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Characteristics of the Heavy Rainfall Disaster in Central Taiwan, July 29 to 30, 2001.

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ABSTRACT

Typhoon No.0108 (Toraji) struck central Taiwan July 29 to 30, 2001, and caused a heavy rainfall disaster. In Hualien and Nanto prefectures hourly precipitation of more than 100mm lasted 3 hours, and the total precipitation was more than 500 mm. As a result heavy debris flows occurred in many places in both prefectures, and severe flooding occurred due to both overtopping flow and bank breaches, in Nanto Prefecture. Owing these flood and sediment disasters, more than 210 persons were killed or missing and severe damage was done throughout the country. Typhoon No. 9608 (Herb) had struck this same area in July 1996, and rainfall stronger than that of the 2001 event was recorded. The damage done by typhoon No.0108, however, was greater than that done by typhoon No. 9608.

1. INTRODUCTION

Heavy rainfall that occurred in the central area of Taiwan from July 29 to 30, 2001, caused extensive damage in Nanto and Hualien prefectures and surrounding areas, and 214 persons were killed or reported missing. Because this event was one of the severest rainfall disasters in Taiwan in resent several decades, we investigated the area from Aug. 13 to 17, 2001. The characteristics of this disaster are here discussed based on our field survey findings.

2. PRECIPITATION CHARACTERISTICS

2.1 Outline

The heavy rainfall was caused by typhoon No. 0108. Typhoons usually are identified by numbers in Japan, although they have international names, assigned them by the Japan Meteorological Agency based on the table of the ESCAP/WMO Typhoon commission. Its international name was Toraji, and its Taiwanese name "桃芝" (peach turf). Here we refer to it as

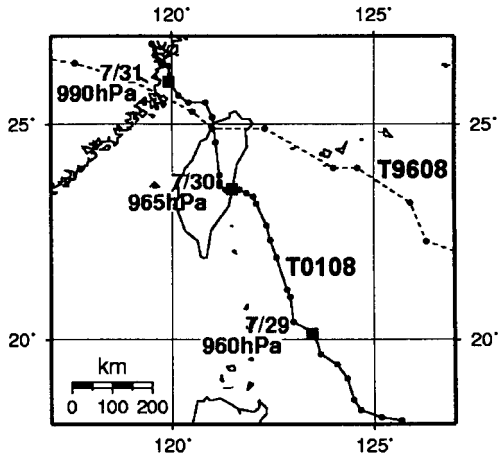

Fig. 1 The course of typhoon No.0108

Fig. 2 Isoheytal map of cumulative precipitation in Taiwan from July 29 to 31.

KEY WORDS: Typhoon No.0108 (Toraji), heavy rainfall, sediment disaster, Nanto Prefecture, Hualien Prefecture, Taiwan.

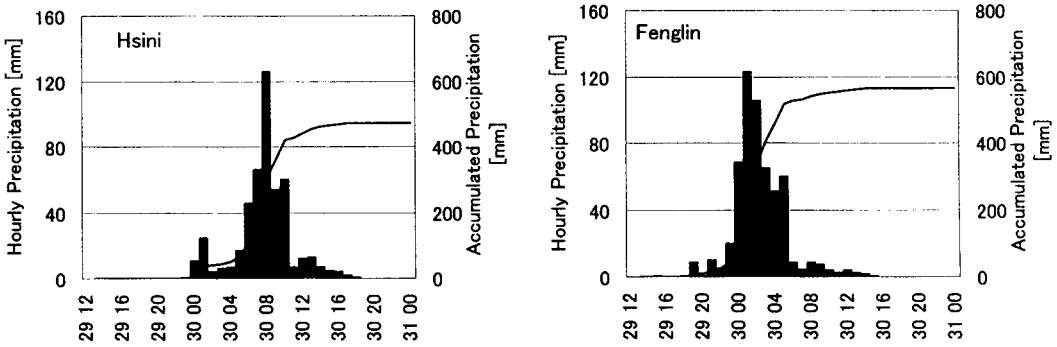

Fig. 3 Hourly and cumulative precipitation at Hsini (Nanto P.) and Fenglin (Hualien P.).

typhoon No. 0108.

It appeared in the Philippines Sea at 9 a.m., July 27, 2001 and moved north west, striking the east coast of Taiwan at 12 a.m., July 30. After crossing central Taiwan, it had changed into a tropical storm when it reached southern China at 9 a.m., July 31 (Fig.1). When the typhoon struck Taiwan, its central pressure was 965 hPa, central wind speed 35m/s, and radius of wind speeds 15m/s was 300km. This typhoon ranked as "a strong typhoon of medium size" in the classification system of the Japan Meteorological Agency.

2.2 Precipitation during the typhoon

As typhoon No. 0108 approached on July 29, rain began to fall in Taiwan, heaviest on July 30 and stopping on July 31. An isohyetal map for precipitation accumulated from July 29 to 31, based on records of surface observatories is shown in Fig. 2. The heaviest rainfall occurred in the central mountain area, the highest recorded precipitation was 758 mm at Alishan observatory (alt. 2406 m).

Heavy rainfall (100mm/h or more) lasted for about 3 hours in Hualien and Nanto prefecture in central Taiwan (Fig. 3). The 1-hour precipitation high was 149 mm (Kuangfu), and the 3-hour precipitation high 390 mm (also Kuangfu).

For several days before the typhoon's approach, there had been hardly any rain in Taiwan. Until May 2001, the precipitation recorded at Alishan was approximately the same as in a normal year, but there was very little rain after June, the accumulated precipitation from July 1st to 28 being 54% that of a normal year; i.e., there had been very little precipitation preceding the typhoon.

2.3 Comparison with normal precipitation

Normally, the western plain area of Taiwan receives little annual rainfall, whereas the north and central mountainous areas have high rainfall. (Fig.5, Taiwan Central Weather Bureau, 2001). In the central and southern areas, the rainy season is from May to September, and the difference in precipitation between the rainy and dry seasons is high (Figs. 4, 5).

Nanto Prefecture, which had heavy rain from typhoon No. 0108 is a high rainfall area in Taiwan; e.g., the highest normal monthly precipitation (September) at Alishan is 820 mm. Hualien Prefecture is a lower rainfall area than Nanto Prefecture, the normal highest monthly precipitation at Hualien City is 385 mm and

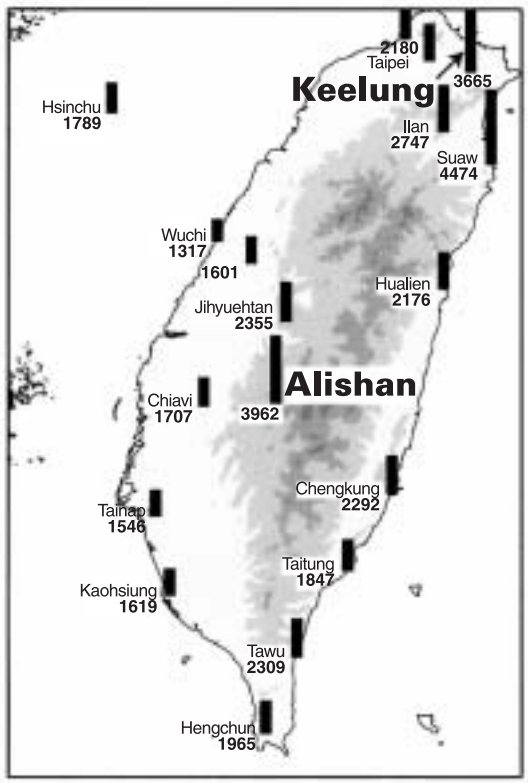

Fig. 4 Yearly mean precipitation in Taiwan, 1961 to 1990.

at Chengkung 366 mm (both, September). The highest accumulated precipitation from typhoon No. 0108 in Hualien Prefecture was 565 mm, recorded at Fenglin. The normal precipitation at Fenglin is unknown, but the normal precipitation at Hualien City can be assumed to be similar because of their being in proximity and having similar topographies. Given this assumption, the recorded 3-day precipitation (565 mm) is equivalent to an amount much higher than the normal highest monthly precipitation.

2.4 Comparison with recent heavy rainfall events

The highest 2-day precipitation at Alishan per month from 1997 to 2001 is shown in Fig. 6. Each year there have been a few 300mm or more 2-day precipitations recorded, but no event comparable to the heavy rainfall of July 29-30 had occurred in the pre-

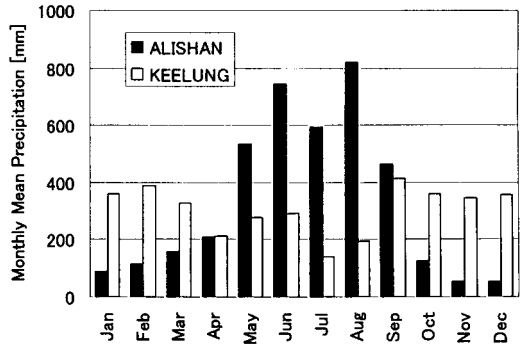

Fig. 5 Monthly mean precipitation at Alishan and Keelung, 1961 to 1990.

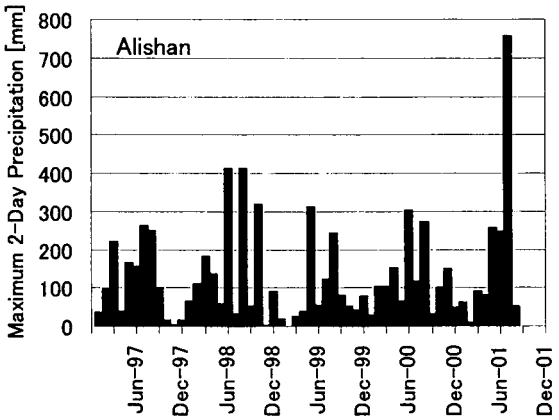

Fig. 6 Monthly highest 2-day precipitation at Alishan, Jan. 1997 througho Aug. 2001.

Table 1 Comparison of Typhoons No.9608 and 0108

	No.9608(Harb)	No.0108(Toraji)
Scale		
Central pressure	930hPa	965hPa
Highest wind speed	53m/s	35m/s
Precipitation		
Rainfall period	1996/7/30～8/2	2001/7/29～7/31
Highest cumulative precipitation	1994mm(Alishan)	757mm(Alishan)
Highest 24-hour precipitation	1746mm(Alishan)	715mm(Alishan *1)
Highest 1-hour precipitation	113mm(Alishan)	147mm(Kuangfu)
Damage		
Killed and missing persons	73	214
Ruined and Half- ruined buildings	1383	1611(*2)
Locations closed to traffic due to road destruction	101	111
Disconnect of phone	205,000	71,000(7/31)

*1 Daily precipitation on July 30, 2001.
*2 Nanto and Hualien prefectures only.

vious five years.

The heavy rainfall that fell in Taiwan July 30 to August 1, 1996 as a result of typhoon No. 9608 (Herb) is recognized as one of the heaviest rainfalls in recent history (Hydrotech Research Institute, National Taiwan University, 1997). That heavy rainfall also was concentrated in the central mountainous area. The highest accumulated precipitation over 3 days was 1994 mm, and the highest 24-hour precipitation 1748 mm, both recorded at Alishan. Moreover, a precipitation rate of 80 mm or more per hour continued for 12 hours. The heavy rainfall area was more extensive than in typhoon No.0108. For that typhoon, the area with accumulated precipitation of 600 mm or more was about 150 km^2, whereas for typhoon No. 9608, it was about 400 km^2. The 24-hour precipitation of 1748 mm recorded at Alishan in 1996 approached the highest rainfall recorded anywhere in the world. Although while typhoon No. 0108 was indeed produced heavy rainfall, it is clear that a typhoon with much higher rainfall rates had been documented several years previously (Table 1).

Table 2 Human casualties

Prefecture (city)	Number of persons		
	dead	missing	injured
Hualien	31	16	16
Nanto	39	80	172
Changhua	8	1	
Taichung	13	4	1
Taichung (city)	5	2	
Chiayi		2	
Yunlin	1	1	
Miaoli	6	5	
Total	103	111	189

3. DAMAGE CHARACTERISTICS

3.1 Damage Outline

The heavy rainfall on 29 to 30 July triggered many flood and sediment disasters throughout Taiwan. The number of dead and missing persons was more than 210. Table 2 gives the number of dead and missing persons by prefecture as of 8 August 2001 ([Taiwan] National Fire Administration, 2001).

Material damage was reported throughout Taiwan (Taipei Times, 2001a) : There were 93 debris flows or landslides. Electricity was cut off to about 340,000 houses, and the water supply to about 520,000 houses was suspended. Roads were destroyed at 109 points mainly in Nanto and Hualien prefectures. The agricultural and livestock losses were estimated at NT$ 1.28 billion (as of August 2001, NT$ 1= 3.64 Japanese Yen).

3.2 Flood Disasters in Nanto Prefecture

The Choshui River, the longest river in Taiwan, rises in the Central Mountains and the Alishan Mountains and flows westward debouching in the Taiwan Channel. The design flood discharge at the river's mouth is 27,000m^3/s (Water Conservancy Bureau, Taiwan, Republic of China, 1996). This river has many tributaries, inclouding the Chingshui River. The Tungpurei River, one of its left-side tributaries upstream of The Chingshui River, overflowed its banks near the Yenping Bridge in the suburb of Chushan, Nanto Prefecture (see Fig.7). Near that overflow point, the river bank also was breached. As a result, Mujiliao Village downstream was hit by a flood and nine persons were killed or missing. Damage in the village is shown in Photo 1. This area is very near the seismic center of the 1999 Chichi earthquake (Iemura, H. et al., 2000). The river width near the Yenping Bridge is about 100m, and the estimated mean grain size in the river bed more than 50mm (visual measurement). The averaged bed slope from Yenping Bridge to the confluence of the Choshui River is 0.01 (Water Conservancy Bureau, Taiwan, Republic of China, 1996).

The Tungpurei River overflowed its left bank just upstream of the Yenping Bridge, and flood cascaded down forward Mujiliao

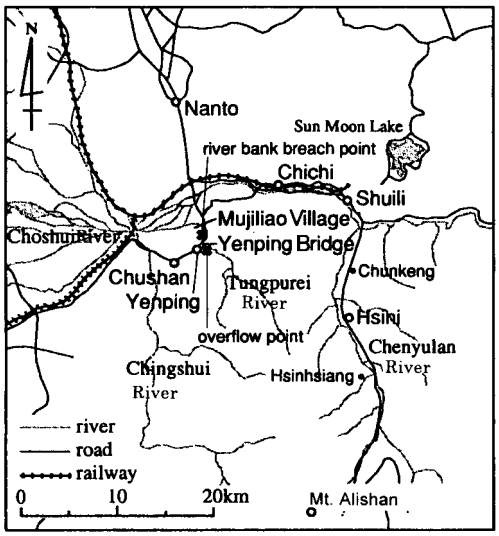

Fig.7 Locations surveyed in Nanto Prefecture

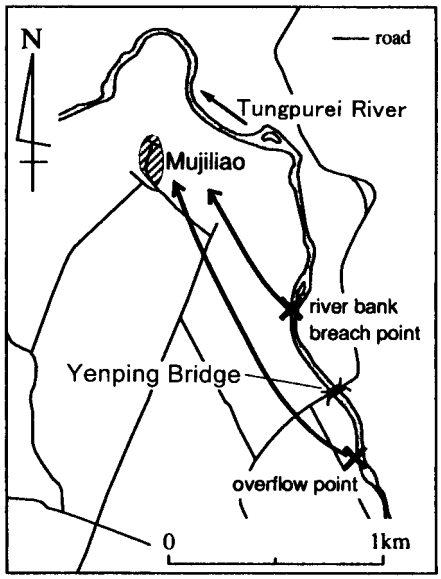

Fig.8 Inundation at the Yenping Bridge on the Tungpurei River

Photo 1: Flood damage at Mujiliao Village

Village in the low elevation area. There after, the left river bank was breached downstream of the bridge, and the flood flow battered the village (Fig.8). That is, flood flows caused by both the overflow and bank breach struck the village at separate time. According to members of the Disaster Prevention Research Center of National Cheng Kung University who accompanied us, the maximum discharge at that time amounted to more than 1,630m^3/s the 50 year return period discharge.

The causes of the overflow and bank breach are not still not clear, in the central area of Taiwan, there was heavy rainfall caused by a typhoon. Five years ago, from 30 July to 1 August 1996, at which time the total rainfall exceeded that the 2001 event. River bed elevation produced by sediment runoff in the flooding of 1996 may have facilitated the later overflow and bank breach.

In the upstream area of the Tungpurei River, rainfall intensity increased from dawn 30 July, and the highest river water stage occurred at about 8:30 on 30 July near the bank breach location. According to residents of the village, at about 7:30, those who had been informed of the high river water stage started to evacuate the village. As houses were destroyed by the flood flow just after 8:30, the lives of some of the residents may have been saved by that evacuation. Many large boulders with a maximum diameter of more than 1m were deposited along the trace of the flood flow. The flood flow carried a great deal of sediment. Moreover, the pass that the water flowed down was very narrow, indication that the flow occurred at high speed without stoppage or diffusion. In the stricken village, there was very little distance between completely destroyed houses and those that remained intact.

Our survey was made about two weeks after the flood disaster, when such temporary measures as restoration of the river bank and the dredging of sediment were being carried out. At that time, some residents still were taking refuge at the junior high school in Chushan.

3.3 Sediment Disasters in Nanto Prefecture

Heavy rainfall also occurred from dawn on July 30 along the Chenyulan River, a tributary of the Choshui River, on the west side of the Central Mountains and the Yushan Mountains in Nanto Prefecture. Consequently, many sediment disasters occurred. Heavy damage was concentrated in the area of Shuili and Hsini counties. The number of dead or missing persons was 39 in Shuili County and 51 in Hsini County.

Along the national road from Shuili to Hsini, some villages located on steep slope areas had been destroyed by debris flows. Heavy damage caused by debris and sediment flows in particular occurred at Chunkeng in Shuili County, at Hsinhsiang in Hsini County and elsewhere. Photo 2 shows Chunkeng Village after the debris flow. This photo clearly indicates the severity of the debris flow by the trace it left. In this village, the first floor of the social activities center was demolished by huge boulders. The building which, if in Japan, would be used as a refuge shelter was badly damaged by the debris flow. Further upstream, the scale of the debris and sediment flows damage was even greater, and huge boulders and large deposits of sediment could be seen in many places in Hsini County. Moreover, many roads and bridges also were damaged.

Although the cause of those sediment disasters clearly was the heavy rainfall of more than 400mm that occurred during 24 hours,

Photo 2 Result of the sediment disaster at Chunkeng Village

Fig.9 Locations surveyed in Hualien Prefecture

Photo 3 Debris left by the sediment disaster at Tashing Village

previously this area had frequently experienced heavy rainfall; heavy rainfall greater than that of 2001 event had been recorded five years before, but no severe sediment damage was reported at that time. Due to the heavy rainfall, the great volume of unstable sediment left by the Chichi earthquake of September 1999 in the mountainous area, may have moved and flowed down abruptly. The local newspaper reported that another possibility for the huge sediment yield was that betel palm plantations planted illegally in the public mountainous area may have made worsened soil conditions (Taipei Times, 2001b).

3.4 Sediment Disasters in Hualien Prefecture

Hualien Prefecture was hit by heavy rainfall during the evening of 29 July, and debris flows occurred at eight locations early in the morning of 30 July. Tashing Village in Kuangfu County and Shuiyuan in Fenglin suffered particularly heavy damage (Fig.9). Though Hualien Prefecture is famous for the production of marble, but the disasters occurred in a geological andesite zone.

At Tashing Village, the large scaled debris flow was caused by slope failure. An enormous volume of gravel and sediment yield flowed down, some of which overflowed the bank and struck houses and fields. Photo 3 shows part of destruction at Tashing Village. Forty-one persons died or were missing. About 200 houses were damaged, 16 of which were completely destroyed, and about 50 hectares of fields were buried under sediment. Maximum sediment accumulation thickness was 15m, and the total volume of sediment moved was estimated to be about 1.5 million m^3. Public officials of the Hualien prefectural government said that when removal of the sediment and driftwood was finished, they planned to make residents affected by the debris flow move to a new location.

A debris flow also took place at Shuiyuan in Fenglin. The total volume of sediment yield was estimated to be about 70 thousand m^3. Three houses were buried, one of which housed seven persons, five of whom were killed and one missing. The number of houses inundated was about 100.

4. CONCLUSION

(1) A heavy rainfall disaster occurred in the central area of Taiwan, July 29 to 30 2001, that was caused by typhoon No.0108 (Toraji).

(2) The highest accumulated precipitation for typhoon No. 0108 was 758 mm (3-day), recorded at Alishan (Nanto Prefecture, alt. 2406 m). In Hualien and Nanto prefectures an hourly precipitation of 100 mm or more continued for about 3 hours. The highest 1-hour precipitation was 149 mm, and the highest 3-hour precipitation 390 mm. There had not been much precipitation preceding the event.

(3) Nanto Prefecture is a high rainfall area in Taiwan. The highest monthly normal precipitation at Alishan (Nanto P.) is 820mm (Sept.), higher than the accumulated precipitation of the 2001 event. In contrast, the highest accumulated precipitation for typhoon No. 0108 in Hualien Prefecture was 565 mm, about 1.5 times the region's normal highest monthly precipitation. The rainfall of July 29-30, 2001 may have been very high for Hualien Prefecture but not so high for Nanto Prefecture, even though the accumulated rainfall was higher for the latter prefecture.

(4) When typhoon No. 9608 (Herb) descended on Taiwan in July 1996, rainfall higher than that for 2001 event was recorded over a wide area (the highest 3-day precipitation was 1994 mm). The damage done by the 2001 event, however, was

greater than that done by typhoon No. 9608.

(5) The heavy rainfall triggered sediment disasters in many places in Nanto and Hualien prefectures. Moreover, in Nanto Prefecture severe inundation flows caused by both overtopping and river bank breaching struck a village downstream, causing severe damage.

(6) As to the sediment disasters in Nanto Prefecture, there is the possibility that a great volume of unstable sediment left on the mountains by the Chichi earthquake of September 1999 was caused to flow down violently owing to this heavy rainfall.

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