水理学の最近の発達

By Dr. Ven Te Chow*

要　旨　本文は昭和 33 年 8 月 30 日関西支部主催の水理講習会で行われた Chow 博士の特別講演の内容であつて，その要旨はつぎのとおりである。

水理学における最近，とくに過去 10 年間の進歩はいちじるしく，その範囲も広いから，この問題の一般的な傾向を述べることは事実上不可能である。したがつて，ここでは最近の水理学の傾向および，とくに，いちじるしく発展した二，三の話題について述べよう。

水理学は理論と応用の二つの分野にわけて取り扱われる。すなわち，前者は理論的な流体力学の領域に属し，後者は前者の応用のみならず，その工学的な問題を取り扱う。いま一つ，水工技術者に親しいものは水文学であるが，工学的問題におけるこの知識の応用は非常に重要であり，一般に水工計画における基礎的な段階を形成する。ここでは，応用水理学および，その一部としての応用水文学について述べよう。

水理学の研究で重要なものは，（1）計測器利用における進歩，（2）理論の進歩，（3）模型実験，および（4）設計基準の決定である。

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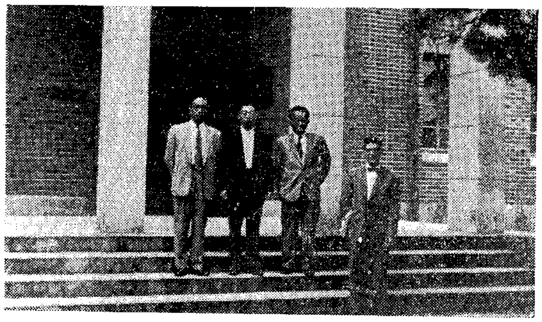

1．計測器利用における進歩　水理研究の進歩とともに発展した計測装置は，多方面にわたり改良されている。すなわち，Ott の流速計，磁場による流速測定，原子力平和利用計画における isotope の利用などである。isotope は地下水流，管流，河川の乱れの測定にすぐれたものであり，また米国工兵隊の電子管式積雪測定器に用いられている。水文気象学においてはレーダーが降雨量の推定に，また地下水文学では作為分極法が地下水資源探査に応用されている。

水理研究に最も重要な計測器は，電子管式計算機，すなわち analog 演算器，および digital 演算器である。analog 演算器は多くの水理学上の問題の解析に用いられ，日本でも発達している。また digital 演算器は，水理研究において使用され初めたばかりにすぎないが，ぼう大な労力と複雑な数式のために解きえなかつた多くの問題も解決されている。たとえば Ferranti 計算機は St. Lawrence 河水路計画の背水計算に，IBM-602 A は各種のサージング関係の計算に用いられ，驚くべき効果をあげている。洪水流のような複雑な不定流現象の解析も行われ，米国工兵隊では Univac 計算機を用いて，Ohio 河と Mississippi 河との合流点付近における洪水を解析し，Ohio 河については 13.5 日を要する計算を 6.75 時間で完了しているが，IBM-704 を用いると計算時間がさらに短縮せられ 1/15 になるようである。これらは水資源の計画をたてる場合にも有効であつて，英国の技術者はスーダンおよびエジプトにおける Nile 河の水資源開発計画を決定している。なお，IBM-650 が Columbia 河流域の洪水予報に用いられており，こうした計算機の利用は水理学および，水工学の分野で非常に広く，将来の発展はきわめて注目すべきものであろう。

2．理論の重要性　水理学の知識がとぼしかつた時代の水工設計は主として経験的であつたが，水理研究者は常に水理現象の基本理論について研究をすすめてきた。たとえば境界層や空洞現象の理論あるいは波の理論が発展し，地下水水理学では Theis あるいは Boulton の理論が提唱された。また開水路における不定流の理論は，Massau 以来，特性曲線法および近似積分法たる instantaneous regime 法によつて展開され，とくに近年多くの実用問題に対し驚くべき発展をしている。漸変流については，Bakhmeteff 以来その理論的進展がめざましく，また水面形状の解析には Poincare 以来の特異点の理論がある。また表面流出を取り扱う水文学では単位図法があるが，近年は linear operation の概念によつてすすめられている。

水理水文資料の確率解析に当つては，極限値分布の理論が洪水頻度の研究に用いられて以来，多くの理論が展開されてきたが，貯水池容量の問題には operation research における queuing の理論が適用せられ，貯水池

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計画における確率追跡法が可能となり，流入流出の種々の組合わせに対し，設計基準が具体的に示されるようになつた。なお，河川水理学，とくに土砂水理学においては種々の注目すべき理論が提唱せられ，実用化されてきている。

3. 模型実験の使用 水理研究における模型実験は，きわめて複雑で理論的解析のむづかしい問題の解決に必要であつて，土砂水理学，空気混入，排水・支配構造物および海岸構造物などの研究に広く用いられている。最近ヨーロッパやアジアの水理実験室でも，多くの港湾模型が作られ，海岸工学の進歩とともに研究が盛んになつている。海岸工学会議は 1951 年以来すでに 6 回開催され，その結果が議事録として出版されているが，米国では 1930 年に Beach Erosion Board が開設され，この分野の発展に大いに貢献している。これらの研究は多方面にわたつているが，“Hydraulic Research in the United States” および “Recherches Hydrauliques” にその状況が詳述されている。

4. 設計基準の決定 水工計画における設計基準は，構造工学関係にくらべると，かなりおくれている。水文気象学および水文学の進歩にともなつて，水工関係の設計基準も次第に合理的になつてきたが，主任技術者や政策担当者の判断にまつものが少なくない。最近 ASCE では，この基準を明確にするために，計画洪水および余水吐容量の決定法や，洪水資料の統計解析の精度について研究を進めているが，まだ十分な成果はえられていないようである。

以上は著者の考えの一部にすぎないが，この機会に人類の利益と福祉の増進のため，水の制御と利用の発展にたえず興味をもち努力を払つておられる皆様と知己になつたことを感謝する次第である。

【京都大学助教授　正員　**岩佐　義朗**　抄訳】

註：Ven Te Chow（周文命）博士は，ドクター・オブ・フィロソフィーの肩書を持つイリノイ大学教授で，上海交通大学を卒業後 1948 年渡米，ペンシルバニア州立大学大学院を卒業後，イリノイ大学土木工学科へ移り，助教授，準教授を経て 1958 年 9 月正教授となられた，本年 39 才の新進気鋭の学究である。最近のおもな業績には次のようなものがある。

1) Integrating the Equation of Grandually Varied Flow, Proc. ASCE., Sep. No. 838, Vol. 81, Nov. 1955
2) The Log-Probability Law and Its Engineering Apprications, Proc. ASCE., Sep. No. 536, Vol, 81, Nov. 1955

なお現在水理学に関する 8 年間の労作を著書として印刷中とのことである。

【原文は次ページ以下にあり】

書評

土木工学ポケットブック（JR 版）

土木工学ポケットブック編纂委員会編　オーム社　刊

最近の一つの傾向として，各工学の分野に応じ，ポケットブックまたはハンドブックが，さかんに出版されるようである。これは各工学の最近のめざましい発展と，細分化に応ずる一つの手段としてとられたものである。つまり土木工学の分野について考えれば，水，土，構造，材料等々の分野はそれぞれ専門的にいちじるしい発展をとげ，全般を完全に理解した上に立つて仕事を総合するように勉強してゆくことは非常に困難となつた。しかし土木工学の対象となる仕事は，これらの細分化したものを総合する技術をもつてはじめてよりよい形で完成されるとこが多い。このような現場に直面した人が具体的な形で把握できる総合された本が必要である。ポケットブックはある意味においてこのような要求に応じ，簡易にしかも正しい判断を与える指針が盛られたものでなくてはならない。この点が他の啓発を主とした著書との大きな相違点である。従つてその内容は時代によつて大きく変化してゆくものであつて，ただ現在では正しいと考えて実施される技術が具体的に説明されておれば，これらの要求が満たされたものと考えてよい。すでに土木学会からこの種のハンドブックが出版されているが，時代の流れとともに改訂されるべき時期に達し，その実行が着々と運ばれていることをきく（編集部注：34 年 12 月発行予定）。同じような目的をもつて出版された本書は土木学会出版のものとまた別の意味の編集方針で貫き，比較的その所期の目的を達しているものとみなされる。すなわち土木工学のすべての分野にわたつてはいないが，古くから分類されている分野にわたつて，具体的な例を比較的多くとりいれ，高い学力を有しなくても平易に理解できるように説明を施している。

ただここで述べねばならない一つの点を言うと，最近の技術の傾向からいうと，単に古い土木の分野だけでは解決できないものが多く，電気，機械，計測，物理，化学等の知識も必要である場合が多い。これらのうち接触の多い面について具体的に説明を加えてあれば，はじめてこうしたポケットブックの目的が完成される。その意味において他の分野での最新の知識を吸収し，さらに直面した問題に対して改良工夫する一つの示さを与える，といつた点では不満足であるが，手早く慣習に従つて問題を解決するにはよい座右の書であり，特に現場で働いている方々におすすめできる。

委員長：正員　沼田政矩・早大教授，以下執筆委員 36 名，幹事 2 名。A 5 判 1174 ページ，ビニール・カバー装上製箱入，定価 2 200 円，昭 33.11.15 発行。

RECENT DEVELOPMENT IN HYDRAULIC STUDIES*

*by Dr. Ven Te Chow***

Chairman, Ladies and Gentlemen: First of all I wish to thank you for your kindness of inviting me to visit this famous city and of asking me to deliver a speech at this important occasion. I should like to say that this is indeed a great privilege which I treasure considerably.

The director of your office, Professor Ishihara, has asked me to talk on the subject of the recent development in hydraulics and hydraulic engineering. As you know, the science of hydraulics has been progressing by leaps and bounds in recent years—particularly in the last decade. The extent of the progress is so vast that it is practically impossible to discuss even a general scope of this subject within a limited amount of time. Therefore, I shall restrict my discussion merely on the trend and on the few topics which are seemingly outstanding in the progress of hydraulic studies in recent years.

Like most branches of science, hydraulics may be treated in two categories: the theoretical hydraulics and the applied hydraulics. Theoretical hydraulics is in reality within the domain of theoretical fluid mechanics which is more or less an extended knowledge from physics. Applied hydraulics, however, deals with the application of theoretical hydraulics together with practical assumptions to the solution of engineering problems. Another science familiar to hydraulic engineers is the hydrology which is primarily a natural science dealing with the occurrence and behavior of water on earth. The application of this knowledge in engineering problems is becoming so important that it generally constitutes the initial steps in the design of a hydraulic engineering project. In the present discussion, I shall confine my discussion to applied hydraulics and include the applied hydrologic studies as a part of the applied hydraulic studies.

The important features in the trend of hydraulic studies to be discussed are: (1) progress in instrumentation, (2) emphasis of theory, (3) use of model studies, and (4) determination of design criteria.

Progress in Instrumentation New instruments developed for hydraulic studies are multifarious. Owing to new demands, many instruments of the old types have also been improved and refined. Let me just mention a few: A new design of the component runner for modern current meters manufactured by A. Ott in Kempton, Bavaria offers a great improvement in accuracy even in very turbulent and divergent channels. A new approach of measuring flow velocities by means of an electric field induced into the flow by a magnetic field offers least amount of interference with flow. With the availability of radioactive isotopes in the program of "atoms for peace," many otherwise impossible hydraulic measurements are being made possible. The isotopes are excellent tracers for the measurement of groundwater movement, flow in pipes, and turbulence in rivers. They also act as radiation elements, for example, in a new electronic snow gauging system developed by the U. S. Corps of Engineers.

In the realm of meteorological hydrology, or hydrometeorology, the weather radar is being utilized as a means to delineate precipitation pattern and to supply additional rainfall information for hydrologic designs. In groundwater hydrology, the effect of so-called "provoked polarization" created by introducing direct current into the ground has been found useful in prospecting groundwater resources.

By far the most important instrumental aid to hydraulic studies is the electronic computer. There are two main categories of electronic computers, namely, the electronic analog and the

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digital computer.

The principle of the electronic analog is to utilize the analogy between the flow of current in an electric circuit and the flow of water in a system. In other words, an electric circuit can be constructed with its circuit equation analogous to the hydraulic equation which represents the principle of the flow. Many hydraulic problems have been successfully solved by the analog, such as the routing of flood through reservoirs and river channels, the determination of flow pattern to a well or drain pipe and across a dike or dam, surge and water hammer problems, flow distribution in pipes and estuarine channels, etc. In Japan, for example, analogs for reservoir routing and stream flood routing have been recently developed by Professors Ishihara and Hayami of the Kyoto University.

A simple type of analog computeris the network ana lyser, which is capable of solving only linear equations and is thus applicable to the determination of flow distribution in pipes. For non-linear hydraulic problems, more complicated analog computers are necessary. Consequently, the design of an analog computer usually requires an advanced knowledge in electronic circuit engineering and the operation demands a special training on the part of the operator. Furthermore, the loss in the electric circuit of an analog is usually high and therefore may result in a relatively appreciable amount of errors in the computation if accuracy is required.

The digital computer is a device for the making of computations in digital form. As far as computation is concerned, it can do nothing more than ordinary desk computer. However, the digital computer is unique in the following characteristic abilities : to perform involved computations at a fantastic rate of speed, to be programed to follow a very long and involved series of computations, to store a multitude of intermediate results of separate computations for use in a later step, and to alter the course of computation according to the intermediate results obtained. In general, the digital computer has its specific qualities of high speed and automation. These qualities have brought forth a revolutionary impact which will be bound to produce far-reaching consequences in engineering studies.

The use of digital computers in hydraulic studies is just beginning. Already a sizable number of problems have been successfully solved. Many problems which defied a practical solution because of the unsurmountable amount of labor required in the ordinary way of computation or because of the complexity of the mathematical equations involved, have now been tackled by the digital computer. For example, a Ferranti computer did the work of about 50 men on the calculations of backwater curves in the hydraulic design of the St. Lawrence Seaway project. In the same project, an IBM-602 A was used to compute surges in tunnels and to calculate the speed of closing gates at Niagara to keep minimum surges. It took a month to set up the program for the computer to use in making the computations. Then, it took the computer only one day to carry out the computations.

Owing to the formidable mathematical difficulties the complete analysis of an unsteady flow of flood waves was considered for a long time as merely wishful thinking. Professor H. A. Thomas of the Carnegie Institute of Technology once said "In a large river with many tributaries, the movement of a flood wave is a phenomenon of such utter complexity as to defy complete and exact analysis by human beings." Now, with the use of digital computers, this impossibility is more or less becoming a reality. With the aid of the Univac computer, the U. S. Corps of Engineers has carried out computations of floods in Ohio and Mississippi Rivers and through the long Kentucky Reservoir. In the computation it took roughly a minute to compute the flow for an hour in the 375-mile stretch of the upper Ohio River, and about one-half minute for a flow of one hour either through the junction of the Ohio and Mississippi Rivers or through the 184-mile long Kentucky Reservoir. Thus, for a flow calculation of 13.5 days in the Ohio River about 6.75 hours of computer time were needed. However, the computers are being constantly improved and the operating speed is being greatly increased. If the much faster operating IBM-704, for example, were used, the time of computation would be cut down in the ratio of about 1 to 15.

The digital computer has been also found useful in the design and planning of water resources projects. In the last three years, the British consulting engineers have used the digital computer successfully with a great saving in cost for the planning of the Nile Valley water resources development. In this planning, it was required to know the adequate control of the Nile and its tributaries in order to provide the largest possible amount of irrigation water for the Sudan and Egypt. The method of solution was by trial and error, involving a tremendous amount of numerical data. The solution was made possible with the use of the IBM computers. Not only this solution was found to be rapid, flexible, and accurate, but the engineer responsible could see all the time exactly what could be happening in his planning.

Similarly, the digital computer IBM-650 was recently used by the U. S. Corps of Engineers, which has made possible a direct and objective procedure of flood-forecasting for periods up to 10 days in advance in the Columbia River Basin.

Other applications of the digital computer in hydraulic studies are many, such as the pipeline design computation, unitgraph computations, surge computations, etc.

There are various makers and kinds of digital computer. Whether or not a computer of high caliber should be applied to any specific problems should depend both upon the speed and accuracy required for the results as well as with the frequency the problem is performed. For small quantities of work involved in flood studies, for example, the U. S. Corps of Engineers has found that a part of the computation can be performed in a way much cheaper and more efficient by a portable computer, such as Burroughs E-101. For more involved situations, the use of larger computers are justifiable.

In general, the purpose of the digital computer is to perform complex mathematical equations and complicated analytical operations at tremendous speeds without the element of human error entering into the computations. There is no doubt that the use of digital computers in hydraulic studies is just gathering momentum and henceforth will be expanded extensively and indefinitely in the field of hydraulics and hydraulic engineering.

Emphasis of Theory Owing to the lack of knowledge on the hydraulic theories, early hydraulic design and analysis were largely empirical. In order to achieve economy and efficiency in modern hydraulic engineering works, hydraulicians have been constantly searching for the basic understanding of the hydraulic phenomena—that is searching for the theories to interpret the phenomena. Along with the progress in theoretical fluid mechanics, the hydraulics is benefited and leaning more and more on the theoretical basis to achieve sound rational procedures for analyses and designs. For example, the theory of boundary layer has been greatly advanced due to the rapid progress in the aeronautical and space engineering and this theory is therefore applied to the study of roughness and flow behavior in channels and pipes and around submerged bodies, such as bridge piers and abutments. Similarly, the theory of cavitation was investigated and applied to the study of hydraulic pumps, turbines, and siphons. Also, the theory of waves is being introduced extensively in the studies of tidal hydraulics and coastal engineering.

In groundwater hydraulics, the use of Theis' theory of nonequilibrium equation has been developed and applied to the unsteady flow condition in artesian wells. In the case of free-aquifer wells, however, the Theis' theory is not applicable, except as a very rough approximation, particularly in problems involving shallow aquifers and large drawdowns. Fortunately, a general nonequilibrium theory for free-aquifer conditions has been developed by Boulton and can be applied to practical problems.

The theory of unsteady flow in open channels has progressed tremendously in recent years, particularly with respect to its application to practical problems. In fact, the basic mathematical equations for the theory were set up by French mathematician Massau as long ago as 1889. It was until recently that these equations were giving practical solutions through the use of the method of characteristics developed by Henry, Bergeron, Khristianovich, Preiswerk, Levin, Craya, Holsters, Stoker, Dmitriev, and Lin, and the method of instantaneous regime developed by Oltjen, Reinecke, and Bernadskii. The method of characteristics is a method of finite approximations applied graphically to the soluton of the simultaneous equations set up by Massau. The method of instantaneous regime is a method of approximate integration of the Saint Venants differential equations. Both are numerical methods that can now be solved more readily by the use of the digital computer as mentioned previously.

In the gradually varied flow in open channels, the theory using varied flow function originally developed by Bakhmeteff has been greatly improved. For high accuracy, a numerical integration was used in the analysis of flow in circular conduits by the engineers of the Chicago Bureau of Public Works. Again, this method of numerical integration can be readily adaptable to conduits of any shape by means of the digital computer.

Another development for the analysis of flow profiles in channels is the method of singular point. The mathematics of this method was originally developed by Poincare and then applied to the problem by Masse. Renewed interest in this method for new and extended application is being developed by Hamma, Escoffier, and Lazard.

In applied surface water hydrology, the theory of unitgraph has been greatly advanced since Sherman first proposed it in 1932. In the new theory the concept of a linear operation is introduced, as the same concept is being used in other branches of engineering, such as servomechanisms and the analysis of electrical networks. The assumption of linearity implies that the resultant runoff hydrograph due to several rainfall durations is simply equal to the sum of those hydrogaphs due to each duration. Consequently, any hydrograph may be considered as the sum of all hydrographs due to an instantaneous duration multiplied by the effective rainfall intensity for the given duration. The hydrograph due to an instantaneous duration of unit volume of effective rainfall is known as the instantaneous unitgraph. In operational mathematics the response of a system to a very short period of unit volume is known as the indicial response of the system to unit impulse. By analogy, thus, the instantaneous unitgraph corresponds exactly to the indicial response; and according to the operational mathematics, the resultant hydrograph defined above can be expessed by a so-called DuHamel's integral.

In the probability analysis of hydraulic and hydrologic data, the Fisher-Tippet theory of extreme-value distribution was first introduced to the study of flood frequencies by Gumbel and further extended to other problems. In parallel to this theory, the theory of logarithmic normal distribution and the theory of partial duration series were also developed and applied to hydrologic frequency problems. In the meantime, many hydraulic and hydrologic engineers have also attempted to use the non-parametric distribution in their probability problems. For the theoretical soundness of the definition of recurrence interval, a new definition has been proposed by Thom of the U.S. Weather Bureau. The new definition calls for a distribution of the actual recurrence interval instead of the distribution of the magnitude of the statistical variable, whereas the recurrence interval in ordinary sense is in reality an average all the recurrence intervals.

The probability theory is also being introduced to the solution of reservoir storage problems. This is a method first recognized by Moran in Australia and then proposed by Langbein of the U. S. Geological Survey. The method is based on analogies of the amount of holdover storage for regulating streamflow with queues and thus utilizes the queuing theory developed in the new science of "operations research." A queue is a waiting line. The impounded water behind a dam is apparently a queue waiting for going through the control gates or openings.

According to the queuing theory several important characteristics are to be recognized, which can be used to describe water storage. The arrival rate is a characteristic to describe a frequency or time distribution of the arrivals, the demand for service, or in the case of reservoirs, the inflow. The characteristic of so-called "queue discipline" refers to the rule establishing priority of offering service to those in the queue. A simple rule is that first come, first served. However, special rules may be set up or observed according to the necessity, such as that emergency cases get quicker attention of the doctor than an ordinary case of illness. In case of a reservoir, any cubic foot of water is usually as good as another, but selected drafts may be required from different levels because of a specific requirement in temperature, turbidity, or salinity. Another characteristic is the "service function" which defines the rate of service of items in the queue. This is a control like a traffic light or cop on the flow of traffic in time sequence. The service function in a reservoir is the control gate which regulates the outflow according to the demand and storage. The characteristic of "attrition rate" is the rate of deserting the queue. In general, persons may depart or refuse to join a queue if the line is too long. The attrition rate depends on the nature of service. A line waiting for service at a ticket office in front of a theatre, for example, may be very long if the show is supposed to be of an excellent quality. If the show is bad, the queue may not be formed at all. Similarly, in the case of a reservoir, the impounded water particles may leave the reservoir, say through the process of evaporation, if the waiting time is too long.

By the queuing theory, reservoirs are classified according to the characteristics described above. The theory enables the use of a mathematical procedure of the so-called "probability routing" in the design of storage reservoirs. The probability routing eliminates the assumption of an initial storage as required in a conventional procedure, such as the mass curve method. It is non-parametric or independent of the initial frequency distribution of the flow. Furthermore, the probability routing automatically assures that all possible combinations of inflows and discharges are reflected in the results and avoids the selection of a combination from an infinite array. The method furthermore gives a design criterion on the basis of uniform risks so that a critical period for storage design is not necessary.

In the field of river hydraulics, various theories have been proposed, particularly in connection with sediment and sedimentation and mostly in the empirical nature. Notable theories such as Lacey's regime theory, Einsten's bed-load function, and Leopold-Maddock's hydraulic geometry, are being tested, verified, and modified for practical applications.

Use of Model Studies The use of models for hydraulic studies is necessary for problems which are extremely complicated and unamenable to theoretical analyses. Most of the problems are of three-dimensional nature and rapidly varied with respect to time and space. Frequently they involve uncertain amounts of turbulence and irregular configuration of boundary. Examples of these problems are sediment and sedimentation; air entrainment; and various drainage and control structures and coastal structures.

In the United States, with the rapid development of highway, agricultural, hydropower, and flood control programs, many drainage and control structures of various kinds have been investigated by model testing for the purpose of achieving high standards of design for efficiency and economy. Notable recent studies are different designs of spillway and sluices, flow through multi-opening constrictions in open channels, flow through culverts, and scour at bridge crossings.

During my visits in recent years to many hydraulic laboratories in countries in Europe and Asia, I found that a great number of harbor models have been built for hydraulic studies. Such studies are no doubt greatly stimulated by the recent progress in the field of coastal engineering—particularly on the subjects of density currents, beach erosion, and tidal hydraulics. In 1951, the first conference of coastal engineering sponsored by the Council on Wave Research of the Engineering Foundation took place at the University of California. Since then proceedings of six such conferences have been published, reporting various hydraulic studies of the subject. Since the Beach

Erosion Board was created in 1930 by the U. S. Department of Army, studies in coastal engineering have become very active, particularly in recent years. Results of such studies are currently reported in various technical memoranda issued by the Board.

In general, hydraulic studies by model are numerous and diversified. Current activities, however, are generally given in the annual issues of "Hydraulic Researches in the United States" published by the U. S. National Bureau of Standards and in the annual issues of "Recherches Hydrauliques" published by the International Association for Hydraulic Research.

Determination of Design Criteria The question of design criteria in hydraulic works is not as well settled as in the case of other kinds of structural works because the amount of water to be handled by a hydraulic structure is in many cases uncertain and speculative. In the early days, the design criteria for hydraulic works were purely empirical, depending on personal judgement and experience, and on some untreated historical record.

As the science of hydrometeorology and hydrology progresses, statistical analysis of hydrologic data and hydrometeorological determination of storm models have been developed. These methods are applicable to large watersheds where data are available for the analyses. The results of such analyses serve an index for design purposes which is evidently far more rational than empirical rule of thumb. The adoption of a certain index for the design, however, is still to be decided by the senior engineer or the policy maker. In the case of small watersheds, adequate data for the analyses are generally lacking. By the knowledge at the present time it is practically impossible to correlate the rainfall frequency with the runoff frequency so that the latter can be derived from a given set of rainfall data. Several methods have been attempted, but none has yet been found satisfactory.

Owing to the need of a more clear understanding of the hydraulic design criteria, the American Society of Civil Engineers is recently recommending an investigation and report on current practices and recommended standards of practice for the following items : hydrologic considerations, policies, and methodology for determination of design flood flows; policies, criteria, and methodology for determination of spillway capacities in relation to design flood flows; and adequacy of statistical analyses of hydrologic data pertinent to flood flows.

It is apparent that the determination of design criteria is not only one of the old and urgent problems, but also one of the most difficult problems in hydraulic studies. Much effort has been done, but little result has yet been achieved.

Because of the limitation in time, I cannot extend my discussions further. The discussions that have been presented represent only the fragments of my thoughts which I have gathered most of the time in the airplane travelling half way around the world.

In conclusion, I wish to add that I consider this occasion not merely as a privilege to deliver a speech but also as a pleasure to get acquainted with the members of this group. I feel particularly happy with this group because I believe that all of us are deeply concerned with a common cause— that is to utilize the gift of Nature for the benefit of mankind and for the promotion of humanity and human welfare. This gift is our ability to control and use the water. To develop this ability depends largely on our interest and effort in hydraulic studies.

准員の全面的な正員への転格について

すでに発表致しましたとおり，土木学会定款の一部変更にともない，現在の准員各位は，来る3月31日付をもつて，自動的に正員へ転格が行われますから御諒承下さい。

会費は4月1日以来一律に年額 1 000 円となります。従つて論文集は 62 号（5月10日発行予定）より年間6回にわたり配付いたします。名誉員，特別員，賛助員，学生員は従来どおりであります。
