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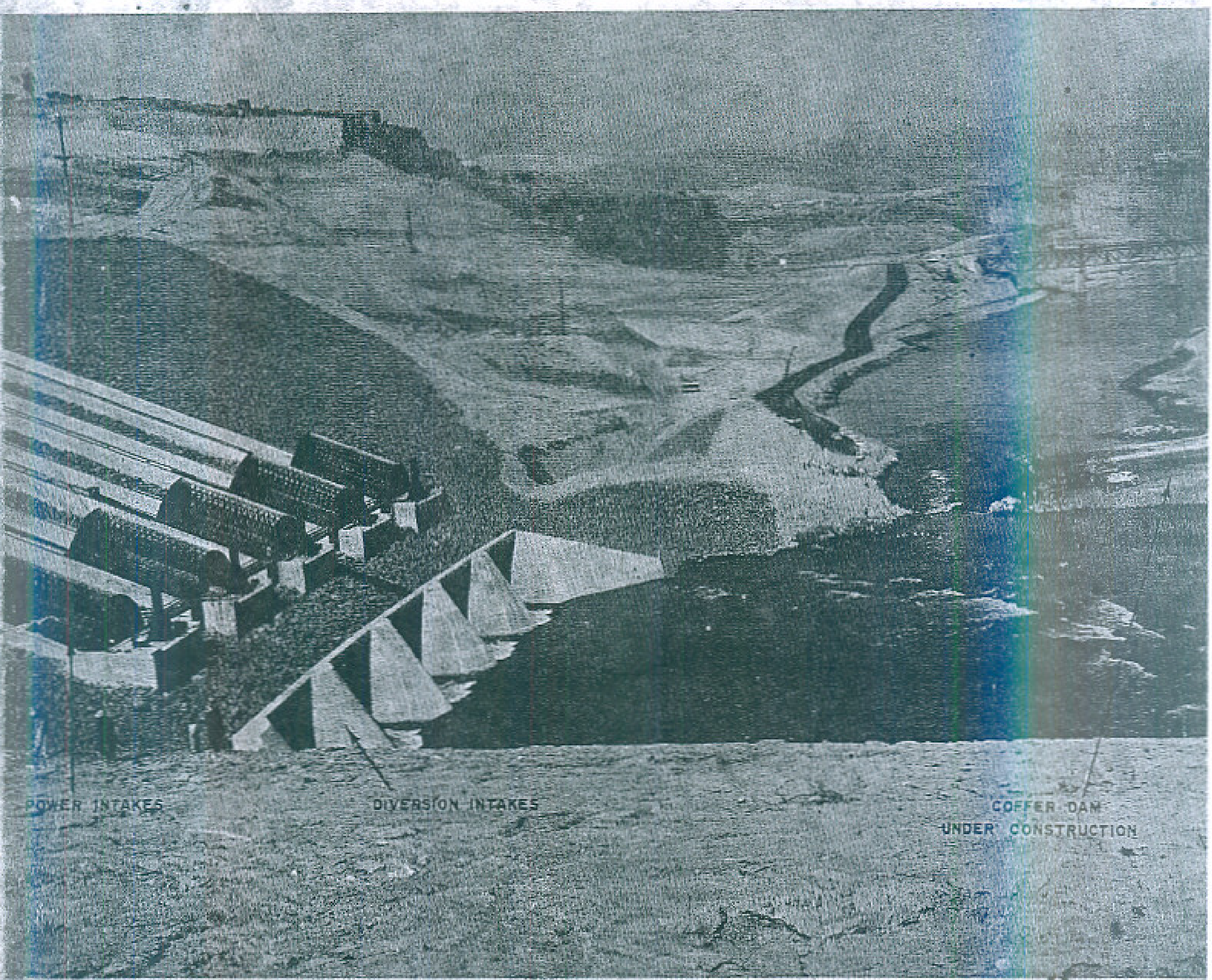
No. 3

DIVERSION INTAKES OF MANGLA DAM



ENGINEERING NEWS

QUARTERLY JOURNAL OF THE WEST PAKISTAN ENGINEERING CONGRESS

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ENGINEERING NEWS

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Vol. X September 1965 No. 3

In this issue

From the small

distribution transformers...

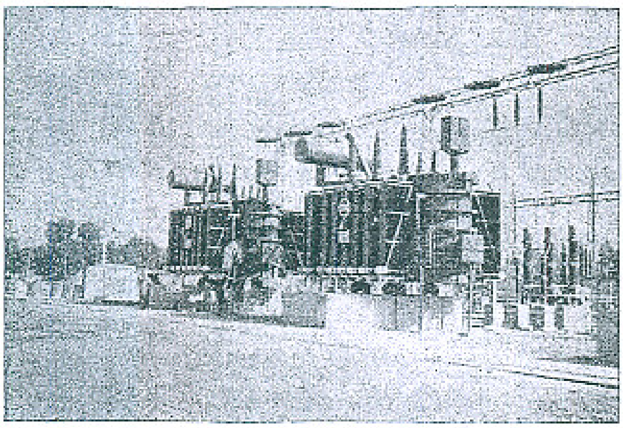
...to the large

power transformers...

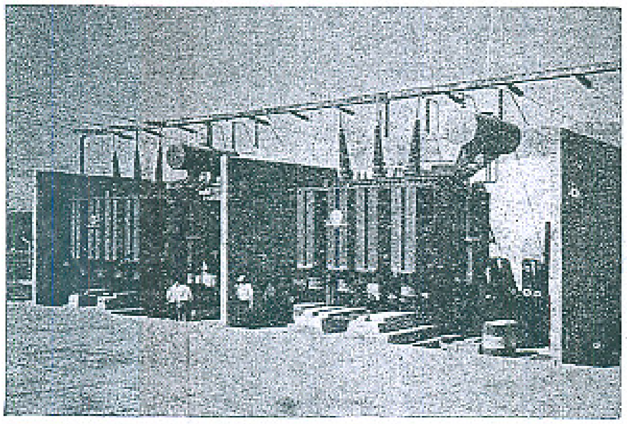
supplying

the provincial
the present
and the future
Capitals of

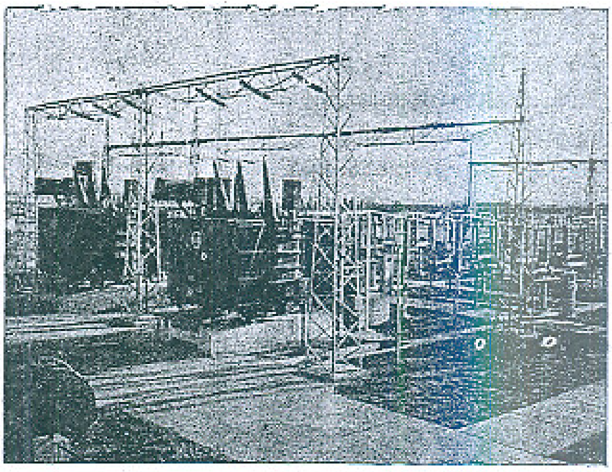
PAKISTAN



3 units 32 MVA 132/71 kV at Lahore



2 units 12.5 MVA 132/11 kV at Rawalpindi



2 units 16/5/11 MVA 132/36/12 kV
at Islamabad

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Research Council for Irrigation, Drainage and Flood Control Inaugurated

The long awaited Research Council for Irrigation, Drainage and Flood Control was inaugurated recently at Rawalpindi. In 1962, the Government had agreed to establish five such Research Councils. The present one is one out of these.

On independence, we inherited a grand system of Irrigation serving the largest single unit of culturable land. Its maintenance was entrusted to the Irrigation Engineers. The prosperity of this country depends on irrigation. Drainage is complementary to irrigation and on it rests the healthy performance of the land that has for long years sustained the life of this region and added to the prosperity of the inhabitants. Land too has its problems and the Research Council is the most appropriate body to take steps towards their solution. Before Independence, the Central Board of Irrigation was a well-organized scientific body of Irrigation Engineers. It used to meet twice a year and besides taking note of the Irrigation, Drainage and Flood Control problems, discussed measures to solve them. After independence, Pakistan was deprived of this facility and, except for the West Pakistan Engineering Congress and the Institute of Engineers (Pakistan), which occasionally discussed some aspects of the problems, till now there is no forum or any organized attempt to find solutions to the problems of land and water.

Before independence there were also several well organized laboratories and institutions where active research work on soil and irrigation was conducted. The Irrigation Research Institute, Lahore, was one such organization, which undoubtedly was a leading institution of the time. After independence, however, problems became so numerous that they were beyond the capacity of the Research Institute. The Irrigation Engineering problems of maintenance and construction of hydraulic structures also multiplied, but the Irrigation Research Institute has handled them efficiently and expeditiously. Although the problems of soil, their interrelation with water, the soils drainage and reclamation etc., are now equally multifarious. The existing organizations have not been expanded proportionately. In this connection, one is reminded of the River Side Research Laboratory of America, the Rathamstead Research Station, Harpenden, England, the Agricultural Chemistry and Soil Chemistry Institute, Budapest and organizations in Russia, France and other countries that have much less resources in land and water but have institutions well staffed with specialists and qualified soil and water scientists. Those who have the good of our country at heart have always recommended that this deficiency be made up and have suggested the improvement and expansion of the existing research organizations in keeping with the available resources of manpower and funds. Naturally it is now the responsibility of the Council to guide the Government in making up this deficiency and act in such a way as to make this country self-sufficient in all kinds of research. The Government also is keen and alive to the needs of the country, and that is why the Council for Irrigation aud Drainage has been set up. The country does need a reorientated outlook. Development of water and power is claiming the largest share of the resources of the country, but keeping the land in production is equally important. That the Government is also interested in the development of land is also evident from the award of honours made this year. Seven Engineers of West Pakistan have been honoured, out of these five belong to the branch of Irrigation Engineering.

Pir Mohammad Ibrahim, Mian Alim-ud-Din, Syed Monawar Ali, Dr. M. S. Qureshi and Mr. M. U. Arain are Irrigation Engineers actively working for the good of the country. This is the importance which the Government attaches to the development of hydraulic structures and power resources. It is gratifying to note that in the recent deliberations of the scientists who had gathered at Swat at the suggestion of the President of Pakistan, the problem of drainage and land improvement received the importance it deserved.

It is a matter of great satisfaction that with the inauguration of the Council, a body of competent engineers to look after the problems of drainage, waterlogging and salinity has been set up and active investigations on the lines indicated by the C. S. I. R. Laboratories and Atomic Energy Commission will soon start. The Pakistan Science Council has already proposed institution of a study group for going into the waterlogging and salinity problem. It was entrusted to the Irrigation and Drainage Council, and there is no question but that the organization will rise to the occasion.

River Jhelum Diverted Through Tunnels

RAMIZ AHMAD MALIK*

On the 12th of September 1965 the River Jhelum was diverted to flow through tunnels of the power-house of Mangla Dam. This diversion was originally planned to be affected in the presence of Head of the State but due to, the emergency, the whole Programme had to be changed. The river discharge at the time of diversion was 21000 cusecs and it was falling every day by 500 to 1000 cusecs. The whole process of diversion was successfully completed by 16th September. In this article Mr. Ramiz Ahmad, Director Mangla, has given a brief detail of the diversion procedure of the Jhelum river.

DATE FOR RIVER DIVERSION

The successful diversion of the Jhelum River through five tunnels on 16th September, 1965 closed a very controversial chapter of choosing a proper date for the diversion. In the Tender Documents it had been given out that the river diversion should be carried out in any year as soon as possible after the Monsoon season. Accordingly Mangla Dam Contractors indicated in their Construction Schedule, attached with the Tender Documents, that the river diversion would start from 1st of October 1965. The Contractor was required to submit another Construction Schedule within 90 days of the award of the Contract. Mangla Dam Contractors submitted this schedule during May, 1962 and advanced the date of river diversion by 16 days which meant that the river diversion would be carried out by 15th of September, 1965.

During June, 1965, the Contractor gave a detailed programme of his diversion operations, synopses of which are given below and the various works performed in this connection are shown in the Plan A.

Date	*Work to be done*
5th September	Start building upstream closure dam across River Jhelum by dumping gravel from right bank.
8th & 9th Sept.	Lower tailrace coffer dam to elevation 911.
10th September	Raise tailrace water level to river level by opening tunnel gate No. 1. Extend coffer dam across Jhelum River to give waterway

**Director, Mangla Dam, Wapda, Lahore.*

wide.

Breach tailrace escape dam.

12th September	Open gate of tunnel No. 1 again.
16th September	When waterway is 100 feet wide, all the gates of the tunnels will be opened.

This programme indicated that diversion operations would actually start from 5th of September and would be completed by 16th September. In selecting the date of diversion of the river three important aspects had to be examined :—

1. Coffer dam in the river Jhelum is not over-topped by any flood during September.
2. Power Station Coffer Dam is not over-topped by any flood which enters the tailrace area from the gap in the tailrace escape dam.
3. Safety of the tunnels.

These three aspects are discussed in more detail as below :—

Over-topping of the Coffer Dam in Jhelum River

Studies of river flow in the Jhelum River indicated that the coffer dam in the Jhelum River would be over-topped with the levels and discharges given below :—

Level of Coffer dam	*Flow which over-tops the Coffer dam (in cusecs)*
900	55,000
910	85,000
920	112,000
930	132,000

Studies for the river flow during the month of September for the past 40 years' record indicated that the flow greater than the discharges mentioned above had taken place during the month of September for the following number of times :—

Period	Flow greater than 132,000 cusecs	Flow greater than 112,000 cusecs	Flow greater than 85,000 cusecs	Flow greater than 55,000 cusecs
1st to 15th Sept.	2	4	5	20
16th to 30th Sep.	1	1	2	5
1st to 15th Oct.	0	0	1	2

From these studies we concluded that the Contractor's diversion programme was rather enthusiastic and he was undertaking some unnecessary risks. Model experiments had indicated that it was safe to attempt diversion of the river when river discharge falls below 50,000 cusecs. As shown above, the discharge in Jhelum River has exceeded 55,000 cusecs in 20 days in 40 years from 1st to 15th September. In our view, therefore, it was not safe to start diversion operation on 5th of September, breaching Tailrace Coffer Dam on 10th of September and opening tunnel No. 1 on 12th September.

Flood hydrograph showed that a peak of 3,55,000 cusecs had been recorded on 25th of September, 1954. September is still a month of floods for the Himalayan Rivers and cloud outbursts of severe intensity in the Himalayan catchments during this month are not infrequent. Thus there was the possibility that the Coffer Dam in Jhelum River might be over-topped if diversion is attempted earlier than 15th of September, 1965.

1966 after having completed the closure dam to elevation 930. The quantity of fill materials required for raising the closure dam from elevation 930 to elevation 980 is 1.36 Million Cubic Yards. In planning earlier diversion of the river the Contractor's intention was to gain more time for placing this tremendous quantity of fill. During early stages of the Coffer Dam up to elevation 930 if some flood did occur to over-top the Coffer Dam (closure dam), the quantity of materials wasted was not very much and therefore the Contractor could attempt to build up the closure dam again to elevation 930 by 1st November, 1965.

6. Final Decision

After long discussions with the Consultants and the Contractor the following procedure was agreed to—

1. The Contractor should proceed with his diversion programme from 5th September, 1965.
2. A very close watch of the weather forecasts would be kept and in case there is the possibility of any impending flood on or after 10th of September, 1965, the tailrace escape dam will not be breached.
3. The gap in the tailrace escape dam would be gradually widened after 10th of September and, if adverse forecast is received before the coffer dam in the Jhelum River is completed, tunnels would be closed and tailrace escape dam rebuilt to elevation 910 or above so that the flood can be passed in the original course of the river. The Consulting Engineers indicated that an experienced meteorologist would be able to forecast any impending flood 3 days in advance.
4. The contractor will build the coffer dam round the power-house elevation 915.

With the above-mentioned procedure it would be possible to keep the works safe up to 20th of September after which the possibility of floods would be considerably reduced.

7. Actual Diversion of the River

The Contractor has been very lucky with his diversion programme. It has been an exceptionally dry year for the Jhelum River and at the time of starting diversion operations the discharge in the river was about 21,000 cusecs with the daily fall of 500 to 1,000 cusecs. Unfortunately the diversion operations fell within the emergency period and the Contractor's night shifts had to be closed. In spite of this, everything went well. The tailrace escape dam was breached on 12th of September instead of 10th of September and gates of tunnels No. 1 were opened on the same date. Construction of coffer dam from the right bank of the river was started on 10th September and completed on 16th September at 100 hours.

Further Programme

After the completion of the coffer dam and diversion of the river, slurry trench cut-off was to be put in the river bed below the closure dam so as to minimise seepage downstream. However on opening up the foundations it was found that the seepage was minimum and there was no necessity of putting in a slurry trench. This has given the Contractor additional time in putting in fill materials as quickly as possible. The closure dam has arisen to elevation of 965 by 1st of December, 1965 and the Contractor hopes to raise it to 1083 by middle of March, 1966. Thus he is ahead of his own schedule by $2\frac{1}{2}$ months.

Physico-Chemical Characteristics of the Suspended Material in River Water

Ch. MUHAMMAD HUSSAIN*

It has always been said that the presence of silt in river water is beneficial for Irrigation purposes. In t year 1935-36, this problem *was investigated in the Irrigation Research Institute and the main conclusio were that there was no particular chemical which can be beneficial for crops. This question has not be further investigated. It is only now that Ch. Mohammad Hussain, Director, Land Reclamation on the bas of his recent analysis has come to the conclusion that there is chemical activity present in silt which helpful to the soils. The analysis and the conclusion of Mr. Mohammad Hussain are put forth in this note*

Problem of great economic importance for the farmers is the fertility level of the farm lands, rise of salts with ground-water table, absence of drainage, use of poor quality of Irrigation water and improper soil management result in development of Salinity and Alkalinity conditions. The river water used for irrigation in Indus Plains is of good quality. For this reason the farmers have always preferred to use the river water, instead of water got from ground-water sources. River water loaded with silt is given preference over the same quality of water but without suspended material.

The good effects of silt are probably known to the farmers from their experience with the fertility value of the alluvial silt deposits occurring in the active flood plains. Perhaps on this very account the farmers c Thatta region have strongly resented th use of silt-free water from river Indus whic is supplied through Kalri Lake. The sus pended material settles down in the Lak and the farmers receive clean silt-free wate supplies in the channel which take off fron the lower portion of the Lake. This sus pended material, according to the notion of the cultivators, helps in maintaining th fertility level of the soil. Also the silt loadec water while flowing in the channels anc ditches helps to suppress the growth of water-weeds. Now-a-days the profuse growth o Algae and Mosses in channels having silt-free flow of water has become a serious problem requiring constant weed clearance. In this note, studies have been conducted to determine the manurial value of silt.

**Director, Land Reclamation, West Pakistan, Lahore.*

Collection of silt samples for analysis

In September 1965 silt samples of river Indus at Ghulam Mohammad Barrage and from the Lower Chenab Canal at R.D. 9,500 were collected for analysis. The sediment content was dried and its chemical characteristics were studied. The physical tests included the mechanical analysis and the chemical analysis included the determination of Calcium, Carbonate and other fertilizing nutrients such as Nitrogen, Humus, Potash and Phosphorus etc.

(i) Mechanical analysis

The mechanical composition of the silt samples of rivers Indus and Chenab are given in Table No. 1, below :—

The results indicate that the suspended material collected at Ghulam Mohammad Barrage from River Indus has 5.4% clay, 23.1% silt and the rest 71.5% is the fine and coarse sand. In case of the suspended material collected from the Chenab there is 3% clay, 10% silt and the remaining 86.7% is the fine and coarse sand. The suspended material in River Indus at Ghulam Muhammad Barrage is finer in nature as compared to the suspended material collected from the Chenab water in the northern part of the Indus Plain. The alluvium in the northern part of the Indus Plain is coarser as compared to the southern part, so that the soils of the northern areas of the Indus are generally of light and medium type and of Sind areas are heavy. The application of silt to the light and medium soils is beneficial to improve its physical properties. In the fine textured soils, the permeability of the soil is improved as the silt added has a fairly large amount of fine and coarse sand. Besides, the addition of the ions help in the formation of granular structure of the soil which improves the aeration and drainage in the root zone.

Table No. I showing the Mechanical Analysis of River Silt.

Sampling Site	Physical Tests				
	Clay	Fine Silt	Coarse Silt	Fine Sand	Coarse Sand
	%	%	%	%	%
Silt samples collected from River Indus at Ghulam Mohammad Barrage ..	5.4	17.9	5.2	67.9	3.6
Silt samples collected from Chenab Water (Lower Chenab Canal at R. D. 95,000) ..	3.0	5.0	5.0	85.5	1.2

(*ii*) Chemical Analysis

The chemical constituents of silt both for soluble and adsorbed ions is given in Table II below :—

Table II showing Chemical Analysis of the suspended material.

	Soluble Constituents		Adsorbed Ions	
	Indus River Silt	Chenab River Silt	Indus River Silt	Chenab River Silt
	(Value in Me/L)		(Me/100 Gm.)	
1. Calcium	2.00	4.00	3.9	3.21
2. Magnesium	1.60	1.45	3.1	1.19
3. Sodium	1.67	1.52	nil	nil
4. Potassium	0.2	0.2	nil	nil
5. Carbonate	nil	nil	—	—
6. Bicarbonate	2.45	2.80	—	—
7. Chloride	1.50	1.50	—	—
8. Sulphate	1.52	2.87	—	—
9. Total Cations	5.47	7.17	—	—
10. Electrical conductivity (M. Mhos/Cm) ..	0.45	0.59	—	—
11. pH	8.1	8.0	—	—
12. Res. CO_3 Me/L	nil	nil	—	—
13. SAR	1.24	0.92	—	—
14. SP%	41	40	—	—

The estimation of insoluble calcium carbonate was also carried out. It was found to be 9.7% in the Indus silt and 4.15% for the Chenab Silt.

The proportion of fertilizing nutrients such as nitrogen, humus, total phosphorus and potash was as under :—

Table III showing the results of fertilizing nutrients in silt samples

	Indus River Silt	Chenab River Silt
1. Nitrogen %	0.028	0.0224
2. Rumus Mg/Gm.	3.510	3.120
3. Total Phosphorus	Traces	Traces
4. Potash %	0.263	0.235

DISCUSSION

In the past efforts have been made to evaluate the fertility status of the silt from the chemical composition. In 1936, analysis was carried out for Calcium Carbonate, pH value, Total Phosphate, Potash and Sodium in Acid Extract, Available Phosphate, Nitrogen, Exchangeable brass, total exchange capacity and Clay Percentage.

The calcium carbonate was present in large quantity, about 9-10% and the other constituents were negligible. The previous workers, however, considered, the presence of calcium carbonate in silt, of little importance to the Punjab soils which are generally alkaline in reaction.

In the present investigations the critical examination of the analysis data of the suspended material has led to the important conclusions.

(*a*) Water soluble and Exchangeable Cations

(*i*) Absence of residual sodium carbonate in the suspended material is due to the presence of calcium and magnesium in appreciable quantity. Any sodium present in the form of sodium chloride or sulphate will not have a direct adverse effect except the raising of the salinity status of the soil and which can be leached down easily during the course of irrigation. In the exchange complex, calcium and magnesium would have a favourable effect on soils.

(*ii*) The total amount of the soluble constituents to be added during irrigation applications are, however, radically small. Taking 0.15% an average figure of the suspended material for the Indus water at Ghulam Mohammad Barrage and 0.2% for the Chenab River and assuming 5 acre feet irrigation application during the year, the amount of calcium and magnesium added in the soluble form will be 0.57 lb. and 0.92 lb. per acre per annum respectively.

(*iii*) The quantity of the exchangeable calcium and magnesium with 5 acre feet irrigation application will be 23.33 lbs. and 18.3 lbs. per acre per annum for the two rivers. The obvious reason for the presence of small quantity of calcium and magnesium in the soluble form, compared with the large amount in the exchangeable form is due to the suspended material having been remained in suspension in the river water. In the evaluation of the fertility status of the suspended material, it is necessary to take into account both the calcium and magnesium in the soluble as well as in the exchangeable form. The constant addition of calcium and magnesium will definitely improve the soil texture granular formation which helps in soil aeration moisture holding capacity and mositure penetration. The alkalinity hazard of the soil will also be suppressed due to the constant supply of calcium and magnesium, which in a way reflects on the fertility status of the soil.

(*b*) Fertilizing Constituents

On the basis of 5 acre feet annual irrigation application on the fertilizing nutrients added per acre per year as per Table III work out to be 5.5 lbs. of nitrogen, 56 lbs. of potash, 72.0 lbs. of humus and negligible amounts of phosphorus. Compared with nitrogen, phosphorus and humus, the potash added is in quite a reasonable amount and for this very reason probably, the canal-irrigated areas are not deficient in potash. The beneficial effects of other nutrients although in small quantity but if added constantly, upkeeps the fertility level to some extent. The notions held by the cultivators about the fertilizing effect of the silt loaded water are, therefore, not unfounded.

(*c*) Presence of Calcium Carbonate

The amount of calcium carbonate added with 5 acre feet irrigation application works to about 2000 lbs. in case of Indus water and 1000 lbs. in case of Chenab water. It may not be easily available, being in insoluble form and soil being of alkaline nature, but some quantities of it may come in solution gradually during the course of crop growth. Needs for the calcium are constantly met with from our irrigation water and our efforts should keep it in available form by suitable biological within the means of our cultivators by other means.

(*Continued on page* 24)

Gumti River and its Problems

By K. AZEEMUDDIN*

The river Gumti has a history of tragedies and those recorded almost date back to 300 years. It has earned a reputation as the "River of Sorrow" of East Pakistan. Records show that as far back as 1669, embankments came to be constructed on its banks to prevent its spill and consequent damage to land and property.

As more and more embankments came to be constructed on both the banks, the river became contained for longer lengths, with the natural consequence that the river started silting up resulting in higher and higher flood levels. With the instinct of self-preservation the cultivators must have started raising these embankments to meet the challenge of these higher levels—the vicious circle thus started. Today the flood levels in the river are normally 15 to 20 ft. higher than the ground levels below the embankments. The problem must have become very acute as early as 1793 when permanent settlements were regularised and it was made the special responsibility of the Maharajah of Tippera to maintain these embankments.

The Gumti river, which has its source in the Tippera hills now in Bharat and enters Pakistan alluvial plain near Bibir Ganj village, is a small river with a catchment area of only about 837 sq. miles, when compared to the giants flowing closeby. Its floods apparently have not exceeded 30,000 cusecs as compared to the normal yearly flood of 5,000,000 cusecs in the Meghna near Chandpur barely a distance of about 25 miles.

As early as 1883 its flood problem attracted the attention of technical officers and the first report on these embankments was made by Mr. D. B. Horn, who recommended the abandonment of embankment to the west of Comilla. In 1890 Government approved the repairs of the whole left bank embankment and for only 4 miles of the embankment on the right bank beyond which point the embankments were asked to be lowered. In spite of Government orders for almost abandoning the entire embankment on the right bank, people started raising new embankments to prevent flooding of their lands. In a conference held in 1939 at Calcutta it was decided that the ideal solution would be abandoning the embankments altogether except for the portion in front of the Comilla town. It appeared that the

*Managing Director, Associated Consulting Engineers Ltd.

people who attended the conference were mostly towns people and there was protest from the cultivators and the Government did not agree to the solution suggested by the conference. Since then strengthening of embankments and dredging in the river bed and in the loops was carried out, but these served only a temporary relief.

Embankments or no embankments has been a subject of long and abstruse analysis not only in pre-Partition India but also in other parts of the world, particularly in USA. The plan of embankments - at any rate the way in which it has been carried out here in a haphazard manner—has undoubtedly failed to accomplish its design; but can the embankments be altogether done away with? The answer is definitely in the negative since the flood levels have increased to such a height that this will create far greater loss and damage to land and property. The very fact that the Government failed to implement such a programme in the past is ample proof of this fact.

No proper record of the breaches prior to 1906 is available but between 1906 and 1963 as many as 116 breaches have been recorded in the first 20 miles of the river between Bibir Bazar and Jafferganj, which gives an average of two every year. Flood damage during the period 1951-61 have been estimated by enquiry and reference to official records where available and it has been estimated that direct losses ranged from a minimum of Rs. 0.307 million to a little over Rs. 18.242 million per year. This represented an annual loss of Rs. 95 per person affected, which considering their economic condition is a heavy financial burden, particularly as many of these people will be subject to this loss quite frequently.

In 1962, we were entrusted to find a solution for this Gumti flood problem. The first and foremost consideration was to determine the extent and magnitude of probable maximum flood discharge in the river. The Krug Mission report had estimated the probable maximum flood to be of the order of 100,000 cusecs. During the last 50 to 60 years, for which some records were available, this flood discharge apparently never exceeded 30,000 cusecs. In the last 300 years as well such a flood could not have possibly occurred. Such a flood would have completely washed away the town of Comilla which is situated on the bank of the river. Even assuming the occurrence of a breach in the embankment upstream of Comilla, it would have to be a big breach to save Comilla town and such a breach would have easily carved a new course for the river Gumti.

The catchment area of the river is 837 sq. miles. The rainfall in the catchment area can be taken as 100 inches. Although these two factors incline towards the adoption of the higher figure suggested by the Krug Mission and give the impression that even ordinary recurring annual floods should be above 50,000 cusecs, but there are certain factors which have to be considered as they have an appreciable influence in diminishing this value. Mostly the catchment area is heavily wooded and there are lakes just below the hills through which the river has to pass before entering into Pakistan territory. It is also gathered from the maps that as much as 153 sq. miles of the catchment area consists of sandy and pervious hills which absorb the rain waters and prevent the formulation of a continuous stream system. The river also passes through a narrow gorge where it is likely to form a pond upstream during a flood of high magnitude. Unfortunately it has not been possible to evaluate the influence of these factors correctly as the entire catchment area lies in Bharat and we have no access to this information.

A preliminary check has been made by determining the total volume of flow in a particular year and the extent of runoff, in order to verify whether the percentage of runoff is reasonable. The period selected is from April 1955 to March 1956. The total rainfall in this period at Comilla has been 84" and the total discharge of the river 1.826 million acre feet. This gives the percentage runoff at about 50%. This may slightly reduce if we take into consideration that in the upper parts of the catchment area, there is a possibility of heavier rainfall for which we have no means to ascertain. But even so the percentage of runoff is not likely to be very much lower and will still be reasonable for the rainfall. This analysis confirms that a great deal of runoff is retarded by the many factors discussed above and the water so absorbed eventually finds its way as a prolonged flood or higher winter flows.

The anticipated flood discharge has been estimated by adopting the analysis advocated by different authorities based on flood frequency, rainfall runoff relation and some empirical formulae particularly those that have been evolved by experience in the sub-continent of India and Pakistan. The results of these analyses are given below :

	100 year frequency flood in cusecs.	1000 year frequency flood in cusecs.
1. Unit hydrograph method ..	39,040	47,720
2. Fosters flood frequency analysis ..	28,200	34,800
3. Harzin's flood frequency analysis ..	29,800	41,000
4. Richard's method of flood estimate ..	46,600	68,300
5. California culvert practice ..	40,300	50,400

In addition the following empirical formulae have also been used to find th maximum possible flood discharge :

(a) Ryve's formula 60000 cusecs.
(b) Dicken's formula 61960 ,,
(c) Fanning's formula 55800 ,,
(d) Craig's formula 53400 ,,
(e) Iszkowski's formula 50600 ,,

It is felt that an assumption of 40,00 cusecs for a 100-year frequency flood an 50,000 cusecs for a 1000 year frequency ca be a fair value to adopt.

Various alternatives have been examine to find out a solution of this problem and t determine the best way of overcoming th annual catastrophe of breaches. The alternatives considered and later abandone before arriving at the final proposals are :

(1) Excavating one or more escapes t divert the flood waters.
(2) Providing fuse plugs in the embankment
(3) Abandoning the embankment and onl protecting the Comilla Town to sav residential and business places.
(4) Dredging of the river to pass the flood at low water level.
(5) Constructing dams in the hilly catchmen areas.

Two escapes have been estimated in som detail. One takes off upstream of Comill meeting the Big Feni River and passe through the highest available ground. It i found that in spite of giving a fall of nearl 9.6 ft. at its offtake, the water level in miles of its length will still be 9 to 11 ft above normal ground level. The length c this escape will be 42 miles against 22 mile of embanked section of Gumti and as th escape will be running intermittently i times of floods, the chances of breaching it embankments will be greater than in Gumti The cost of this escape for a carryin capacity of 6000 cusecs is estimated to be Rs. 21.6 million. Another escape diverting the entire Gumti from Mainamati Hills to Daudkhandi has also been considered. The length of this escape will be 24 miles and allowing the H.F.L. of water to remain 10 ft. above ground level, two falls aggregating into a total fall of 13.4 ft. will have to be constructed. The cost works out to Rs. 40.00 million.

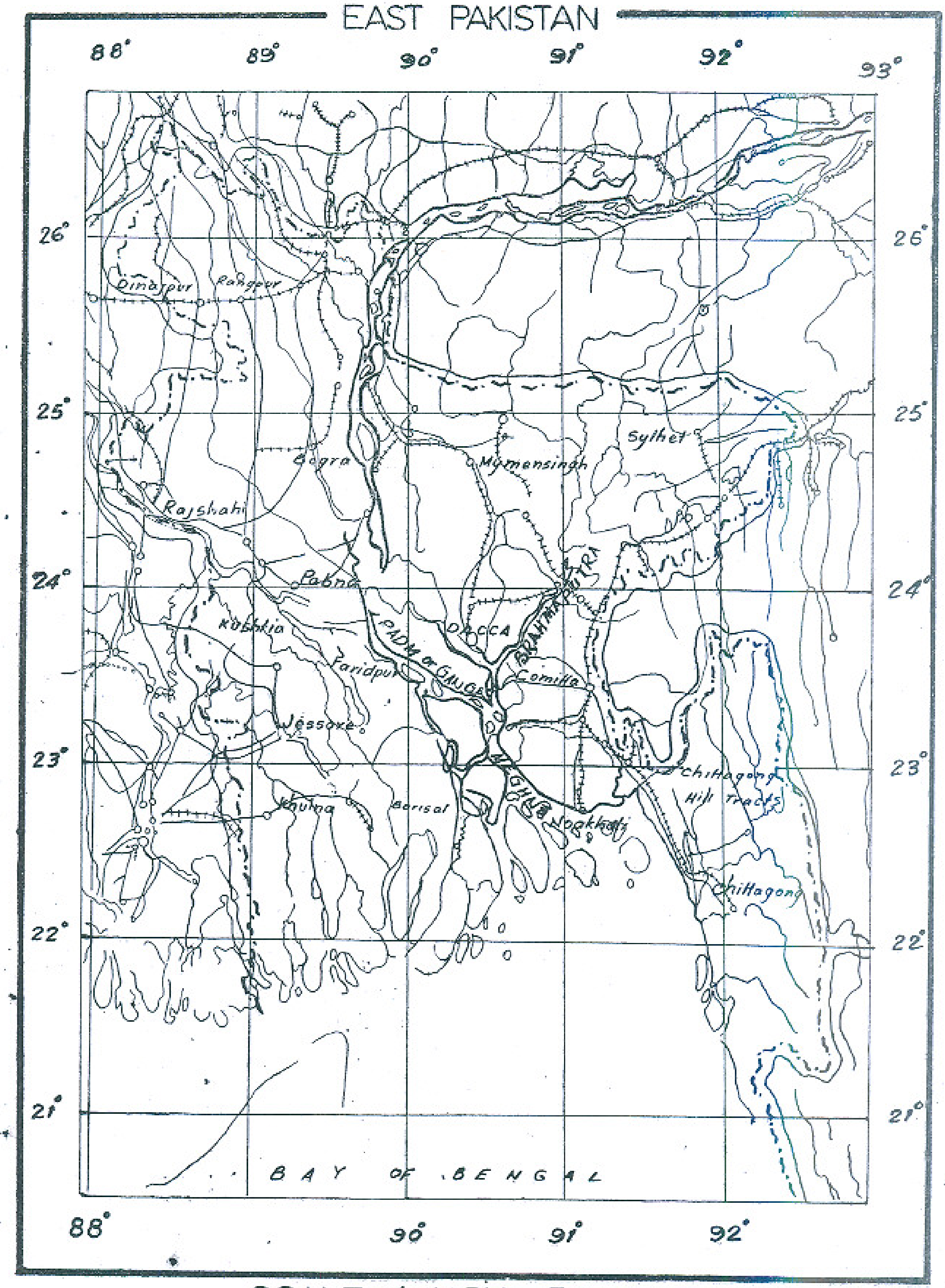
Analysis shows that even with a diversion of 6000 cusecs the H.F.L. in the Gumti can only be lowered by 1 foot and the danger of Gumti banks breaching is not averted. Further, both the escapes are costly needing considerable land acquisition at a time when land is badly needed for growing crops and the danger of breaches through them is greater as more lengths of embankments need constant patrolling and looking after. These escapes will not solve the project, on the other hand we will be introducing fresh areas that will be subject to threats of danger and loss due to breaches in embankments. Taking these points into consideration this alternative has been rejected.

The alternative of providing breaching sections to give relief at the time of high floods has been discarded mainly because the cultivators consider the breaches as an "Act of God", but in the case of a breaching section it will be considered as an artificial breach due to a wilful act on the part of the administration, which will render Government responsible to pay the entire cost of damage to crops and property. This will be a recurring and heavy financial burden on the Government.

The question of abandonment of embankments has been vehemently opposed in the past by the cultivators of the area and rightly too. In addition to the heavy damage that such high flood levels may cause, there is also another factor to consider. At present the breaches generally occur late in the season when the crops are high enough to withstand submergence and only the crops in the vicinity of the breaches are damaged. With the removal of embankments, crops in their early stage of maturity are also likely to be damaged and the damage will also be in much bigger area than at present.

Dredging of the river to increase the waterway is also a solution but it is found that the present cross-sectional area of the river channel up to its berm level is only 15 to 20 per cent of the total area of floodway, and even if the river is deepened to almost double its existing cross-section, the additional area will add another 15 to 20 per cent to the floodway, but this can be more economically achieved by adjusting the embankments a little further, wherever necessary. Further, the disposal of this dredged material will be a problem ; if it is placed on the berms it will reduce the waterway and much of the advantage gained will be lost, on the other hand pumping the dredged material beyond the embankments will need extra land involving conflict with the cultivators owning the land. There is also the possibility of the dredged channel silting up by degradation of bed upstream in the Indian territory. Hence, dredging the river to pass the floods at low levels is not considered as any permanent solution.

Lastly, the idea of constructing dams in the hilly areas of the catchment has to be given up because all the sites lie within Indian territory and as such this solution is not practicable under the present political circumstances.



SCALE - 1 INCH = 50 MILES

The only alternative left is to improve the existing embankments. There is no doubt in the fact that these embankments have come to stay. A survey of these embankments shows that they have been constructed by the cultivators in the past in a very haphazard manner. They have evidently been constructed to meet the exigencies of the moment. Their location must have also been governed by the influence a particular owner of land exerted to keep his fields on the outer side. One silver lining in the present state of this river appears to be that the river has attained a somewhat stable regime for its altered status of an embanked channel. During the course of 100 to 200 years of an embanked status the river has aggraded to a more or less stable level. Maximum flood levels recorded at the close of last century give almost similar figures with corresponding rainfalls under the present conditions.

I would like to make a little digression from the discussion of this project and deal a little with the general flood problem in East Pakistan, because herein lies a main controversy: embankments or no embankments. No one can deny the fact that wherever embankments have been constructed some deterioration has taken place in the river regimes, but to wave the embankments altogether on this consideration alone without taking other economic and social factors into consideration we will not be doing justice to the problem. East Pakistan is an entirely deltaic plain with no control over the head reaches of two of the mightiest rivers of the world, the Brahmaputra and the Ganges which bring a normal annual flood of 2 to 3 million cusecs respectively, and which flood large tracts of land almost every year. The situation is further aggravated by the fact that the density of population is one of the highest in the world, at places as much as 1700 per square mile. The rate of growth of population is also alarming. The present average holding of a family ranges between 1.5 to 2.5 acres, and every inch of land is cultivated. The most urgent problem of this tract is to keep on growing more and more food crops to cope with feeding the teeming millions. Under present conditions where the fields are flooded annually with 5 to 10 ft. of water over a major portion of East Pakistan, there is little possibility of improving the yields. The only way to cope with the yearly growing demand of food grains is to control the floods effectively, introduce irrigation and fertilisers with better methods of cultivation and under these conditions is there any alternative but to gradually embank all the rivers? Experts have come and no doubt with a theoretically correct analysis have expressed the opinions that embankments on these big rivers must not be constructed, but what is the other alternative—floods, starvation and deteriorating economic conditions of the area. Those who know East Pakistan and its problems will not think twice before recommending the flood control by constructing the embankments along the rivers, because it is lesser of the two evils. These embankments may create some problems for the future generations, but one can only hope that with the advancement of technique they will be able to cope with its evil effects, if and when the time comes.

Coming back to the Gumti problem, it has been found that at places the embankments along this river are as much as 3000-4000 ft. apart whereas at other places the distance between the embankments is hardly 500 to 600 ft. Naturally, it is these narrow sections which control the flood levels between the embankment and are responsible for maintaining these levels at a higher elevation. There is also another drawback which has creeped into this haphazard development. The land in between the embankments belong to the cultivators and therefore wherever the berms are wide enough the cultivators grow aman, jute and sugarcane, crops that can withstand some submergence. These crops are generally at the stage of maturity or high at the time of floods which occur normally at the tail end of the monsoon season. These standing crops increase the coefficient of rugosity of the channel resulting again in higher flood levels. If these drawbacks are removed it will be possible to reduce the present flood levels.

After a study of the hydraulics of the channel and the existing alignments of embankments, it has been recommended that these embankments may be aligned in smooth sinuous curve taking maximum advantage of existing banks, so that there is a uniform width of 1000 ft. in between the embankments, and that the land in the floodway must be acquired by Government so that crops do not form an obstruction to the flow during high floods. Even where the embankments are very far apart, it is economical to bring them closer to this 1000 ft. distance, because the cost of acquisition of land will be more than the cost of constructing new embankments. Analysis showed that if these measures are carried out the flood levels within the embankments can be reduced by nearly 3 ft. as compared to the levels that will be attained under the present conditions for a flood of once in 100 year frequency i.e., 40,000 cusecs. The banks have been recommended for a free board of 6.5 ft. above this level and even if there is a flood of 50,000 cusecs the encroachment on free board margin will not exceed 2 ft. leaving the embankments safe with 4.5 ft. of free board still remaining.

For an additional safety to the town of Comilla it is proposed to cut the loop in the river at this point and divert it much further away than at present. This will give a much greater sense of security to the inhabitants of this town, who pass many a sleepless night almost every year. The left embankment passes at present through the town area itself.

It is also proposed to make this a multipurpose scheme with the introduction of irrigation. The low flows in the winter season are about 250 cusecs which can be put to use for this purpose. Even in the monsoons any deficiencies in rainfall can be made good. It is estimated that an area of 49,500 acres can be brought under cultivation. This can be achieved either by pumping direct from the river at suitable places or by constructing a regulator at the tail end of embankments near Jaffargunj and supply the water by gravity. The latter will need some model studies to ascertain the influence the regulator may exert on the regime of the river. The introduction of irrigation adds great financial stability to the project besides providing extra food and other crops so badly needed in East Pakistan.

Transitory Irrigation Development

By RAYMOND HILL*

In this short note reproduced from Civil Engineering of March, 1965, Mr. Raymond Hill has brought attention of the Irrigation Engineers to the most dangerous build of salt in soil as a result of too much water. Lack of proper attention to salt balance in soil has resulted in transitory benefits of Irrigation Development but ultimately it has caused destruction of once most prosperous civilization of the world. It is a warning for irrigation engineers of this country to realise the hazards of salinity in irrigated soils.

Downstream Users Suffer in Irrigation

Too little water and too much salt have been a most important factor in the demise of civilizations dependent upon irrigation. The same factors are as important today to irrigated areas in this country.

There are a few areas in the world where irrigation is necessary for the growing of crops and where there is also an ample supply of water for such use. Generally, and particularly in the southwestern portion of the United States, the potential demand for water is greater than the supply, so that each new development constitutes a threat to some prior development. Sooner or later someone has to do without water. In such cases, the Rule of high priority, promulgated by a legendary Montana judge, is invoked and the downstream users suffer.

Rio Grande Sufferers and Colorado River Basin

One example of this situation is the Rio Grande, which is the sole source of water for the lands in the Rio Grande Project of the U.S. Bureau of Reclamation in the El Paso area. Although the Rio Grande Compact of 1938 contemplated a normal release of 790,000 acre ft. per year from Elephant Butte Reservoir for irrigation of lands in this project, to supply water to Mexico under the existing treaty and to provide for removal of excess salts from the irrigated valleys, the average amount released from this reservoir during the past 15 years has been only 490,000 acre ft per year. Some of this deficiency in water supply may be ascribed to general drought conditions, but a substantial part of it is due to consumptive uses of water from the Rio Grande above

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Elephant Butte, for in excess of the amounts permitted under the interstate compact. It is obvious that there is too little water in the Rio Grande to support the present level of development.

A similar though less acute condition exists in the Colorado River Basin. New projects in the Upper Basin, now under construction or planned for the foreseeable future, will reduce the supply of water naturally available for use in the Lower Basin below the level of present uses from that river. When that happens, it will necessarily be followed by curtailment of irrigation agriculture unless water is imported from the Pacific Northwest. This will occur independently of the decree in the action of Arizona *vs.* California which merely defines who shall bear the burden of shortage.

Transitory Development in Central Arizona

These examples, which are only two of many that might be cited, are illustrative of the transitory nature of irrigation developments that require more water from a stream system than in fact exists. Another type of transitory development is that characterized by the mining of water in Central Arizona and on the high plains of Texas. In both places, hundreds of thousands of acres of land are being irrigated with water pumped from subsurface basins, which have virtually no recharge. Groundwater levels have progressively fallen throughout these areas; they will continue to fall until the physical or economic limit of pumping is reached. Most of these lands must sooner or later go out of cultivation; they are truly transitory developments.

I once held the view that each irrigation development should be limited to the area that could be supplied with water permanently available. Over the years, however, I became converted to the concept of transitory developments, provided that there be full recognition of the fact that they are transitory and that steps be taken to create a new economic base to supplant the prior agricultural base. My conversion has not, however, extended, to the point of accepting curtailment or abandonment of irrigation because of failure to prevent the accumulation of salts. Yet this has been the primary cause, throughout the history of the world, of the deterioration and even collapse of economies dependent upon irrigation.

Salinity Eat away Empires

All of you have read of the growth and eventual decline of city states and empires in Mesopotamia and elsewhere in the Middle East. Some of you, as have I, have had the opportunity to travel through these areas and see the remains of these old cities and even of some of the ancient irrigation works. A few of you may have had occasion to delve into the causes of abandonment of what at one time or another were extremely large irrigation developments. I believe that the successive city-states of Mesopotamia existed only so long as the lands near them were capable of producing the foods and fibres needed by the populace.

I recall seeing the traces of one irrigation system of almost textbook pattern, which must have served at least 200,000 acres, in an area now virtually uninhabited between the Tigris and the Euphrates about half-way between Baghdad and Basra. Although I saw this only from a small airplane at an altitude of about 1,500 ft., it was apparent for the lack of vegetation and the color of the soil that this once productive area had been destroyed by too much salt. Of the once great Chaldean Empire only ruins remain. The city of Ur, near the Persian Gulf, is now surrounded by a salt flat. These are not exceptional conditions: they are characteristic of the region. All that remain of most of the city states of Mesopotamia are a few ruins, a few traces of irrigation works, and an expanse of barren land.

We can only surmise that waterlogging of the irrigated land near each city took place with concurrent accumulation of salts in the soils, forcing abandonment of these and progressive extension of irrigation into other areas further away from the central city. We can only surmise further, because there was no transportation in the modern sense, that this drain on the economy of each such city continued until it was either conquered and destroyed, or was simply abandoned. We do know, nevertheless, that great areas of irrigated land were permanently abandoned and that the dependent city states are now the only means in history. Regardless of what did happen, it is clear that such irrigation developments were transitory in nature.

The effects of too much salt are not limited to the Middle East. The need for proper drainage to prevent the accumulation of salt is ever present, but too often ignored, even by those who know better.

Salt Balances, a menace of sustained Agriculture

Thirty years ago, C.S. Scofield, formerly Principal Agriculturist in Charge, Division of Irrrigation Agriculture, U.S. Department of Agriculture, pointed out the need of maintaining a "salt balance" in irrigated areas. His concept was simple. If more salt is brought into an area than is removed from it, there will eventually be a sufficient accumulation of salt to do damage. A few have listened to him, but his has generally been a "voice in the wilderness". For example, an average of about one million tons of salt per year are contained in the water diverted from rivers for use in the Salt River Valley in Arizona. For less than this amount is carried away. The balance remains, either in the soils or in the groundwaters underlying the valley. This has given concern to only a few people even though these groundwaters are reused for irrigation.

Salt balance conditions in the Rio Grande Federal Reclamation Project, for each year since 1932, have been the subject of special reports by the Salinity Laboratory of the Department of Agriculture. Unfortunately, these studies were terminated in 1963 just when the long-term effect of too little water was becoming apparent. In one quasi-official statement, discounting the finding of an adverse salt balance, the point was made that from 1931 to 1959, the outflow from El Paso Valley carried 265,000 tons of sodium and 1,120,000 tons of chloride in excess of the amount of these ions in the water released from Elephant Butte Reservoir. No consideration was given to the fact that much if not most of the sodium chloride in the out flow was derived from highly saline waters which are being flushed out by circulation to drains of water percolating from canals and irrigated fields.

The 265,000 tons of sodium, just referred to, had an equivalent weight of 11,500 tons equivalent; the 1,120,000 tons of chloride had an equivalent weight of 31,500 tons-equivalent. The difference, 20,000 tons-equivalent of chloride, did not leave the valley. The problem thus is not simple; the findings of the United States Salinity

Laboratory are deserving of more than casual dismissal. In this connection, I urge that recognition be given to the equivalent weights of the cations and anions in solution in all waters and to the fact that they are always in pairs; one positive, one negative. The use of parts per million instead of milligrams-equivalents per liter is as archaic as single-entry book keeping in this day of double entries of debits and credits to keep books of account in balance.

Many are alert to the immediate effects of too little water. I ask that all become alert to the long-term effects of too much salt. Transitory irrigation developments may be justified in some cases, but only if foreseen by those affected.

(*Continued from page* 13)

(*d*) **Water-weed problem present in Channels and Ditches**

In silt-loaded water there is no proper penetration of light necessary for the growth of water-weeds. These water-weeds, Algae and Mosses, are generally noticed in the drains carrying silt-free seepage water for a large part of the year. Since the water taking-off from the Kalri Lake flowing into the channels is free of suspended material there is heavy weed-growth.

SUMMARY

The suspended material in the river water has some quantities of nutritive elements, the constant addition of which is beneficial to the upkeep, to a certain extent at least, of the productivity of the soil. It has the physical effects in improving the texture and structure of the soil and it also helps in the correction of the alkalinity hazard.

INDEX TO ADVERTISERS

Compressibility Characteristics of Typical East Pakistan Soils

By MD. TASLIM*

This paper presents data, developed from tests performed on East Pakistan soils, which can be compared with approximate criteria suggested by some renowned Soil Scientist for estimating soil compressibility. The data on different soil tests of over 150 soil samples are presented in charts relating liquid limit, moisture content and the compressibility ~~index~~. The significance of the data is explained and a simplified example of estimating soil compressibility is presented.

Introduction

The soils of East Pakistan are almost all alluvial and were deposited throughout history by the world's three great rivers—The Padma, the Brahmaputra and the Meghna. The soils are generally sands, silts, clays, peats and other intermixtures like loam etc. Rock, boulders and gravel are rare in occurrence. The soils having been deposited by the unpredictable behaviour of the rivers are frequently and severely stratified and heterogenous.

The clay soils of East Pakistan have low to medium plasticity, the silts are generally non-plastic and the sands are fine grained. Peat appears to be black, weak and compressible in many areas—particularly in the Khulna region. The reddish brown soils of Dacca recharacterised by their hardness when dry and softness when wet.

High ground watertable and frequent floods affect the engineering characteristics of East Pakistan soils.

This paper has been prepared for the benefit of those who are interested in soil engineering in East Pakistan and has the primary objective of presenting data and relationships concerned with soil compressibility.

Methods of determining soil compressibility

When a load from a building structure, embankment, dam or similar facility is imposed on a soil, the soil yields beneath the load. The process of yielding results in compressing the soil particles closer together and sometimes years will pass before compression will be complete. In soils mechanics terminology this phenomenon is called consolidation. Consolidation can only occur by compressing the soil grains, compressing air voids or by squeezing

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water from the soil voids. Below the ground watertable, where practically all soil voids are filled with water, compression is primarily and overwhelmingly the results of ejection of water from the soil voids as the individual grains are pushed closer together.

Soil compression results in the downward movement of the structure, embankment, etc. This is not always detrimental if the movement is uniform. Unfortunately the movement is not uniform and differential settlement occurs when one portion of the structure, embankment, etc. settles more than another. In buildings this results in shearing stresses which can crack walls, break windows, jam doors and may lead to ultimate collapse of the building. In highways and air-fields differential settlements result in uneven surfaces which are hazardous to vehicles and aircraft.

The primary procedure for determining soil compressibility is by consolidation testing in devices called consolidometers. A small representative sample of the soil to be tested is placed in a loading ring as shown in Figure 1. A load is applied to the soil

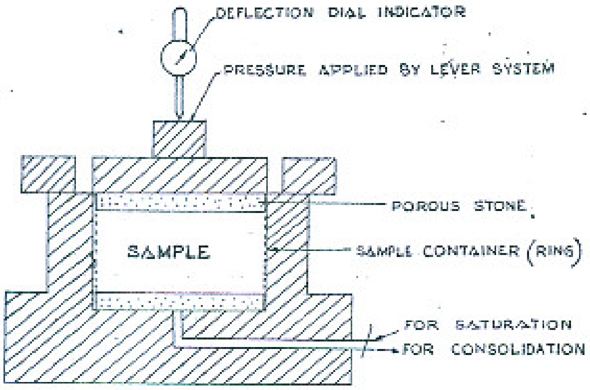


Fig. 1.—Sectional Diagram of Consolidation Device

sample and the amount of yielding or compression of the soil is measured at various time intervals. At the end of 24 hours, an increased load is applied and compression readings continued. Successive larger loads can be applied and finally a graph of soil compression *versus* time prepared as shown in Figure 2. From this data the graph shown in Figure 3 can be developed showing reduction in voids ratio *versus* logarithm of loading pressure (e-log p plot).

The slope of the straight line portion of the e-log p curve is termed the compressibility index C_c and is defined by the following relation:

$$C_c = \frac{de}{d\,(\log_{10} p)}$$

The compressibility index is a measure of soil compressibility.

In general, the C_c is used to estimate the settlement of a loaded facility in accordance with the following relationship :

$$S = \frac{C_c}{1+e_0}\,(H)\,\log\left(\frac{P_o+P_1}{P_o}\right)$$

Where S = Settlement of loaded facility

C_c = Compressibility index

H = Thickness of soil layer

P_o = Existing soil pressure at centre of soil layer being compressed.

P_1 = Additional pressure at centre of soil layer due to loaded facility.

An example of settlement calculations will be presented later in this paper.

Two internationally known Soils Engineers have suggested indirect methods of estimating the compressibility index.

The first is by Peck, et al (1953) who suggested :

$$C_c = 0.009\,(LL-10)$$

where LL = liquid limit of soil.

The second is by Hough (1957) who suggested:

$$C_c = 0.30\,(e_o - 0.27)$$

where e_c = in place void ratio of soil.

The liquid limit of soil defines the water content at which the soil exhibits the characteristics of a liquid rather than a solid.

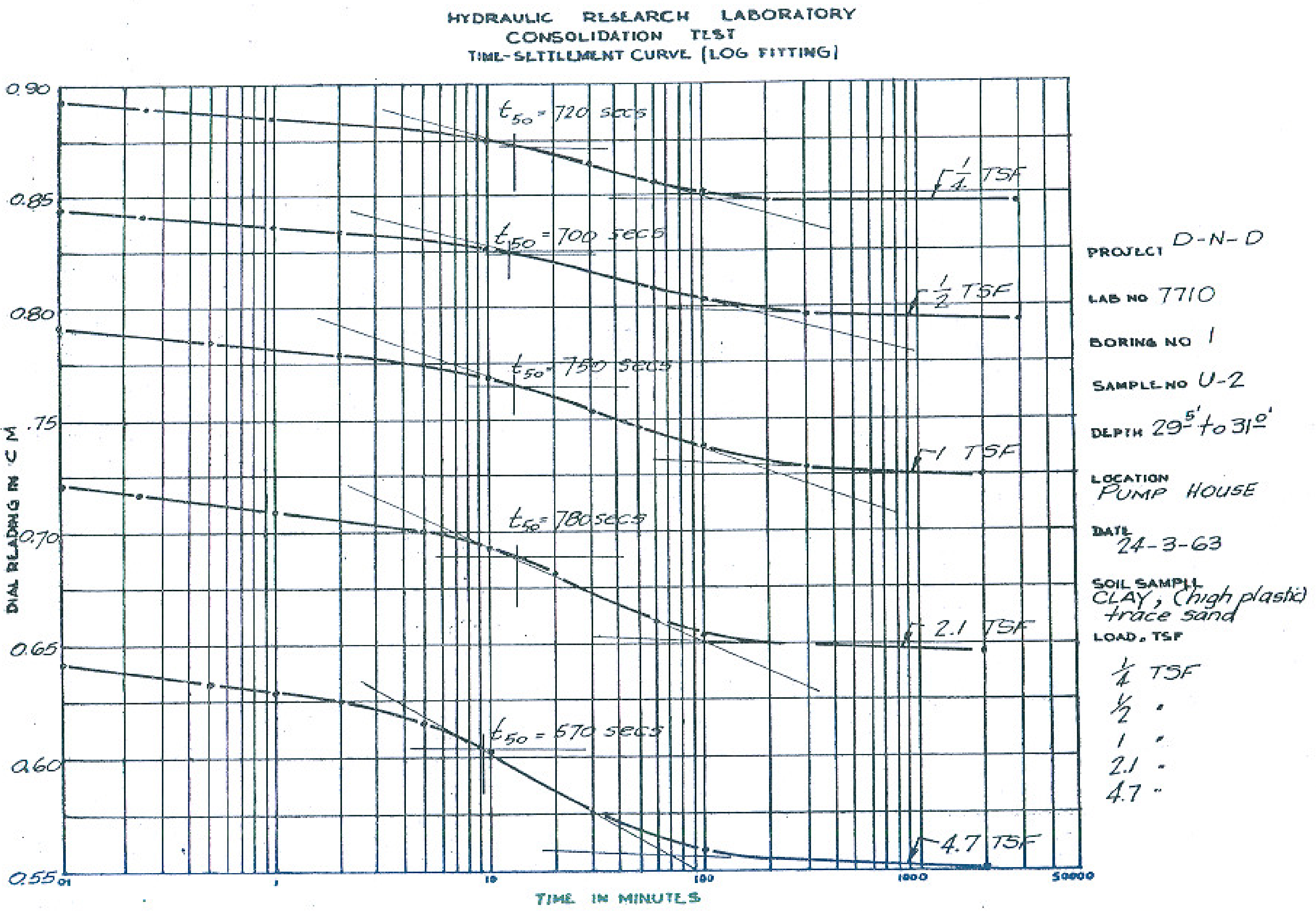


Fig. 2.—Pressure-time curves for consolidation data.

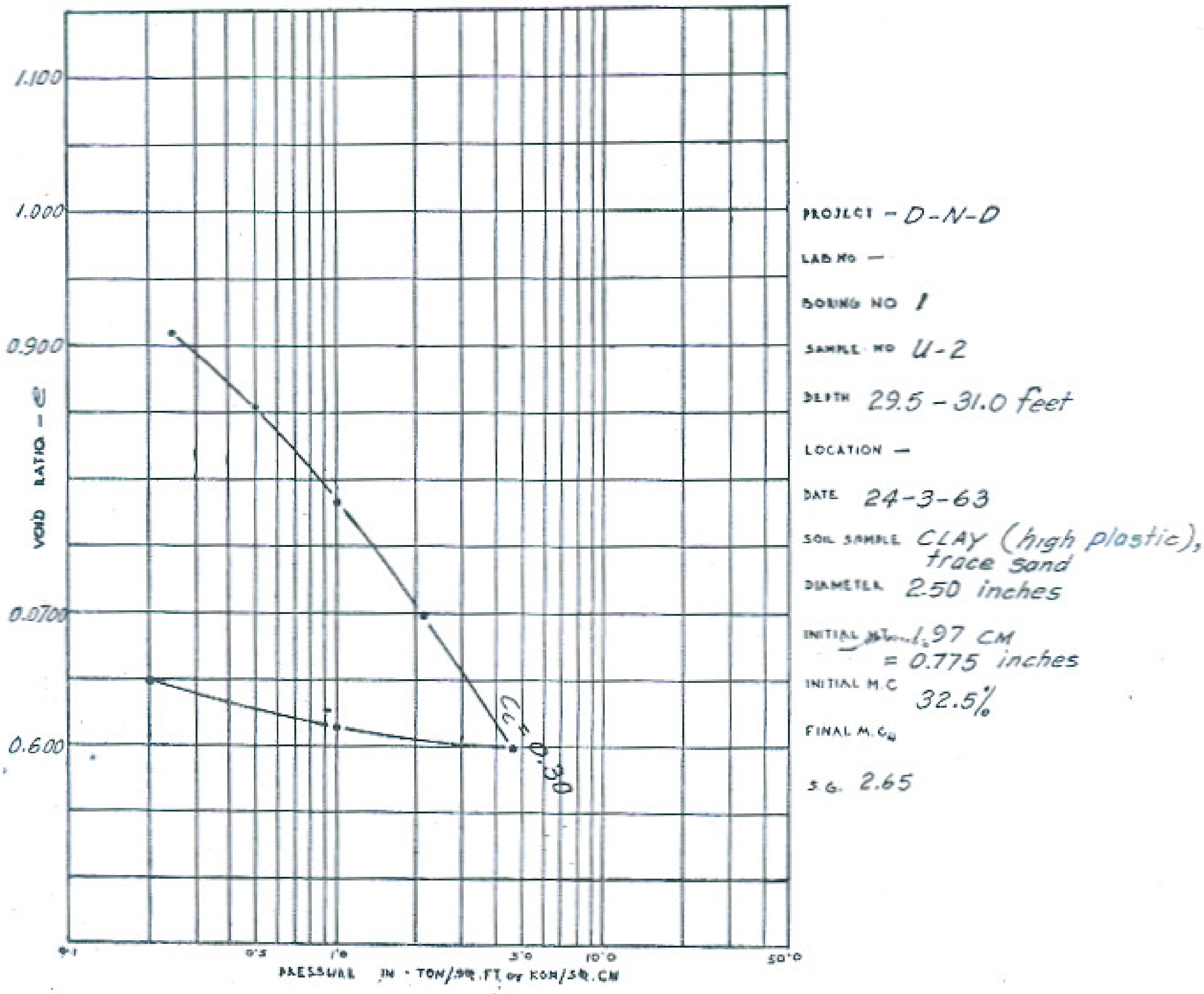


Fig. 3.—e—Log P

The void ratio *e* is the ratio between the volume of voids and volume of soil in a soil mass. The greater the volume of voids, the larger will be void ratio and the more compressible is a soil. Voids ratio and soil water content can be related as follows:

$$Se = G.w$$

where:

S=per cent of soil voids filled with water (per cent saturation). Below the ground water table S=95—100%.

e=voids ratio

G=specific gravity of soil grains,

W=water content in per cent of dry weight of soils.

Compressibility characteristics of East Pakistan Soil

The data for water content, liquid limit and compressibility index for more than 150 different soils of East Pakistan were collected form soils reports completed during the past four years. Figure 4 presents a graph of the compressibility index C_c, as determined from consolidation test data plotted against liquid limit for the same soil. The apparent wide scatter of points is typical of test data for soil as heterogenous as those of East Pakistan. The scatter is the result of difficulties in getting exact, dupli-

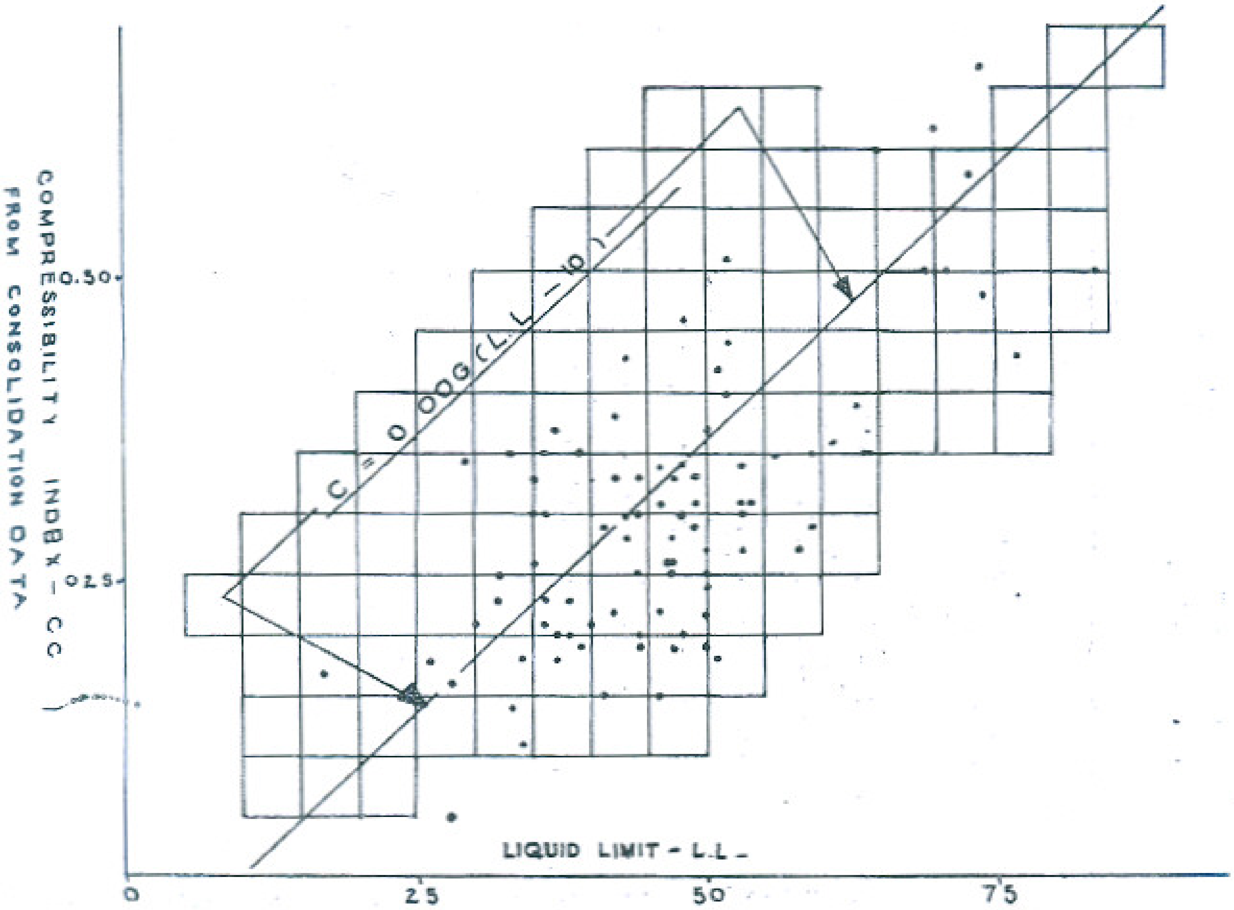


Fig. 4.—Data from tests on East Pakistan Soils.

cate and representative soil samples, test erratics and, probably, a lack of perfect correlation between the two variables.

The line drawn on the chart is the graphical solution of the equation $C_c=0.009$ (LL—10). It is proposed that the line fits the plotted data within reasonable limits. It is also proposed that East Pakistan Soils have similar compressibility characteristics as those used by Peck, et al, in the development of their equation and consequently the equation is valid for use in East Pakistan.

Figure 5 presents a proportion graph of C_c developed from the above stated equation and C_c from consolidation test data. This chart further shows the validity of the Peck equation for East Pakistan soils and presents, also, the possible range of variation.

Figure 6 presents water content plotted against C_c from consolidation test data. The line drawn is selected to best fit the data and has the mathematical relationship, $C_c=0.0125\ (W-20)$.

Most soils of East Pakistan have specific gravities ranging from 2.50 to 2.75 and a reasonable average is 2.65. Assuming that soils below the ground watertable are 97 per cent saturated and using an average value of 2.65 for specific gravity, the following relationship may be developed:

$$Se_o=Gw$$

$$97e_o=2.65\ w$$

$$\therefore\ w=36.6\ e_o.$$

Introducing this relationship in the equation from Figure 6, the following is

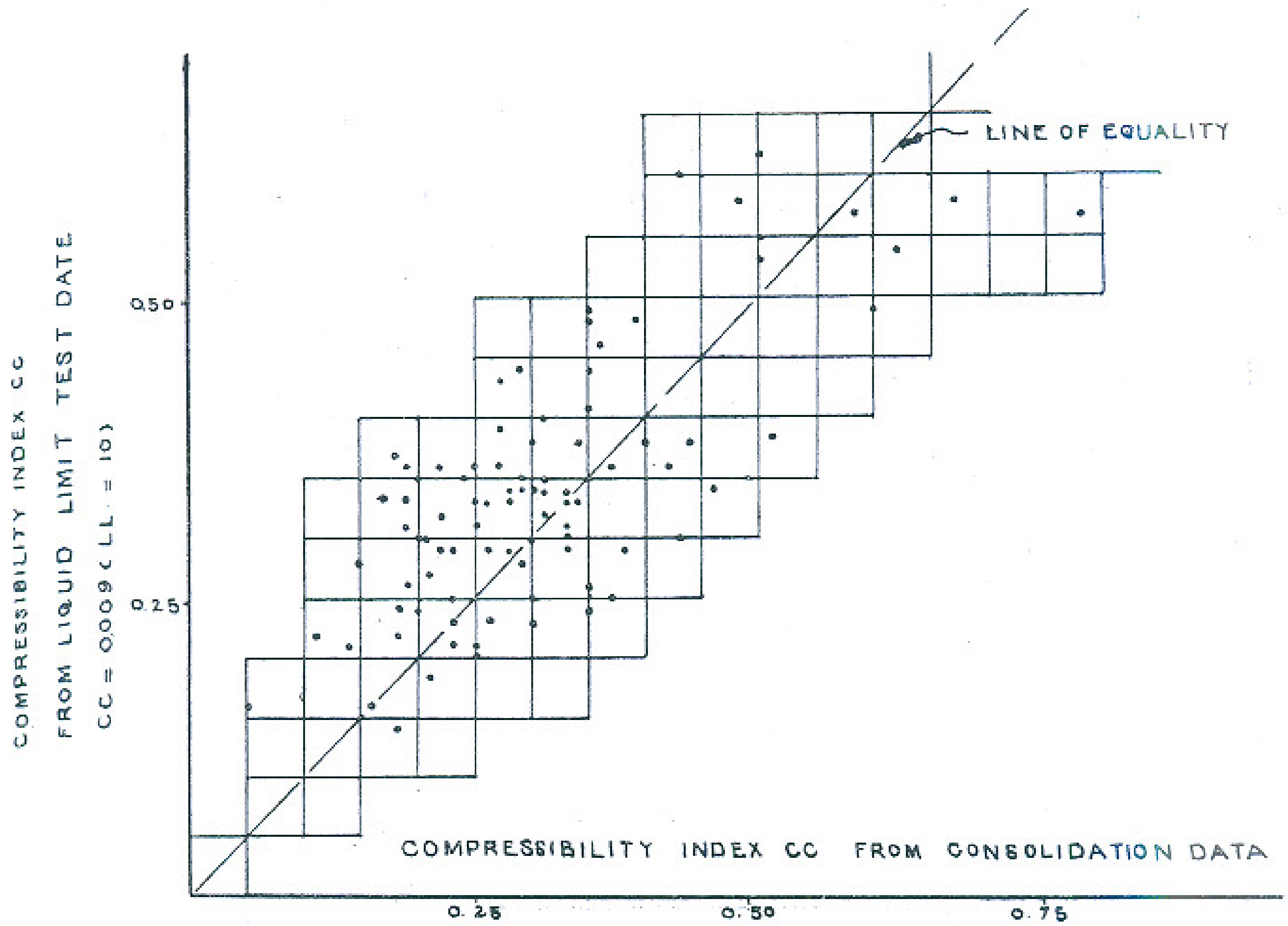


Fig. 5.

obtained :

$$C_c = 0.0125\ (w - 20)$$

$$C_c = 0.46\ \ (e_o - 0.54)$$

This equation is somewhat different from that suggested by Hough, 1957 and indicates that the soils of East Pakistan are somewhat more compressible than those used to develop his equation. More data must be collected in the future to further examine this relationship. Until then it is suggested that the mathematical relationship shown in Figure 6 will serve as a good approximation of C_c.

Estimation of settlement

Large, expansive and important structures may generally benefit from a comprehensive soils evaluation involving settlement calculations based on consolidation test data from numerous soil tests. The heterogenous deposition of soils at some sites precludes testing all possible variations. In these cases C_c derived from water content and liquid limit can be a helpful adjunct to the consolidation test data.

Small, simple structures sometimes require that a settlement analysis is made. In these cases it may be economically necessary to utilise C_c from water content or liquid limit exclusively. Therein lies the primary benefits from establishing the relationships discussed in this paper.

Following now is a simple example of settlement analysis.

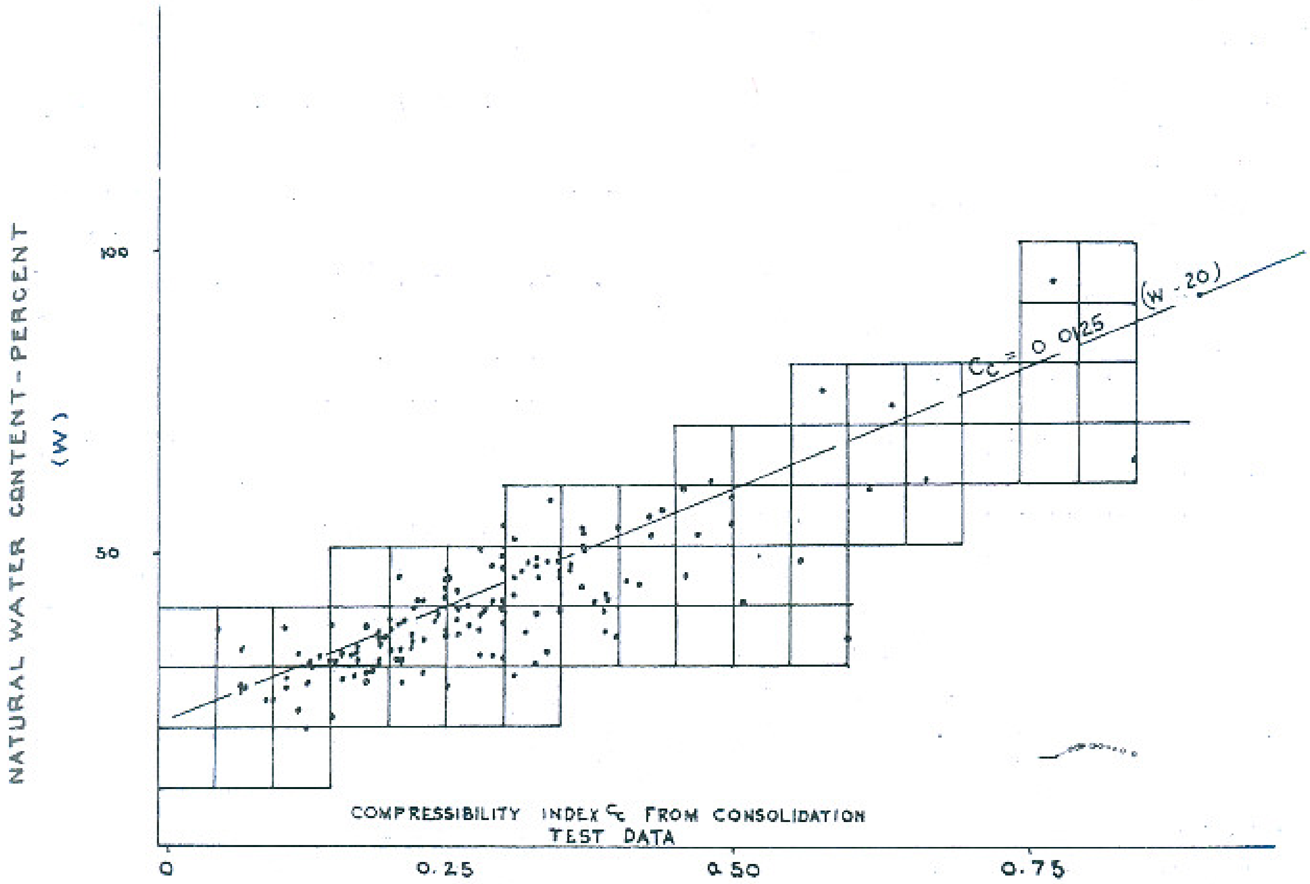


Fig. 6.—Relationship between Water Content and C_c

Figure 7 presents a spread footing 4 feet by 5 feet in area resting on a silt. At a depth of 9 feet there is an 8 feet thick layer of clay.

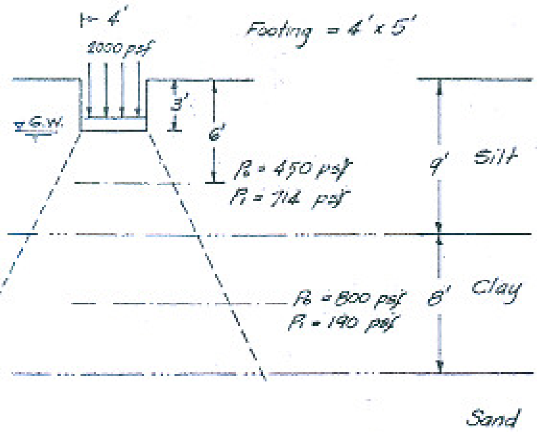


Fig. 7.—Example of Settlement Computations.

The following test values are real and were taken from a soil report completed during the past four years.

	Silt	*Clay*
Water content (w)	53.4	44.0
Liquid limit (LL)	53	73
C_c from consolidation test data ..	0.30	0.41

For Silt Layer—

$$P_0 = 3\ (100) + 3(50) = 450 \text{ Psf}$$

$$P_1 = \frac{(4)(5)(2000)}{(7)(8)} = 714 \text{ Psf.}$$

For Clay Layer—

$$P_0 = 3(100) + 10(50) = 800 \text{ Psf.}$$

$$P_1 = \frac{(4)(5)(2000)}{(14)(15)} = 190 \text{ Psf.}$$

$$S_t = S_{silt} + S_{clay} = \frac{C}{1+e_0}\ (H)\ \log\left(\frac{P_0+P_1}{P_0}\right)$$

For C_c from consolidometer—

$$S_t = \frac{0.30}{1+1.46}(6)(12)\ \log\left(\frac{450+714}{450}\right)$$

$$+\frac{0.41}{1+1.20}(8)(12)\ \log\left(\frac{800+190}{800}\right)$$

$$= 3.63 + 1.64 = 5.27'' \longleftarrow \text{St.}$$

For the silt we obtain values of C_c as follows :

$C_c=0.42$ by (w)
$C_c=0.39$ by (LL)
$C_c=0.30$ by (consolidation)

For the clay we get the following :

$C_c=0.30$ by (w)
$C_c=0.57$ by (LL)
$C_c=0.41$ (consolidation).

The range of settlements for the example of Fig. 7 are as follows :

Based on water content (W), $S_t=6.23''$
Based on liquid limit— $S_t=7.00''$
Based on consolidation— $S_t=5.27''$

These results are not untypical and, differences do occur, the results all tend to confirm that settlement of the footing under the imposed load may be a problem...

Conclusion

The data presented in this paper confirm that short cut methods of estimating settlement based on soil water content and liquid limit are possible. The primary application of these methods will be for small, simple structures although some benefits may be gained even in analyses for larger structures.

The data confirm that Peck's relationship $C_c=0.009$ (LL—10) is applicable for East Pakistan soils while Hough's relationship $C_c=0.30$ ($e_o-0.27$) may give C_c results which are low when voids ratios are greater than 1.00.

As we stated above, more data will continue to be collected to study further these relationships.

ACKNOWLEDGEMENT

The author has consulted standard books on Soil Mechanics and tried to examine Peck's et al and Hough's relationships relating to compressibility characteristics in East Pakistan Soils. He claims no originality in writing this paper and only endeavoured to justify the applicability of those relationships in particular reference to East Pakistan Soils. He has made extensive use of many experimental data from Hydraulic Research Laboratory's Soils publications since 1961 in writing this treatise.

The author wishes to express his gratefulness to Director, Hydraulic Research Laboratory for his permission to utilise the tests data available in the laboratory. He extends his heartfelt thanks to Director for his active interest and support in the paper.

He is also grateful to Mr. Md. Serajuddin, Deputy Director (Soils) for his suggestions and encouragement in preparing this paper. He was kind to go through the paper and suggested its improvements.

The author further wishes to appreciate Mr. R. A. Bridges' (an Adviser of IECO) efforts in helping to write this paper and in preparation of the drawings for this paper.

In the end the author wishes to express his thanks to Mr. M. A. Hai, Asstt. Technical Officer, Hydraulic Research Laboratory for his preparation of drawings shown in Fig. 1 for this paper and further that Mr. M. A. Hai was associated with most of the consolidation experiments, data of which have been used in this paper.

Use of Burnt Clay as Pozzalanic Material in Portland Cement

By **G. F. ZAFAR, I. H. HAMDANI and IRSHAD AHMAD**

Use of fine ground burnt bricks to replace some percentage of cement and yet to have the same strength, was studied in the year 1951 in the Irrigation Research Institute. The aim was not only to save cement but also at the same time to acquire some pozzolanic properties in the mixture. The present studies are in continuation of the previous ones. In these the replacement of cement was done by burnt clay which is a waste product of the brick kilns. The authors have concluded that the use of this waste product can also result in saving of 20 to 25% of the cement.

INTRODUCTION

As a result of extensive researches particularly in U.S.A. in the last century, the pozzalanic cement has been established to be superior in many respects to normal portland cement. It has been successfully used in some important structures in U.S.A. like Atlus, Borneville, Hungry Horse and Devis Dams, as well as in massive piers and anchorages at San Francisco subjected to the action of sea water. On the strict condition, of course, that properly selected pozzalans are used for admixture with Portland cement in optimum proportion. The pozzalanic cements are known to have definitely the following advantages over ordinary portland cemen :

1. Economy in cost.
2. Less heat of hydration and volume change.
3. Better sulphate resistance.
4. Improved tensile strength.
5. Less leaching of soluble compounds (specially lime) from concrete, therefore better water tightness specially in later stages of usage.

In other characteristics also, the pozzalanic cements do not lag behind the normal portland cement and therefore the tendency to use proper pozzalanic cements is widely growing at present.

Fine grounded well burnt brick (surkhi) has been found to possess pozzalanic properties as a result of investigations carried out in the Institute in 1952. Its use in cement has the advantages of pozzalanic cement as enumerated above. The present investigations were carried in the Soil Mechanics and Materials Section of Irrigation Research Institute to determine the effects of replacement of cement by fine burnt clay passing 100 mesh on its strength and other properties such as resistance to salts. This material is produced from the brick kiln, during the baking process of the bricks in the kiln, when a cover of semi-dry clay is spread over the entire portion of bricks so as to minimise the heat loss. This semi-dry soil also gets baked. This material is used over and over again till it is burnt to lose its cohesive properties. This happens after three or four cycles. The material is then rejected a waste burnt clay. In the present studies this material was used to determine the possibility of its replacement of cement and to check if it could be used in place of surkhi which is costly as it is obtained by burning bricks and then grinding them. These processes are eliminated while using the burnt clay.

Studies

Investigations were conducted by mixing cement with different proportions of burnt clay. Briquettes and cubes were made out of the different proportion of the mixture. The studies included the determination of consistency, setting time, tensile and compressive strength, and resistance to the action of salt. The following admixtures of burnt clay with portland cement were tried.

1. Determination of Consistency

The results of determination of consistency are indicated in table No. 1 below. Addition of burnt clay slightly increases the normal consistency.

TABLE 1

Cement (part by weight)	Burnt clay (parts by weight)	Termed as replacement %	Water for normal consistency %
100	0	0	22.5
90	10	10	24.4
80	20	20	25.1
70	30	30	25.7
60	40	40	26.1
50	50	50	26.5

2. Setting Time

It was determined both for the initial and the final setting.

(*a*) *Initial* : setting time as specified in B.S.S. 12 for portland cement should not be less than 30 minutes. In this case (Fig. 1) up to 30% replacement the tendency of the curve, time versus replacements, is a straight line. There is gradual increase in time, but

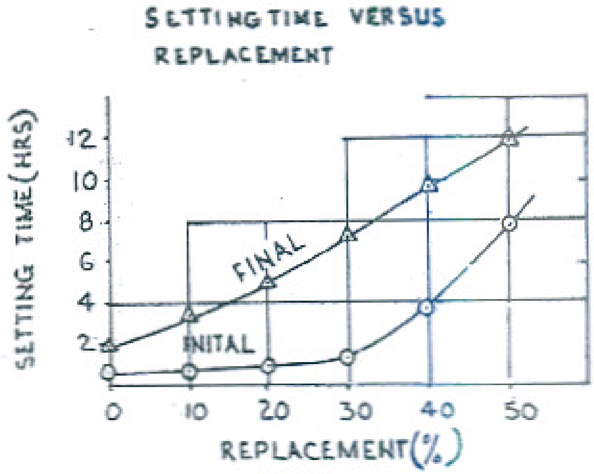


Fig. 1

beyond 30% replacement the initial setting time abruptly increases showing unsuitability of the performance of the mixture.

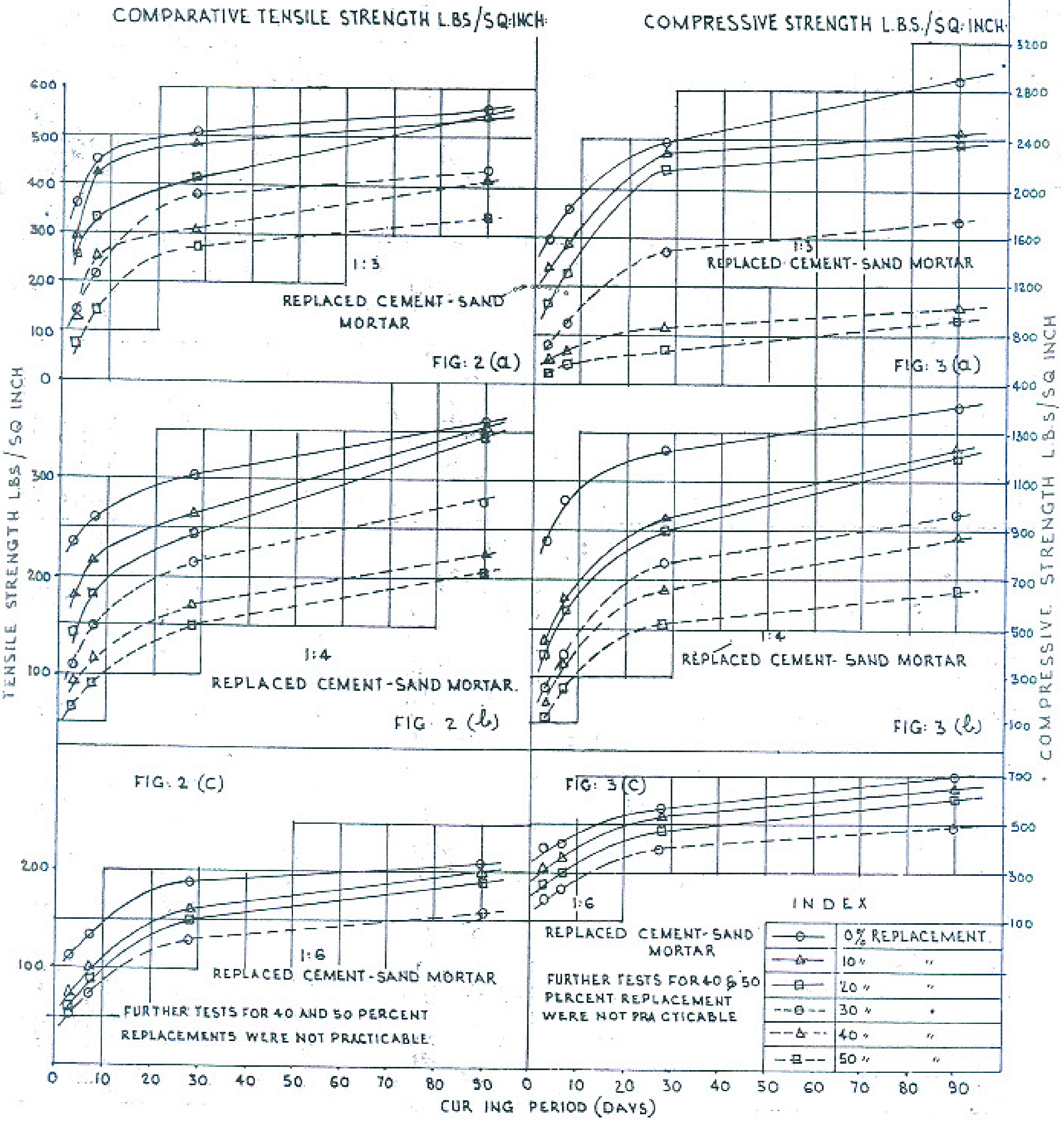
(*b*) *Final* : setting time as specified in B. S. 12 for portland cement should not be more than 10 hours. In the present case it falls within limits up to 40% replacement. The results of this study are shown in table No. 2 and Fig. 1. It may be noted that both initial and final setting times are satisfactory and workable up to an admixture of 30% replacement.

TABLE 2

% replacement	Setting time	
	Initial	Final
0	35 minutes	1 hr. 50 minutes
10	43 ,,	3 hrs 15 ,,
20	57 ,,	5 hrs
30	84 ,,	7 hrs 15 minutes
40	3 hrs 40 minutes	7 hrs 40 ,,
50	7 hrs 50 ,,	11 hrs 55 ,,

Tensile and Compressive Strength

It was determined for the six admixture ratios of cement and burnt clay. The briquettes were made for replacement: sand ratios of 1 : 3, 1 : 4 and 1 : 6. The sand used was according to B.S.S. standard and it was a local sand available at Daudkhel. The tests were conducted after 3, 7, 28 and 90 days of curing. The results of tests are shown in tables No. 3 to 5 and are plotted in figs. 2 and 3. With reference to these tables and figures it may be noted that the British standard specifications in case of 1 : 3 mortars (300 PSI for 3 days and 375 PSI for 7 days) are fulfilled up to 10% replacement only whereas 20% replacement is slightly



short of it but after 90 days the mixture attains a higher strength. It appears that with 20% replacement of cement we remain within the specifications.

In the tables mentioned above, the results obtained during 1951-52 by using cement and well burnt surkhi are also given for comparison. Up to 20% replacement, the results are comparable.

Compressive Strength

The compressive strength of the cubes was determined after the same period of curing and for the same mixture of cement, clay and sand as determined for tensile strength. It may be noted after a study of the data that in case of compressive strength, the differences are not very wide between 0 %, 10%, and 20% replacements of all the mortar ratios (*viz.* 1 : 3, 1 : 4 and 1 : 6) and thus a replacement up to 20% appears to be safe.

Sulphate Resistance Tests

These were carried out by using 5% sodium sulphate solution and briquettes of 1 : 3 mortars. Tensile strengths were compared between 2, 4 and 6 cycles of wetting and drying and continuous curing in clean water for equivalent periods. The results of these tests are plotted in fig. 4 and are given in table 3.

TABLE 3

Replacement %	Water content with burnt clay	Average Tensile Strength lbs/sq. inch: 3 days		7 days		28 days		90 days	
		With fine burnt clay	As obtained in 1951 with fine burnt surkhi	With fine burnt clay	As obtained in 1951-52 with fine well burnt surkhi	With fine burnt clay	As obtained in 1951 with fine well burnt surkhi	With fine burnt clay	As obtained in 1951 with fine well hurnt surkhi
				1 : 3 mortar					
0	8.1	365	320	453	357	508	403	562	469
10	8.6	293	305	429	347	487	414	541	474
20	8.8	255	301	335	341	412	415	547	496
30	8.9	145	276	220	315	381	433	437	502
40	9.0	129	231	256	283	308	384	415	462
50	9.1	78	97	147	242	277	367	339	457
				1 : 4 mortar					
0	6.9	236	207	260	246	303	392	360	349
10	7.3	180	193	216	220	265	268	355	364
20	7.5	140	175	180	202	343	261	345	370
30	7.6	110	151	150	167	215	245	281	376
40	7.7	90	131	115	145	173	217	225	311
50	7.8	66	105	90	114	150	179	207	303
				1 : 6 mortar					
0	6.1	113	110	134	133	189	183	210	203
10	6.5	75	101	100	117	162	181	200	231
20	6.7	60	88	90	109	150	178	190	239
30	6.9	55	80	75	94	130	157	160	207
40, 50	Found inpracticable with burnt clay and hence comparative results not included.								

SODIUM SULPHATE SOUNDNESS TEST
1 3 POZZOLANIC CEMENT MORTARS

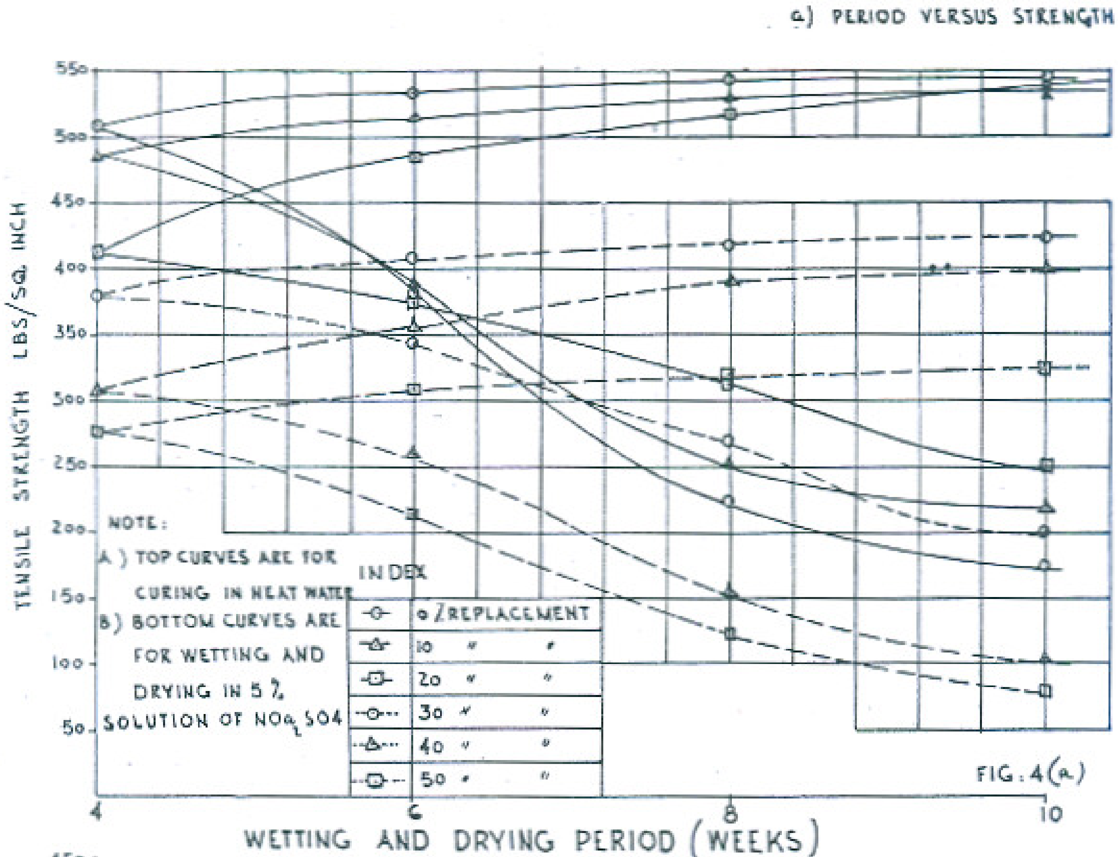


FIG. 4(a)

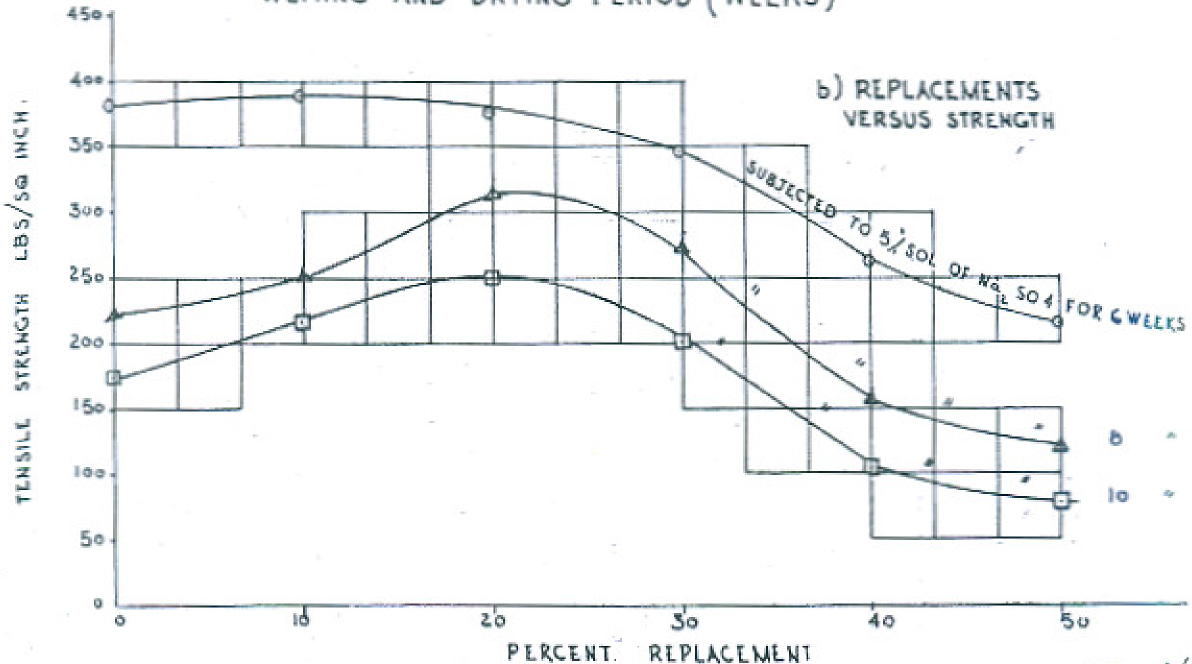


FIG. 4(b)

TABLE 4

S. No.	Replacement %	Water Content	Average compressive strength lbs/sq. inch for curing period of			
			3 days	7 days	28 days	90 days
			1 : 3 mortars			
1	0	8.1	1603	1857	2397	2900
2	10	8.6	1356	1560	2292	2446
3	20	8.8	1049	1300	2169	2360
4	30	8.9	742	900	1490	1734
5	40	9.0	601	680	880	1040
6	50	9.1	483	560	691	940
			1 : 4 mortars			
1	0	6.9	847	1030	1238	1420
2	10	7.3	449	631	960	1240
3	20	7.5	397	574	900	1207
4	30	7.6	258	401	770	970
5	40	7.7	195	360	660	883
6	50	7.8	140	259	520	663
			1 : 6 mortars			
1	0	6.1	401	435	570	700
2	10	6.5	324	370	540	650
3	20	6.7	258	315	480	610
4	30	6.9	191	245	410	490

Note.—40 and 50 percent replacements were not found practicable and hence the results are not included.

TABLE 5

Sulphate resistance of 1 : 3 pozzalanic mortars using burnt clay (fine) subjected to six cycles of wetting and drying in 5% solution of sodium sulphate

Replacement of cement	Water content %	Tensile strength lbs/sq. inch						
			After 2 cycles		After 4 cycles		After 6 cycles	
		After 28 days curing in water	Subjected to wetting and drying.	Cured in water for equivalent period	Subjected to wetting and drying	Cured in water for equivalent period	Subjected to to wetting and drying	Cured in water for equivalent period.
0	8.1	508	383	534	222	544	175	545
10	8.6	487	389	514	250	530	218	535
20	8.8	412	375	487	315	518	250	540
30	8.9	381	345	410	270	420	200	425
40	9.0	308	262	358	155	392	105	400
50	9.1	277	216	307	122	318	80	325

Inferences

It is indicated that :—

1. It is possible to use burnt clay from brick kiln to replace cement up to 20% without affecting the ultimate strength of cement.

2. From compressive strength consideration also replacement up to 20% is possible with slight fall (7—20%) in strength.

3. These results are very nearly identical to those obtained by using surkhi made out of well burnt bricks and after grinding them.

4. This admixture gives all the properties of pozzalanic cement to produce low heat, salt resistance and attaining a high strength after a long time.

Further Tests

Further tests to determine its physical properties such as abrasion characteristics, permeability, capillarity and resistance to salt together with the standardization of the burnt clay are in hand.

Acknowledgements

The authors acknowledge with gratitude the valuable suggestions and guidance of Dr. Nazir Ahmad, Principal Research Officer and encouragement by Dr. Mushtaq Ahmad, S. K., Director, Irrigation Research Inst., Lahore.

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(*ii*) Indian Concrete Journal Nov. 15th 1950 "Pozzalanic cement" by S. K. Chopra and N. K. Patwar Dhan.

April 15th, 1951 "Leaching action of water in masonry dam by K. Venkataramanan.

(*iii*) Pozzalans Building Research Bulletin No. 2, Department of Scientific and Industrial Research (India).

(*iv*) Bureau of Reclamation Denver, U.S.A. Department of Interior, "Burnt clay or surkhi as pozzalan" by Khan and Verman Bulletin No. 24, Indian Industrial Research.

(*Continued from page* 48)

Influence Lines for Statically Indeterminal Plane Structures

By W. J. LARNACH.

Macmillan & Co., Ltd. London. Distributed in U.S. by St. Martin's Press, Inc., 175 Fifth Avenue, New York, N. Y. 10010, 1964, 256 pp. bound. $18.99.

The book gives method for calculation of influence lines for specific problems as they arises.

* * *

Concrete : Plain, Reinforced, Prestressed, Shell

(By RHYDWYN H. EVANS and CHARLES B. WILBY.

American Elsevier Publishing Company, Inc., 52 Vanderbilt Avenue, New York, N. Y. 10017, 1963. 252 pp. bound. $8.50)

The publication deals with theoretilca fundamentals of the design of structural elements and reinforced and prestressed concrete.

* * *

Handbook of applied hydrology: a compendium of water-resources technology

Edited by Ven Te Chow. New York, McGraw-Hill, 1964, 1418 p. plus index, 614 illus., $39.50. (McGraw-Hill Hand-book series).

A comprehensive manual on modern hydrology which presents a complete, practical review of the basic theories, principles and data required for the study and management of water and water-resources projects.

PAKISTAN ENGINEERS HONOURED

Engineering News presents hearty congratulations to the eight Engineers honoured by the President of Pakistan on Independence Day, the 14th August 1965. They are :

1. Dr. M. S. Qureshi, *T.P.* (Tamgha-i-Pakistan).
2. S. M. Ali Hussainy, East Paikstan Wapda, *T.Q.A.* (Tamgha-i-Quaid-i-Azam).
3. K. B. Pir Mohammad Ibrahim Qureshi, *S.Q.A.* (Sitara-i-Quaid-i-Azam).
4. Mr. Imtiaz Ali, Chief Mechinical Engineer, P.W.R., *T.P.* (Tamgha-i-Pakistan).
5. S. Monawar Ali Shah, *S.K.* (Sitara-i-Khidmat).
6. M. U. Arain, *T.Q.A.* (Tamgha-i-Quaid-i-Azam).
7. Dr. Akmal Hussain, *S.K.* (Sitara-i-Khidmat).
8. Mian Alim-ud-Din, *S.K.* (Sitara-i-Khidmat).

We have reproduced below their brief achievements for the information of the readers.

Pir Mohammad Ibrahim Qureshi, I.S.E. (Retired) has been awarded *S.Q.A.* by the President of Pakistan. Throughout his life he has been a Research Engineer. Mathematics has formed his greatest point of interest. Right from his College days he has excelled in Mathematics in which he got certificates of merits. Graduating from Roorki Engineering College where his superior talent was apparent from his result of standing first in all papers except in one and that too by one mark, in the final examination, he joined the Indian Service of Engineers in October, 1924.

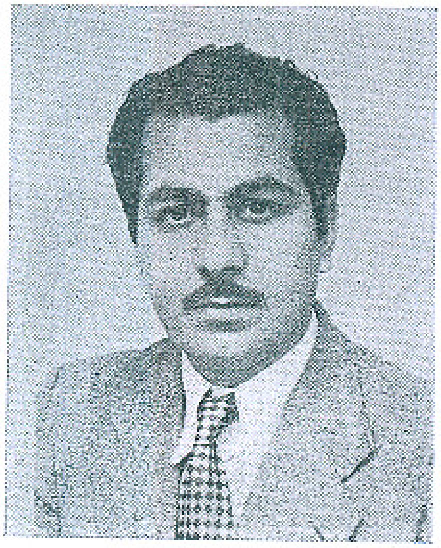
Throughout his service of 42 years he has devoted himself to the construction of hydraulic work. His first official responsibility was with respect to the construction of Bikaner

Lined Canal the first of its kind in Indo-Pakistan. He reconditioned the Ferozepur Headworks which had developed hollows underneath and took a major part in the completion of Jinnah Barrage on the Indus.

Since the last few years he is known for his construction of dams. His pioneer work in this venture has given the country several small dams of medium height and now relatively high dams are also his interest.

As a research worker in hydraulics, the publications of the Laws of Liquid Flow and the New Design of Hydraulic Falls on the basis of his Laws goes to his credit. His creative work has often been appreciated by men like N. White, Chief Engineer and Secretary, Irrigation Department, by Mr. Crump, the most well known Research Engineer of the Irrigation Department, by Sir W. L. Stand and Mr. Savage, the famous Engineer for Dams of U.S.A. The appreciation of his work has resulted in the title of Sitara-i-Quaid-i-Azam which is well deserved for him.

Mr. Imtiaz Ali, recipient of Tamgha-i-Pakistan is Deputy Chief Mechanical Engineer (Construction), Pakistan Railways. He



is on this post since September, 1959, and was responsible for the programme of manufacture and assembling of carriages and wagons in the Railway Workshop of Pakistan Western Railway. Under his supervision, the railway workshop has undertaken manufacture of 1500 wagons and can assemble, finish and furnish 100 all welded steel carriages per year. The railway workshop assembles 2000 dismantled wagons in a year. All this work is being supervised by Mr. Imtiaz Ali who has received specialized training in the manufacturing of all welded light-weight steel carriages in France, Switzerland, Holland and then in Germany, where he was trained by Messrs. Linke-Hofmann-Busch, in the manufacture of six-axled bogie wagon.

He has been directly associated with the preparation of plan for setting up a factory for manufacture of all welded steel carriages. Mr. Imtiaz Ali is a young man of 45 years having been born in September, 1920 and joined the Railway service in 1939 after graduation from the Institute of Mechanical Engineers, London. He is an experienced person having represented Pakistan in Commonwealth Standard Conference and as a delegate of Pakistan Railways attended the E.C.A.F.E. Railway Sub-Committee's meeting.

The management of the Engineering News extends hearty congratulations for the well deserved award of Tamgha-i-Pakistan.

Mr. Monawar Ali, has been awarded Sitara-i-Khidmat at the time of Independence day. He is one among the Engineers who has done considerable pioneering work for the good of the country. For the last 13 years he has been specializing in the planning and investigating problems connected with

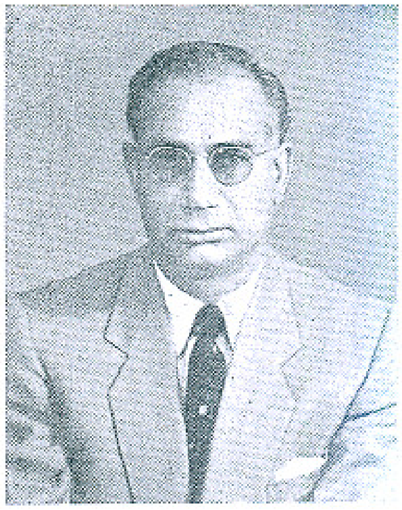
water resources of the country. Graduating from the Punjab College of Engineering, Lahore in 1943, he joined the Irrigation Department. In September 1947 he was posted as Assistant Design Engineer which post he held till 1951 and was promoted to hold charge of the Rasul Division and saw the teething troubles of the Rasul Power House which was commissioned in April 1952. It was during this period that the idea of constructing a Dam and creating a storage at Mangla was first mooted. He carried out the preliminary surveys and later in January 1953 opened the first Division to investigate possible Dam sites in West Pakistan. He had to investigate the feasibility of water storage schemes for Mangla, Tarbela, Kalabagh, Darband, Kunhar and Karachi Irrigation Project, etc.

In 1959 when Mangla Dam Project was taken over by West Pakistan Water and Power Development Authority, Mr. Monawar Ali came over to WAPDA and joined its head office as Deputy Director, Mangla and later on as Director, Planning and Investigation and Project Director, General Investigations. During this period he also started two other Indus Basin Projects namely Link Canals and Barrages and acted as their first Project Director. At present he is holding the post of Director-General, Planning and Investigations.

Besides representing WAPDA in various meetings Mr. Monawar Ali was a member of the Surplus Manpower Commission appointed by the Government of Pakistan. He is a member of various Engineering Societies both at home and abroad.

The Engineering News wishes him hearty congratulations.

Mr. M. U. Arain has been awarded TAMGHA-I-QUAID-I-AZAM after his meritorious services of 26 years in the Irrigation Department.



After graduating from N.E.D. Engineering College in 1939, he joined the Sind Government Service of Engineering and held various posts as Class II and Class I Engineer on the basis of competitive examination held by Bombay-Sind Public Service Commission. He was Executive Engineer in 1950, Superintending Engineer in 1953 and Deputy Chief Engineer since 1961 which post he still continues to hold.

Most of his duties included the construction of canal system in the Lower Sind Barrage Project. On the basis of his meritorious services he was awarded a special pay of two months and in addition one-month pay to the general bonus.

Being a son of the former Sind Province having been born on 16th October, 1917 in Sanghar District (West Pakistan), he has continued to serve his country close to the region of his birth and training.

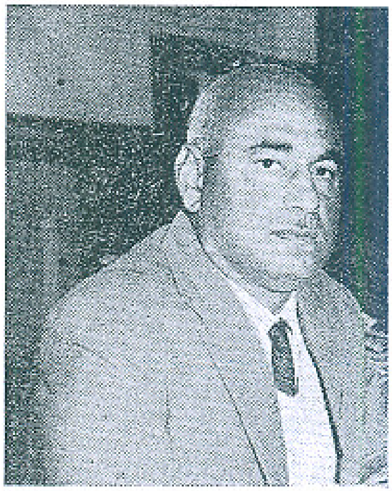
The *Engineering News* extends hearty congratulations for the recognition of his services to the country.

Dr. Akmal Hussain, the recipient of Sitara-i-Khidmat is the Director of Technical Education in West Pakistan. He is holding

this position since 1958 and during this period he has been instrumental in spreading technical education in West Pakistan by developing Polytechniques, Engineering Colleges, University of Engineering and Technology and other Institutions. He is an educationist having spent about 18 years in the Engineering College, Moghalpura, Lahore. He joined as a Lecturer and very soon rose to the position of Professor of Mechanical Engineering. Dr. Akmal had been thus connected with the Engineering Education for about two decades, before taking over as Director Technical Education.

Dr. Akmal had a brilliant educational career, obtaining B.Sc. degree with honours and was a recipient of a gold medal. He was awarded Ph.D. Degree in 1953 by the London University. He is one of the few Engineering Educationists who have done a great service to the country towards advancing its technical education. The *Engineering News* congratulates him on his well deserved honour.

Mian Alim-ud-Din, Chief Engineer, Lahore Region, has been awarded Sitar-i-Khidmat for his meritorious services of nearly 27 years in the Irrigation Branch. During his long service, he has accumulated vast experience of running and maintenance of Irrigation canals, construction of link, looking after, projects serving millions of irrigated areas.



He is a product of Civil Engineering College, Roorke, India from where he qualified in 1937 at the age of 24 years. He joined the Punjab Service of Engineers, Class II in 1942, was promoted to Class I in 1945. He served as Executive Engineer from 1947 to 1950. His other assignments included as Investigation Officer and Under-Secretary to Irrigation Department. As Superintending Engineer, Drainage Circle, he prepared several flood and drainage schemes. In 1952 he was selected to construct the biggest link canal, the Marala Ravi carrying a discharge of 24,000 cusecs. The link passed through a terrain requiring cross drainage works and innumerable bridges. This Project of 100 million rupees was completed in a short time of 2½ years. For about two years from 1957 to 1959, he was Superintending Engineer, Lower Chenab Circle and later on in charge of Link Circle. In 1959 as Deputy Chief Engineer, he was in charge of the operations of canals both perennial and non-perennial, aggregating to about 30,000 miles. From March 1961, onwards for about a year, he worked as Deputy Chief Engineer (Administration) dealing with cases of nearly 300 Class I and an equal number of Class II Officers. He was to look after the cases of about 30,000 non-gazetted staff as well. In May 1962 he was posted as Chief Engineer, Irrigation, Sukkur Region which consists of eight circles. His charge included three Barrages on the Indus River *viz.* the Guddu Barrage, the Sukkur Barrage and the Ghulam Mohammad Barrage. Besides the Irrigation of the culturable area of Sukkur Project, amounting to nearly 6.5 million acres, he had to plan drainage of about half million acres. Arduous job of looking after stability of bunds, about 500 miles in length, on both sides of the Indus, was also his responsibility as Chief Engineer, Sukkur Region. The Thatta Sajawal Bridge which is yet to be constructed was also under his charge. He has recently taken over as Chief Engineer, Irrigation, Lahore Region and it is hoped that his ripe experience will be helpful in improving this important Region of the Irrigation Canal system. We wish him all success in his future life as an Irrigation Engineer of vast experience and energy.

NEWS AND NOTES

Late SIR JOHN RUSSELL

With the passing away of Sir John Russell, the world has lost a person who was a dominant figure in the agricultural world for about a half century. He died at Goring on July 12, 1965. He was Director of Rothamsted Experimental Station during 1912 to 1943. Russell was the son of a school teacher. His family was unconnected with either agriculture or science. Chemistry fascinated him from early age but he was unable to pursue it. Russell failed at his first attempt at the London B.Sc. degree because his physics and mathematics were not up to the standard. Professor Dixon appointed him a Research Assistant at ten shillings a week, when to make ends meet, he did other diverse jobs. At his second attempt he passed the B.Sc. with honours in chemistry. He did research on oxidation of phosphorus and obtained his D.Sc. degree in 1901. In 1901 he moved to Rathamsted where he started using his missionary zeal to get scientific methods applied to agriculture. There he wrote his classic book, "Soil Conditions and Plant Growth" in 1912. In the same year he succeeded Hall as Director, a post he held for 31 years. Russell by his hard work brought the station to world fame. He managed to add botany, physics, microbiology, pathology, biochemistry statistics and the study of pesticides besides the agricultural chemistry. Russell served on many Government committees. His services as an Adviser were often sought and he always willingly gave it to many foreign Governments and organizations overseas. To have left school at fourteen and be elected to the Royal Society at forty-five is perhaps unique for a self-made success. His book on "World Publication and World Food Supplies," published in 1954, is an excellent example of his experience and travel. The Organization of Rothamsted Experimental Station owes much to his hard work and researches.

* * * *

ASSOCIATION OF ARCHITECTS AND CONSULTING ENGINEERS

In the general meeting of the Association held at Rawalpindi on 6th September 1965, it was unanimously resolved to place the services of the Association at the disposal of the President of Pakistan for any national service in the present emergency. The members also assure the President of their full cooperation and are prepared to undertake any duty which they may be called upon to discharge.

The following office-bearers were also elected unanimously for the year 1965-66 :—

President, Mr. Iqbal A. Sheikh.

General Secretary, Lt.-Col. B. H. Abbasy (Retd.).

Treasurer, Qazi Muhammad Shaffi.

*　　*　　*　　*

FAO HELPS GUINEA

Reclaim Rice-Land Swept by Tides

A team of United Nations Food and Agriculture Organization is working to rehabilitate area of rice land in Guinea, which is subject to tidal intrusion. The reclamation of this African country is being carried out under 5 years United Nations special funds Project. The Project is to cost nearly 2 million dollars. This area is flooded by sea water. The Scientistss, Hydrologist, and Engineers will work together to construct dikes to protect the land from becoming salty. Rice, growing in the warm, moist climate of lower Guinea, in paddy fields which are flooded with water from June to September, constitutes the region's main agricultural crop. Unfortunately, over the years, the drainage and irrigation works have deteriorated to the point where they are operating only intermittently and rather inefficiently, while reclamation work has come to a virtual standstill. Some of the outer dikes have been breached, saline water has crept into the paddy basins, and rice growing has become impossible over quite large areas.

The Government hopes to construct, or repair, the dikes so that salt water can be kept out of the rice-growing areas during high tides. They will install control structures with automatic gates to prevent saline water from coming into the paddy fields but which will drain off the excess rain water.

(Continued from page 47)

foundations and impounds a 1,760 million m^3 of water. This dam has 24 buttresses, 14 m, in width. In this article besides the complete engineering information, data about measurement of instrument for observing behaviour of the dam is also given.

An Application of Photoelastic Transducers to Load Measurement in Building Foundations.

Ivor Hawkes, R. K. Dhir and H. Rose, Post-graduate School in Mining, University of Sheffield.

Several recent publications have described the fundamentals of the measurement of loads and stresses in rocks, foundations and structures using photoelastic transducers. The object of this paper is to describe the application of the photoelastic transducers in the form of stressmeters and earth pressure cells to a specific foundations problem in the field of civil engineering.

Abstracts of Papers

Instrument for Determining Behaviour of Dams.

The practice of installing instruments to study the behaviour of dams in their construction is very common. This practice has not yet been adopted in this country. The following three cases are mentioned in which instruments were installed and useful results are being obtained.

Soil Mechanics Problem in the Design and Construction of Mattmark Dam.

B. Gilg, Schweizerische Bauzeitung, Vol. 83, *No.* 11, 18 *March,* 1965, *P.* 169, 10 *pp.,* 16 *ff.,* 5 *Tables.*

This dam is a rock fill. It is 100m high and is based on alluvial soil. No clay was available locally for the impervious core, which was constructed from a suitably selected aggregate. The instrument installed in the dam recorded pore pressure, settlement and water pressure etc. These are being recorded regularly along with the measurement of the drainage under the tunnel.

Observation of Dam Behaviour During Impounding.

X. Ract-Madoux and Y. Le May, Travaux, No. 365, *May* 1965, *p.* 225, 11 *pp.,* 28 *ff.*

In this article the use of pressure cell, piezometer and settlement measuring tube an clinometers at the surface etc. are mentioned. Vibrating wire type strainmeters are installed to measure localised deformations in concrete dams. Pressure cells are used to measure pore pressure in earth dams and piezometer tubes indicate the seepage profile. Sometimes theodelite and levels are used to determine changes in earth dam and changes of temperature in construction are also recorded. All these observations are used to check the design calculations and the model results.

Menjil Dam

J. Muller, Travaux, No. 361, *January* 1965, *p.* 1, 24 *pp.,* 35 *ff.*

It is a buttress structure, 106m above

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Books of Engineers' Interest

Concrete Mix Design

By J. D. McINTOSH,

Published by the Cement & Concrete Association, 52 Grosvenor Gardens, London S.W. 1. September, 1964. Price 25*s*.

This book is a collection of data which has been published previously by the Road Research Library.

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Cement and Concrete Engineering

By E. N. SIMONS.

Published by Frederick Muller Ltd., Ludgate House, 110 Fleet Street, London E.C. 4, May 1964. Price 11*s*. 6*d*.

It gives a comprehensive account of the manufacture, application and classification and of concretes in use today.

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New Structures

By P. L. NERVI

Published by The Architectural Press Ltd., 9-13 Queen Anne's Gate, Westminster, London S.W. 1. pp. 168, Price 63*s*.

The book now translated into English contains an introduction dealing with the basic ideas of design and construction and shows 25 examples of buildings and projects.

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Water Resources, Use and Management

Published by Melbourne University Press, Victoria, Australia. $25.00.

The basis of the book on the forty papers and their discussion presented in the International Symposium at Water Resources, Use and Management held by Australian Academy of Science in September, 1963.

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Building Construction Cost Data 1965

Published and distributed by Robert Snow Means Co., P. O. Box 36, Duxbury, Mass. 02332, 1965. 148 pp., Price $3.50.

Average current unit prices of a wide variety of building construction materials have been collected in the book for use in making up engineering estimates.

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