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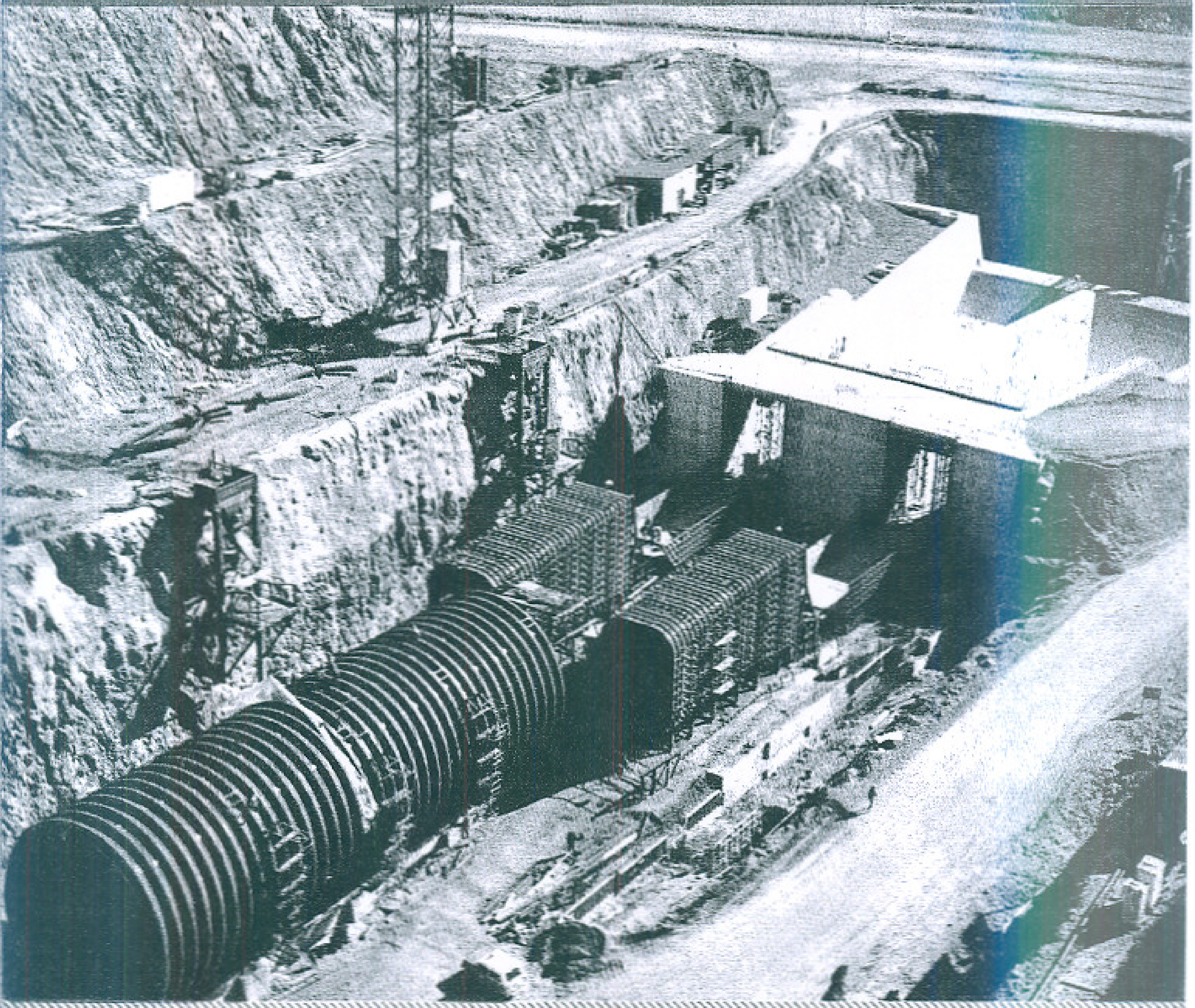

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TWENTIETH YEAR OF PUBLICATION

ENGINEERING NEWS

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Vol. XX MARCH, 1975 No. 1

In this Issue

TITLE COVER

A view of outlet area and preassembly of cans in front of Tunnel No. 5 (Courtesy NESPAK)

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The Twentieth Century Oracle

Every man-made object was designed and constructed somehow, somewhere, by someone. The ancient civilized man sought divine guidance and consulted the oracle before applying his native wit, ingenuity and innate sense of proportion and rhythm, to the problem at hand. Today, his counterpart turns towards the modern oracle - the consultant - for answers to his specialized and complex problems. In the field of engineering and technology, the consultant has assumed a special significance.

Technical know-how is a salable commodity. The fact that under - developed countries wish to import modern technology, and the developed countries find it highly profitable to oblige, has given a great boom to the business. In the context of international co-operation, the concept of engineering and technical consultancy has acquired a new dimension, promising unlimited scope. However, the modern oracle is not infallible. Problems arise when technology of one country proves unsuitable for the prevalent conditions of another. Again, political and economic implications of the proposed deal may be un-acceptable to the receiving country. Exchange of technical know-how between unequal partners, under the garb of co-operation and assistance, is a double edged sword, that must be wielded - or dodged - with the utmost caution. The minimum and obvious need, therefore, is complete self-awareness which will, in due course, lead to self-reliance.

We, the engineers, have been harping long enough on the theme of self-reliance. It is time to demonstrate that, to us, the phrase means more than just a clichē, a new year's resolve or a vague ideal. This requires very hard work indeed. Self-reliance is not a magic wand that will open all doors to progress and prosperity instantaneously. It is not a legislation that can be promulgated by an act of Parliament and enforced with the help of a law enforcing agency. It is a concept that must be adopted as a way of life and practised at all levels, at all times. The question arises: are the engineers in Pakistan ready to take on the responsibilities and challenges of self-reliance ?

To the People's Party Government must go the credit for reposing the highest confidence in the ability of Pakistani engineers and taking the first practical steps towards better utilisation of their talent. The need for gathering on suitable platforms professional men of vision who can view engineering, vast and complex as it is, as a single field of operation, with relatively few laws and methods, has been recognised. Such people, having gained experience and judgement, will be able to plan and direct vast enterprises.

Pakistan has a sizable core of talented engineers. We could benefit from their proper organisation and application. Also, there are other people in this world, less privileged than ourselves, who could utilize their knowledge and skill. It is a heartening sign that Pakistani engineers are pooling their knowledge and resources to explore these possibilities both at the government and private level.

To emphasize the need for further development of engineering consultancy services, we are starting a regular feature on Pakistani Consulting Engineers in this journal. We hope this token of appreciation will encourage brother engineers to work with greater zeal to win laurels for themselves and their country thus, one day, fulfilling the long cherished dream of a strong and prosperous Pakistan.

Heart to Heart

Mr. Engineer so and so, get rid of that false notion, fear, complex, and what have you. You DON'T have to be a brilliant research scholar to qualify as a contributor to the Engineering News. Original research papers do have a cherished place in our scheme of things but they are rare birds, as we all know too well. Besides, Engineering News is YOUR journal and that, to us, means not only writing FOR YOU but also writing ABOUT YOU.

For instance, what about that interesting field work, besides hunting, of course, that you have been doing lately? why not send us a brief report, with pictures, if possible. Surely, you find time from your absorbing meetings and coffee sessions, to do that dull, routine, and tiresome office work. There is news in those files spread across your table. The chances are, it is not even classified, and does not come under the Official Secrets Act. Have you won any distinctions lately? No, we are not referring to the lists of 303 and 1300. What about that prized promotion or that challenging new assignment? Believe it or not, that is news - and good one at that. What is happening in your departments? They are all going down fast, agreed ; but there must be some departmental tit-bits that could make headlines in our columns. Don't be afraid to share your little secrets.

Finally, if you are not very pleased with our familiar, heart to heart talk - there is an even chance that you are not - if you violently disagree with any or all the opinions expressed or statements made in this journal, then get hold of pen and paper - just ring the bell, and your peon will push the required implements within easy reach - and fire a letter to the Editor, Engineering News. A space will be reserved for YOUR contribution in the next issue.

Irrigation
and
Power Section

Freeboard in Unlined Irrigation Channels

by

M. ISMAIL SHAHEED

(1) The freeboard of a channel is defined as the vertical distance from the top of the bank to the water surface. This distance should be sufficient to prevent over-topping of the banks. It also provides factor of safety against settlement of banks, excess flow in channels, sudden reduction in out-flow like closing outlets in bad weather etc.

(2) The factors to be considered in determining the freeboard in channels are :

(i) Top width of bank
(ii) Channel size
(iii) Operation policy of channels
(iv) Wind action i.e. its direction and intensity
(v) Soil characteristics
(vi) Velocity and variation of flow
(vii) Silting or scouring tendency in channels
(viii) Location of channel with relation to thickly populated and highly developed areas
(ix) Safety devices like escapes and waterways

(3) Freeboard is an important item in design and maintenance of channels and various authorities the world over have devised empirical relations for working it out.

(a) **Mr. Gerald Lacey** advocated the following relation for working out the freeboard of canals :

$$\text{Freeboard} = 0.65 + 0.15\, Q^{\frac{1}{3}}$$

This works out to :

Discharge	Freeboard
cs	ft
10	1.07
100	1.34
1,000	2.15
10,000	3.87

(b) **Australian Practice**

In un-lined channels, which have been constructed upto a maximum capacity of 1500 cs, the freeboard is :

Small channels	1.3 ft
Large channels	3.25 ft

(c) **U.S. Practice**

U.S. Bureau of Reclamation recommends the following empirical relation :

$$\text{Freeboard, } F = \sqrt{CD}$$

D= Depth of water

C= Coefficient varying from 1.5 to 2.5 for canals of 20cs to 3000cs

C	D	Freeboard	Discharge
	ft	ft	cs.
1.5	1.6	1.55	10
1.5	2.85	2.06	100
2.5	5.7	3.42	1,000
2.5	12.0	5.5	10,000

(ii) Another formula of U.S Bureau of Reclamation is :

$$F = \frac{1}{2}(\sqrt{B} + \sqrt{D})$$

It gives results as under :

Q	B	D	Freeboard
cs.	ft	ft	ft
10	4.7	1.6	1.71
100	20.0	2.85	3.08
1,000	72.0	5.7	5.45
10,000	240.0	12.0	9.48

This gives much higher results than the first formula.

(d) **Prof. Etchevery's** formula is :

$$F = \sqrt{\frac{W}{2}}$$

Where W = mean width of channel

This gives :

Discharge	Width	Freeboard
cs.	ft	ft
10	5	1.12
100	22	2.35
1,000	78	4.32
10,000	245	7.8

(e) **Davis formula**

$$F = 1 + \frac{D}{4}$$

It gives :

Discharge	Depth	Freeboard
cs	ft	ft
10	1.6	1.4
100	2.85	1.7
1,000	5.7	2.4
10,000	12.0	4.0

(f) **Indian Practice :**

Channel size	Freeboard, ft
Small channel upto 100 cs.	1.5 to 2.0
Medium channels in cutting 100 to 350 cs.	2.0 to 3.0
Large canal of more than 350 cs.	3.0 to 4.0

(g) **Prof. Sharma's** recommendation :-

Channel size	Freeboard
cs	ft
Upto 10	1.0
11-25	1.25
26-100	1.50
101-250	
More than 250	2.0

(h) **Punjab Manual of Irrigation Practice**

Main Canal	3.0 ft
Branch Canal	2.5 ft
Distys & Minors upto 300 cusec	1.5 ft
Water courses	0.5 ft

The above recommendations are tabulated hereunder :-

Discharge	Lacey	Australia	U.S. Bureau of Reclamation (i)	(ii)	Etchevery	Manual of Irrigation Practice.	India	Prof. Sharma
10	1.07	1.3	1.71	1.55	1.12	1.5	1	1.0
100	1.34	1.3	3.08	2.06	2.35	1.5	2	1.5
1,000	2.15	3.25	5.48	3.42	4.32	2.5	3	2.0
10,000	3.87		9.48	5.5	7.8	3.0	4	

As stated above, the existing instructions on the subject for Punjab Canals are contained in the Manual of Irrigation Practice Chapter-8 which lays down the freeboard as under :

Main Canal	3.0 ft
Branch Canal	2.5 ft
Distys	1.5 ft

Now it so happens that a main canal is of 1,000 cs and freeboard = 3.0 ft (Abbasia Canal), a branch canal is of 2,500 cs and freeboard = 2.5 (A.P. Branch) and a disty. is of 485 cs and free board=1.5 (Hayat Disty. of Thal Canal).

So the real criterion of freeboard should be the discharge and not the distribution classification of a channel i.e. main canal, branch and disty.

(5) To remove this lacuna, the recommendations of Lacey appear most appropriate for adoption wherein the freeboard increases with discharge. $Q^{\frac{1}{n}}$ is a very important parameter in fluvial engineering. Lacey has used it in his regime theory as under :-

$$V = 0.472 \left(\frac{Q}{f}\right)^{\frac{1}{3}}$$

$$P_w = 2.67\, Q^{\frac{1}{2}}$$

$$R = \left(\frac{Qf^2}{4.0}\right)^{\frac{1}{6}}$$

$$S = \frac{f^{\frac{5}{3}}}{1844\ Q^{\frac{1}{6}}}$$

Langlis uses Q as follows :-

Meander length $= 30\, Q^{\frac{1}{2}}$

Meander belt $= 56\, Q^{\frac{1}{2}}$

Thickness of slope pitching of guide bank $= .06\, Q^{\frac{1}{3}}$

Therefore, relating freeboard with discharge is a very rational approach.

The following values can be adopted :

Discharge	Freeboard (Lacey)	Recommended to be adopted
cs.	ft.	ft. cs.
10	1.07	1.0 for 0-25
100	1.35	1.5 for 26-250
350	1.71	
500	1.84	1.75 for 251-500
750	2.015	
1,000	2.15	2.0 for 501-1,250
1,500	2.37	
2,000	2.54	2.5 for 1,251-2,500
3,000	2.82	
4,000	3.03	3.0 for 2,501-6,000
5,000	3.21	
7,500	3.59	
10,000	3.87	4.0 for 6,001-12,500
20,000	4.72	5.0 for 12,501-20,000

In addition to above rationalization, 25% additional freeboard should be provided in "kaller" and bad soil reaches and bermless reaches ; 50% more freeboard be provided where the channel passes in filling through some town or factory area.

The object of this paper is to acquaint the readers with the available information on the subject, to make them think, and to induce them to go in search of data adequate for the formation of true judgements.

Tarbela Tunnel Failure Cost Pakistan £ 100 m

More incredible photographs of the Tarbela site and August's tragic tunnel collapse reached *NCE* this week as Wilson V. Binger, partner of designers Tippetts-Abbett-McCarthy-Stratton, passed through London on Friday, returning to New York.

At the site, the contractor consortium by Impregilo is now racing to reconstruct the broken tunnel, repair the linings and cofferdams, and restore the right abutment before the Indus goes into flood next year. Loss of this year's water behind the dam due to the emergency drawdown has been estimated by the Pakistan Government as over £ 100 m in crops alone.

Now, according to Binger, 'We have a fighting chance of getting the job done in time to save next year's irrigation waters.' Great store is being placed on the dry lean concrete fill scheme outlined in *NCE* 7 November - which will involve placing nearly 500,000 cu m of fill in the tunnel swallow hole and digging a new tunnel.

The concrete air duct, which was suspended for weeks in an amazing fashion above the tunnel collapse, has also been demolished into 500 t, 20 m long sections which are being removed at about one chunk a day. Two attempts were needed to blow up the reinforced tube with its 1.25 m thick walls.

As the dry lean is placed, a 17 to 18 m diameter hole along the original line of the tunnel is to be formed by placing earthfill. After the completion of the fill, the earth will be removed. The new tunnel section will be 11 m inside diameter instead of the original 13.25 m and will continue as an "inside sleeve" 60 m or so downstream into the unbroken tunnel, and upstream in the conduit section that joined the intake and the old tunnel portal.

Two of the three diversion closure gates in each of the intakes of tunnels 1 and 2 still need checking and repairing, if necessary. The centre gate in each intake will be abandoned and the water passage immediately downstream plugged with concrete, at the same time that repairs are made in the heavily eroded gate piers. Service gate piers will be built at each tunnel transition, including the installation of rails, so that the service gates can be used as the first line of defence in tunnels 1 and 2, allowing the closure gates to be closed or opened under balanced head.

Except for a limited inspection of that part of the inside of the tunnel I intake that can be seen above the water line, which shows erosion of the closure gate piers similar to that revealed in the tunnel 2 intake, nothing is known about the condition of tunnel 1. It is not known whether tunnel 1 repairs can be accomplished between 1 February, 1975, when the tunnel 1 closure gates are to be closed and all flow passed through tunnels 3 and 4, and July, 1975, when TAMS want to have all tunnels available for service.

Mr. Horace Johnson, who was chief resident engineer at Tarbela from 1968-70 has returned to Tarbela for TAMS to co-ordinate design and construction required for repair and restoration. Since August, Arthur Casagrande and Johnson have gone to Tarbela on three separate occasions.

When contacted this week, Impregilo in Milan gave no cost estimate for repair works in Pakistan, but admitted to quite a wrangle going on between lawyers, insurers and others. What also emerged is the urgent task facing the contractors in preventing next Spring's flows from entering tunnels 1 and 2 which are far lower than tunnels 3 and 4. The protective bund to tunnels 1 and 2 is currently set at a level of 363 m, which will need to be raised to 372 m by February.

New Civil Engineer, 28 November 1974

Tarbela rescue: 380,000 cu m plug beats the flood

Engineers at Pakistan's giant Tarbela Dam are winning their battle to complete repairs on damaged diversion tunnels before the Indus River begins its annual rise late this spring.

'We've made good progress and unless something unforeseen comes up, we will be ready', says John Lowe III, a senior partner of the New York-based consultant Tippett-Abbett-McCarthy-Stration (TAMS). Mr Lowe, returning to New York from the site, and Wilson V Binger, another TAMS senior partner making the reverse journey, crossed paths briefly in London last week and provided *NCE* with photographs and repair details.

Primary tasks of the Italian-led consortium, Tarbela Joint Venture. (TJV), are repairing a 67 m collapsed section in tunnel 2, one of the dam's four diversion tunnels, and replacing 380,000 cu m of fill which escaped through the collapsed section during the harrowing weeks of the reservoir drawdown last summer (see *NCE* 3 October, 1974). In addition, tunnel I has also been closed to repair intake and upstream conduit sections which took a beating during the drawdown.

With both tunnel 1 and 2 blocked for repairs, the Indus is flowing quietly through the remaining diversion tunnels 3 and 4. Liner plate failures downstream of the tunnels 3 and 4 outlet gates have been repaired.

The river is currently flowing at about 400 cms its low point during the year, says John Lowe. "The flow will begin to increase in March and the annual rise will start in May. Repairs to both tunnels need to be completed by then because even with tunnels 3 and 4 open, the reservoir will begin to fill rapidly."

Major reconstruction began mid-October as soon as the reservoir was low enough. The emergency lowering had taken its toll on the intake area, where water rushing into the collapsed section of tunnel 2 was forced to flow over a wall between intakes 1 and 2, eroding the rock about 9 m below foundation levels. Before damage to tunnel 2 could be properly assessed, this hole had to be filled with tremie concrete. Also, the concrete headwall between the intakes was raised by 24 m to protect reconstruction sites against possible flash flooding and impervious blanket material was placed upstream from the wall.

The cryptic words of a TAMS report describe the condition of tunnel 2 and the awesome task facing the engineers:

'Principal damage was the collapse of the entire right side of the tunnel from the portal to a point some 200 ft downstream. The uncontrolled flow of water into the collapsed section had eroded a large volume of surrounding rock from a (500,000 cu yd) crater like hole extending to the vicinity of tunnels 1 and 3 and for about 80 ft further downstream from the collapsed section. The left side of the tunnel lining remained intact and a substantial portion of rock remained in place on the tunnel crown. The concrete air vent conduit to the diversion intakes of tunnels 1 and 2 remained intact, spanning the large open hole surrounding the collapsed section of the tunnel. The interior of the upstream conduit section and the intake were heavily eroded. The lower portion of the gate piers in the intake downstream of the closure gates had been almost completely destroyed by erosion. The centre closure gate had been damaged in falling (it fell just after the collapse) and a number of gate rail sections were missing. Erosion of the tunnel lining also had occurred downstream from the collapsed section, principally around the invert. A considerable amount of hoop reinforcing had been exposed and pulled out, apparently as a result of having been subjected to high velocity flow and passage of debris at the invert.'

The strategy for repairing this damage stems form an idea conceived by Mr Lowe. 'There were some thoughts tossed around (filling the entire hole with concrete and then excavating the tunnel out of the concrete was one) but the only thing we could really do was fill,' Mr Lowe remembers. His initial plan was to fill the tunnel's collapsed section with earth, prior to covering it and the huge hole with a lean mix called rollcrete (bank run gravel mixed with a small amount of cement and placed by dumping and compacting). Once the rollcrete operation was completed, the tunnel would be excavated and lined. An earthfilled vertical shaft would be left to provide subsequent access to the tunnel.

'We later decided not to fill tunnel or the shaft, but take advantage of the lining still intact, place steel forms protectively over the collapsed section and rollcrete around the tunnel cavity,' Lowe explains. 'This way, work on the tunnel could go ahead immediately instead of having to wait for the rollcreting to finish.'

When rollcreting was completed on 15 February, the invert plus right and left sides of the new tunnel lining were also finished and work was beginning on the crown.

'We wouldn't have even started on the tunnel itself by now if we had filled the tunnel instead of protecting it,' says Lowe.

Preparing the cavity for fill operations began in late October. Some initial fill was dumped into the hole for cushioning and large concrete air vent duct were blasted, demolished and removed. Extensive stabilisation of the rock walls had to be carried out and a de-watering system installed before rollcreting could begin in early January.

Organising the rollcrete operation required major co-operative effort by all concerned. The Pakistan government made certain Tarbela's cement requirements of 2000 t daily received preferential treatment. The railways set aside 70 wagons daily to haul cement to Tarbela and TJV brought in 110 t belly dump trucks originally used for the main embankment to haul the cement from the railhead.

'We were lucky those dumpers were still there,' says Mr Lowe. 'They had finished and in another few weeks would have been gone.'

The rollcrete was mixed by placing the alluvium aggregate and cement on to a conveyor and dropping it into a 16 m high reverse-louvred chimney which emptied into a hopper. Water was added to the top of the chimney. Dumpers transported the mixed concrete to the cavity where it was placed in 450 mm thick layers. Because of the confined space initially, 35t rear dumpers were used, but as the filling progressed and more room became available, 70t rear dumpers and finally the 110 t belly dumpers were utilised. Loaded dumpers did the original compaction, but once space restriction were not so severe a conventional vibratory roller was used.

'The mixing and placing of rollcrete is very different from normal concrete,' points out Wilson Binger. 'Essentially we handled the rollcrete as one would handle fill.'

While there has been some limited usage of cement-stabilised soil in the past, most of it has been confined to roadways and other narrow strip applications. It has never been used before on such a scale, according to TAMS, 'We chose rollcrete because we needed something which was strong and that wouldn't erode.' explains Lowe. 'We didn't want high loads on tunnel 2, so it seemed to be the best solution.'

The original plan called for rollcreting from a height of 329 m (just under the tunnel 2 lining) to 366 m, but TAMS decided to add another 9 m of rollcrete when engineers saw foundations on either side of the tunnel, remnant couldn't be excavated as deeply as planned. A total of some 180,000 cu m of rollcrete was placed during the operation with TJV consistently placing a breath-taking 13,000 cu m daily, working on 24-hour cycles. An additional 180,000 cu m of earth fill is now being placed on top of the rollcrete at a rate of 4 m per day.

Meanwhile, other damage around the tunnel 2 intake has been repaired. The damaged centre closure gate has been sealed and the two side gates thoroughly inspected and the gate fastening rails reinforced. Heavy concrete erosion in the gate piers, intake passages and conduit section has also been renovated and the two side closure gates are now operable. The damaged lining of the existing tunnel 2 has been reconstructed with missing reinforcing steel replaced and concrete surfaces restored.

Early last month, engineers blocked tunnel 1 and made their first full inspection since the reservoir drawdown. They reacted with a collective sigh of relief for they found no major damage they did not already know about.

'There was heavy damage around the intake, but we had known that for a long time,' says Lowe. 'Aside from this no special repairs will be required. It will take about six weeks to two months to replace surfaces and reinforcing steel around the intake, but there is no reason it won't be ready when the reservoir rises.'

Two of the three closure gates at the intake suffered damage to wheels and axles and one of them was so badly bent it couldn't be repaired. It has been replaced by a bulkhead gate originally intended for use in the service gate shaft. The centre closure gate will be sealed and a concrete plug installed in the gate passage, while both side gates will be reconnected to the hydraulic hoists.

Last summer's disaster has caused a redesign of tunnels 1 and 2 to make them strong enough to withstand any future emptying of the reservoir, should this be necessary.

Contingency plans for future emergency emptying of the reservoir follow discovery of numerous sinkholes one 5 m diameter and 2 m deep in the impervious blanket upstream from the dam's main embankment after the reservoir was emptied last October. Further dewatering and inspection revealed more sinkholes - mostly in the vicinity of suspected subsurface openwork - and a number of cracks and pressure ridges in the blanket. While previous tests carried out both during original filling and emergency draining of the reservoir gave no indication of underseepage problems, reinforcing of the blanket was ordered. Between November and the time tunnel I was closed in February, submerging the blanket, nearly 4 million cu m of additional blanket material was placed.

While the final price tag on last summer's failure is not yet in, sources close to the project indicate insurance claims in the neighbourhood of $30m have been filed. Says Binger: 'We had to move as fast as humanly possible, so there was no way to economise on the repairs.'

Any additional trouble could push initial power generation from Tarbela back into 1977. It won't be known until September if tunnel I will be needed again for emergency drawing and only then can work begin connecting tunnel 1 to the power house.

'If work starts in September, we should be ready to generate power about mid-1976,' says Lowe. 'This is about the same time as the generating and transmitting equipment will be ready so if there are no more problems, the delays on power generation will have been minimal.' If tunnel I is needed this fall, it will delay power generation by about one year.

While repairs at Tarbela are proceeding at breakneck speed, little information has been made available on the cause of the tunnel 2 collapse. Some, including both Binger and Lowe, feel the exact cause may never be pinpointed.

'The primary evidence was destroyed by the time we were able to get a look,' says Mr Binger. 'The closure gates were stuck so we couldn't close the tunnel and get a look inside until everything had been carried away. My guess is that something fell on the lining which caused it to fail. I just can't see a lining of that thickness—2 m—with number 18 rebars, caving in on its own.'

Ironically, it is now believed the lack of a few critical tack welds caused the gate rails to bend and the gates to stick.

'The gates run on rails which are held in place by clips which in turn are fastened to a base plate,' says Binger. 'A couple of tack welds at the base plate which should have been made, weren't. It's the old story of a battle being lost for lack of a very minor detail.'

Tyler Marshall
New Civil Engineer, 6 March 1975

Runoff Agriculture

Once rainwater runoff has been harvested from slopes, it can be used for crop production (Figures 13 and 14). The combination is known as runoff agriculture systems in various parts of the world.

Runoff agriculture was developed almost 4,000 years ago to permit crop production on lands receiving as little as 100 mm. average annual rainfall. Extensive investigations reveal that ancient farmers in the Middle East cleared hillsides to increase runoff water and built rock walls along the contours to collect it and ditches to convey it to lower lying fields. These systems allowed agricultural civilizations to survive in desert regions that today support only a small human population and produce few crops. Warfare and political upheavals resulted in mismanagement and neglect of the ancient farms, but the techniques of runoff agriculture are still applicable today. Runoff farms, using modern technology and crop varieties selected for local conditions could benefit many desert regions. Artichokes, asparagus, flower bulbs, some fruits and nuts, barley, sarghum, pearl millet and forages, all are potentially important crops for runoff agriculture, most are now grown in large runoff agriculture field trials in the Negev Desert.

Methods

In runoff agriculture, the principles and practices depend on rainwater harvesting. The basic need is a rainwater catchment that provides enough water to mature the crop. Obviously, the crop's own water requirements and general water conservation techniques are crucial to a successful harvest. Poor crop yields in drought years are usually offset by production in good years.

The type of farming practiced must make the best use of the water. In general, perennial crops with deep root systems adapt better to runoff agriculture, because they can use runoff water stored deep in the soil, safe from evaporation. Some deep rooted, drought-resistant fruit trees can be very successful. Shorter lived crops can also be grown ; grains, such as pearl millet that mature rapidly and require only one rainfall hold particular promise. Plants that become dormant during dry periods and begin growing when water becomes available are particularly suited to runoff agriculture.

The desert soils and climate of the Negev have been found suitable for a variety of crops under runoff agriculture. Excellent yields have been obtained from

Abstracted from "More Water for Arid Lands, Promising Technologies and Research Opportunities", National Academy of Sciences, Pakistan.

pasture plants, field crops and orchards, well above those on dryland farming and comparable to yields in irrigated farming (Table I).

8. A companion report on tropical plants, now in preparation, describes some lesser known grains that can be grown to maturity with a single flood irrigation. (See BOSTID publication 16, P. 153.)

Runoff Farming

Ancient runoff farms in the Negev (Figures 15 and 16) had several cultivated fields, fed by watersheds of 10 to 50 ha. The watersheds were divided into small catchment areas of 1 to 3 ha that allowed runoff water to be collected in easily constructed channels on the hillsides and were small enough to prevent uncontrollable amounts of water. Channels directed the water to cultivated fields which were terraced and had stone spillways so that surplus water in one field could be led to lower ones. Farmers dammed the small channels between the catchment and the fields with rocks ; by removing strategic rocks from the channel walls they could guide the water to different fields at will.

Table I yields from Runoff Agriculture, the Negev, 1971.

Crop	Tons/hectare
Peaches	6-12
Apricots	3-8
Grapes	12-15
Figs	6-8
Almonds (dry shelled)	0.3-1.8
Barley	1.3-4.8
Wheat	1.1-4.5
Peas (seeds)	5.4-6.9
Sunflowers (seeds)	2.2-2.7
Alfalfa (Medicage sativa, fresh weight)	16-37.7
Wild Oats (Avena sterlis, fresh weight)	20-31.2
Pistachios	0.4-1.8

Source : Evenari, Shanan, and Tadmor, 1971.

A form of runoff farming that utilizes water from small, deliberately built catchments has been practiced in Botswana [9]. The water is used on school vegetable gardens. The catchments have included school playgrounds, roads, etc.

9. Intermediate Technology Development Group Ltd., 1969. p. 70.

Water Spreading

In arid areas the limited rainfall usually falls during short, intense storms. The water swiftly drains away into gullies and then flows, sometimes for many miles, toward the sea or an inland lake. Water is lost to the region, and floods caused by the sudden runoff can be devastating, often to areas otherwise untouched by the storm.

Water spreading is a simple irrigation method for use in such situations : floodwaters are deliberately diverted from their natural courses and spread over adjacent floodplains (Figure 17) or detained on valley floors (Figures 18 and 19). The water is diverted or retarded by ditches, dikes, small dams, or brush fences. The wet floodplains or valley floors can then be used to grow crops. Water spreading is also frequently practiced on range and pasture lands.

FIGURE 13 A good barley crop produced by runoff agriculture in the Negev Desert. (L. Evenari)

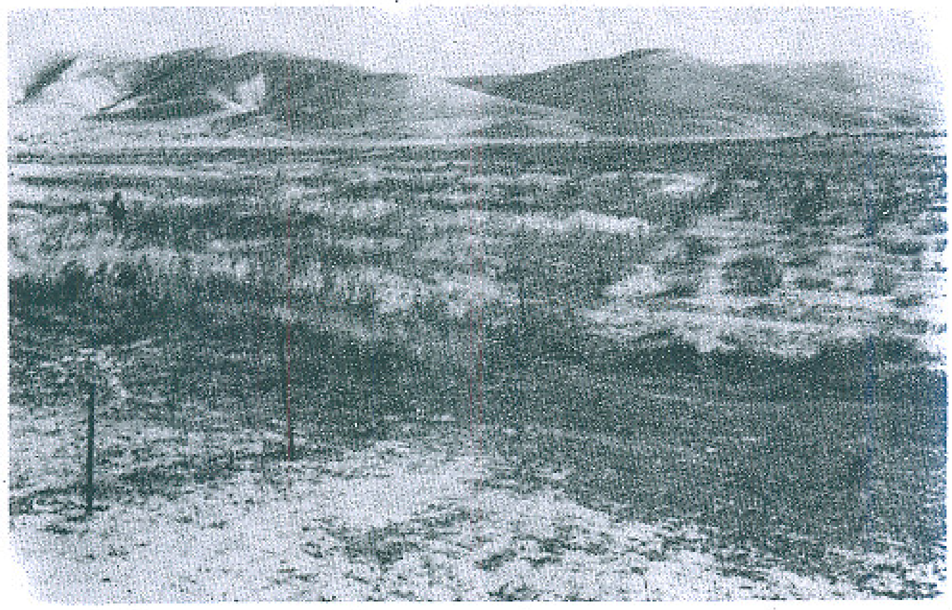

FIGURE 14 Wadi Mashash, Israel (annual rainfall 100 mm). Left: runoff-treated pasture. Right: overgrazed natural pasture. (U. Nessler)

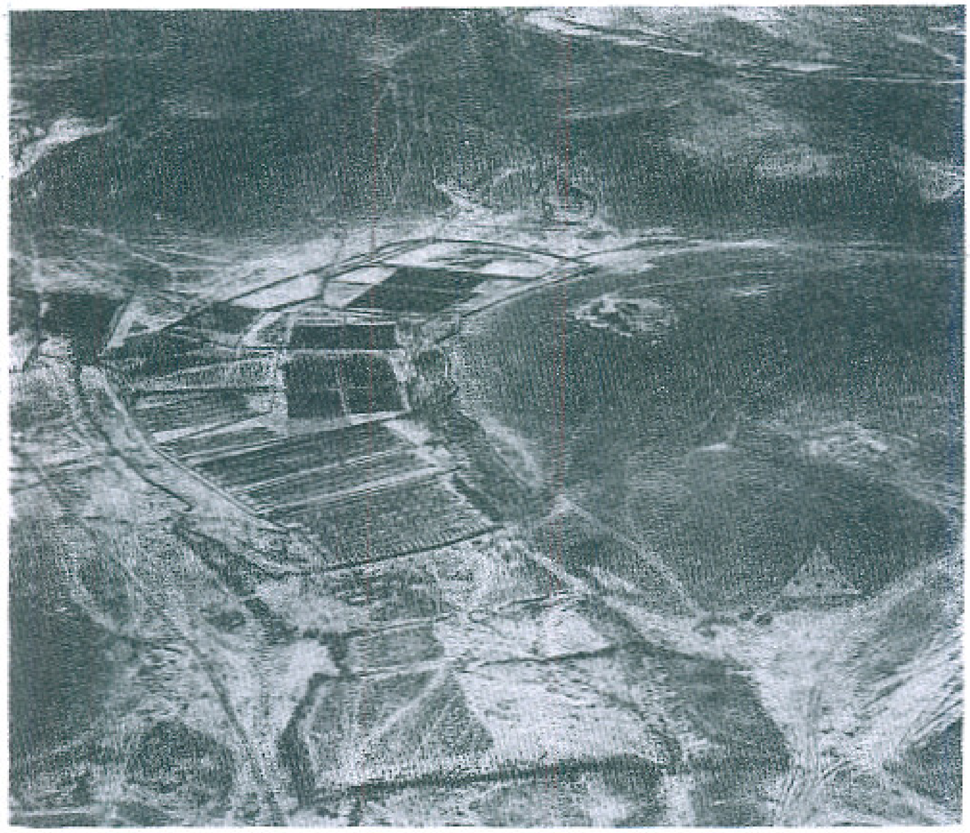

FIGURE 15 Reconstructed ancient farm at Avdat in the Negev. Farm is, and was, watered by runoff from surrounding slopes and wadis. In the foreground are four reconstructed terraces; in the background, four reconstructed channels lead runoff to the farm. To the right are traces of three channels that once carried runoff water to the lower terraces. Ratio of catchment to cultivated area is 20:1–each ha of cultivated land receives runoff from 20 ha of slopes, as well as direct rainfall. Cultivated area receives water roughly equal to a rainfall of 300-500 mm from actual rainfall of 100 mm. (L. Evenari)

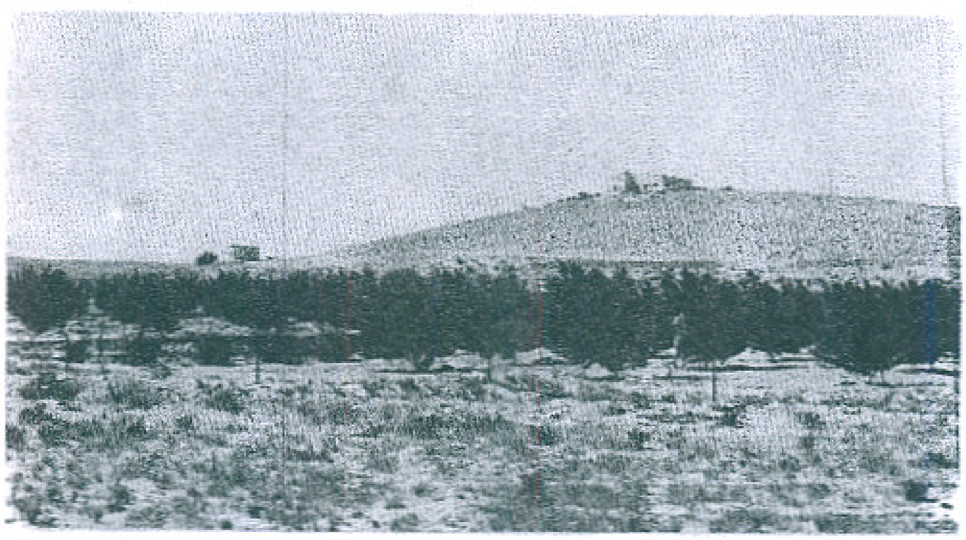

FIGURE 16 Orchard in Negev. Rainwater falls on the slope behind and runs down to strategically located ditches that convey it to the trees. In temperate regions agriculture is based on direct precipitation and on practices, such as plowing, that encourage rain to infiltrate the soil. Runoff agriculture is an indirect method suited to arid lands; it collects rain from a larger area and concentrates it on a smaller, cultivated area. (L. Evenari)

Water spreading systems need a careful design and engineering layout to withstand flood waters. Potential sites are found on many arid and semi-arid ranges, sometimes (as in the rainshadow of a mountain range) where floods are more common than rain. These must be selected with full consideration for topography, soil type and vegetation. Two requirements are essential ;

Runoff waters, available for spreading produced by an upstream drainage area that gives at least a few water flows each year ; and floodplains or gently sloping areas where the soils are suitable for crop production.

Inherently more risky than standard irrigation, the system depends on fairly regular rainfall and on soils (e.g. loess) that facilitate runoff. A constant concern is that sediment and gravel carried by flood waters may adversely affect the crop land.

Microcatchment Farming

A plant can grow in a region with too little rainfall for its survival if a rainwater-catchment basin is built around it, forcing rainfall from a larger than normal area to irrigate the plant. This practice is called microcatchment farming. The previously described principles apply to this micro-scale runoff agriculture ; many of the same soil treatments mentioned in Chapter I can be used.

Microcatchments used in the Negev Desert range from 16 m^2 to 1,000 m^2. Each is surrounded by a dirt wall 15-20 cm high (Figures 20-23). At the lowest point within each microcatchment a basin is dug about 40 cm deep and a tree planted in it. The basin stores the runoff water from the microcatchment. The size of the basin is matched to the water harvest expected.

The basins are fertilized with manure, and, unlike the catchment area, their soil surface is kept loose to encourage water penetration. A mulch may also be used to decrease water evaporation from the soil.

On an otherwise barren desert plain, microcatchments provide enough additional water to ensure the growth of fruit trees and forage plants. Microcatchments and variations of this method are used in Tunisia for growing olives and apparently have been since ancient times.

In the Negev, microcatchment construction costs are very low, from U.S. $5 to U.S. $20 per ha, depending on the catchment size. The cash return from crops repays their construction costs within a few years[10].

Microcatchment are more efficient than large scale water harvesting schemes because conveyance losses are minimized.

10. Evanari ; Shanan, and Tadmor, 1971.

In light rains, they provide runoff water when others will not. It is much cheaper to convert a certain area into microcatchments than to construct a runoff farm because microcatchments do not need channels, conduits, terraces and terrace walls. Also, microcatchment can be built on almost any slope, including almost level plains, enabling the farmer to use large, flat areas un-suited for runoff farms.

Desert Strip (or Contour Catchment) Farming

Desert strip, or contour catchment, farming is a modification of microcatchment farming. It employs a series of terraces that shed water into a neighbouring strip of productive soil. They are often tiered up hillslope, (Figure 24), but on level terrain an artificial slope for the catchment can be made by mounding soil between the strips.

The catchment section can be left in a natural state or cleared of rocks and vegetation, planted with range grasses, or made impervious by the sealants. Desert strips are, in general, even easier to install and maintain than microcatchments. These methods are being tested in Arizona ; in Wadi Mashash, Israel, it is used to produce grazing for sheep (Figure 14).

Advantages

Runoff water can allow plants to grow in otherwise too arid habitats. Highway edges often illustrate the principle : because the road acts as a catchment, roadside vegetation on the lower side is greener and more dense. It has even been proposed that water-storage tanks be built besides road pavement at the foot of suitable hillslopes to collect water.

Runoff agriculture can be used to make new agricultural lands where water is otherwise inadequate to support agriculture and yields from already cultivated areas can be increased without installed costly irrigation projects to bring in water from a neighbouring region. It has particular promise for marginal areas ; runoff agriculture can lower the risk of crop failure.

Runoff used to grow forage can relieve grazing pressures on nearby rangelands. Overgrazed areas can be revegetated and the carrying capacity of grazing land greatly increased. For example, the weighted average productivity of an 80-ha water-spread area at "Conneybar", Byrock, New South Wales, Australia, from 1968 to 1973 was 2.66 sheep per ha. Without water spreading the carrying capacity of this region is 0.18 sheep per ha (as measured over the 25 years 1947-1972). Seasonal feed shortages still occur in poor rainfall years at Conneybar, but their consequences are much less than they would have been without water spreading. High grazing intensities have been applied for short periods. Upto 586 sheep per ha have been grazed on a 28 ha pasture for periods of upto 4 days. Runoff irrigated fields are used as special fields to increase control over, and minimize losses of newly born animals and to hold stock during shearing, dipping, mating, etc.[11]

Runoff agriculture can extend the season during which forage is succulent and nourishing, providing green forage when it is especially needed.

Water spreading can provide erosion control, for it deflects the torrent of water and dissipates its energy.

11. Cunningham. 1973. (See Selected Reading.)

Limitation

Runoff agriculture requires a deep soil that can store water between rains. It works best for deep-rooted crops, such as trees and shrubs, which can tap stored water and depend less on frequent rainfall. Annual crops, in contrast, need rain at the begin-

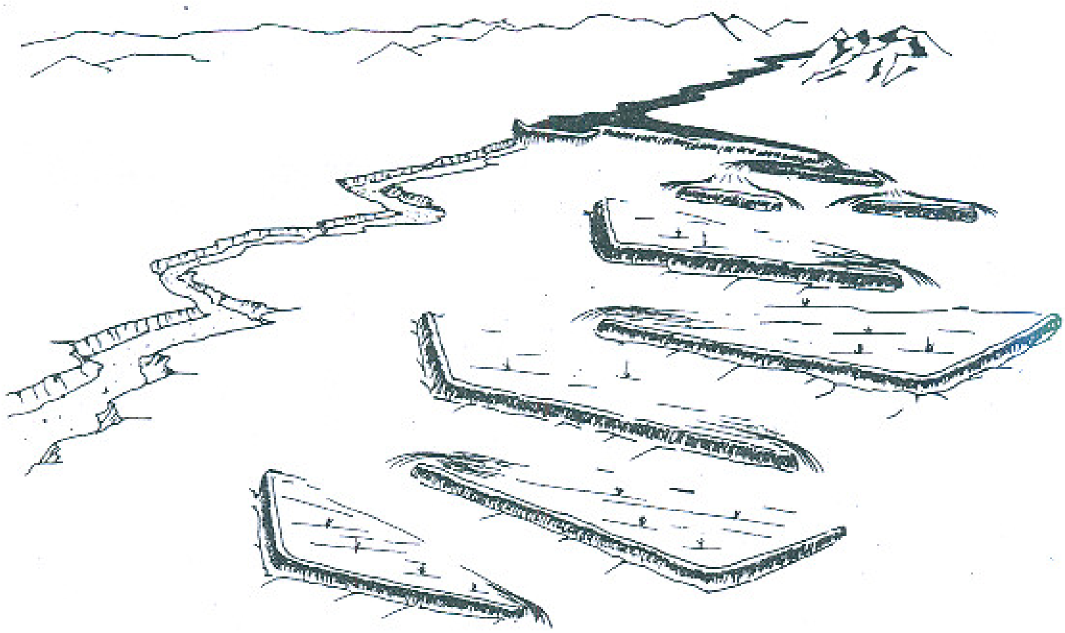

FIGURE 17 Sketch of water-spreading dikes built in Pakistan. Zigzag pattern slows the torrent of floodwater and allows it to penetrate the soil. Crops are then planted in the wetted areas behind the dikes. (Adapted from French and Hussain. 1964. See Selected Readings)

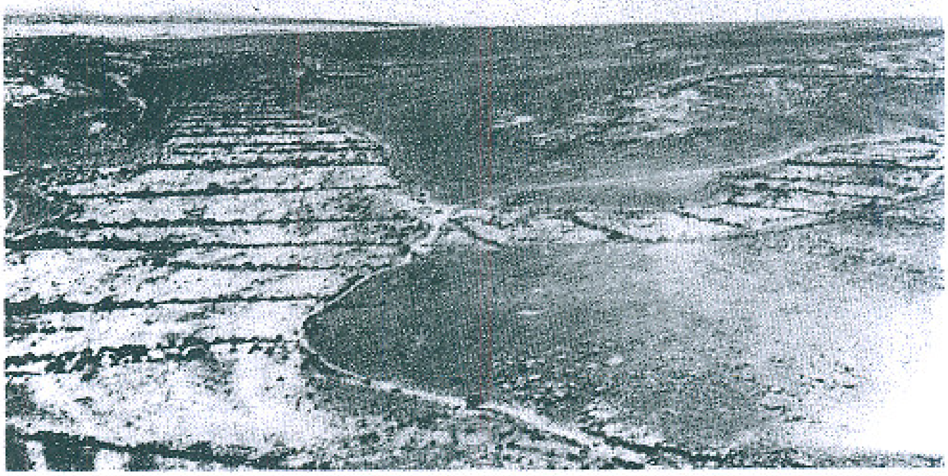

FIGURE 18 Man-made terraces (reinforced by unpalatable bushes) built in ancient times to slow down and capture floodwaters in this wadi in the Negev. Built thousands of years ago, some are still used for farming by Bedouins. Terrace walls are 10-50 m apart and about 30 cm high. Rain brings wild flooding; surplus water pours over the terraces; but the walls retain a pool of water that slowly sinks into the soil. Experiments here have shown that these walls are high enough to fully moisten enough soil to get crops such as barley or wheat to maturity. Water spreading may predate irrigation. Ancient farmers built many such systems throughout the Middle East, South Arabia, and North Africa. (L. Evenari)

FIGURE 19 In 1972 near the small town of Tchirozerine (close to Agades), Niger, West Africa, Touareg nomads build a rock wall to capture flood waters. The soils here absorb little moisture, and the rainfall runs away in flash floods. Using stones gathered from the fields, Touareg workers built eight 1-m-high walls across the plains so that rain is retained, and absorbed by the soil. When summer showers fell in 1973, the water retained by stone dams and walls flooded nearly 1 square mile on the plain and grass flourished—extraordinary events in that area. (Oxfam-America)

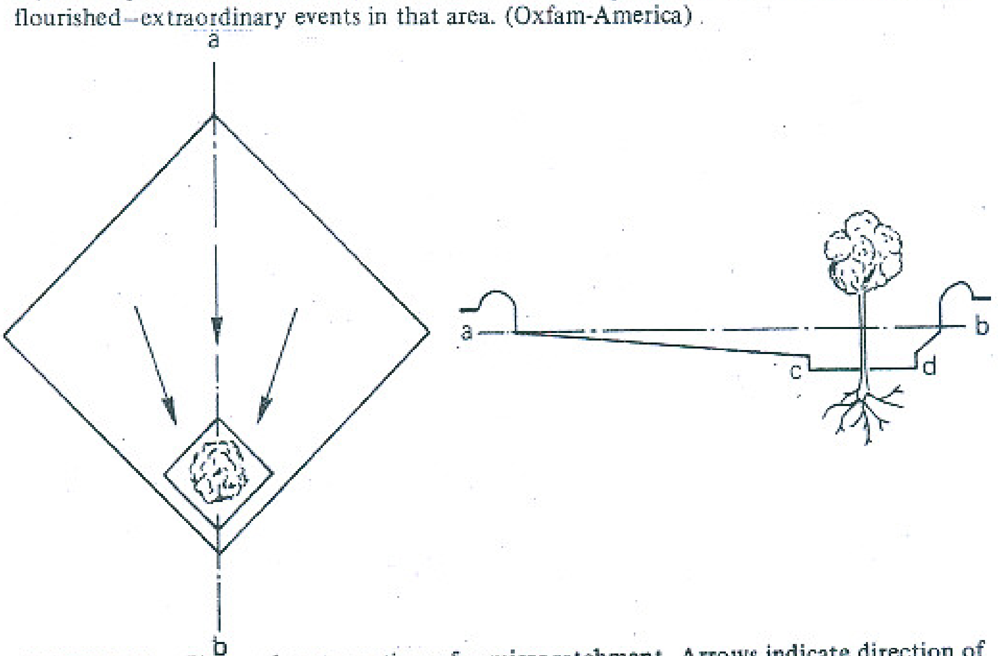

FIGURE 20 Plan and cross-section of a microcatchment. Arrows indicate direction of runoff flow. Cultivated plot (c–d) is placed at the lowest point of the natural terrain within the catchment; its position varies. Walls are 15-20 cm high; c–d is about 40 cm below the catchment, holding seeping water close to the plant; root-zone soil must be at least 1.5 m deep; the a–b distance can be less than 5 m or more than 30 m, depending on climate and crop. (M. Evenari)

ning of the growing season and sometimes at intervals thereafter.

The method is enhanced by plant varieties able to withstand intermittently wet and dry soil. As in normal agriculture, yields also depend on insect and disease control.

Environmental prerequisites are :

* A minimum mean precipitation or 80 mm per rainy season if the rainy season coincides with the cold period of the year, more than 80 mm if it occurs during summer when evaporation is greater.

* Crust-forming or impermeable soils on the catchment areas.
* Soils in the cultivated areas with high water-storing capacity ;
* Not more than 2-3 percent salinity in the cultivated soil, and
* A minimum of 1.5-2 m of soil depth in the cultivated area (unless water-storage facilities are available).

In runoff agriculture the water must be distributed evenly over the cultivated area to prevent prolonged ponding, over-irrigation, or deep percolation losses. In some cases the area to be cultivated can be constructed so that any excess spills a lower collection level. The cultivated area must be uniform, without gullies or ridges. Before deciding on runoff agriculture one needs to consider.

* The water-use characteristics of plants to be grown ;
* Their yields ;
* Their ability to resist drought ;
* Whether the soils in the cultivated areas can store enough water to mature the crop ; and
* The amount of evaporation from the soil surface.

Stage of Development

In ancient times runoff agriculture was widespread over the whole arid region of the Middle East, southern Arabia, and North Africa. On many thousand of hectares of the Negev Desert, it was the basis for civilization.

Runoff agriculture has been shown to be technically sound for modern use, too. Its rebirth as a systematic method took place in the Negev Desert in Israel, where large-scale experiments have been conducted for the past 15 years (Figures 15,16 and 21) and a training school for developing-country personnel is located at Wadi Mashash (Figure 23). Some microcatchment farming occurs today in several other arid countries such as Mexico, Botswana (Figure 22), India, Pakistan and Australia. The microcatchment method is used to grow wheat and fruit trees over a 70,000-ha area in Khost province, Afghanistan.

Needed Research and Development

Runoff agriculture can be used today if care is taken in selecting the site, designing the system, and selecting the crop. With good management it can make arid wasteland productive and can be economically sound investment. Modern experience, however, is limited to a few isolated projects. Intensive techno-economic evaluations in several regions of the world with different climates, soils and crops are needed to identify its potential for the future.

To make runoff agriculture more effective, there is a need to develop crops better suited to it. For example, if crops matured in 60 instead of 80 days, the soil would not have to store so much water, the risk of crops failure would be lessened, the system would require less rainfall, and management requirements would be reduced.

In microcatchment farming the crucial problem is still the optimal size of the microcatchment for each species. It is obvious that this parameter is relative not only to each species but also to precipitation, soil quality, and steepness of gradient. We have much to learn about such matters. Other problems concern optimal depth and the size of the basin in relation to the size of the catchment area. These factors are most important because they determine, inter alia, the size of the surface area wetted by the flood and the volume and depth of the water column in the soil. These, in turn, affect the time during which the soil containing the root system is waterlogged and soil and root aeration is bad. A knowledge of these factors may even lead to different patterns of constructing the basins and the placing of the trees perhaps on a knoll inside of the basin. There may also be the possibility of increasing runoff volume by pretreating the soil surface of the microcatchments in different ways[12].

12. Evenari, Shanan, and Tadmor. 1971. Op. cit. p. 228.

Techno-economic studies are particularly needed for runoff agriculture using chemically treated and ground covered catchments.

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FIGURE 21 Microcatchment farming in the Negev. Pomegranate trees grow in 500-m^2 microcatchments in a 100-m-rainfall region. The only soil treatment is shaping. The orchard is less dense than those in temperate climates; 40-60 pomegranate trees per ha are planted. Smaller trees, such as grapevines, can use smaller catchments (80-100 per ha); catchments of just over 30 m^2 (320 per ha) are enough to grow a saltbush plant and guarantee a supply of forage even in severe drought. (L. Evenari)

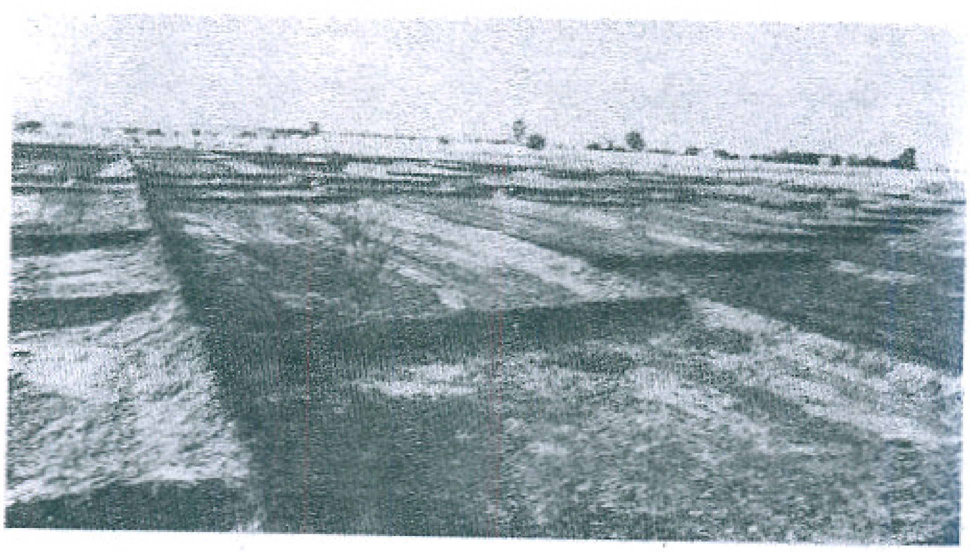

FIGURE 22 Microcatchments in Botswana with 2-year-old apricot trees. (U. Nessler)

FIGURE 23 Participants in the international training course in the Negev Desert preparing microcatchment plots (see chapter 2 Contacts). (U. Nessler)

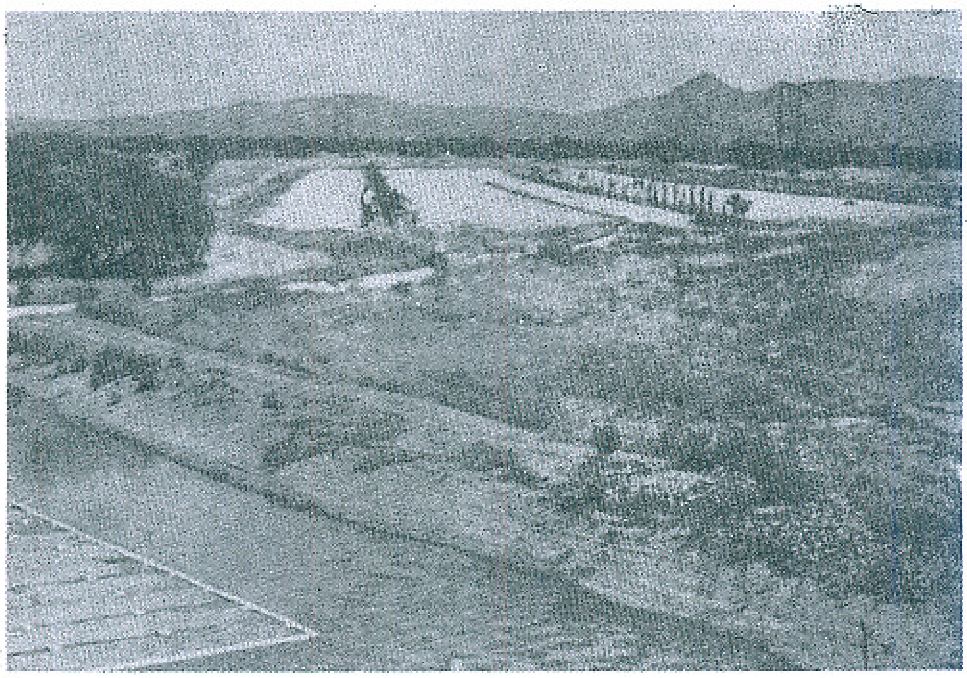

FIGURE 24 Desert strip runoff farming at Page Experimental Ranch near Tucson, Arizona, USA. Grapes are cultivated in drainage ways. Catchment area treated with sodium chloride remains bare; untreated foreground area has returned to native grasses. Bottom left-hand corner shows part of an expanded-polystyrene floating cover designed to reduce evaporation from the pond (see chapter 7). (C. B. Cluff)

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Contacts

Central Arid Zone Research Inst: Jodhpur, India (H S. Mann, Director).

College of Agriculture, University of Arizona, Tucson, Arizona 85721, USA (W.G. Matlock)

Department of Agronomy and Plant Gentics, University of Arizoaa, Tucson, Arizona 85721, USA (N.F. Oebker)

German Agricultural Group, P.O: Box 183, Kabul Afghanistan.

Intermediate Technology Development Group Ltd., Parmell House, 25 Wilton Road, London SWIV IIS, England.

Oxfam B.P. 489, Ouagadougou, Haute Volta, Africa (M. Behr) Soil Conservation Service of New South Wales, Condobolin, New South Wales 2877, Australia (C.M. Cunningham)

Wadi Mashash, a runoff agriculture training center in the Negev Desert for trainees from arid lands all over the world (M. Evenri Botany Department, Hebrew University of Jerusalem, Israel). Also contact: Wadi Mashash Information Center, 61 Darmstadt, Paulusplatz I. West Germany (C. Schenk and U. Nessler).

The Other Side of the Mississippi River*

This is where it begins, quietly and softly, amid the pine forests of Northern Minnesota. This secluded setting is the birth place of the mightiest river in North America. The Ojibwa Indians, who roamed its tree-lined banks, called it Mississippi great river. Only a few miles from its source the river already expands its banks, spreads and deepens its channels. Is it eager to prove the right to its name ? For more than 2000 miles from Lake Itasca to the Gulf of Mexico the mighty Mississippi slices through heartland of the United States ; a broad and moving ravine that glides past an ever-changing panorama of scenic wonders, rich farm – lands, busy cities and picturesque river towns. The Mississippi, a blessing to millions of Americans who live, who work, who play along its banks, and frolic upon its wide expanses — the Mississippi, source of water to sustain human life, source of water necessary to industry, providing a broad natural highway for moving supplies and products vital to the economic progress in America. This great river, with its scores of tributary rivers and streams, forms the network of the Upper Mississippi river basin. During the pioneer years, when the United States was being shaped, it was only natural that man chose to settle alongside the rivers. Men built their lives, homes, cities and businesses, on the banks of this massive inland waterway. The Mississippi and its tributaries have kept pace with those it serves, by supplying answers to many of mankind's needs and desires. Great river - father of waters - the mighty Mississippi, serene in the sunset hush of its gently flowing waters, until it becomes a terrifying maelstrom of rolling ugly waters, violent, cruel, a destroyer of land, property and human lives. Residents of the Upper Mississippi river basin will long remember 1965, as the year of the big flood. Earlier floods of 1950 and 1952 had smashed previous high water and property damage records, some of them dating back to 1880, but the big flood of April, 1965 was to be greater, of longer duration, and even more devastating than any Upper Mississippi river flood in the memory of man. The river, turned killer, spilled from its banks, inundated 3 million acres of some of America's most productive farm-land ; invaded some 125 cities and towns, paralysed rail, highway, and river transportation, caused the death of 15 persons and damaged or destroyed 157 million dollars worth of public and private property. Later, after the angry water had receded, leaving millions of tons of foul-smelling muds, and

**Transcript made from the sound - tracks of U.S. Army Corps of Engineer's colour film, "The Other Side of the Mississippi River."*

rotten debris, river residents asked each other : "What is it that makes normally friendly river go on periodic rampages"? How did the big flood of 1965 happen ? It started with snow. During March, snow fell almost every day. Throughout that month, many parts of Minnesota and Wisconsin received 3 times the average snow-fall. Billions of tons of wet, heavy snow covered the area, a water equivalent to 4 - 11 inches. The earth beneath the moisture ladden show-pack was solidly frozen to depths of 2 - 4 feet, thus billions of gallons of melted snow, which in an average year was absorbed by the earth would, instead, this year seriously overload streams and rivers. The hope was that a slow warm-up would melt the snow cover gradually. Instead, there was more snow. The outlook was grim, with a forecast in mid March for a general potential flood of 2 feet over flood stage throughout the entire Mississipi river basin in Minnesota.

The public was forewarned. As new information came in from the field, it became obvious that the threat of a major flood was mounting fast. The predictions were regularly updated. Forecast was tragically accurate. The big flood of 1965 was underway. In order to understand how the flood occurred, we must look at the area's river geography. It is a region laced with complex small streams that flow into larger rivers which, in turn, empty into the Mississippi. This network of moving water drains vast areas in Minnesota, Wisconsin, Iowa, Illinois and Missouri, that comprise the Upper Mississippi river basin. Weeks before the epic flood, the State of Minnesota Office of Civil Defence had sponsored a pre-disaster conference of State, Country and Municipal Officials, Personnel of U.S. Weather Bureau, compiled data on expected river crests and issued a complete flood forecast. Corps of Engineers in the Weather Bureau then defined the flood threat and pointed out the areas likely to be hardest hit. The Corps outlined, step by step, procedures that would prevent, or at least lessen, large-scale property damage. District Engineers visited threatened areas to advise officials of the seriousness of the impending flood threat to their area and to stress the importance of advance preparations. The Television, Radio, Newspapers, U.S. Weather Bureau and the Engineers alerted and advised the public. What it takes to fight a flood is sand, millions of cubic yards of sand, and earth, and burlap, and showels, trucks, equipment, know-how, and sweat. Unpaid volunteers bent their backs, many of them working around the clock. Once a flood begins, the time for flood control is long since past. What all the towns can do is to build their defences and ready themselves for the inevitable. Then, the worst thing possible happened - rains ; in sections of Southern and Central Minnesota upto 1 inch fell within a 24 hours' period. During the flood, 5 inches of rain fell in some areas. On April 9th, waters of the Minnesota and blue Earth rivers rose to over 29 feet at Mankato, the highest stage since 1881. Down river, the Minnesota hit St. Peter, Henderson, Carver, Chaska, Shakopee and St. Paul. Other rivers overflowed the Zumbro, the Crow, St. Croix, Chippewa, Cannon Root, Upper Iowa, Kikapoo and Wisconsin. The St. Croix alone added about a billion and quarter gallons of water per hour to the already swollen Mississippi. When the floods' full fury struck, new high water marks were recorded in community after community. Across Wisconsin, nearly 6 feet above the flood stage, Rock Island, Illinois and devornport, low, over 7½ feet, Guttenberg, low, more than 8 feet, Mankato, Minnesota, 11 feet, St. Paul 1 feet, and at Somerset, Minnesota, the water stood at more than 21 feet above the flood stage level. And so the flood fight went on - man against nature on the loose - in scores of communities along the Mississippi and its tributaries. While the one on Minnesota won its battle with the river only after waging a massive 8 day fight, hundreds of volunteer workers placed 350,000 cubic yard of earth, filled and placed 1,300,000 sand bags and used upto 100,000 square yards of plastic sheeting, building a 9 mile long dike as high as 15 feet. When water seeped under the earth and dike, 57 portable pumps threw the water back into the main river. The city estimates of their heroic flood fight cost about two million dollars, but it prevented about twenty million dollars worth of damage to public and private property. Tragically, in some communities emergency flood fighting measures were too late, too little, or not at all. In some towns, volunteers and local authorities fought stubbornly and lost. At Mankato, 240 acres of the city works were inundated with water that rose above first floor windows causing damage to 62 Industries, 1 High School and 350 homes. 4,500 Mankato residents were displaced. At Carver, Minnesota, the river went 16 feet over flood stage and covered half of the town above the first floor. At Chaska, 1,500 persons were forced to flee their homes in haste when the dikes failed. Emergency dikes saved the city sewerage plant in its County Court House. At Prairie du Chien, Wisconsin, some 250 homes were flooded, 1,000 people were evacuated, and 59 business establishments damaged. Rail road traffic drowned to a halt. Flood fighting is intensly personal. It is men and women fighting, sometimes with their bare hands, to save their towns, their homes, their business firms and their lives. During the flood of 1965, more than 100,000 residents of flooded communities worked until their backs ached, their hands blistered and their eyes grew red from lack of sleep. Officers and men of the Minnesota, Iowa, Illinois and Missouri National Guard, performed rescue operations. More than 600 Corps of Engineers employees aided by several thousand temporary emyloyees provided advice and assistance to officials in 65 flood localities and built emergency dikes of several locks and dams along the river. The responsibilities of the Corps of Engineers in flood fighting are defined by Federal Law.

The role of the Corps is to advise State and Local Authorities when requested to do so, and to assist when States or Local Authorities have exhausted their capabilities, or are unable to cope with the flood situation. Thus, after all local resources were exhausted, the Corps furnished flood beseiged communities with sand bags, lumber, plastic sheeting and other flood fighting materials, in addition to trucks, pumps, portable lights and hand tools. Coast Guard craft patrolled the river, rescued the stranded, and prevented looting. Navy, Air Force and National Guard aircraft flew rescue and reconnaisance missions.

At last, the savage brown water began receding after 22 days at St. Paul, a month at Contin, Iowa, 6 weeks at Hannibal, Missouri, making the big flood of 1965 not only the most severe in Upper Mississippi river history, but the longest as well. As residents began the dreary task of restoring their damaged homes and business firms, State, County, and Local officials throughout the flood area began adding up the cost. The total was almost staggering. Throughout the Upper Mississippi river above Hannibal, Missouri, damage to public and private property is estimated to be more than 92 million dollars, damage to agriculture more than 44 million dollars, and damage to transportation systems more than 21 million dollars. In Minnesota alone, an estimated 21 thousand families suffered losses and 40 thousand families required flood aid. Many thousands more in Wisconsin, Iowa, Illinois and Missouri, were forced to flee their homes. 15 million dollars worth of damage is monumently tragic statistics yet, behind that massive loss lies personal tragedy that can never be measured by dollars and cents. Money and time and sweat can rebuild a flood battered community. Soapwats and elbow grease were removed to dirty brown marks, but the emotional scars of the flood survivors - do they ever really heal? How does one measure that kind of loss in dollars? Fighting the big flood cost the affected States and communities - some 11 million dollars - a tremendous sum. However, that 11 million dollars prevented more than 260 million dollars worth of damage that surely would have-resulted, had it not been for the emergency dikes that were constructed along the Mississippi and its tributaries.

May, 1965 was beautiful. The sun had warmed the lands; the rivers were returning to normal; most area residents pushed memories of the flood into the dim recesses of their minds, except those who had suffered through the nightmare of angry water that crept, crawled, added, and swirled through the streets and buildings of their town. Many of the more thoughtful asked the question: "Can we make this flood, the last flood"?

The Corps of Engineers was established in 1775. In 1824 it was made responsible for maintaining the nation's navigable rivers, for conserving water resources. In 1936, the Corps was assigned the additional responsibility for assisting States and communities in developing and carrying out local flood control programmes. The Corps of Engineers employ several techniques for controlling floods. However, one of the most effective methods for water conservation and reduction of downstream levels during flood periods is to store the excess water in reservoirs, holding it until river levels have subsided. In addition to reducing floods, where reservoirs are feasible and desirable, they conserve an area in many other ways. They can provide industrial and municipal water supplies, water for power generation, irrigation, recreation and conservation of fish and wild life. Hundreds of these man-made lakes have been constructed. The combined short-lines of such reservoirs now in use by the public across our nation already is nearly three times the distance of the United States coast - line from Maine to the State of Washington.

Rivers are nature's gift to man. However, if man hopes to be able to continue using the magnificent resources of our nation's rivers, he must learn to utilize flood plain lands in such a way as to minimize the potential for periodic flood damage. Play grounds, picnic areas and base ball grounds suffer little or no damage if flooded occasionally and can be easily cleaned up and restored to use. Naturally, not all flood plain land can be devoted to recreation facilities. Flood plain information reports would provide sound advice for proper land use by the local community. On many occasions it may require upstream reservoirs, local levees, or flood walls, as well as regulations to resolve the conflict between man and nature over the use of the flood plain. While State and local officials, assisted by the Corps of Engineers, tackle problems of flood plain management and flood control planning, Federal authorities are meeting the immense challenge of conserving and utilizing all the nation's waterways. In 1962, Congress assigned responsibility for developing and co-ordinating this broad and large-scale planning to the Corps of Engineers, included in the Upper Mississippi basin study. Partners in this gigantic undertaking are the United States Departments of Commerce, Agriculture, Interior, Health, Education and Welfare ; the Federal Power Commission and the seven States that comprise the Upper Mississippi river basin. Flood plain management, flood control planning and Upper Mississippi river basin development, are the responsibility of every one, from man in the street to the State Capital to Washington D.C. A community must become familiar with the flood hazards of its rivers, which helps to exist alongside the rivers in relative peace and tranquility. Man will always be plagued by floods, but wise use of floods plain lands combined with modern flood control measures, hopefully can reduce future damage of the magnitude of the big flood of 1965 and can change the face of the other side of the river.

Levees on the Lower Mississippi*

This is the Mississippi river. It is a meandering river, a restless river, following a serpentine course through the centre of the continent to the sea. And these are levees - black lines on the map, in the office of the United States Army Engineers. Black lines on the map, but so much more, for levees are the difference between flood disaster and security in the lower Mississippi river valley. Flood swollen streams have been a dread to the habitation of river valley since the dawn of civilisation, and the use of levees for flood control is almost as old as recorded history. In the lower Mississippi valley, levees were first used in the early 1700 at New Orleans, then under the flag of France. French Law required each land owner to build levees along his river front property, or to forfeit the land to the Crown.

The small haphazard levees of that day have long since given way to the large precision-built earth walls. Levee construction methods have evolved from the use of geared barrels, through new drawn equipment of early motor driven machines, to modern day diesel and electric equipment. Today, an effective system of levees literally walls-in the lower Mississippi river. A drainage basin of the Mississippi covers 1¼ million square miles, all a part of 31 states. The upper portion of the valley is old, millions of years old, but the lower portion is young, only a few thousand years old. A flat alluvial valley, broken only by a few blasts and ridges. For centuries, the Mississippi meandered at will, over the 35 thousand square miles of the alluvial valley. Before civilization came, it did not matter that the great river flooded vast areas every Spring. But now the lower valley is homed by more than 9 million people. They and their cities, industries and agricultural areas must be protected from the ravages of the great river, and for that protection, man falls back upon his ancient friend, that levee. Beginning at covered hills, just south of Cape Girardeau on the west bank of the Mississippi, the levee extends unbroken to the Wappapello Reservoir on St. Francis river near Wappapello. From that point, levee extends to the mouth of the White river. The longest continuous levee in Mississippi river system, probably the World's longest levee begins near Pine, Arkansas, flows the south bank of the Arkansas river to its mouth, down the Mississippi, across old river, with its two control structures and navigation locks, and extends to its terminus at Venice,

**Transcript made from the sound - tracks of U.S. Army Corps of Engineers' colour film, "Levees on the Lower Mississippi"*

Louisiana, a total distance of about 650 miles. Levees surround the city at Cairo, Illinois, at the confluence of the Mississippi and Ohio rivers. On each bank of the river between Hipman, Kentucky, and Memphis, Tennesse, levees and natural bluffs alternate to provide flood protection. In all Memphis, a levee 270 miles long extends to a point just above Vicksburg, Mississippi. From Vicksburg to Baton Rouge the river banks are hilly. At Baton Rouge the levee begins again and runs unbroken to Houma, Louisiana. From Cairo to Baton Rouge the levee lines do not follow the banks of the river but lie at some distance, often several miles from the Mississippi. During period of high water, the flow of the river may increase to 28 times the low-water flow. At such times the river overflows its banks, extends from levee to levee under control. Cities, industry and plantations are protected by the levees. Below Baton Rouge the slope of the river decreases, the banks are more stable, the current is less swift and the levees run close to the river banks to a point well below New Orleans. How did this vast and horrible levee system come into being ? Why, when, by whom, was it conceived and built ? Who watches over it, and keeps it ready to resist the onslaught of floods ? The answers to these questions are the story of levees on the Lower Mississippi. In the Lower Mississippi valley, the year 1927 is remembered as the year of the flood. This flood was in every sense the worst in the history of the valley. More than 26 thousand square miles were flooded ; hundreds of lives were lost and property damage went to hundreds of million of dollars. Seventeen breaks in the levee system existing at that time totalled more than 5 miles in length. Loss and destruction wrought by the great flood, resulted in Federal Flood Control Act of 1928, which directed that action be taken to control the Mississippi river in its alluvial valley from Cape Girardeau to the Gulf of Mexico. This flood control plan, authorised by Congress, developed and being carried out by the Corps of Engineers under the direction of the Mississippi River Commission, includes flood-ways to divert excess water from the main channel ; reservoirs to hold tributary waters back from the main river, until the Mississippi can safely carry the extra burden ; channel improvement and stabilization accomplished by dredging, dikes, bank protection to put the Mississippi in a desirable alignment and to hold it there, and most important of them all, levees. Before 1928, flood control was largely a local responsibility. The people of the valley through their own flood control organizations spent millions of dollars building hundreds of miles of levees in an effort to protect themselves against Mississippi river floods. Control of floods became a national responsibility under the Act of 1928. That Law provides for the enlargement of the existing levees built by local interests, and for the construction of additional levees at Federal expenses, but left levee maintenance the responsibility of the local flood control groups. Army Engineers plan and supervise construction of levees to prescribed standards, developed after many years of study and research, which included the use of hydraulic models and the techniques of soil mechanics. First of all, the levee must be right for the location in which it is to be built. Preliminary investigations and surveys must be conducted to ascertain the most desirable location and the most economical design. All existing improvements for flood control which may be effected by new levee construction must be taken into consideration. Existing drainage problems, or problems which might develop later, must also be considered. After this survey, the soil sample drills cut deep into the earth to obtain specimens of the underlying strata, which are then analysed and tested. The Soil Testing Laboratory checks the samples of the earth to determine whether the foundation is adequate to support the weight of the proposed levee, and to forecast the amount of seepage. Present day, the Mississippi river levees are designed and built high enough and strong enough to protect the valley from flood far greater than any which has ever yet come down the Mississippi. The designed flow lines were established by Engineers at the Mississippi River Commission. The computations were based on previous floods data and on extensive hydraulic studies. This line represents the crest of greatest flood probable in the lower valley under any conditions. Then an extra factor of safety was added in the form of freeboard. The physical height of the levee is determined by the natural elevation of the construction site as compared to the elevation of water surface when the design flood occurs. The degree of the levee slope is determined by the height of the levee. River side slopes must be gentle enough to allow mowing of the protective covering of grass, otherwise they are steep as the nature of the soil permits. The land side slopes are usually less steep. Some Mississippi levees are 30 to 40 ft. high, but the average is about 25 ft. above the level of the surrounding area. This is a somewhat distorted schematic cross-section of typical main line levee. For strength, the levee is 10 times as wide at the base as it is high. All main line levees, with roadways on top, slope upwards to a 25 ft. crown. During flood periods, water may seep through layers of sand beneath the levee. As the seepwater flows, it may carry material from the levee base and produce sand boils near the land side toe. Sand boils, if not controlled, to enlarge themselves and endanger the levee. Where the possibility of sand boils is known to exist, land side berms are constructed. The berms force the dangerous seepage to travel beyond the toe of the levee and to reach the surface at the safe distance with reduced velocity and volume of flow. Construction of the levee begins with an operation more suggestive of the destruction of a building. Bulldozers clear the land of trees and under-brush, exposing the soil on which the protective barrier arise. The composition of the base material is already well known. Engineers know its surface and its underlying structure. They want to know exactly what lies along the side of the proposed levee. So, instead of building, they first dig. They dig a ditch to explore the levee side and to make sure that no pipe line, log or other unwanted material is burried deep into the levee base. After the inspection, the ditch is back-filled, and the earth is compacted. The base is then ploughed to a depth of 6″ or more. Roots and other objectionable materials are removed. Under ordinary conditions, a heavy disc plough is used. If one heavy root growth is present, a ripper does the work. The levee has been planned and surveyed, the foundation has been analysed, prepared and inspected. Now it is time to place material and really begin construction. This particular levee is a composite of many already constructed along the Mississippi, is being built by the haulage method, one of the several ever evolving methods in use. Here, bottom dump hauling units of 6 to 18 cubic yards capacity, loaded with earth, move into the levee site, hauling it in the bottom pit. As the material is placed, it is spread and compacted by bulldozers. It is usually spread in 12″ layers, then compacted by three passes of a Crawler tractor or rollers to almost solid dense mass. Elevations and distance are constantly checked to see that the earth is placed in accordance with the limits prescribed by the specifications. No guess work or rule of thumb here. Placement of the earth in the levee is sometimes accomplished by the cast-in method. Specialised equipment cast the soil under the levee direct from the borropit. Here a dragline excavator places material. During, and after placement, the material is spread and compacted. Another way to cast-in material is by means of a tower excavator. Its 16 cubic yard bucket is very efficient where working conditions are suitable, and where the volume of work warrants moving of huge machines and constructing a power line for it. Compaction takes place during the placement and spreading of the material. Hydraulic methods may be used to build the embankment. Hydraulic construction becomes necessary when suitable borrow material is not available in the vicinity of levee line. A dredge is used to dig and dump the materials, sand or silt, and to discharge it through movable pipelines into levee embankment. Hydraulic fills require no additional compaction. The crown and slope of the hydraulic fills are normally covered with an earth blanket to reduce seepage, support the growth of grass, and to make future maintenance easier and less expensive, Regardless of the method used, the levee is always finished to close tolerances. Compacted and shaped, it is now ready for starting. After ploughing, fertilizing, the surfaces are planted with grass A or some other variety which will produce a sturdy growth to curtail erosion. Levee crown and slope are finally smoothed and compacted. In constructed areas, concrete flood walls some times take place of earth levees. This happens where industrial or other developments are located near the river banks. Flood walls provide equal strength and protection and require less room ; but they are more costly than earth levees.

So, these are levees. The Mississippi river levee system is almost 1,700 miles long-longer than the great wall of China, Building system has required over 5 times the amount of work excavated in constructing the Panama Canal. One mile of main line levee contains about 1 million tons of earth. Construction of this levee system ranks among the great engineering feats of the world, and returns to the people of United States almost 9 dollars in benefits for each dollar spent in its accomplishment. Levees are built well, built to last. But like all man-made structures they can fail, unless they are properly maintained. Chance of failure during floods is lessened by the simple understanding and application of good maintenunce by local Flood Control Organizations, clearing of trees and underbrush, poisoning of stumps, continuous diligent, thorough maintenance, performed year after year, during both low and high water periods. Levee failure by overtopping is a remote possibility. But erosion, seepage, scour, or burrowing animals, can cause the strongest levee to fail. All of these can be, and generally are, prevented by maintenance, mowing, clearing, replacing sod, and other work as required. Many levee districts have found pasturing cattle on levee a good practice to follow. The grazing keeps the grass, cropped and the levee becomes park-like in appearance. Local interests represented by levee and adjoining districts, community, County, and State Governments, have developed experienced workers to carry on maintenance operations. Levees and other flood control works constructed by the Federal Government, maintained by local groups, protect your land and crops, your cities, your industry, your economy, your valley. The Mississippi is not, and probably never will be, a completely controlled river. Studies, research, and improvement, must continue to ensure that the measures of protection provided keep pace with the development of the valley. The tremendous force i.e. the river, will have to be watched and cared until the end of time. Nevertheless, there are some effective controls of the river, and levees are the major line of defence. The Mississippi river is the greatest single physical asset of the United States. But it is an asset which if not properly safeguarded, can become a great liability. It is the Nations's duty, it is our duty, to safeguard it.

Buildings
Bridges
and
Highway
Section

Rajdhani Bridge Project Mechanised Construction of Pakistan

The site of Rajdhani Bridge is located in Azad Kashmir on River Poonch about 40 miles from Mirpur on Mangla Periphery Road. The object of construction of the bridge is to provide a road access to Dudyal and other villages confinded by River Jhelum and River Poonch. The bridge is spanning two high cliffs and is one of the most difficult sites for construction of a bridge in this part of Azad Kashmir.

The work of construction of Rajdhani Bridge was awarded in March 1972 by the P.W.D. (Azad Kashmir) with a lump sum contract of Rs 37,00,000.00. The work was taken in hand immediately but the progress was held up due to abnormal increase in cost of construction. The matter was referred to Azad Kashmir Government to review the costs in the light of the prevailing market rates for labour & material. The construction cost was reviewed by Azad Kashmir Government in a meeting held on 10.12.1974. The revised cost amounting to Rs 68.50 lacs, was approved without the cost of decking, which was to be intimated later on.

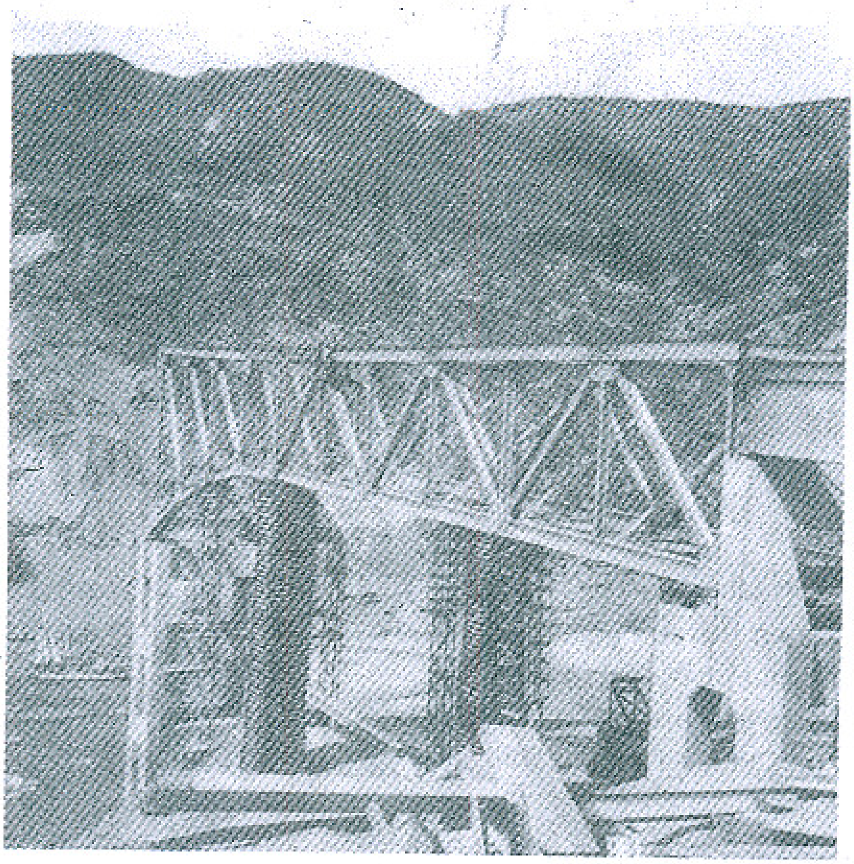
The salient features of Rajdhani Bridge are given as under :—

(i)	Type of bridge.	-	Steel structure
(ii)	Span	-	(a) Truss span 800 ft.
			(b) Girder span 128 ft.
(iii)	Road way		24 ft.
(iv)	Loading	-	IRC A class two train, almost equivalent to M.E.S. class 70 ton loading.

The steel super structure consisted of one girder span and one truss was purchased from TARBELA DAM PROJECT, which was put across Indus River near Tarbela Dam site to provide access facilities in preliminary stage. The bridge structure was manufactured and supplied by M/S. Dominion Bridge Co, of Canada. The steel super structure is shop-welded fixed with high strength bolts. No welding is required for its re-erection. The width of the road way is 24 ft, with a walk way of 4 ft. on one side.

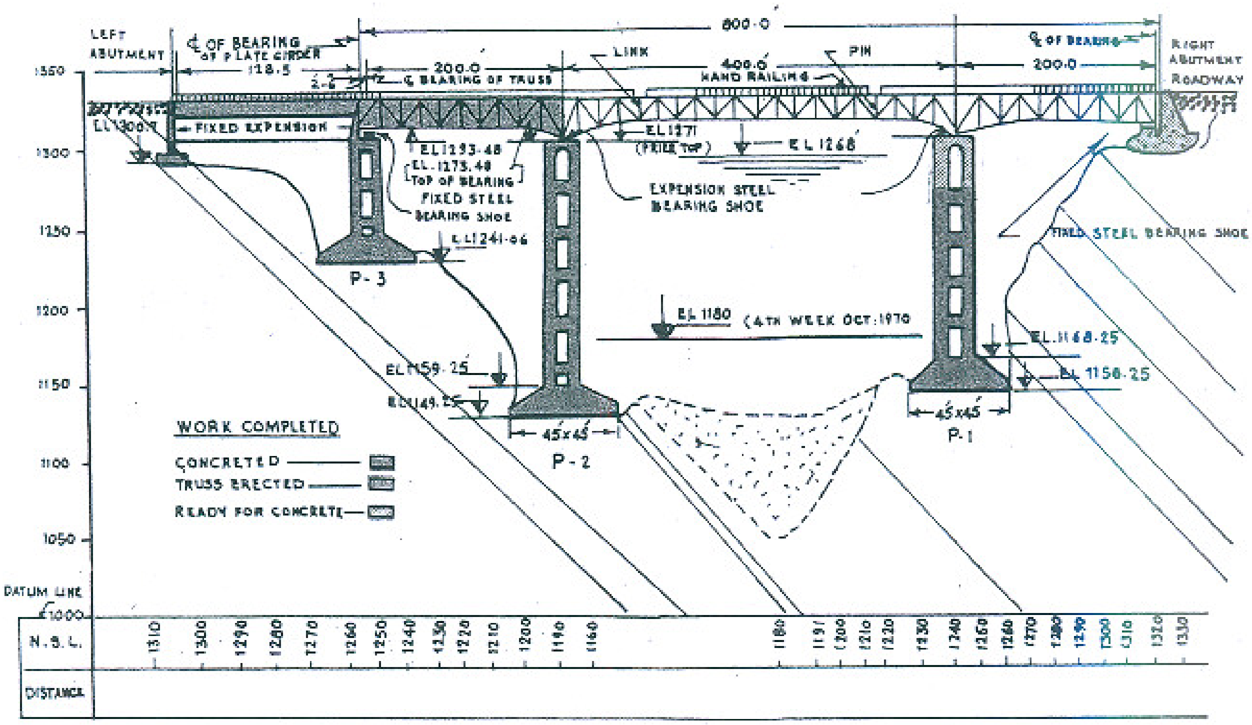
The gross weight of truss span is 896.24 tons and of girder span 85.4 tons. The complete super structure has been transported through low bed trailors and Railway wagons.

The construction of Rajdhani Bridge also involved civil work. The R.C.C. piers are required to be completed prior to start



Launching of Bridge between Piers 3 and 2.

Launching of Bridge between left abutment and pier 3.



.of launching. The main civil work can be divided as following :

(i) Construction of left approach, 2,050 ft (including excavation grading, making culverts, soling and black topping).

(ii) Excavation of right approach and right abutment. The work involved excavation of rock about 11,00,000 cu.ft. of rock by blasting.

(iii) Construction of R.C.C. pier, which consists of construction of 3 piers and 2 abutments. The position of pier and abutment is shown as per figures above.

The present stage of construction is that left abutment and piers 2 & 3 have been completed and for pier No. 1 and right abutment 3 pours are left to complete the R.C.C. work as 100%.

The excavation on right approach has been completed as 80%. The girder span and 200 ft. truss span has been launched completely. The work of construction of Rajdhani Bridge is scheduled to be completed by August, 1975.

The estimate of decking was submitted to Azad Kashmir P. W. D. Authorities during March, 1972 and it is likely the decking work will be done by A. K. P.W.D authorities themselves.

The Director General, Wapda is working as Engineer of the Project and is responsible for design and providing working drawings for the construction. The construction of Rajdhani Bridge is being done under the supervision and direction of the Engineer.

General Section

An Idea in Engineering Education

by

MAZHARUDDIN*
B.Sc. (Eng), C. Eng., M.I.C.E. F.I.E. (Pak)

Foreigners have generally described the Pakistani engineers as 'paper tigers', wanting in practical expertise ; which is a fair criticism but this might connote that they were strong in theory. Ironically enough, this implication is not justified. The Pakistani engineer - barring exceptions - is inferior both in practical and in theory and this assessment is based primarily on my own observations. I have been dismayed by my own and of my colleagues' inadequacies as engineers ; of lack of grasp both over fundamentals and practical details of the student and the professional. I am reminded of a contemporary of mine - a top student of final year of electrical engineering who was asked by the Professor how A.C. flowed through the circuit. He indicated the sine wave - then explained it oscillated up and down through the wire. This confrontation with painful reality has led me to ponder over the issue from time to time. The conclusion I have reached is that our educational technique is fundamentally wrong and that the system needs a total reversal of approach.

In a flash-back, I can visualise myself haplessly sitting in the class room many years ago ; the teacherstalking in straight to the black board and start developing abstruse diagrams and mathematical formulae dealing with Strain energy theory or the Clapeyron's theory of three moments. I have no idea how and why this problem has arisen ; what is its relation with the material world. I fail to relate these figures to realities and to myself. With the utmost good will my attention flags, my comprehension clouds. The same story repeats itself in class after class, of hydraulics, of practical mathematics and of survey. It has always struck me that this want of establishment of firm relationship between the practical concrete things, the theory and myself was the biggest stumbling block in my engineering training. This was the crucial integration that was forgotten. This lack of integration has disastrous consequences, inhibits deriving full benefit from education in the colleges and obstructs relating theoretical knowledge to practical use in professional life subsequently. How

**Chief Officer Research, P.W. Railway Research Centre.*

Lecture delivered to the faculty members in the syndicate room of the University of Engineering and Technology, Lahore.

to achieve this integration is the question.

It is an interesting phenomenon that whatever the nature of problem a Muslim tends to hark back to and derive inspiration from the great heritage that is Islam and my mind cannot help being drawn to the institution of 'Salat' - which is essentially a system of moral education of the psycho-physical entity that is Human Being. You observe the fusion of the physical-practical with the psychological-theoretical, both aspects completely integrated. The emphasis is on the practical; the verbal prayers uttered of secondary significance - the centre of attention Allah. Perception or the cognitive processes are based on sensory stimuli. The practical and concrete, the object, not only has to be associated with the process of learning, but ought to have precedence. Even in the real world of technological exploitation practice runs ahead of full understanding of the theory involved. We must, therefore, emphasise the concrete over the abstract and the practical over the theoretical, and observe that order of precedence.

If you want to teach about an electrical generator, the steps should be to present the machine in actual work situations, its use, its construction and the general principles before the mathematical theory. Familliarisation with the object should remain a step ahead. Theoretical question would arise automatically. Unilateral imposition of problems and solutions by the teachers should be avoided, as it militates against involvement and adversely affects comprehension and assimilation. Identification and formulation of the problem is part of the process of learning. Students should themselves search for and suggest the appropriate solution out of the available range; the teacher guiding and goading them and filling in the gaps of knowledge according to the felt need.

Our current method of teaching is based on proceeding from the elements to the whole. We start on bits of knowledge; theory of structures, geology, soil mechanics, hydraulics etc; hoping that these bits and pieces would somehow fit into a jigsaw puzzle to provide the comprehensive knowledge required to maintain or build a house, road, a power house or an irrigation headworks. This pious hope remains unrealised and the expected whole picture does not emerge. The situation is aptly illustrated by the parable of the four blind men and the elephant. I am sure you have all heard this parable but it might bear reiteration.

Once upon a time there were four blind men who wanted to discover what an elephant was. Each one explored a separate part of the body of the elephant by his hands and came to diverse conclusions. One who had got hold of the ear thought that the elephant was like a broad fluttering fan; the second, who happened to touch the leg thought the elephant was like a pillar; the third who had stroked the trunk concluded that the elephant was really like a thick smooth rope: the fourth one who had confined himself to the back of the elephant opined it was a vast table.

It is obvious that this blindness to the totality; this inability to see the wood for the trees is inherent in the approach which proceeds from the part to the whole. We have to strike at this approach if we wish to understand the totality. We have to entirely reverse this method and approach from the whole to the part. We have to adopt what I may be permitted to call the Strategic approach instead of the Tactical.

The gigantic task of reconstruction of the country awaits the Pakistani engineer. Grand planning continues to suffer from poor and tardy implementation. Actual jobs have to be done. Engineering education must therefore be given a strong task-orientation it lacks today. It should be tailored to the actual job requirements. And this is not to underrate the importance of providing a broad framework of technical knowledge and mathematical facility - a framework into which more detailed and advanced knowledge can be later fitted according to individual talent and opportunity. If we want to produce a useful civil engineer, he must also be able to manage construction plant. He should be acquainted with the normal range of compressors, welding plants, cranes, earth-moving equipment etc. He would be required to requisition and should know the type and capacity of plant. He need never know how to design the winding of an electric motor. He would almost certainly be called upon to construct a house. It is more important that he should know about plan arrangement, sizes of rooms, aspect of the house, materials of construction, use of concrete mixer, internal wiring circuit rather than the slope deflection method of analysis.

What is the broad function of an engineer ? It is to provide the physical facilities for the sustenance and progress of human civilisation be the engineer civil, mechanical, electrical or what have you. The 'Town' epitomises and concretises this function ; particularly for Pakistan where just to keep up with the rampaging population growth, we should every year build twenty-five towns of one lakh persons each. You see the staggering magnitude of the problem and shudder at the task that confronts the engineers. You find the present towns nothing better than slums and the villages even worse. In fact the entire physical facility of the country needs to be replaced. To me, therefore, the 'Town' and its creation represents the central theme and goal for the engineers of Pakistan.

Arising out of the foregoing general premise the scheme proposed is to confront all engineering students on the very first day of their college with a single project which they would be required to complete jointly in their entire stay at the college : "Plan a self-contained town of one lakh persons with arrangements for meeting all its needs for communications, housing, industry, water supply, education, culture."

The 'Town' project should be the central theme and discussions should begin with the needs of the Town ; how they can be met ; teasing the students, making them ask questions, suggesting alternatives and giving them injections of theoretical knowledge as the need arises and when they thirst for it. Let me trace one possible abridged ramification of the scheme as an example ;

TOWN - area required - you are offered an area - how to delineate it and prepare a map - introduce surveying, mapping - zoning and sectoral relation - buildings, industrial, commercial, recreational, residential - housing - classes of housing plot areas, floor areas, layout of rooms, sizes - sketch layouts - number of storeys - foundations - what are the requirements, what should be the sizes, materials - introduce foundation engineering, soil mechanics - walls, materials, sizes - introduce strength of materials - ventilation requirements, windows, their details, how to span them - introduce beam theory, cantilever etc. You can trace use of beams, cantilevers in other type of buildings and design a number of them for various usages - roofs, various types, their selection - R.C.C. slab roof - materials used - introduce slab theory - internal wiring system - power requirements - types of wiring, methods of casting, wiring circuits, introduce relevant theory - etc.

By the end of this exercise the students would get a fair idea of how to go about the business of constructing a small house and the relevant theories which can be developed and advance by taking a more complex but concrete situation such as a multi-storeyed municipal office or a power-house or a sports stadium.

Modern technology runs on team work. In every significant real-life activity, people have to work in groups - groups of various specializations complementing each other. It would be well therefore if the training programme of engineers is devised to enable students of various disciplines to work together as a team, to learn to integrate their efforts with other specialists, to consult them, to feed them with information, to know where their own conclusions or decisions affect the other's work and vice-versa.

To inculcate this teamwork and to take advantage of the intellectual chain reaction generated by group effort, the Project should be tackled by a carefully selected group of students which should include some bright elements. This group should consist of two students each from the civil, mechanical and electrical and one each from architecture, town planning, chemical, metallurgical and mining, making a total of eleven. The inclusion of the metallurgical or the mining students should not surprise anybody. After all, the end product of their strivings, like those of others, is consumed in the Town. The metallurgist has to advise other engineers what metals would suit their requirements. He ought to know first what performance is expected from various components of different machines before we can expect him to develop metals and substitutes to give that performance. This group should jointly complete the project in all its aspects; prepare a general index map and typical details for road, rail, power house cultural centre, mosque, flour mill, drainage, water supply, housing, chemical plant etc. Different classes of facilities can be given to different groups - say one group designs housing for low-income group and the other flats and so on. All groups put together will give you a fair picture of the

(Contd. on page 48)

News and Notes

Saad Tarique takes over as New Wapda Chief

Maj. Gen. Saad Tarique took over as new Chairman of WAPDA with effect from January 29, 1975.

The 51 years old grey-haired General of the Pakistan Army Engineers Corps has 23 years of varied experience to his credit. During this period he worked on numerous important assignment in the Army. Before taking over as WAPDA Chief he was the Engineer-in-Chief of Pakistan Army which post he held for a tenure of 3 years. He had been the Commandant of the Corps of Engineers for 4 years. Besides this, he also served the Pakistan Air Force as Director of Works and Chief Engineer. Maj. Gen. Saad Tarique is a graduate from the Command and Staff College Quetta and a Fellow of the Institute of Engineers (Pakistan).

In the realm of Engineering he gained practical experience in India and Pakistan. Later, he proceeded to the United States of America for higher training. Initially, Maj. Gen. Tarique was educated in the Government College, Lahore and was commissioned in the Royal Indian Engineers in 1943. As Engineer-in-Chief of the Pakistan Army he accomplished extremely difficult and strategical jobs, the most important amongst which is the construction of Kurakurum Highway in northern areas.

Abu Dhabi to invest over 30 Million Dollars in Fertilizer Plant

Abu Dhabi has increased its cash back for an oil and Fertilizer plant at Multan, raising its shareholding in the company from 30 to 48 percent. Total capital of the Pakarab Company ,has been raised to 65 million dollars of which this Gulf Oil state will now contribute 31,329,000 dollars under an amendment signed in continuation of agreement dating from Nov : 1973.

Switch Gears to be Made in Pakistan Soon

Pakistan will start manufacturing, by the end of this year, extra High Voltage Switch Gears used for transmission of bulk power by Wapda and Karachi Electric supply Corporation. Both these organisations spent million of dollars to import the switch gears from various countries. The state Electrical Corporation of Pakistan has started a project ; a joint venture with Brown Boveri ; A letter of intent has been issued to Brown Boveri for preparation of detailed designs and the Project Report. The production facilities existing at the old Factory of the Corporation will be extended and modified to manufacture, 66 KV and 132 KV minimum old circuit Breakers.

The report will be ready within 3 months. The new project will save substantial foreign exchange and eliminate delays in execution of Wapda's power projects caused by long delivery periods.

Rs. 100 Crore Fertilizer Complex for Hazara

A Rs. 100 crore fertilizer complex will be established in Haripur, Hazara. The project will be completed in about 3 years and the construction work is expected to start immediately. On the completion of the Project it will yield Rs. 12 crore to the provincial Government. The project is a joint venture with Federal Government.

Quetta Plans to Revive 800 Dead Karezes

An ambitious five year plan has been prepared by Baluchistan's department of rural development and agrovilles for re-activating 800 dead Karezes (underground irrigation (channels in the province.

The plan envisages re-activating one dead Karez in each district during the first year. On the basis of costs and benefits so experienced, three more Karezes would be re-activated during the second year.

In five year's time, all the dead Karezes are proposed to be reactivated.

On an average a Karez brings 50 acres of land producing two crops per annum. Re-activating 800 dead Karezes would thus bring under the plough 40,000 acres of land. Inspired by this prospect the government of Baluchistan has decided to undertake this project under the Integrated Rural Development Programme.

By reviving dead Karezes, the government aims not only at increasing the province's food production but also bringing about a social change in the way of life of the province's nomads. It is hoped that economic propsects on lands irrigated by the rehabilitated Karezes would be sufficient attraction to the nomads to abandon their wandering ways and lead a settled life.

Engineering council soon.

President Fazal Elahi Chaudhary said that the engineers were equal partners in the great partnership of administrators, planners and executors, which the peoples' government was endeavouring to establish for the gigantic task of pulling Pakistan out of difficulties. Inaugurating the 19th convention of the Pakistan Institute of Engineers on 9th March at Hyderabad, the President said it was for this reason that the government emphasised that engineers were no longer handy men to administrators. Speaking about the Institute Headquarters and regional centre, he urged upon the engineering community not to let their centres be reduced to social clubs. Let these centres be centres of excellence and exchange of ideas for engineering knowledge. He assured that government both at Federal and Provincial levels, would provide financial and administrative support to the Institute in achieving these objectives.

Referring to the disasters which beset the country in the recent past the president said, that one was natural, while two were partly natural and partly attributable to human failure. It was indeed gratifying that engineers had applied their minds and given whole-hearted attention to remedial measures, where human endeavour was capable of doing so. Repair of the damaged works at Tarbela, he said, had been attended to with the utmost speed and the situation was now under control. The power crisis had been successfully over-come. The earthquake disaster was a challenge for planners and builders, which will be accepted with zeal and patience. He assured the engineers that an Engineering Council will be established soon.

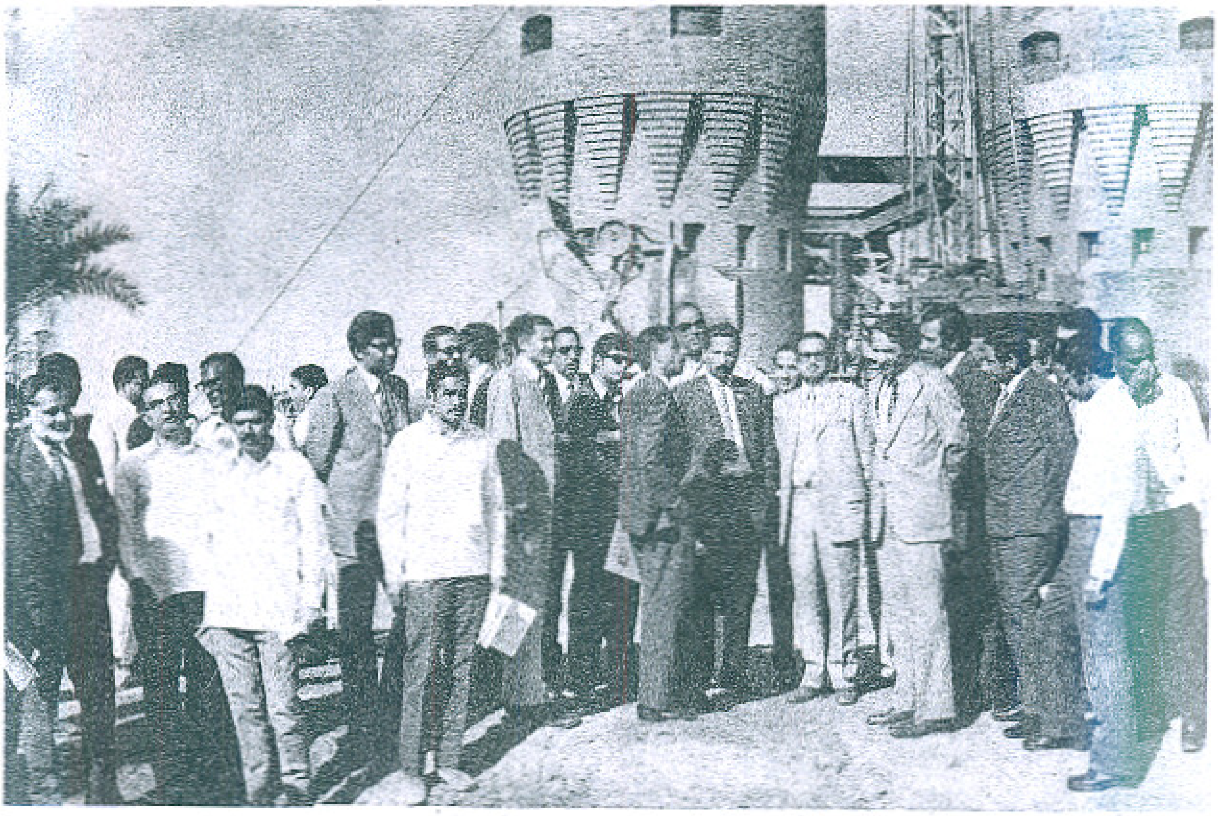
Earlier, Mr. Shah Nawaz Khan, President of the Institute of Engineers, welcoming the President, said that the major question mark before them was "are we big and strong enough to meet the challenges of our object poverty, low standards of learning and a marked depreciation of normal values". As a representative of the engineering community, he said, he could not claim that the Engineers all by themselves were in a position to provide all the answers to all the problems that beset the country. He hoped the community will act to the call of the nation for building a strong Pakistan, and Engineers will play their legitimate part and contribute their mite towards the achievement of national goals.

(Contd. from page 44)

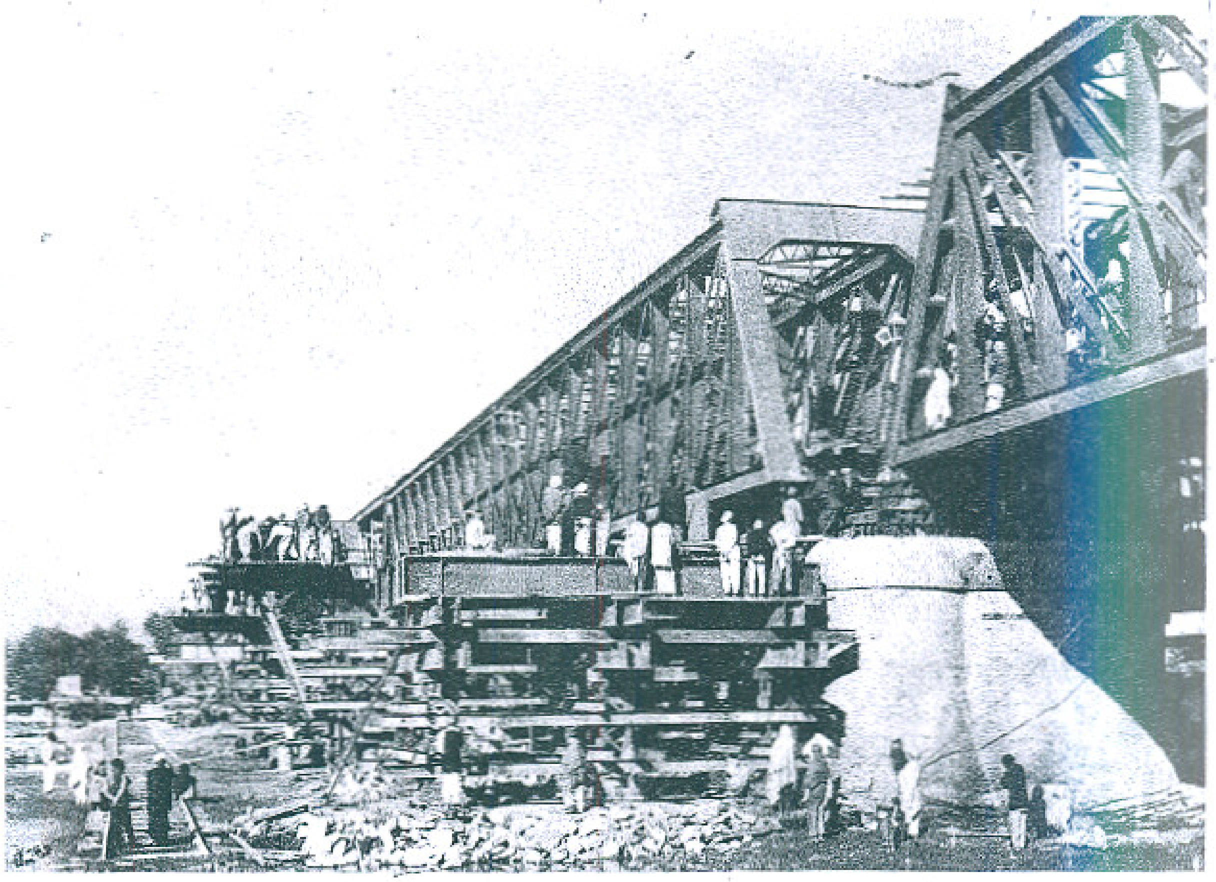
whole Town and you will have plenty of material to exercise all your theoretical knowledge and some more.

Even the class lectures should also be common for various disciplines as far as possible. They should be designed in a series starting from the basic 'Town' concept. Segregation of various branches should occur when a stage beyond the scope of a particular specialisation is reached. From simpler start, each new course could provide the occasion for more and more refined and advanced activity converting the university into a vast research centre, continuously making real contributions towards the building of a new Pakistan.

News in Pictures



Delegates of Pakistan Engineering Congress visited Shershah after the annual session in October, 1974 and inspected the work of regirdering of Railway Bridge.



Shershah Bridge under construction.

News in Pictures

Engineers who visited Tarbela Dam in February, 1975, under the auspices of the Institute of Engineers (Pakistan) are seen here with General Manager Tarbela Dam

(Photo Engineering News)

Delegates of Institute of Engineers (Pakistan) visiting Tarbela Dam in February, 1975, inspected damaged Tunnel No. 2. *(Photo Engineering News)*

Special Feature

ATTENTION MEMBERS

MEMBERS' DIRECTORY

THE SECOND ADDITION OF THE MEMBERS' DIRECTORY OF PAKISTAN ENGINEERING CONGRESS IS PROPOSED TO BE PUBLISHED IN OCTOBER 1975 FOR DISTRIBUTION AT THE ANNUAL SESSION.

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INCHARGE
MEMBERS' DIRECTORY
PAKISTAN ENGINEERING CONGRESS
LAHORE.

Introducing Pakistani Consulting Engineers

1. NESPAK

Background and Formation

The National Engineering Services (Pakistan) Limited, (NESPAK), an engineering consultancy service, was constituted in May 1973, by the Government of Pakistan. The philosophy behind the formation of this organization was to pool up and mobilize the best available engineering talent for providing professional consulting services both at home and abroad.

Administration

NESPAK has been designed as a private limited company, registered under the company's act, but owned wholly by the Government. This singular arrangement gives it the complete flexibility and dynamism of a commercial enterprise, coupled with the stability of a state-backed organisation. The affairs of the Company are controlled by a board of six directors, all of whom are nominated by the Government. A whole-time Managing Director, himself an experienced design engineer, looks after the day to day functions of the company. NESPAK has been able to collect on one platform some of the best brains in engineering design available in the county. Thus, in a short period of two years, NESPAK has grown into a self-sufficient and competent multi-disciplinary design organization.

Range of Services

NESPAK offers the broadest spectrum of expert technical services to its clients, from the conception to the completion and operation of development projects requiring a high-grade expertise. This covers the entire gamut of consultancy operations: from project planning, project appraisal, and feasibility and financial studies through project design, specifications, contract documents and construction drawings to actual supervision during construction, operation and maintenance, and general engineering services.

The wide range of the disciplines in which NESPAK specializes, include :

(i) dams, barrages, irrigation networks and river control
(ii) highways, bridges, tunnels and transportation planning
(iii) ports, harbours and inland navigation
(iv) groundwater development & land conservation
(v) hydel, thermal, and conventional parts of power system in nuclear power stations
(vi) transmission, distribution and protection systems
(vii) town planning and architecture
(viii) buildings and industrial complexes
(ix) economic and regional planning
(x) public health engineering
(xi) environmental design and pollution control.

Performance & Growth

The Company started its operations with a basic paid-up capital of only Rs. 10,00,000. It was able to generate its own finances, and its total budget for 1973-74, only 14 months after its inception, stood at Rs. 95,78,115. That year, the Company made a net profit of Rs. 11,45,758. A fast growth rate has been maintained and the budget estimates for the year 1974-75 have risen to Rs. 3,56,09,000.

The strength of the Company today stands at 736, as against 50 at the end of June 1973. This number includes 235 qualified engineers and geologists, with professional experience ranging from 5 to 35 years. In addition, there are 185 ancillary technical staff, and a team of competent economists, agronomists, architects and technicians.

Overseas Operations

NESPAK is currently engaged in a crash programme for generating business abroad. This is in keeping with the Government's express desire for the export of Pakistan's considerable technological know-how and expertise. The small but significant list of initial successes includes :

Nigeria :	Groundwater investigation and development project covering an area of about 10,000 square miles, costing Rs. 1.5 crore. Development of water resources and water supply at Soba, Zonkwa and Saminaka through construction of small dams for the conservation of water flows. (Reports submitted)
Tanzania :	Planning & Design of a substantial Industrial Estate.
Gulf States:	Planning & Design of a major township and housing project costing Rs. 50 crores.
Abu Dhabi :	An office has been established and similar offices elsewhere are under consideration.

NESPAK is on the approved list of consultants for World Bank Projects. The prospects of expansion in the overseas operotions are quite good.

Domestic Operations

In Pakistan, NESPAK has an impressive record of achievements. Progress on some of the major projects is briefly outlined below :—

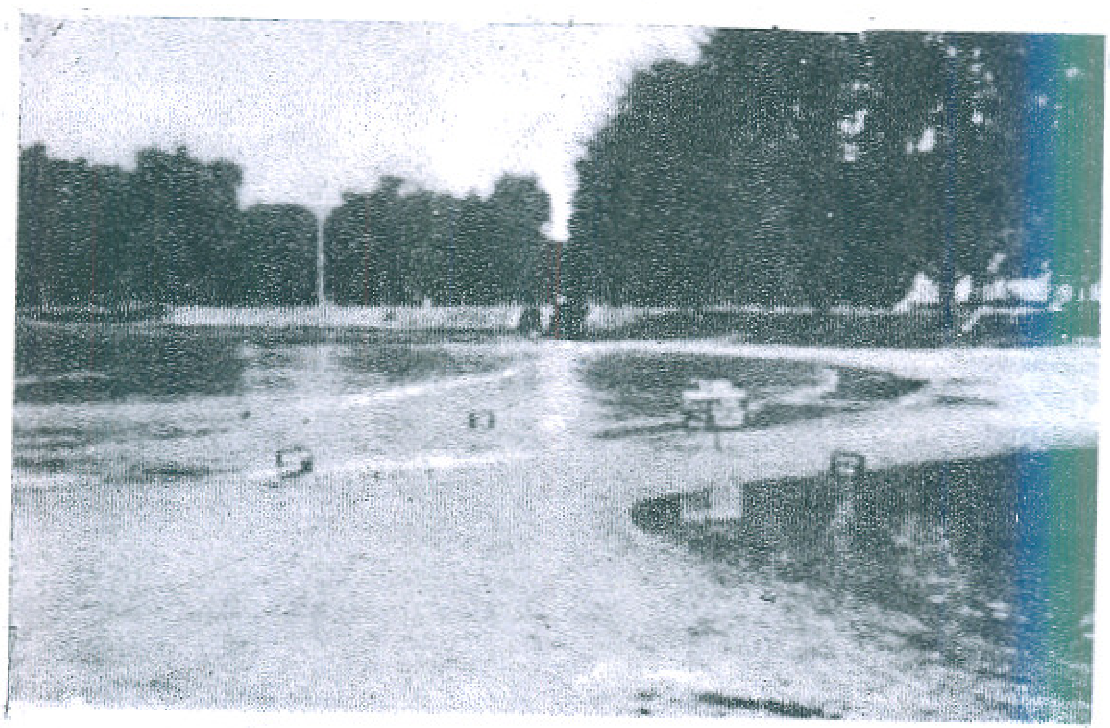
(i) **Left Bank Irrigation Tunnel Tarbela**

The Rs. 70-crore L.B.I.T. Tarbela, the project with which NESPAK commenced its operations, is proceeding satisfactorily, from 10 to 29 weeks ahead of schedule, and to the entire satisfaction of the client and their general consultants.

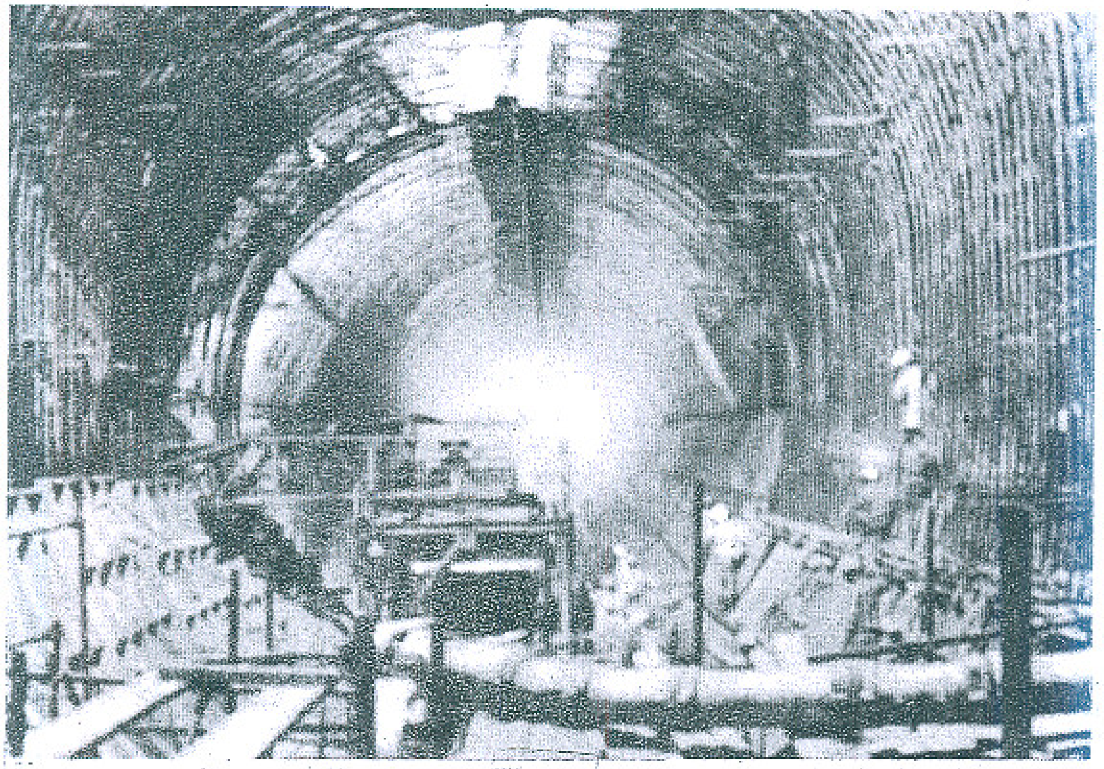
The L.B.I.T. Project comprises a 2,065 ft. tunnel downstream of the Stub, and includes 225 ft. long Gate passages and transition, 1840 feet long steel lined pressure tunnel with a finished internal dia of 36 ft., and also a 630 ft. long Outlet Control Structure including a Flip-bucket.

This project is scheduled for completion in 1976.

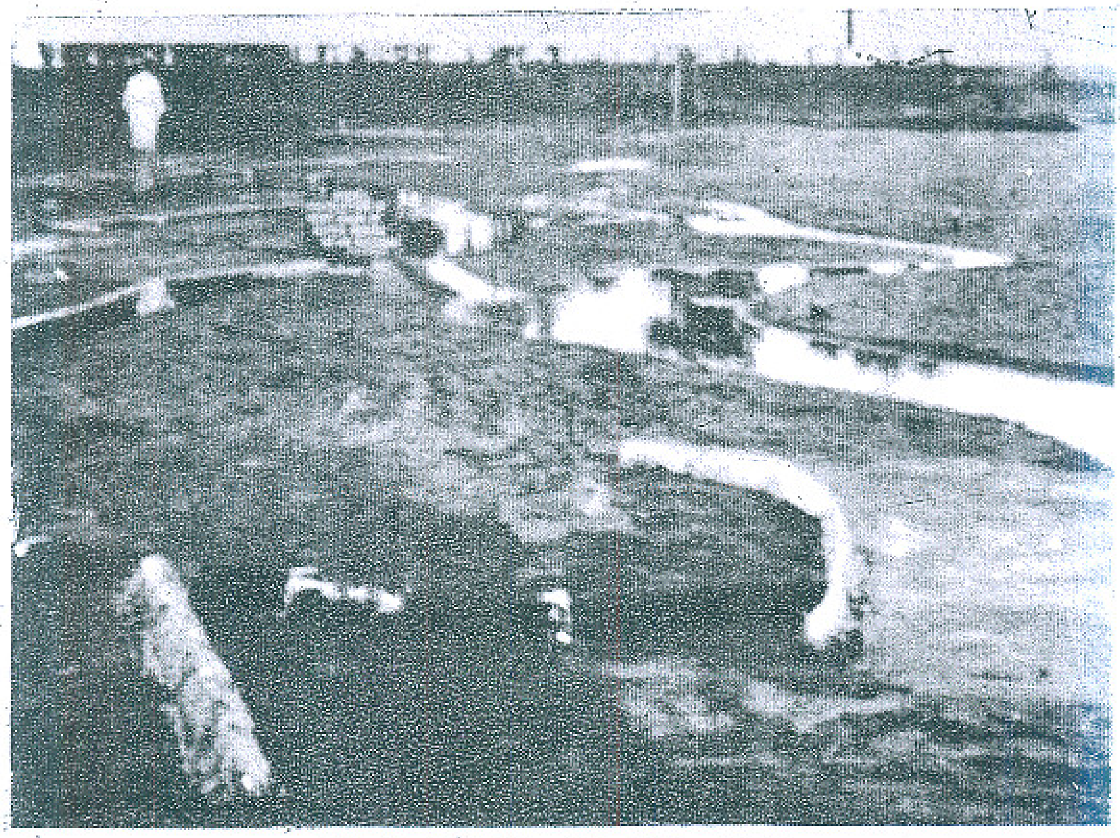
Indus River Training Works - Model Studies



Model Studies of the Gwadar Fishing Harbour



L.B.I.T. Tarbela - Fabrication and erection in the gate passages and transitions.



Site for D. I. Khan Darya Khan Bridge

(ii) **Indus Super Highway**

As general consultants to the Indus Super Highway Board for the Rs. 500 crore Indus Super Highway, NESPAK has almost completed the first phase of the assignment by laying down the basic criteria and guide-lines to be followed by the sectional consultants in the design of the highway; finalizing various technical and economic reports; assisting the Board in the selection of 10 sectional consultants, and in their negotiations with the manufacturers of heavy earth-moving and road-construction equipment.

The 1230 km. Highway is being planned as a four-lane divided freeway with a design speed of 70 mph for a minimum of 4000 vehicles per day per carriageway. It is scheduled to be completed in 1979.

(* The final design may in fact be a two-lane highway).

(iii) **Mohammad Bin Qasim Port**

NESPAK has successfully completed the first phase of work for the Rs. 230 crore Mohammad-Bin Qasim Port and given its final recommendations in the form of a Planning Report. The port, on completion in 1985, will be able to handle ships of upto 75,000 tons dead weight, with a total annual cargo handling capacity of 18 million tons.

(iv) **Darya Khan-D.I.Khan Bridge**

The design report for the Darya Khan-D.I. Khan Bridge has been completed. The Project entails the construction of a 3000 ft. long bridge across the Indus, alongwith about 16 miles of guide banks and river training works to control the mighty waters of the river. The bridge shall have 19 spans of about 160 ft, each, and a 35 ft. wide deck.

The Project is estimated to cost about Rs. 16 crores, and is scheduled for completion in 1978.

(v) **Gwadar Fish Harbour**

The preliminary design and tender documents for the Rs. 12.50 crore Gwadar Fish Harbour have been drawn up. Meanwhile, extensive on-site, sub-soil investigations have also been completed; the results of which shall be ready by the end of June, 75 after which the design and documents shall be given final shape.

(vi) **Karachi Steel Mill**

NESPAK is engaged in the design and implementation of three contracts with the Pakistan Steel Mills Corporation covering the design and construction, supervision of the Construction Base, and the planning, design and construction supervision of the storm-water disposal system, the sea-water intake and outlet system, and the sewerage system for the Rs. 936 crore Karachi Steel Mills at Pipri. The construction work has commenced.

(vii) **Mangla Power House Extension Project**

NESPAK has completed the planning and design of the Civil Structures. This extension project envisages the installation of two 100,000 KW units on Mangla's fourth tunnel, and is expected to be completed in 1978.

The Indus Super Highway:

The 800-mile Indus Super Highway shall run on the western bank of the Indus and connect Karachi with Peshawar, reducing the distance between them by approximately 250 miles as compared to the existing road facilities.

(viii) **Chashma Nuclear Power Project**

NESPAK is conducting the site investigations for the Project. Its various studies and recommendations dealing with Geology, foundations, soils, earthquake potential and construciion materials have been finalised. Pakistan Atomic Energy Commission have also engaged NESPAK for rendering general services in connection with all of their various projects in the country.

(ix) **Karakoram Highway Bridges**

NESPAK has handled the planning and design of 12 bridges along the Karakoram Highway. Some of these bridges have already been constructed, commissioned.

(x) **Salinity Control and Reclamation Project**

NESPAK has been engaged by WAPDA for investigations and planning for the reclamation of about 2000 square miles in the Fordwah and East Saddiqia Canal Command and D.G. Khan Canal Command.

(xi) **Industrial Complexes in N.W.F.P.**

NESPAK has recently been engaged by the Sarhad Development Authority for the planning, design and construction supervision of six major industrial complexes in the NWFP. These include a corn complex at Pehur, an ice-plant, cold-storage and freezing tunnel complex at Peshawar, a tannery complex at Jehangira, and cold-storage and ice-plant complexes at Mardan, Haripur and Swat.

(xii) **Inland Navigation Route, Port Qasim-Sukkur**

NESPAK has already completed its prefeasibility studies and investigations to determine the possibility of an inland water route connecting Port Qasim with Sukkur. This route is being considered to handle the bulk of Port Qasim's cargo capacity, and to ease the pressures that are expected to build up on the country's rail and road transportation facilities with the commissioning of the new port. NESPAK's findings and recommendations are being shaped into a Reconnaissance Report for submission to the Planning Division.

In addition to the above mentioned projects, NESPAK has been engaged by various agencies for the planning and design of the structural elements of some multi-storeyed buildings, like the 18-storey House-Building Finance Corporation House at Islamabad and the 8-storey MPA's Hostel at Egerton Road, Lahore.

(The facts and figures for the above introduction have been provided by NESPAK. ED.)

Key Personnel of NESPAK

Shahnawaz Khan
Chairman
B.Sc. Engg : (Civil) Punjab
F.I.E. (Pak), A.M. ASCE

Irshad Ahmad
Managing Director
B.Sc. Engg : (Civil) Punjab
M.A.Sc. (Water Power Engg :) University of Toronto USA
FIE (Pak)

Zaheer-ud-Din Khawaja
Director
M.R.T.P.I., A.R.I.B.A., F.I.A.P., F.P.I.C.R.P.
Chartered Architect and Town Planner.

Syed Baber Ali
Director
B.A. Punjab
Advanced Management Programme University U.S.A.

Nafis Ahmad
Executive Deputy to Managing Director
Project Manager CHASNUPP
B.Sc. Engg : (Mechanical) Punjab,
B.Sc. Engg : (Civil) Punjab
M.Sc. Engg : (Civil) Purdue University U.S.A.
MIE (Pakistan)
Member of Pakistan Engg : Congress.

B.A. Ghani
General Manager Planning, Programming & Contract management & Project Manager Tunnel.
B.Sc. (Civil Engineering) Punjab.

Jamil Asghar
General Manager Lahore
Project Manager

(i) Mangla Power House Extension Project
(ii) Tarbela Power House Extension Project.
(iii) Karakoram Highway Bridges,
(iv) Industrial Projects of the Sarhad Development Authority NWFP.
(v) Gwadar Fish Harbour.

B.Sc. Punjab, B.Sc. Engg : (Civil) Punjab,
M.A. Sc. (Civil Engineering) University of Illinois U.S.A.
Diploma in Barrages, France.

Ch. Mohammad Din
Secretary/General Manager Finance & Services
Ex Accountant General West Pakistan &
Ex Deputy Auditor General Accounts & Audit.

Saleemullah Khan
General Manager Communications
M.Sc. Aligarh University
Assistant Engineer's Certificate from
Thomason College of Civil Engineering
Roorkee
Ex-Chief Engineer and Project Director
Railways.

Hamid Akhtar
Manager Contracts
B.Sc. Engg : (Civil) Aligarh.

Fayyaz Ahmad
Chief Structure's Division
B.Sc. Engg : (Civil), Punjab M.Sc. Engg :
(Civil) Columbia USA

Amjad Agha
Chief Soils and Foundation Division
B.Sc. (Civil Engineering) Peshawar
Advanced Courses in Soil Mechanics and
Foundation Engineering Columbia and
Princeton Universities USA.

Ch. M. Abdullah.
Chief Heavy Equipment and Mechanical
Division
B.Sc. Engineering (Mechanical) Punjab
Training Programme in Equipment
Management
U.S. Bureau of Reclamation

M.A. Lateef
Chief Groundwater Division
B.A., B.Sc. Engg : (Civil)
FIE (Pakistan).

Dr. Asad Asghar Ali
Chief Electrical Division
B.Sc. Engineering (Electrical) Punjab.,
Superior Studies Certificate in Electrical
Technology University of Paris
Ph.D, University of Paris
Member Cigre

Mumtaz Ali
Chief Economic Studies Division
M.A. Economics.
M.A. Statistics
Post-Graduate Diploma in Hydrology.

Dr. Talib Chaudhry
Chief Hydraulics Division.
B.Sc. Engineering (Civil) Punjab.
M.Sc. Engineering (Civil) Punjab.
Ph.D. Colorado State University USA.

M.I. Chishti
Chief Resident Engineer Tarbela
B.Sc. Engineering (Civil) Punjab, F.I.E. (Pak)

Inam Bari Pervaize
Chief Highways Division
Project Manager Indus Super Highway
B.Sc. Punjab, B.Sc. Engg : (Civil) Punjab
Training in Modern Highway Construction,
Canada.

Hasan Mohammad Naqvi
Chief Ports and Harbours Division
Project Manager Port Qasim Karachi
B.Sc. Engg : (Civil) ; Str. Engg : Exam of
the City and Guilds of London Institute,
I.E. (Pak)
M. ASCE, A.M.I.E. (Pak), M.ACI

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CODE OF ETHICS

PAKISTAN ENGINEERING CONGRESS

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

In the name of God, the Beneficent, the Merciful.

WHEREAS Allah enjoineth upon his men to faithfully observe their trusts and thei covenants ;

that the practice and profession of engineering is a sacred trust entrusted to those whor Nature in its magnificent bounty has endowed with this skill and knowledge ;

that every member of the profession shall appreciate and shall have knowledge as t what constitutes this trust and covenant, and

that a set of dynamic principles derived from the Holy Quran shall guide his conduct i applying his knowledge for the benefit of society.

Now, therefore, the following Code of Ethics is promulgated. It shall be incumber upon the members of the Pakistan Engineering Congress to subscribe to it individually an collectively to uphold the honour and dignity of the engineering profession :

١- إِنَّ اللّٰهَ يَأْمُرُكُمْ أَنْ تُؤَدُّوا الْأَمٰنٰتِ إِلٰى أَهْلِهَا وَإِذَا حَكَمْتُمْ بَيْنَ النَّاسِ أَنْ تَحْكُمُوْا بِالْعَدْلِ إِنَّ اللّٰهَ نِعِمَّا يَعِظُكُمْ بِهٖ

"Allah commands you to render back your trusts to those to whom they are due, and that when you judge between people, you judge with justice. Allah admonishes you with what is excellent". iv : 58

1. You shall be honest, faithful and just, and shall not act in any manner derogatory to the honour, integrity or dignity of the engineering profession.

٢- أَوْفُوا الْمِكْيَالَ وَالْمِيْزَانَ بِالْقِسْطِ وَلَا تَبْخَسُوا النَّاسَ أَشْيَاءَهُمْ وَلَا تَعْثَوْا فِي الْأَرْضِ مُفْسِدِيْنَ ○

"Give full measure and weight justly and defraud not men of their things, and act not corruptly in the land making mis chief". xi : 8

2. You shall use your knowledge and ski of engineering for human welfare, an render professional service and advice whic reflects your best professional judgment.

٣- وَلَا يَجْرِمَنَّكُمْ شَنَاٰنُ قَوْمٍ عَلٰى أَلَّا تَعْدِلُوْا اِعْدِلُوْا هُوَ أَقْرَبُ لِلتَّقْوٰى

"And let not hatred of a people inci you not to act equitably. Be just ; that nearer to observance of duty". v :

3. You shall not injure maliciously, direc ly or indirectly, the reputation or emplo ment of another Engineer, nor shall you fa to act equitably while performing profe sional duty.

٤- أَوْفُوْا بِالْعُقُوْدِ ○

"Fulfil the obligations". v :

4. You shall faithfully observe and ful all your obligations.

٥- وَلَا تَأْكُلُوا أَمْوَالَكُم بَيْنَكُم بِالْبَاطِلِ وَتُدْلُوا بِهَا
إِلَى الْحُكَّامِ لِتَأْكُلُوا فَرِيقًا مِّنْ أَمْوَالِ النَّاسِ
بِالْإِثْمِ وَأَنتُمْ تَعْلَمُونَ

"And swallow not up your property among yourselves by false means, nor seek to gain access thereby to the judges, so that you may swallow up a part of the property of men wrongfully while you know". ii : 188

5. You shall not abuse your position or power, nor accept illegal gratification of any sort.

٦- وَقُولُوا قَوْلًا سَدِيدًا

"And speak straight words." xxxiii : 70

6. You shall express your opinion on engineering or other matters in a frank, open and straightforward manner.

٧- اجْتَنِبُوا كَثِيرًا مِّنَ الظَّنِّ إِنَّ بَعْضَ الظَّنِّ إِثْمٌ
وَلَا تَجَسَّسُوا وَلَا يَغْتَب بَّعْضُكُم بَعْضًا

"Avoid most of suspicion for surely suspicion in some cases is sin; and spy not nor let some of you backbite others". xlix : 12

7. You shall not criticise another engineer's work without his knowledge, nor malign, or injure his professional reputation.

٨- وَلَا تَقْفُ مَا لَيْسَ لَكَ بِهِ عِلْمٌ إِنَّ السَّمْعَ
وَالْبَصَرَ وَالْفُؤَادَ كُلُّ أُولَٰئِكَ كَانَ عَنْهُ
مَسْئُولًا

"And follow not that of which thou hast no knowledge. Surely the hearing and the sight and the heart, of all these it will be asked." xvii : 36

8. Your professional advice shall be based on full knowledge of the facts and honest conviction, and you shall not write articles or advertise in self-laudatory language or in any manner derogatory to the dignity of the profession.

٩- وَتَعَاوَنُوا عَلَى الْبِرِّ وَالتَّقْوَىٰ وَلَا تَعَاوَنُوا
عَلَى الْإِثْمِ وَالْعُدْوَانِ وَاتَّقُوا اللَّهَ

"And help one another in righteousness and piety, and help not one another in sin and aggression and keep your duty to God." v : 2

9. You shall help one another in upholding and doing what is right, and shall not associate with those who transgress and those who indulge in unethical practices.

١٠- وَأَمْرُهُمْ شُورَىٰ بَيْنَهُمْ

"And whose affairs are decided by counsel among themselves." xlii : 38

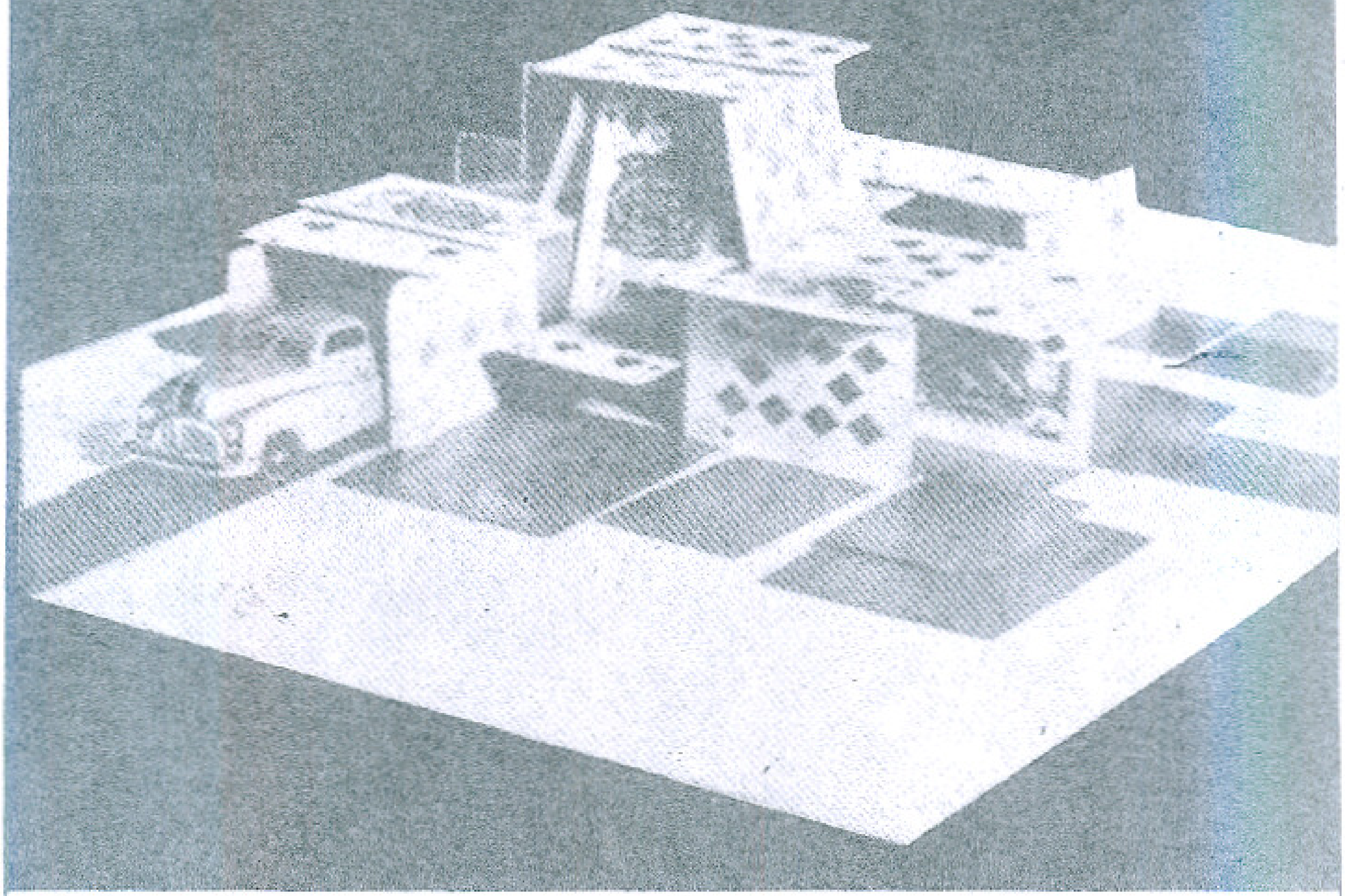
10. You shall decide matters of common professional interest by mutual consultation.

١١- وَاعْتَصِمُوا بِحَبْلِ اللَّهِ جَمِيعًا وَلَا تَفَرَّقُوا

"And hold fast by the covenant of God all together and be not disunited." iii : 102

11. You shall strive individually and collectively to enhance the prestige of the engineering profession by ordering your conduct in accordance with this Code of Ethics, and shall not be disunited.

اب کس کی مجال کہ ہمارے گھر کو تاش کے پتّوں کا گھر کہے؟



ہمارے مستقل جمہوری آئین نے مضبوط پاکستان کی تعمیر کے لیے ہمیں ایک پائیدار بنیاد فراہم کی ہے۔ اس کی ایک ایک اینٹ ہم محبت بھرے ہاتھوں سے لگائیں گے اور اس کی چنائی یقین محکم کے ساتھ ہوگی انشاءاللہ۔ ہمارے مستقبل کی عمارت نہایت بلند اور عالیشان ہوگی۔ اب کس کی مجال کہ ہمارے گھر کو تاش کے پتوں کا گھر کہے؟

ایسوسی ایٹڈ سیمنٹ

sasa lahore