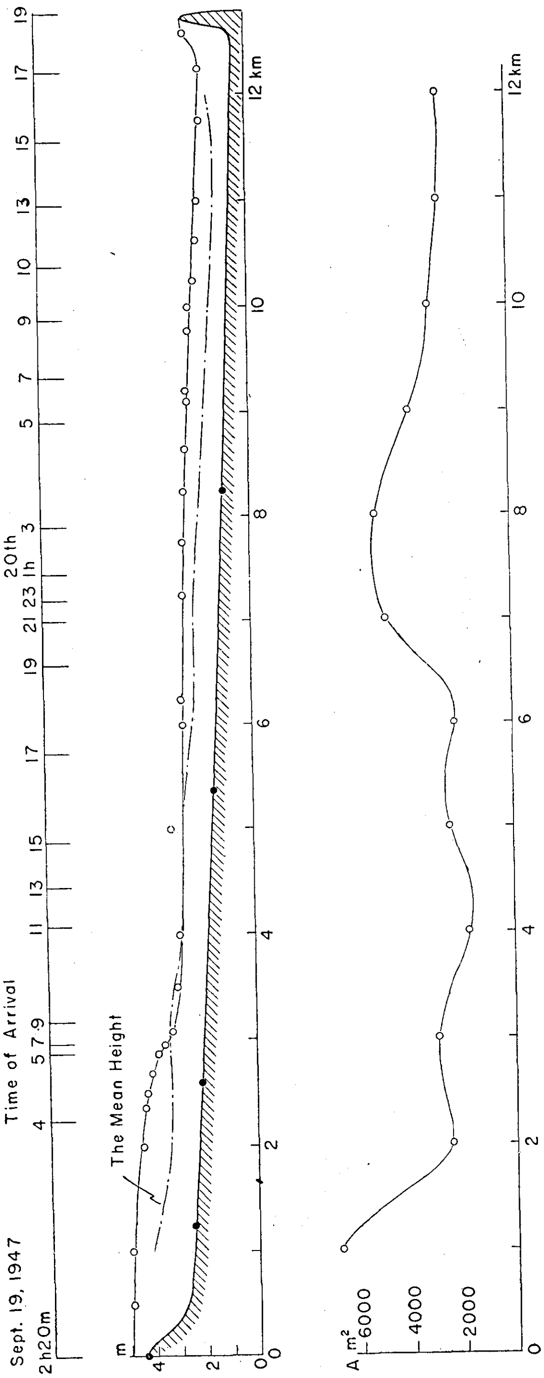

Fig. 3. Horizontal section along the main flow.

The author investigated the relation between a tsunami considered as a flood and the damage to houses caused by the tsunami.[2)]

In conclusion, the author wishes to express his hearty thanks to the Geographical Survey Institute of the Ministry of Construction for the courtesy of offering useful data. The author thanks Prof. R. Takahasi for his guidance and encouragement in the course of this study. His thanks are also due to Assist. Prof. K. Kajiura for his valuable help and advice in the preparation of the manuscript.

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40. 昭和22年9月関東洪水の市街地における粗度係数

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1947年9月15日本邦を襲つたカスリーン台風は，関東・東北各地に甚大な水害を与えたが，特に利根川および荒川の支流を含めた数個所の河川堤防が欠潰し，埼玉県および東京都の東部地域に洪水をもたらした．

建設省国土地理院（当時の地理調査所）は被災直後，洪水地域における詳細な調査を行なったが，その調査資料の内，江戸川の桜堤の欠潰によつて生じた，東京都葛飾区・江戸川区における洪水地域各所の流速および粗度係数を計算し，市街地と田畑地区との相異を考察した．

桜堤の欠潰点から江戸川区東船堀町に亘る Fig. 1 に示すような，洪水の主流に沿つて 1 km 毎に主流と直角な断面図を求めた．(Fig. 2) Fig. 3 は洪水の主流に沿つた縦断面図を示すもので，平均浸水高の勾配は図から $i=2.6\times10^{-4}$ である．

Fig. 3 に示すように，洪水は巾の広い矩形断面の開水路に流れる不等流として取扱い，Chézy の公式を応用して，流速は

$$v=C\sqrt{Ri}\ ,$$

ただし $R\fallingdotseq h$ (R: 径深，h: 平均浸水高 m)，i: 水流の勾配で表わされる．Fig. 3 に示すように洪水の到達時刻が観測されているから，これと浸水高とから連続の条件で各断面間の流量が推定され，流速が導き得る．したがつて C は上式から求まる．Table 1 に各断面における諸値を示す．

次に Forchheimer の公式

$$C=\frac{1}{n}R^{0.2}\quad (m\ \text{一秒単位})$$

を用い，主流に沿つた各点での粗度係数 n が求まり，Fig. 1 に示す地形を考察すれば

市街地　$n=0.023$
田　畑　$n=0.012$

となる．平均流速は約 1 m/sec で，市街地域で遅く田畑地域では速い．したがつて粗度係数は市街地域が田畑地域より大きく，常識的に矛盾のない結果が得られた．

洪水の現象は，陸上に溢流した津波の動向に類似した点が多く，津波の溢流速度を求めるとき，ここで得た粗度係数は一つの資料となりうるであろう．

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2) T. Hatori, "A Consideration of the Damage to Houses due to a Tsunami," will be published in *Bull. Earthq. Res. Inst.*, **41** (1963), Pt. 4.