**In Dry Winter Months Evaporation is of a High order.**

Another surprising information for West Pakistan engineers is the high order of evaporation during winter dry months. In West Pakistan we are accustomed to find very low evaporation during winter. It is nearly 1/3rd of the total, and high evaporation occurs in summer. In East Pakistan, conditions are just the reverse. In Table 3 we have put forth the order of free water surface evaporation as observed at eleven stations. The evaporation particularly during the months of March, April and May is the highest. This is a reason for the quick loss of soil moisture.

**Moisture Characteristics of East Pakistan Soils**

East Pakistan soils are relatively heavy and soil crust is also fairly thick. The water table generally exists in the soil formations.

A heavy soil often with a moisture content of 32 to 35 per cent shows saturated conditions with free gravitational water. For such soils, the field capacity moisture is about 25 to 28 per cent. A plant grown in a heavy soil starts wilting when the moisture percentage falls below 8 to 10 per cent.

A loss of 5 to 7 per cent moisture can change a soil with gravitational or free moisture condition to an unsaturated field capacity moisture. A soil with 35 per cent moisture will show existence of free water in a pipe or in a hole dug in it, but under field capacity condition no free water will be seen. Thus just with a change of 5 to 7 per cent moisture, soils of East Pakistan will show appearance or elimination of watertable.

**Soil Evaporation can Cause Field Capacity and Unsaturated Conditions**

Another factor which needs consideration is the evaporation from soil. The relation of the amount of soil evaporation to depth of water table is shown in Fig. 5.

With water table at 2.5 feet below surface the soil evaporation is nearly 50 per cent of

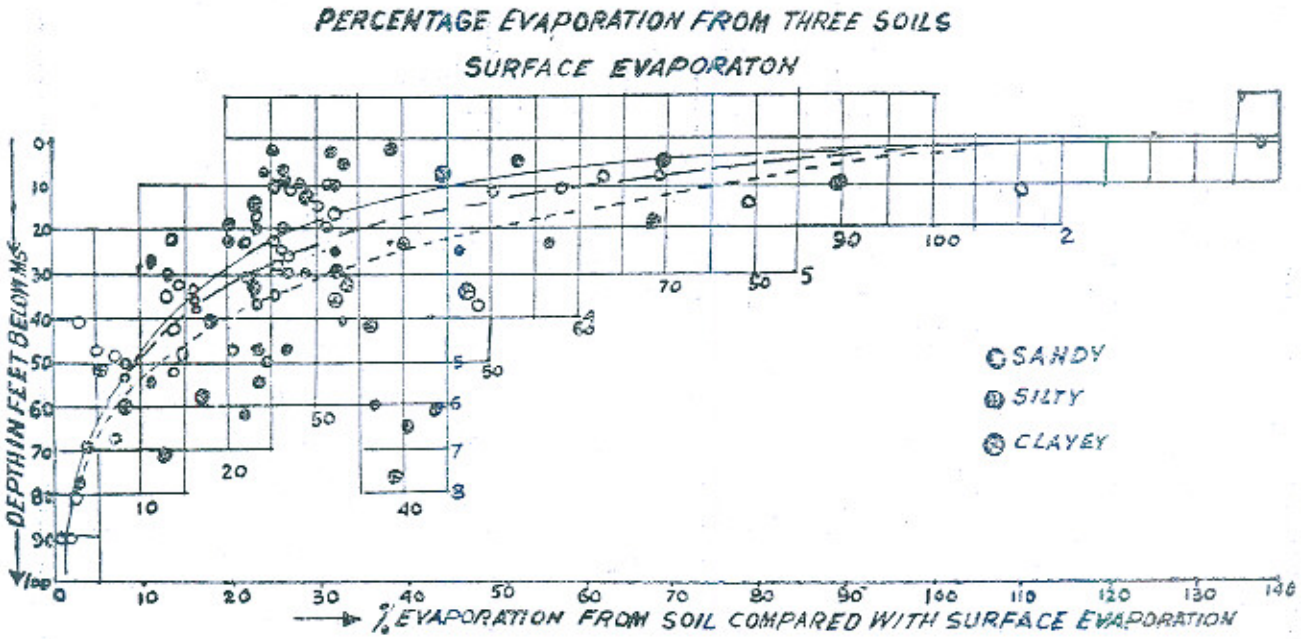



Fig. 5

the free water surface evaporation. This is reduced to about 5 per cent with watertable taken down to a depth of ten feet. This is just sufficient for a soil with free watertable to attain field capacity moistures and to show disappearance of water table.

The net result of topography, evaporation, drainage of land, fall in levels of rivers etc., is that in East Pakistan a quick fall in levels of watertable starts just after October. This is clearly shown in Fig. 6 which shows the progressive fall of water table in a year

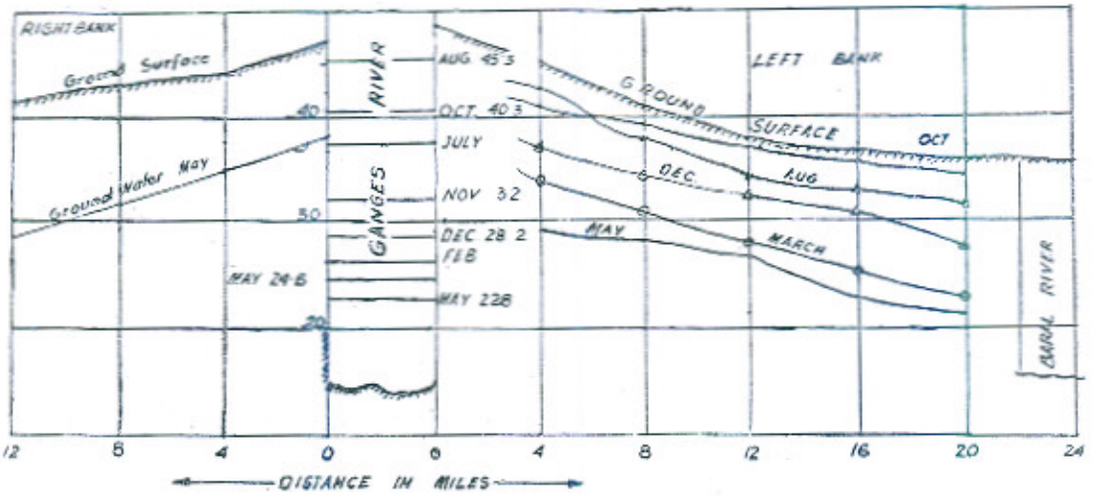
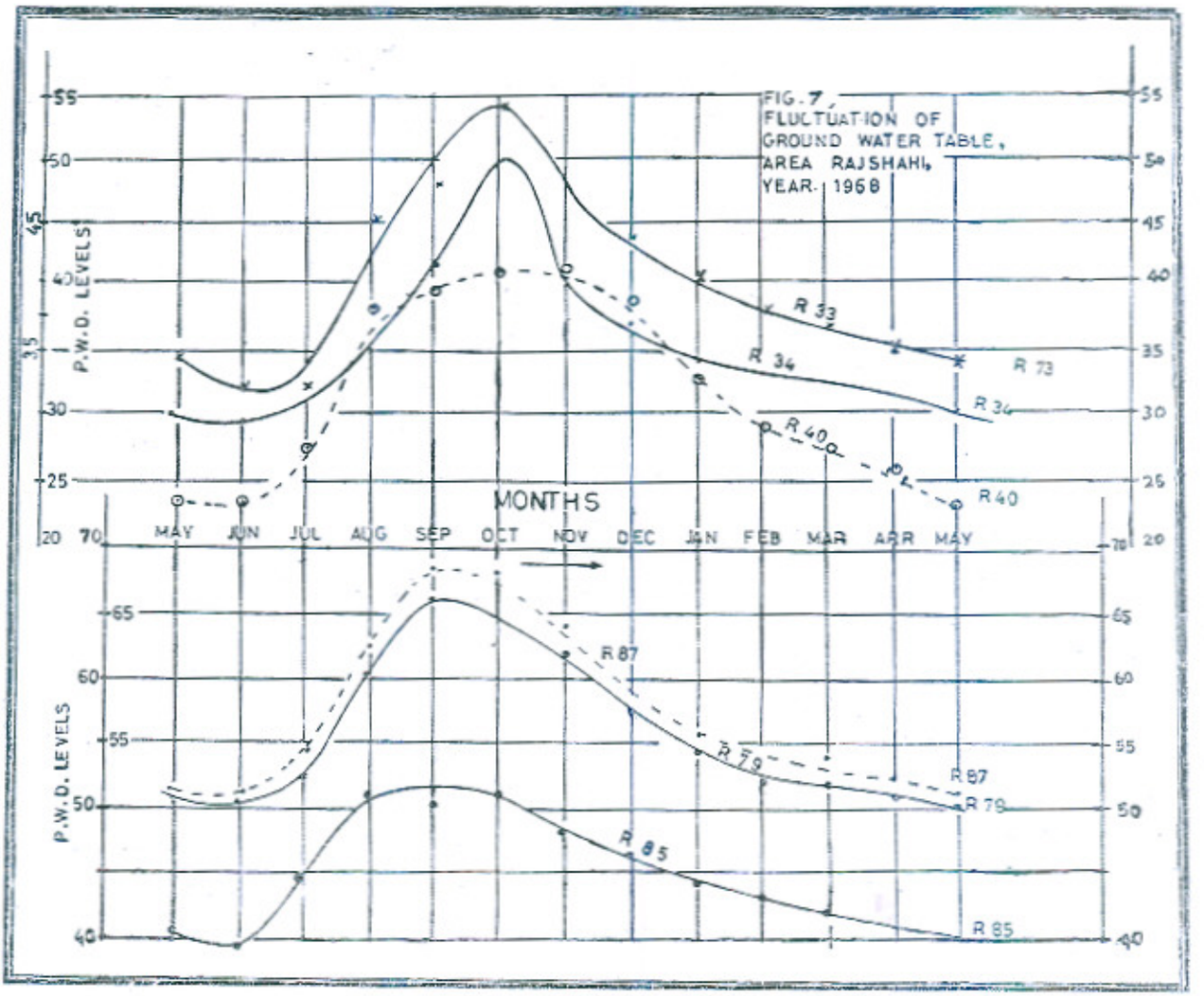



Fig. 6



mainly due to evaporation. In East Pakistan a fall in water table of 10 to 15 feet between the rainfall and flood period and in dry months is very common. In Fig. 7 change of groundwater level of a few observation wells is shown.

The moisture in top one foot thick soil which sustains crops is subjected to all these climatic and physical changes. For these soils the wilting percentage is high so that no crop production is possible without irrigation. The experience of West Pakistan that just after floods dry winter crops can be grown on residual moisture does not hold for East Pakistan.

**Groundwater Resources of East Pakistan**

High groundwater levels, intensive surface sources of fresh water, floods, their infiltration, deltaic alluvium formations, etc., leads everybody to believe that East Pakistan has extensive groundwater resources. Every foreigner has felt the enormous groundwater resources lying untapped. Many Pakistan Engineers are of the same view but the facts are otherwise. Although no systematic detailed investigations have yet been carried out but a few exploratory bores carried out in different areas of East Pakistan and a few tubewellls installed have shown that the underground formation even though classed as coarse and sometimes containing gravel contains fine particles which make the formation compact and low water yielding. A few gradation curves are shown in Figs. 8a & b. The uniformity coefficient of sand grades is slightly more than 2, but the presence of fine particles not only make the formations more compact with low yield and low permeability but has other defects in durability of tubewells.

Certain formations called Barind Tracts lying in the districts of Rajshahi and Pabna and Madhopur soil adjacent to the district of Dacca possess considerable depth of silt or clay (see Fig. 9). These are very low water yielding.

Areas close to sea coast such as Khulna and Barisal generally have fine sand formations (see Fig. 10) and hazards of proximity of sea.

No doubt alluvium formations vary from place to place. There are areas with very good formations. Even shingles are in existance but in general the formations are low yielding and not suitable for big capacity tubewells.

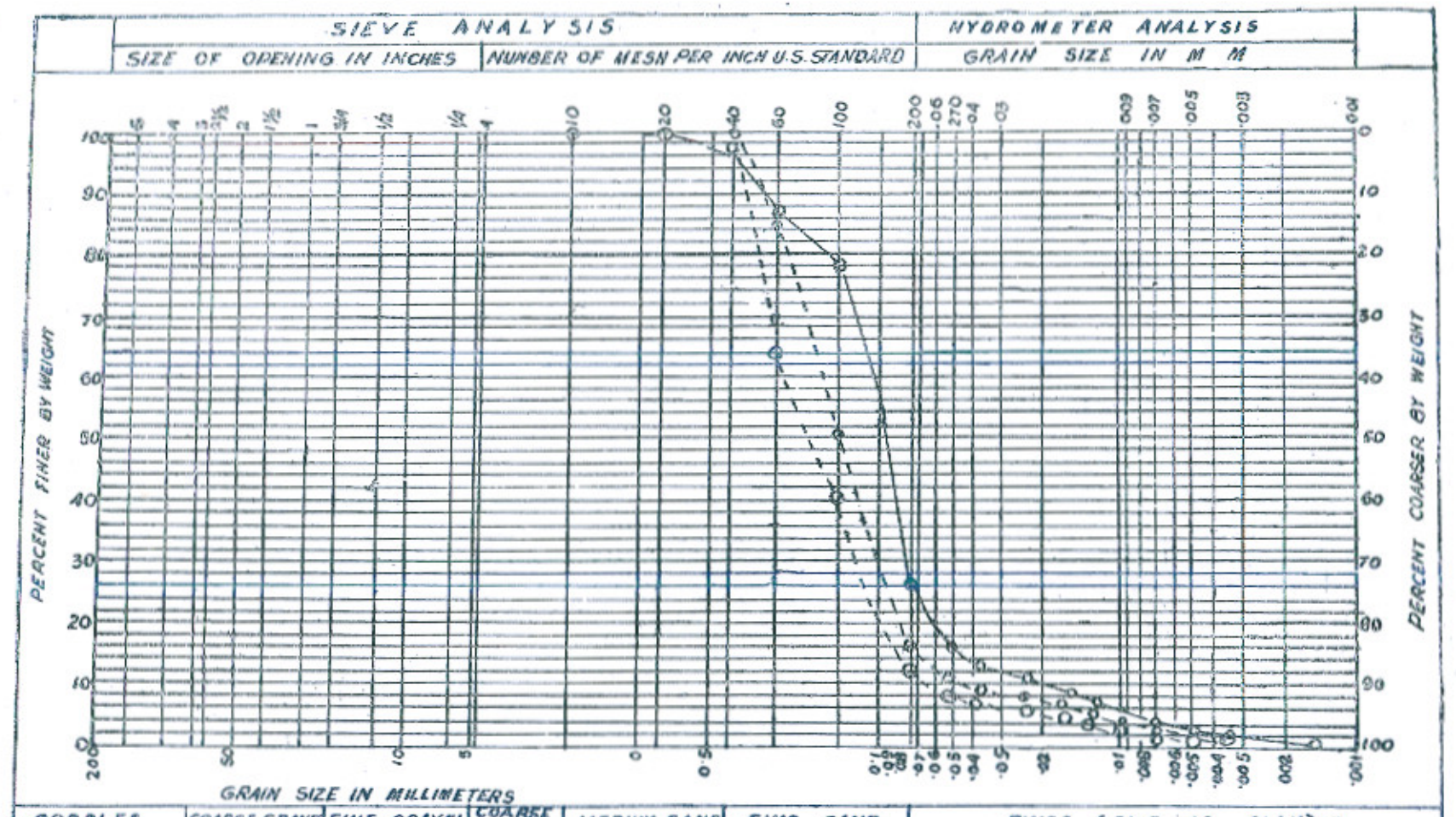
Recently Dr. Lackner conducted permeability tests on nine tubewells of Dinajpur area

TABLE 4

*Permeability test results of Dinajpur Tubewells conducted in February, 1969.*

| Well No. | Discharge in cusecs | Depression head ft. | Dep. H/per cu. | Permeability in $10^{-4}$ ft. per sec. |
|---|---|---|---|---|
| 11 | 4.00 | 43 | 10.6 | 1.03 |
| 53 | 3.25 | 59 | 18.0 | 0.341 |
| 80 | 2.42 | 59.4 | 24.2 | 0.370 |
| 133 | 4.5 | 28.5 | 6.35 | 1.224 |
| 134 | 4.25 | 25.0 | 5.9 | 1.012 |
| 135 | 4.4 | 32.6 | 7.75 | 0.698 |
| 154 | 4.4 | 49.6 | 11.2 | 0.626 |
| 205 | 4.5 | 29.5 | 6.55 | 0.916 |
| 289 | 4.24 | 49.6 | 11.8 | 0.508 |
| 366 | 3.9 | 49.6 | 12.0 | 0.384* 0.469† |

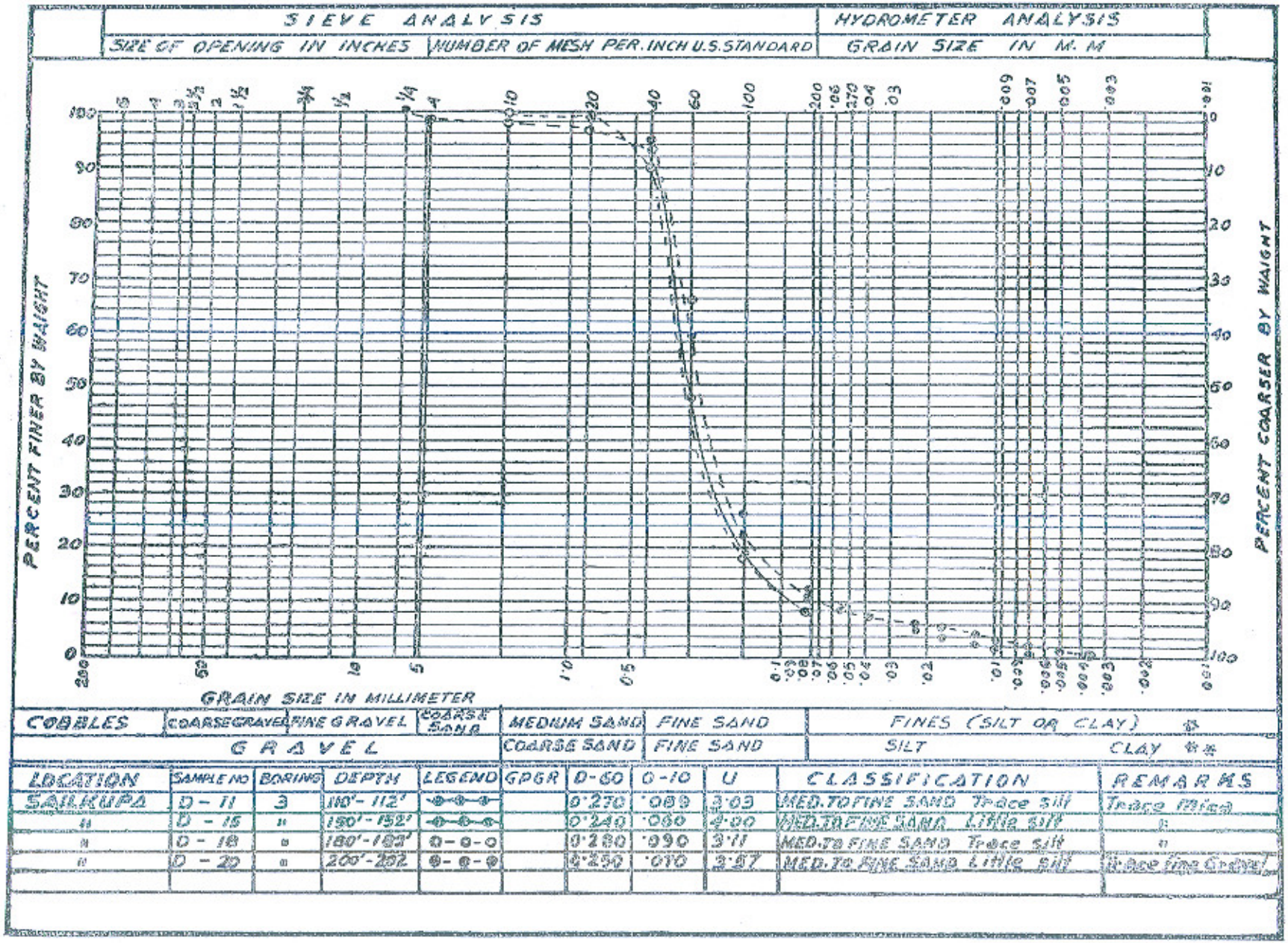
* Unconfined † Confined.




| LOCATION | SAMPLE NO | BORING | DEPTH | LEGEND | SP GR | $D_{60}$ mm | $D_{10}$ mm | U | CLASSIFICATION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| Kesabpur | D - 18 | 7 | 188'-190' | O-O-O | | 0·230 | 0·64 | 3·59 | FINE SAND little Silt trace | mica. |
| " | D - 19 | " | 200'-202' | ●-●-● | | 0·170 | 0·46 | 3·70 | FINE SAND little Silt trace | mica. |
| " | D - 20 | " | 210'-212' | ●-●-● | | 0·105 | 0·20 | 5·25 | FINE SAND Some Silt trace | mica |

* UNIFIED SOIL CLASSIFICATION
** A.S.T.M SOIL CLASSIFICATION

Fig. 8 (*a*)




| LOCATION | SAMPLE NO | BORING | DEPTH | LEGEND | GP&GR | D-60 | D-10 | U | CLASSIFICATION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| SAIKUPA | D - 11 | 3 | 110'- 112' | | | 0·270 | ·089 | 3·03 | MED. TO FINE SAND Trace silt | Trace Mica |
| " | D - 15 | " | 150'- 152' | | | 0·240 | ·080 | 3·00 | MED. TO FINE SAND Little silt | " |
| " | D - 18 | " | 180'- 182' | | | 0·280 | ·090 | 3·11 | MED. TO FINE SAND Trace silt | " |
| " | D - 20 | " | 200'- 202' | | | 0·250 | ·010 | 2·27 | MED. TO FINE SAND Little silt | Trace fine Gravel |

Fig. 8 (*b*)

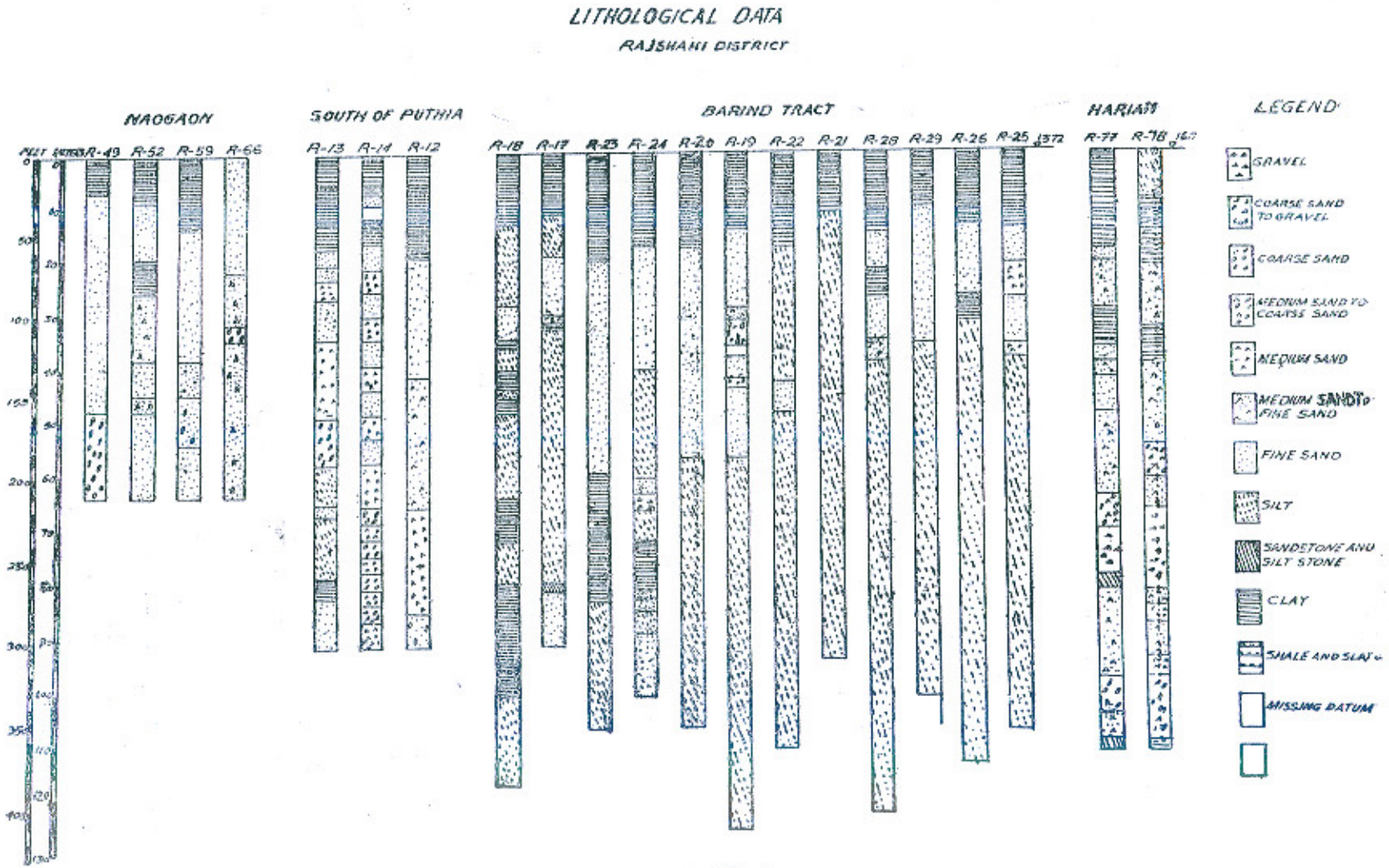

LITHOLOGICAL DATA
RAJSHAHI DISTRICT
NAOGAON
SOUTH OF PUTHIA
BARIND TRACT
HARIAN
LEGEND
R-49
R-52
R-59
R-66
R-13
R-14
R-12
R-18
R-17
R-23
R-24
R-20
R-19
R-22
R-21
R-28
R-29
R-26
R-25
R-77
R-78
GRAVEL
COARSE SAND TO GRAVEL
COARSE SAND
MEDIUM SAND TO COARSE SAND
MEDIUM SAND
MEDIUM SAND TO FINE SAND
FINE SAND
SILT
SANDSTONE AND SILT STONE
CLAY
SHALE AND SLATE
MISSING DATUM

Fig. 9

TABLE NO. 5

*Performance Data of Public Health Tubewells in Ganges Barrage Area.*

| Sl. No. | Site | T/W No. | Strainer | | Yield | | Draw down. ft. | Pumping level, ft. | Sp. Cap. gpm/ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Dia. inches | Length ft. | gpm. | Cusec | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1. | Rajshahi Laxmipur | 3 | 6 | 90 | 175 | 0.466 | 0.54 | 23.12 | 324* |
| 2. | Rajshahi Kaderganj | 3 | 6 | 90 | 194 | 0.52 | 10.45 | 31.87 | 18.5 |
| 3. | Kaderganj | 1 | 6 | 98 | 193 | 0.52 | 7.13 | 28.50 | 27.0 |
| 4. | Kaderganj | 2 | 6 | 88 | 194 | 0.52 | 1.04 | 26.04 | 186.5* |
| 5. | Jessore Barindipara | 6 | 8 | — | 458 | 1.22 | 16.33 | 3.91 | 28 |
| 6. | Jessore Puratan Kashba | | 8 | — | 458 | 1.22 | 15.83 | 4.54 | 28.8 |
| 7. | Barisal Kawnia Road | 6 | 6 | 96 | 158 | 0.423 | 30.8 | 35.40 | 5.2 |
| 8. | Barisal Bogra Road | 5 | 6.0 | 104 | 160 | 0.427 | 14.08 | 17.46 | 10.8 |
| 9. | Barisal Putuakhali Thanapara | 2 | 6 | — | 153 | 0.418 | 18.85 | 18.85 | 8.1 |
| 10. | Faridpur | 5 | 6 | 96 | 292 | 0.783 | 5.52 | 10.29 | 52.9 |
| 11. | Faridpur | 6 | 6 | 96 | 295 | 0.79 | 5.75 | 4.71 | 51.2 |

*Doubtful result.

TABLE NO. 6

*Performance Data of Tubewells of Public Health for Water-supply in various Cities.*

| City | T/W location | Depth, ft. | Dia. of strainer, inches | Length of strainer, ft. | Shrouded Yes or No | Year of test | yield | | Deptt. head | Sp. Cap. gmp/ft. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | g/hr. | cusec | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Comilla | South Well Dharmasagar | 283 | 6 | 96 | No | 1962 | 14800 | 0.655 | 16 | 15.4 |
| | | ,, | ,, | ,, | ,, | 1965 | 12000 | 0.54 | 14.25 | 19.0 |
| ,, | ,, | 266 | 6 | 88 | No | 1962 | 17000 | 0.754 | 16.0 | 17.7 |
| | North Well Dharmasagar | | | | | | | | | |
| ,, | ,, | ,, | ,, | ,, | ,, | 1965 | 15800 | 0.7 | 16.25 | 16.4 |
| Dacca | Railway W.S. | 424 | 8 | 154 | Yes | 1964 | 25000 | 1.11 | 41.33 | 10.1 |
| Darsana | ,, | 294 | 8 | 104 | ,, | 1963 | 47500 | 2.1 | 9.9 | 79 |
| Dinajpur | Kanchaghat Well No. 1 | 452 | 8 | 136 | ,, | 1964 | 22600 | 1.32 | 31.5 | 15.3 |
| ,, | Belabari Well No. 3 | 373 | 8 | 153 | ,, | ,, | 22250 | 1.0 | 24 | 15.3 |
| Jamalpur | Madrasha Well No. 1 | 470 | 6 | 104 | No | 1963 | 12000 | 0.54 | 10 | 20 |
| ,, | Amlapara Well No. 3 | 453 | ,, | ,, | ,, | 1964 | 13500 | 0.6 | 10 | 22.6 |
| ,, | Well No. 2 | 437 | ,, | ,, | ,, | 1963 | 13500 | 0.6 | 5 | 44.5 |
| Jessore | Housing Settlement | 271 | ,, | 80 | No | 1964 | 15000 | 0.7 | 7 | 36.5 |

which is considered the best and high capacity tubewells are installed in the region. The average permeability coefficient as shown in table 4 was found equal to be 0.0007 ft. per second, which is low for the type of formation classified as coarse and very coarse. Some other investigators have also found permeability of the formation which are generally of a low order in East Pakistan.

For these reasons tubewells installed in East Pakistan generally yield low discharge and work at high depressions. Their specific yield is also fairly low.

In tables 5 and 6 is given performance data of tubewells located in Dacca and some other areas including the Ganges Barrage regions. These tubewells are of very low performance.

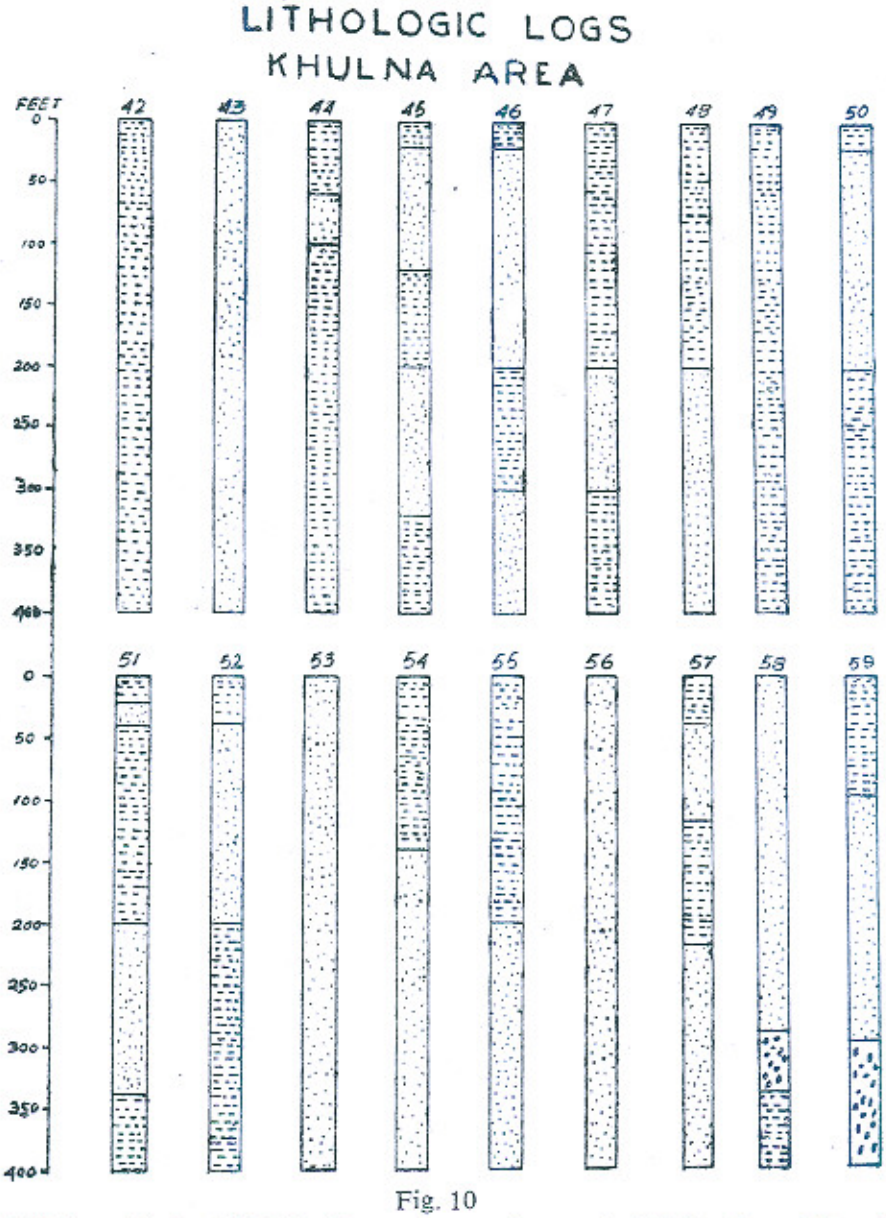



Fig. 10

**Low Durability of Tubewells Installed in East Pakistan**

The groundwaters of East Pakistan have high contents of carbonates and iron. As shown in Tables 7 and 8, soluble calcium bicarbonates content in some cases is upto 80 percent. Iron content varies 1 ppm. to 15 ppm. At a few places pockets of saline

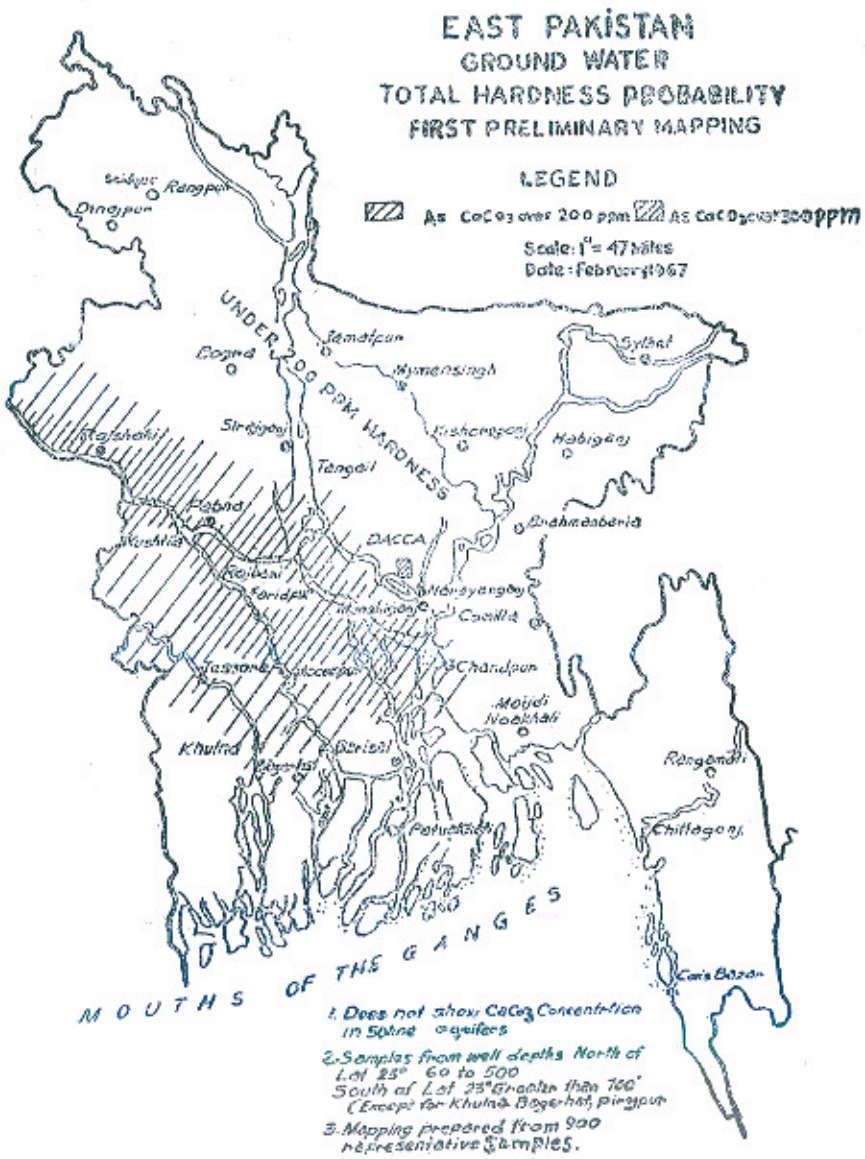

EAST PAKISTAN
GROUND WATER
TOTAL HARDNESS PROBABILITY
FIRST PRELIMINARY MAPPING
LEGEND
As CaCO3 over 200 ppm
As CaCO3 over 300 ppm
Scale: 1" = 47 miles
Date: February 1967
UNDER 200 PPM HARDNESS
Rangpur
Dinajpur
Bogra
Jamalpur
Mymensingh
Sylhet
Rajshahi
Sirajganj
Tangail
Habiganj
Pabna
Kushtia
DACCA
Brahmanbaria
Faridpur
Narsyangdy
Comilla
Jessore
Madaripur
Chandpur
Meherpur
Khulna
Barisal
Noakhali
Rangamati
Patuakhali
Chittagong
Cox's Bazar
MOUTHS OF THE GANGES
1. Does not show CaCO3 Concentration in Sohne aquifers
2. Samples from well depths North of Lat 25° 60 to 500
South of Lat 25° Greater than 700'
(Except for Khulna Bagerhat, Pirojpur
3. Mapping prepared from 900 representative Samples.

Fig. 11

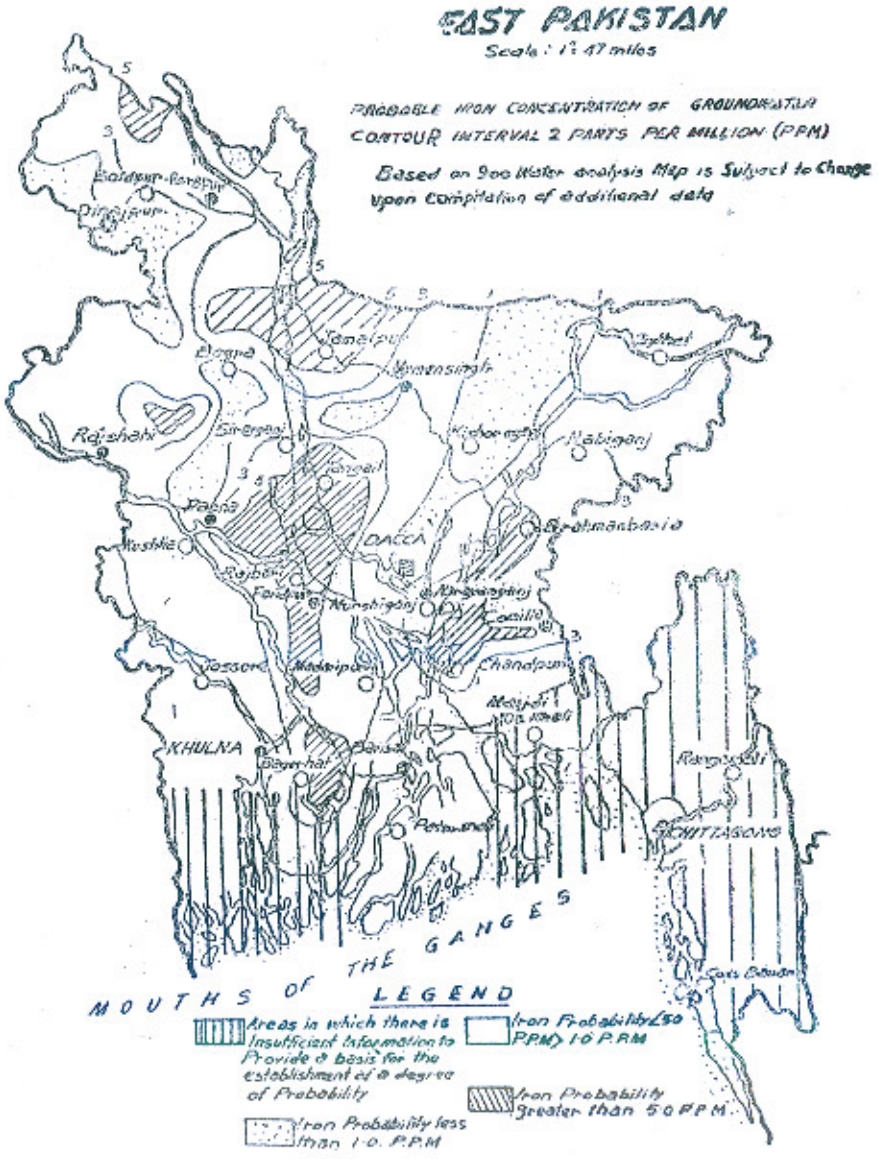

EAST PAKISTAN
Scale: 1" 47 miles
PROBABLE IRON CONCENTRATION OF GROUNDWATER
CONTOUR INTERVAL 2 PARTS PER MILLION (PPM)
Based on 900 Water analysis Map is Subject to Change upon Compilation of additional data
Rajshahi
Sirajganj
Tangail
Pabna
Kushtia
DACCA
Brahmanbaria
Faridpur
Comilla
Jessore
Madaripur
Chandpur
KHULNA
Bagerhat
Barisal
Rangamati
CHITTAGONG
Cox's Bazar
MOUTHS OF THE GANGES
LEGEND
Areas in which there is Insufficient Information to Provide a basis for the establishment of a degree of Probability
Iron Probability less than 1.0 P.P.M
Iron Probability 1.0 PPM to P.P.M
Iron Probability Greater than 5.0 PPM

Fig. 12

TABLE No. 7

*Chemical Analysis of Waters from Shallow Wells Located Across the Ganges*

Date of Sampling, April 1969

| Sl. No. | Lab. No. | District & Description of Wells | pH | E. C. mmhos/cm at 25°C | Cl- P.P.M. | $HCO_3$ P.P.M. | 304— P.P.M. | Ca++ P.P.M. | Mg++ P.P.M. | T.D.S. P.P.M. | % Na | Residual $Na_2CO_3$ me/L | S.A.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | | **KUSHTIA** | | | | | | | | | | | |
| 1. | 962 | RB-1, W-1, Insafnaga | 7.4 | 0.00 | 38 | 459 | 25 | 46 | 31 | 512 | 39 | 2.6 | 2.0 |
| 2. | 963 | RB-1, W-3, Mohishkundi | 7.5 | 0.90 | 31 | 438 | 35 | 64 | 50 | 576 | 18 | nil | 0.8 |
| 3. | 964 | RB-1, W-4, Jaypur | 7.6 | 0.70 | 23 | 389 | 25 | 50 | 34 | 448 | 24 | 1.1 | 1.1 |
| 4. | 965 | RB-1, W-5, Natun Pakuria | 7.6 | 1.08 | 138 | 719 | 31 | 20 | 86 | 1000 | 54 | 3.6 | 4.8 |
| 5. | 936 | RB-1, W-7, Prajpur Bazar | 7.4 | 1.00 | 48 | 515 | 45 | 60 | 62 | 640 | 18 | 0.2 | 0.9 |
| 6. | 967 | RB-1, W-10, Dharmadah | 7.5 | 1.40 | 136 | 441 | 54 | 72 | 76 | 896 | 28 | nil | 1.8 |
| 7. | 968 | RB-1, W-15, Takala | 7.6 | 0.90 | 49 | 484 | 33 | 32 | 66 | 576 | 21 | 0.9 | 1.0 |
| | | **RAJSHAHI** | | | | | | | | | | | |
| 8. | 969 | LB-1, W-1, Kishorepur | 7.7 | 0.70 | 32 | 375 | 37 | 46 | 39 | 448 | 20 | 0.5 | 0.8 |
| 9. | 970 | LB-1, W-4, Keshabpur | 7.4 | 1.10 | 58 | 564 | 45 | 62 | 42 | 704 | 40 | 2.6 | 2.4 |
| 10. | 971 | LB-1, W-5, Hossainpur | 7.2 | 2.00 | 352 | 529 | 92 | 138 | 103 | 1200 | 22 | nil | 1.7 |
| 11. | 972 | LB-1, W-9, Binodpur | 7.5 | 0.80 | 38 | 438 | 29 | 50 | 45 | 512 | 21 | 0.8 ? | 0.9 |

TABLE 8

*Summary of water analysis carried out by Public Health Engineering Department*

1967 Pre-Monsoon Season

| Town | Well Dia. (In) | Well Depth (Ft.) | pH | Iron (mg/1) | Chloride (mg/1) | Hardness (mg/1) | Alkalinity as $CaCo_3$ (mg/1) | Total dissolved (mg/1) Solids |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **JESSORE DISTRICT** | | | | | | | | |
| Jhenaidah | 1½ | 172 | 7.1[F] | 6.40[L] | 0.5 | 327 | 230 | 285 |
| Magura | 1½ | 210 | 7.2[F] | 5.40 | 11 | 358 | 424 | 495 |
| Jhenaidah | 6 | 289 | 7.2 | — | — | — | — | — |
| Jessore Sadar | 6 | 347 | 7.2[F] | 0.5[F] | 6 | 301 | 400 | 460 |
| **KHULNA DISTRICT** | | | | | | | | |
| Khulna | 6 | — | 8.0 | 0.76[L] | 97 | 121 | 315 | 545 |
| Satkhira | 6 | 375 | 7.0 | 4.0 | 9 | 300 | 308 | 360 |
| Khulna | 6 | — | 7.5[L] | 0.32[L] | 600 | 529 | 575 | 1645 |
| Mongla Port | — | — | 7.85[L] | Trace[L] | 525 | 185 | 350 | 1290 |
| Mongla Port | — | — | 7.85[L] | Trade[L] | 625 | 185 | 360 | 1420 |
| Phultala | 1½ | — | 8.15[L] | Trace[L] | 34 | 52 | 740 | 900 |
| Bagerhat | 1½ | 36 | 15L | 6.40[L] | 73 | 344 | 368 | 520 |

TABLE NO. 9

*Data of Govt. Tubewells in rural areas, Diameter of well 1½ inches, depth about 200 ft. fitted with hand-pump.*

(Data from Govt. Publication No. 67/68-4841 F-Im)

Data collected on 1.7.67.

| District | No. of T/W Total | No. of Choked T/W. | % of Choked T/W. |
|---|---|---|---|
| Rajshahi .. .. | 8338 | 963 | 11.54 |
| Pabna ... ... | 6494 | 913 | 14.20 |
| Kushtia ... ... | 3668 | 602 | 16.40 |
| Faridpur ... ... | 13893 | 2241 | 16.15 |
| Khulna ... ... | 7221 | 2033 | 28.21 |
| Barisal ... ... | 12500 | 3515 | 28.05 |
| Jessore ... ... | 6859 | 892 | 13.00 |
| Total .. .. | 60973 | 11159 | 18.35 |
| Dacca .. ... | 13745 | 2046 | 15.0 |
| Mymensingh .. .. | 21085 | 2631 | 12.5 |
| Faridpur ... ... | 13723 | 2241 | 16.2 |
| Rangpur ... ... | 11333 | 1361 | 12.2 |
| Bogra ... ... | 7970 | 924 | 11.6 |
| Dinajpur ... .. | 4213 | 485 | 11.5 |
| Chittagong ... ... | 8910 | 1140 | 12.8 |
| Comilla .. .. | 14747 | 1614 | 10.9 |
| Noakhali ... ... | 8161 | 711 | 11.6 |
| Chittagong Hill Tract .. | 948 | 222 | 23.6 |
| Sylhet .. .. | 8523 | 1293 | 19.8 |
| Provincial Total .. .. | 158614 | 23623 | 14.8 |

groundwater are in existence. In the Ganges Barrage area in particular carbonate alkalinity is excessive as shown in Fig. 11. At many sites the iron content is also of very high order. In Fig. 12 the distribution of iron is shown in groundwater of East Pakistan. Some groundwater may not be fit for use on land. The serious defect is that calcium carbonate and iron incrustation will be very quick and serious. Even the electrically charged colloidial particles will help to plaster the slots of a strainer. This is the usual experience with the existing tubewells. Even hand pump worked occasionally for domestic purposes get incrusted in a few years. In Table 9 is given the distribution of hand pumps which are chocked and are being replaced after 3 to 5 years of their installation. Apparantly irrigation by tubewells as envisaged and suggested as alternative for such a large area as is to be served by the Ganges Barrage is a far-fetched idea.

**The Cost of Tubewells**

Due to the local conditions in East Pakistan with shortage of power, little means of power generation and transmission even electric tubewells are very costly. A single tubewell of Dinajpur (380 tubewells scheme) has cost about Rs. 280,000, the cost of tubewell alone was about Rs. 120,000, the rest Rs. 160,000 were spent on generation and transmission of power.

Diesel operation is still more costly.

If East Pakistan is to depend upon groundwater in the region of Ganges Barrage Zone, to get 60,000 cusecs, one must put in at least 45,000 tubewells of 1.5 cusecs each, provide additional 10% (4500 T/w) against failure and fall in yield at a high capital cost and see the loss of this capital within a few years of operation. It appears that tubewells for irrigation on such vast scale as an alternative to the Ganges Barrage are not realistic.

**Regeneration into the Ganges**

Ganges like many rivers flowing in the alluvium of their delta has built up its high beds by deposition of the sediment loads.

The river as it enters East Pakistan is found to flow on a high elevation. On the north side, the land slop is in a reverse direction. On the south side its slope is towards the sea. The Ganges being on a high elevation, feeds the formation on both sides so that the natural surface as well as the groundwater slopes from the river both to the north and to the south. The general slope of groundwater remains in the same direction throughout the year although the water level in the river starts falling down after October. The slope of the sub-soil water remains unaffected, even one mile from the river. This is illustrated in Fig. 6 which is a cross section through the Ganges.

The watertable lies in soil of low permeability and drains, if at all, at a very low rate.

Some water can regenerate back into the river from the banks' storage. Estimate of release from banks' storage is hardly 800 cusecs from Farakka to Hardinge Bridge. Even one mile away from the bank, the slope of the groundwater is away from the river. The fall exhibited in the groundwater level corresponds more as a result of soil evaporation and not due to drainage.

Gauge readings were started by Railway Department, at the Hardinge Bridge in 1910. Actual discharge measurements were undertaken after 1934.

The discharge at the Bridge was measured by observation of surface velocity and multiplying it by a factor 0.85 to determine the

average velocity irrespective of the depth width ratio of the water. These observations had been conducted on the upstream end of the Bridge, in between the piers. Current meter had been used to record the surface velocity. The depth has been measured by using a maximum of 56 lbs. weight.

The discharge estimated by this technique is open to objection as it has so many sources of error.

The piers obstruct the flow and reorientate the velocity distribution. in the central portion it is increased and near the piers it is reduced. This change in velocity is manifested throughout the depth in a complicated manner. The surface velocity currents will be different at depth due to reorientation caused by piers. Even the measurement of surface velocity at the time of high flows and high winds becomes difficult.

The average winter months discharge at the bridge is about 70,000 cusecs. Minimum ever recorded is 41,000 cusecs. The mean velocity is determined by multiplying the surface velocity with a factor 0.85 which varies with depth-width ratio. In deep narrow channels usually this factor rises to 0.9 and in shallow wide channels it falls below 0.85.

A difference of 0.05 in the coefficient may cause an error of about 4000 cusecs in a discharge of 80,000 cusecs.

The discharge estimated by a current meter on the basis of surface velocity is very often inaccurate. An error of 2 to 5 per cent in discharge estimated by a current meter is common.

The recording of depth by dropping a weight also brings inaccuracy. There always occurs a sag depending upon the velocity of flow. High discharges in particular when the velocity range goes beyond 5 ft. per second are especially inaccurate.

On account of these defects a site at Paksey, about 2500 feet up-stream of the Bridge was selected and started recording discharge by modern methods using echo sounders for depth estimation and velocity measurement at 0.2 and 0.8 feet depth. This was a superior method. Simultaneous observations at Hardinge Bridge and Paksey were thus helpful to determine the true discharge even for the previous years when the Paksey site did not exist. India also started observation at Farakka in 1948. She supplied observed discharge data to Pakistan.

Assuming India discharge estimate to be as accurate as at Paksey, a study on gains and losses of water in the reach between Farakka and the Hardinge Bridge gave about 2000 cusecs.

If the gains and loss are worked out for separate periods between 1949 to 1954, 1955 to 1961, 1962 to 1966, the gains are found to be 900, 4700 and 800 cusecs respectively.

The average regeneration during the same hydrograph periods for all the 13 years of the study amounted to 2158 cusecs.

If India diverts the dry weather supplies as planned, East Pakistan is not only to suffer for this loss of historic flow but the other effects of drying of the Ganges River are even more serious there will be not only serious shortage of water but will increase the lift of the already installed pumps at Ganges-Kobadak Project. It will seriously affect the navigation in the Ganges and its spill channels which in East Pakistan is the main means of its communications. Saline water of sea which is kept pushed down will penetrate inland with serious effects on agriculture, municipal supplies and industrial uses.

A change in the existing regime of the Ganges may cause the river bed to rise thus increase flood heights and increase flood hazards.

**Salinity Intrusion**

At present a considerable area of Khulna and Barisal districts are subjected to frequent salinity intrusion. Studies have been carried out to determine the limits of saline water into various streams and channels under the present conditions. At present the effects of inraid of sea water are to a considerable extent held back by upland flow of fresh water and the limits of intrusion is kept checked.

When the upland discharge will be cut off, the sea water inraid will move much farther upward and the extent of the present limit of saline area will increase. There will be less dilution of the saline water and water of High salinity will stay in the rivers and the streams for a longer period. Naturally the saline water will seep into the formation spoiling the zone of good quality groundwater.

The level of saline groundwater is kept deep due to the pressure of good quality water at top. A fall in head of good quality water at top will reduce the pressure on the interface of the saline water which can rise upwards by 40 feet for every one foot fall in water pressure at top. It would result in rise of saline water upward, thus spoiling good water quality aquifer.

If Pakistan takes up intensive pumping to meet its requirements of irrigation water, the effect on the rise of saline groundwater will be still serious.

The Sundarban forests in Khulna district grow close to the sea coast only as a result of intensive floods and rainfall which have build up fresh water zones floating on saline water. The fresh water in areas of heavy upland discharge is deeper so that the Sundari trees are more prosperous in the area. As one moves down closer to the sea with less possibility of build-up of the fresh ground water, the heights and dimensions of the trees deteriorate.

If the upland fresh water pressure is reduced, the saline sea water at bottom will rise by 40 feet for every one foot drop of fresh top water. The deterioration of the forests is obvious.

Fish and rice are the two relished food for East Pakistani. Abundant fish is cultured in the ponds, beels, and depressions, sustained by fresh waters of the Ganges.

A change in water supply both in quantity and quality is bound to affect the biological conditions and habits of the different species of fish. The present type of fish will either have to adjust to new conditions and environments or be eliminated. The loss to Pakistan both as food and fish industry will be immense.

River navigation is the one big means of communication. In East Pakistan one can see boats and barges conveying goods and passengers as do the trucks and buses in West Pakistan. Waterways are the main communication channels in East Pakistan. The drying of the Ganges water will thus have adverse effects on the economics, habits, resources of East Pakistan.

Any change in natural resources of water will be disastrous for East Pakistan where existence of more than 23 million people is tied with the water of the Ganges.

This article is the first of its kind dealing with the Ganges Barrage Project; more will follow.

# Abstracts of Papers of Proceedings of West Pakistan Engineering Congress, 51st Annual Session

*At the time of 51st Annual Session of the West Pakistan Engineering Congress seven papers are to be presented and discussed. These deal with the various subjects of great interest to the Profession. We have reproduced brief abstracts of each paper for the information of the members.*

PAPER No. 391

**Technical Appraisal of Salinity Control and Reclamation Project-1 with Reference to Decline of Water Level**

*By Ch. Ata-ur-Rehman*

Salinity Control and Reclamation Project-1, covering an area of 1.2 million acres, went into operation early in 1961. The average pumpage from over 2,000 project wells, Rasul wells and private wells is of the order of 2.40 feet per year. Since the operation of the project, water level data were being collected by WASID to determine the average decline of water levels as a result of ground water withdrawal. Enough water level data are now available to attempt an approximate water balance for the area to compare the observed behaviour of the project with the anticipations made in the project report and its feasibility review.

In the project report an operational yield of 2 feet per year has been calculated, assuming 30 per cent storage coefficient, one foot lowering rate per year, and that the component of the recharge and discharge would balance at 15 feet below the natural surface. The average depth before reclamation operation was approximately 9 feet below the land surface. According to this estimated lowering rate the water level in SCARP-1 was forecast to stabilise after 6 years of pumping.

In the feasibility review of the project report it was concluded that the recharge from the canal leakage was over-estimated, while the availability of ground water from storage was under-estimated because of low assumed value of storage coefficient. According to this review, assuming 30 per cent storage coefficient and abstraction rate of 1.25 feet per year, the water level in SCARP-1 would lower to pre-irrigation level in a period of 40 years, provided there is no development in contiguous areas.

Analyses of the observed data indicate that the average water level decline in the SCARP-1

since June 1960 to June 1966 is 7.6 feet, while the predicted lowering under the abstraction rate of 1.25 feet per year is 19 ft. Further analysis of the observed decline rate indicates that under the present operational conditions and environment, the water level in the SCARP-1 would not lower to more than 20 feet after 40 years of pumping.

The water balance study for July 1965 to June 1966 shows that the effective average recharge to the ground water reservoir is approximately 2.38 feet per year while the contribution from the ground water storage is 0.6 feet per year. The approximate future operational yield of the project under present condition will be in the order of 2.4 feet per year as compared to the predicted value of 2 feet per year in project report and 1.25 feet per year in feasibility review. The contribution from ground water storage would be zero.

If the feasibility review decline is to be achieved by 2,000 A.D. the approximate pumpage required is 3 feet per year. The analysis of the tubewell operation indicates that 0.7 feet per year of pumpage is being lost through lack of distribution work and no demand. If this pumpage can be saved by providing additional uses of the water during the year, the ground water withdrawal can be raised to 3.1 feet per year thus increasing the present lowering rate without additional tubewells. In addition, wherever necessary, private tubewell development within the SCARP-1 can be considered if the water level to pre-irrigation level by 2,000 A.D. may be desirable.

In the discussion of the conclusions the author has again stressed that according to the feasibility review the decline in SCARP-1 by June, 1966 would have been 19.0 feet, while the actual lowering is only about 8 feet. This indicates that some of the assumpti or operational conditions visualized in report did not actually exist in the field. T major departure is probably in the assum tion that to start with all the pumpage wo be from storage. It appears that even start with the net abstraction from the grou water reservoir was not more than 0.55 f as compared to the assumed value of 1. feet. The remaining pumpage was bei supplied by areal recharge and canal leaka already taking place at that time.

The operational yield of 1.2 feet estimat in feasibility review is based on the vario estimates of recharge and storage depleti of 0.4 ft. per year. The average pumpa since 1962-63 is of the order of 2.4 feet. Th indicate that the operational yield is und estimated probably because of the und estimation of recharge from the canals a infiltration from farms and water courses. is, however, observed that the projected low ing in the original project report is closer the actual field condition.

PAPER 392

**Railway Electrification (Power Supply Syste**

*By Dr. F. A. Hamdani*, P.R.S.

As a part of its modernization programm Pakistan Western Railway has embark upon the introduction of railway electrific tion on its Lahore-Khanewal Section extendi over 178 miles. The project which started June, 1966, is gaining momentum with the pa sage of each day. While the Lahore-Raiwi Section is planned for trial runs initiall apprehensions are expressed often by laym as to the viability of the project in regard power supply system dependent as it wou be on an external source outside the contr of Railway *viz.*, WAPDA supply. Frequen

of failure of ordinary low tension power supply in cities and fluctuations in voltage in a locality is probably the criterion and as a basis would perhaps justify such misgivings and in consequence has caused reflections on the thinkings of many. It may be stated at the outset that power in feed to the P.W.R. Electric Overhead Traction System would be from the WAPDA High Tension integrated Grid Supply where incidence of outrages, interruptions is rather rare and almost negligible.

P.W.R. Electrification Cell, however, as Engineers & WAPDA's prospective consumers have looked into every aspect of the proposed supply system as has WAPDA itself to meet its responsibilities.

Based on the location of important WAPDA Grid Stations contiguous to Railway track from Lahore to Khanewal, five Track Feeder Stations have been determined *viz.*, at Kot Lakhpat, Wan Radha Ram, Sahiwal, Mian Channun and Khanewal. WAPDA has 132 KV Grid Stations at Kot Lakhpat and Sahiwal, while 66 KV Grid Stations at Mian Channun and Khanewal. Details of the equipment and its functioning are explained in the paper.

In fact Lahore-Khanewal Electrification Scheme has been designed allowing maximum use of indigenous power supply facilities without throwing excessive burden on the WAPDA supply system. Continuity of train operation is ensured even under adverse conditions when two of the five Grid Stations supplying power to the Track Feeder Stations fail, while banking heavily on the 132 KV Grid Supply at Kot Lakhpat and Sahiwal.

PAPER No. 393

**Design Aspects of Municipal Water Supply Pilot Projects**

*By Syed Arshad Ali*

A loan agreement was signed between the Government of Pakistan and U.S. AID for 3.6 million dollars on 17.9.1964. Out of this amount, 2.15 million dollars were for commodity aid for the construction of municipal water supply systems in Sheikhupura, Gujranwala, Multan, Nawabshah and Hyderabad: and 1.45 million dollars were for consulting services. An agreement was signed between the Public Health Engineering Department (PHED) and an American Consulting Engineering Firm, Parsons Corporation, on 27.3.1965. According to the agreement, the consultants were required, besides other responsibilities, to evaluate the existing feasibility reports and, in conjunction with the PHED, to prepare designs, drawings and specifications for the pilot projects.

The Consultants, their Pakistani associates, and the PHED staff, altogether known as the General Advisory Services for PHED, started work on the planning and design of the pilot projects in July, 1965. Since then, master plans for water supply of the project towns have been prepared and designs of the facilities needed to meet the immediate water supply needs in Sheikhupura, Gujranwala, and Multan have been finalized. The design of the Nawabshah project, which also consists of the facilities needed to meet the immediate needs of the town, is also in final stages, except that the location of tubewells is not finally decided. Investigations are being carried out to find ground water of suitable quality as near the town of Nawabshah as possible. The design of a 5 mgd treatment plant to raise the capacity of the existing plant from 5 to 10 mgd and a one million gallons ground reservoir at Hyderabad has been finalized. These facilities have been designed independent of the master plan for water supply of Hyderabad, and are insufficient even to cater for the immediate needs of

the city. Construction of the projects is well underway in Sheikhupura and Gujranwala, and is in the initial stages in Multan and Hyderabad. Construction of the Nawabshah project is also expected to start in the near future.

The paper gives the general design criteria for each site.

The design period has been fixed at 25 years during which the increase of production and its water requirements has been considered. The next point given consideration is about water quality, its source and design of tubewells. Details of pump, drive units and disinfection of water supply is given before discussing the problem of each site in details including the financial aspects.

PAPER No. 394

**Land and Water Management in West Pakistan**

*By Ch. Muhammad Hussain*

The paper begins with information of land and water resources of West Pakistan and their utilization. For self-sufficiency in food on a firm footing, the implementation of a well planned programme under the existing conditions is necessary. The author mentions that "there are about 5.2 million acres lying adjacent to rivers, large parts of which are fit for crop production with the moisture left after floods. For the middle and southern Indus plain and the quadrangle of Baluchistan Plateau comprising an area of 13400 sq. miles which is Arid but some of the highlands can produce fruits similar to as done in Afghanistan.

Similar use of submontane lands and those in Potwar Plateau is suggested for proper type of cultivation.

The high rainfall areas under the foot of the mountains are suggested for forest growth.

In case of irrigated areas it is suggested to reduce the conveyance losses which rise to 50% of the water let into the canals.

It is rather difficult and expensive to eliminate losses from the unlined channels, but the conditions can, however, be improved in case of field water courses (more than 60,000 in number) by straightening the water courses, keeping them free of vegetation and sealing the previous beds of water-courses with some impervious material. Even if the present losses which may amount to about 20% of the discharges at outlet head, are reduced, it will give at least a saving of about 5 M.A.F. of water for crop use. A regular campaign is needed for education of the cultivators in this direction. Services of the basic democrats and farm guides can be used for this purpose.

It is stressed that as high yielding varieties of wheat, rice and maize have been introduced, attempt may be made to improve the cotton yield as well.

Other items which help in the land management are the improvement in Irrigation efficiency, system of landholding and timely agricultural operation.

Dealing with water management, the author has discussed the soil salinity, their type and the chemistry of salt combinations. He has put forth his own results on the use of water of high salt concentration, has discussed a modification in the concept of Residual Sodium Carbonate and its effects on leaching.

The results of latest experiments conducted by him in his originization are put forth.

In the end it is concluded that cropping area and crop yields can be increased in rain-fed and active flood plain areas by using proper conservation practices and improved soil management.

Mechanized farming will contribute considerably to the economy of the country.

Bullock-power is under utilized and not economical and efficient.

Reduction of seepage losses from the water conveyances will save considerable water which can be used for irrigation.

Ground waters will contribute to the size and yields of irrigated areas. Quality standards of water as used now will have to be revised especially with respect to the limits of soluble salts and the residual sodium carbonate content. Results show that RSC limit might be higher than 2.5. The SAR limit might have to be raised also.

PAPER No. 395

## Some Methods of Computing Retrogression in Channels Due to Change in Sediment Charge

*By Mushtaq Ahmad and A. Rehman*

The design criteria of the regime channels in Indo-Pakistan sub-continent is the Lacey theory. This theory with its set of relations was based on the data of stable channels that carried specific load pattern of sediment of coarse and medium sand in summer and winter periods. After the building of dams, the situation will change considerably. Relatively silt-free water to a varying degree will be diverted into the existing stable or quasi-stable channels which will disturb the existing regime. As the incoming water will bring less silt than the carrying capacity of the channel, the fine and medium sediments in the bed of channel will get into suspension and be carried away resulting in a lowering of the bed. Moreover, the bed grade will gradually become coarse by the removal of fines from the bed by selective sorting. The depths will increase and slopes will flatten out, the bed and surface levels will retrogress. This process will continue till new equilibrium conditions of depth and slope are attained. The retrogression, if not provided for in the design of Hydraulic works, will expose the foundation and endanger the safety of the structures.

The object of this paper is to develop some simple methods that could be used by a field Engineer to estimate the order of retrogression of levels when the sediment charge reduction is 25%, 50%, 75% and 90% of the original sediment intensities, so that provision may be kept in the design for the future safety of the control structures.

All the parameters affecting bed deformation of alluvial channels have been enumerated, Relations between sediment charge and discharge intensity have been derived and their application attempted. The affect of degradation of the bed material and the calculation of slope are put forth. Practical examples have also been solved employing the proposed methods.

In the end conclusions and discussion of results are put forth.

The calculations made by different methods for estimating change in velocity, depth and slope as a result of reduction in the silt charge, are compared in Table IX. Ning Chein's relation connecting $^{f}VR$ and $^{f}RS$ to $(q_s/q)$ and author's plotting of velocity $\propto(q_s.w)^{1/4}$ give almost the same values for regime parameters after different sediment reductions. It will be realised that reduction of silt charge results in the scouring of sandy bed, and the calculated percentage increase in depth will be 70%, 16.5% 37.5% and 69% for the corresponding sediment reduction of 25%, 59%, 75% and 90% with changes in velocity and depth, the changes in the Lacey's silt factor are very obvious. The Froude No. of flow, for the new regime may decrease from its normal value of $F_r$=0.2 to 0.1 for almost silt-free water. The percentage reduction in slope as worked out in Table IX is 3.7%

10-9%, 24% and 36.5% for the corresponding sediment reductions. It is noted that the ultimate new slope may be about 60% of the initial slope.

In conclusion simple methods of estimating the ultimate degradation for different sediment reductions have been given. It is yet not so easy to estimate the rate of degradation involving all the variables. It is necessary to study the mechanics of degradation more thoroughly and for that more detail data of the bed material will be needed. the bed contains coarse material that coul act in such a way as to armour the bed for given velocity, the process of degradation wi stop earlier. But for the safety of the work it is necessary to know what ultimate degrad tion is expected so that it could be provide for in the design. This is exactly what ha been attempted in this paper.

TABLE IX

*Change in Velocity, depth and Slope with percentage reduction in silt by different methods.*

| Sediment Reduction Percentage | 0 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| | | Change in Velocity & Depth | | | |
| 1. Velocity | | | | | |
| (i) V: $(q_s.w)^{1/4}$ .. .. | V | 0.94V | 0.86V | 0.74V | 0.60V |
| (ii) Ning Chien $^{f}VR^{q}s/q$ .. .. | V | 0.94V | 0.88V | 0.71V | 0.57V |
| Average: | V | 0.94V | 0.86V | 0.725V | 0.585V |
| 2. Depth = q/V | | | | | |
| (i) V: $(Q_s.w)1/4$ .. .. | D | 1.07D | 1.16D | 1.35D | 1.67D |
| (ii) Ning Chien $^{f}VR$: $q_s/q$ .. | D | 1.07D | 1.17D | 1.40D | 1.75D |
| Average .. | D | 1.07D | 1.165D | 1.375D | 1.69D |
| 3. Lacey Silt Factor : $f_o/f_1$ .. | 1 | o.83 | 0.64 | 0.38 | 0.2 |
| | | Percentage Change in Slope by % Reduction in Silt Change | | | |
| 4. Slope | | | | | |
| (i) $q^{2/3}$ S*/W: $(C)^{1/3}$ .. .. | $S_o$ | 6.5 | 11.0 | 26.5 | 42.3 |
| (ii) Ning Chien $f_{RS}$ : qs/q. .. | $S_o$ | 3.5 | 8.5 | 16.0 | 25.0 |
| (iii) Brown Einstein $(\phi - \psi)$ .. | $S_o$ | 4.5 | 10.5 | 27 | 43 |
| (iv) Engllund Curve D/d $\psi'$ $^1/_2$ $\beta - ^1/S$ | $S_o$ | 0.2 | 13.5 | 36.5 | 26.5 |
| Average slope % reduction .. | So | 3.7 | 10.9 | 24 | 36.5 |

PAPER No. 396

## Recording of Temperature Changes Inside The Concrete of Sukkur Barrage Arches

*By Dr. Nazir Ahmad*

This paper gives the results of electrical wire resistance thermometers which were installed in November, 1966 in the Road Arch No. 8 of Sukkur Barrage. Thirty-three thermometers were installed in the crown section of the Road arch and nine close to the springing. Similarly eighteen thermometers were fixed in the Gate Arch No. 8 on 25 April, 1967 in the crown section only.

The depth of installation of thermometers varied from ½ inch to 1, 2, 3, 6, 12 and 18 inches inside the arches starting from the bottom surface.

The thermometers have continued to record the observations for more than two years without any defect.

In the paper the technique of preparation of thermometers, and the method of their recording is described in detail. It was observed that each thermometer recorded the temperature within the arch where it was located.

In case of concrete close to springing where the arch is 2.25 ft. thick and has a covering of 5.75 feet of lime concrete, the effect of daily variation of temperature was recorded 18 inches inside the arch. This was the depth up to which the thermometers were located. This variation was 5% of the air temperature. The daily variation of temperature within 6.0 inches of the concrete was about 20% of the air temperature.

The difference between the maximum in hot season and the minimum in cold season of air temperature at Sukkur was found equal to 67°F. This caused a change within 6.0 inches of the arch equal to about 65% of the air temperature. At three inches depth the variation rose to 68% of the air temperature.

TABLE No. XI

*Mean Annual Variation of Temperature at various depths in Cement Concrete.*

| S. No. | Mean air temp. °F | 1/2" depth | | 3" depth | | 6" depth | |
|---|---|---|---|---|---|---|---|
| | | Percentage variation | Mean highest temp. °F | Percentage variation | Mean highest temp. °F | Percentage variation | Mean highest temp. °F |
| 1. | 57.0 | 70 | 37.5 | 68 | 35.0 | 65 | 33.00 |
| 2. | 70.0 | 70 | 46.06 | 68 | 37.5 | 65 | 35.5 |
| 3. | Quartzite, Dolomite 10% increase | 70 | 50.66 | 68 | 41.2 | 65 | 39.5 |
| 4. | Rhyolite, Basalt, Granite 25% less | 70 | 34.58 | 68 | 28.2 | 65 | 26.6 |
| 5. | 90.0 | 70 | 62.19 | 68 | 46.3 | 65 | 45.6 |
| 6. | 70+20 | 50 | 56.06 | 25 | 42.5 | 20 | 39.5 |

In West Pakistan the annual variation of the highest and the lowest temperature of air between the summer and winter seasons is about 70 F. For this temperature the expected variation of temperature at 6.0 inches depth is about 36°F when the concrete is made of reinforced limestones as aggregate. If the aggregates used were Quartzite and Dolomite, due to the higher thermal conductivities of these materials, the range of temperature at 6.0 inches depth will fall to about 27°F.

A few days in a year may be exceptionally hot or cold causing a change of ±10°F in the mean temperature of ten days. It has been estimated that this exceptionally high or low temperature may cause a change of temperature at 1/2, 3 and 6 inches depth equal to 56, 42 and 40°F if the high or low temperature persists for a day or so.

If it is assumed that this type of temperature persists for several days and will have the same types of variation as the annual one then this 90°F change of temperature will raise the temperature to 59,46.3 and 45.6 °F at 1/2, 3, 6 inches depth. All this information discussed above is given in Table 11.

It is apparent that the change of temperature within the arches, in a year, is below 60°F at all depths.

PAPER No. 397

**Design and Construction of Sutlej Bridge**

*By M/s Abdus Salam and Abdul Waheed Choudhry.*

The integration of various units into the Province of West Pakistan brought into sharp focus the necessity of improved communications in the Province. The completion of Multan-Lodhran road and a boat bridge over river Sutlej near Bahawalpur was a first step in this direction. The traffic developed rapidly and the urgency of a modern permanent road bridge over the Sutlej came in force.

The design project for this bridge was prepared by the Directorate of Bridges, Communication and Works Department, Lahore, and approved by M/s Donovan H. Lee & Partners, Consulting Engineers, London. The bridge was started in 1966 and opened to traffic on 26th December, 1968. This new crossing facility would be a great boon to the area and will go a long way to stimulate economic progress.

The paper is a very exhaustive one. It deals with all aspects of the design and construction of the Sutlej Bridge.

Discussion of the site and the characteristics of the river, its discharge and its flow characteristics has been discussed.

The site was investigated and the depth of foundation and waterway was determined.

Model experiments were also run in the Irrigation Research Institute.

Salient features of the bridge include discussion of design loadings, free board, river training and finally the approach road.

This is a very detailed paper, dealing with all aspects of the design and construction. It is a good record of an important structure.

Barring aside the problems and difficulties discussed in this paper the project was successfully accomplished. One fact is, however, very significant that, in its planning, design and construction, only Pakistani staff were associated. The standards maintained and achieved are strictly in keeping with the international requirements of a project of this magnitude. It is indeed a matter of great satisfaction for the designers that the practical execution of the work did not at any stage call for any modifications or improvements to

suit the practical problems.

It was found that the absence of launching truss did not pose any formidable problem. In fact, it is felt that for bridges like Sutlej and Chichawatni, this costly piece of equipment is not necessary at all. Experience has shown that it is not very difficult to construct such bridges in Pakistan in conventional manner, unless they are of very large length with unfavourable river hydragraph, such as the proposed bridge over river Indus near D. I. Khan. Conventional methods may be slightly more expensive but this consideration must override the fact that no contractor in the country, who does not possess a launching truss, would like to invest a sizable amount to own a launching truss which he may not have to use again on a number of occasions. A substantial amount in foreign exchange would be saved if the use of launching truss can be avoided. The example of Thatta Sujawal Bridge can be quoted in this respect where the design was such that work could be done without a launching truss.

The contract documents for the Sutlej Bridge provided a great improvement on the stereotyped P.W.D. Contract Forms by minimizing the cash lock-up of the contractor. It is suggested that the P.W.D. Contract Forms need to be modified (if they are to be used for similar projects) to become in line with modern contracting practices.

# NEWS & NOTES

## FINDINGS ON CRACKS IN SUKKUR BARRAGE ARCHES

A report has recently been circulated among officials about the appearance of cracks in the Sukkur Barrage arches and their effect on the stability of the structure.

Mr. A. R. Kazi inspected the Sukkur Barrage on 14th April 1964 and noticed developing failure of the guniting on the soffits of the arches of the regulating bridge of Sukkur Barrage. In a letter which he sent to the Government he stated that "The Sukkur Barrage is a masonry structure in Hydraulic lime with the exception of road bridge and the regulating bridge which are reinforced concrete elliptical arches. In the year 1949, cracks were noticed in the upper portion of some of the parts of the piers and also a few fine cracks developed in the arches of the regulating bridge. On detailed examination, oxidization of the reinforcement was noticed. This gave rise to many fears. After great controversial discussions over the soundness of the structure (including some very adverse and disquieting remarks by the foreign consultants) the barrage was rendered safe by heavy grouting by Cementation Company Limited. Their work also included guniting of the arches to prevent air entering the area around the reinforcement and thus saving the structure from further deterioration.

It is now obvious that the guniting material outside the reinforcement of arches has in the following period of last 10 years or so and, in particular during the last one year or two, has developed a tendency to separate from the original construction material. The cracks in the gunited material are now widening and almost every span has these cracks visible to the naked eye. This can lead to early deterioration of reinforcement in the arches. Some urgent and effective measures are needed to prevent serious damage and probably a disaster."

He appointed a Technical committee to go into the minute details and submit a report as soon as possible.

The committee after a few preliminary meetings selected Mr. Mazhar Ali, now Chief of Water and Power, P. & D. Department, as

officer on Special Duty to conduct detailed investigations. After very intensive investigations Mr. Mazhar Ali prepared the report, different phases of which were discussed in the 15 meetings of the Technical committee held between 4th May 1964 and 30th August 1968. Each progress report, work at site and other connected matters were considered in details and finally approved on the action and suggestions to the Government.

The recommendations are contained in a Report on Sukkur Barrage Arches. It was got printed by the Technical Committee.

It is a very useful document dealing with all phases of the barrage. The committee has gone in minute details of each aspect and many useful suggestions and conclusions are contained in the report. The report is accompanied by 14 appendixes.

The Committee is now confident that reinforced concrete arches of Sukkur barrage can be repaired effectively and economically by guniting and they can be rendered safe for design loads. The arches at present are not in a happy position and if early repairs are not undertaken, corrosion of steel would continue to increase and may give rise to undesirable stresses. There are, therefore, no grounds for complacency. As has been clearly brought out by experience gained during experimental work of road bridge, arch No. 7 guniting is highly sensitive to field control. With the best of specifications, good results can be achieved but under constant, unrelenting expert supervision. Any relaxation or departure from the essential high standards would result in the first instance in localised or general failure of the repair job by appearance of shrinkage cracks and separation of deposited materials. This would be followed by appearance of more cracks due to rusting of buried steel and bursting of cover concrete as happened soon after the 1953-56 repairs.

The committee would like to recommend that repair work may preferably be undertaken departmentally as in that case it would be possible to phase the work properly over a number of years. It would also provide a good training opportunity for our Engineers and would result in steady improvement in specifications and technique of repairs. It is hoped that a high standard of workmanship can be achieved by proper, on the spot control, and the arches would not cause any concern at least for a reasonable length of time.

The Committee would also recommend continuation of research work. Data on temperature observations should continue to be collected and processed as it would be of considerable value and assistance in improving the design assumptions. Behaviour of shotcrete may also be watched and efforts continued to improve the specifications. Research work is also called for determining the coefficient of thermal expansion of concrete mixes, the influence of vibration on repair work. Efforts may be continued at an increased pace to open up new vistas and widen the frontiers of knowledge.

The report is for official use only.

## ASIAN INSTITUTE OF TECHNOLOGY GRADUATION CEREMONY

On 23rd of May 1969, the Assian Institute of Technology conferred degrees of Master of Engineering on 55 candidates which included eleven Pakistanis, one each from Hong Kong and Malayasia, seven each from Philippines and Taiwan and twenty-eight from Thailand.

This was the ninth annual Graduation. So far 282 candidates from-eight countries

have to date received the Master of Engineering degrees from the Institute.

Practically every candidate prepared a thesis on a subject, 15 of which were for hydraulic subjects and 12 on soil, structure and transportation etc. We may be issuing brief results of the thesis submitted by Pakistanis in the next issue of the Journal.

## PURE WATER SUPPLY FOR ABU DHABI

Abu Dhabi in Arabian Gulf is to have a water desalinization plant producing 2 million imperial gallons of fresh water per day. The water produced will have dissolved solids not more than 25 ppm. Ewhank and Partners Ltd. of London, S.W. I. are the Consulting Engineers for Power and desalination plant which is to cost about 2 million.

### Libya

A desalination plant is being installed by Accidental Oil Company in Libya for about 100,000 inhabitants of Agedabia District.

## TEESTA PROJECT IN EAST PAKISTAN

Binnia and Partners, Consulting Engineers of London, have been selected for Teesta Barrage Project in East Pakistan. Teesta river rises in Sikkim and is a tributary of Brahmaputra. It is proposed to construct a 2000 ft. long barrage to serve a gross area. of 1.85 million acres of rice cultivation. The winter flow of the river is 4 to 5 thousand cusecs, the maximum recorded flood is about 150,000 cusecs.

### Qartar Water Supply

Qartar has no rivers. Its annual rainfall is very limited. In 1954 Doha arranged for Evaporator unit to produce 1.5 m.g.d.

The expected requirements by 1971 are 5 m.g.d. In 1967 a contract was awarded to Weir Weslgarth Ltd., London to construct two 34 stage flash evaporators to produce 1 m.g.d. of fresh water.

This supply is in addition to the departmental pumping from wells. The rain water percolates and produces a reserve of low salinity water superimposed on highly saline water at bottom. The fresh water is recovered by pumping.

### Saudia Arabia arranges for piped water supply.

Saudia Arabian Government has given a contract to an English consulting firm to investigate design and supervise construction of a project to pipe water from special wells to thousands of villages in Arabia.

### Desalination Unit for Iran

Prof Hossein Nuhdani of the Arya Mehr Institute of Technology, Teheran, has completed a design of a pilot model capable of producing 14000 imperial gallons per day of fresh water through rapid evaporation process. The fuel to be used is natural gas or fuel oil.

### Japan's Position in Industrial Progress

In 1952 Japan produced 6 million tons of steel In 1968 its production has reached 65 million tons. Japan's position in the world is fifth in production of watches, fourth in machine tools, third in steel, second in automobiles electronics, cameras, and petro chemicals and first in ships.

Japan to day enjoys the reputation of the highest quality of the goods produced by it.

## BIO-MEDICAL ENGINEERING

A new branch of Bio-Medical Engineering is fast developing in which electrical and electronics engineers have to play a leading role. Medical Science is now no longer limited to prescriptions of a few chemicals or medicines. Already nuclear physics is an essential tool of modern hospitals. Innumerable appliances and instruments based on the principles of physics are in use. New with the use of artificial limbs, engineers have started producing implements which can be used for replacement of the worn-out organs.

India, recently in January 1968, organized a world symposium on Bio-Medical Engineering in Khanpur in which 27 papers were contributed by various authors.

### Channels—a New Monthly

British Hydromechanics Research Association and the Hydraulic Research Station is issuing this monthly journal. It will be devoted to Civil, Hydraulics and Aerodynamics, Notes and New Engineering Literature.

Twelve volumes, January to December, will cost in U.K. U.S. $66.0 or £27-105 and in Europe U.S. $70.50 or £29-7$-6d.

Applications for purchase to be addressed to the British Hydromechanics Research Association, Carnfield, Bedford (U. Kingdom).

## INDONESIA PUBLISHES BULLETIN OF GEOLOGY AND MINING

The National Institute of Geology and Mining, Bandung is issuing a Bulletin based upon monthly science meeting on Geology and Mining.

The journal can be had from Mr. H. Higasinaka, Editor, Bulletin of National Institute of Geology and Mining, Djalan Ganesha, 10, Bandung, Indonesia.

# Ah H. J. ASAR!

Twenty fifth of May, 1969 was a mournful and sorrowfull day for all those who loved the promotion of Engineering Profession, Engineering Science and Technology, Engineering prestige and every thing connected with Engineering in this country. On this day we lost one of our beloved engineers, best friend and most noble personality, perhaps too noble for a long sojourn in this troubled world!

He was so dedicated to the cause of the profession that he never cared for his health and personal comforts. He had gone to Dacca to prepare a memorable memorandum to be presented to the Government on behalf of the Engineering Profession. He worked on it day and night. Up till one P.M. on Sunday, the fateful day, he was working on it along with his colleagues. The memorandum was to be presented to the Engineers of the Institute on the next day but God had wille otherwise. He went to his room for a brie rest and at 2-30 P.M. was discovered sittin on a sofa with the memorandum fallen fror his hand and thus himself left the earthl abode for ever!

The shocking news was flashed all over th country. Even the hardest heart could nc stand the sad news. None of the communit of Engineers, his own personal friends acquaintances, innumerable admirers coul stand the news without tears.

None had ever a complaint either in h official position or in his private life. He wa so noble, so gentle and so much helpful t everybody.

The engineers owe much to his perseveranc and hard work. For the last two decades, h worked and worked without a rest for raisin the position and prestige of the Engineer He was associated with the West Pakista Engineering Congress for more than tw decades. He worked as Secretary successivel

for the three years. As a member of the Institute of Engineers for several years, as vice-President, regional President and finally the President, his services to the engineers will ever shine as a great mark of achievement. He was one of the most active members who strived to get the Government recognize the Associate Members of the Institute equivalent to the Engineering graduates. Hundreds benefited from this decision of the Government.

Just a month earlier before his death, he was trying to get research project approved by the Irrigation, Drainage and Flood Control Council. He actually got its outlines accepted in the Council.

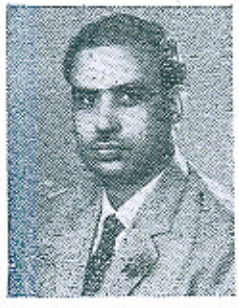
Day in and day out, he had the good of the Engineering and its promotion at heart.

His loss is not only a great shock to his family, which he has left at so early an age with many dependents unsheltered, and unsettled, his innumerable friends, his acquaintances, young engineers for whom he worked so hard will ever find a great vacuum.

The writer has lost a personal friend, a friend for the last 50 years, a friend who played at school, in the college and then throughout his short life of this world.

May God console all those whom he has left for ever so soon and shower all His benevolence on his soul which now abides eternally in Heaven!—Amen !

# M. M. YUNUS TAKES OVER HIS NEW ASSIGNMENT



Mr. M. M. Yunus, Director Designs, WAPDA, completes his enterprising assignment of the design of Taunsa-Panjnad Link Canal on International standard as a Pakistani consultant.

The construction of the Link is also complete.

He is now going to contribute to the design and construction of Tarbela Dam with M/s. TAMS, Consultants for Tarbela Dam Project.

Mr. M. M. Yunus is one of the foremost creative design Engineers of West Pakistan and has been working with M/s. Tipton & Kalmbach, Consultants, Link Canals, WAPDA, on the design of seven Link Canals which were being handled by the aforesaid Consultants. He joined the Consultants' office as an Executive Engineer in 1960, and by dint of his capabilities and hard work he was promoted to the rank of Superintending Engineer in 1962 and also given the highest post of Job Engineer in the Consultants' office which post is generally held by seni expatriates of the Firm.

His services were requisitioned by M Ghulam Ishaq, Chairman, WAPDA, in 19 to handle the design and contract document tion of T.P. Link Canal which was given WAPDA by the World Bank as a te case. He completed the design and doc mentation of this Link not only ahead schedule but also effected a substantial savi in the cost apart from establishing the fa that Pakistani engineers could also hand such assignments on international standard T.P. Link Canal is one of the eight Li Canals which were to be designed and co structed under the Indus Basin Projects as result of Treaty on water dispute betwe India and Pakistan and lies in Lower Th area and connects rivers Indus and Chena This Link is 38 miles in length and is designe for the discharge of 12000 cusecs. It h 30 major structures constructed through its length. The total cost of the Link about eight crores of rupees. It may be r called that this is the only Link Canal und

(*Continued on page 7*

# LIFE MEMBERS

## SH. M. A. HAMID, D.Sc. (HON) *SI. SQA*

Dr. M. A. Hamid belongs to an early batch of Engineers who took over the guidance of the vast Irrigation Department just after Independence.

He graduated from Thomson Engineering College, Roorke in 1921 and was selected for a post in Indian Service of Engineers in the same year. His apprenticeship started in Central Provinces in the Buildings and Roads Department. In 1922 he was transferred to the Punjab Irrigation where he was employed on the construction of Sutlej Valley canals up to 1930 when he went over on deputation to Bahawalpur State for development of canals. In 1934, he was posted as Executive Engineer on Islam Headworks. In 1937 he came over to the Irrigation Secretariat as Under-Secretary, where he worked till 1942 when he was posted as Executive Engineer at Amritsar. He constructed a staff colony for Amritsar Irrigation Workshops. He served during 1943-44 as Professor of Civil Engineering in the Lahore College of Engineering and on promotion as Superintending Engineer was posted in the field in 1944.

In 1946 he again joined the Irrigation Secretariat as Deputy Secretary and on the creation of Pakistan on 7th August 1947 was appointed as Chief Engineer.

In 1949 he was sent as a leader of Pakistan Government delegate to attend United Nations Conference for the Utilization and Development of Resources.

In April 1952 he was on deputation to the Pakistan Government to work on the Indus Basin Water Dispute.

In 1955 he was posted as Chief Engineering Adviser to the Indus Basin Dispute. After about three years in 1958 he was posted as Chief Engineering Adviser and as such continued to work on Indus Basin Water Dispute including the Farakka Barrage Dispute. In 1960 he worked as Commissioner Indus Basin Water Treaty in addition to his own duties.

He retired from Pakistan Government Service in 1964.

In his professional attainments, he contributed a paper on Energy Dissipation below

Falls and Weirs to the International Hydraulic Conference at Minniopolis in 1953. He was the first President of the Punjab Engineering Congress after independence.

He was Vice-President of International Conference on Large Dams and International Commission of Irrigation Drainage and Flood Control in 1951.

He is a member of the Institute of Civil Engineers, Pakistan and a member of the Irrigation, Drainage and Flood Control Research Council.

He was awarded the title of Khan Bahadur by British Indian Government in 1941 and was decorated with *Sitara-i-Qaid-i-Azam* in 1959 and *Sitara-i-Imtiaz* in 1964 by the President of Pakistan.

We wish him long and healthy life.

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(*Continued from page* 70)

the Indus Basin Projects which has been designed and constructed on international standard exclusively by Pakistani engineers, without the help of foreign experts who are handling the other seven Link Canals. The outstanding effort of Mr. Yunus was not only appreciated by the WAPDA authorities but even by the Government of Pakistan, the World Bank, and other Consultants. He was given a Civil Award of *Tamgha-i-Khidmat* in 1967. He presented a set of designs and contract documents of T.P. Link Project prepared by him to Mr. A. G. N. Kazi, Chairman, WAPDA, on his transfer to Tarbela Dam.

While in the Irrigation Department, Mr. Yunus has the credit of handling the design of BRBD Link along with the design of the downstream works of the Rasul Hydro-electric Project. He also designed a number of other Projects in the Irrigation Department like Rasul Tubewell Project and Mianwali Hydro-electric Project.

With age-long experience at his back, Mr. Yunus is now aspiring for his contribution to the design of Tarbela Dam Project. He told our correspondent that he was locking forward for his future assignments with great spirits and determination to make major contribution in the design of the gigantic Tarbela Dam Project. He has been deputed to TAMS, Consultants for Tarbela Dam Project, to work as one of their Principal Engineers. He is determined to plan and organize work in the same masterly manner as he did on the design of T.P. Link.

# Dr. Nazir Ahmad Retires

*Dr. Nazir Ahmad retired on the eleventh of April, 1969, after serving the Irrigation Research Institute for nearly 36 years.*

In May 1934 with an M.Sc. Physics degree, he joined the Hydraulic Laboratory of the Irrigation Research as a Research Assistant. For about ten years he conducted investigations on Hydraulic problems pertaining to Surface and Sub-surface flow of water. During this period he specially interested himself in the uplift pressure under Hydraulic Structures, in the study of changes of river regime by river model and the design of energy dissipators for weirs and canal falls. The results of some of these Investigations formed a part of his Ph.D. thesis submitted to the University of the Panjab in 1940.

In 1944, he was selected for research on developments of methods of Experimental Stress Analysis by means of Photo-elasticity, electrical strain gauge, stress coat and structural models. This was a pioneer work undertaken in this country for the first time.

In the end of 1945 he was entrusted with the guidance of Research on the Problems of Soil Mechanics, Foundations, Ground Water, Tubewells, Soil Physics, Canal Lining, Silt and Sediment transport etc. In fact except for surface hydraulic of rivers and canals, all other problems of Irrigation Engineering, of Land and Water, Waterlogging and land drainage etc. formed part of his investigations. It was partly due to the dearth of scientific research workers at the time of Independence in August, 1947. Till his retirement he headed all these Research Laboratories not only at the Lahore centre of the Irrigation Research Institute and at Niazbeg Field Research Station but also at Karachi and Hyderabad.

As a result of his intimate studies in these problems, during the last 22 years he has published more than 150 research papers and prepared about 500 technical reports on various subjects.

Tubewells and Ground water were the subjects of his special interest in which he

made the largest contributions. His latest book on Tubewells Construction and Maintenance is partly a result of his research on the subject and is the only book on the subject produced in this country.

For his research contributions on Tubewells, Groundwater, Waterlogging, Drainage and Soil Physics, he was several times invited by foreign countries to contribute to International meetings organized by them. In 1952 he was invited by Turkey and UNESCO to contribute to the first conference on ground water exploration and also to deliver lectures in Turkey, Egypt and Syria. In 1958 he was invited by Iran, in 1963 by Russia and in the same year by SEATO Graduate School of Engineering, Bangkok. In 1964 he attended symposium on Sodic Soils in Hungary. He was an invitee to the first South-East Asia Soil Mechanics Conference in Bangkok in 1967. The expenses of all the International meetings and conferences were pre-paid by the sponsoring authorities. His contributions can thus be seen in many of the UNESCO, FAO and Hungarian Publications, Journals and Books dealing with Soil, its Drainage, Ground water and Tubewells etc.

His contributions to the Engineering and Science Journals and conferences of Pakistan are many. The West Pakistan Engineering Congress, the Institute of Engineers (Pakistan), the Association for Advancement of Science and so on are a few of the organizations which contain his significant contributions.

The University of the Panjab awarded him another doctorate degree of D.Sc. for his investigations on water conservation in 1964. He was awarded a Gold Medal by the Engineering Congress for his paper on "Dewatering of Foundations".

In 1967, he went to advise the Government of Nepal on feasibility of tubewells for irr tion in that country.

He is an active member of several scien organizations. He is a life member of s of these. He is a member of Pakistan A emy of Sciences.

As for his educational activities, he lectured at SEATO Graduate School, Uni sity of Engineering and Technology and taken part in innumerable symposia science conferences.

He has been a member of board moderater for M.Sc., Physics, a membe board of studies in Physics, a member o Academic Council of the West Paki University of Engineering and Techno and member of several educational scientific committees.

He has been associated with ENGINEERING NEWS, a quarterly jou of West Pakistan Engineering Congress the last fourteen years. The progress o journal has been mainly due to his eff as its editor.

His present interest as Director W logging and Salinity Study Group i collect and assimilate known literatur this vexed problem of the country, its e causes, development of counter meas their successes and the future lines of ac

For the last six months he is act engaged on problems of East Pakistan regard to utilization of its ground resources, and their development, Sa intrusion from the sea into East Pak rivers, and the Hydrological aspects o Ganges, etc.

He is a son of Pakistan dedicated t science of Irrigation Engineering an applications in Pakistan. His writings contributions will ever remain a symb inspiration for the coming generations.

# Dr. Mushtaq Ahmad Retires

*Dr. Mushtaq Ahmed, retired on the 16th of June, 1969 after serving Irrigation Research Institute for about 36 years.*

Immediately after obtaining his M.Sc. degree in Physics with honours, from Government College, Lahore in September 1933, he joined the Hydraulic laboratory of the Research Institute. Throughout his service activities, his main interest has been Research on Hydraulic Problems. From September, 1933 to April, 1942 he was a Research Assistant in Hydraulic. For about six years he worked as an Assistant Research Officer, Hydraulic. In September 1947, he took over as Hydraulic Officer and head of the Hydraulic Research Laboratories of the Irrigation Research Institute. In September 1958 he was posted as Director Irrigation Research Institute with much broader interest but still mainly devoted to hydraulic research till his retirement on 16th June, 1969.

On account of his researches, he is known not only in this country but in the whole world as one of the topmost persons in the science of hydraulic engineering. When investigations in connection with Indus Basin work were to be conducted in 1958-59, it was his established reputation which won the confidence of the foreign consultants bent upon utilizing foreign laboratories for hydraulic model tests, to get their investigations conducted in Pakistan under his supervision.

In 1968, simply on the basis of his research work, he was elected as a General Reporter for the session of the International Association for Hydraulic Research. He is a member of the International Committee for Sub-Soil flow. His scientific contributions won him Gold Medals thrice from the West Pakistan Engineering Congress. In 1952, for his paper on "Observation, records and analysis of Pressure pipes, data of weirs on permeable foundations", he was awarded a Gold Medal. In 1967, his paper on "Studies of some Hydraulic Features of Design of Taunsa

Barrage" again won him a Gold Medal. He is the only person who got Kennedy Medal on his paper of "Design of Alluival Channels as influenced by the sediment charge". The President of Pakistan himself awarded him this medal at the time of the Golden Jubilee Session of the West Pakistan Engineering Congress in 1963.

In his earlier years as a Research Assistant he devoted himself to the problems of Weirs on Sand Foundations. He prefected a Capillary flow techniques for the study of Sub Soil flow under hydraulic structures. His was a pioneer work in river training and control to apply the results of Hydraulic models on to prototype. His publications include more than 600 Technical reports issued mainly during 1947 to 1969. He has published about 300 research papers on hydraulic model research some of which won him the Gold Medals as mentioned earlier. His research work also includes investigations on Falls, Aqueducts, Syphons, Dams, Barrages, Bridges, etc. His investigations on sediment transport and design of fluvial channels with particular references of sediment exclusion devices are equally well known. In fact no hydraulic structure during the last thirty years has been constructed in this country in which his guidance has not been availed off.

His work is referred to in Civil engineering books (reference pages 1059 & 1866) published by Butworth Scientific Publications, Jhonson by E. H. Probest in the Design of Weirs on Permeable Foundations and in the Regime of Channels by T. Blench.

In 1957 he visited more than a dozen hydraulic Research Laboratories of U.S.A., England and France. At several places he delivered lectures and took part in the symposia arranged due to his presence. He delivered lectures at Iowa Institute of Hydraulic Research, Colorado State University, Fort Collins etc. He was invited by SEATO Graduate Schools to deliver lectures in Bangkok and Manila. West Pakistan University of Engineering also arranged for a series of lectures delivered by him on the sediment movement and its analysis.

Irrigation Research Institute since its inception in 1924 had two significant periods of importance. The first period was from 1931 to 1942 when Dr. E. Mckenzie Taylor worked as Director of the Irrigation Research Institute. He established seven divisions of research headed by most eminent scientists of those days. The second bloomy period of the Research Institute was from 1958 to 1969 when Dr. Mushtaq headed the Institution as its Director.

Nandipur Research Station owes its origin, establishment and development solely to his efforts. It was started in 1948 and now at the time of his retirement, it ranks foremost among advanced Hydraulic Research Stations in the world. It was his research work and his confidence which helped him to complete the investigations which materially effected the development of the Research Institute, by obtaining much of the foreign manufactured scientific equipment. It was his efforts to obtain funds and get started Hydraulic Investigations under Irrigation Research Council at Lahore, Nandipur, Hyderabad and Karachi Laboratories.

He has left a three storey building and a grand hydraulic investigation hall with much better expanded facilities, of equipment & staff, in all laboratories at Lahore, Karachi and Hyderabad. This all goes to the day-in, day-out efforts of one devoted scientific worker whose achievements will ever remain a symbol for the coming generations to follow.