Engineering News

Vol. XI, Nos. 1 & 2, MARCH - JUNE, 1966

Institute of Engineers (Pakistan) Head Quarter at Dacca

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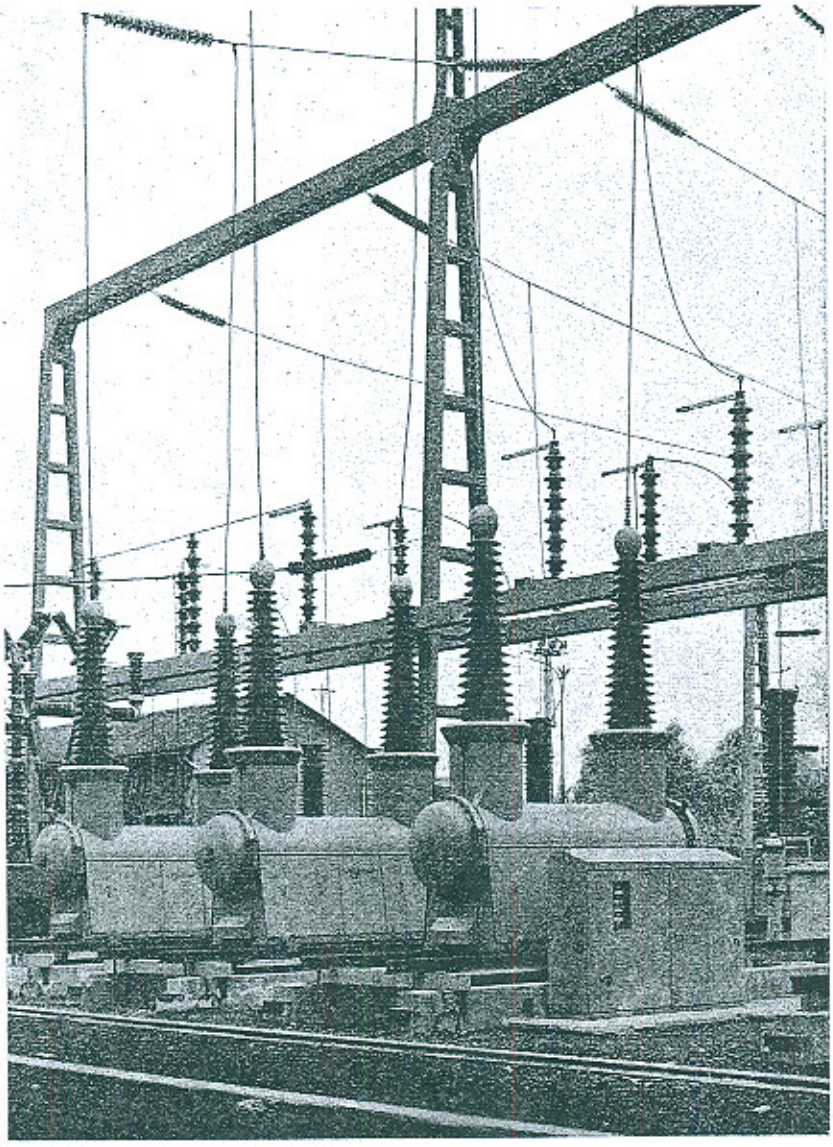

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Vol. XI March - June 1966 Nos. 1 & 2

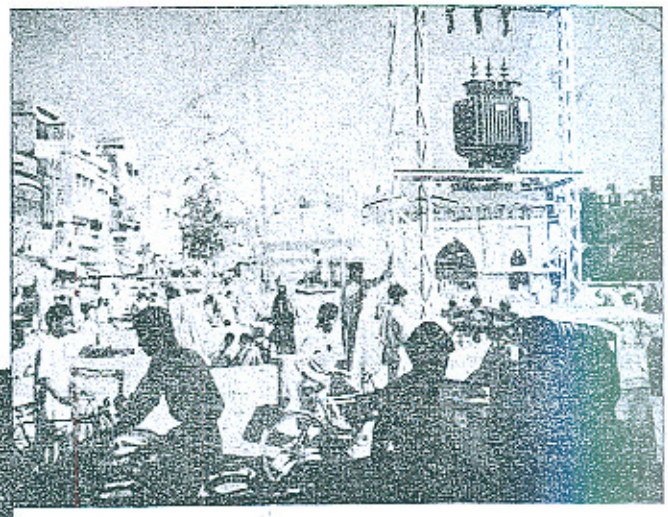
In this issue

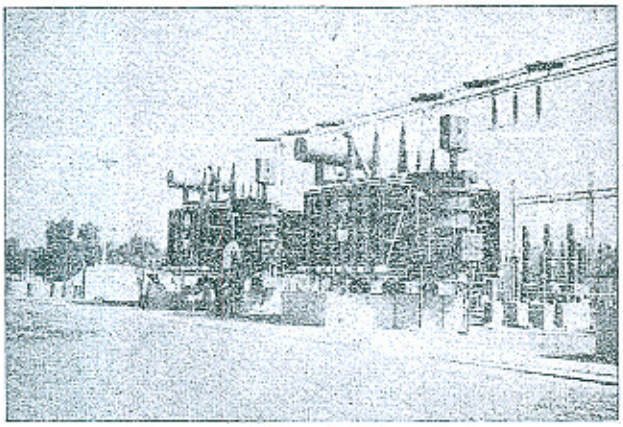
From the small

distribution transformers...

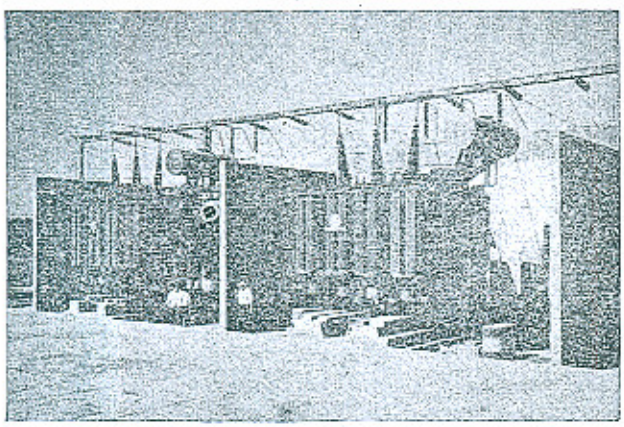
...to the large

power transformers...





3 units 32MVA 132/71kV at Lahore



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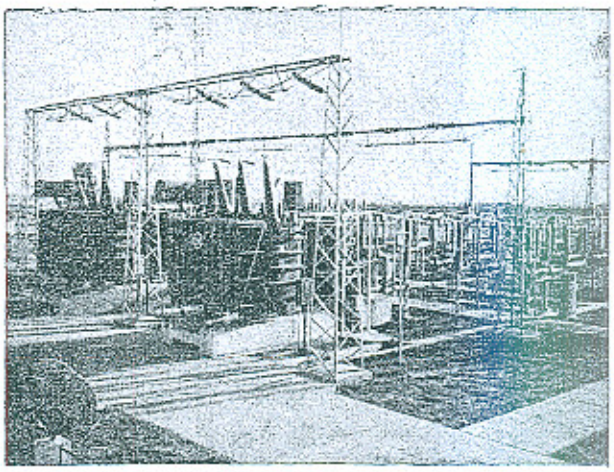

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HOPE FOR THE FUTURE

Engineering has always been considered to be based upon two fundamental aspects: theory and practice.

Theory deals with strength of materials and their application in such a way as to produce a thing of practical utility; *e.g.*, a dam, a bridge, a road, a building, etc. Technical Institutions and Engineering Colleges are the organizations where such basic knowledge has been acquired. However, the science of engineering has another important component practice. This is the art of practical application of the engineering knowledge acquired from teaching Institutions and Engineering Colleges. This second part is much more important, and that is why practical training with an engineering firm of repute has been given preference to make a perfect engineer.

It was in 1860 when the British Engineers considered the desirability of establishing an Institute for the recognization of the practical training of engineers. Thus the British Institute of Civil Engineers was established in London. It was a society formed to recognize the practical trained engineers, create conditions for the improvement of their bookish knowledge and provide a platform where the experience of the Engineers could be disseminated for the information and guidance of the profession in general.

The British engineers who were working in different parts of the world on various assignments of public utility found the Institute to be a medium of great utility. They could pen down their achievements, note down new techniques of construction and new ideas put into practice, and read them for the information and guidance of other members of the profession.

The Institute was soon recognized by the Government by the issue of a Royal Charter and the membership of the organization was recognized for employment with Government at par with Engineers trained in the Universities.

To facilitate young engineers who had practical training with reputable firms, a system of examination was also introduced for the engineer who aspired for the membership of the Institute.

Every Engineer knows the part played by the Institute of Engineers, London, in teaching and promoting the technique of Engineering. This was a useful system which was adopted by other countries as well. America had soon its own Institute of Civil Engineers, and so had the Dominions of the British Empire.

An Institute of Engineers was established in India in 1930, and it was recognized by the Royal Charter in 1935. At the time of independence, Pakistan formed its own separate Institute of Engineers. This young budding organization, during the last 18 years of its existence, is working on the British pattern and serving the country. Six thousand student members on its roll are those young Engineers, both qualified and unqualified, aspiring for the associate membership of the Institute.

The annual Convention, twelve of which have so far been held, is an important occasion to present new ideas, new experiences and new knowledge, gained by a particular member working on a particular job, for the information and guidance of others. This is an occasion to hold direct discussion and to bring out important aspects of a contribution. The Institute also issues a Monthly Journal which is a medium for contribution of engineering articles, communications of information and propagation of new products.

The need for such an organization in our country was great. It will not be out of place to mention that the Engineers of the area which now constitutes West Pakistan, considered it very desirable to have a society for the dissemination of Engineering know ledge and learning by discussion with other fellow Engineers. They established the Punjab Engineering Congress, now called the West Pakistan Engineering Congress, as far back as 1912 and every engineer knows the immense good this organization has done to the country in spreading engineering knowledge. Before the setting up of this organization, the engineers had no definite centre of their own. The West Pakistan Engineering Congress had always been located in the P.W.D. Secretariat. It was a good omen that with the joint efforts of the Institute of Engineers and the Engineering Congress a joint plot has been purchased to develop a centre of engineering activities in Lahore. The President of Pakistan laid the foundation stone and it is hoped that it will very soon prove to be a centre for all the aims and objects for which the Institute of Engineers was established and the West Pakistan Engineering Congress is working.

About the most important activity of the West Pakistan Engineering Congress is the magazine you are now reading. It has contained engineering articles by reading which you have added to your knowledge. It can contain articles of the highest quality. You have, therefore, two duties: to increase membership, and to send good articles for inclusion in the Magazine. We know you have little time for writing, but don't you think writing is worth while if it increases the knowledge of your brother engineers? Let us admit that the standard of this Magazine is not as high as it should be. It is your duty to try your best to raise its standard. When this is achieved, the future of Engineering in Pakistan will really be bright.

Effect of Bicarbonate Ions in Irrigation Water on Soil Conditions

By

MUHAMMAD HUSSAIN* *and*
NUR-UD-DIN AHMAD**

In assessing the suitability of water for irrigation use four major characteristics considered are the total concentration of soluble salts, the proportion of Sodium to Calcium and Magnesium, the concentration of Bicarbonate ions and the occurrence in toxic amounts of the minor elements such as Boron. The extent to which the soil will adsorb Sodium from the water by cation exchange and the total salt concentration of water adequately gives an idea of alkalinity hazard in irrigation water having no or low carbonate or bicarbonate content. In waters containing appreciable amounts of carbonates there is a tendency for the carbonate and bicarbonate to precipitate as Calcium Carbonate in the soil and thereby increase the proportion of Sodium in the soil solution, and on the soil exchange complex. Irrigation with such a water will in time become hazardous to soil condition and plant growth. Very little is known about the quantitative effect of bicarbonate water on soils. Since the bicarbonates are present in many tubewells or ground water the effect of these waters on soil and the eventual preventive measures should be investigated and determined if a sustained irrigation agriculture is to be maintained. This experiment has been designed to determine certain effects of the bicarbonate-containing water on normal soils.

Review of literature

Eaton[1] considered the precipitation of Calcium and Magnesium to be quantitative when irrigation waters are applied to the soil. The author proposed the concept of Residual Sodium Carbonate (RSC) for evaluating high carbonate waters. He defined "R.S.C." as

$$R.S.C. = (CO_3 + HCO_3) - (Ca + Mg)$$

In addition to RSC Eaton proposed the following two terms to predict the sodium hazard.

1. Soluble-Sodium percentage "found"
$$= (Na \times 100)/(Ca + Mg + Na)$$
2. Soluble-Sodium percentage "possible"
$$= (Na \times 100)/(Ca + Mg + Na) - (CO_3 + HCO_3)$$

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**Research Officer (Soil), Directorate of Land Reclamation.

where the CO_3+HCO_3 deduction does not exceed Ca + Mg.

Wilcox *et a.*[2] in their study on the effect of bicarbonates on suitability of water for irrigation concluded that waters with more than 2.50 meq/l of RSC are not suitable for irrigation purposes. They also postulated that waters containing 1.25 to 2.50 meq/l are marginal and those containing less than 1.25 meq/l are probably safe. Their conclusions were arrived at after a long use of irrigation water on soils which were intensively cropped. The waters used were of variable total and relative concentrations of HCO_3. The authors also found out that the accumulation of exchangeable sodium was significantly greater under a low leaching regime than under a high one from waters having RSC in excess of 2.50 meq/l. The sodium accumulated was unaffected by the Calcium Carbonate content of the soil.

Kelley[3] stated that the use of irrigation water containing Bicarbonate in excess of Calcium and Magnesium may lead to relatively high concentration of Sodium Bicarbonate in the soil solutions, but not generally to agriculturally significant amounts of Sodium Carbonate. He concluded that the expression RSC of an irrigation water is a misnomer. The precipitation of Calcium Carbonate in consequence of applying water containing Bicarbonate tend to bring about an increase in the Sodium percentage in the soil solution, but where the drainage conditions are favourable, the concentration of the soil solution is held in check by leaching which normally result from the ordinary irrigation practice. The general reliability of the R.S.C. concept for evaluating the Na hazard of irrigation waters has, therefore, become questionable.

Bower *et al*,[4] stated that for evaluating the useability of water containing CO_3 and HCO_3 in excess of Ca+Mg, the RSC concept of Eaton seems to have some merit. However, for waters containing no RSC the concept is unsatisfactory. Consequently the authors proposed emperical equation (E.S.P=2SAR+2SAR (8.4—pHc) involving the SAR and a modified Langelier index. Preliminary studies indicate that the new formula appears to be reasonably satisfactory for predicting the Sodium hazard of high carbonate waters regardless of whether they indicate the absence of RSC. They are of the opinion that the equation of the so-called calculated ESP should be used on a tentative basis, pending further study of its reliability.

Massland *et a.*[5] made a detailed analysis of the characteristics of some of the tubewell waters of SCARP I both on the basis of RSC and calculated ESP. The percentage of tubewells considered hazardous came out to be equal when both the standards were used. They observed that the concept of "RSC" has more validity than is sometimes believed.

Material and Methods

In order to study the effect of different qualities of water on soils, laboratory studies were conducted in glass cylinders of 2″ internal diameter and 20″ in length. They were vertically placed in Buchner funnels and fine sandy loam soil was compacted after giving 20 (times) tapping from 1″ height. In this way a soil column of 16″ was created and a portion of 4″ was left at the top for applying irrigation water. The following four types of water were prepared for percolating through these columns:

1. Control (Canal water fit for all agricultural purposes).

2. Water containing less than 1.25 meq/l of RSC but high HCO_3 contents.
3. Water with calculated ESP more than 20.
4. Water containing more than 1.25 RSC.

The analysis of each type of water is given in Table I.

During the experiment 12", 24", 48", and 60" respectively of the above 4 types of waters were percolated through the soil columns in 3" instalments with an interval of 5 days. There were 2 replications of each set. Soil was analysed in the beginning. The results are given in Table II.

After the total quantity of water had percolated the soil columns were allowed to drain off and were then taken out and cut into four equal segments.

The segments were analysed for different chemical constituents. The maximum temperature was 93°F and minimum 71°F with relative humidity 41-69% of the experimental room during the period the experiment was under operation.

Four and eight irrigations of three inches delta corresponding to a total of 12" and 24" irrigations constituted the low leaching regime, while sixteen and twenty irrigations of the same delta corresponding to a total of 48" and 60" irrigations constituted the high leaching regime.

The chemical methods employed were those regularly used at the U.S. Salinity Laboratory[6].

Results and Discussion

Average results of the duplicate soil columns under both low and high leaching regimes with different qualities of water are given in Table III (Appendix).

TABLE I—*Showing Summary of Water Analysis*

Milliequivalents per litre								D.S. (by Evop.)	EC × 10⁶ at 25°C	pH	Cal. ESP.	Res CO_3 me/l	S.A.R.
Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	Total Cations / Anions						
1. Canal water (Water fit for agricultural purposes).													
1.56	0.94	0.85	..	1.49	0.26	1.60	3.35	192	300	8.00	2.31	Nil	.76
2. Water containing no Residual carbonate but high HCO_3 contents.													
5.70	4.90	11.00	..	10.10	6.40	3.10	21.60	1280	2000	..	24.99	Nil	4.75
3. Water where the Calculated ESP is more than 20.													
2.60	4.40	14.10	..	7.30	6.25	7.55	21.10	1280	2000	..	33.3	.30	7.50
4. Water containing RSC more than 1.25 meq/l.													
2.50	2.70	15.90	1.00	11.60	6.70	1.80	21.10	1280	2000	..	46.20	7.40	9.85

TABLE II—*Showing analysis results of soil before treatment.*

Milliequivalents per litre												
Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	Total Cations/Anions	$EC \times 10^3$ at 25°C	pH	E. S. meq/100 grm.	Res. CO_3 meq/1	SAR
3.92	2.33	9.25	..	6.32	5.90	3.28	15.50	1.50	8.10	1.90	.07	5.25

The data show that good quality canal water with 300 EC, nil RSC and 0.70 SAR washed down all cations and anions except bicarbonate ions which remained essentially the same. The total salinity and the SAR have also been lowered. For all practical purposes the RSC has remained unaffected. There has been an increase in the exchangeable sodium of soil irrigated by all qualities of water tested as is indicated in the table IV below:—

TABLE IV—*Showing percentages Increase in Exchangeable Sodium contents of the soil with different qualities of water.*

Type of water / Delta	I	II	III	IV
12″	7.63	99.15	47.63	93.94
24″	59.47	107.38	115.47	96.68
48″	42.84	79.05	119.99	240.41
60″	27.36	13.63	29.68	81.26

The exchangeable sodium in case of quality water No. I has increased by 7.63, 59.47, 42.84 and 27.36% with 12″, 24″, 48″ and 60″ respectively, but is within the permissible limits of 2-3 meq/100 gm. In this connection it is also pointed out that Bower *et al*[7] came to the conclusion that soils which contain no more than 2-3 meq of exchangeable sodium per 100 g. following the removal of excess salt do not require reclamation. Those having an exchangeable sodium content of 3-5 me/100 g. can probably be reclaimed in a few years by good irrigation and cropping practices, especially if rice is grown, whereas those having an exchangeable sodium content of 5 me/100 g. or more

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TABLE III—*Showing Analysis Results of Soil after treatment.*

Type of Water	Delta	Milliequivalent per litre Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	Total Cations / Anions	D. S. (by Evap.)	EC×10³ at 25°C	pH	E. S. meq/100 gms.	Res CO_3 me/l	S.A.R.	Cal. E.S.P.
									I. Canal Water (Water fit for Agriculture Purposes).							
		1.56	0.94	0.85	..	1.49	0.26	1.60	3.35	192	3.00	8.00	..	Nil	.76	2.31
									Original Soil.							
		3.92	2.33	9.25	...	6.32	5.90	3.28	15.50		1.50	8.10	1.90	.07	5.25	6.09
									Treated Soil.							
1.	12″	2.86	2.16	2.78	..	6.04	2.42	.13	7.93		.79	7.91	2.04	.94	1.67	1.18
2.	24″	1.98	3.65	.46	..	4.42	1.96	.06	5.99		.60	8.20	3.03	..	.27	.85
3.	48″	1.86	2.44	4.56	..	4.62	2.97	.08	8.93		.89	8.45	2.71	.30	3.20	3.34
4.	60″	1.57	2.22	3.20	..	3.87	2.67	.55	7.00		.70	8.50	2.42	.23	2.33	2.12
									II. Water containing no residual Na_2CO_3 but high HCO_3 contents.							
		5.70	4.90	11.00	..	10.10	6.40	5.10	21.60	1280	20.00			Nil	4.75	24.99
									Original Soil.							
		3.92	2.33	9.25	..	6.32	5.90	3.28	15.50		1.50	8.10	1.90	.07	5.25	6.09
									Treated soil.							
1.	12″	4.44	1.85	10.50	..	5.58	6.83	4.44	16.75		1.67	8.01	3.78	.02	5.94	6.97
2.	24″	2.13	3.43	10.21	..	5.96	6.10	3.24	15.80		1.58	8.47	3.94	.62	6.40	7.56
3.	48″	2.71	3.07	12.09	..	6.00	7.70	4.17	17.88		1.78	8.59	3.40	.42	7.14	8.49
4.	60″	2.34	1.67	9.24	..	5.35	7.13	.84	13.25		1.32	8.27	2.15	1.31	6.53	7.72

Type of Water	Delta	Milliequivalent per litre								D. S. (by Evap.)	EC×10³ at 25°C	pH	E. S. meq/100 gms.	Res CO_3 me/l	S.A.R.	Cal. E.S.P.
		Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	Total Cations / Anions							
						III. Water where the calculated ESP is more than 20.										
		2.60	4.40	14.10	..	7.30	6.25	7.55	21.10	1280	20.00			0.30	7.50	33.30
						Original Soil.										
		3.92	2.33	9.25	..	6.32	5.90	3.28	15.50		1.50	8.10	1.90	.07	5.25	6.09
						Treated Soil.										
1.	12″	4.47	2.65	11.49	..	5.90	6.47	6.51	18.87		1.88	8.02	2.80	.48	6.53	7.72
2.	24″	1.74	4.03	10.72	..	6.47	6.00	4.02	16.50		1.65	8.52	4.09	.83	6.35	7.49
3.	48″	3.71	2.92	12.85	..	6.42	6.95	6.11	19.42		1.94	8.45	4.18	.62	7.15	8.51
4.	60″	2.17	1.41	11.02	..	4.92	6.00	3.92	14.70		1.47	8.61	2.46	1.39	8.52	10.15
						IV. Water containing Residual Na_2CO_3 more than 1.25 meq/1.										
		2.50	2.70	15.90	1.00	11.60	6.70	0.80	21.10	1280	20.00			7.40	9.85	46.20
						Original Soil.										
		3.92	2.33	9.25	..	6.32	5.90	3.28	15.50		1.50	8.10	1.90	.07	5.25	6.09
						Treated Soil.										
1.	12″	2.66	1.93	13.00	..	6.58	6.16	4.81	17.60		1.75	8.27	3.68	2.03	8.58	10.22
2.	24″	1.82	1.92	12.91	0.012	8.75	4.75	3.18	16.68		1.66	8.63	3.73	5.00	9.54	11.35
3.	48″	2.12	2.03	15.37	..	7.15	5.72	6.43	19.44		1.94	8.31	6.46	2.93	10.40	12.35
4.	60″	1.61	.79	12.09	..	6.50	6.25	1.99	13.99		1.34	8.23	3.44	4.10	11.01	13.02

will likely require special reclamation treatment such as relatively large applications of gypsum if it is decided to irrigate them.

The data for exchangeable sodium for both the original soil and treated one are higher than should normally be expected. This is due to the fact that some salt-affected soils contain certain forms of sodium which are not readily soluble in water. Although these might not be truly in exchangeable form they will dissolve when treated with extracting solution for determination of exchangeable cations. This occurs, also, when salt solutions such as ammonium acetate or others are used for extraction. This causes higher values for the exchangeable sodium than the true amounts should be.

With water No. II (Nil RSC; 24.9 as Calc. ESP; 4.75 SAR and EC 2000 micromohs) no washing down has been observed either in total salines or in individual cations and anions. Some increase has been observed for the SAR and RSC. The results clearly indicate that even if RSC is absent, the high bicarbonate contents of irrigation water increase the RSC contents of the soil. In case of ES considerable increase has occurred, which is of the order of 99.15, 107.38, 78.05 and 13.63% with 12″, 24″, 48″ and 60″ of leaching respectively.

The third type of water with 2000 EC (micromohs); 33.3 as calc. ESP; 7.5 SAR and 0.3 RSC has also little effect on the washing down of the total salines and the individual cations and anions. The RSC has, however, increased significantly. The percentage increase in case of ES has been observed as 47.63; 115.47; 119.99 and 29.68 with 12″; 24″, 48″ and 60″ respectively.

In case of the quality of water shown in the last column in table I with EC 2000 micromohs, as much as 7.4 RSC; 9.85 SAI and 46.2 Calc. ESP where the Ca and M contents have either been reduced or remaine unaffected, there is considerable increase i the soluble sodium content of the soi Likewise the RSC and SAR have significantl increased. The ES has increased by 93.9 96.68 and 81.26% with 12″, 24″ and 60″ c water respectively. This is the natura result of the poor quality water. The effec of such water is quite pronounced with lov irrigation applications.[8]

Water quality Nos. II, III & IV of th same conductance *viz.* 2000 micromohs/cn but with varying amounts of SAR, RSC anc Calc. ESP have deteriorated the soil to varyin degrees. The presence of individual constituents play more important role in affecting the soil than the total salts as measured by conductivity would indicate.

The experimental data show further that the good quality water reduces the calculated ESP of the soil to a considerable degree. On the other hand the high salinity waters have substantially increased the calculated ESP of the soil. The trend of increase or decrease will continue until the soil approaches the equilibrium with irrigation water in respect of their chemical composition.

The results show that the unscientific and indiscriminate use of the poor quality water for irrigation is bound to bring deleterious effects both on the crops and the soil. This has also been confirmed in the observation plots in SCARP I, where the waters of poor quality were used without taking care of the leaching requirements and the permissible limits of good quality of water for irrigation, has distinctly brought about deterioration in the soil.

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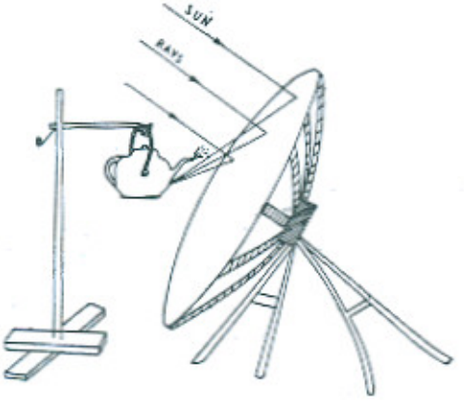
(Continued from Page 14)

Adjacent the Reflector for Parallel Rays

The focus of sunrays is adjusted to form a minimum image. In case the image is not circular, the screws at the bottom of the aluminium pieces are adjusted to focus the sunrays to form a patch on the kettle which



is kept hung at some distance from the reflector for boiling water.

Performance and Special Features of the Cooker

This cooker has been designed to be useful for the under-developed countries which have plenty of sunny days. The cooker is portable and can be handled by one person. It does not require technical skill to operate it. The adjustment of the minimum shadow of the needle is so simple that even a layman can do it and in villages any man with a little commonsense can make this simple adjustment. The cooker is made of ordinary aluminium sheet, sold in the market. The brightness is sufficient for reflecting infrared rays and the brightness does not appreciably decrease even after six years of use. The cost of the cooker is about Rs. 30. Rubbing the aluminium surface with chalk by a rag improves the shine of the aluminium pieces. The cooker brings the water in a blackened kettle to the boiling point in about 25 minutes. The temperature at the focus of the reflector is fairly high. It is nearly 300°C and a solder placed at this point melts in no time.

A Cheap Solar Reflector for Cooking Meals

By

A. G. CHOWDHARY

Mr. A. G. Chowdhary is Professor in the Physics Department of the Panjab University, Lahore. He is conducting research on the utilization of Solar Energy in Pakistan. Sometimes back he contributed an article on the uses of 'Thur' for heat accumulation. This was published in volume 10, No. 2, June, 1965 Issue of the Engineering News. This is another popular article which might be of use to those interested in the uses of Solar Energy.

Concentration of Solar Energy

There are two ways in which Solar Energy can be utilized for domestic purposes *viz.*

1. Direct concentration of Solar Energy in the form of heat.
2. Conversion of Solar Energy into electrical energy.

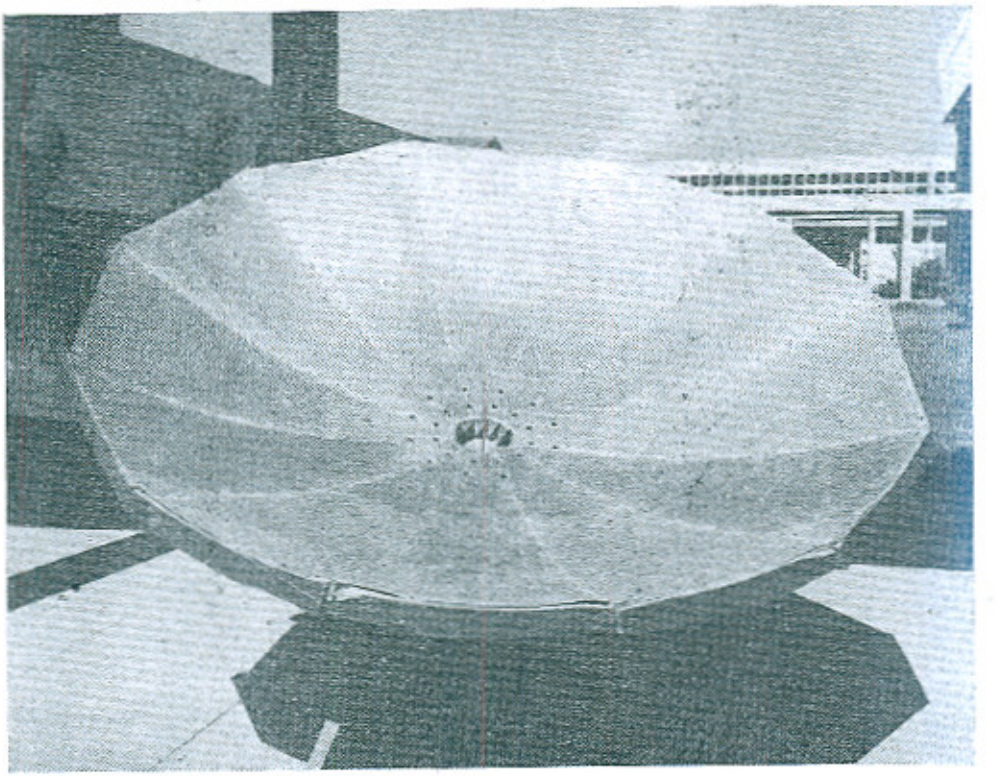
For domestic purposes the cheapest method is the direct use of the solar energy. It can be concentrated by constructing parabolic reflectors which may be either cylindrical or spherical. The sypherical reflectors do not focus the energy at a point and hence cylindrical reflectors are preferred for the purpose.

The University of the Panjab has been experimenting with cylindrical reflectors and it is only recently that parabolic reflector have been undertaken. Several preliminary trials were made to prepare a uniform paraboloid surface by using iron sheet or pasting tin-foil on earthen surface. It was noted that using wood commercial alumunium sheets was satisfactory and it formed a good reflector of sufficient aperture. The paraboloid constructed had a focus length of 50 cm. and 120 cm of aperture. The construction of the paraboloid was undertaken according to the equation $Y^2=4ax$ where a is the focal length equal to 50 cm.

For certain values of Y, the values of X determined were as under:—

Y	X	Y	X
5	0.125	30	4.5
10	0.5	35	6.125
15	1.125	40	8
20	2.0	50	12.5
25	3.125	60	18

Using these values a graph was plotted for the parabola. Its aperture was kept to



The Solar Reflector (Cooker) provided with a needle in the centre

120 cm. A replica of this graph was now made on a plastic sheet. Twelve pieces of wood 2 feet long, 2 inches wide and 1 inch thick were taken. These were made into a parabola form with the help of plastic replica. These 12 arcs of wood were fitted in the form of a circle and were screwed on a wooden disc of 15 cm. radius and 2.2 cm. thickness. The arcs were not taken to the centre of the circle. A gap of 5 cm. radius was, however, left in the centre.

Fitting Aluminium sheet on the wooden Arc

In the beginning the cardboard were cut and were held on the paraboloids. The cardboard were made to touch exactly one another. Pieces of alumunium were made screwed on to the wooden arc. The paraboloid so formed had a circle of 6 cm. radius in the centre.

Stand for the cooker

The Reflector was provided with three legs two of which were fixed and a third was hinged to a circular wooden disc. With the help of this slab it was possible to djust the reflector to the directions of the parallel rays from the sun.

Providing of a needle in the centre of the Reflector

An iron needle 8 to 9 cm. high was fixed on to the wooden disc. This needle helped to adjust the reflector for parallel light. The Reflector was rotated to find out the position when the shadow of the needle was the smallest. This will be the correct position for the reflector. Once a reflector is adjusted, it can remain so for about an hour.

(*Continued on Page* 12)

Role of Irrigation Research in West Pakistan

By

KHALID MAHMOOD, PSE-I*

IRRIGATION SYSTEM OF WEST PAKISTAN

Irrigated agriculture has been practised in West Pakistan since 3000 B.C. Archaeological finds indicate that Harrapa-Mohenjo-Daro civilisations owed their prosperity to their irrigation systems and the now desolate expanse of Baluchistan once thrived on a system of small dams and canals. The Modern Irrigation System of West Pakistan was founded in 1859 with the construction of Upper Bari Doab Canal. Over the last century, it has developed into the world's largest system of contiguous canal.

The total length of canals and distributaries in West Pakistan amounts to forty thousand miles and the aggregate conveyance capacities of canals at their heads is about four hundred thousand cusecs. In space-age analogies, the canals stretched end-to-end can go almost twice round the earth and channel conveyance capacities accumulated over a day would form a continuous two-foot diameter column extending to the moon. About three-fourth of the cultivated area in West Pakistan is irrigated by the canal system and in an average year seventy-five million acres feet of water are diverted to cultivate about twenty-three million acres of land. The present system has now developed to the complete utilisation of the available winter river supplies.

PROBLEMS OF IRRIGATION AGRICULTURE IN WEST PAKISTAN

A typical irrigation project can be divided in three major components: The diversion structure on the river, where the water is headed up and diverted; the canals that convey the diverted supplies and the land, where the water is used as a catalyst for cultivation. Many of the problems involved in the planning, designing constructing and operating the diversion structures and the canals are peculiar to the alluvial plains of West Pakistan.

Alluvial Channels

The alluvial rivers are meandering channels, that may erode their banks by as much as a thousand feet in a year. Their

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discharges vary in great extremes over a year and the highest discharge at a site may be as much as one thousand times the lowest. The alluvium, on which the structures have to be built, consists of geologically recent deposits of silt and clay with a varying degree of permeability and generally low-bearing capacities. In addition to these, there is the unknown heterogeniety of the deposits. The design of these structures cannot, therefore, proceed on the basis of rigid mathematical analysis or ordinary engineering principles alone.

Water

As water flows down the ranges or seeps out of geological formation, it gathers impurities. Its erosive power adds sediment and its solvency adds mineral salts. The irrigated agriculture, therefore, does not get pure water but a sediment-salt-water complex. These impurities of sediments and salts are cumulative in their effects. The sediment concentrations in our rivers during floods are high. During winter, when the river discharges are low, the sediment content is also small. If the sediment concentration prevalent in the rivers during medium and high stages are allowed to pass into canals unabated, the conveyance channels would silt up. Similarly if the coarse river sand is delivered to the fields, the soil would loose its fertility in time. The salt water content of our rivers is small on the average totalling to less than 250 parts per million. But even this insignificantly small quantity is sufficient to leave about two thousand pounds of salt on one acre of land utilising about three acre feet of canal water by evapotranspiration, unless this is washed down into the sub-soil by adequate irrigation supplies, rainfall or flooding.

Waterlogging and salinity

Two additional problems arise in our irrigated agriculture on a longer range basis than the problems discussed above. These are the problems of waterlogging and salinity. The alluvium in the pre-irrigation period had obtained a certain balance between the inflow and outflow of the sub-soil water over the millenia of its formation. This balance is upset by the increased inflow caused by the seepage from canals and distributaries, as well as by the obstruction to surface drainage caused by the canals and other embankments like roads, railways etc. that necessarily follow agricultural development of land. Consequently, the water table rises. The alluvium has its inherent salination, besides the salinity added by the irrigation supplies. The rise of the water table, thus creates the problems of waterlogging and salinity, which adversely affect the fertility of land and the crop yields.

The irrigated agriculture of West Pakistan therefore, has three types of problems. Problems of immediate concern, which relate to the design and construction of the diversion structures and the conveyance channels; problems of medium range, which relate to the operation and maintenance of the projects and problems of long range, which concern the malefic effects of irrigated agriculture in general. At the time, when the development of our irrigation system started, the engineering knowledge on all of these problems was meagre. The initial development, therefore, proceeded on a trial and error basis, but soon the limitations of this painful process of learning were realised. A systematic research has been undertaken into all the three categories of our problems for more than forty years

now. It has provided useful information on the design criteria and solutions for many of our problems.

RESEARCH IN THE FIELD OF IRRIGATION

Research in the field of Irrigation in West Pakistan started in 1924, with a modest beginning. Over the last forty-two years, the Irrigation Research has developed in two directorates (Directorate of Irrigation Research and Directorate of Land Reclamation) with two laboratories in Lahore, and five field research stations. The research on the hydraulics of surface and sub-surface flow as well as that on the engineering materials is done by the Irrigation Research Institute, while the agronomic and land reclamation research is done by the Land Reclamation Directorate. The activities and achievements of Irrigation Research over its life are voluminous and cannot, therefore, by covered here, even briefly. Some salient achievements of this research are described as follows:

ACHIEVEMENTS OF RESEARCH IN THE PAST

Stable Channels

The conveyance channels are generally earthen without any artificial lining. Such channels have two problems in general: the problems of tugosity and scouring or silting. If the unlined channel has a shape, slope or velocity beyond a certain well-defined range, it is likely to suffer damage from scour of bed and banks. On the other hand, an unlined channel can only carry a certain limited amount of sediment determined by its hydraulic and the sediment characteristics. If the inflow of sediment into the channel is more than its carrying capacity, it will chok up by silting. The research into the criteri for stable channels started towards the en of nineteenth century, when this problen was actually felt on the then existin canals. This research, on the field channels is continuing even to this day but now, w have better means of designing such channel than ever before. The Irrigation Researcl Institute played an important role in th collection of data on both the field an laboratory channels and in deriving nev methods of design of stable earthen channels

Design of Foundations on Permeable soils

The permeability of our alluvium ha already been referred to. On a diversio structure, while there may or may not be an surface flow over the structure, a seepag flow persistently takes place below th structure as long as a differential waterhea exists. This seepage force exerts an uplif pressure on the structure and is also capabl of creating soil movement at the downstrean end. The mechanism of these two aspect of seepage flow was not understood for long time and at least two major and man minor structures were damaged due to thi lack of knowledge. A systematic researcl on this subject was carried out in the Irriga tion Research Institute and this resulted i the development of theories and method of analysis, which have won a wid recognition. We can now cater for th effects of sub-surface flow with a great dea of confidence all due to the results of thi research.

Location of Regulators

For delivering water to various parts o the area under its command, an irrigatio channel has to be split up again and agair

At each point of split, it has to be seen that the requisite distribution of water takes place and also that the sediment load in the canal is proportionately divided. Working on small scale laboratory models, Irrigation Research Institute has provided design criteria which can achieve this proportional distribution of the sediment water complex.

Location and Design of Tubewells

The effect of the location of tubewells with respect to the source of seepage was not adequately understood when these were initially used as an anti-waterlogging device. The Institute analysed this effect, as well as the mutual interference of tubewells. Many types of tubewell strainers, made from indigenous and non-conventional materials were also studied by the Institute and their performance was observed under field conditions. As a result of this work, design criteria and new materials for tubewells have been evolved.

Evaporation Losses

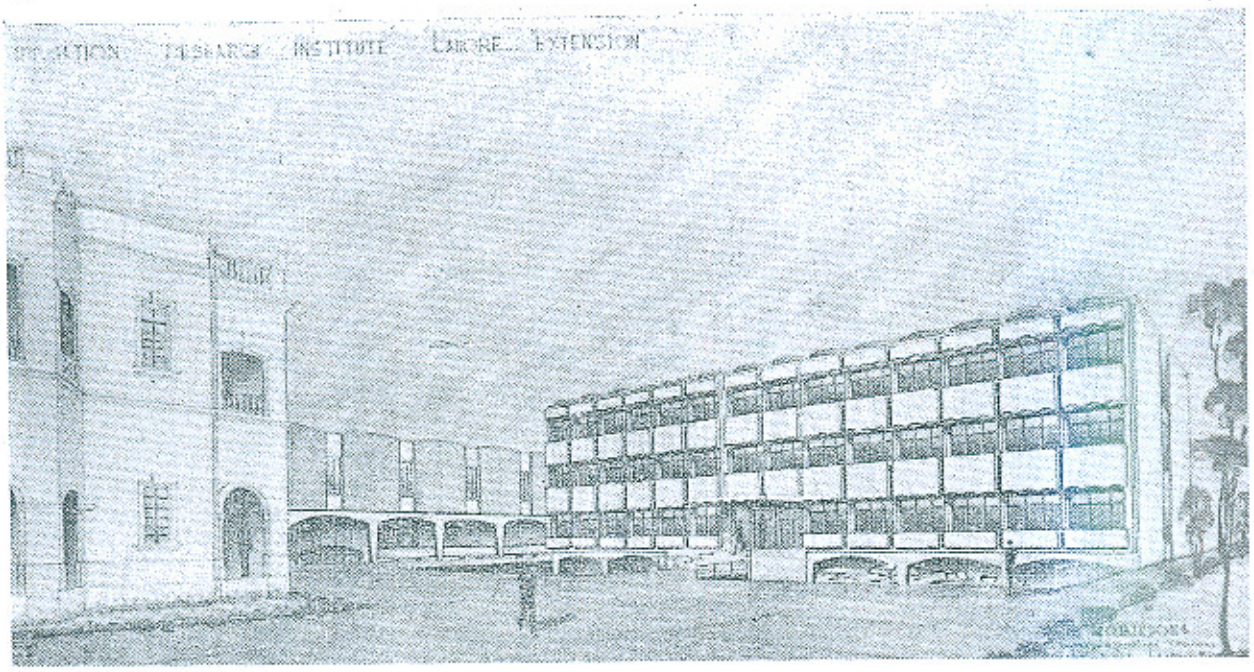
A constant loss of water takes place from all free water and wet surface by evaporation. Solar energy is the prime-motivating force for evaporation and the extent of water loss by evaporation is determined by meteorological factors like wind, humidity, temperatures, duration of sunshine hours etc. In our country, where water is a limiting resource, it is of great economic importance to control these non-beneficial losses. The first step in this direction would, however, be the assessment of the such losses.

The Irrigation Research Institute has collected data for actual free surface evaporation from nineteen different sites over West Pakistan and by using meteorological data over fifty-one sites have determined relatio ships between the meteorological factors ar total evaporation, which are applicable to o conditions. These relationships have show that the amount of evaporation loss vari from about nine feet per annum in Darw (ex-Sind) to about three and a half feet p annum in Quetta. It has thus been estimate that from the reservoirs at Mangla ar Tarbela Dams a total loss of 1200 cubic fe of water per second will take place on th average. With this data in hand, th economics of evaporation loss prevention ca be worked out. Another major source non-beneficial evaporation is from wate logged surfaces. Work on this aspect a well as the cheaper methods of reducin evaporation losses from free surfaces continuing.

In addition to these, the Institute ha carried out useful generalised research o the location, siting, waterway requiremer etc. of diversion barrages and river contr works; evapotranspirational requirements c crops; effects of salinity on crop yields etc etc.

SPECIFIC RESEARCH FOR IRRIGATION PROJECTS

As already stated, the peculiar characte istics of the alluvial rivers and their heterc geniety do not lend their problems to precis mathematical analyses. A cheap and hand tool for analysing such problems is b analogy of small scale models. Specifi research into the problems of designin original or remedial works is generally carrie out by this analogy. The natural wate courses or their structures are reduced to small scale according to certain known an proven principles of similarity and the prc



An Artist's View of Irrigation Research Institute, Lahore

President of Pakistan is being explained by the Director, the activities of Research Institute at an Exhibition arranged on the Centenary of West Pakistan Engineering Congress.

posed works are tested on these for their performance.

A miniature river structure model may represent a twenty mile stretch of a river course by a few hundred feet long laboratory channels, and a mile long structure by a few tens of feet. The discharges, velocities and times all shrink on such a model. If Jonathan Swift was to land in a laboratory of West Pakistan Irrigation Research Institute, he would be pleasantly surprised to see his fictional creation come true. Here he would be surrounded by lilliputian rivers, barrages and canals, all alive and flowing, meandering and flooding like their natural counterparts. He may miss the human models, but he will surely find consolation in the fact that the models of Irrigation structures are neither as simple nor as easy to achieve as his fictional models. They are based on profound scientific theories and a century old practice.

The scope of small scale model studies in connection with specific problems of various structure is illustrated below:

Diversion Weirs

In a typical irrigation diversion project, the first problem to be studied is that of the location and siting of the structure in the wide river valley. In the laboratory river, various locations and orientations of the structure are studied for optimum placement, for all

Model of Qadirabad Barrage of River Chenab, Upstream River Training Works

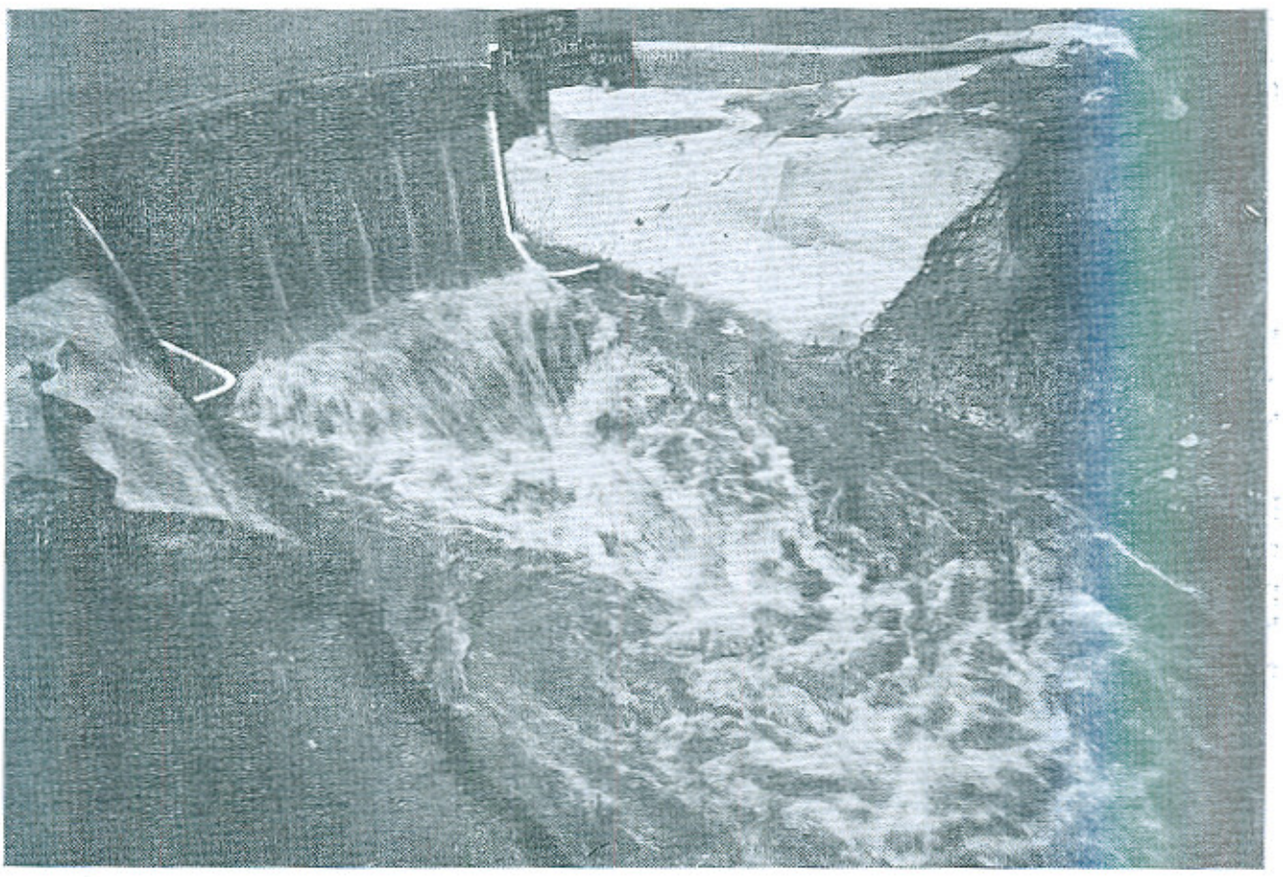
conditions of possible river approaches in the future. The second problem to be studied would relate to various dimensions of the structure like the length of the barrage, the length of the guide bank and the design of any river training spurs needed. The next problem may pertain to the plan of construction and diversion of river during construction stages. The discharge characteristics of the structure and its energy dissipating devices may be studied next. Yet another study may pertain to the silt excluding devices and measures. Most of these studies start at the design stage of the project and last till the final completion of the project. Their objective is to provide important performance tests of the proposed structure and their components. They are the most economical ways of determining the cheapest solutions. It costs much less to experience failure on the miniature model than on its prototype.

Canal Structures

The canals taking off the diversion weirs have a variety of structures on them. There are falls to lower the water levels, bridges to cross the lines of communication, cross-drainage works, regulators to control distribution of flow etc. etc. At many of these structures, the site conditions may be such as to exclude the use of generalised design principles. The designs in such cases are evolved from laboratory model studies.

Flood Protection and Bank Erosion

The occupancy of flood plains presents a constant threat due to flooding and bank



Model of Rawal Dam spill-way with designed discharge

erosion. Depending on the economics of the problem flood protection measures may be adopted for a certain degree of safety. These measures, which may consist of river channel improvement levees or river diversion are always tested on small scale models for their performance and safety limits. Similarly where a river may be threatening some costly area by bank erosion, the remedial measures are invariably determined by study on miniature models.

The economics of model study has long been recognised and it is not considered necessary to establish the economic justification of such model studies any more. The cost of these studies generally range from less than one tenth of a per cent of the total cost of the new projects to two per cent of the cost for medium sized remedial measures. The savings in cost accruing due to such studies cannot be accruately determined but is believed to be many many times over the cost of the studies.

FUTURE ROLE OF IRRIGATION RESEARCH IN WEST PAKISTAN

In the existing irrigation system in West Pakistan the problems will worsen with its age. Some of these problems have already been experienced while others have only cast their shadows. The probelms of water-logging and salinity have been acutely felt and although they are being solved, the permanency of our irrigation system can only be assured if a long term salt-balance of land and water is achieved. The sediment exclusion from canal diversions means that more silt is left in the rivers to be transported by lesser water. In the past, the rivers in Indus Valley are known to have built up their beds at a rate of less than two feet per century. With increasing withdrawals, this rate will enhance many times over. This means a continuous deterioration of river channels and a need for remodelling of diversion structures. It also means higher flood heights. We have only recently entered the field of storage dams. The local effects of these structures can create many problems on the rivers and the loss of the useful storage capacity of dams by silt deposition continuously impairs their utility.

The past performance of Irrigation Research in West Pakistan indicates that solutions have found as the problems arose. The need of the moment, however, is to expand the research in proportion to the magnitude of the problems. The research consciousness in Pakistan is today better developed than ever before. National Research Councils have been set up in many fields of Science including one for Irrigation, Drainage and Flood Control. It is hoped that this Council will be able to provide impetus to research in the field of irrigation by arranging financial assistance for the existing research institutes. The future role of Irrigation Research in West Pakistan is vital and it is only by a continuous and ever increasing research effort that we can obviate the fate of many better developed irrigation agricultural systems of antiquity.

Research on the Utilization of Saline Water for Irrigation in Tunisia

By

J. W. VAN HOORN

The utilization of saline water for irrigation in Tunisia is often referred in this country. Recently an article has appeared in Volume I, No. 2, June 1966 of the Nature and Resources Bulletin of the International Hydrological Decade.

In this article some information about the water quality, the depth of groundwater table, the nature of soil and the crops is given. We have reproduced this information for our readers.

In Tunisia and neighbouring countries of North Africa and the Middle East, irrigation water contains varying amounts of soluble salts, as does also the water-table of the irrigated area. Irrigation under these conditions has very often resulted in the deterioration and even in the sterilization of the soil.

It is in the south, in the oases of the Gabes and Shott Djerid regions that the oldest forms of irrigation are practised. The irrigation water is brackish to a varying degree, its salts content ranging from 1 g. to 3 g. per litre, and the soil is often gypseous. Observations made in the oases indicate that the biggest problem is how to obtain good drainage. Lowering the water-table from 80 cm. to 1.30 metres apparently doubles the date crop, especially with the "deglet noor" variety. The importance of drainage has also been noted in olive plantations, where the selection of light, impermeable soils is equally important.

Since 1958, the Tunisian Government has had four test plots prepared in the south-east near Sfax, which are irrigated with water having a saline content of 4 to 5 g. per litre. The soil is generally sandy, initially non-saline or only slightly saline, and with limestone and gypsum pans at depth. The plots range from 40 to 100 hectares in size. As the water-table in three of them (Mellouleche, Ahzeg and Nakta) was already 3 to 6 metres below ground before they were prepared, a network of drains 50 metres apart was installed, at a depth of 80 cm. at Mellouleche and 1.50 metres at the other two places. On the fourth (Henchir El Hicha), the water-table is at a depth of more than 30 metres.

Whereas on the plots drained to a depth of 1.50 metres the water-table has not risen beyond 1.20 metres or so, at Mellouleche it had risen to 80 cm., in the lower part of the

area, causing heavy salinization and even sterilization of the soil. When the drainage network was lowered to a depth of 1.50 metres, a considerable improvement was noted and crops revived. This confirms observation made elsewhere in Tunisia as the importance of drainage as a means of preventing a continuous rise in the water-table beyond the level of 1.0 to 1.20 metres.

Crops were rotated as follows: vetches, oats, ryegrass, cotton, beans, grain sorghum, wheat, and sudan grass for fodder, but 15 per cent of the land is kept under lucerne and 15 per cent under fesue for three years, followed by rotation. As an experiment, some market garden crops such as tomatoes, melons, asparagus, onions, carrots and artichokes have also been tried out. On the Henchir El Hicha plot, although the olive plantations came along well, the leaves of the apricot trees and almond trees regularly suffered from salt-burns. Per hectare yields for all crops were satisfactory, ranging from 30 to 40 quintals for wheat, 45 to 50 quintals for maize, 60 to 100 tons for sudan grass, 15 to 20 tons for alfalfa hay and 20 to 30 tons for tomatoes.

In the lower valley of the Medjerdah River in the north of Tunisia, after building dams and installing the main network of irrigation canals, the Tunisian Government has begun to plant crops requiring irrigation. The dam on the Mellegue, the largest tributary, has a storage capacity of 300 million cubic metres of water, and the average annual intake is in the region of 150 million cubic metres. The main irrigation canal leading from the storage dam at El Aroussia, at the entrance of the lower valley, can provide a flow of 14 cubic metres a second, which means that about 20,000 hectares can be irrigated in summer and double that area in winter.

The annual rainfall in the lower valley is about 400 mm., the rainy season lasting from the end of September to the end of April.

The salt content of the irrigation water ranges from 1 g. per litre in winter to 3 g. in summer. Half of this is sodium chloride and the Na/Ca index is 2. The main purpose of the Wadi Ellil Dam is to provide fresh water (0.2 to 0.4 g. per litre) for Tunis. The Tunisian Government is proposing to build dams on other tributaries of the Medjerdah in the same region as the Wadi Ellil Dam, where river water is fresh on account of the high rainfall (about 1,000 mm. a year), thus permitting an increase in the irrigated area, an improvement in the quality of the irrigation water, and the reduction of summer salinity to between 1.5 and 2 g. per litre.

Unlike the soils of the hillsides, where trees, vines and market-garden crops are grown, the soils of the lower valley are generally of average or heavy texture with about 30 per cent calcium carbonate. Once the agrarain reform has been intiated, these lowlands, which used to be planted with cereals because of the low rainfall and the proximity of the saline water layer, will be reclaimed after drainage, subdivided and developed by irrigation. They will be used, in the light of pedological and hydrological studies, for high yield fodder crops and market gardening.

The first problem to be solved before these lowlands can be developed is how to ensure adequate drainage. In the plains, the upper layers of the soils are usually not very saline (ECe in the region of 1 to 3)[1], but at depths exceeding 1 metre the soils are highly saline (ECe in the region of 8 to 12)[1].

As the water-table is highly saline frequently containing from 10 to 15 g. per litre) and at a depth of 0 and 1 metre in winter and between 1 and 2 metres in summer, rapid salinization could be expected to occur when the balance existing between winter rainfalls and summer capillarity is upset by the arrival of brackish irrigation water for which there are no adequate discharge facilities.

The first attempts to drain these lands were made from 1959 onwards with the installation of tile drains 150 metres below the surface at intervals of from 40 to 80 metres according to the permeability of the soil. This drainage proved sufficient to prevent continual rising of the water-table and salinization of the soil.

Since 1961, the Tunisian Government has been studying an experimental area of heavy-texture soil containing about 50 per cent clay, with the object of observing the effect of drainage on the water-table and the salinity of the soil and the water requirements of the crops. Thanks to the installation of deep and well-spaced drains and leachi by winter rains, no serious difficulties ha been met with so far, despite the texture the soil and the high salinity of the irrigati water (up to 3.8 g per litre). Water co sumption is in the region of 12,000 cul metres per hectare for alfalfa, 8,000 f tomatoes and 5,000 for artichokes a maize. The potential evapotranspirati of alfalfa, measured by lysimeters, rises fr a minimum of about 1 mm. a day in win to maximum of about 12 mm. a day summer.

Several Research Stations have be established to determine the effects of sali water on the land. Field studies have be carried out in Medjerdah Valley. T conclusions are that the experiments carri out in Tunisia on irrigation with bracki water have shown that it is possible to u such water for irrigation either for annu crops or for trees and shrubs. It wou seem that the main problem lies in obtaini sufficient drainage to permit leaching and reduce the capillary rise of the salts.

Institute of Engineers Pakistan

TWELFTH ANNUAL CONVENTION

The Institute of Engineers Pakistan held its Twelfth Annual Convention at Lahore for the first time. It was inaugurated on the 3rd of May, 1966. Mr. H. J. Asar as President of the region and Chairman Reception Committee welcomed the delegates and the participants. Mr. M. A. Jabbar, President of the Institute of Engineers of Pakistan read his presidential address. He welcomed the President of Pakistan Mohammad Ayub Khan, the Governor Malik Amir Mohammad Khan and other invitees. We have reproduced these addresses of and the advice of the President to the Engineering profession.

Mr. H. J. Asar, Chairman Reception Committee stated that:—

It is a matter of great honour and pleasure for all of us to have you among us this morning at the 12th Annual Convention of the Institute of Engineers (Pakistan). On behalf of the Members of the Institute in general and the Lahore Centre in particular, I have the privilege to welcome you most heartily and to express our deep sense of gratitude for your having so graciously accepted the invitation to be the Chief Guest on this memorable day. We are conscious of your great preoccupation with the affairs of the State and our sense of gratitude is, therefore, all the more deepened for your having found time to grace this occasion.

Mr. President, the city of Lahore is the home of ancient culture and traditions. The war of September last thrust upon us by India has added a glorious chapter in the history of our country. The indomitable fortitude and valour displayed by our Armed Forces on all fronts would be remembered for all time to come and would serve as a beacon of light for posterity. In this hour of need, the engineers also contributed their mite in the struggle against the ruthless enemy, shoulder to shoulder with the fighting forces. The trains were kept running, the communication lines stood fast, essential industries were maintained and canals were kept flowing. The B.R.B.D. Canal responded excellently and was kept flowing in spite of enemy attacks. The question of rehabilitating the displaced persons in the war affected

areas has already engaged the attention of all branches of the Engineering profession. Brisk and earnest efforts are being made to accomplish this task in minimum time.

Mr. President, under your guidance and leadership, phenomenal progress has been achieved in agriculture. Industry has attained surprising dimensions. The national economy has thus become dynamic and forward looking. The conclusion of the second Five Year Plan in June 1965 has marked a turning point in the economy of Pakistan. Radical changes have been brought about in almost all spheres of life, trade, commerce, and industry, social welfare, labour welfare, water and power developments, postal services, civil aviation, broadcasting, television; in fact, all these are new signs and symbols of progress.

In our deliberations at the 12th Convention that you are going to inaugurate today, subjects of varied natures covering nearly all the branches of engineering are going to be discussed. We are also holding a Symposium on "Utilization of Manual Labour for Major Civil Engineering Projects". This subject is of national importance in view of the need of making proper use of our vast manpower and reducing expenditure of foreign exchange. We hope that these discussions and exchange of knowledge between engineers with firsthand experience of these matters will be of great benefit to the profession and to the implementation of our development programme.

We are looking forward to having a building of our own at Lahore. Our Centre is very active with about 1,000 qualified

Mr. H. J. Asar, Chief Engineer and Chairman, Reception Committee delivering his welcome address

engineers are on the roll. On an average about 400 students appear in the examinations every six months for which we need a hall of our own. This long-cherished desire is ultimately going to be fulfilled with the laying of the foundation stone of the building to-day by the President of Pakistan. We are most grateful to the Lahore Improvement Trust and its Chairman who allotted us this plot of land for the purpose.

In the end, I thank you, Sir, once again for your gracious presence amongst us today. I also thank all of you, gentlemen, who have assembled here to welcome our Chief Guest and join our function.

Pakistan Paindabad !

* * *

Mr. M. A. Jabbar, the President of the Institute of Engineers, welcomed the President and stated:

President of Pakistan,
Field-Marshal Mohammad Ayub Khan,
and Gentlemen.

May I, on behalf of the members of the Institute of Engineers (Pakistan), extend to you our most cordial welcome to this Twelfth Convention which, incidentally, is the first-ever held in the historic city of Lahore. We feel a special satisfaction in choosing to hold the function in this heroic city which has acquired a new glory by becoming the symbol of the nation's grim determination, matchless valour and unyielding invincibility against the covetous aggression of the enemy. We remember with pride the brave and heroic deeds of our armed forces. Many laid their lives in the defence of the country's freedom and honour. Their names will be enshrined for ever in the hearts of the people.

Mr. President, by graciously consenting to inaugurate this Convention, you have given yet another proof of your abiding interest in the promotion of science in general and engineering in particular. On our part, we Engineers renew our pledge to stay solidly behind you in your war against poverty, ignorance and social evils. Whatever knowledge, talent and skill may be in our possession, are dedicated to the great cause you pursue.

I shall beg your leave to speak today on the role of engineers in our developing economy. I have selected this theme, Mr. President, in the confident knowledge that the economic development of the country is so close to your heart and so vital to our very existence that any steps which may be required to accelerate its pace will meet your immediate and earnest attention. We are deeply conscious of the fact that you have spared no efforts to achieve the targets and the goals set for economic developments. The impact of your far-sighted policies and dynamic leadership is there for all to see. The world at large has widely acclaimed the results; our rate of economic growth has been adjudged to be next only to Japan in the whole of Asia which is no small an achievement.

The Engineers of Pakistan have contributed to the buoyancy of the nation's economy in their own humble way. They have built some of the world's largest barrages, canals, flood embankments, roads, townships, railways, telecommunication system, power networks, ports and waterways—works in which we can legitimately take some pride. We know, much more is required. The battle against floods, cyclones, waterlogging and salinity is yet to be won,

It has been estimated that about three-fourth of the expenditure in any development Plan is such that it is to be handled by engineers in one form or the other. A great responsibility, therefore, rests on their shoulders. It calls for an imaginative approach, exercise of the highest skills and observance of the best standards of professional conduct. They have not only to build the works involved according to schedule but also ensure that their cost is as low as possible and indigenous materials are used to the maximum extent without sacrificing the efficiency. The operation and maintenance of the works makes similar demands on their skill.

Considering the part that the Engineers have played and can play in speeding up the economic development of the country, it would be in the fitness of things if they are helped with the problems facing their profession. We have been heartened to note that certain steps were taken to solve these problems, but some of the factors responsible for causing frustration and lack of confidence in the engineers are yet to be remedied. The profession no longer holds a special attraction to talented persons and it has been noticed that sizeable number of really gifted engineers have left Pakistan to look for jobs in the developed countries.

The Engineering bodies of the country have from time to time urged upon the Government to give equal opportunities to the engineers to fill policy-making posts concerned with developmental works. I am sure that they will prove their worth if confidence and trust are reposed in them.

Mr. President, under your direction, various Commissions have been appointed in the past to look into the problems facing practically all professions such as police, law, education, medical, etc. etc. We have no dearth of problems facing us and they are on the increase, with the passage of time. It would be, in our opinion, desirable to appoint some special panel or committee, so that a country-wide survey may be carried out and all such problems which engineers are facing in Pakistan, be investigated and remedial measures taken.

Research is the basic requirement for progress of a country, whether it is in the field of industry, water and power, communication and transport, ports and harbours or any other sector. In our developing economy, backing of research is very important because our resources are limited while our needs are large. We have noted with great satisfaction the establishment of the Irrigation, Drainage and Flood Control Research Council and the Works and Housing Research Council. We wish on similar basis further steps be taken by the Government to encourage research activity in the country in other engineering fields as well. The Institute is grateful to the Government for giving it an opportunity to be represented on the Irrigation Research Council and would suggest that it be given a representation on the other Councils also.

In establishing the economy of the country on a sound footing, the private sector has an important role to play. We are glad that our Government have taken certain policy decisions to facilitate the establishment and further development of Pakistani firms of consulting engineers and contractors. One way to give it impetus may be to declare such firms as protected industries and given tax holidays. Of course, we cannot totally dispense with the services of foreign speci-

alised organisations and individuals. Even advanced countries like America and Russia avail of such consultations from other parts of the world. However, the employment of foreign consultants and foreign contractors in fields where necessary know-how is available in the country needs to be discouraged, rather forbidden. It is said that we have to employ foreign consultants and contractors because of the conditions imposed by the international financing agencies, but the confidence of the Government in our own men will lead to trust and confidence of the foreigners in our private enterprise, our own consultants and contractors. We appreciate that a panel has already been appointed by the Government to look into the matter. The Pakistani engineering profession is waiting the outcome of this study.

Mr. President, we feel the need for the establishment of an academy for engineers in the country. We have academies of civil service, finance and other professions but there is no academy for the training of the engineers and to help in broadening their outlook for shouldering the administrative and executive responsibilities more efficiently. We hope this long-felt need of the engineering profession will be fulfilled and such an academy established at an early date.

Sir, I would now say a few words about technical education. Admittedly, human resource is the greatest asset, a country can possess and ours is a land of teeming millions. But these constitute only a potential wealth. In spite of abundance of population, we have to import men from abroad for setting up our infrastructure plants and running our industries. Our human resources development programme is falling behind our physical development plan and we may soon be discomfited by production falling behind schedule, even after the industrial plants have been installed, only because of a time lag in the supply of skilled workers and technicians. There may be difficulty for a growing nation to forecast the progressive requirement of technical manpower. But that should not lead us to adopt an over-cautious policy in this respect. Government has been taking steps to increase the technical manpower. What we venture to suggest is that, as far as our resources permit, more and more facilities be created for scientific and technical studies so as to meet the rapidly increasing demands. In planning these facilities, we have also to keep in mind that our engineers can make significant contribution in the development of the Afro-Asian countries and thereby consolidate our friendship with them.

It may be interesting in this connection to mention some statistical information from some developed countries on this matter. The number of University or College produced Engineers was 2,35,000 in West Germany which had a population of 50 million in 1955. This gave a ratio of 1 (one) Engineer for every 213 people. Yet that country was considered to be short of 50,000 Engineers. The U.S.S.R. in the same year in the population of 200 million, had 5,00,000 Engineers. The number of students graduating in Engineering in that year was 63,000 and the number of enrolled Engineering students was 3,00,000. On this basis of population there was 1 (one) Engineer to every 400 people in that country. Even for a country like Denmark, the Engineer population ratio was 1: 360. We have yet to reach a figure of 1 in 10,000. These figures have not been quoted with a view to advocating the production of technical

personnel on population basis in our country but only to show the extent of the leeway to be made up in the long run and the need for accelerating our present programme of human resources development.

Gentlemen, the Institute in its small way is trying to contribute toward higher technical training through its various courses and examinations offered to the junior technical personnel in services. The number of such persons currently undergoing training is about 5000. This endeavour will continue with greater emphasis and is expected to make a significant impact on the overall supply of qualified technical personnel.

The Institute, besides holding Examinations and seminars and organising conducted tours of important Projects and presenting technical papers, publish regular periodicals for the benefit of the profession. These are of immense value. But for the existence of the Institute, these and other valuable papers would not have been written or published. I request our senior Engineers to devote more time in this direction for the benefit of the new-comers. We must ourselves build up a store of experience and knowledge for our future generation. No outside body is going to tackle technological problems that arise in Pakistan. We have to hold our own in the field of agriculture and industry. Who else, but ourselves, will safeguard our interest and realise our aspirations? Let us all, Scientists, Engineers, Technicians, Agriculturists and Industrialists, unite and play our part fully and faithfully to make this country happy and prosperous.

President of Pakistan, Mr. Mohammad Ayub Khan, addressed the engineers at the 12th Annual Convocation of the Institute of the Engineers

To the members of the Institute, I express my heart-felt gratitude for having re-elected me last year as President of the Institute for a second term which is now coming to a close. I have taken this as a great honour. It has been my proud privilege to have been actively associated with the Institute since its very inception and it has been a rewarding experience for me. Very earnestly I hope my worthy successor will be able to help its further growth.

My colleagues and office staff, I wish to thank whole-heartedly for the co-operation extended to me over the past two years and to the Lahore Centre for making so fine an arrangement for holding this Convention at short notice.

Gentlemen, I must offer my sincerest apology for taking so much of your valuable time. I must thank you once again and before saying good-bye, I have the honour to request the President of Pakistan, Field Marshal Ayub Khan, to graciously inaugurate this 12th Convention of the Institute of Engineers (Pakistan) and to lay the foundation stone of the building for the Lahore Centre of the Institute.

Pakistan Paindabad !

The President laid the foundation-stone of the Lahore Centre of the Institute of Engineers, Pakistan

THE PRESIDENT OF PAKISTAN, Mohammad Ayub Khan inaugurated the Twelfth Annual Convention of the Institute of Engineers and also laid the foundation-stone of the Lahore Centre of the Institute in Gulberg. The President re-emphasised the need for injecting a greater degree of realism in the development work and suggested that the planning of future Project should be based on the maximum utilization of indigenous resources of both material and manpower. The President asserted that research was vital for progress. The President said that the Engineers of the country had a number of major works to their credit and many of them were a standing testimony to their skill, foresight and imagination.

He agreed with the President of the Institute, Mr. M. A. Jabbar, that two major problems affected the country to which satisfactory solution had yet to be found. One was the floods in East Pakistan and the other salinity and waterlogging in West Pakistan. The Government, he said, had given and would continue to give the highest priority to the solution of those problems.

Flood control, according to the President, was the part of the overall development of water resources in East Pakistan. A master-plan for the development of the water and power resources of the Province had already been prepared and was being studied by Government in consultation with the World Bank. That was a challenging problem which would tax the ingenuity, skill and resourcefulness of the engineers of the country to the fullest extent.

PROCEEDINGS

during the Twelfth Annual Convention of the Institute of Engineers fourteen Papers were presented. Their brief excerpts are recorded in this volume.

The Problems of the East Pakistan Delta

By B. M. Abbas, A.T., S.Q.A.

Mr. Abbas gave some details of the topography, geology, climate of East Pakistan and then discussed the major problem of rivers which flow through the area. Three mighty rivers, Ganges-Padma, Brahma-putra, Jamna and the Meghna which together drain an area of more than 600,000 square miles mainly outside the country, flow through East Pakistan. In an average year 107 million acres feet of water flows into the country from the catchments outside the province. About 100 million acres feet of run off from rainfall is added to it within the province. This volume water is equivalent to 34 ft. depth of water when spread over the entire area of East Pakistan. The present population is estimated at 60 million which may rise to 100 million by 1985. The average farm size is 3.5 acres of which 3.1 acres are cultivated. The Engineers of East Pakistan are thus faced with many problems, most urgent of which are the floods, cyclones, water shortage and the navigation. The average yearly flood peaks of the Ganges and Brahmaputra

rivers ranges from 3.7 to 4.5 million cub. ft. per second. About 34% of the total land which is more than 10 million acres gets inundated every year. The significance of flood control means in East Pakistan is to reduce the damage to the greatest degree.

The second type of calamity is the cyclone which frequently occurs and causes extensive damages. Although it is impossible to control cyclone but damage can be minimised. Again in spite of the excessive amount of annual flow of water, the area suffers with shortage of water from the months of November to March. Unless irrigation is developed it is impossible to grow crops. Maintenance of Navigation through silt-laden rivers is another big problem of the area. The Engineers of the Region are facing the complex challenge by undertaking several counter-measures. It is proposed to construct Dams across Megna, and construct thousands of miles of coastal embankment to safeguard against intrusion of saline water. Hydrological data of the Region which is essential to counter the devastating calamity is being collected to plan other measures.

The Place of Apprenticeship in a System of Engineering Education

Training of Engineering Graduates and Students

By Dr. Muhammad A. Haque

No system of engineering education can be considered to be complete without adequate provision for practical training of engineering graduates and students. In the practical field today, old skills are continually being discarded and newer methods take their place. The engineering and technical knowledge of yesterday is displaced by the results of scientific discoveries of today, which in turn are applied in the engineering workshop of tomorrow. Therefore, in all technically advanced countries greater emphasis is being placed on the need for practical training of engineering personnel.

The author brings out a thesis that suitable provision for practical training of engineering graduates and students does not exist in Pakistan. He, therefore, contends that the future Pakistani engineers can never attain that high standard of professional efficiency which is evidenced among their counterparts in other advanced nations of the world. He reviews at length the existing facilities available in the country and makes extensive recommendations for the upgrading of Polytechnic and Technical Colleges emphasizing closer relation between such institutions and Apprenticeship training in industry.

The author maintains that sufficient contact does not exist between the Engineering Institutions and the engineering industry. It is necessary to encourage the closest co-operation between the two, in order to produce engineers of high calibre and standard. This demands close and frequent consultations between the Engineering Universities, the firms and all concerned should see that this close contact does exist.

Free-Piston Engine Theory, Cycle Analysis and Applications

By M. IBRAHIM, Ph.D., DIC, AMI Mech. E., Mem ASME, MIE (Pak.)
Head of Mechanical Engineering Department, University of Karachi.

The development of Free-Piston Engine in recent years is surveyed to establish its rapidly growing popularity as a low cost

power unit having desirable features such as high thermal efficiency at all loads, mechanical simplicity and simple foundation requirement.

Possibilities of Sub-Irrigation in East Pakistan

By MOHI-UD-DIN KHAN

The economies, advantages and disadvantages of various types of irrigation such as flow irrigation, tubewell irrigation and low lift pump irrigation have been discussed. Sub-irrigation may compare favourably with flow irrigation, as it has some advantages over it. The recurring costs of sub-irrigation are the lowest and it is multipurpose unlike other forms of irrigation. This will be an excellent supplement to tubewells and low lift pump irrigation.

Behaviour of Prestressed Composite T-Beams of Lightweight Aggregate Concrete Without Shear Connectors

By ABDUL HASNAT,

Director of Advisory Extension and Research Service, University of Engineering and Technology, Dacca.

Lightweight aggregate concrete is being increasingly used for construction because of its reduced dead load and non-availability of certain sand and gravel aggregate in areas. Compared with sand and gravel aggregate concrete, lightweight concrete has lower modulus of elasticity and modulus of rupture, greater shrinkage and creep, and uncertain bond quality. Prestressed composite construction offers economy over normal prestressed concrete design, but little data is available on prestressed composite construction with lightweight aggregate concrete. In order to collect information in this factor tests were conducted on prestressed composite T-beams without shear connectors to study their flexural behaviour and to determine whether shear connectors are necessary for full composite action.

This study lead to the conclusion that :—

1. Bond strength between precast web and *cast-in-situ* flange is a function of the *in-situ* concrete strength and increases with the increase of concrete strength. Natural bond may not be sufficient and should not be relied upon for the development of ultimate strength.
2. Differential shrinkage reduces significantly the cracking stress in a composite T-beam. When inclined cracks reach the interface, the vertical stress at interface becomes critical. However, it is difficult to predict whether the final failure is due to vertical stress or horizontal shear stress at the interface.

Drag Characteristics of Hemispheres and Cones in Non-Uniform Flow Fields

By A. K. M. HAMIDUR RAHMAN KHAN,

Assistant Engineer, East Pakistan, WAPDA.

In this study the effect of the non-uniformity of approach velocity on the drag coefficient of hemispheres and cones was considered. Tests were made in a wind tunnel and it was found that if the drag coefficients were defined in terms of the velocity corresponding to the height of the body, $C_D = 2F_D/\rho v^2_k A$, then the drag coefficient decreases with the increase of non-uniformity of the velocity. On the other hand, if the drag coefficient is referred to the local stagnation pressure, $C_D = 2F_D \int_o^k \rho v^2 dA$, then it increases with the increase of non-uniformity of the flow. The results showed that there was a greater consistency between drag coefficient and non-uniformity of the velocity if the latter definition for drag coefficient is used.

Hydrology of the Brahmaputra River

By KHANDKER MAZIDUL ISLAM and JOHN A. ROBERSON

The Brahmaputra River with a drainage area of 228,000 sq. miles has a mean flow of 0.067 million cusecs and an average specific yield at Bahadurabad of 3.23 cfs/sq. miles. This study revealed that 90% of the total discharge of this river comes from its catchment area in Assam which represents only about 33.5% of the total basin area.

Floods and droughts of the river have been analysed by Gumbel's probability theory and the 100 years and 1,000 years floods were found to be 3.16×10^6 cusecs and 3.8×10^6 cusecs respectively. Similarly the 100 year and 1000 year draught were found to be 38,950 cusecs and 19,150 cusecs respectively.

The flow duration curve was plotted and the variability index was determined therefrom.

The recession coefficient K in $q = K_q$ was found to vary from 0.555 for the highest range of discharge to 0.959 for the lowest discharge. This information should allow accurate forecasts for the flow to be made.

The foregoing results should be of considerable value for future industrial or agricultural development. The river basin hydrological characteristics are often necessary for design and construction.

Development of Soil Sealant for Low Cost Canal Lining

By Dr. NAZIR AHMAD and MALIK ABDUR RAZZAQ

This paper describes the results of tests conducted during the last five years in the Irrigation Research Institute on various types of sealants being developed in foreign countries. The paper aims at bringing to the notice of the engineers and the chemists of our country, the possibility of developing emulsions out of local materials which might be used to reduce percolation of our canals, majority of which are earthen and are in operation having all the problems and difficulties of their lining with bricks or concrete.

Use of soil sealants is a new line of approach for lining of the existing operating canals. During the last few years' research has been directed to develop materials in the form of emulsions, the ingredients of which are normally insoluble in water but in emulsified form can be diluted with water. When these emulsions come in contact with soil particles, break into their original components which are insoluble in water and have the property to stick around the soil particles and so block their pores.

The emulsion presently being developed, have the basis in Asphalt, Wax and some mineral oils. Several organizations of the world are conducting intensive research to produce a suitable type of soil sealant which will effectively block the pores and be durable at the same time.

Rainfall Runoff Relation at Halda Basin-II by Unit Hydrograph Method.

By MUSTAFIZUR RAHMAN TARAFDAR

This article describes how Unit Hydrograph has been employed in the calculation of runoff at the Halda Basin. An introduction is given outlining the historical development of unit hydrograph and the theory in the derivation of the same. Unit hydrographs have been derived from isolated storms in the basin, analysing all the available rainfall and discharge observation records.

EPWAPDA set up this experimental catchment area at Halda Basin with a network of rainfall, water level and discharge observation stations in order to study rainfall runoff

relation. An analysis of the records was made by the author and rainfall-runoff relation was made by the co-axial graphical correlation. Results achieved by the application of unit hydrograph compare well with that of the co-axial graphical correlation method.

A storm of 10-day duration is selected and unit hydrograph is employed for runoff calculation in the basin. The result achieved is satisfactory. This unit hydrograph method in calculating runoff from rainfall may be successfully used in the Matamuhuri, Sangu and Feni Rivers.

Roads in Waterlogged Areas of West Pakistan

By B. A. MALIK and MUZAFFAR IQBAL SHEIKH.

The author has discussed the cause of failure of roads in waterlogged area. He has suggested the field and laboratory investigations to be concluded for each site for proper remedy. He has discussed the Mechanism of Road Failure and has put-forth Remedial Measures which includes depressing the water-table by drainage, increasing the thickness of Road crust, improving the sub-grade etc.

Reconditioning of Wooden Sleepers on French Railways

By A. E. CHAUDRY

Pakistan is not self-sufficient in meeting the requirements of its wooden sleepers for its Railway from indigenous sources. The sleepers have to be imported from abroad at a great expense. The author of the paper had visited France, where reconditioning of sleepers is carried out at a nominal cost of Rs. 2, per sleeper. The reconditioned sleeper is utilized in the track and the useful life of the sleeper is thus prolonged for 8 to 10 years. In this paper the author has described their method and has suggested the utilization of the same methods for Western Railway in this country.

Heat Consumption and Capacity Test of EPIDC, Fenchuganj Power Station.

By S. A. ZAIDI

The Fertilizer Factory of Fenchuganj has its own Thermal Power Station of 36,000 K.W. It operates with natural gas. The author in his detailed paper has given method for determining head consumption and its capacity. He has given information about the gas flow meters, steam flow meters, barometer and thermometer and finally has worked out the characteristics for turbine plant for main alternators.

Statistical Design of Research Experiments

By HABABUDDIN AHMED QAZI

The author has explained the use of statistical methods for the design of an experiment. He has used the method on water gas shift reaction.

Some Aspects of Optimum Starting of DC Motors

By S. A. NASAR

The conditions for the optimum starting of D.C. motors are determined by using the methods of calculus of variations. Here the optimum is considered as that when the energy consumed due to the copper losses in the armature circuit is a minimum over the period of acceleration. The variable voltage as well as the variable-resistance methods of starting are studied, and the necessary conditions for the optimum starting of separately-excited and compound motors are found. General equations are derived for two different types of loads. Numerical results are included to give some idea of the magnitudes involved in the general equations. An outline of the variational principles is also given for ready reference.