REPORT OF THE INSTITUTE OF INDUSTRIAL SCIENCE

UNIVERSITY OF TOKYO

VOL. 5, NO. 3 (SERIAL NO. 37) AUGUST, 1955

東 京 大 学

生 産 技 術 研 究 所 報 告

第 5 巻 第 3 号

(通 巻 第 37 号)

UDC 627. 15 : 627. 42

GRADUAL ALTERATION IN THE FLOW CHARACTERISTICS OF THE CHIKUGO-RIVER FLOOD

BY

YUTAKA TAKAHASI, *Research Associate*

昭和 30 年 8 月

既　刊　報　告

第　1　巻

第1号　高木　昇，尾上守夫：水晶濾波器の研究（狭帯域濾波器）　1950年5月
第2号　勝田高司：自然換気に関する実験的研究　1950年8月
第3号　鈴木　弘：逆張力引抜加工に関する研究　1950年12月
第4号　高橋武雄，木本浩二：高粘性アルギン酸に関する研究　1951年1月
第5号　山田嘉昭：二次元塑性理論とその塑性加工への応用について　1951年2月
第6号　竹中規雄：切削仕上面の粗さに関する研究　1951年3月
第7号　沢井善三郎：抵抗溶接の溶接機構と溶接条件の選定　1951年3月
第8号　玉木章夫：境界層理論による熱伝達の研究　1951年3月
第9号　加藤正夫：ダイ鋳物用亜鉛合金に関する研究　1951年3月

第　2　巻

第1号　小川正義：精密ねじに関する研究　1951年4月
第2号　糸川英夫：圧力変動の測定法と剝離流の渦に関する研究　1951年8月
第3号　原田正道：木船の縦強度　1951年11月
第4号　亘理　厚：回転軸の運動に関する研究（英文）　1952年3月
第5号　森脇義雄，猪瀬　博：分布結合回路の帯域濾波特性　1952年4月
第6号　久保田広：干渉色計算表（英文）　1952年5月
第7号　福田武雄：鉄道鈑桁架換機に活用した高強度アルミ合金部材について（英文）　1952年6月
第8号　糸川英夫，清水健太郎，大野昭三，氏家秋果：麻酔深度のメーター指示に関する研究（英文）　1952年8月
第9号　糸川英夫：音響インピーダンスによる微小変位測定法及びその表面仕上検査機とスピーカー・ペーパー・コーンの振動測定への応用（英文）　1952年8月
第10号　糸川英夫，吉山巖，大野昭三，金沢磐夫，米田円生，漆谷章：超低周波帯における微小電圧の増幅及び記録に関する研究，特に生研式インクライターの脳波・心電図等への応用（英文）　1952年9月

第　3　巻

第1号　糸川英夫，熊谷千尋：ヴァイオリンの製作に関する研究　1952年9月
第2号　木本浩二：硫酸セリウムによる有機工業分析法の研究　1952年10月
第3号　安藤良夫：生研試作アルミ艇の構造について　1953年3月
第4号　松下幸雄，森　一美：溶融スラッグの物性並びに反応性に関する研究　1953年11月
第5号　石井義郎，山下雄也：可塑剤の合成研究　1954年2月
第6号　橘　藤雄：対流放熱器の研究（英文）　1954年3月
第7号　池田　健，富田文治：新しい容量型歪計について（英文）　1954年3月
第8号　鳥飼安生，藤森聰雄：平面板における超音波の透過　1954年3月

第　4　巻

第1号　平尾　収：4サイクルガソリン機関の放熱に関する研究　1954年8月
第2号　猪瀬　博：全電子管式擬似トラック装置（英文）　1954年10月
第3号　藤森栄二：有機蛍光および感光物質の研究（英文）　1955年2月
第4号　金森九郎，舘充，中根千富，佐藤利雄，相馬胤和，前田一徳，松瀬昭三，和泉沢信：高炉湯溜り吹精法に関する研究　1955年3月
第5号　尾上守夫：円筒函数の商函数（英文）　1955年3月
第6号　大和田信：撚線の機械的性質に関する研究　1955年3月
第7号　安藤良夫，山口勇雄，飯田国広，今井保穂：鋼材に及ぼす溶接と冷間加工の重畳効果（英文）　1955年3月

第　5　巻

第1号　丸安隆和，水野俊一：現場においてコンクリートの配合設計を行う場合目標とする平均強度の取り方について　1955年3月

THE Institute of Industrial Science was established on May 31, 1949 on the campus of the then Second Faculty of Engineering, located in Chiba City, some thirty miles southeast of the main campus of the University.

The main objective of the Institute is to carry out scientific research on technical problems of engineering and industry as well as to develop certain aspects of the results achieved through research. Contract research is also an active feature.

The Institute comprises at present the five research departments listed below. Each of these departments is divided into several research divisions, each under the administrative charge of the various professors and or assistant professors. Under certain circumstances, however, specific research groups organized among research scholars belonging to the various divisions of the Institute or in some instances to other institutions of the University may be organized for the purpose of solving specific problems. By arrangement, researchers of outside organizations may also be invited to take part in such cooperative research projects.

The results of various studies and research projects are published in the Report of the Industrial Science. The Institute also publishes a monthly journal entitled "SEISAN-KENKYU" (literally, Industrial Production Research) to inform the concerned industries and interested persons about the objectives and activities of the Institute, to provide assistance to such industries and to promote a closer relationship and cooperation between the industries and the Institute.

INSTITUTE OF INDUSTRIAL SCIENCE
UNIVERSITY OF TOKYO
CHIBA CITY, JAPAN

RESEARCH DEPARTMENTS OF THE INSTITUTE

Department of Technical Physics——Applied mathematics; Applied optics; Acoustic engineering; Physics of solids; Fluid physics; Applied electronics; Radiation engineering; Strength of materials.

Department of Mechanical Engineering and Naval Architecture——Kinematics and dynamics of machineries; Mechanism; Heat transfer; Heat engines; Hydraulic machineries; Chemical machineries; Machinings and machine tools; Casting, forging and drawing; Precision technology; Welding engineering; Plate structures and ship construction; Dynamics of naval architecture.

Department of Electrical Engineering——Theory of electric circuits; Electrical machines and apparatus; Electric-power engineering; Electric-control engineering; Electron-tube engineerng; Communication apparatus; Ultrashort-wave engineering.

Department of Industrial Chemistry and Metallurgy——Industrial chemical analysis (inorganic); Industrial chemical analysis (organic); Inorganic chemistry; Electro- and photochemistry; Synthectic dyestuff; Coaltar derivatives; Rubber, plastics and others; Fuels, oils, fats, proteins and others; Carbohydrates, cellulose, fermentation and others; Chemical engineering; Ferrous metallurgy; Non-ferrous metallurgy; Metallurgical technology; Alloys.

Department of Construction Engineering——Soil engineering; Civil engineering structures; Traffic engineering; Hydraulic engineering; Surveying; Structural design of architecture; Architectural hygiene; Architectural interior design; Architectural production; Architectural planning; History of engineering and technology.

UDC 627.15: 627.42

GRADUAL ALTERATION IN THE FLOW CHARACTERISTICS OF THE CHIKUGO-RIVER FLOOD

by

YUTAKA TAKAHASI*

(Accepted April 27, 1955)

CONTENTS

§ 1. INTRODUCTION

At the end of June, 1953, several parts of Japan suffered severe flood damage; especially, that of Chikugo River (or Tikugo River) in North-Kyûshû district was remarkable and gave impetus to certain investigators to reconsider flood phenomena fundamentally. The writer intends to make clear how the characteristics of flood flowing through the Chikugo River altered during the last seventy years.

It is, indeed, very difficult to estimate different causes which should have an effect on flood damage. In the case of the Chikugo-River flood of 1953, the amount of rainfall was exceptional, exceeding all records. Attracted by the unexpected rainfall, one may simply ascribe the flood disaster to it and would not inquire into the cause of disaster but to point out that river works were inactive and forests were cut down excessively since the war. In the meantime, men of insight have already remarked that the damaging floods which occurred recently in Japan may have uneven characteristics with those we experienced before. At the major floods occurred recently in this country, the maximun runoff attained often an amount which had been seldom exceeded until then; and records of damage reveal the coincident alteration. The trend has become rather general since 1947. On the other hand, the total amount of rainfall which led to the major flood is recognized as almost unaltered. The writer pays attention also to the fact that the Chikugo River belongs to the important rivers in this country on which channel-regulation and flood-control works have been carried out carefully, and which is, consequently, regarded as an ideal of engineered river in Japan.

* Former Graduate Student

Then, the general increase in peak discharge of the major flood must be put forward to elucidate its behaviour quantitatively. The writer describes, in this paper, how the frequency of the major flood has changed, and what manner the rising as well as falling velocity of river stage at flood time has altered.

§ 2. MATERIALS AND METHODS

Information on river stage is available at more than ten gauging stations of which the uppermost, the Kuma Station, lies 84.5 km above the outlet, and the lowermost, the Beniya Station, near the mouth. Measurements of stage are carried out twice a day, or, in the case while the "warning" stage is being exceeded, at intervals of one hour.

The measurement work has been continued since the end of the nineteenth century, but the records up to 1923, are, regrettably unaccessible at almost all stations and even the records since 1924 are, to make the matter worse, very often interrupted owing to various causes.

Because of completeness and reliability, records concerning the following items are highly esteemed in this paper:

(1) The peak stage of individual floods observed since 1924 at the Shiwa, Tsukajima, and Taruho Stations which are located 54.7, 38.0, and 32.8 km above the mouth respectively; that observed since 1917 at the Kuma Station; and that observed since 1884 at the Senoshita Station located 25.8 km above the outlet.

(2) The high-water stage at the Senoshita Station which has been observed at intervals of one hour in case of individual floods. Data on this item have been well preserved and are the accurate among the others.

Records of the item (1) are used to determine the high-water frequency, those of the item (2) to examine the rising as well as falling velocity of high-water stage.

Records of the peak water stage obtained at the other stations or over the other terms might be employed in the study, if they were preserved with fewer lacking. More care in collection and preservation of hydrologic data is desirable. Disregard of such basic data may be, in certain case, attributed to the fact that they have been merely employed in analysis of river behaviour or in design of river works.

§ 3. RESULTS OBTAINED

(1) The frequency of high water: -Out of the above-mentioned records those cases are, first of all, picked up in which the peak stage exceeds the level defined at proper height for each station; the date and gauge reading of the peak stage in the selected cases are tabulated below (table 1, 3, 5, 7, 9). Then, the cases are sorted into several groups in respect to time of occurrence and to magnitude of flood. The length of time period into which they are classified is fixed at five years for the Kuma, Shiwa, Tsukajima and Taruho Stations; and at ten years for the Senoshita Station. They are, next, ranked with height of stage into several groups. Those cases are put into the first rank in which the peak stage lies between the "warning" stage and the stage α cm higher than it; ranks correspond the divisions of gauge height, each of them having the same range of α cm. The

value of α is defined as 50 for the Senoshita Station, and as 25 for the others.

Table 2, 4, 6, 8, 10 show the number of cases counted and classified in this way. Figures 1, 2, 3, 4, 5 show the frequency representing in table 1, 3, 5, 7, 9 respectively in bar graph.

(2) The rising and falling velocity of higher-water stage: -Making the use of the records of flood stage at Senoshita, the writer has constructed a series of stage hydrographs. Then, on each of them, is determined the time required by flood to rise or fall successive one metre. For the sake of simplicity so defined time is taken instead of velocity. Results are shown in table 11.

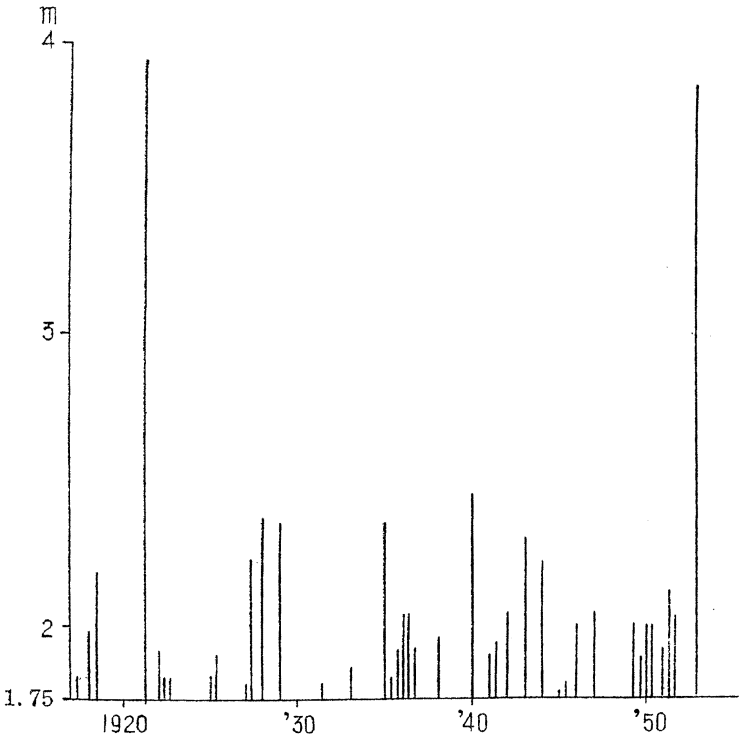

Fig. 1. *Frequency of high water at Kuma since 1917.*

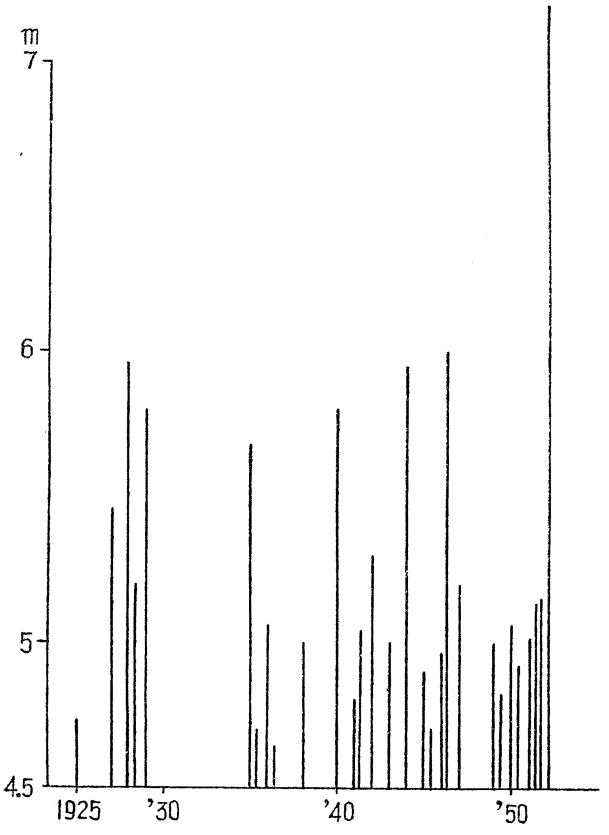

Fig. 2. *Frequency of high water at Shiwa since 1924.*

Next, the cases are divided with respect to time into seven periods having an equal length of ten years. The time required to rise or fall successive one metre is averaged to each period, and summarized in table 12.

From the examination into the tables the following results are obtained.

(1) At Kuma, Shiwa, and Tsukajima, the flood with lower peak stage has become frequent, meanwhile the frequency of floods with higher peak stage has remained almost unchanged (table 2, 4, 6); and at Taruho and Senoshita, frequency of floods has, in general, remarkably increased (table 8 and 10). Especially noticeable is that the maximun of peak stages at Kuma appeared in 1921, and, on the contrary, peak stages at the other stations of the flood of 1953 were higher than those of the flood of 1921.

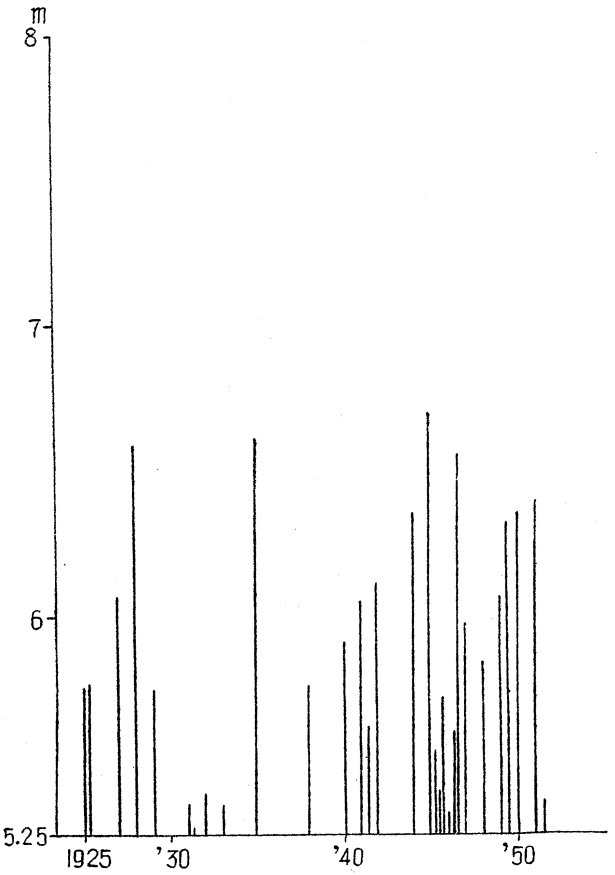

Fig. 3. *Frequency of high water at Tsukajima since 1924.*

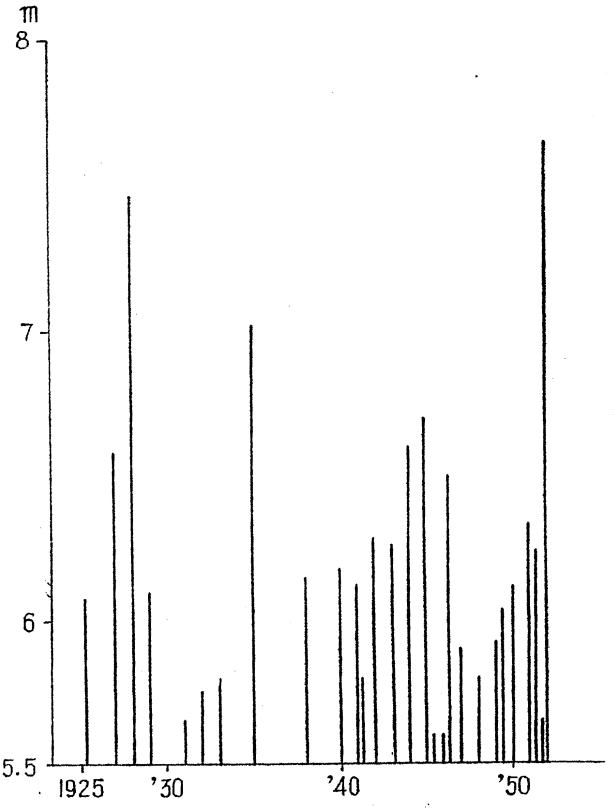

Fig. 4. *Frequency of high water at Taruho since 1924.*

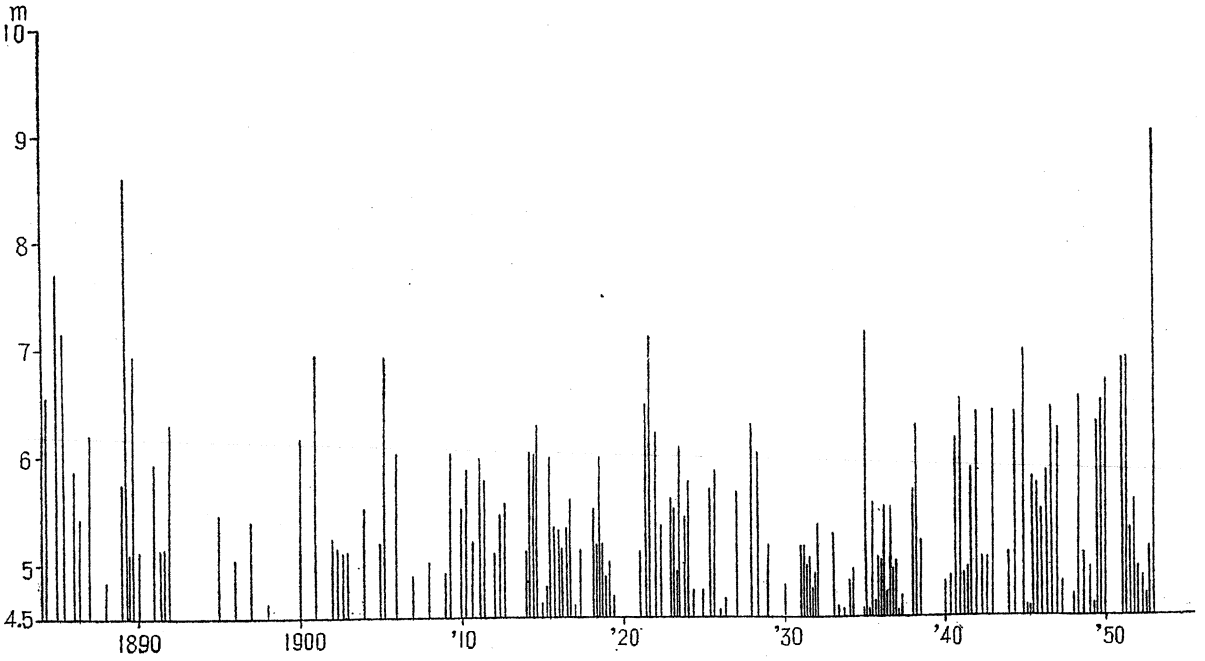

Fig. 5. *Frequency of high water at Senoshita since 1884.*

(2) The increase in rising and falling velocity of high-water stage has been conspicuous at Senoshita. This may be regarded as general on the whole stretch of the Lower Chikugo River, as such a tendency could not occur locally.

To talk over phenomena of river flow on the basis of hydrologic data, it is necessary to consider the reliability and accuracy of the data. As the writer uses here the data of river stage, he must, first of all, inquire into the datum of each gauge which may be shifted from its original position sometimes gradually by geological movement, sometimes abruptly by renovation works. In this case, information about the shifting of datum cannot be available; and he can assume indirectly that, if the datum had been shifted, the amount may be so small that it does not influence the result seriously.

Whereas hydrologic data obtained by routine works may include, indeed, some faults, the data used in this paper can be regarded as sufficiently reliable.

§ 4. CONCLUSION

The high water of the Chikugo River has become, with the lapse of time, gradually frequent on the whole stretch of the river, especially on the lower reaches.

The rising and falling velocity of high water at Senoshita has become remarkably increased.

ACKNOWLEDGEMENT

The writer is indebted to Professor Kōichi Aki and Assistant Professor Syôhei Inokuti for helpful criticisms and valuable suggestions relating this investigation. It must be noted with gratitude here that the writer has been subsidized by the Education Ministry with respect to this study.

Table 1. *Peak stages higher than 1.75m on the gauge of Kuma.*

Date	Hour	Stage (m)	Date	Hour	Stage (m)
Aug. 12, 1917	18	1.82	July 23,	12	1.92
June 16, 1918	4	1.97	June 14, 1938	17	1.95
July 12,	7	2.18	Aug. 11, 1940	13	2.45
June 17, 1921	15	3.94	June 27, 1941	16	1.90
June 20, 1923	11	1.91	Oct. 1,	17	1.94
July 5,	12	1.82	June 14, 1942	15	2.10
July 12,	15	1.82	Sep. 20, 1943	13	2.30
May 8, 1925	15	1.82	Sep. 17, 1944	13	2.22
June 26,	16	1.89	July 12, 1945	19	1.77
Aug. 6, 1927	9	1.80	Oct. 10,	24	1.80
Aug. 10,	21	2.22	June 22, 1946	8	2.00
June 27, 1928	1	2.37	June 24, 1947	12	2.10
July 5, 1929	19	2.35	June 21, 1949	9	1.75
July 6, 1931	15	1.75	July 5,	18	2.00
July 12,	19	1.80	Aug. 17,	20	1.88
July 25, 1933	21	1.85	Sep. 13, 1950	24	2.00
June 30, 1935	1	2.35	Sep. 16,	3	2.00
July 16,	7	1.82	July 10, 1951	12	1.92
Aug. 11,	7	1.75	July 14,	21	2.12
Sep. 24,	17	1.91	Oct. 15,	1	2.03
July 2, 1936	4	2.10	June 26, 1953	14	3.85
July 6,	16	2.10			

Table 2. *Frequency of high water at Kuma.*

Period	The number of high waters with the peak stage higher than			
	1.75m	2.00m	2.25m	2.50m
1919—1923	4	1	1	1
1924—1928	5	2	1	0
1929—1933	4	1	1	0
1934—1938	8	3	1	0
1939—1943	5	3	2	0
1944—1948	5	3	0	0
1949—1953	9	6	1	1
Total	40	19	7	2

Table 3. *Peak stages higher than 4.50m on the gauge of Shiwa.*

Date	Hour	Stage (m)	Date	Hour	Stage (m)
June 26, 1925	16	4.73	Sep. 17, 1944	13	5.95
Aug. 10, 1927	22	5.45	July 12, 1945	14	4.89
June 26, 1928	23	5.97	Oct. 10,	21	5.70
June 28,	21	5.21	June 22, 1946	9	4.96
July 5, 1929	20	5.80	July 8,	11	6.00
June 30, 1935	1	5.68	June 24, 1947	10	5.20
July 16,	7	4.70	July 5, 1949	17	5.00
July 6, 1936	17	5.06	Aug. 17,	22	4.82
July 23,	14	4.64	Sep. 14, 1950	1	5.05
June 14, 1938	18	5.00	Sep. 16,	5	4.92
Aug. 11, 1940	15	5.80	July 10, 1951	12	5.02
June 27, 1941	18	4.69	July 14,	22	5.14
Oct. 1,	18	5.04	Oct. 15,	2	5.15
June 14, 1942	16	5.30	June 26, 1953	15	† 7.20
Sep. 20, 1943	15	5.00			

† As the gauge was washed away by the flood, this height was estimated.

Table 4. *Frequency of high water at Shiwa.*

Period	The number of high waters with peak stage higher than					
	4.50m	4.75m	5.00m	5.25m	5.50m	5.75m
1924—1928	4	3	3	2	1	1
1929—1933	1	1	1	1	1	1
1934—1938	5	3	3	1	1	0
1939—1943	5	4	4	2	1	1
1944—1948	6	6	4	3	3	2
1949—1953	8	8	6	1	1	1
Total	29	25	21	10	8	6

Table 5. *Peak stages higher than 5.50m on the gauge of Tsukajima.*

Date	Hour	Stage (m)	Date	Hour	Stage (m)
June 26, 1925	22	5.50	Sep. 20, 1943	17	6.26
Sep. 18,	5	6.08	Sep. 17, 1944	16	6.60
Aug. 11, 1927	3	6.58	July 12, 1945		6.70
June 27, 1928	5	7.47	Sep. 4,	2	5.60
July 5, 1929	24	6.10	June 22, 1946	13	5.60
July 6, 1931	23	5.65	July 8,	14	6.50
July 11,	14	5.48	June 24, 1947	13	5.90
July 8, 1932	1	5.75	July 6, 1948	11	5.80
Apr. 26, 1933	11	5.80	July 5, 1949	20	5.92
June 30, 1935	11	7.02	Aug. 18,	1	6.03
July 16,	11	5.50	Sep. 14, 1950	9	6.12
June 14, 1938	20	6.15	July 10, 1951	14	6.33
Aug. 11, 1940	19	6.18	July 13,	16	6.24
June 27, 1941	19	6.12	Oct. 15,	4	5.65
Oct. 1,	23	5.80	June 26, 1953		† higher than 7.65
June 14, 1942	24	6.29			

† As the gauge was washed away by the flood, exact height was unknown.

Table 6. *Frequency of high water at Tsukajima.*

Period	The number of high waters with peak stage higher than				
	5.50m	5.75m	6.00m	6.25m	6.50m
1924—1928	4	3	3	2	2
1929—1933	5	3	1	0	0
1934—1938	3	2	2	1	1
1939—1943	5	5	4	2	0
1944—1948	7	5	3	3	3
1949—1953	7	6	5	3	1
Total	31	24	18	11	7

Table 7. *Peak stages higher than 5.25m on the gauge of Taruho.*

Date	Hour	Stage (m)	Date	Hour	Stage (m)
June 26, 1925	22	5.77	Sep. 18, 1944	17	6.36
Sep. 18,	6	5.78	July 12, 1945	21	6.71
Aug. 11, 1927	4	6.08	Sep. 4,	2	5.54
June 27, 1928	6	6.60	Sep. 18,	4	5.40
July 6, 1929	1	5.76	Oct. 11,	1	5.72
July 6, 1931	23	5.36	June 16, 1946	21	5.32
July 13,	1	5.28	June 22,	14	5.60
July 8, 1932	2	5.40	July 8,	14	6.56
Apr. 26, 1933	9	5.36	June 24, 1947	14	5.98
June 30, 1935	18	6.62	July 6, 1948	1	5.84
June 14, 1938	22	5.77	July 5, 1949	21	6.07
Aug. 11, 1940	18	5.92	Aug. 18,	2	6.32
June 27, 1941	21	6.05	Sep. 14, 1950	10	6.36
Oct. 1,	21	5.62	July 10, 1951	16	6.40
June 14, 1942	24	6.12	Oct. 15,	5	5.37
Sep. 20, 1943	18	6.10	June 26, 1953		†

† As the gauge was washed away by the flood, exact height was unknown.

Table 8. *Frequency of high water at Taruho.*

Period	The number of high waters with peak stage higher than				
	5.25m	5.50m	5.75m	6.00m	6.25m
1924—1928	4	4	4	2	1
1929—1933	5	1	1	0	0
1934—1938	2	2	2	1	1
1939—1943	5	5	4	3	0
1944 -1948	10	8	5	3	3
1949—1953	6	5	5	5	4
Total	32	25	21	14	9

Table 9. *Peak stages higher than 4.50m on the gauge of Senoshita.*

Date	Hour	Stage (m)	Date	Hour	Stage (m)
July 17, 1884	15	6.57	July 2, 1912	20	5.11
June 18, 1885	12	7.72	July 14,	7	5.47
July 1,	7	7.17	July 24,	17	5.56
July 8, 1886	7	5.89	May 21, 1914	6	5.11
Sep. 25,	15	5.42	June 21,	1	6.04
July 13, 1887	3	6.22	June 23,	1	6.02
July 3, 1888	19	4.82	June 25,	14	6.28
June 30, 1889	12	5.75	May 11, 1915	16	4.64
July 5,	19	8.62	June 11,	23	4.79
July 20,	24	5.08	June 26,	6	6.01
July 24,	21	6.95	Sep. 8,	22	5.35
July 7, 1890	2	5.11	June 27, 1916	7	5.32
June 23, 1891	5	5.94	July 10,	24	5.13
July 13,	22	5.14	July 11,	22	5.35
July 16,	5	5.15	July 13,	15	5.59
June 23, 1892	7	6.32	June 17, 1917	20	4.61
June 27, 1895	17	5.47	Aug. 13,	4	5.14
July 3, 1896	5	5.05	June 12, 1918	18	4.52
July 11, 1897	18	5.37	June 16,	11	5.50
June 4, 1898	24	4.61	June 26,	23	5.18
July 16, 1900	21	6.18	July 12,	23	6.00
July 16, 1901	4	6.96	Aug. 12,	21	5.19
May 9, 1902	19	5.23	Oct. 6,	15	4.88
July 20,	24	5.14	July 2, 1919	19	5.02
Sep. 8,	18	5.11	July 4,	21	4.70
May 19, 1903	11	5.11	June 16, 1921	19	5.11
June 26, 1904	1	5.53	June 18,	5	6.49
July 19, 1905	17	5.21	June 19,	4	7.11
July 27,	8	6.94	July 4, 1922	15	6.22
June 30, 1906	24	6.04	July 10,	19	5.35
July 11, 1907	11	4.89	June 17, 1923	18	5.62
July 16, 1908	20	5.02	June 20,	21	5.53
July 5. 1909	21	4.92	June 28,	3	4.94
July 13,	8	6.05	July 2,	5	6.09
June 17, 1910	3	5.52	July 5,	22	5.43
July 4,	4	5.37	July 12,	23	5.77
Sep. 7,	7	5.23	Aug. 25, 1924	1	4.75
June 16, 1911	1	6.00	May 8, 1925	22	4.75
June 28,	10	5.79	June 27,	2	5.67

Date	Hour	Stage (m)
Sep. 18, 1925	11	5.86
July 4, 1926	11	4.56
July 7,	20	4.66
Aug. 11, 1927	6	5.66
June 27, 1928	10	6.29
June 29,	7	6.02
July 6, 1929	2	5.19
July 7,	12	4.50
Aug. 13, 1930	20	4.81
July 7, 1931	1	5.17
July 11,	18	5.16
July 13, 1931	3	4.97
July 17,	15	5.05
July 21,	11	4.76
July 26,	22	4.90
July 8, 1932	6	5.36
Apr. 26, 1933	13	5.27
May 17,	2	4.59
July 26,	4	4.58
July 24, 1934	20	4.84
July 25,	21	4.94
June 24, 1935	17	5.09
June 30,	24	7.15
July 6,	14	4.54
July 16,	13	5.56
Aug. 11,	13	4.62
Sep. 25,	1	5.05
July 2, 1936	12	5.01
July 6,	22	5.52
July 8,	24	4.74
July 23,	20	5.52
Aug. 4,	1	4.94
Aug. 6,	23	5.02
Aug. 9,	24	4.51
July 28, 1937	18	4.70
June 14, 1938	4	5.69
June 15,	1	6.29
Oct. 4,	12	5.22
June 30, 1940	1	4.83
July 15,	2	4.88
Aug. 11,	19	6.17

Date	Hour	Stage (m)
June 27, 1941	23	6.53
July 7, 1941	24	4.92
July 10,	18	4.96
Oct. 1,	23	5.88
June 15, 1942	5	6.40
June 19,	1	5.04
July 2,	24	5.06
Sep. 20, 1943	21	6.42
May 11, 1944	12	5.10
Sep. 17,	19	6.40
July 12, 1945	18	6.98
July 17,	1	4.60
July 18,	7	4.57
Sep. 4,	6	5.80
Sep. 18,	6	5.72
Oct. 11,	6	5.72
June 16, 1946	18	5.51
June 22,	15	5.84
July 8,	18	6.45
June 24, 1947	15	6.25
July 19,	22	4.81
July 4, 1948	2	4.69
July 6,	3	6.54
Aug. 27,	4	5.09
June 2, 1949		4.95
July 2,		4.60
July 5,		6.30
Aug. 18,		6.50
Sep. 14, 1950	12	6.67
July 10, 1951	18	6.90
July 13,	18	6.90
July 20,	1	5.32
Oct. 15, 1951	6	5.57
June 23, 1952	14	4.94
July 3,	12	4.85
July 10,	2	4.69
Sep. 14,	18	5.13
June 26, 1953	17	9.00

Table 10. *Frequency of high water at Senoshita.*

Period	The number of high waters with peak stage higher than				
	4.50m	5.00m	5.50m	6.00m	6.50m
1884—1893	16	15	10	7	5
1894—1903	10	9	2	2	1
1904—1913	16	14	8	4	1
1914—1923	33	26	14	9	1
1924—1933	22	11	5	2	0
1934—1943	30	18	11	6	2
1944—1953	30	21	17	12	7
Total	157	114	67	42	17

Table 11. *The time required by high water to rise or fall every successive one metre at the Senoshita Station.*

Date	Time of rise within the gauge height (unit ; hour)				Time of fall within the gauge height (unit ; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.5	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
I.								
July 16, 1884				17	27	19		
June 15, 1885	4	5.5		12	25	28		
June 30,		7	8.5	9.5	18	18	16	
July 7, 1886		2.5	8			14	14	
July 12, 1887			9			14	13	
June 28, 1889		13	16			19	18	
	5	7	14	5.5	13	16	22	
July 19,	8	13		13		30	31	
July 20, 1891		7	7.5			19	19	
June 21, 1892	1	2.5	11			13		
Average	4.5	7.19	10.57	11.4	20.75	19.00	19.00	
II.								
June 25, 1895	1.5	5.5				18	12	
July 15, 1900		4	12			19	31	
July 14, 1901				16	13	17	21	
Average	1.5	4.75	12	16	13	18.00	21.33	
III.								
July 26, 1905					23	20	20	

Date	Time of rise within the gauge height (unit; hour)				Time of fall within the gauge height (unit; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.5	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
June 30, 1906		3	4			24	17	
July 12, 1909		4	5			13	16	
June 15, 1911	2.5	2.5	6			14	15	
Average	2.5	3.17	5.00		23	17.75	17.0	
IV.								
May 21, 1914	3.5	3					14	
Aug. 25,	5							7
Apr. 28, 1915	4							
May 11,	4	4					12	
June 11,	3	7					14	
July 5,	5							15
Sep. 8,	2	2					15	
Oct. 26,	6							
June 27, 1916	5	3						
June 17, 1917	2.5	5.5						
June 30,	3	9					14	
July 7,	8							18
Aug. 13,	4	2				11		
June 12, 1918	2.5	5						
June 16,	3	2	6			19	16.5	
June 24,	4	8						
Aug. 12,	2	2					13	
Sep. 14,	3.5							11
Oct. 6,	4	5						
June 22, 1919	4							11
July 2,	2	4					17	
Sep. 10,	6.5							
June 28, 1920	2							
Aug. 18,	3							
Apr. 25, 1921	3.5							11
July 9,	1.5							12
Aug. 1,	2.5							9
	2.5							16
Sep. 13,	4							17
June 27, 1922	4						12	
June 17, 1923	3	3	5.5, 6			13		
June 2,	4	5, 4	5			14	11	
July 7,		2				16		

Date	Time of rise within the gauge height (unit ; hour)				Time of fall within the gauge height (unit ; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.5	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
July 12,		5	11					
Total	116.4	80.5	33.5			73	164.5	127
Average	3.64	4.24	6.70			14.6	13.7	12.7
V.								
June 16, 1927	3							
July 7,							16	
Aug. 6,	2						11	
June 25, 1928	4						16	
July 18,								20
Aug. 30,	3						9	
Sep. 29, 1929	6							
May 3, 1930	4							
Aug. 13,	2.5	8					14	
July 7, 1931		3					20	
July 11,							20	
July 17,		4					21	
July 27,		7						
July 8, 1932							18	
Apr. 26, 1933		2					15	
May 17,		10					18	
July 26,							9.5	
Total	24.5	34					207.5	
Average	3.5	5.67					15.95	
VI.								
July 25, 1934		4					13	
June 24, 1935		3.5					11	
June 30,		4	13	18	14	21	19	
July 16,		2	4			11	12	
Aug. 11,							12	
Sep. 25,		2.5					16	
July 2, 1936		2					12	
July 6,		6.5	4			12	19	
		11.5					14	
July 23,		2	4			11	11	
Aug. 4,		8					11	
Aug. 6,		5					16	
Aug. 9,		5					13	

Date	Time of rise within the gauge height (unit ; hour)				Time of fall within the gauge height (unit ; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.5	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
July 12, 1937							13	
July 28,		6						
Sep. 11,							11	
Oct. 8,		5						
May 30, 1938		3	5.5			14	16	
July 7,							11	10
Oct. 4,		6					9	
June 30, 1940		4					10	
July 15,		3						
Aug. 11,			3.5			11		
Sep. 1,		6					12	
June 27, 1941		6	6		11		13	
July 10,		8						
Oct. 1,		2	2			10	13	
June 15, 1942		3	2			8	11	
June 19,		11					20	
July 2,		3					10	
July 3, 1943		4					10	
Sep. 20,		8	5			11	11	
Total		134	49		25	109	349	
Average		4.96	4.90		12.5	12.1	12.93	
VII.								
July 22, 1944		3					9	
Sep. 17		1	1			10	9	
July 12, 1945		1	1	3	8	9	13	
		5					10	
July 21,		4						
June 22, 1946			5			12	13	
July 8,		2	1	2.5	9	15	13	
June 24, 1947		4	2			10	11	
July 19,		3.5					9	
May 3, 1948	6							
June 15,	6							
July 1,	3.5							
July 6,		4					8	
		2	1.5	5	7	8	14	
July 6,		2.5	1.5	4.5	7.5	8	14	

Date	Time of rise within the gauge height (unit ; hour)				Time of fall within the gauge height (unit ; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.,	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
Aug. 27,		4.5					12	
Sep. 14, 1950			6	8	6	8		
July 10, 1951			6	4				
June 23, 1952		3					8	
June 27,							10.5	
Sep. 14,							11	
Total	15.5	39.5	25	27	37.5	80.0	164.5	
Average	5.17	3.03	2.78	4.50	7.50	10.0	10.97	

Table 12. *Average of the time required by high water to rise or fall every successive one metre at Senoshita. Figures in brackets mean the number of cases.*

Period	Time of rise within the gauge height (unit ; hour)				Time of fall within the gauge height (unit ; hour)			
	2.5—3.5	3.5—4.5	4.5—5.5	5.5—6.5	6.5—5.5	5.5—4.5	4.5—3.5	3.5—2.5
1884—1893	4.50(4)	7.19(8)	10.57(7)	11.40(5)	20.75(4)	19.00(10)	19.00(7)	
1894—1903	1.50(1)	4.75(2)	12.00(1)	16.00(1)	13.00(1)	18.00(3)	21.33(3)	
1904—1913	2.50(1)	3.17(3)	5.00(3)		23.00(1)	17.75(4)	17.00(4)	
1914—1923	3.64(32)	4.24(19)	6.70(5)			14.60(5)	13.70(12)	12.70(10)
1924—1933	3.50(7)	5.67(6)					15.95(13)	
1934—1943		4.96(27)	4.90(10)		12.50(2)	12.10(9)	12.93(27)	
1944—1953	5.17(3)	3.03(13)	2.78(9)	4.50(6)	7.50(5)	10.00(8)	10.97(15)	

REPORTS ALREADY PUBLISHED

Vol. 1

No. 1 Noboru TAKAGI and Morio ONOE: *Narrow-band Quartz Crystal Filters.* May, 1950

No. 2 Takashi SHODA: *Experimental Studies on Natural Ventilation.* August, 1950

No. 3 Hiromu SUZUKI: *Research on Back-tension Wire Drawing.* December, 1951

No. 4 Takeo TAKAHASHI and Koji KIMOTO: *Studies on High Viscous Alginic Acid.* January, 1951

No. 5 Yoshiaki YAMADA: *On the Theory and its Application of Two-Dimensional Plasticity.* February, 1951

No. 6 Norio TAKENAKA: *Studies on the Surface Roughness of Metals Finished by Cutting.* March, 1951

No. 7 Zenzaburo SAWAI: *Welding Mechanism of Resistance Welding and Determination of Welding Procedures.* March, 1951

No. 8 Humio TAMAKI: *Studies of Surface Heat Transfer based on the Boundary Layer Theory.* March, 1951

No. 9 Masao KATO: *Studies on Zinc-Base Die Casting Alloys.* March, 1951

Vol. 2

No. 1 Masayoshi OGAWA: *On Precision Screw Threads.* April, 1951

No. 2 Hideo ITOKAWA: *Methods of Measuring Aperiodic Pressure Variation with Special Reference to Vortices in Separated Air Flow.* August, 1951

No. 3 Masamichi HARADA: *On Longitudinal Strength of Wooden Ships.* November, 1951

No. 4 Atsushi WATARI: *On the Motion of Rotating Shafts* (In English). March, 1952

No. 5 Yoshio MORIWAKI and Hiroshi INOSE: *Band-pass Characteristics of Distributed-Coupled Circuits.* April, 1952

No. 6 Hiroshi KUBOTA: *Tables of the Interference Color* (In English). May, 1952

No. 7 Takeo FUKUDA: *On High-strength Alminium Alloy Members Used in an Erection Truss for Replacing Railway Plate-girders* (In English). June, 1952

No. 8 Hideo ITOKAWA, Kentaro SHIMIZU, Shozo OHNO and Akimi UJIIE: *Meter Indication of the Depth of Anesthesia* (In English). August, 1952

No. 9 Hideo ITOKAWA: *A New Method of Measuring a Small Displacement by Acoustic Impedance Change, with Applications to Profile Recorder and the Measurements of Vibrating Speaker-paper-cone* (In English). August, 1952

No. 10 Hideo ITOKAWA, Iwao YOSHIYAMA, Shozo OHONO, Iwao KANAZAWA, Marumi YONEDA and Akira URUSHIDANI: *Researches on the Amplification and Recording of Microvoltage Waves in very Low Frequency-Range, with Special Reference to Seiken-type Ink-writer and its Application to E. E. G. and E. C. G.* September, 1952

Vol. 3

No. 1 Hideo ITOKAWA and Chihiro KUMAGAI: *On the Study of Violin and its Making.* September, 1952

No. 2 Koji KIMOTO: *Studies on Technical Organic Analysis by Ceric Sulfate Method.* October, 1952

No. 3 Yoshio ANDO: *On the Structure of a Tentatively-built All-aluminium Boat.* March, 1953

No. 4 Yukio MATSUSHITA and Kazumi MORI: *A Study on the Properties and Reactivity of Molten Slags.* November, 1953

No. 5 Yoshio ISHII and Yuya YAMASHITA: *Studies on the Synthesis of Rlasticizers.* February, 1954

No. 6 Fujio TACHIBANA: *An Investigation of Cabinet Heaters* (In English). March, 1954

No. 7 Ken IKEDA and Bunji TOMITA: *On a new capacitance-type strain meter* (In English). March, 1954

No. 8 Yasuo TORIKAI and Fusao FUJIMORI: *Transmission of Ultrasonic Waves through a plane plate.* March, 1954

Vol. 4

No. 1 Osamu HIRAO: *On the Heat Dissipation of 4-Stroke Cycle Petrol Engines.* August, 1954

No. 2 Hiroshi INOSE: *An All-electronic Artificial Traffic Machine* (In English). October, 1954

No. 3 Eiji FUJIMORI: *Organic Fluorescent and Photosensitive Substance* (In English). February, 1955

No. 4 Kiiro KANAMORI, Mitsuru TATE, Chifu NAKANE, Toshio SATO, Tanekazu SOMA, Kazunori MAEDA, Shozo MATSUSE and Shin IZUMISAWA: *On the Bessemerizing Process in the Hearth of Blast Furnace.* March, 1955

No. 5 Morio ONOE : *Formulae and Tables, The Modified Quotients of Cylinder Functions* (In English). March, 1955

No. 6 Shin OWADA : *Research on the Mechanical Properties of Twisted wire Ropes or Cables* March, 1955

No. 7 Yoshio ANDO, Isao YAMAGUCHI, Kunihiro IIDA and Yasuho IMAI : *Effect of welding when superposed upon Prestrained Steel* (In English). March, 1955

Vol. 5

No. 1 Takakazu MARUYASU and Shun-Ichi MIZUNO : *Statistical Studies on the Method of Determing the Average Strength of Concrete for the Mix Design.* March, 1955

No. 2 Atsushi WATARI : *Dry Friction Damper and its Condition of Tuning* (In English) August, 1955

東京大学生産技術研究所報告　第5巻　第3号
通巻 第37号

昭和 30 年 8 月 20 日 印 刷
昭和 30 年 8 月 25 日 発 行

発行所　東京大学生産技術研究所
千葉市千葉局区内弥生町 1

印刷所　三美印刷株式会社
東京都千代田区神田多町2の7

この報告は不定期に発行し，累計およそ 300頁で巻を改める．

PUBLISHED AT IRREGULAR INTERVALS BY THE
INSTITUTE OF INDUSTRIAL SCIENCE, UNIVERSITY OF TOKYO
CHIBA CITY, JAPAN