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CONTENTS

FLOODS AND FLOOD DAMAGE IN 1950

The Bureau of Flood Control attempts here to give a rough picture of the flood damage caused in various countries, principally in Asia and the Far East, in 1950. The descriptions are based mainly on accounts of floods as given in the chief newspapers of the region.

1. BURMA

Several portions of the railway track between Mogaung and Namti stations on the Mu Valley main line were breached by heavy rains and floods in August. The local train service had to be suspended and its resumption was not expected for some time. A number of major and minor breaches were reported. The cyclonic weather and floods were responsible for blowing away a 39-span bridge near Namkhwin station. In some cases the railway tracks were submerged to a depth of three feet, an occurrence unknown in the annals of Mu Valley. Forty-eight inches of rain were reported to have fallen in the area in 48 hours - another unprecedented phenomenon. In consequence, the 1950 flooding of the Mu Valley was the most serious in living memory. Over 150 villages in Kachin State and Katha district were reported to have been submerged in chest-deep water Standing crops were totally destroyed and many head of cattle lost.

2. CHINA

Intensive rehabilitation of dikes, which protects nearly half the Chinese population on the continent, has been carried out since last year. The overall strengthening of dikes has successfully prevented the frequent occurrence of floods on practically all rivers, except on the Huai.

The total earthwork completed from 1949 to June 1950 amounted to 360 million cubic metres. As many as 4,690,000 people participated in the work and also over ten million refugees were engaged in the rehabilitation which

/formed a

formed a part of the relief programme.

The main dikes of the Pearl River (including the West, North and the East rivers) are successfully protected. The same holds for the Yangtze, though the flood level at Sha-si (the upper end of the dike system) broke all previous records. One breach is recorded on the Han River, a main tributary of the Yangtze with its junction at Hankow.

A flood patrolling force consisting of 270 thousand workers was organized for the defence of the dikes of the Yellow River during floods. The "China's Sorrow" has safely passed the flood period this year. In the North China rivers, heavy local rainfall had caused inundations along the tributaries, though the main dike was successfully maintained. The total area subject to flooding amounted to 1,133,000 hectares.

Most serious of all is the flood situation along the middle course of the Huai River. During the latter part of July, the flood level of the Huai broke all the previous records and attained a level 1 metre higher than that of 1941, which was considered as the maximum anticipated. Overtopping and breaches occurred in numerous places. Total area subject to inundation was 2-1/2 million hectares, affecting a population of 13 million.

3. INDIA

Assam

Severe flooding of the Brahmaputra River in upper Assam, following a series of earthquakes, was reported in August. The Dihang, a tributary of the Brahmaputra, burst into flood on 20 August and overtopped all barriers which had been thrown up a few days previously by an earthquake. Simultaneously the Luhit, the principal tributary of the Brahmaputra, was reported to have dried up rapidly as a result of blocking of the river by boulders and landslides in eastern Tibet above Sadyia, headquarters of the aboriginal hills district. The Deputy Commissioner had to ban fishing in the "dark, sulphurous waters" of the Brahmaputra as it swept past Gauhati. Shoals of fish were swarming the banks as if to escape suffocation. Nearly three-quarters of the town of Sibsagar in

/upper Assam

upper Assam was flooded when the bund of the nearby Dikhow River - a tributary of the Brahmaputra collapsed in three places.

Tea estates in Assam were said to have suffered considerable damage. Surface communications in the province were totally disrupted. By 20 August, 20,000 people were estimated to have been rendered homeless by the series of earthquake tremors and succeeding floods; 50,000 head of cattle were destroyed and thousands of acres of arable land were laid waste. Whole villages were completely swallowed up by the flood waters and the loss of human life, although not directly ascertainable, was described as considerable. Millions of tons of water, blocked in the upper reaches of the Dihang, which has its origin in Tibet, overwhelmed all barriers and rushed down. In Gauhatai, the Brahmaputra had a freak rise for two days, on August 16 and 17. On 20 September the Brahmaputra was reported to have risen by three feet in 48 hours. The Subansiri was also in spate again at that time.

Bihar

By 23 August the Kosi River had swept and devastated an area of about 320 square miles with a population of more than 500,000 in Darbhanga district. The paddy and maize crops were feared to have been completely lost. In money value the loss of crops and property was estimated at more than Rs. 30 million.

Knee-deep to chest-deep water flowed in more than 500 villages. An area of more than 100 square miles at Nirmali, Saharsa sub-district, was described as under chest-deep water. Nirmali is the most important trading centre on the Bihar-Nepal border. In Darbhanga district, 100 square miles were affected in Sadar sub-division, 168 square miles in Madhubani and 54 square miles in Samastipur.

This year's floods were not totally unexpected. Since 1938, when the Kosi took a sharp westward swing, eastern Darbhanga has been annually swept by floods, and each year new areas have been affected. In the Kosi belt some areas remain under water throughout the year making cultivation impossible

/Orissa

Orissa

In August about 400,000 acres were flooded when the rivers of the province were in high flood in Cuttack, Puri and Balasore districts. In the submerged areas almost the entire autumn paddy crop was completely destroyed and heavy damage was caused to the jute crop.

Patna

In the middle of August the Sone, a tributary of the Ganga, was in high flood and inundated over 100 villages on its eastern banks. On 12 August the water level of the Sone stood at 23 feet - one foot higher than the highest recorded level in 1923 - and registered a further rise of three inches the following morning. In Bhagalpur division alone about 3,000,000 maunds of maize were destroyed by heavy and untimely rain and floods, to a total value of Rs. 70 million at the prevailing prices.

United Provinces

Flood occurred in Allahabad in the middle of August when 100 houses collapsed in a surburb of the city following rainfall of seven inches in two days. Rail traffic between Lucknow, Partabgarh and Allahabad was dislocated. Allahabad's normal rainfall is 40 inches.

Over 100 villages in Gonda, 82 villages in Bahraich and 10 villages in Deoria district were affected by floods in August. The Ghagra breached the Lucknow-Colonel Ganj Road at several places. The Chitauni Dam on the Gandak River, built at a cost of Rs. 10,000, was washed away. Kharif crops were severely damaged. Floodwaters of the Ganges, Ghagra and Gomati rivers flooded over 400 villages in widely scattered parts of the United Provinces in August. The Ramganga and Rapti rivers overflowed their banks. Seven of the United Provinces' 49 districts were affected by floods.

Saurashtra

Forty-five persons were drowned and 7,000 head of cattle washed away in various parts of Saurashtra as a result of the heavy rains and floods in the second half of July. About 2,000 houses were destroyed and 3,600 damaged

/rendering 11,000

rendering 11,000 people homeless. In addition to Madhya, other areas seriously affected were Morvi, Rajkot, Bikaner, Gondal and Jetput. Rainfall ranging from six to eighteen inches was recorded in almost all parts of Saurashtra. This caused the principal rivers to rise in spate inundating low-lying areas. The extent of the damage as a result of rains and floods in Saurahstra is estimated at over Rs. 3,300,000.

West Bengal

The Ganga breached a dike near Shahebpur on the eastern bank about the middle of August and inundated an area of about 25,000 acreas of Aus paddy. The loss was estimated at 100,000 maunds of paddy.

4. JAPAN

Early in September "Typhoon Jane" which blew over Japan killed at least 250 people and rendered more than 250,000 homeless. The densely-populated Osaka-Kobe-Kyoto area received the full impact of the winds which reached a maximum of 108 miles per hour. Several cultural treasures were destroyed and official reports stated 12,000 homes were totally destroyed, 22,000 were partially destroyed and more than 170,000 were flooded.

5. PAKISTAN

Punjab

Two hundred thousand people were rendered homeless and damage estimated at over U.S.$50 million was caused by heavy rains and gales in East Punjab in September. Vast areas of the Punjab were flooded, with Lahore threatened by the rising Ravi. The floodwaters of the three great rivers of the Punjab - Chenab, Ravi and Sutleg - extended almost unbroken for hundreds of miles. The Chenab floods in Sialkot district were more threatening than those of the Ravi which, earlier, drove thousands of refugees from the countryside into Lahore. The water levels of the Chenab and Ravi near Lahore exceeded the peak points recorded in recent times.

While the Ravi level reached about 16 feet at Shahdra Bridge gauge, that of the Chenab at Khanki headworks exceeded the level recorded in 1929

/which was

which was the highest in the 50 years immediately preceding. Over 250,000 people were affected in the suburbs of Lahore which was flooded. Damage done by the Chenab and Ravi was described as "trememdous". In all the two rivers affected about 7,000 square miles.

East Pakistan

In June the Teesta River, which flows in a south-easterly direction from West Bengal into the Brahmaputra in East Pakistan, was in flood following heavy rains in the foothills region of the Himalayas. It inundated about five hundred square miles of Rangpur district in East Pakistan. The river Dharala, which flows almost parallel to the Teesta about 15 miles north of it and also joins the Brahmaputra, was also in spate causing considerable damage.

6. PHILIPPINES

Fourteen people lost their lives in floods which swept across Central Luzon for three days in the first part of August. The typhoon floods damaged or destroyed crops, roads, buildings and bridges throughout Pampanga, Tarlac and Nueva Ecija provinces.

7. THAILAND

Floods occurred in the north-east of Thailand following heavy rains on 9 September which came at the heels of a low pressure area moving in from the east coast of Indochina. Passing over the north-east and northern parts of Thailand the depression caused swelling of the M Ping in the north and the Menam Shee, Menam Moon and Menam Pasak in the north-east. The depression then continued towards the China Sea. The Me Ping broke its banks to flood Chiengmai and the surrounding districts and started the first fears of a flood in Bangkok which, however, did not materialize.

8. AUSTRALIA

By the middle of June, 10,000 people were reported to have been rendered homeless and 15 deaths had been reported from drowning in northern New South Wales where hundreds of square miles of rich farmland were turned into a vast inland sea by torrential rains. The main streets of many big provincial cities

/were flooded

were flooded, including Kempsey, which was the victim of the greatest disaster in Australian history in August 1949.

9. CANADA

Heavy floods were reported in June in western Canada. In British Columbia and the Pacific Northwest nine persons were reported drowned and more than 2,000 rendered homeless. The situation was grave in British Columbia where a state of emergency had to be declared in the town of Harrison, a hot springs resort near Vancouver. Five hundred residents were ordered to evacuate as water filled the town.

10. UNITED STATES

Seventeen people were reported drowned and 25 more were missing when 35-foot floods swept over a wide area of central West Virginia, causing damage running into millions of dollars.

/Embankments and

Embankments and Bank Protection Works of Taiwan Rivers

(Abstract of a paper prepared by Dpl. Ing. Lee-Tang Sih, Deputy Director, Bureau of Hydraulic Engineering, Taiwan, China.)

I. Introduction

The Island of Taiwan possesses a fairly large number of rivers, originating mostly from the central or Taiwan mountain range, and flowing down to the sea, either to the East or to the West.

Due to narrow drainage basins, steep slopes of rivers, the enormous amounts of sand gravel and boulders which they carry and scarcity of rainfall in the dry season against extraordinary floods during the wet season, specially in the typhoon season, all rivers in Taiwan run off rapidly and flow unchecked.

According to statistics of flood disaster for the years 1919-1942, 98 floods occurred in Taiwan during these 24 years, of which 56 were typhoon floods and 42 ordinary floods. The maximum damage in any one year before the flood control works were started was TW$12,593,917 (US$6,796,958) in 1912.

In Taiwan, therefore, no important scheme of development can be carried out, unless the flood problems of its torrential rivers have been solved.

II. General Features

Taiwan, with a total area of 35,760 sq. km., and a population of 7,398,200, consists of the Island of Taiwan (Formosa) and a group of small islands known as the Pescadores.

The Island of Taiwan proper resembles a tobacco leaf in shape and is 383 km., from north to south, and 142 km., from east to west at its broadest point. The central or Taiwan mountain range and Tzu kao, Hsin Kao Mountains, with more than 60 peaks higher than 3,000m., traverse the island from north to south dividing it into two parts, the rocky mountainous region on the east, and the wide plain on the west.

/Geologically it

Geologically it consists of schists, clay slates and some sedimentary rocks with foldings and dislocations which are fragile. Erosion is very active on account of the subtropical climate and the heavy rainfall.

Of the total area of 35,760 sq. kl., 75 per cent is hilly (100 m., above sea level), and the remaining 25 per cent is plain. The total area of forests in the mountainous district is about 1,821,196 ha., about 51 per cent of the total area of the island; but the hilly slopes have been denuded to a great degree by the people for planting bananas, pineapple and tea. In the mountainous region, there are about 130,000 aborigines, who still live in a primitive state and are in the habit of burning trees. In addition, extensive felling by the Japanese during the war for their timber requirements, and by the people after the war for their fuel needs, has led to a steady deterioration of most of the river basins. The heavy rainfall caused by typhoons, and the deteriorated river basins result in serious floods, which cause extensive damage to crops, buildings, highways, railways and public utilities and the loss of human life.

The total area of arable land in Taiwan during 1949 was 863,157 ha., which yielded 1,293,931 tons of rice, 2,002,864 tons of sweet potato, 3,113,061 tons of sugar cane etc. The area of arable land provided with irrigation and drainage was 599,490 ha., of which about 442,000 ha., lie along the rivers and are irrigated by their waters. The floods damage 4,700 ha., annually by inundation, and 1,578 ha., by deposition of gravel which converts them into barren wastes. The flood control works are, therefore, designed to protect the cultivated fields, and the lines of communication.

/III. Rainfall

III. Rainfall

On account if its peculiar situation, Taiwan is visited by typhoons year after year, which cause heavy damage. The typhoon season usually sets in in June and ends in October, and the most dangerous months are from July to September. Typhoons start in the sea east or north-east of Luzon and travel usually northeast, traversing the island of Taiwan or sweeping across either its northern or southern extremity, and finally entering the continent. When a typhoon passes over the island, it is often accompanied by heavy rain which causes floods, even though its intensity may not be severe. Therefore, the typhoon season is considered to be the flood season in Taiwan.

The average rainfall for the island is about 2,500 mm., the heaviest 8,408 mm., at Huoshaolia (420 m. M.S.L.) in 1912. The minimum recorded rainfall in the island is 1,050 mm., at Rochiton on the west coast; while in the Pescadores Islands, the average rainfall is only 943 mm. Generally speaking, the maximum daily rainfall of other districts in Taiwan varies from about 10 to 15 per cent of the annual rainfall for the same year.

IV. Flood Damage

Resulting naturally from the meteorological, topographical and geological peculiarities of the island, the rivers of Taiwan are of unparalled violence, and once the flood comes, the cultivated fields and villages along non regulated rivers are damaged considerably. Even along the regulated rivers, if the maintenance is not perfect the embankments and bank protection works easily break down. Besides, the lines of communication, both railway from Hualian to Tatung may have to be suspended for about 100 days during the flood season every year. After the flood subsides, the inundated lands are usually covered with sand and gravel

/and are

and are converted into a barren waste. According to statistics available for the 19 important rivers in Taiwan for 31 years from 1912 to 1942, the maximum amount of damage was caused in 1912 and amounted to T.W. $12,593,917 (U.S.$6,296,958) while the average annual loss was about T.W.$2,342,244.

Characteristics of Taiwan Rivers.

The island of Taiwan has 19 important rivers, 29 ordinary rivers and 64 small rivers. The biggest and longest river, Choshui, is 170 km., long, with a drainage basin of 3,144 sq. km., and its maximum estimated flood discharge is 22,000 c.m.s.

The main characteristics of Taiwan rivers are:

(1) Steep slopes.

The central mountain range running north to south with peaks over 3,000 m., high is the principle watershed of the island from which the rivers originate and run down to the sea, either east or west. All rivers are rather short and, therefore, very steep. For example, the Taan River, the most typical torrential river in Taiwan, is only 87 km., long, with its origin at an altitude of 3,030 m. It dashes down with an average slope of 1 in 29. Even in its lower course, it has a slope of 1 in 90, which is 24 times steeper than the Rhone, known to be the steepest river in Europe, and big boulders are to be seen in its estuary. The Tsengeven River, one of the slowest flowing rivers in Taiwan, has a slope of 1 in 820 in its lower course, which is about 2.7 times that of the Rhone.

(2) Large unit flood discharge.

The specific flood discharge of Taiwan rivers varies from 2.9 to 9.1 c.m.s., per sq. km., of drainage basin, while that of rivers in other countries varies from 0.007 to 0.370 only. The coefficient of regime (ratio of minimum to maximum discharge) of Taiwan rivers varies

/from 1/900

from 1/900 to 1/6850, while the corresponding values for rivers in other countries are relatively much more, viz., 1/8 to 1/364. According to European practice rivers are called slow-flowing and good rivers if their coefficients of regime are bigger that 1/100, and are termed rapid and bad rivers, if these coefficients are small than 1/1000. Now, the coefficients of Taiwan rivers being even smaller than 1/1000, we can say that all of them are very rapid and possess the worst characteristics.

(3) Enormous quantities of sand, gravel and boulders.

In hilly and mountainous regions, where the slopes are considerable, forests furnish a very notable defence against the surface flow of precipitation into the streams, and the retarding effect of trees, humus and forest waste generally holds the water until it is absorbed by the ground. The fluctuations in the volume of flow are thus reduced. Furthermore, forests are a very great defence against the erosion of surface soil. The need for this protection increases with steepness of slope and looseness of soil.

In Taiwan, the mountainous region which is the source of all rivers, comprises about two-thirds of the total area of the island, being thickly forested, and consisting of fragile schists and clay slates. Extensive felling and denudation of steep slopes has generally increased the tendency to erosion. With abundant, torrential rainfall, erosion is more rapid on cleared land than on forested slopes. Erosion once begun, soon develops gullies that furnish so much sand, clay and cobbles to the streams that they become overloaded, and are unable to carry their full load. The excess load of sand and cobbles is not only deposited in fans in the upper river course, but is also transported as bed load to the lower course by the flow, so that big boulders can be seen even in the estuaries of some of the most rapid rivers.

/Table

The silt contents of Taiwan rivers
in comparison with foreign rivers.

	Taiwan rivers				Foreign rivers	
	Silt content in per cent by weight		Remarks	Name	Silt content in per cent by weight	
	Maximum	Mean			Maximum	Mean
Ilanshui	0.0170	0.0056	measured at Ilan	Colorado	3.81	1.94
T-Ko-Kan (Tributary of Tanshui	0.5359	0.0671	Shi-men	Yellow	1.00	0.40
				Mississippi	0.147	0.067
				Rhone	--	0.056
Houlung	0.0035	0.0009		Nile	0.158	0.050
Tachia	0.0104	0.0007		Donau	--	0.050
U	0.0064	0.0003		Yangtze	0.141	0.027
Choshui	0.6289	0.1445		Saine	0.274	0.004
Shaitanshui.	0.0614	0.0005				

Although deposited sand etc., make the river bed slopes flatter, the beds become higher and higher, specially on rivers in the east. This rise of river bed not only endangers the embankments, but also causes the flooding of cultivated fields, and the life of reservoirs is shortened by the enormous quantity of sediment

(4) Diversities of river courses.

The high velocity of flood discharge and the enormous quantity of sediment render a river unstable in its own course. It either ramifies itself, or meanders unhampered. For example, the Choshui River, which is the biggest in Taiwan, used to radiate into four rivulets to the sea before 1914 when its regulation was taken in hand. After its embankments were completed, the same river flowed in a single channel. This phenomenon is seen not only on non-regulated rivers, but also on the foreshores of regulated rivers, and the breaking down of embankments and bank protection is largely due to the hammer-like action of unchecked dashing caused by the vagaries of the river course.

/VI. Classification

VI. Classification of Taiwan Rivers

On the basis of the above characteristics, the rivers of Taiwan may be technically classified as follows:

(1) Plain rivers: Ilanchoshui, Tanshui, U, Chochui and Shiatanshui.

(2) Rapid rivers:

(a) High mountainous rapid rivers - Taan and Ta-chai.

(b) Medium mountainous rapid rivers - Fengshan, Touchien, Tsongkang, Houlung, Tanapa, Linpien.

(3) Slow-flowing rivers: Piekang, Putsu, Pachan, Chishui, Tsengven, Yenshui, Ertsenghsing and Tungkang.

(4) Eastern rivers:

(a) Longitudinal valley rivers: Pienata, Hsinkuluan and Hualian.

(b) Transverse valley rivers: Chihpen, Luchia, Sapotang and Taparogu.

VII. Flood Control Works in Taiwan

(1) Past activities:

The rivers in Taiwan were not regulated scientifically until the end of the last century. After the two successive big floods of 1911 and 1912, which damaged a land area of 30,413 and 35,183 ha., respectively, the Government started to pay attention to flood control works. Many emergency works were constructed in the beginning. Later, in 1927, systematic improvement plans were commenced on the 19 principal rivers. During the 48 years from 1898 to 1945, a total of 419 km., of embankments have been constructed, protecting an area of 123,244 ha.

(2) Present activities:

River regulation works in Taiwan, which had been prepared with

/much care

much care and expense, received a fatal blow at the outbreak of the Pacific war. During the three years before the armistice, river management in Taiwan was entirely abandoned. The violent rivers, like wild beasts breaking out of their cages, did incalculable damage. The total length of embankments damaged was 33 km. Besides, most of the embankments protected by galvanized iron wire cylinders filled with stone, having already rusted, fell easy victims to the floods.

From October 1945 to July 1950, i.e., a period of less than 5 years, the Chinese Provincial Government repaired or rebuilt a total length of 76 km., of embankments, with 375 groynes on the 19 important rivers. In addition to this, a total length of 16 km., of levees with 36 groynes have been repaired or rebuilt by different Hsiens under the supervision of the Provincial Government.

Besides, a length of 52 km., of emergency work with 268 bamboo groynes was completed during the flood seasons in these five years. Since 1947, the annual expenditure has varied from U.S.$2 to 3.8 million

VIII. Methods of Construction.

(1) General description:

As rivers in Taiwan have no facilities for navigation, river regulation during low water is of little importance. The purpose of river works is mainly flood protection, such as combining divergent water channels into one channel, closing old and less important tributaries for reclamation, checking meandering and restricting the flood flow within the limits of the proposed river channel. As the plains are densely populated and well cultivated, the regulation works are concentrated along the lower portions of rivers, and consist of embankments, bank protection and groynes. But since all rivers, both rapid and slow, are of unparalled violence in character, the methods of construction have to be very sound. Due to severe erosion and

/scour caused

scour caused by the flood flow, the life of an embankment depends on the strength of its bank protection, and the life of the bank protection depends, in turn, on the adequacy of the protection of its toe, which has to be designed and constructed with the greatest care.

(2) Embankments or levees.

Embankments are made of boulders and gravel for rapid rivers, and of sand covered with a layer of clay for slow rivers, as these materials are easily available nearby. Stone levees are generally built at places where the river slope is steeper than 1/300 to 1/400, while earth levees are employed where the slopes are flatter. The crown of the levee is kept from 2.7 to 3.6 m., in width for stone levees and from 4.0 to 5.45 m., for earth levees. The free board allowed is 1.8 to 2.0 m., for stone, and 1.2 to 1.8 m., for earth levees. These values are more than the 1.0 m., usually allowed in other countries because of the meandering of the river course, and the possible rise of bed. Although it is realised that the cost of a levee increases in proportion to the square of its height for similar sections, the increase of free board is absolutely necessary for the torrential rivers of Taiwan.

Standard cross-section of stone levees is comparatively smaller, because of the rather short duration of floods, while the cross-section of earth levees is somewhat larger as the available materials are schists and clay slates which are lighter and less cohesive. The river side slope is 1:2 for stone and 1:2.5 for earth levees; the land side slopes being 1:2 and 1:3 respectively. Berms on the river side are added for levees with considerable height, and are also used as a method for executing emergency work during floods.

(3) Bank Protection

The design of revetment depends on the tractive force of the flow and the material of river bed. The value of tractive force computed

/for some

for some important rivers in Taiwan is given below:

Name of rivers	Slopes of the river bed (J)	The depth water during floods (t)	The tractive force S = 1,000 x J x t kg./m^2
1. Taan	1/90	6.55	S 73 kg./m^2
2. U	1/370	6.86	S 18.5 "
3. Choshui	1/430	6.50	S 15.2 "
4. Tsengwen	1/820	5.61	S 6.85 "

Tractive force that can be resisted by different materials, as given in text books, is as follows:-

Material	Tractive Force kg./m^2
Grass	2.0 - 3.0
Mattress	7.0
Brick pavement	10.0
Stone pavement	16.0
Concrete pavement	60.0
Reinforced concrete	80.0 - 100.0

As regards the scouring action of the flow, the experiments of Du Buat gave the ratio between the size of material and the critical velocity at which the particle begins to move. Their relation may be computed by the following equation:

$$v = 3.5 \sqrt{d}$$

where v is the critical velocity in m.s. and d is the size of material in mm.

d - 1 mm.	v - 0.10 m.s.
d - 1 cm.	v - 0.35 m.s.
d - 10 cm.	v - 1.10 m.s.
d - 100 cm.	v - 3.50 m.s.

The bottom velocity for Taiwan rivers is rather high, so that the depth of erosion at some places may be as much as 6 to 8 m., for rapid rivers and 10 m. for slow rivers.

The construction of bank protection consists of two parts:

(a) Slope protection:

The types employed are stone pavement (dry or wet pitching protected by wire cylinders), concrete, reinforced concrete slab, concrete blocks (1 m. sq. 15 cm. high) for rapid rivers, and brick pavement for slow rivers.

/(b) Toe or

(b) Toe or foot protection:

The common types in use are wire cylinders for rapid, and fascine mattresses for slow rivers. The wire cylinder, filled with stone or boulders, has many advantages such as its flexibility, ease of construction and repair.

The wire cylinder is a development of the bamboo cylinder, which was used in China some 2,000 years ago as a kind of river work. Bamboo cylinders, filled with boulders, are still employed for emergency works during floods.

(4) Type sections of embankments and bank protection.

(a) Stone levee with wet pitching and wire cylinders. This costs U.S.$125 per metre or U.S.$104 per metre for one layer of cylinders only. It is strong, flexible and easy to construct and repair, but the wire lasts only for about 10 years and the maintenance cost is high.

(b) Stone levees with reinforced concrete revetment. This type is employed for the most rapid part of rivers and costs U.S.$375 per metre. Its advantages are its great strength, long durability and low maintenance cost, but it is expensive and difficult to construct because they need deep foundations and may require pumping.

(c) Stone levee with wet pitching and concrete block protection, This is suitable for medium rapid rivers and costs U.S.$109 per metre. The concrete blocks, which are interconnected with iron bars, lie about two metres below the river bed. The blocks can resist scour individually and collectively, and are comparatively cheap, but wet pitching alone cannot resist rolling boulders and the small concrete blocks are liable to be carried away by floods.

(d) Stone levee with wet pitching and concrete protection. A good substitute for the type with wet pitching and wire cylinders, when wire

/is short

is short in supply. Its advantages are greater strength, longer durability and low maintenance cost, but construction costs are high (U.S.$159 per metre) and they are difficult to construct as deep foundations are needed for the toe concrete, and pumping may be necessary.

(e) Earth levee with concrete block protection. Blocks 1.5 m. sq., 0.15 m., high are used. The cost is U.S.$95.50 per metre. It is easy to construct and maintenance cost is low, but the piles used decay easily.

(f) Earth levee with wet pitching and fascine mattress. This is cheap and easy to construct and maintain. Can be used only where boulders are available at a reasonable price.

(g) Earth levee with brick pavement and fascine mattress. Very widely used, especially where boulders are not available. Special bricks (22 by 11 by 6 cm.) are used. Bricks have two holes and are connected together by two galvanized iron wires 4 mm., in diameter. This type is easy to construct and repair, and is flexible, but its life is short as it may be silted after the floods.

(h) Retaining wall. Used to protect important cities where space and beauty are important considerations. Long life and low maintenance are its two advantages, though in construction cost it tops the list.

(5) Spur dykes or groynes. As a kind of revetment, they have extensive application on most of the important rivers, and are placed at intervals along the levees on the foreshore, where the revetment is not strong enough to prevent the erosive action of the flood flow, or where continuous revetment can be economically omitted.

With respect to flood levels, spur dykes are classified as non-overflowing and overflowing types. The non-overflow type is a solid cross levee of considerable length carefully protected at its head. It is usually built on the concave side of slow rivers to correct the flood flow. The crest is kept about one or two metres above low water level at the levee

/end, and

end, and slopes down at 1 in 30 to 1 in 50. Groynes are constructed either perpendicular to the current direction or inclined up to 15° upstream of the perpendicular, in order to divert the current away from the bank.

The types in use are wire cylinder groyne or reinforced concrete crib groyne (rarely used at present) for rapid rivers, and permeable piles with braces and fascine mattress for slow rivers. The length of groyne varies from 30 to 50 m., and the spacing between them is 1.5 to 2.5 times the length.

The methods employed for their construction are somewhat similar to those described for toe protection of revetment.

IX. Reservoirs in Taiwan

There are four reservoirs, of which two are already completed, one was formed naturally following earthquake, and the fourth is still under construction.

The first, Sun Moon Lake, produces 100,000 K.W. of hydro-electric power and is now the main source of power for Taiwan industries. The second, Chia-nan irrigation 150,000 ha., by rotation every 3 years. The third, Tsaolin, is a natural reservoir across Tsing-shui River, a tributary of the Cho-shui, with a storage capacity of 150 million c m. This can serve as a multi-purpose reservoir for flood control, water power (57,000 K.W.) and irrigation (14,000 ha.). This natural dam, formed by earthquakes, is porous and leaks and the temporary spillway is very steep. There is immediate need to prevent failure of this dam, and necessary protection works have been started.

The fourth is a rolled fill earth dam for the A Kontien reservoir, which is a multi-purpose project for flood control and irrigation started in 1942 and expected to be completed at the end of 1951. Its total capacity is 45 million c.m. of which 16.5 million will be reserved for flood control, 10 million for irrigation and 3.5 million for water supply.

/X. Conclusions.

X Conclusions

The rivers in Taiwan are the most rapid in the world. Due to high intensity of rainfall especially by typhoons, flood damage occurs very often. Four hundred and nineteen kilometres of embankments were constructed during the Japanese occupation of 50 years, protecting 123,244 ha. The average cost of embankments is U.S.$230 per protected hectare.

During the past five years a total length of 76 km., of embankments have been constructed at a cost of U.S.$100,000 per km. The high cost is due to the strong protection necessary for the rapid rivers, as the embankments are liable to destruction during floods in spite of all their strength. The difficulty lies in the large flood discharges and the enormous quantities of sand, gravel and boulders carried during floods.

The flood problem of Taiwan cannot be entirely solved by constructing embankments alone. Any future programme of flood control must consider the fundamental cause of all the difficulties, soil erosion, and combine soil conservation to check the silt, gravel and boulders with storage reservoirs for flood prevention.

/SOIL CONSERVATION

SOIL CONSERVATION

The Government of India have constituted a Central Board of Forestry to secure close coordination in forestry matters and more specially in integrated land use and help in maintaining adequate standards in forestry education. It will consist of the Union Minister of Agriculture as the Chairman and Ministers in charge of Forests of States, Secretary and Joint Secretary of the Central Agriculture Ministry, Inspector General of Forests and the President, Forest Research Institute, as members.

The functions of the Board will be:

(1) Co-ordination and integration of forest policy pursued by States in the management of their forests;

(2) The adoption of conservation measures affecting forest resources and soil;

(3) Integration of plans for land use and national reconstructic in which forestry has come to play a progressively important role;

(4) Promotion of legislation considered necessary for various States for the management of private forests;

(5) Regulation and development of forests in inter-state river valleys, which are the concern of the Central Government;

(6) Maintenance of adequate standards of training of officers;

(7) Co-ordination of forest research conducted in Central and State Institutes; and

(8) Any other matters affecting forestry, which are relevant to the objective of the Board.

/Combating Soil

Combating Soil Erosion in Kashmir

The Kashmir Government has recently set up a Soil Conservation branch within the Forest Department to adopt measures to combat the growing menace of soil erosion in the State.

Soil erosion is showing signs of rapid growth particularly in the Kandi area of Jammu Province. Vast areas of fertile land have gone to waste and desert conditions are being apprehended. On account of the depredation caused by denudation and soil erosion, it is proposed to undertake improved cultivation, large-scale afforestation, regulation of grazing and reclamation of waste and marshy lands. Plantation boards have been set up in both Jammu and Kashmir, who have intensified plantation in exploitable forests of quick-growing species.

Punjab (India)

To put a stop to the menacing extension of soil erosion and to reclaim already eroded tracts, the joint advisory council of Punjab, PEPSU and Himachol Pradesh has decided to set up a joint board of three forest chiefs to outline measures to be followed in their mutual interest.

No less than 1,150 sq. mi., of area of only cultivable land had turned into a sandy tract due to soil erosion in a limited area of Punjab alone. More area was threatened in all the three States. In view of this common danger from soil erosion, it was agreed to set up a joint body to deal with a common enemy.

U. P. - Its Soil Problem

United Province, the largest unit of the Indian Union in area and population, has a gigantic problem of soil conservation for several reasons. It has over 25,000 sq. mi., of problem soils needing attention. Some areas need afforestation, some need protection of lands by bunds for soil and water conservation, others need drainage and still others reclamation of salts.

/Finding that

Finding that the area of forests in U.P. had dwindled down to 13 per cent of the total area of the State, and that this was the main cause of the large scale land erosion, the U.P. Government constituted in 1945, the Land Management Circle and put it on a permanent footing in 1948. Its task is to take measures to control erosion, reclaim ravines, waste lands and other denuded areas, afforest State lands and provide fuel and fodder reserves. Government has so far acquired 65,583 acres of land in different places spread over the State for afforestation, and the creation of fuel and fodder reserves.

Pilot schemes of ravine and salt reclamation and afforestation are progressing satisfactorily near Etawa and Lucknow. Progress is also made on planting canal and railway lands, camping grounds and road avenues.

/PAKISTAN

PAKISTAN

(Abstract of a paper on Drainage Basin Management by Dr. R. M. Gorrie, presented to UN Scientific Conference on Conservation and Utilization of Resources.)

A recent detailed investigation showed that the total badly gullied area in the Rawalpindi, Cambalepur, Gujrat, Sialkot, Mianwali, Shahpur and Jhelun Districts of Punjab, to be 1,750,000 acres out of a total of 14,693,972 acres, most of which is classified as forest and uncultivable waste, says Dr. R. M. Gorrie. Much of this deeply gullied land consists of excellent soil, which has been exposed to considerable depths below the ground level. Gullies are eating into the plateau land at a terrific rate.

Fifteen thousand acres of this area has been reclaimed with the aid of tractors and bulldozers at a cost of Rs. 80/- to Rs. 150/- per acre, which amount is recovered from the owners. The cost is said to vary with slope. Gorrie gives the following figures with a D4 tractor:

Slope	Cost of reclamation per acre
0-2%	Rs. 90
2-4%	Rs. 105
4-6%	Rs. 150
6-8%	Rs. 200
Over 8%	Rs. 250

This shows clearly that costs rise steeply with the slope and above 8% the cost mounts so quickly that it soon becomes uneconomic to terrace for fields. Somewhere around 8 per cent, therefore, is the margin between reclaiming for fields and for afforestation. Steeper slopes can, however, be profitably worked by tractors to produce a contour ditch and ridge on which tree planting or grass cultivation may still pay a good profit through the quicker and better growth which will result as compared with planting on an improved slope.

It will pay the government to purchase land at the prevailing market rates, reclaim it and then sell it.

Gorrie further expressed the opinion that land reclamation will fail, if we do not insist upon each unit catchment being dealt with as

/completely and

completely and as comprehensively as possible for water conservation and flood control.

The endless and rugged fringe of bad cultivation retracting before each advancing gully head has got to be mastered, and it can only be made safe and profitable by adopting every possible type of land use and adopting our machine attack towards easy afforestation, fodder production, village tanks and ponds as well as plough land.

Ceylon
Eater Conservation in Coconut and Rubber Estates - Abstract of speech by Dr. R. Machgan Gorrie

Dr. Gorrie was alarmed and shocked at the amount of dessication which was taking place throughout the Northern dry zone. Every main road and every village road edge had been burnt to clear the weeds and the forest constantly, penetrating up to a quarter or half a mile into the jungle.

Ceylon soils had a very low percentage of clay amongst a lot of grit and sand. Once that clay was washed out the rest was practically sterile and useless. Somewhat similar losses were going on in their paddy fields owing to a far too liberal use of irrigation water. Continuous movement of water across every paddy field stole the clay particles. In the same way plantation tea and coconut soils were being robbed of their clay contents and leading to accelerated erosion.

The answer was controlling their grazing and establishing a good ground cover, preferably of pasture value, and keep the rotation of grazing on a basis which would develop the ground cover to withstand the long drought periods.

/PAPERS FOR

PAPERS FOR FLOOD CONTROL CONFERENCE

Twelve papers prepared by flood control experts of the ECAFE region have already been received by the Bureau for the Technical Conference on Flood Control to be held in New Delhi from 7 to 9 January 1951. These are being mimeographed and distributed to all interested in the conference. Further papers are expected shortly.

The papers received so far include:

1. "The Use of Embankments for Flood Control - Their Merits and Demerits" and "The Use of Permeable Dikes for River Training of the Yungting River" by Mr. Shi-Ta Hsu, Department of Civil Engineering, National Taiwan University, Taiwan, China.
2. "Planning of Soil Conservation on the Damodar Valley" by Mr. A. Vajda Chief Conservation Engineer, Damodar Valley Corporation, India.
3. "Laws of Liquid Flow" by Pir Mohamed Ibrahim Quraishi, Chief Engineer, West Punjab, Pakistan.
4. "Soil Conservation and Flood Control" by Mr. D. D. Saigal, Central Waterways, Irrigation, Navigation Commission, India.
5. "Embankments and Bank Protection of Taiwan Rivers", by Mr. Lee-Tang Shi, Deputy Director, Bureau of Hydraulic Engineering, Taiwan, China.
6. "Study of Flood Protection and River Training Measures on Certain Asian Rivers with the Help of Models", by Dr. H. L. Uppal, East Punjab Irrigation Research Institute, India.
7. "Silt Transportation Theories and Silt Measurement Apparatus", by Dr. V. I. Vaidianathan, Physicist, East Punjab Irrigation Research Institute, India.
8. "Control of Rivers without Embankments", by Mr. L. J. McLean, Department of Irrigation, Burma.
9. "Summary Review and Recent Progress on the Theory of Stable Channels", by Mr. S. L. Malhotra, Secretary, Central Board of Irrigation, India.

/10, "Soil

10. "Soil and Water Conservation - Key to Flood Control by Dr. M. A. Huberman, Chief of the FAO Forestry and Forest Products Working Group of Asia and the Pacific, Regional Office of FAO, Bangkok, Thailand.

11. "The Control of Floods by Dikes in North Viet-Nam" by the Government of Viet-Nam.

12. "Notes on Water Control and Water Management of the Damodar River Basin", by H. J. Ajwani, Planning Engineer, Damodar Valley Corporation.

13. "Rivers of Japan", by the River Bureau, Government of Japan.

14. "Dyking and Training of the River Krishna for Flood Control Purposes", by Shri Narasimha Rao, Executive Engineer, Madras.

15. "Soil Conservation as Affecting Flood Control in Ceylon", by R. M. Gorrie, Soil Conservation Officer, Ceylon.

16. "Floods and Rainfall", by S. K. Pramanik, India Meteorological Department, Poona, India.

Invitations to attend the conference have now been addressed to the various Governments and technical organizations concerned, as well as to experts both inside and outside the region, the United Nations Specialized Agencies and other interested bodies.

The following technical organizations have accepted the invitation and have arranged to be represented at the conference:

1. The International Meteorological Organization.
2. The Commission Internationale des Grands Barrages (The International Commission on Large Dams).
3. The World Power Conference.
4. The International Association for Hydraulic Research.

ERRATA

We regret to state that an error occurred in printing of Creager's formula on page 31 of Journal No. 3. The formula should read -

$$Q = 46\ C\ A^{\left(0.894\ A^{-0.048}\right)}$$

and on page 38, line 1, "capacity of 85,000,000 kilowatts" should read "capacity of 85,000,000 kwh/year".