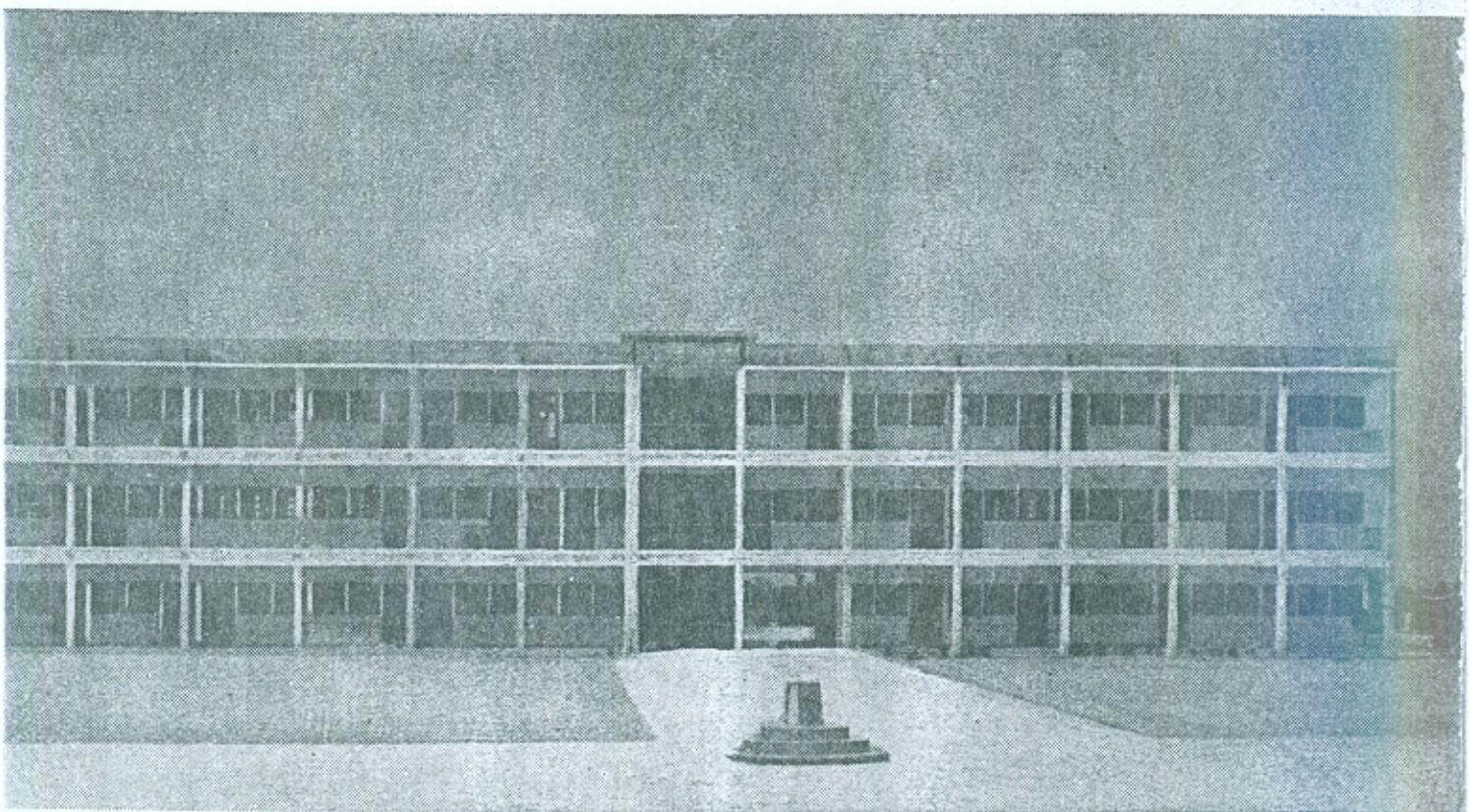
ENGINEERING NEWS

Vol. 15 • No. 1 & 2 MARCH - JUNE, 1970



Quarterly Journal of the West Pakistan Engineering Congress, Lahore

FIFTEENTH YEAR OF PUBLICATION

ENGINEERING NEWS

Quarterly Journal of the West Pakistan Engineering Congress

Vol. XV MARCH-JUNE 1970 No. 1 & 2

In this issue

Page

Salute to New Provinces
—*Editorial* 3

West Pakistan Engineering Congress, 51st Annual Session, 1970 5

Abridged Address of the President of Engineering Congress 8

Election of New Council for the year 1970 13

Introduction—Mian Alim-ud-Din PSEI, *SQA, SK* the New President of West Pakistan Engineering Congress 15

Introducing S. M. Ayoob, PSEI, new Editor-in-Chief, *Engineering News* 17

Foundations of Hydraulic Structures in Relation to Under Seepage and Uplift
—*Shafaat Ahmad Qureshi* .. 19

Culvert with No Afflux
—*Gordon R. Mckay* 36

Crushing Strength of Concrete made from Locally Expanded Clay Aggregates
Ashfaq Hasan, Abdul Qayyum and Mohammad Gulzar Ahmad .. 39

Thermal Insulation of Buildings
—*Shaukat Ali* 50

Memorandum on Class-I Status for Graduate Engineers in West Pakistan
Issued by the Punjab Gazetted Engineers Association 68

Book Review 75

• All communications should be addressed to the Editor, *Engineering News*, P W.D. Secretariat, Lahore (W. Pak.)

• Price Rs. 2.50 per copy. Rs. 10.00 a year in advance. Free to members of the West Pakistan Engineering Congress. Change of address should be intimated promptly giving old as well as new address along with membership number.

• Contributions to this journal in the form of articles, news of engineering works, news about engineers, photographs and technical data etc. are cordially invited.

• Reprints from this journal be made on condition that reference is given to the *Engineering News*, its Vol. No., and the author.

• West Pakistan Engineering Congress is not responsible for any statements made or opinions expressed in this journal.

• Advertisements are accepted at the following rates :—

	Rs.
Back Cover, Outer Page ...	300
Front Cover, Inner Page ...	250
Back Cover, Inner Page ...	200
Ordinary Full Page ...	100
Half Page ...	60

Price of this Issue : Rs. 5.00

BOARD OF EDITORS

S. M. AYUB (*Editor*)

ASHFAQ HASAN
AFZAL ZAFAR
MAZHARUDDIN
M. H. BOKHARI
SH. MOHD. SADIQ (*Staff*)

TITLE COVER

A view of the newly constructed Building, Research Station, built near University Campus, Canal Road, Lahore. The building which is adjacent to Road Research Institute was completed at a cost of Rs. 5.5 lacs. The research campus comprises of 25 acres of land.

Printed by Mirza Muhammad Sadiq at Ripon Printing Press Ltd., Bull Road, Lahore.



SALUTE TO NEW PROVINCES

When the morning breeze of first of July kissed the buds to awaken them to new life of bloom, the moving finger has already started writing a new chapter of our national history. The four Provinces of West Pakistan regained their identity. The traditional flute of 'Ranjha' was once again vibrant with the warmth of Punjab's breath ; the rugged mountains of Frontier echoed the rhythmic beats of drums accompanying the youthful Khattak dance ; Sind, the seat of oldest human civilization, the land of mystic poets, was fragrant with devotional songs of Shah Bhitai and the barren vastness of Baluchistan had rediscovered the footprints of the missing 'Sassi' on the sands of time. The Caravan has turned another corner on way to new accomplishments.

We lived with the administrative unity of West Pakistan for fifteen years. What are fifteen years in the span of a nation's life—just a speck of fleeting moment. But we have not lived together merely for this fleeting moment. The bond is eternal—from the dawn of history to the twilight of existence. The administrative unities are mere expediencies ; the real unity lies in the hearts and that is there beyond all passing conveniences of making or unmaking of One Unit. Our faith, our culture, our history and above all our political geography has moulded us as one ; our joys and tribulations

are one and our hearts are moulded to react alike for the common anguishes and sorrows.

We welcome the re-emergence of new Provinces. This was the desire of the people and must have been fulfilled. Many of the stresses and strains will disappear. The nation will evolve new vigour and vitality for its onward march to common goals of progress, prosperity and social justice. The awareness of this common objective is basic to our unity. The developmental resources are common. Indus with its tributary rivers is the common lifeline which winds its way through the contiguous strip of land. This is an integrated system wherein you cannot move a finger without moving a star somewhere. Let us enunciate our consciousness that whatsoever be the politico-administrative dispensation of this wing of country, we cannot eliminate mutual dependence for economic development ! In point of history we have moved through period of economic integration. Only at our peril we can ignore the interlinked river system, the common power grid, the network of railway roads, telecommunication and gas supply.

On engineers rest a great responsibility in the wake of coming into existence of new Provinces. They are the people to manage and operate these ingredients of economic development. There are bound to be conflicting demands of various regions to share these vital and scarce resources. It is for the engineers to rise above parochial considerations and to bring to bear on these issues a broad national outlook and impartial technical considerations. We have created common base of technology and it is easier to talk on this wavelength rather than the discordant humming of slogans and rhetorics. If we, the engineers are conscious of our onerous responsibility, we can be the better agents of harmony and national solidarity. National unity and integration is no longer the outcome of mere sentimental slogans. People are getting growingly conscious of economic development and soical justice. No region, no group of people, no individual is to groan under a sense of deprivation and to suffer disparity. Let us pledge to create national unity through technology. God has given us everything, fertile stretch of land, brimful of rivers, abundant sunshine and above all finely carved human resources. Let technology be the common base to bring the fruits of abundance and better living at the doorstep of everyone.

West Pakistan Engineering Congress

51ST ANNUAL SESSION, 1970.
27th March—2nd April, 1970.

The Annual Session of the West Pakistan Engineering Congress was held from 27th March, 1970 to 2nd April, 1970, at the Panjab University Hall. Lt. General M. Atiqur Rahman, H.Q.A., S.Pk., Governor of West Pakistan, inaugurated the session. Sh. Ahmad Hassan, President West Pakistan Engineering Congress read an address of welcome and briefly outlined the activities of the Congress and of the various Engineering departments. First one and a half day was devoted to discussion of seven technical papers. The afternoon session on 28th March 1970, was devoted to symposium on Water Resources development. The abstracts of technical papers and the symposium of this session have already been printed in the previous two issues of the Engineering News. In this Issue an abridged address of the President of the Congress, and the reply of the Governor of West Pakistan are reproduced. Lt. General M. Atiqur Rahman addressing the forum of Engineers remarked:—

I am very pleased to be asked to attend the Annual Session of this august body and inaugurate its deliberations. I am also grateful and honoured by the opportunity to meet so many eminent Engineers and to be able to address them on some matters of vital importance to the nation.

The Annual Session of this Organization, spread over the last 50 years or more, has proved to be an excellent forum for disseminating the experience, knowledge and achievements of able and eminent Engineers. It must be a source of great pride for you, the Engineers of West Pakistan, that you have developed your profession in an atmosphere of mutual discussion and regular exchange of techical knowledge at this forum.

In the sphere of learning, progress is only possible if continuous opportunity is available to individual talent to express itself. The platforms of professional societies such as this one, meet an important requirement in the march of progress. Such societies are a repository of the collective knowledge of a profession and impart a sense of achievement and brotherhood to its members. I am happy to learn that the Engineering

Congress is playing a dynamic role in this connection, and I cannot help complimenting the members on keeping up the Congress tradition in a steadfast manner. Very few learned bodies can boast of such a record of useful existence.

Gentlemen, by the very nature of things, developing countries provide the greatest challenge for the labour and genius of Engineers. Mr. President, you have rightly pointed out that the Engineer transforms his knowledge of Science and Mathematics into projects that benefit humanity. It is this role of the Engineer to transmute the abstractions of Science into concrete purposeful realities to serve human needs that makes the Engineer, the most-sought-after professional in a developing society, and rightly so.

If we look at the world around us, it gives us an idea of the important role that Engineers are playing and have to play. The developing countries—and Pakistan is among them—are seething with expectations to fulfil their dreams of a better living standard by conquering hunger, disease and ignorance. The national freedom movements had promised the common man to translate these dreams into material reality. This obligation is to be met to a large extent by the efforts of Engineers who have to play the vital role of harnessing and harmonizing the latent forces of nature and developing material resources to meet the basic human wants—of food, fibre and shelter. The Engineer has to be conscious of this responsibility. In order to be able to serve this cause and his people, he has to work with honesty and devotion. In this connection I would also like to stress the ever-growing importance of Research at all levels.

At the present juncture of our national history, we are caught up in a number of fast-moving events. We are preparing to take certain steps which are bound to have a far-reaching effect on the entire society in the country. I refer to the decision taken by the present regime to restore Democracy in this country.

Democracy is not merely a system of holding elections : it is a way of life. The authority of State rests with the elected representatives of the people. The people, acting through their elected agents, are the custodians of national resources and they are the ultimate decision-makers in all national affairs. They will provide funds for your schemes and will determine priorities for your projects. They are the link between the felt needs of the common man and your technical skill.

Here I must also underline the necessity of mutual comprehension between the technical expert and the layman who is acting on behalf of the people. The Engineer must learn to be intelligible for the non-technical. His arguments should be as convincing to the layman as they are sound from technical considerations and he should be ready to submit to the final authority of the elected representatives in all policy decisions.

One more thing that the Engineer in this country has to remember is that it is his duty to improve himself constantly, so that the product of his professional skill commands respect and admiration and does not give rise to adverse comments and distasteful inquiries. He should be able to feel proud of what he helps to build : whether it is a huge Dam or a small dispensary. He should be able to hold his head high and say : I am responsible for this. You cannot find fault with it. This pride and confidence can only be generated by faith in one's own

ability and respect for principles of honesty, integrity and complete devotion to duty. I visualise this forum to be the jealous guardian of these principles and also for upholding the highest traditions of the profession. As in any walk of life, there are bound to be some people even in this profession who are likely to err. It is the sacred duty of this forum to ensure that these few individuals do not sully the fair name and the high traditions of the profession.

Gentlemen, in the context of coming events, I must also refer to the decision to restore the pre-Integration Province in West Pakistan. In accordance with the wishes of the people of various Provinces, several of the functions of Planning, developing and managing the material resources which were hitherto performed at one place will be decentralized. Nature has carved this vast region of West Pakistan in such a way that the various Provinces will not be able to eliminate mutual dependence in the use of resources like water, gas, communications, etc. Many of their problems spring from common causes. As technical advisers, a great responsibility would rest on you to bring to bear a nationalistic and patriotic outlook on the solution of these problems. Given the desire for good-will and harmony, no problem can defy solution. After all, the new Provinces will just be convenient geographical divisions ; otherwise the people remain at heart as always a single and unified Nation. The losses and gains are common.

Mr. President, you have hinted at a number of problems of the Engineering Services and the profession. I can only say that the Government is fully aware and conscious of these problems. As you yourself have quoted on the authority of the President of Pakistan, the Government has already set up Committees to find solutions to these fundamental problems. There cannot be two opinions that all the issues causing concern to the members of the Engineering profession must be resolved speedily. In the context of our problems, no Government can ignore the demand to create conditions conducive for the professionals to render maximum service to the cause of the Nation. Reorganization of the Service structure should be able to redress many of the grievances commonly spelled out by most of the Services. For the specific problems of Engineers, the Provincial Government would see that the Committee seized of the matter is given full assistance and urged to complete its task as early as possible.

Gentlemen, I thank you again for inviting me here this morning. I feel great pleasure in inaugurating this Session. My good wishes are with you, and I hope that the Nation and the Engineering profession will profit from your deliberations.

Abridged Address of the President of Engineering Congress

Sh. Ahmad Hassan, President of West Pakistan Engineering Congress, addressed the Governor, distinguished guests and members of the Engineering Congress:

"It is a matter of privilege and great honour for me to welcome you all here this morning. We are particularly grateful to you, Mr. Governor, for accepting our invitation to inaugurate this 51st Session of the West Pakistan Engineering Congress. Your presence with us, Sir, reflects your interest in the development of the Engineering profession and in the welfare of the Engineering services in West Pakistan. We could not hold our annual session last year as the country was in turmoil. However, with the return of normality and the welcome announcement by the President of Pakistan for the restoration of democracy, we are now able to hold our session.

During the course of development, every organization builds its own reputation and its own conventions and traditions. This Engineering Congress, founded in 1912, is the most representative body of the Engineers in this wing of the country, and has acquired a unique position in matters connected with the promotion of our engineering effort. The Congress, with a total membership of over 1,000, represents engineers from almost all the Engineering Departments and autonomous bodies under the Government of West Pakistan in the public sector and professional men from most of the eminent engineering institutions in the private sector. Through its Annual Sessions, the Congress has regularly afforded the engineers with an opportunity to discuss national engineering issues, problems of mutual interest, recognised research problems in related fields, and has disseminated knowledge for improving the general engineering standards in West Pakistan. The proceedings of the Annual Sessions are regularly recorded in a conference volume which is a welcome addition in most of the engineering libraries.

Engineering is not merely a science but a profession. An engineer transforms his knowledge of Science and Mathematics into projects that benefit humanity. A past President of this Congress summed it well when he said that the engineer is, in fact, the link between abstract knowledge and the hard

facts of life, between man and his needs. "Engineering is a symbol of continued human effort of marching towards its ultimate goal by conquering the forces of nature. Of necessity, then, the engineer as an educated Professional man must be deeply concerned with the impact of his work upon society. He must develop social consciousness as well as engineering competence. While it is not possible that the engineers have a complete mastery of all the related professions and disciplines; it would indeed be helpful if they developed an appreciation for the non-technical problems of society, a sense of professional responsibility and the capacity to effectively communicate and reason in non-technical terms."

Sh. Ahmad Hassan further observed:—

"Although engineering is one of the oldest professions, yet when considered against the ever-broadening frontiers of knowledge and technology, it could still be considered in its stage of infancy. Today, the problems of engineering have assumed a space dimension harnessing of the water resources of this earth for human consumption and usage, the development of power potential for mechanising agriculture and promoting industry, the erection of a network of highways and railroads, inland waterways, seaways and airways, the establishment of a foolproof system of communication on this globe and in space, the subjection of nuclear energy for peaceful uses, the culmination of man's desire of a trip to the moon and preparation for his space effort to reach the Mars, are only some of the fields where the engineer has to operate in one position or the other to make them a success. Thus, the Engineer's day is just dawning and he is thrown with a colossal challenge to face and find solutions to the problems of today and tomorrow. This challenge has been heartily accepted by the engineers of West Pakistan. While in some fields like the network of canal irrigation, West Pakistan is an example of engineering feat to the other countries in the world, it has also stepped into the field of nuclear energy where it had lagged behind in comparison to the more developed nations of the world. The Karachi Nuclear Power Project is one example which will bring 137 megawatt of nuclear power to West Pakistan and the rich experience acquired from this Nuclear Reactor will be utilised in training more and more men for handling similar nuclear projects in this country. But this pace of his movement into the areas of a relatively new science could be accelerated only if the engineer received appropriate encouragement from the society and the Government he serves."

Touching on the subject of unemployment of Engineers, he remarked,

"Self-reliance in the use of technological advancements is basic to the preservation of national independence. This can only be brought about by producing a large group of zealous, vigorous and aggressive seekers of technical knowledge. It is not sufficient merely to produce scientists and engineers but it is equally fundamental that such persons are productively and usefully employed. It is, unfortunately, a hard reality that trained engineers are going or trying to go abroad on a large scale to find jobs in other countries, when Pakistan is in a crucial stage of development and needs more and more of its trained and skilled men to build it.

"In my Presidential Address at the 15th Annual Convention of the Institute of Engineers inaugurated recently by the President of Pakistan in Dacca, I had the opportunity to highlight some of the problems of

Engineers. The response of the President of Pakistan was most heartening. He assured us and I can do no better than to quote him verbatim:

"Mr. President, in your address you have referred to a number of service matters which are causing concern to the members of the engineering profession. You have, in particular, raised the issues of service security, promotion prospects and ensuring for the engineers a due share in the decision-making sphere of the Government. You have also commented on the desirability of reorganisation of service structures, creation of a single class cadre for engineers and improvement of their status in the warrant of precedence. As you have yourself pointed out, I have already appointed a Committee for the examination of these issues. A separate Committee has also been set up for specifically dealing with the problems of the engineers.

"I assure you that the recommendations of these Committees will receive careful consideration of my Government."

The Congress President further stated, "Gentlemen, you all know that the Committee under the Chairmanship of Mr. Justice A. R. Cornelius entrusted with the task of proposing reorganization of service structures is expected to soon submit its report. The other Committee headed by Mr. A. G. N. Kazi does not appear to have made much headway as no meeting has been held after the first meeting on the 17th of November, 1969. A similar assignment given to Mr. S. S. Jaffri two years earlier produced no results."

At Dacca, President Agha Muhammad Yahya Khan also addressed himself specifically to the question of unemployment. He said, and I quote from his text once again:

"In a growing economy such as ours, the lack of employment opportunities for technocrats can only be a temporary phase. I assure you that my Government will give a careful consideration to your proposals for increasing the employment opportunities for talented engineers.

"Concerning the private sector, this forum has on past occasions drawn the attention of the Government to the need to encourage, promote and develop locally available consultatory and contractual services. It is increasingly felt by the members of this Congress that the foreign consultants have no more, an edge over the local experts except in some very rare and sophisticated areas. This progressive self-reliance of the Pakistani engineers should be acknowledged and Pakistani firms should be increasingly engaged in the national projects."

The President of the Congress then briefly reviewed the major activities of the various Engineering Departments and Development Agencies in the Province and said:

"In the third Five-year plan, in the Water Sector, the objectives were to provide the most rapid development of water potential, to improve drainage and increase fertility by a proper reclamation so as to increase agricultural produce. The Irrigation Department, WAPDA, A.D.C. and the Land and Water Development Board were engaged in various activities in this sector. The surface water supply position has been steadily improved due to vigorous efforts by the Irrigation Department. The canal withdrawals rose from 85 million acre feet at the end of second plan to 120 M.A.F. during 1968-69. This increased canal supply has had an immense impact on the agricultural

production and has helped West Pakistan in achieving self-sufficiency in food. The revenue expected during the year is rupees 43 crores against the working expenses of Rs. 17 crores. Several components of Indus Basin Project have been completed during the past two years.

The total installed generation capacity now is 1160 M.W. The first four units of Mangla Dam capable of generating 400 M.W. have been put into full operation by 1969. Work on Guddu Thermal station is going on at a great speed and it is anticipated that Unit No. 1 and 2 would be commissioned by 1972 to generate 220 M.W. The transmission of electricity and interlinks has been considerably improved. WAPDA is making great efforts to improve reliability of the power system and to stabilise the voltage."

Reviewing the progress of Pakistan Western Railways, the President said:—

"Kot Addu-Dera Ghazi Khan Railway Link has already been opened to traffic. Work to link Kashmore with D. G. Khan is in progress and would be 40 per cent complete during the current year. The electrification of Lahore-Khanewal Section is nearing completion. Work on the carriage factory at Islamabad is in an davanced stage.

"In the Roads and Bridges Department about 200 miles of new roads and 400 miles of improvement of roads would be completed during the current year. Karachi-Hyderabad Super Highway is almost complete. Detailed designs of other important Super Highways have already been completed. R.C.D. Highway connecting Karachi to Iranian Border via Lasbela-Khuzdar-Quetta and Nushki is of particular significance on which the work is in progress.

"In the Housing and Physical planning sector, much progress has been made. The highest priority has been given to water supply and sewerage schemes. Progress on Greater Karachi Water Supply Scheme, Greater Lahore Water Supply and Sewerage Scheme are in advanced stages. Lahore Township Scheme envisages development of an area of 3,000 acres. About 65 per cent of the entire development work of this scheme would be completed by the end of current year. Nine polytechnics located at various places in West Pakistan are being completed.

"Manufacturing and mining efforts have been made to go ahead with projects relating to Heavy engineering, fertilizer, and cement production. The Heavy Engineering Industry Projects of Karachi-Shipyard and Engineering Works, the heavy Mechanical complex at Taxila, and machine tool factory at Landhi would be substantially completed by the end of the current year and would be in partial completion.

"In the Engineering Profession, design and research is essential. Sh. Ahmad Hassan suggested that "we must train the improved use of interior space, for the conservation, utilisation and control of our water and power resources, for the development and use of transport for communication facilities."

Continuing the President of the Congress said, "I started this address welcoming the decision of the President of Pakistan to restore democracy in the country. We hope and pray that the year 1970 may well be remembered by posterity as the year when all Pakistanis rededicated themselves to the ideology and unity of Pakistan. Within a few months, the Constituent Assembly will, Insha Allah, meet to frame a Constitution for our country.

"What this Assembly will accomplish will affect the lives of all future generations of Pakistanis. We want democracy to flourish in our land but it is said that the functioning of democracy is handicapped in lands where mass illiteracy is rampant. Hence the suggestion for "Functional Representation" needs a very careful consideration. Appropriate representation in the Legislatures of various professional and technical organizations would ensure and promote confidence of all the professions in the future national life".

Concluding his address, Sh. Ahmad Hassan said: "I would like to leave a few thoughts with you all. Today we are on a path of trial, a path that offers great opportunities for national and self-development. We are building a new country in a troubled century characterized by wars, social unrest, student problems, decaying signs of big cities, less water to drink and for irrigation, polluted air to breathe and mounting deaths on the highways. While we look back with pride to what we have achieved, let us also look forward to broader and greater responsibilities that devolve upon our shoulders. We are on a trial. We have a nation to transform. Fellow Engineers, let us indeed make a concerted effort. It will be for ALLAH to reward you; and for our people and the Government to grant recognition to you all in this national transformation.

"I wish to express my profound thanks to you once again, Mr. Governor, for honouring us with your presence today. I am also grateful to the distinguished guests who made it convenient to come and attend this function. I am indebted to the members of the Congress for electing me their President and to the members of the Council and the office-bearers who helped me in running the Congress.

"I now request you, Mr. Governor, to declare the 51st Session of the West Pakistan Engineering Congress open".

Election of New Council for the year 1970

The members of the Engineering Congress met on Sunday *i.e.*, 29th March, 1970 for business session and elected Mian Alimud Din P.S.E.I., Managing Director and member Wapda, as the new president of the Congress. Six Vice-President were also elected from various departments. The General body also elected four office-bearers and 21 members of the Council. The new council constituted as under :

President:

Mian Alim-ud-Din, S.Q.A. S.K. P.S.E.I., Managing Director, Wapda, Lahore.

Vice-Presidents:

(1) Mr. A. A. Jamal-ud-Din, Chief Engineer, Highways Department, Quetta.

(2) Mr. Manan Khan, Chief Engineer, Irrigation, Peshawar.

(3) Mr. M. S. Minhas, Chief Engineer, West Pakistan A.D.C. Lahore.

(4) Mian Mazhar-ul-Haq, General Manager Lahore Improvement Trust, Lahore.

(5) Mr. S. A. Majid Chief Engineer, Electricity, Wapda House, Lahore.

(6) Sh. Ahmad Hassan Vice-Chancellor, West Pakistan, Engineering University, Lahore.

Office Bearers:

(1) Mr. Ashfaq Hassan Director, Buildings Research, Lahore. (Hon. Auditor).

(2) Mr. Aman Ullah Khan Director, Wapda, Lahore. (Hon. Publicity Secretary)

(3) Mr. S. M. Ayub Director, Irrigation Research Institute, Lahore. (Hon. Treasurer).

(4) Mr. Ashfaq Ahmad Qureshi, Executive Engineer, 2nd Provincial Buildings division, Rawalpindi. (Hon. Business Manager).

Members:

(1) Sh. Ahmad Tariq, Director, Water Allocation, Shadman Colony, Lahore.

(2) Mian Anwar-H-Rahman Superintending Engineer, Depalpur Canal Circle, Lahore.

(3) Rana Allah Dad Khan, Rana Motors Lahore.

(4) A. R. Durrani, Executive Engineer, Paharpur Canal Division, D. I. Khan.

(5) Izhar Irshad, Sub-Divisional Officer, "F" Provincial Building Sub-Division, Lahore.

(6) Fayaz Ali Shah, Deputy Chief Engineer, Highways, Bahawalpur.

(7) H. R. Toosi, Executive Engineer, Sheikhupura Division, Sheikhupura.

(8) Sayed Irshad Hussain, General Manager, Packages Ltd., Lahore.

(9) Iqbal Ahmad Shahab Project Director SCARP, II, 221/A Satelit Town, Sargodha.

(10) Jamil Asghar Khan, Deputy Chief Engineer, I.B.P. Wapda, Lahore.

(11) Khurshid Zia, Executive Engineer, Fordwah Division, Bahawalnager.

(12) Sh. Mohammad Akram, Retd. Chief Engineer 1-E-Gulberg-III, Lahore.

(13) Ch. Mazhar Ali, Chief, Water and Power and Industries Planning and Development, Government of West Pakistan, Lahore.

(14) M. R. Vehra, Deputy Secretary Buildings department, Lahore.

(15) Mr. M. A. Beg Ghazi, Superintending Engineer, Provincial Buildings Circle, Victoria Road, Karachi.

(16) S. M. Ismail S.E., G.M. Barrage, A. D.C. Hyderabad.

(17) Mohammad Akhtar Qureshi, Technical Officer, Highways Department, Lahore.

(18) Mohammad Rafiq Shad Executive Engineer, Lahore Improvement Supply Maintenance Division, 3 Davis Road, Lahore.

(19) Mohammad Amin, Interhome Limited, Lahore.

(20) Noor Ahmad Malik Executive Engineer, Lahore Township Division, Lahore.

(21) Ch. Mohammad Khurshid, Executive Engineer, 2nd Provincial Buildings, Division, Lahore.

On the first meeting of the new Executive Council of West Pakistan Engineering Congress elected the following Honorary office-bearers:

Honorary Secretary:

Mr. Abdul Latif Mirza, O.S.D. Director, Remodelling Works, Irrigation and Power department, Lahore.

Joint Secretary:

Ch. Mohammad Khurshid Executive Engineer, 2nd Provincial Buildings division, Lahore.

Publicity Secretary:

Amanullah Khan Director, Wapda, Lahore.

To fill in the resultant vacancies, the Council co-opted the following as its members.

Hon. Treasurers:

(1) Mr. Y. A. Siddiqui, Chief Engineer, Buildings, Lahore.

(2) Mr. Shah Nawaz Khan, General Manager, Tarbela Dam.

(3) Mr. T. M. Sheikh, Chief Engineer, Buildings, Hyderabad.

The Council asked Mr. S.M. Ayub P.S.E.I., Director Irrigation Research Institute to edit the Engineering News in addition to his present duties of Honorary Treasurer.



MIAN ALIM-UD-DIN

S.Q.A., S.K.,

The New President of West Pakistan Engineering Congress.

Mian Alim-ud-Din was elected the President of West Pakistan Engineering Congress for the year 1970-71.

He was born on the first of July, 1913. He is from Thompson College of Civil Engineering Roorkee, India from where he qualified in 1937. He joined Irrigation Branch of Punjab P.W.D. as Temporary Engineer in March, 1938.

He was promoted to P.S.E. Class II, in 1942, and to Punjab Service of Engineers Class I, in 1945.

From 1938 to 1943 he worked in various Sub Divisions as Sub-Divisional Officer in charge of Distribution of Canal Supply, Revenue Matters pertaining to Irrigation Supplies, Assessment of Revenue and maintenance of Canals and Branches.

In 1943 he was posted as Superintendent Gray Canals with the Revenue Department and continued there till 15-8-46.

In August 1946, he was promoted as Executive Engineer and posted in Indus Canal Division, Dera Ghazi Khan where he continued till February 1948 when he was posted as O.S.D. Irrigation Branch Inquiry Agency in Secretariat.

In 1949 he was posted with the Partition Committee for a few months and from there he was posted as Under Secretary to the Government of Punjab. He worked in that capacity till 14-12-1950 when he was promoted as Superintending Engineer and posted in the Drainage Circle.

In the Drainage Circle, he was responsible for preparing several Flood Schemes and Drainage Plans. He also worked as Secretary and Member Punjab Flood Commission set up by the Pakistan Government, prepared the famous Flood Commission Report which was accepted by the Central Government and eventually published. He also prepared 20-year Reclamation Plan for the Punjab Thur affected areas.

In 1952 he was selected for the construction of the biggest Link Canal *i.e.*, the Marala Ravi, carrying a discharge of 24,000 cusecs. The Link passed through a terrain requiring cross drainage works of about 55000 cusecs aggregate discharge and innumerable bridges. This project of 100 million rupees was completed in a record time of 2½ years and within the project amount.

For about two years from 1957 to 1959, he was Superintending Engineer, Lower Chenab Circle West, where he was the administrative head for scientific distribution of water, Revenue Work involved up to the assessment

stage, Maintenance of Barrage and the distribution system of about 500 miles. A flood of 1.1 million cusecs was safely passed through Khanki Headworks.

In 1959 he was again posted as Superintending Engineer, Link Circle with Marala Ravi Link, Balloki - Suleimanki Link and Bombanwala Ravi Bedian Depalpur Link in his charge.

In 1959 he was promoted and posted as Deputy Chief Engineer (Operation) in the Office of Chief Engineer, Irrigation West Pakistan. He had to deal operational problems pertaining to the entire Irrigation network and Barrages of West Pakistan.

In December 1959, he was posted as Deputy Chief Engineer (Construction), where he continued up to May 1960. In this assignment he had to deal with the Construction problems of West Pakistan including canals, headworks, Links, Dams and Floods.

Again in May 1960 he took over as Deputy Chief Engineer Operation and continued till March 1961 when he was posted as Deputy Chief Engineer (Administration) with the Chief Engineer, Irrigation West Pakistan. He continued on this job till April 1962.

On 1st May 1962, he took over as Chief Engineer, Irrigation Sukkur Region—a vast region consisting of 8 Circles, three Barrages on Indus *viz.*, Guddu, Sukkur and Ghulam Mohammad.

Under his guidance Drainage Plan for an area of about 5 lac acres and costing about Rs. 12 crores was prepared.

Many development Projects of Importance were designed and executed during his stay in that Region *viz.* construction of Prestressed concrete Bridge across Indus connecting Thatta with Sujawal cos.ing about Rs. 4 crore Prestressed concrete Bridge across Rohri Canal costing about 42 lacs of rupees and fall on Rohri Canal costing about Rs. 45 lacs. In recognition of Services rendered in that region he was awarded "SITARA-E-KHIDMAT".

In June 1965 he took over as Chief Engineer, Lahore Region. During the War with India in September 1965, it was on account of his conscentious work, which kept the channels running and maintained the morals in ranks and files.

In recognition of his devotion to work he was awarded "SITARA-E-QUAID-E-AZAM".

In 1969, he was entrusted with a big role. He took over as Chief Engineer INDUS BASIN PROJECTS in WAPDA. He had to deal with the problems of Tarbela Dam under construction, Mangla Dam which has problems of maintenance, Chashma Barrage under Construction, Chashma-Jhelum Link, Taunsa-Panjnad Link under construction, Rasul Barrage, Rasul-Qadirabad Link, Marala Barrage, B. S. II Link, with problems of their maintenance and removal of defects which have been quite serious with respect to Rasul and Marala Barrages.

In September 1969, he was selected for post of Secretary, I & P, West Pakistan, then as Chief Engineering Adviser, Pakistan Government. He finally took over as Member/Managing Director West Pakistan Wapda on 6-12-1969.

On dissolution of One Unit he has taken over as Secretary, Irrigation & Power Government of Punjab.

He is an eminent Engineer with vast and varied experience in all fields of Engineering. In all situations he always finds a solution to every problem. Let us all wish that our new Congress President creates a new life amongst the Engineers and is helpful in securing the rightful demands of the Engineering Community.



INTRODUCING

MR. S. M. AYOOB, P.S.E.I.

The New Editor,
Engineering News.

Mr. Syed Muhammad Ayoob has been elected Editor of the Engineering News by the Executive Council of the West Pakistan Engineering Congress.

He was born in District Muzaffarnagar of United Provinces, India on 8-9-1924. He got his Engineering Diploma of Civil Engineering from Thomason College of Civil Engineering; Roorkee, in 1944.

He joined Irrigation Branch of P.W.D. United Provinces on 1st August 1944, and was posted on the construction of Muhammadpur Power Station of about 10,000 K.W. capacity on the Ganges Canal.

During his two years stay on the Project he carried out :

> Preliminary Surveys, Lay-out of works, detailed designs of some components of the Power Station, Fall on the By-pass Channel and Road Bridge on the Power Channel and Supervision of the construction of more than 100 foundation wells, reinforced concrete foundation raft and Road Bridge.

Subsequently, in July 1946 he was transferred and posted in First Sub-Division of Upper Division Eastern Jumna Canal where apart from regulation he was in charge of several cross-Drainage and River Training works.

He migrated to Pakistan in December, 1947 and was appointed as temporary Engineer in the Irrigation Branch of P.W.D. of West Punjab. He worked in various project Sub-Divisions and contributed in preliminary surveys, investigations. designs and preparation of various projects.

He was appointed Assistant Executive Engineer in Punjab Service, of Engineers Class I, in July 1949.

In June 1951 he was posted as Sub-Divisional officer Marala Headworks. He was promoted as Executive Engineer in October, 1952, and posted as Executive Engineer Marala Division, where he continued till October 1954. During his stay at Marala apart from Regulation, normal maintenance of Headworks and other anciliary works, Remodelling of Upper Chenab Canal to a capacity of 16,000 cusecs was carried out. Remodelling of the channel section and

remodelling of over 20 bridges and drainage Syphons was carried out.

From October 1954 to November 1960 he worked in various offices, as Personal Assistant to the S. E. Link Circle, under-Secretary Government of Punjab, Technical officer, Lahore Region Irrigation, Assistant Director Design & Research, Assistant Director Construction and Executive Engineer (O.S.D.) Water dispute in the office of Chief Engineer Irrigation, West Pakistan. From November 1960 to June 1961 he was in charge of Kot Adu Division of Taunsa Barrage System.

In June 1961 he was promoted as Superintending Engineer and posted to Quetta Irrigation Circle. From Quetta he was transferred to Sukkur Region where he worked as Superintending Engineer Headquarters for a couple of months and then posted to Khairpur Irrigation Circle where he was having administrative control of world's largest Barrage—Sukkur Barrage. During his stay in this circle a 7′ fall on Rohri Canal was constructed for a design discharge of 15,000 cusecs. Seven Prestressed Concrete Bridges across Rohri Canal were also executed under his administrative control.

In August 1965 he was transferred from Sukkur and posted as Superintending Engineer, Lower Bari Doab Canal Circle where he continued up to October 1967. He put in efforts for the exploitation of ground-water and got approved four Tube-well schemes. Remodelling of Lower Bari Doab Canal for a capacity of 8,000 cusecs was also taken up.

In 1967 Government of Pakistan selected him for an International course of Hydraulics Engineering sponsored by UNESCO in Holland. He was awarded diploma in Hydraulic Engineering Delft. His specialised course was Hydraulic structures. During his assignment in Holland, he visited many European countries, visited Engineering Works and International famed research organisations.

Due to his varied experiences in applied Engineering, designs, and administrative fields he was appointed Director Irrigation Research Institute, Lahore, in August 1969. His field of work has been enlarged in Basic and applied researches. His technical know-how and professional skill has infused a new life in the Research Institute, which is very well known in the world for its research works, especially in Hydraulic field. It ranks foremost among advanced hydraulic research stations in the world.

The management of Engineering News welcomes this Engineer as a new Honorary Editor-in-Chief of this journal. May his patronage and guidance upgrade the standard of this publication in quality and quantity, and the material published in this esteemed journal be a source of knowledge to the Engineers by and large.

Foundations for Hydraulic Structures in relation to under seepage and uplift

By SHAFAAT AHMAD QURESHI

This note by Mr. Shafaat Ahmad Qureshi was written by him as a Seminar for presentation in the Engineering University in his M.Sc. course. In view of its concise nature dealing with the rudiment of barrage design is, however, found to be useful and it is hoped will be interesting and beneficial to many, particularly to the young Engineers in the field. Various graphs have also been included along with solved examples to illustrate the method for calculating the uplift etc.

Introduction

In ordinary foundation problems it is well known that presence of water makes things difficult. Various soils behave differently as foundation material. Their bearing capacities may undergo change and methods of construction and design may have to be altered to suit the allowable conditions at site during construction and during the life time of the foundation.

In case of foundations for hydraulic structures which are in general to be always subjected to the action ot water especially seepage and hydrostatic uplift, the manifestation of the problem is going to be severe.

Behaviour of soils to static action of water having been already known and catered for in design, here we shall only discuss the problems created by under-seepage and uplift pressures.

Although many types of structures may be classified as hydraulic structures but the discussion here shall be restricted to such masonary structures as Dams, Weirs across large rivers, Canal falls and bridge abutments, that impound water and of which foundations are across the natural course of flow. Other foundation problems can be solved on the same basis, subject of course to such variance as may exist at site.

The safety of these structures apart from their resistance to overturning, excessive settlement of foundation which may impair even its very utility, etc. etc., largely depends on the seepage underneath and uplift pressures.

Importance of Exploration and Geological Study

Since these factors so vitally important and affecting the design of foundations of hydrau-

*Assistant Director, Review Cell, Irrigation and Power Deptt., Lahore

lic structures are related to soil properties which may extend and be influenced to quite a depth; and in view of huge expense of time, money and labour, on the construction of such structures, it is very necessary to have site exploration in detail. The study should include determination of the geologic structure and its significance, the composition, absorptive capacity, and permeability of the rocks strata. The prevailing bedding and joint systems the thickness and relative tightness of strata; and the presence, magnitude, the course of solution passages and of any other systematic or unsystematic openings are significant. The ground water table as it exists, and as it may be expected to be modified by the proposed construction, is important. If there is evidence of underground flow in a direction parallel to the axis of the structure, the proper uplift assumption may be affected. The quality of water to be impounded should be studied — for instance, whether it is hard or soft — to determine the possible effect of the water on drains and grouted cutoffs. In short, it is not possible to know too much about subsurface conditions.

Lessons from the Failures : Failures of Dams, Weirs etc.

To learn from the failure is the basis of scientific investigation and every failure leaves us much wiser, as it spotlights the points where the emphasis should be laid.

Failure of earth dams due to weak underlying soil strata have occurred sometimes. Usually the failure took place during construction and was evidenced by slumping of one of the slopes in a manner indicating rotational type of slide. As a rule, an underlying saturated clay layer was found to be responsible for the failure. This was true in the case of Chingford Dam in England and the Marshall Creek Dam in the United States. The disastrous consequences of weak foundation material under a concrete dam, according to official report on the failure of 205 ft. high St. Francis Dam resulted in the known death of 236 and 200 missing.

The generation of high uplift pressures at the toe of dam and neglect thereof was the cause of the 1911 failure of the concrete dam at Austin, Pennsylvania with a loss of over 100 lives. To sum up I also quote some extracts from the paper No. 2431 Vol: 117 of the transaction of American Society of Civil Engineers, year 1952. "The most noteworthy failure of concrete or masonry dams in the United States have been those of Austin, Tex; Austin Pa; the St. Francis Dam in California; and Dam No. 26 on the Ohio river. In all these cases failure was due to inadequate resistance in the foundation to horizontal movement—that is, to shearing failure in the foundation. Also, in all these cases there was evidence that uplift contributed to the failure by reducing the effective weight of the structure, and consequently, the frictional resistances dependent upon weight. At least in the United States, no important failure has been due to overturning of a dam; nor have any failures been ascribed to the development of internal pore pressures in the concrete or masonry itself".

These considerations lead to the conclusion that uplift effects especially in the foundation, are always to be reckoned with and are an essential element of design.

In the case of weirs, to quote from cases of failures in Indo-Pak sub-continent, examples may be cited of failure of Rasul Weir in 1929 and damage to Marala Weir in 1928 which were the result of bed scour and unbalanced head at the trough of standing wave during

flood. The failure of Islam Weir in 1929 called attention to the dangerous consequences of retrogression of downstream bed levels if not adequately provided against in the design, which increased the exit gradient.

In fact the failure of Khanki Weir in 1895 and Narora Weir in 1898 paved the way for a thorough investigation of the factors governing the designs of hydraulic works resting on permeable foundations.

The more recent failure of Tando Masti Khan fall in March, 1957 has opened more vistas where the scope of research and further investigation lies.

Strengthening Foundation Soil

To check against failures due to weak underlying structures various methods of strengthening the foundation soils are in use. The chief purpose of the methods lie either in sealing the fissures in rocks or porous soil in order to stop the flow of water or to stabilise a soft soil so as to increase its strength—safe bearing capacity. In case of foundation for hydraulic structures either compaction or soil injection techniques are generally selected.

Soil Injection

A procedure that is sometimes used in foundation work is the injection under pressure of various materials into soil or rock. The materials commonly used for injection may be divided into three general types called suspension, solution and emulsion.

Suspension are mixtures of cement and water and sometimes cement and clay and water. The relative amounts of water or solids that are used in the mixtures can vary over a considerable range, although it is customary to use as high a %age of solids as practicable. Suspensions of this type are useful for grouting for rock fissures or for grouting of beds of coarse sand or gravel. After the cement has set up, it not only waterproofs but also strengthens the rock or soil into which the suspension has been injected.

The solutions that are used for soil injection are chemical compounds and the basic chemical, that has been used so far for this purpose, is sodium silitate, often called waterglass. A second chemical is used which combines with the sodium silicate to form a stiff silica gal so that the soil is water-proofed as well as strengthened.

Emulsion of bitumen and water have also been used. This is a more recent development than the use of former two methods. The emulsions can be pumped into sands of medium grain size and they act primarily as water-proofer.

The pumping pressures that are required in the various injection methods are often quite high and pressures as great as 100 p.s.i. and more are sometimes used. The possible effects of such high pressures in the adjoining parts of the structure or the existing structures in the vicinity may not be overlooked. Pressure grouting with cement sand emulsions have successfully been carried out at various headworks in Punjab whenever cavities below weir foundations were noticed.

Compaction

Compaction may be utilised to improve the bearing capacity of natural soil deposits or man-made fills when soft or loose soil deposits are encountered. The deposits may be removed by a new compacted fill or may be compacted by various in place compaction methods. Some of the more common methods are:—

1. *Vibration :* Heavy vibratory rollers and compactors may compact a layer of

granular soil to a depth of several feet.

2. *Vibro-flotation :* A commercial method which combines the effect of vibration and jetting. A heavy cylinder known as "Vibroflot" is inserted in the ground while the cylinder vibrates due to rotary eccentric weight. A water jet on the tip of the vibroflot supplies a large amount of water under pressure. As the vibroflot sinks, clean sand is added into the crater that develops on the surface. In the recently constructed barrages under I.B.P. at various places the bearing capacity of the soils has been increased by this method—Rasul Barrage is an example.

3. Mechanical tampers are used to compact soil in areas inaccessible to the large roller or where the use of heavy rollers are prohibited to avoid damage to the adjacent or underlying structures. Tempers are powered by compressed air, gasoline or electricity and vary in weight from about 30 to several thousand pounds.

Vibratory compactor is a cylindrical roller compactive effect of which is amplified by vibrating weight within the roller drum. The weight revolves at a constant speed powered by gasoline engine mounted on the unit. This type of roller is very effective in compacting granular soils.

The driving of pile into beds of loose sand produces compaction not only by vibration but also by displacement.

Underseepage and Uplift

Preliminaries.— Design of foundations for hydraulic structures against underseepage and uplift require an intimate knowledge of the mechanics of sub-surface flow or flow through soils. Therefore before proceeding further, it is advisable to first give the terminology and meaning that is generally used in this connection.

Permeability.—It is defined as the property of soil which permits the passage or seepage of fluids such as water and/or oil for example, through its inter-connecting voids.

Although theoretically all soils are more or less porous, in practice, however, the term permeable is applied to soils which are porous enough to permit the flow of water through sub-soil and the soils which permeate with great difficulty are termed as impermeable.

The resistance to flow depends upon the type of soil, size and shape of soil particles (rounded angular or flaky), the degree of packing (the density of soil, and thus upon the size and geometry of voids), also the resistance is a function of the temperature of water (viscosity and surface tension effect) and is denoted by 'K' the coefficient of permeability.

Flow Line.—As water percolates through a permeable material the individual water particles move along paths which deviate erratically but only slightly from smooth known curves as flow lines.

Soils the textural sizes of which are smaller than fine gravel are considered as allowing only laminar flow *i.e.*, in which the adjacent flow lines of water are parallel. In the vast plains of Indo-Pakistan sub-continent the sub-soil generally consists of alluvium whose particle size varies from that of very fine colloidal clay to very fine sand. In some cases, however, particularly in the upper middle reaches of our rivers the soil consists of coarse sand and gravel. The foundations of Kala-

bagh Barrage are a typical example. Therefore for all practical purposes in studying flow through sub-soils only a laminar flow will be considered.

Although seepage underneath a massive dam, a weir or through an earth dam, at the beginning of flow will be of an unsteady nature but with some time lag the flow will attain a steady character.

As will be seen from the foregoing that if the foundation rests or extends up to impermeable strata somehow, there will be no seepage and no hydrostatic uplift under the structure. It is, therefore, only when the foundation rests on permeable strata that such problems come up. Discussed below is a short description of development of design theories for weirs resting on permeable foundation. It may be added that method of calculation of uplift pressure and exit gradient for all such structures is alike and can be substituted easily for others.

Development of Design Theories

It is well known that science of sub-surface hydraulics particularly in relation to design weirs on permeable foundations started in indo-Pakistan sub-continent with the failure of a part of Khanki weir in 1895 *i.e.*, hardly after 3 years of its construction.

(*a*) **Darcy's Law**

The law of flow of water through permeable soil was first enunciated in 1856. According to Darcy's law:—

The flow velocity $V = K \times \frac{H}{L}$ where K is the coefficient of permeability and H/L is the Hydraulic Gradient. H depicting the head causing flow and L the length of the passage traced by the water particles in moving from one point to another.

The validity of this law was tested by Col: Clibborn in 1896 in connection with repairs to Khanki weir.

(*b*) **Hydraulic Gradient Theory**

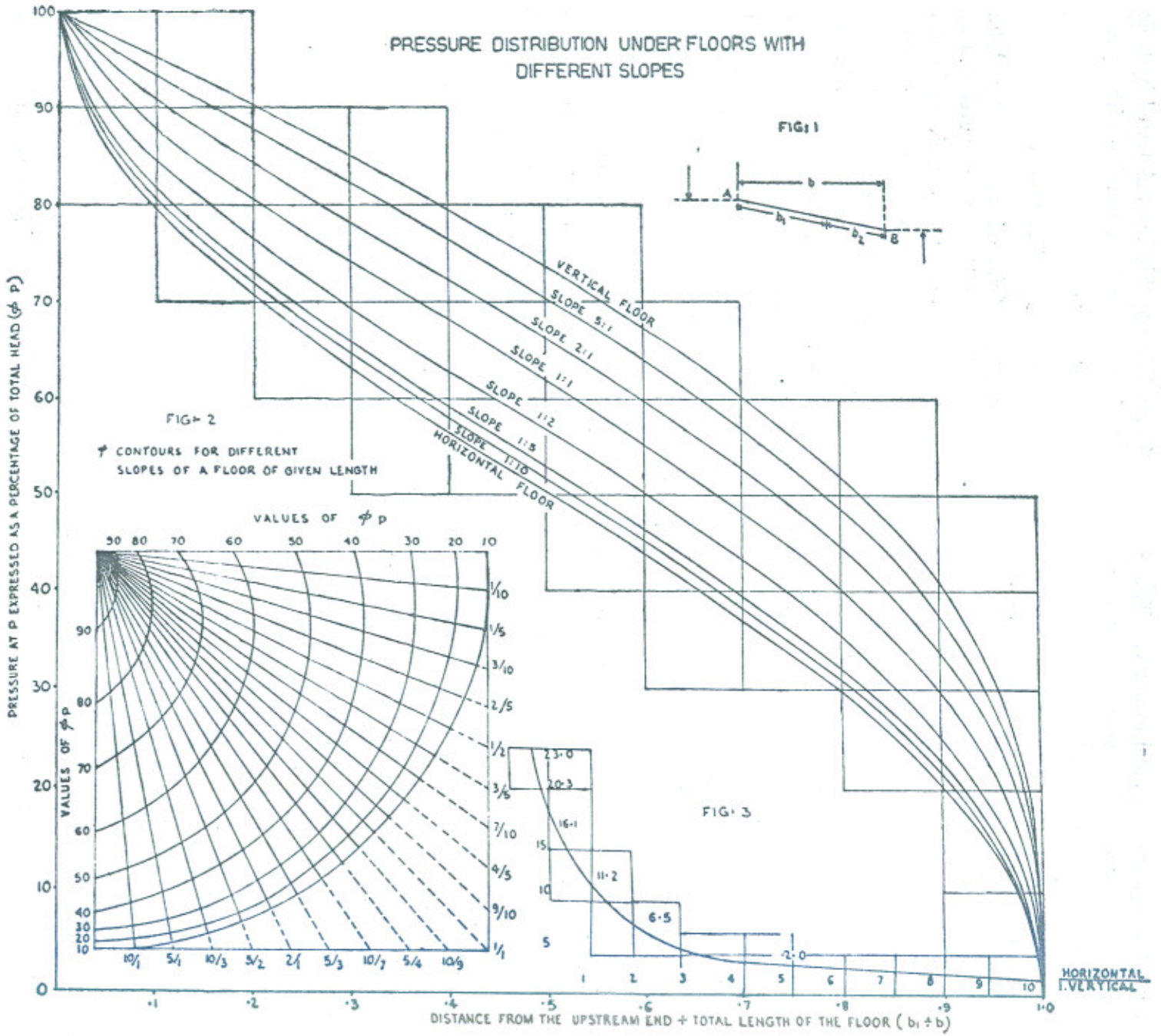
Apparently originated between Sir John Ottley and Thames Highan was developed as a result of experiments; by Col. Glibborn. with the publication of whose results in 1902, the hydraulic gradient theory came to be accepted in India. According to which "In those cases where the chief danger to a weir is from under scour and not from parallel currents, the true measure of security of a weir on permeable bed is the distance through the soil which a current of water has to travel before it could rise up below the weir, and it is of little consequence if vertical cut-offs are provided or masonry is laid horizontally on the weir bed, so long as the current passing through the soil below the structure are exposed to the friction of the same length of passage.

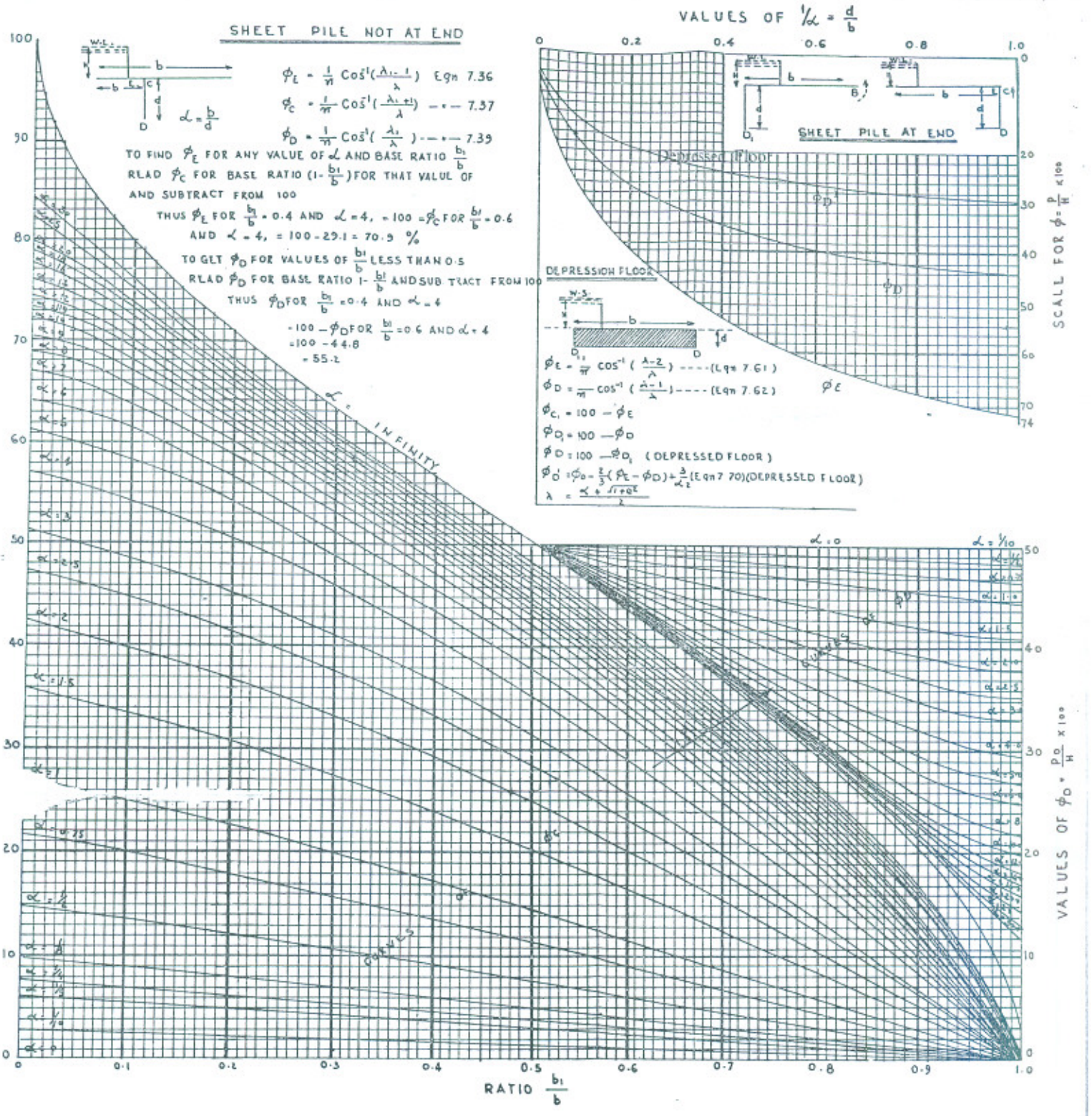
(*c*) **Bligh's Creep Theory**

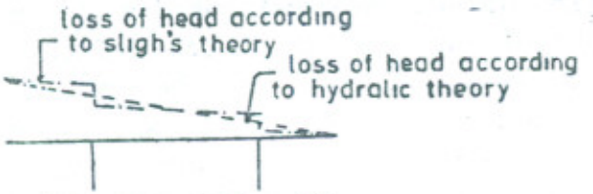
Bligh made a simplification of the problem of sub-soil flow. He enunciated his theory in 1910 and elucidated the same further in his book "Dams & Weirs 1918". He assumes that percolation water creeps along the contact of base profile of the weir with the subsoil and loses head en route. He further assumed that the length of paths of flow had the same effectiveness in reducing uplift pressure whether the creep of flow is along vertical or horizontal.

He called the loss of head per unit length as creep co-efficient and assigned a safe value for C for different classes of soil.

C varies from 5 — 9 for boulders and shingle, to 18 for river bed of higher silt and sand as those of Nile or Mississipi.


PRESSURE DISTRIBUTION UNDER FLOORS WITH DIFFERENT SLOPES
FIG: 1
A
B
b
b1
b2
VERTICAL FLOOR
SLOPE 5:1
SLOPE 2:1
SLOPE 1:1
SLOPE 1:2
SLOPE 1:5
SLOPE 1:10
HORIZONTAL FLOOR
FIG: 2
ϕ CONTOURS FOR DIFFERENT SLOPES OF A FLOOR OF GIVEN LENGTH
VALUES OF ϕ p
VALUES OF ϕ p
FIG: 3
PRESSURE AT P EXPRESSED AS A PERCENTAGE OF TOTAL HEAD (ϕ p)
DISTANCE FROM THE UPSTREAM END ÷ TOTAL LENGTH OF THE FLOOR (b1 ÷ b)
HORIZONTAL / VERTICAL


SHEET PILE NOT AT END
$\phi_E = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1 - 1}{\lambda}\right)$ Eqn 7.36
$\phi_C = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1 + 1}{\lambda}\right)$ — " — 7.37
$\phi_D = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1}{\lambda}\right)$ — " — 7.39
$\alpha = \frac{b}{d}$
TO FIND ϕ_E FOR ANY VALUE OF α AND BASE RATIO $\frac{b_1}{b}$
READ ϕ_C FOR BASE RATIO $(1-\frac{b_1}{b})$ FOR THAT VALUE OF
AND SUBTRACT FROM 100
THUS ϕ_E FOR $\frac{b_1}{b}$ = 0.4 AND α = 4, = 100 − ϕ_C FOR $\frac{b_1}{b}$ = 0.6
AND α = 4, = 100 − 29.1 = 70.9 %
TO GET ϕ_D FOR VALUES OF $\frac{b_1}{b}$ LESS THAN 0.5
READ ϕ_D FOR BASE RATIO $1-\frac{b_1}{b}$ AND SUBTRACT FROM 100
THUS ϕ_D FOR $\frac{b_1}{b}$ = 0.4 AND α = 4
= 100 − ϕ_D FOR $\frac{b_1}{b}$ = 0.6 AND α = 4
= 100 − 44.8
= 55.2
α = INFINITY
VALUES OF $\frac{1}{\alpha} = \frac{d}{b}$
SHEET PILE AT END
Depressed floor
DEPRESSION FLOOR
$\phi_E = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda-2}{\lambda}\right)$ ----(Eqn 7.61)
$\phi_D = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda-1}{\lambda}\right)$ ----(Eqn 7.62)
$\phi_{C_1} = 100 - \phi_E$
$\phi_{D_1} = 100 - \phi_D$
$\phi_D = 100 - \phi_{D_1}$ (DEPRESSED FLOOR)
$\phi_D' = \phi_D - \frac{2}{3}(\phi_E - \phi_D) + \frac{3}{\alpha_2}$ (Eqn 7.70)(DEPRESSED FLOOR)
$\lambda = \frac{\alpha + \sqrt{1+\alpha^2}}{2}$
SCALE FOR $\phi = \frac{p}{H} \times 100$
VALUES OF $\phi_D = \frac{P_D}{H} \times 100$
RATIO $\frac{b_1}{b}$

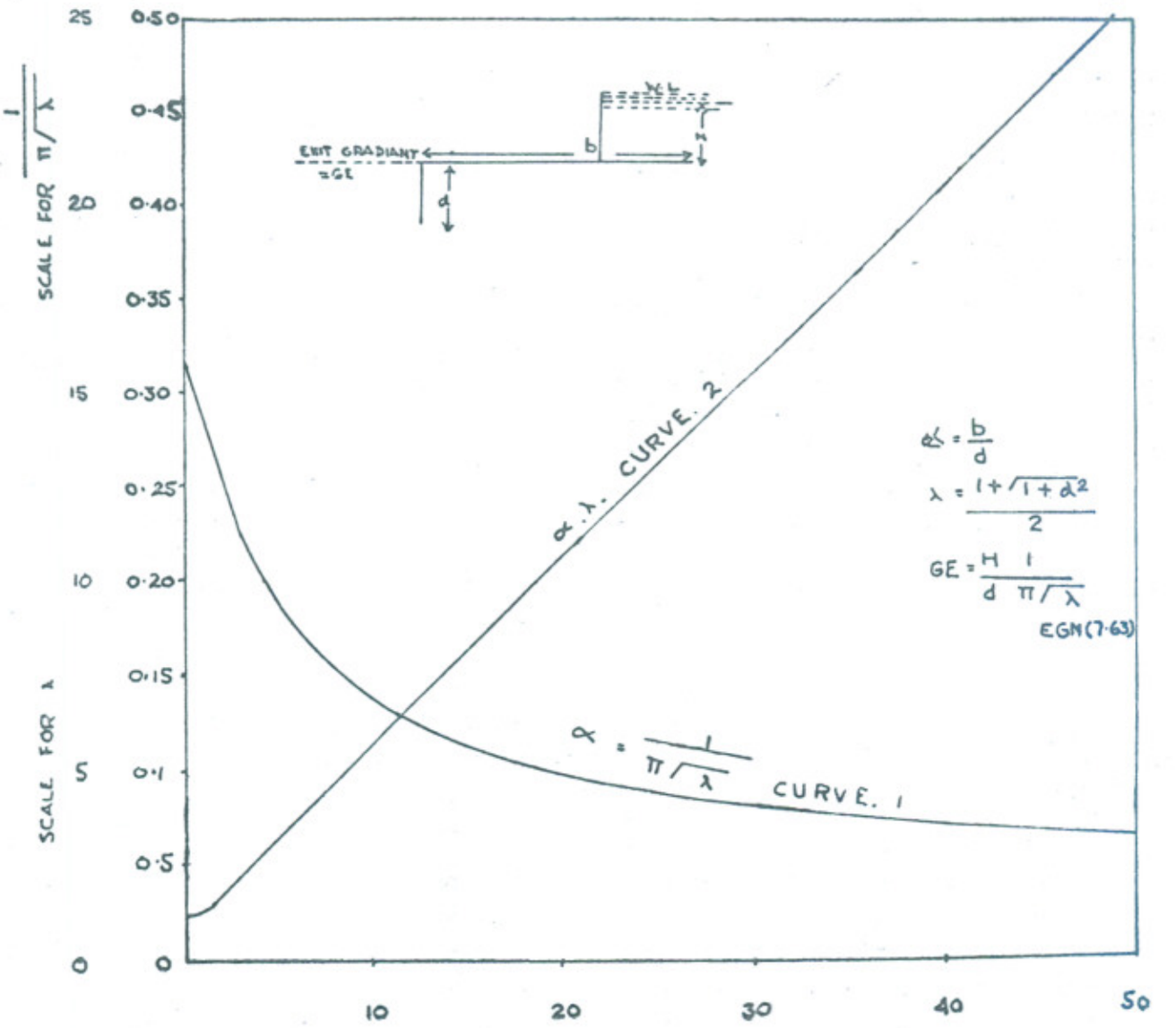


(*d*) Weighted Creep Theory

Mr. Lane after analysing over 200 dams all over the world evolved his theory which may be called an improvement in Bligh's theory of creep. According to this theory more weight is given to vertical cut-offs (1/3 to horizontal and one to vertical).

(*e*) Theory of Exit Gradient

In 1929 Karl Terzagbi gave this concept. He stated and proved by laboratory experiments that failures occurred by undermining if the hydraulic gradient at exit was in excess of which he called as flotation gradient; as it implies a state of flotation of the soil mass at the toe of the work, if exit gradient there exceeded the limit of 1:1, at which limit the upward force due to the flow of water are almost exactly counterbalanced by the sub-



merged weight of unit Vol. of soil:

$$Ws = W(1-E)(P-1)$$

where Ws = submerged weight of unit volume of the soil,
W = weight of unit Vol. of water
E = pore space in unit Vol.
P = specific gravity of sand particles.

In 1935 Haigh (Paper No. 182 Punjab Engg. Congress, Lahore) and Harza (Paper No. 1920 A.S.C.E.) independently brought out two papers. Hazra also found out close agreement between values of uplift pressures obtained from electrical models and those obtained theoretically from some of the simple cases dealt with by Weaver mathematically.

It is now well known that the undermining of the sub soil starts from the tail-end of the work. It begins at the surface due to the residual force of seepage water at this end, being in excess of the restraining forces of the sub soil which tend to hold the latter in position. Once the surface is disturbed the dislocation of sub-soil particles works further down and if progressive, leads to the formation of cavities below the floor into which the latter may collpase. According to the commonly accepted ideas, this undermining is supposed to result from what is known as "piping" that is, the erosion of sub soil by the high velocities of flow of water through it, when such velocities exceed a certain limit. But as will be shortly explained, this conception of undermining is incomplete. Water has a certain residual force at each point along its flow through the sub soil, which acts in the direction of flow, and is proportional to the pressure gradient at that point. At the tail end this force is obviously upwards, and will tend to lift up the soil particles if it is more than the submerged weight of the latter. (The frictional resistance, cohesion etc., of the adjacent soil will have to be considered in certain cases). Once the surface particles are disturbed, the resistance against upward pressure of water will be further reduced, tending to progressive disruption of the sub soil. The flow gathers into a series of pipes in the latter case and dislocation of particles is accelerated. The sub soil is thus progressively undermined. Soil erosion can also occur through natural pipes, or faults in the sub soil.

Factors that increase the exit gradient:

1. Scour holes caused by formation of swirls on the downstream end of weir.
2. Local surges or waves which act as suction pump.
3. The sudden application and reduction of head.
4. Retrogression—lowering of bed levels D/S weir or dam etc.
5. Faults and fissures in sub soil formation.

Importance of Exit Gradient and Safe Values

From the foregoing discussion it is clear that it is extremely necessary to keep the exit gradient within control and the maximum value that can be assigned to it is provided by the flotation gradient. Experiments conducted in Irrigation Research Institute, Lahore show that if the sub soil at the tail end of a work has once been subjected to a gradient more than critical the whole soil mass gets disturbed as a result of flotation does not settle back to its normal packing even though the gradient is reduced. Thus once the stage of flotation is crossed the mischief is done.

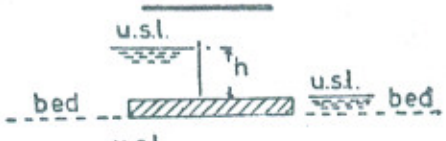
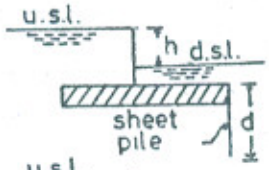
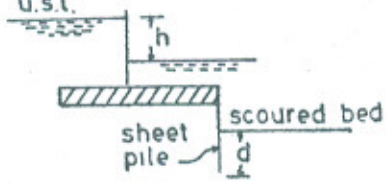
There being many uncertain factors, enumerated above, as well as, conditions such as homogeneity of the soil, or presence of a local intrusion of clay bed which deflects flow, faults and fissures in the sub soils formation

etc., they call for ample factor of safety to be applied to critical value of the exit gradient to obtain a safe value. Naturally the factor of safety must take note of the class of material, the specific weight, pore space and angle of repose. Since sufficient data is not available correlating those, it has been proposed to apply the following factors of safety:—

Shingle	=	4 to 5
Coarse sand	=	5 to 6
Fine sand	=	6 to 7

Determination of Exit Gradient

The formulae for determining the exit gradient are given in CBI Publication 12. Tabulated below are some standard forms of weirs and their formulae for G_E corresponding to them:

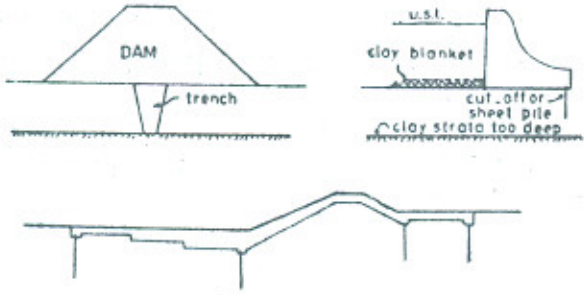
Type of Structure	DIAGRAMS	Exit Gradient
1. Flush Floor		G_E = infinity $G_E = \frac{0.84\ P_O}{d}$
2. Depressed Floor		$G_E = \frac{H}{d}\ \frac{1}{\pi\sqrt{\lambda}}$
3. Floor with downstream sheet pile		$G_E = \frac{H}{(d_1-d_2)\sqrt{\lambda}} \cdot \frac{K}{1-k}$
4. Floor with downstream sheet pile but with scour bed.		or alternatively $G_E = \frac{H}{d}\ \frac{i}{\pi\sqrt{\lambda}}$ where $\alpha = \frac{b}{d}$ $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$

Methods of Reducing Exit Gradient and Control if it is still Excessive.

As has been seen in previous paragraphs the exit gradient is the residual uplift of the under seepage at toe of dam, weir or any other masonry work. The methods to reduce the same therefore consist of adding additional lengths in the way of flow of under seepage. They can be deep cutoff piles, core of impermeable strata below the body of the structure or increase in the horizontal length of the floor.

Wherever a definitely impervious stratum exists in the foundation, it is usually advantageous to connect the grout curtain with this stratum. Where definitely pervious strata are known to exist the curtain should cut off these formations. Where there is little variation in the strata, approximate flow nets may be utilized to determine the desirable depth of cutoff. It will be seen that no rule can be given for this depth.

Having been shown that vertical cutoffs are more effective, it is generally that piles are being made use of these days. Piles may be driven near the toe, in the middle and near the upstream face of the structure.



In case of weirs the depth of upstream pile will be governed by the depth of scour and the downstream one by scour and exit gradient. It may, however, be remembered that with the introduction of D/S pile, while the exit gradient is decreased it helps to build greater uplift pressures under the floor of the work. In contrast the upstream pile line or the clay blanket is relatively more effective in destroying pressure head and reducing uplift pressure under the work. Intermediate pile lines act as second line of defence such as that if either of the pile line fails the damage may not travel beyond the next intermediate pile line.

Pressure Relief Devices

Although the exit gradient may be well controlled and below critical value it is usual to provide protection of graded ballast and stone overlaid with heavy blocks over the bed soil immediately downstream of the impermeable floor. The idea is to protect and prevent erosion of this soil by the action of waves and undermining by seepage flow. The inverted filter as it is generally called, consists of a layer of fine bajri or kankar resting directly on the bed soil followed by ballast of increasing grades and finally spawls and boulders. The filter bed of layers of increasing porosity is from bottom upward and is overlaid and protected by a series of heavy blocks (with open joints).

Other method consists of shallow relief wells in the block apron area just deep enough to pass through some distance or if there is any impervious local layer through the same.

A gravel trench in the concrete block apron area excavated through the local impervious layer if any.

Deep gravity relief wells are also very effective in reducing the pressure under the barrage.

In case of dams, drainage galleries are provided.

Uplift Pressures

From the mechanics of under seepage it may be clear that failure of structure can occur by:

(*a*) undermining of soil—(piping, exit gradient etc.)

(*b*) uplift due to pressure under the foundation floor being in excess of weight over it.

The first factor works equally in case of dams and weirs but the importance of second factor is more pronounced in case of weirs and such structures where relatively thin mass of the foundation is also the body of the structure and is alone (sometimes in conjunction with weight of water above) to resist the uplift. Floors are likely to burst if not adequately strengthened. Dam failures can also occur as it reduces the effective weight of the structure which provides resistance to sliding. (this can however be provided by deep cutoff, well embedded and strong enough to resist the sliding forces).

In fact the two factors are inter-connected and the uplift pressure at any point under the

foundation (of weirs and dam etc.) may be called exit gradient if the impermeable mass of the structure is assumed to terminate at that point.

Opinions differ as to whether the effective pressure at any point under the floor is the full indicated pressure or only a fraction of it. One school of thought considers that as the water and soil cannot be in contact with the under side of the floor at one and the same time hence the full indicated pressure will act only on that part of the surface which is not in contact with the soil. The other school contends that water will exert full indicated pressure on the entire area directly or through the soil grains as the case may be. The problem is similar to that of retaining wall with saturated fill. General indication however is in favour of the assumption that the full indicated pressure acts on the entire surface. The sub-committee on the uplift in masonary dam (Trams of A.S.S.E. 1952 Paper No. 2551.) however sets the following criteria for assumption in design.

"It appears in the light of the various figures presented that 100% intensity factor (I = 1) is decidedly conservative particularly if an area factor A of 1.00 be assumed and that the intensity factor of T.V.A. diagram would be substantially supported by U.S. BR data".

Here in Pakistan, however, we do nct reduce the effective pressure because of so many uncertainties.

Method of Calculating Uplift Pressure

Mathematical solutions are available for simple cases to determine the uplift pressures and exit gradient. For simplicity graphs are also available to determine these factors. Neither a complete mathematical nor graphical solution is available for complete and complicated profiles. Khosla has evolved however a method of solution of such cases — known as Khosla's method of independent variable. In this method a complex section is split up into elementary standard sections which are treated as independent of the others. Pressures at key points are calculated (or read from the graphs). The key points are junction points of floor and the pile line of that elementary form, the bottom part of that pile line and the bottom corner in case of depressed floor.

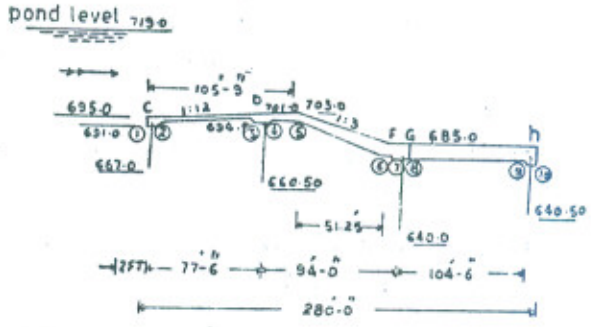
The readings at junction points are then corrected for:—

(1) The mutual interference of piles.
(2) The floor thickness.
(3) The slope of floor.

The method is explained below with an example.

RASUL BARRAGE

NORMAL SECTION OF FLOOR



Consider Point D.—Calculation for pressure at point 4, below the underside of floor shall be as under:—

$$b = 280'$$

$$b_1 = 77.5 + 2.0 = 79.5'$$

$$\therefore \frac{b_1}{b} = \frac{79.5}{280} = 0.284$$

$$\text{Depth of sheet pile} = \left[\left(695 + \frac{79.5}{12}\right) - 660.5\right]$$

$$= 47.12$$

$$\therefore \quad = \frac{b}{d} = \frac{280}{41.42} = 6.79$$

$\therefore$ $\phi 3 = 74.25\%$
$\phi 4 = 53.75$
ϕR.L. 660.5 $= 63.0\%$

Correction

1. For thickness of floor $=$

$$+ \frac{63.0-53.75}{41.12} \times 7.12$$
$$= + 1.60$$

2. Due to interference of sheet pile at G

$$= 19 \sqrt{\frac{D}{b}} \times \frac{d+b}{b}$$

where

D = depth of sheet pile at G i.e. whose effect is to be determined. This depth is with reference to some fixed R.L. say top of floor — 685.0

d = depth of sheet pile at D i.e. of which effect is to be determined. This depth is with reference to some fixed top of floor 701.62.

b = Horizontal distance between piles $= 94.0^1$

b = Total length of impervious floor $= 280.0^1$

$$\therefore \text{ correction} = + 19 \times \frac{41.12}{94} \times \frac{61.62+41.1}{280}$$
$$= + 19 \times 0.662 \times 0.367$$
$$= + 4.62\%$$

Note:—Correction is +ve for backward.
—ve for forward i.e. in the direction of flow.

$\therefore$ corrected value of ϕ at 4 $= 53.75 + 1.60 + 4.62$
$= 59.97\%$

Correction due to slope at 4 is zero and will be calculated for point 5 only.

correction is $\frac{b_3}{b_1} \times k$

where

b_3 = length along horizontal of slope.
b = distance between piles.
k = correction factor from graph.

$$\therefore \quad \frac{51.25}{94.0} \times 4.75 \text{ — — } 2.60$$

This will be +ve because the slope is downward.

To calculate ϕ at 5 :—

$$\frac{b_1}{b} = \frac{105.75}{280} = 0.377$$

$$\frac{b}{d} = \frac{280}{7.5} = 37.3$$

$\therefore$ $\phi 5 = 57.25\%$ (Read ϕ for base ratio of 0.62 and $\lambda = 37.3$ and subtract from 100.)

Correction

1. Due to mutual interference of piles:

(a) due to pile at D
here D $= 703.00 - 660.50 = 42.50$
$d = 7.5$
$b = 26.25$

$$\therefore \text{ correction} = 19 \times \sqrt{\frac{42.5}{26.25}} \times \frac{42.5+7.5}{280}$$
$$= (-)\ 19 \times 1.27 \times 0.1785$$
$$= -4.3$$

(b) due to pile at G
here D $= 703 - 640 = 63$
$d = 7.5$

$$b = 94.0 - 26.25 = 67.75$$

$$\therefore \text{ correction} = 19 \times \sqrt{\frac{63}{67.75}} \times \frac{63.0+7.5}{280}$$
$$= +19 \times 0.967 \times 0.252$$
$$= +4.62$$

2. Correction due to slope $= +2.60$
(as already calculated)