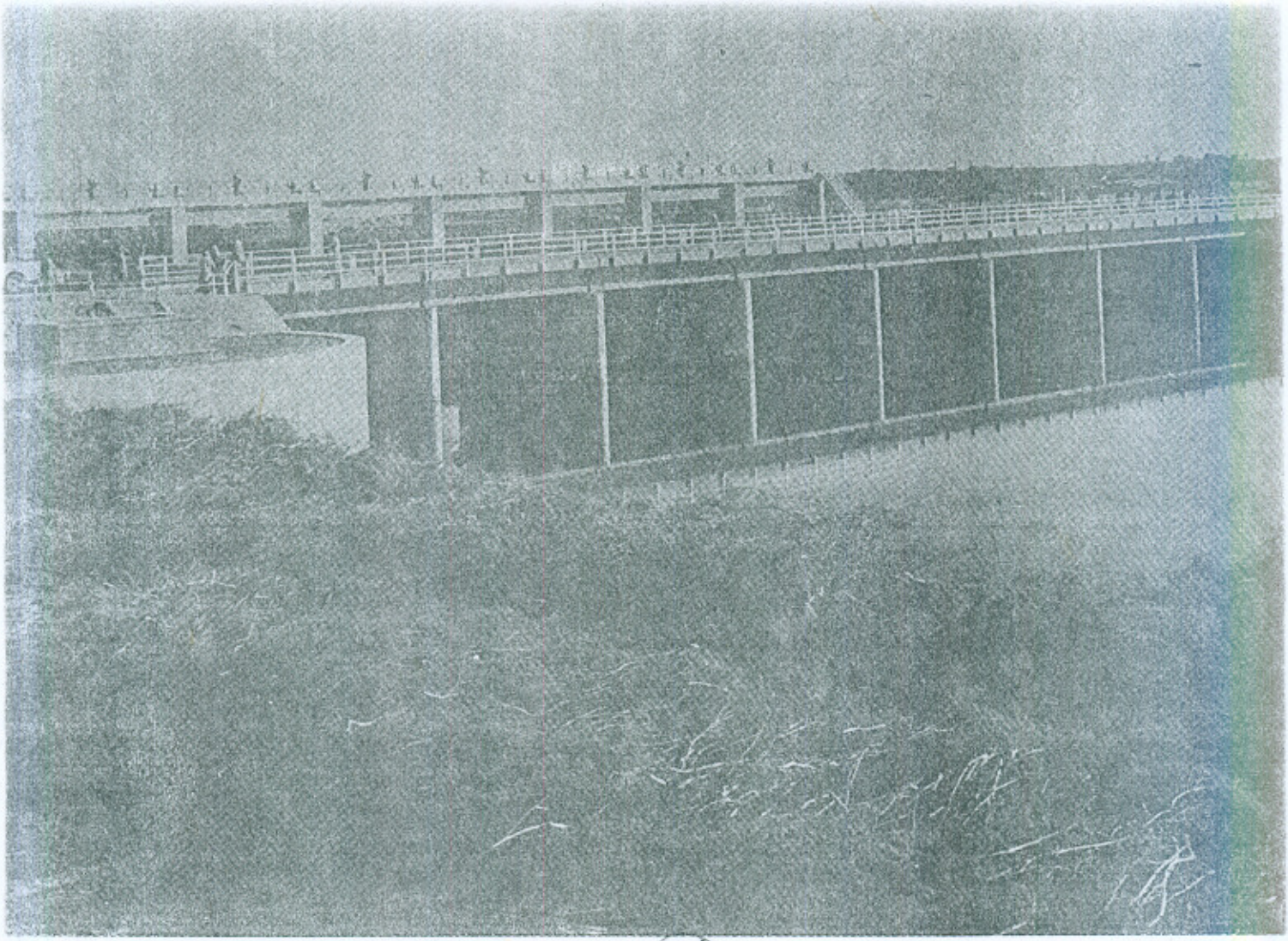

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ENGINEERING NEWS

Vol. 17 • No. 3 SEPTEMBER, 1972 ISSUE

A QUARTERLY JOURNAL OF WEST PAKISTAN ENGINEERING CONGRESS

Attention : Members Please

PUBLICATION OF ENGINEERING NEWS

Members are requested to forward technical papers for publication in the Engineering News. There are five broad sections viz :

a. **Irrigation and Power Section.**
b. **Buildings and Highways Section.**
c. **Industry Section.**
d. **Mechanical and Railways Section.**
e. **General Section.**

Other interesting features are news pertaining to Engineering Professions, abstract of papers and other relevant material.

All papers submitted for publication must be forwarded to the Editor Engineering News two months ahead of the date of publication *i.e.* in January, April, July and October. Papers must be typewritten with double spacing on foolscap paper. Two copies of the paper are to be submitted.

All the relevant diagrams must be properly traced on transparent paper with Chinese Black Ink. Photographs should be on glossy paper. The diagrams and photographs must be properly labelled and numbered.

News in Pictures with brief introduction will be appreciated in every section of this publication.

Articles, news and notes and other suggestions are earnestly requested to make the Engineering News regular and useful for the profession.

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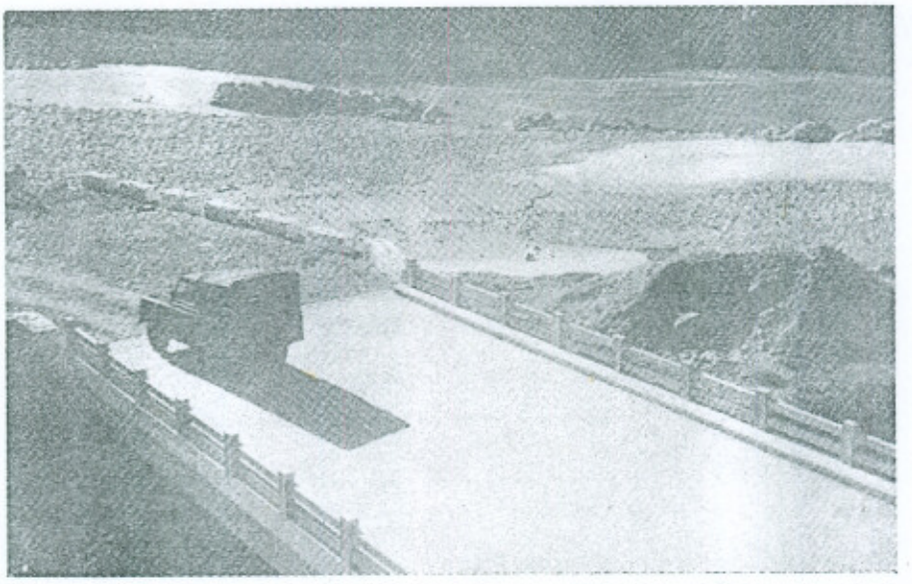

A view of Bridge Constructed in Hilly Tract

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Some of the works undertaken by us with their costs in Lacs of Rupees are Enlisted below :

1.	Construction of Indo Pakistan Boundary Demarcation Pillars	1 07
2.	Construction of General Bus Stand in Badami Bagh, Lahore	5 07
3.	Construction of House Type Food Storage Godown at Pattoki	5 00
4.	Construction of Roads in Kasur	2 05
5.	Construction of Underground Water Storage Reservoir of 6 lacs Gallons Capacity & Pump House in Rawalpindi	5 02
6.	Construction of Roads & Culverts in Muslim Town, Lahore	3 05
7.	Construction of Intermediate Girls College, Islamabad	9 02
8.	Construction of R. T. C. Workshop in Rawalpindi	5 00
9.	Construction of Hostel Block of Composite Degree College for Women, Rawalpindi	4 00
10.	Construction of Road & Culverts in Garden Town Scheme, Lahore	6 00
11.	Reconditioning of Sheikhupura Shahkot Road	6 00
12.	Design & Construction O of R.C C. Bridge on a Hilly Highway	3 35
13.	Construction of Ancillary Buildings in Gujranwala Cantt.	3 47
14.	Construction of Residential & Ancillary Buildings, Okara Cantt	7 50

SEVENTEENTH YEAR OF PUBLICATION

ENGINEERING NEWS

Quarterly Journal of the West Pakistan Engineering Congress

Vol. XVII SEPTEMBER, 1972 No. 3

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

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

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

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

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

Price of this Issue : Rs. 2.50

In this issue

TITLE COVER

T. P. Link—General view of completed tail structure R.D. 183+000 *from upstream left.*

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

People's Works Programme

Since we last commented on the People's Works Programme, more details about the concept and philosophy of the Programme are available. The concept has been further refined and concretized. It is now clear that the Programme has been conceived on well-defined premises. That there is considerable unemployment and under-employment, and that this situation is causing tremendous social strain, is so manifest that it requires no scholarly analysis to get convinced. That we are groaning under the burden of appalling poverty due to stagnation in major part of rural economy is also common knowledge. We are also aware of the fact that there is a vast dormant resource of organizational and management talent in the country which can easily be channelized into the production stream.

Once these very simple and obvious premises are accepted, it becomes clear that the path of salvation lies through stimulating the economy by mobilizing the human capital under the motivational guidance of the local leadership. This stream of thinking leads us to the inevitable conclusion that it is imperative to create an effective nucleus of planning and development at the local level. This links up the People's Works Programme with the Local Government institutions. It is gratifying to learn that the new set-up of Local Government institutions is oriented towards Works Programme and envisages creation of representative elected institutions right at the grass-root level of village and mohalla. It will be these institutions that will serve as nucleus for planning as well as for execution. It is a plain fact that the conventional system of planning by the desk-oriented bureaucrats sitting in the air-conditioned comforts of the Secretariat cannot be an effective instrument to improve the quality of life of a far-flung community. Planning in our country needs be divested of the Western economists' overwhelming preoccupation with Gross National Product or rate of its increase. What we need is not such aggregate indices in their abstraction,

but planning to provide gainful employment to the vast reservoir of manpower. Once we manage to employ each and every working hand in production processes, the GNP will automatically take care of itself.

It is a happy sign that under the present Government the planning process is getting oriented towards the manpower utilization, significantly enlarging the opportunities for gainful work. The other important characteristic of the Works Programme is the distinctiveness of its methodology. The planning as well as execution of work is to be carried through the grass-root level representative institutions. The people will get a forum at the village level to get together, deliberate and discuss their needs and participate in conceiving and then executing works meant to meet their felt needs.

We welcome the Government's initiative to invite participation of the people in building up the New Pakistan through the Works Programme. We are confident that the people at large in whom the Government is placing confidence will definitely rise to the expectations but, can the same thing be said about the Government officials who are also to act as counterparts to the representative institutions to provide the technical and administrative assistance to these institutions. We do not wish to be unnecessarily despondent but we must keep aware of the fact that this aspect may prove to be the weakest link in the whole arrangement. Perhaps there is need for an attitudinal change on the part of Government servants. This requires both a psychological shake-up as well as a fresh pattern of organzational set-up. It is only logical that the present leadership must realize that efforts at development require organic unity in various national institutions. An old pattern of colonial bureaucratic set-up is anachronistic to the system of planning and development now being envisaged. Sooner we realize it the better.

Irrigation and Power Section

While prequalifying Contractors and issuing Tenders for Building Works please do remember

M. MOHAMMAD ABDULLAH

GOVT. CONTRACTOR

WHO HAS SUCCESSFULLY COMPLETED THE CONSTRUCTION OF MULTIPURPOSE BUILDINGS AND CIVIL ENGINEERING WORKS ENUMERATED HEREIN :

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- ☆ Govt. Girls Intermediat College, Baghbanpura, Lahore Costing Rs. 3.50 Lacs.
- ☆ Defence Works under MES in trying conditions and scattered areas ... Costing Rs. 26.00 Lacs.
- ☆ Residential & other Utility Buildings under MES in Okara Cantt. ... Costing Rs. 12.00 Lacs.
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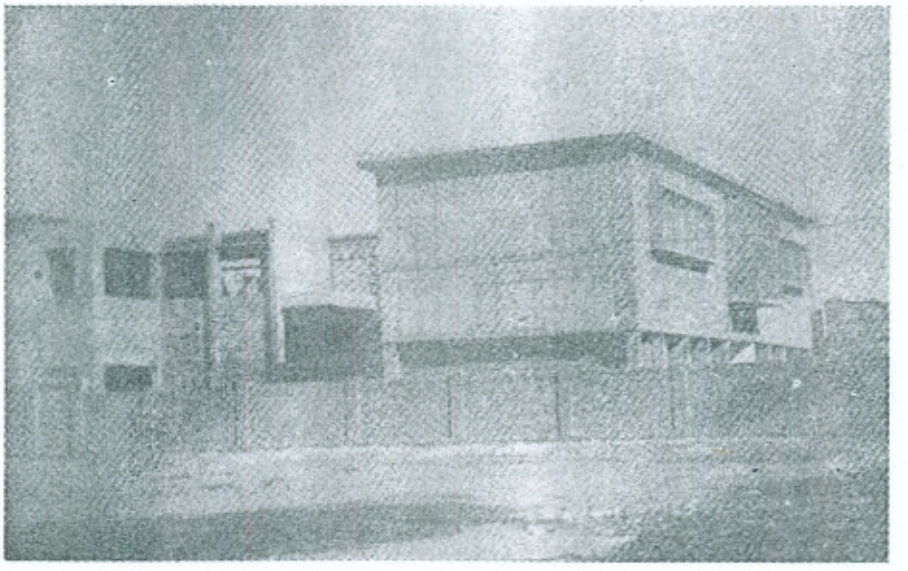

Govt. Girls High School, Shad Bagh, Completed in 1966

Taunsa-Panjnad Link Canal

An Introduction

By S. NAZAR HUSSAIN MASHHADI*
B.Sc. Engineering (Civil), B.Sc. Engineering (Mech.)

The Author of this article has worked on the planning, design, construction, contract administration and maintenance of Taunsa-Panjnad Link Canal for over eight years. He has embarked upon writing a series of articles, for the "Engineering News", on this project which is being described herein as an introduction for the readers. One of the articles of this series has already been published in the "Engineering News," Vol. 17, No. 1, March, 1972 under the caption "Taunsa-Panjnad Link Canal Unlined versus Lined Channel".

General

With ratification of the Indus Waters Treaty 1960, the long-standing dispute between Pakistan and India over the distribution of waters of the Indus River System was resolved. In order to implement the provisions of the Treaty, however, massive multipurpose works were necessary to impound, regulate and transfer waters of the rivers located within the Indus River Basin which collectively form the Indus Basin Project. The specific works of the Indus Basin Project (I.B.P.) included two large storage reservoirs : one on the Jhelum River at Mangla, and one on the Indus River at Tarbela; five barrages : (1) Sidhnai on the Ravi, (2) Mailsi Siphon on the Sutlej, (3) Rasul on the Jhelum, (4) Qadirabad on the Chenab and (5) Chasma on the Indus; three systems of new Link Canals; and the remodelling of various existing Link Canals, Barrages, and Canal Systems. The new Link Canals constructed in three phases consist of eight Links as follows :

First Phase	*Second Phase*	*Third Phase*
Trimmu—Sidhnai	Rasul—Qadirabad	Chasma—Jhelum
Sidhnai—Mailsi	Qadirabad—Balloki	Taunsa—Panjnad
Mailsi—Bahawal.	Balloki—Suleimanki-II	

* Executive Engineer, Taunsa-Panjnad Link Canal (Retd.)

Late in 1959, when it became apparent that an agreement would be reached between the Governments of Pakistan and India on the terms of the "Indus Waters Treaty 1960", the Government of Pakistan designated the West Pakistan Water and Power Development Authority (WAPDA) as the agency responsible for carrying out the engineering and construction of all the works under the I.B.P.

M/s. Tipton and Kalmbach, Inc., Engineers with Headquarters in Denver, Colorado, U.S.A., were retained by WAPDA to provide engineering and consulting services for the Link Canal portion of the Project. However, Taunsa-Panjnad Link Canal which is the eighth and the last in the series was designed and constructed as a purely Pakistani Enterprise and is briefly described in the following paragraphs :

Taunsa-Panjnad Link Canal

Soon after commencement of construction of Links and Barrages under the Indus Waters Treaty of 1960, WAPDA., had been constantly trying to persuade the World Bank for entrusting the design and engineering of some of the Link Canals and Barrages to Pakistani Engineers instead of foreign Consultants. At last in 1964 the World Bank agreed to allocate Taunsa-Panjnad Link for this purpose and accordingly a purely Pakistani enterprise named as "Links Construction Directorate" was created in May 1964 and the job originally entrusted to Messrs Tipton and Kalmbach, Project Consultants to WAPDA for Link Canals, was transferred to this organization.

This Directorate prepared Contract Documents for Construction of WAPDA Camp at Kot Adu and Design Report for the 38-mile long Taunsa-Panjnad Link within one year of the assignment of this challenging job. The design report was reviewed by the World Bank Consultants, Sir Alexander Gibb & Partners, Harza Engineering Company International; General Consultants to WAPDA., the Agricultural Development Corporation and the Irrigation and Power Department of West Pakistan.

The report which covered 300 pages and included about 150 drawings was acclaimed by the various reviewing agencies to be the finest work of designing, worthy of meeting the International Standards and first of its kind prepared independently by a Pakistani Engineering Organization.

The Authority appreciated the work done by the Link Construction Directorate with thanks and congratulations.

The Contract Documents and Prequalification of Contractors.

Immediately after the issuance of Design Report, preparation of Contract Documents and prequalification of Contractors in different countries of the world were taken in hand. It was decided by the Authority to get this link constructed through three different contracts and prequalification of the contractors and contracting was done accordingly. The following three Contract Documents were finalized on International Standards and published on schedule as detailed below :

1. Contract—209—Taunsa - Panjnad Link Canal-Task Force, in February 1966.
2. Contract—218—Taunsa - Panjnad Link Canal - Structures, in February 1966.
3. Contract—229—Procurement of Gates and Hoists for Taunsa-Panjnad Link Canals in September 1966.

Construction Camps

Construction camps for housing the staff of Engineers and the Contractors at site were constructed adjacent to mile 30 of Karam-Dad-Qureshi—Dera Din Pannah road at a distance of 3 miles from R.D. 30 of Link in a plot of about 120 acres of land acquired permanently in 1964. The Engineers' camp comprising buildings detailed herein was constructed at a cost of Rs. 60 lacs while the two Contractors' camps of M/s. Task Force and Sturctures Contractor were completed at contract costs of Rs. 29 and 6 lacs respectively.

Details of Buildings

A. **Engineers' Camps**

(Constructed by M/s. Amin Ullah Nasrullah Khan Contractors).

1.	Office Building and Laboratory	1
2.	Rest House	1
3.	Hospital	1
4.	Club	1
5.	A-type Bungalows	2
6.	B1-type Bungalows	5
7.	B2-type Bungalows	20
8.	C-type Quarters	40
9.	D-type Quarters	14
10.	F-type Quarters	48

B. **Task Force—Camp**

(Constructed by Project Manager T.P. Link Task Force).

1.	Office Building	1
2.	Guest House	1
3.	School Building	1
4.	B-type Bungalows	2
5.	C-type Bungalows	2
6.	D1-type Quarters	8
7.	D2-type Quarters	16
8.	Workshop and allied buildings	1

C. **Structures Contractors' Camp**

(Constructed by Mir Aslam Khan Hastam Khan & Sons).

1.	Office Building	1
2.	Agent residence	1
3.	Engineers' residence	1
4.	Staff Quarters	20
5.	Workshop	1

Note—All the buildings of this camp were temporary and have been disposed of through auction after the end of Structures Contract No. 218.

Land Acquisition

For the construction of this link 4,305 acres of land as detailed herein have been acquired at a cost of Rs. 31.72 lacs including compensation for crops, property and compulsory acquisition etc.

(*i*)	Compulsory acquisition	3,453 Acres
(*ii*)	Transfer from Govt. Agencies	839 Acres
(*iii*)	Temporary acquisition	13 Acres
	Total	4,305 Acres

Location and Alignment

The Link offtakes from the pond of Taunsa Barrage from an existing head regular which was built at the time of construction of Barrage and earmarked to serve a future link canal. After running almost parallel to the Muzaffargarh Canal for the initial 7 miles the link turns south-easternly and outfalls into Chenab river about 19 miles upstream of Shershah Bridge at a point 92 miles upstream of Panjnad Headworks and hence the name of Taunsa-Panjnad Link.

This Link will transfer supplies from the Indus River to Chenab river for use of canals offtaking from the existing Panjnad Headworks.

The tract of land traversed by the link is an undulating part of lower Thal desert characterised by sand dunes, little vegetation and sparse population with only a few small isolated plots presently under irrigation and like all desert areas has the problem of extremely high summer temperatures, very little annual precipitation, frequent sand storms and drifting sand dunes. In the upper reaches the area is heavily waterlogged which necessitated underwater excavation and heavy dewatering for the construction of structures.

Scopes of Contracts

Excavation of the canal except for short reaches near structures, construction of Airstrip and Divide Wall adjacent to the Head Regulator were included in the Contract No. 209 and the construction thereunder has been carried out by Task Force, a WAPDA Sub-Organization, through a negotiated contract.

All the structures and short reaches connected therewith, relocation of Irrigation Channels and Arterial Roads were included in the Structures Contract No. 218 and have been constructed by M/s. Mir Aslam Khan Hastam Khan & Sons, a purely Pakistani Enterprise which had already completed Mailsi-Bahawal Link under the Indus Basin Project.

A separate Contract No. 229 for the Procurements of Gates and Hoists was finalized and this work was done by the Superintending Engineer Mechanical Circle of Irrigation and Power Department after competing an International bidding.

Design Features of Canal

1.	Capacity	12,000 cs.
2.	Length	38 Canal Miles.
3.	Bed Width	266 Feet.
4.	Full Supply Depth :	
	(*a*) Reach R.D. 0 to 59+600	12.2 ft.
	(*b*) Reach R.D. 59+600 to 183+000	11.8 ft.
5.	Bed Slope :	
	(*a*) Reach R.D. 0 to 59+600	1 in 9,000
	(*b*) Reach R.D. 59+600 to 131+300	1 in 8,000
	(*c*) Reach R.D. 131+300 to 183+000	1 in 8,000
6.	Side Slopes	2.5 to 1 without any break.
7.	Berm Width :	
	(*a*) R.D. 0 to 6+540	60 ft.
	(*b*) R.D. 6+540 to 40+000	50 ft.
	(*c*) R.D. 40+000 to 59+600	25 ft.
	(*d*) R.D. 59+600 to 183+000	19 ft.

STRUCTURES

S.No.	Location R.D.	Structures
1	2	3
1.	0+000	Head Regulator (Modifications only).
2.	14+725	Drainage Inlet.
3.	18+645	Village Road Bridge.
4.	23+500	Drainage Inlet.
5.	29+766	Arterial Road Bridge (A).
6.	30+580	Railway Bridge.
7.	38+100	Drainage Inlet.
8.	39+380	V.R. Bridge-*cum*-Aqueduct.
9.	52+730	Foot Bridge-*cum*-Aqueduct.
10.	59+600	Control-*cum*-Canal Road Bridge-*cum*-Aqueduct and Drainage Inlet.
11.	65+500	Drainage Inlet.
12.	72+425	Village Road Bridge-*cum*-Aqueduct.
13.	78+800	Canal Road Bridge-*cum*-Aqueduct.
14.	86+100	Drainage Inlet.
15.	89+920	Foot Bridge.
16.	97+600	Foot Bridge.
17.	106+650	Foot Bridge.
18.	123+400	Drainage Inlet.
19.	124+040	Village Road Bridge.
20.	131+300	Control-*cum*-Canal Road Bridge-*cum*-Aqueduct.
21.	137+000	Drainage Inlet.
22.	141+847	Arterial Road Bridge (AA).
23.	154+130	Village Road Bridge.
24.	157+750	Drainage Inlet.
25.	161+700	Foot Bridge.
26.	171+000	Foot Bridge.
27.	175+500	Drainage Inlet.
28.	181+000	Drainage Inlet.
29.	183+000	Tail Structure-*cum*-Rangpur Canal Crossing, offtake and A.R. Bridge (AA).

In addition to the above listed structures, constructed under the main Structures Con tr act No. 218, eleven Cattle Ghats have subsequently been constructed at R. Ds 26+150 R, 35+000. R, 45+483. L, 54+878 L, 58+720. R, 65+700 L, 76+975 R, 137+970 R, 141+680 R, 147 +690, L. and 153+970. R. A Drainage Culvert under Sanawan Flood Bund has also been constructed adjacent to R.D. 17+765 of Link.

PRINCIPAL QUANTITIES OF WORK

Description	Unit	Quantities			
		Task Force (Contract) No. 209	Structures (Contract) No. 218	Gates & Hoists Contract No. 229	Total
1. Canal Excavation (incl. borrow)	Cu. yd.	22,691,000	2,050,000	..	24,741,000
2. Other Excavation	"	57,000	930,000	..	987,000
3. Portland Cement	Cwt.	35,500	236,500	..	272,000
4. Reinforcement	Cwt.	1,400	32,800	..	34,200
5. Concrete in Structures	Cu. yd.	8,600	53,100	..	61,700
6. Precast Concrete Piles	Lin. Ft.	..	23,200	..	23,200
7. Precast Concrete Girders	"	..	13,800	..	13,800
8. Steel Sheet Piles	Sq. Ft.	15,000	109,000	..	124,000
9. Structural Steel and Metal Work	Tons.	..	330	..	330
10. Installation of Gates & Hoists	Tons	..	400	..	400
11. Brick Masonry	Cu. yd.	..	14,100	..	14,100
12. Stone Pitching (incl. aprons)	Cu. yd.	50,800	39,000	..	89,800
13. Procurement of Gates & Hoists	Tons	..	..	400	400

CONTRACT ACTIONS AND COSTS

Action		Task Force Contract No. 209	Structures Contract No. 218	Gates & Hoists Contract No. 229
Contract Documents Issued	..	September 24, 1965.	June 9, 1966	September 3, 1966.
Tenders Opened	..	Negotiated Contract.	August 18, 1966.	November 4, 1966.
Contract Awarded	..	May 30, 1966	Dec. 16, 1966	April 19, 1966.
Completion Certificate Issued	..	September 30, 1970	July 15, 1969.	Jan. 6, 1969.
Completion of Maintenance	..	September 30, 1971	July 15, 1970	—
Tender Amount Million Rs.	...	75.602	39.053	1.321
Actual Costs Million Rs.	..	52.860	35.895	1.234

Construction Plant and Equipment

Both the main Contractors *i.e.* Taunsa-Panjand Link Task Force and M/s. Mir Aslam Khan Hastam Khan & Sons planned to use both traditional hand labour and donkeys together with modern mechanical equipment to build the Link. The Contractors selected both new and used equipment, most of which was manufactured in the U.S.A., U.K. and West Germany. The major equipment procured under the two contracts is summarized below :

(a) Task Force Contract No. 209

Sr. No.	Type and description of equipment.	Number
(*i*)	Draglines, 1.5 to 6.5 cu. yd. capacity	8
(*ii*)	Motorised scraper units, 14 to 20 cu. yd. capacity	6
(*iii*)	Pull scraper units, 15 to 21 cu. yd. capacity	6
(*iv*)	Supplemental tractors D-7 & D-25	19
(*v*)	Motor Garders	3
(*vi*)	Compacting Rollers	1
(*vii*)	Water Tankers and Sprinklers	2
(*viii*)	Concrete Mixers, ½ cu. yd. capacity	9
(*ix*)	Electrical Generating and Lighting Equipment sets 6 KW to 229 capacity ..	10

(b) Structures Contract No. 218

Sr. No.	Type and Description of Equipment.	Number
(*i*)	Draglines, ½ cu. yd. capacity	2
(*ii*)	Tractors D-7	2
(*iii*)	Front End Loader	1
(*iv*)	Vibratory Compactors	2
(*v*)	Concrete batch and mix plant 1 cu. yd. capacity	1
(*vi*)	Concrete mixers, small	19
(*vii*)	Crawler and truck cranes 30 ton capacity	2
(*viii*)	Trucks and Tractors	88
(*ix*)	Electrical Generating and Lighting Equipment 42.5 KW to 100 KW ..	20

Total costs of construction plant and equipment purchased under Contract Nos. 209 and 218 was 5.3 million rupees and 4.7 million rupees which are 5% and 12% of the respective tender prices against 15% which could be advanced to the Contractors as financial assistance for the procurement of Special Plant under the terms of their contracts.

ENGINEERING ORGANIZATION

(During Peak Construction Activity)

Sr. No.	Classification	Number
1.	Chief Engineer	1
2.	Director Design	1
3.	Deputy Project Director	1
4.	Senior Engineers	9
5.	Assistant/Junior Engineers	27
6.	Junior Research Assistants	2
7.	Accountants	7
8.	Other Revenue Staff (Patwaris)	5
9.	Superintendents	3
10.	Overseers	25
11.	Stenographers, Clerks & Typists	37
12.	Draftsmen, Tracers & Computers	18
13.	Printers, Operators, Seweepers & Chowkidars	11
14.	Peons, Daftaries, Khalasies and Dak Runners	40
15.	Medical Staff	4
16.	School Staff	4
17.	Work-charged Labours	374
	Total	569
	Total number of Engineers in all categories	39

CONTRACTORS' ORGANIZATIONS

(Both Task Force and Structures Contractors

During Peak Construction Activity

1.	Number of Engineers in all categories	25
2.	Overseers/surveyors	35
3.	Administrative Staff	100
4.	Labour :	
	(*i*) Directly employed	1,050
	(*ii*) Donkeys	3,150
	Manual Labour	2,800

TAUNSA-PANJNAD LINK CANAL STATUS OF CLAIMS AND DISPUTES

(All money values in Rupees)

Description	Structures Contract No. 218	Earthwork Contract No. 209
Total Number of Claims	18	39
Total value.	9,028,762.69	4,699,986.94
Rejected	8,762,194.92	4,242,075.42
Accepted	266,567.77	321,396.31
Pending	Nil	136,315.21
Referred to Arbitration		
By Contractor	8,762,194.92*	2,727,754.53
By WAPDA	Nil	Nil

* Amount as per "Statement of Case" referred to Arbitration by Contractor.

REFERENCES

1. "Contract Documents for the Construction of WAPDA Camp for Taunsa-Panjnad Link Canal near Kot Adu", by Links Construction Directorate, WAPDA, August 1964.
2. "Taunsa-Panjnad Link Canal-Notice, Preliminary Information and Instructions for Prequalification," by Links Constructions Directorate WAPDA, September, 1964.
3. "Design Report on Taunsa-Panjnad Link Canal" by Links Construction Directorate, WAPDA, issued in 1965 and Printed, in 1969.
4. "Contract Documents for Construction of Taunsa-Panjnad Link Canal-Task Force Contract-209", by Links Construction Directorate, WAPDA, February 1966.
5. "Contract Documents for Construction of Taunsa-Panjnad Link Canal structures, Contract-218", by Links Construction Directorate, WAPDA February 1966.
6. "Summary of Actions Leading to Award of Contract for Construction of Taunsa-Panjnad Link Canal, Task Force," by Links Construction Directorate, WAPDA December 1966.
7. "Summary of Actions Leading to Award of Contract for Construction of Taunsa-Panjnad Link Canal Structures", by Links Construction Directorate, WAPDA, April 1968.

Taunsa-Panjand Link Canal Unlined versus Lined Channel

By

*S. NAZAR HUSSAIN MASHHADI,
B.Sc. Engg. (Mech.); B.Sc. Engg. (Civil)
**CH GHULAM HUSSAIN
B.Sc. Engg. (Civil)

In the first part of this article published in the March 1972 issue of this journal the author at (*) above had tried to enlighten the readers about the design considerations on the basis of which Taunsa-Panjnad Link Canal had been constructed as an unlined channel. In this second part the authors have given the practical side of the picture wherein it has been endeavoured to show the repercussions of having an unlined channel and, at the same time, to uphold that whatever has been done at site could be the best practicable under the prevailing circumstances.

Taunsa-Panjnad Link Canal was designed and constructed as an unlined channel due to technical restraints discussed earlier in the first part of this article. The link was completed in early May 1970 and placed in operation on May 31, 1970. The discharges in the link were gradually raised to 10,000 cusecs by 11th July 1970 after-which the link was predominantly run at this discharge for a period of $2\frac{1}{2}$ months. During this period, it was observed, that there was a rapid rise in the subsoil waterlevel in the vicinity of the link resulting in the waterlogging of an extensive area, damage to crops and other built-up properties. Accordingly, the link had to be reduced to 5,000 cusecs to afford a temporary relief to the menacing situation thus created. During the year 1971, the link was reopened on January 1, 1971 and gradually raised to its full supply discharge of 12,000 cusecs by July 1, 1971. In view of the heavy silt concentrations in the Indus waters and floods in the Chenab River and to give a relief to the cultivated lands and public utilities threatened by waterlogging, the discharge in the link was gradually decreased and ultimately reduced to nil on August 11, 1971. Thereafter the link was reopened on 2nd Sept. 1971 and continued operation with variable low discharges according to the requirements of the Panjnad Canals indented by the Irrigation Department.

During the peak operation periods, *i.e.* with discharges more than 8,000 cusecs in the link, the problem of severe waterlogging, which cast perilous effects on the agricultural potentials of the cultivable tract and public utilities up to two miles on either side of the

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**Junior Engineer, Taunsa-Panjnad Link.

link, was experienced in both the flow seasons of 1970 and 1971. The hazards of waterlogging were so devastating that green gardens, especially in the reach R.D. 60 to 80, were converted into dry trunks of fuel wood, number of houses collapsed into heaps of debris, the low-lying areas presented scenes of standing lakes of stagnant water and the kacha roads became so marshy that many touching incidents of bogging down of animals were noticed. (See Figures 1 & 2)

The lands along the link canal went out of cultivation and the productivity of other adjoining lands was considerably decreased. It was estimated that about 21,000 acres of canal irrigated area lying on the left bank of the link from R.D. 8 to 84 and R.D. 132 to 154 was rendered unproductive. The remaining area, particularly under barani and well cultivation, situated on both sides of the link, were also adversely affected by waterlogging.

During operation period of 1970, Mianwali-Muzaffargarh road, which crosses the link at R.D. 141+847, was severely damaged and rendered unserviceable near its mile 157 on right side of the link. Consequently, Civil and Military traffic were blocked. Highway Department had to raise the affected portions of the road to maintain the flow

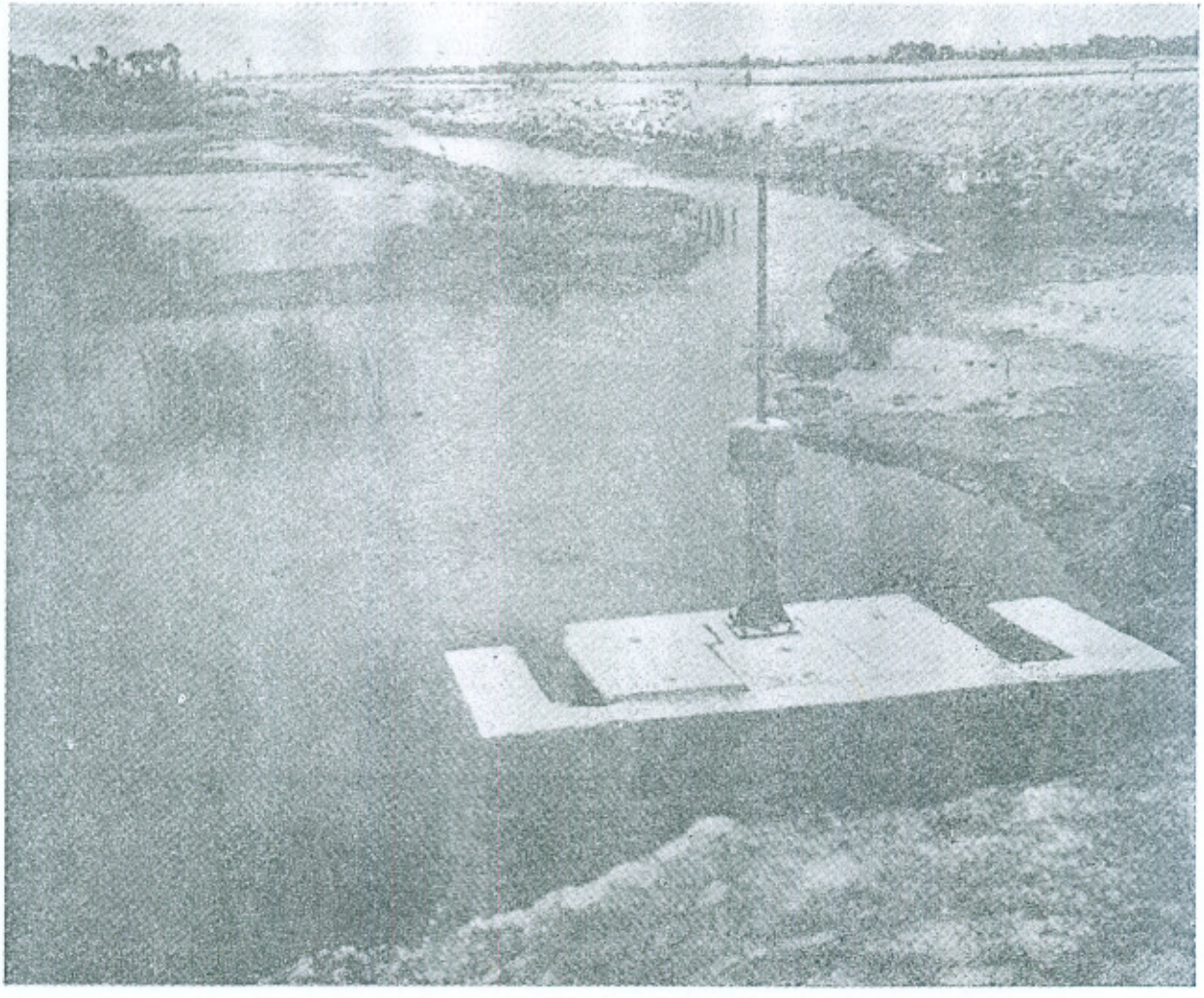

Fig. 1. Downstream end of the Gated Drainage culvert constructed under Sanawan Flood Bund to drain the excessive seepage water in the head reach.

of traffic. In 1971, Khushab-Muzaffargarh road, which is intersected by the link at R.D. 182+900, became boggy and offered hardships to the traffic near its mile 164. (Fig. 3)

Paradoxically enough, the waterlogging had some healthy effects on the drinking water, which was brackish prior to the commissioning of the link, and on kharif crops in the Thal area, as the link acts as a big drain during winter with low or only seepage supplies in it.

Lowering of existing full supply level

A technical committee, consisting of representatives of WAPDA and Irrigation Department, was constituted for preparing a comprehensive report suggesting remedial measures to give permanent relief to the areas apprehended to be damaged by the waterlogging.

In the subsequent meetings of the technical committee, among the other possibilities considered to provide relief to the affected areas, the proposal of lowering the full supply levels of the link by 3 feet was also agreed to be contemplated. To appreciate the feasibility of this proposal it was decided that Deputy Project Director, Taunsa-Panjnad Link would arrange the installations of observation pipes, perpendicular to the direction of flow in the canal at two places, as per design to be supplied by the Project Director Planning and Project Preparation WAPDA. Water levels in these pipes would be observed during different stages of the link operation. Consequently, Project Director Planning and Project Preparation proposed the installation of pipes of 20′—25′ depth with 3—5 feet sand-point strainer at distances of 20′ 50′, 100′ 200′ 500′ 1,000′, 2,000′ and 3,000 from the edge of the canal water at

Fig. 2. Ruins of a T.D.A. Village completely razed to ground due to waterlogging adjacent R D. 149 of Link

R. Ds. 70 and 140 respectively. For a fair depiction of the gravity of the waterlogging on both sides of the link at various stages of link operation, the pipes at the intervals mentioned above were installed up to 2,000′ on left and 3,000′ on the right side.

The study of the water elevations in the observation pipes revealed that subsoil water levels at a distance of about 1,000 feet from the water edge in the canal prism with 7,000 cusecs discharge, *i.e.* when water surface elevation in the link was about 4 feet lower than the full supply level, were about 5 feet lower than natural ground surface. Accordingly, the damages to the lands and built-up properties, because of waterlogging, were sufficiently alleviated. It will not be impertinent to mention here there that this phenomenon of fall in the subsoil water level is consequent not only to the lowering of the water surface elevation in the link but also it is due to the reduction in the canal discharge, which in this case is 5,000 cusecs.

The proposal of lowering the full supply of the link was thoroughly contemplated and concluded to be infeasible because of the following limitations :—

1. Knocking out of the crest of Tail Structure, necessary for lowering of F.S. Levels in the link, is not practicable due to the barrels of Rangpur Canal Culvert which laterally cross underneath the crest of this

Fig 3. Settled and damaged Khushab Muzaffargarh Road near mile 164 due to waterlogging just near Tail Structure of T. P. Link

structure. Besides this consideration, the raised crest of Tail Structure, which is now set just at the high flood level of the Chenab River would, after knocking down, become lower than the high flood level and subsequently may create serious operational difficulties, during the peak flood durations in the Chenab, and have damaging effects on the Tail Structure and the link canal.

2. The comprehensive hydraulic studies have revealed that knocking down of the raised crests alone would not have much qualitative effect in the direction of lowering the full supply of link. The removal of the crest would, however, result in reducing the existing magnitude of the falls at the control structures.

3. Notwithstanding the provision of the brick masonry under the crests for the future adjustments, which, as a matter of fact, provides food for thought about the proposal under discussion, the control structures lack arrangements for the extension of the gates and counterweights guides. Accordingly, the requisite alterations in the existing features of gates and hoists are pretty cumbersome and involve certain substantive changes in the superstructures.

4. The excavation of the whole bed or a cunette, required for depressing the full supply of the link, can be carried out only be deploying draglines, having 200-feet boom lengths, on either bank. But, unfortunately, the draglines with such longer booms are not available with Task Force—a WAPDA Sub-organization that carried out the excavation of the link. Furthermore, the movement of the earth-moving equipment and piling of the excavated materials would result in complete destruction of the spoil-bank plantation and the existing telephone and telegraph system along the link. In view of the foregoing, the prevailing circumstances do not warrant for the implementation of this proposal.

5. The stilling basins of the drainage inlets are designed and constructed in the bed of the link without deep cutoffs at the tail end and would be rendered quite unsafe after further excavation in the prism of the link.

6. The seepage losses of the link were envisaged in the design report by a generally adopted formula according to which seepage loss per million square feet of wetted perimeter is as follows :—

$$K=5.00\ (Q)\quad 0.0625$$

K is the seepage loss per million square feet of wetted perimeter and Q is the discharge of canal in cusecs. Although the percolations from the link given by this formula are not supposed to be very accurate yet the subsequent measurements of actual discharges at various stages of link flow, downstream of all control structures, have substantially corroborated the results of this formula. This formula manifests that discharge and wetted perimeter are the predominant contributors to the percolations from the canal. Inasmuch as the hydraulic parameters of the link remain unchanged, the simple lowering of full supply will not appreciably minimise the seepage additions to the aquifer. Consequently, the execution of this proposal may not bring about the requisite results of alleviating the hazards of waterlogging. The depressed water surface elevations in the link, nevertheless, may ease the waterlogging situation in the immediate vicinity of the link but recharge to the aquifer is likely to remain unchanged. The accurate extent of such relief, however,

cannot be depicted at this stage due to numerous complexities involved in the groundwater hydrology.

However, one basic fact, as related in the preceding para cannot be denied that the link section may be partially perched (as in the existing condition) or deeply entrenched into the natural ground surface (as originally contemplated) the wetted perimeter of an unlined channel with full supply discharge remains the same and hence recharge into the aquifer would essentially remain unchanged so long as the preconstruction ground water table is below the bed of the link. So there could be a possibility that despite low-setting of the link, although the waterlogging trouble might be less pronounced in the areas in the immediate vicinity of the channel, the menace of rise in water table could be still alarming in the distant low-lying areas down-doab of the link.

Preliminary design

The apprehension of some quarters that the adoption of an unlined section for this link would further aggravate the twin problems of waterlogging and salinity in the surrounding Thal Doab, where equilibrium of the groundwater table has already been considerably unbalanced by the canal irrigation carried out by the Taunsa, Kalabagh and Trimmu Canals, was given special attention in the preliminary design of the link as an unlined channel.

In view of the foregoing perspective, the full supply levels of the link were contemplated to be adequately lower than natural ground surface in the originally conceived and proposed profile of the link. The original proposal, which involved tremendous quantum of excavation, could not be materialized, due to the overall policy of utilizing all possible savings from the other I.B.P. Projects to implement the construction of multi-purpose Tarbela Dam which was in jeopardy due to scarcity of funds. Accordingly, on the genuine consideration of economy, the originally proposed bed profile of the link was raised by about four feet in the reach R. Ds. 59+600 to 183+000 and consequently, the falls of 5 feet and 7 feet at R.D. 59+600 and 131+300 were reduced to 1 foot and 3 feet respectively.

As explained in the preceding paras, the threatening situation of waterlogging is substantially relieved during the periods when the link is commissioned with supplies lower than 8,000 cusecs, that is, when water surface elevations in the canal are about 4 feet lower than designed full supply levels. Conversely the link, when running with water surface elevations 4 to 5 feet lower than the present full supply water elevations, functions effectively as a big drain for both subsurface and surface flows. The foregoing state of affairs well substantiates the soundness of the original proposal.

Furthermore, a provision of 50 million dollars was envisaged in the Indus Basin Development Fund for drainage and tube-well facilities to ease the salinity and water-logging situation in the areas that were to be traversed by the new system of the link canals to be constructed under Indus Basin Settlement Plan. In the overall, interest and best execution of the Indus Basin Project, which is of the elemental significance for the economy of the country, the whole amount of 50 million dollars was diverted towards the construction of the gigantic Tarbela Dam. Accordingly the scheme of tubewells installation, as a part of this Project, for pumping the seepage additions from the areas to be affected by the operation of the links, had to

be suspended, with the anticipation to tackle such problems through country's own resources.

Pragmatical limitations about lining

The subsoil-water-levels prevalent at site before commencement of construction were substantially higher than those on which the preliminary consideration of lined and unlined section of the link were based. During the construction of the link it was observed that subsoil-water-levels were higher than the corresponding bed levels up to R.D. 100 and involved considerable quantum of wet excavation. In the event of adoption of lining for this link, the bed levels would have been about 6 feet lower than the existing levels. Subsequently, the construction of lining would have involved far higher expenditure on the dewatering operations which could not be adequately appraised in the original proposal discussed in the first part of this article. The revised cost comparison, as given in Appendix 'A', reveals that the cost of a lined channel would have been more than double the cost now incurred on the unlined section.

Before the commencement of the construction of the structures of the link, an extensive survey was carried out for the selection of high quality bricks. It was found that deposits of materials suitable for making bricks were, unfortunately, not available in the entire sandy tract traversed by the link. Some clayey patches in the head reach were badly waterlogged. Similarly deposits found in the whole Muzaffargarh District and adjoining areas of D.G. Khan District were found to have been badly affected by saline ground water which rendered the materials unsuitable for the production of high quality bricks. As a result of an exhaustive exploration and testing, a few kilns near Multan city could be approved. Non-availability of high quality bricks, in the whole area would have posed serious problem during the construction of the lining and would have adversely affected the quality of the work.

Besides the foregoing problems the alignment of the link is such that it intercepts the natural flow of the ground water which in future would further rise after the construction of the Greater Thal Canal. The 18 feet deep lined link would have acted as a big barrier to the natural drainage of the subsoil water and, consequently, adversely affected the subsoil water table on the left of the link. With the present bed profile and unlined section the link would be acting as a big drain during low or nil supplies.

Conculsions

The lining, as a preventive measure against waterlogging, was not justifiable due to the peculiar condition of the area in which the link is located. In execution of the original proposal, with full supply about 4 feet lower than the existing one, the link instead of creating waterlogging would have functioned as a big drain and might have helped rather than aggravating the problem of waterlogging at least in the areas adjacent to the link.

Besides the above considerations the future effectiveness and successful working of hundreds of tubewells in the SCARP-3 Project area, constructed at a cost of 351.7 million rupees and mostly located down-doab of the link; depends upon availability of good quality water for which T.P. link is the closest source to recharge. In addition the barren areas falling between the right bank of T.P. Link and the eastern irrigation bounderies of Muzaffargarh Canal system could be easily brought under cultivation by tubewells fed from aquifer recharged by seepage from the link. All these benefits would have been ruled out in case the link was lined.

Appendix—A

Characteristics and revised costs of unlined and lined Channels

"A"—Estimated Construction Cost of Link—R.D. 59+600 to R.D. 183+000 (24.7 Canal Miles)

(Cost in Rupees)

Item No.	Description	Unit	Unit Rate	Unlined Channel		Lined Channel		Incremental cost of Lining
				Quantity	Cost	Quantity	Cost	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Excavation	Cu. Yd.	1.42	15,755,589	22,372,936	15,000,000	21,300,000	(—) 1,072,936
2.	Compacted Embankment	,,	0.60	161,203	96,722	1,348,000	808,800	(+) 712,078
3.	Brick Lining	100 s.f.	250.00	0	0	246,800	62,700,000	(+)62,700,000
4.	*Dewatering	Lump Sum	...	...	...	...	5,000,000	(+) 5,000,000
5.	Structures	,,	...	...	25,098,000	...	18,684,000	(—) 6,414,000
6.	Land	Acres	(varies)	2,810	1,700,000	2,810	1,700,000	
				Total	49,267,658		110,192,800	(+)60,925,142

*The cost of dewatering in the unlined section is included in the cost of structures.

"B".—Characteristics of Waterway Sections

Parameter	Unit	Unlined Channel	Lined Channel
(1)	(2)	(3)	(4)
Bed Width ...	ft.	266	100
F.S. Depth ...	ft.	11.8	18
Waterway Area ...	s.ft.	3486.9	2420
Velocity (Q-12,000)	ft./sec.	3.63	5.2
Wetted Perimeter ...	ft.	329.54	181
Wetted Area ...	msf./mile	1.585	0.905
Seepage Loss Rate ...	cs/msf.	12*	2*
Seepage Losses ...	cs/mile	19.7	1.80

*Estimated rate of loss when subsoil water level is sufficiently far below bed of channel as not to affect seepage gradient.

INDEX
TO
ADVERTISERS

Industry Section

Progress in Pakistan towards use of Aluminium in Electric Cables*

By J. G. ELLIOTT
Director & General Manager, Pakistan Cables Ltd.

The technical and economic aspects of the use of Aluminium as a conductor for electric power has been very ably and adequately covered by the excellent papers put forward at this Symposium. I, therefore, intend to confine my comments to the progress made, so far, here in Pakistan towards the general use of Aluminium as a conductor.

To review the progress on a generalised basis would, in my view, do an injustice to those sectors that have made great strides in the use of Aluminium. I, therefore, propose to divide my review in two parts, firstly, cables with conductors of cross sectional area of 0.0225 square inches and above, namely Power Cables, and Overhead Conductors and secondly, Wiring and General Cables.

Power Cables and Overhead Conductors :

It may be seen from this analysis that all the initiative to move to Aluminium has been taken by the large sectors of WAPDA and KESCo.

WAPDA, set up in 1959, has been using Aluminium exclusively as A.C.S.R. Overhead Conductors since 1962 in voltages ranging from 11 kV to 220 kV and as A.A.C. for voltages of 230/400. They have been using insulated Aluminium cables exclusively since 1966 for low and high tension up to 11 kV.

KESCo was set up in 1947. Although carrying out a number of experiments in both overhead and underground cables, did not start using underground cables in Aluminium until 1969, and are now using these up to 15 kV. Before I am attacked for that statement, I must make reference to an

Underground power cable 15 kV and below consumption by conductor weight in tons.

Year.	Electricity Supply		Industry & Others		Total.		Ratio.	
	Copper.	Al.	Copper.	Al.	Copper	Al.	Copper	Al.
1966	734	—	352	—	1086	—	100	0
1967	446	187	439	—	885	187	82.5	17.5
1968	543	188	493	—	1034	188	82.7	15.4
1969	—	239	549	—	549	239	69.7	30.3
1970	—	280	548	34	548	314	63.6	36.4

* The article is published by the Courtesy of Institute of Engineers, Pakistan. This article was presented in a symposium held in Karachi in July 1972.

Aluminium cable laid by KESCo in 1962, and I shall refer to this again later.

KESCo installed an experimental overhead conductor in Aluminium approximately six months ago in the Gulsham area, and I believe that, so far, this has been trouble-free. However, apart from this, they are still using Copper exclusively for overhead conductors.

The Military Engineering Services took the decision, in May 1970, to use Aluminium for their underground electrification schemes.

I consider these bodies are to be commended for taking the initiative thus far. Outside these bodies, no initiative has been taken by industry to substitute Aluminium for Copper.

Why has Pakistan lagged so far behind the rest of the world in the use of Aluminium in this field? Analyses of the reasons given for this reluctance to change can be condensed into two major factors, namely :—

(*i*) Cable Terminations.

(*ii*) Conductor Corrosion.

These two factors do, undoubtably, present problems, but they are not insurmountable problems, as you will hear from other papers presented at this symposium. These papers will cover the technicalities, current practices and available materials and equipment. But there are other factors here in Pakistan affecting the progress towards the use of Aluminium.

Dealing first with Cable Terminations, during many of my discussions with Electrical Engineers, I am frequently told that our people are unskilled and cannot make proper joints. When I enquire as to why compression jointing is, therefore, not used, I am given the answer that the country cannot afford to purchase the variety of equipment needed for compression jointing.

From this, it would appear that the problem associated with jointing and terminating is not the conductor itself or the different techniques necessary, which basically are very little different in method than used for copper, but the lack of trained competent jointers.

Accepting that due to non-availability of funds for purchase of compression jointing equipment where skill needed is less, let us examine what has been done to train jointers in other techniques.

The actual number of trained jointers are unknown as the records may not be complete, but these records show that only 22 jointers have been trained in these techniques, 45 Assistant jointers/line men/electricians, a total of 67 for the whole of Pakistan compared to 62 Executive Engineers, Assistant Engineers and Foremen. The number of trained personnel engaged on actual jointing would appear to me to be inadequate and could well be one of the reasons why many of the joints and terminations give trouble subsequently in service.

There have been occasions when investigating the reasons for joint failures, it has come to light that trained jointers have used the wrong fluxes and/or solders, jointing boxes and accessories of the type intended for copper conductors. On investigating why these were used, it was discovered that the correct materials and accessories were not available from stores and unsuitable materials were issued.

I feel that a more comprehensive and larger training programme is necessary if Pakistan is to reap the obvious economic advantages from using Aluminium as a conductor and avoid the failures that will occur if jointing and terminating are not done correctly. By

a more comprehensive training, I am not confining my remarks to just training Jointers but to Superintending, Executive and Assistant Engineers who must make it their job to convince, train or instruct buyers in the selection and purchase of the most suitable jointing materials and accessories and Storekeepers of the necessity of issuing the correct materials, which are very different from those used for copper. Money, time and effort have been spent training Jointers. All this is wasted if Engineers do not coordinate this with availability of jointing materials. (See Appendices 1 and 2).

These jointing materials exist now in quite a wide range and are now considerably improved in performance and are available from stock here in Pakistan.

On the subject of training that is available in Pakistan :—

(*a*) **KESC Training School :**

Have not yet introduced a course for Jointers. They have, I understand, 20 Jointers (Senior Staff) who have been trained abroad.

(*b*) **WAPDA Training Institute Lyallpur:**

They do not have a specialised course for Jointers as yet, but they do have 33 trained Jointers on their staff.

All of the papers presented at this Symposium look at the problems of the behaviour of Aluminium under various conditions. We have a history of papers examining it as a metal technically and in great detail, but there is little history of the efforts to overcome the problems and train people to use it properly.

The Cable Industry is prepared to give as much training and assistance as is practical within their means, but the industry cannot be responsible for this in its entirety. You Engineers have an active and very important role in training personnel to use the correct techniques, to impress upon them the need for greater care which will eventually become a matter of routine for them.

Turning now to the second problem, that of Conductor Corrosion, again there are some excellent technical papers on this.

Whilst this is a problem and is worse than copper under certain conditions and KESC, in particular, are conducting a number of experiments in this area. There is an excessive phobia here in Pakistan because Aluminium here got off to a very bad start and there is an element of "Give a dog a bad name . . . ."

I refer, of course, as I said I would, to the Aluminium cable laid by KESC in 1962, and this instance is so often quoted against Aluminium without a proper examination of the facts. At that time, the use of Aluminium for sheathing cables was comparatively new and like most new materials and processes unfounded claims are made along with the mistakes that are a part of learning and development, but experience in use proves or disproves these claims and much knowledge, development and modification takes place subsequently.

This particular cable was laid underground with an inadequately protected Aluminium sheath. Following this experience, Aluminium sheaths have been protected with a plastic outer sheath extruded on under vacuum to ensure a tight waterproof jacket. I shall not go into electrolytic action. This has already been covered, but nobody today would consider laying an Aluminium sheathed cable without a plastic waterproof covering directly over the Aluminium in such

conditions as existing here in Karachi. But the faults and failures were not all as a result of corrosion, considerable trouble occurred at the joints and terminations. To my knowledge, no Aluminium sheathed cables have been laid underground in Pakistan since then, and yet this one bad experience is so often quoted as a reason for not using even ordinary insulated Aluminium conductor cables that do not have an Aluminium outer sheath, because they say Aluminium corrodes. Of course, it does, but it can be suitably protected.

However, as I said earlier, WAPDA have been using insulated Aluminium cables underground since 1966 and KESC re-started using these in 1969 for both low and high tension cables and M.E.S. are now using these exclusively, but generally in industry in Pakistan the use of Aluminium has been negligible. Progress has been exceedingly slow and far behind the practice of other countries faced with similar economic problems and, apart from this one instance, there has been insufficient justification for this lack of progress in view of the economic advantages and advances in technology in recent years.

The other incident which gave Aluminium a bad reputation was the experience of KESC[1] using Aluminium conductor in low and high tension overhead network some years ago, when after a short period of one year corrosion had eaten deep into the conductor.

It is generally felt that the corrosive climate of Karachi is the worst in the world. It is interesting to note the B.I.C.C. Report[2] on site corrosion tests of Aluminium and Aldrey overhead-line Conductors after exposure for two years eight months at Karachi. This report covers the effects of corrosion and shows that Smooth Body Conductors that had been treated with a protective film suffered only slight attack and to about the same extent as on a similar conductor exposed for two years at Clay Cotton, a U.K. rural site.

There is much evidence to show that smooth body conductors resist corrosion to a much higher degree and this combined with corrosion resistant and high strength alloys suitably coated with protective films or perhaps better still a Polyethylene outer jacket applied tightly using vacuum techniques of extrusion and resistant to U.V. light could well enable Aluminium overhead conductors to give satisfactory service for all relevant time and with economic advantages.

Wiring and General Cables:

Turning now to cables below 0.0225 square inches, there is very little history to be reviewed as no significant progress at all has been made in Pakistan in the use of Aluminium as a conductor material in this range of cables.

I think this has been largely due to the preoccupation with the use of Aluminium for Power Cable and service connections that little attention has been given to this area. Also, it is realised that these types of cable would be in the hands of a large mass of users very inexperienced with the problems of terminating Aluminium conductors and that the general standards of domestic electrical installations here in Pakistan are of a low order.

We must realistically face up to the fact that the problems in this area are great and different. This range of cables is used largely by the small contractor and the general public, and these cables will be terminated at ordinary common domestic fittings. Therefore, of necessity, the method of termination must be of the simple mechanical compression

type and must be capable of being produced at a low cost.

The history of the production of these types of fittings in Pakistan has a bad record for quality and are generally of a low standard of design. Even in use with copper conductor cables they are prone to overheating and are the cause of many failures and, therefore, if to be used with aluminium conductors, the standard of design and quality must be raised.

Manufacture of these fittings has tended to follow the past practices of the Western hemisphere where the terminal has been mainly of the type commonly known as the Tunnel and Grubscrew fixing, where the area of contact is very small and the compression forces relatively low. Experiments have shown that this type of termination does not produce sufficient rupture of the oxide skin and does not allow sufficiently for the 'Creep' that takes place, as a result overheating of the fittings occur at the termination and these types of fittings even if correctly terminated originally, cannot be broken and re-made unless due care is taken in remaking the connection which is unlikely by the average domestic consumer here.

Many articles have appeared in the newspapers suggesting that the poor standards of electrical installations could be considerably improved by the Pakistan Standards Institute laying down a code of practices for electrical installations and, undoubtedly, this is very much needed in Pakistan but, being practical, this could not overcome the uncontrollable use of electric cables and fittings by the domestic public.

However, this does not mean that Aluminium cannot be used for this range of cables and the economic advantages in this large market lost to the country, as here again, the problem does not wholly lie with aluminium as a conductor but with the method of termination.

However, it is the manufacture of fittings and their design to accept aluminium conductors that I consider the Pakistan Standards Institute can play a leading part in promoting the use of aluminium.

Experiments have shown that if a "Wrap Round" type of fixing having a large flat head giving a much greater surface area of contact, and with the greater mechanical pressure that can be applied, this type of fixing will rupture the oxide skin and maintain good contact. Further, this contact can be broken and remade by an unskilled person.

The introduction of metrication in Pakistan will considerably assist the use of this type of fixing as most countries on metric standards use a single wire conductor for the major part of this range of cables, making the rupture of the oxide skin and contact between the conductor and terminal more positive than in the case of a multi-wire conductor.

The manufacturing industry in Pakistan for electrical fittings, even of the common domestic type, has in the main followed the conventional design of "Tunnel and Grubscrew" terminals. As the industry is still in the early stages of production expansion and design, it will be possible, before the industry grows to a stage where a changeover in the type of terminal used would involve a very high cost in changes to manufacturing equipment, new tools and dies, and as some change in tools and dies will be necessary on adoption of metric standards, consideration should be given to standardising on the "Wrap Round" type of terminal. This or a similar type of terminal would also be suitable for use with

copper conductors, thereby allowing the continued use of these fittings on present installations and will be suitable for use with Aluminium conductors, may be no more expensive to manufacture than the conventional terminal and may well, upon investigation, prove to be cheaper to manufacturer.

Summing up, progress in Pakistan in the use of Aluminium as an electrical conductor has been slow and hesitant. Perhaps, not without reason, but with the new techniques in use, more advanced jointing materials, better designed accessories and new alloys, progress needs to be accelerated rapidly in order to reap the economic advantages.

History for its own sake is of little advantage except perhaps to make interesting reading. It is what we do about the lessons we learn from studying history that really count.

Perhaps we should now close the book of history as there exists an opportunity for history to be made by the creation of a Power Commission, perhaps under the auspices of the Ministry of Science and Technology.

To conduct experiments on the behaviour of Aluminium in our conditions here, develop and experiment with protective coatings and outer jackets. Develop training programmes sponsored by Government, manufacturers and large consumers on a common and co-ordinated basis. Ensure that the accessories manufacturing industry coordinate their designs with those of the cable industry to take full economic advantages of the use of Aluminium. This should be done preferably through the Pakistan Standards Institute who can lay down standards of manufacture and design. To use the opportunity to coordinate this with the conversion to metric and the problems of designing for metric to run in conjunction with existing installations. Consider whether the Power Industry should go metric now or as soon as possible rather than wait for the general metrication programme from 1974 onward.

Pakistan has been slower to take advantage of Aluminium than other countries and such a programme as outlined above cannot be left to private enterprises or service organisations who are very prone to criticism when service failures occ r, as coordination of this order will not be achieved in the power industry except by some such higher guidance, and without this progress will continue to be slow.

Legislation, as in other countries, is needed, banning the use of copper as an electrical conductor, then rapid progress would be made and can be made to overcome these problems and hesitancy to use Aluminium, without necessarily having a high cost of expenditure. Other countries who have passed legislation banning the use of copper have had their teething problems, we cannot deny this, but these have been successfully overcome.

As I have been reviewing history, I would just like to finish by saying that we, intrepid pioneers of aluminium, may be heartened to read an article that appeared in the ELECTRICAL TIMES[3] entitled "THE HEDGEHOG JOINT," the story of a 50 years old Aluminium cable. Apparently between 1910 and 1914 the prices of copper and aluminium were roughly equal and cables with Aluminium conductors were installed by several supply companies in England. One such system was still in service up to 1966 which after 53 years' service was in all probability the world's oldest insulated Aluminium cable.

It is interesting to note that the cable recovered was in excellent condition. to all appearances just as good as the day it was made. Specimen joints were sent for dismantling and examination by a laboratory. The joints were made mechanically using brass sleeves and secured by ten Grubscrews in two rows. These were off centre to allow greater screw length for contact and to force the conductor against the sleeves. These sleeves were tinned inside and out and the grubscrews had flat ends instead of conventional points.

This article also goes on to state that a study of the knowledge about jointing available in 1913 would be salutary to those who believe that it is pioneering to use Aluminium in 1972, it would appear that there was experience at that time of soldering, welding and mechanical jointing and cables with their original joints remained in service until 1954.

In the Hedgehog joint, grubscrews were tightened firmly, contact areas were liberal, jointing surfaces were cleaned in these respects the best modern practice for making screwed connections could improve only a little on what was done then.

Measured against this history, I must end by asking the question, "Just how fast has our progress really been towards the use of Aluminium as an electric cable conductor?"

REFERENCES

1. Mr. Ismail M. Ghadiali—Use of Aluminium as Conductor. The Institute of Engineers, Pakistan, Symposium on Role of Aluminium as an Electrical Conductor. Karachi July, 1972.
2. British Insulated Callender's Cables Limited, Central Research and Engineering Division, Research Report No. K/T. 189. Site Corrosion Tests of Aluminium and Aldrey Overhead—Line Conductors Part 5. Exposure at Karachi.
3. Mr. F. G. Mc Donald *F.I.E.E. A.M.I. Mech. E. The Hedgehog Joint, The story of a 50 year-old Aluminium Cable. ELECTRICAL TIMES 17th August, 1967.

*Mr. Mc Donald was then with Alcan (U.K.) Ltd., London.

APPENDIX I

Oxide Film

An oxide film is present on all aluminium surfaces, this film causes highcontact resistance between conductor and conductor or connector. Since it is present on each strand of stranded conductor, high and unequal resistance is developed between strands.

Cold Flow

The tendency of aluminium to creep or "cold flow" is far greater than that of copper. The effect of this action on compression type electrical connections is to permit greater "relaxation" of pressure with a consequent increase in contact resistance.

Galvanic Corrosion

Aluminium, a metal which ordinarily resists corrosion, is unfortunately anodic with respect to copper, a metal to which it must be frequently jointed in electrical distribution systems. When these metals are

in contact with an electrolyte, a galvanic action occurs and a "cell" is formed in which the anodic material (aluminium) is attacked or pitted, whilst the cathodic material (copper) remains unattacked. Damage due to this eroding action must be prevented if the joints are to maintain a high performance level throughout their service life.

Thermal Expansion

While the thermal expansion properties of aluminium do not effect its usefulness as a conductor, special attention must nevertheless, be given to this aspect when designing connectors. This is necessary since aluminium conductors are frequently clamped in connectors made of metals which expand at lesser rates.

Conductivity

The conductivity of aluminium is less than that of copper and therefore, for a given current carrying capacity the cross sectional area of aluminium required is greater than that of copper.

HOW BICC OVERCOME PROBLEMS ASSOCIATED WITH ALUMINIUM CONDUCTORS

Connecting Aluminium Conductors

Years of research, development and testing have made it possible for BICC-BURNDY to meet the increasing use of aluminium in overhead distribution with a range of connectors designed for this application. This work has indicated that many connectors for aluminium can be similar in general design and shape to equivalent types for copper, and has served to emphasize the importance of giving special consideration to those unique properties of aluminium which make it a more difficult electrical conductor to connect than copper.

Oxide Film

In order to ensure electrical joints of low initial resistance, the effects of the oxide film must be offset in a way that prevents reformation during the service life of the conductor. Penetrox A is a BICC-BURNDY product which has been developed for this specific purpose.

Penetrox A is a compound of zinc granules of carefully controlled particle size suspended in a viscous carrier that provides a readily workable mixture over a wide temperature range. The action of Penetrox A assists in breaking down the oxide film on the aluminium contact surface by providing a great number of current-carrying 'bridges' which fill in all the areas where the film has been broken. In this manner, clean metal-to-metal contacts are provided and the high electrical resistance of the aluminium oxide film is overcome.

Penetrox A also seals electrical joints against oxidation and corrosion.

Cold Flow

Joint deterioration due to this action is eliminated by the contact surface design of BICC-BURNDY connectors for aluminium conductors, the method of exerting pressure, and the materials used. (See also under THERMAL EXPANSION).

Galvanic Corrosion

Damage due to this eroding action is prevented by BICC-BURNDY CONNECTORS in two ways :

1. By the separation of the dissimilar metals involved, either physically or by the use of tin-plated connectors.
2. By controlling the relative masses of these metals.

Physical Separation and Plated Connectors

Since increasing the distance between copper and aluminium conductors which must be joined makes it less likely that a corrosion-causing electrolytic path will be formed between them, physical separation is provided wherever possible. There are many conditions, however, where the relatively wide separation required would make the connector larger that is normally desired, and others where it is desirable to use non-aluminium alloys as the connector material. Under such circumstances, aluminium conductors are best separated by a suitably plated 'buffer' surface. Extensive tests have shown that a properly applied plating of tin is the best method of providing separation under these conditions.

Proporationed Aluminium Connectors

Since the mechanism of galvanic corrosion, as applied to a 'cell' involving aluminium and copper, is such that the anodic material (aluminium is attacked or pitted, it follows that the direct cause of aluminium-to-copper joint failures from galvanic action is the loss of metal from the aluminium conductor. The elimination of this loss, a major aim of the BICC-BURNDY research programme has led to the principle that properly designed and proportioned aluminium connectors can be used for aluminium-to-copper joints as well as aluminium-to-aluminium. When proportioned so that the area and volume of the aluminium connector (the anode) is large compared with the copper conductor (the cathode), such connectors need not be plated, nor do they require soldered-in-copper bushings. It is essential, as with all types of connectors for aluminium, to coat the aluminium conductor and connector contact surface with Penetrox A, and to scratch brush these surfaces.

When an aluminium connector is proportioned so that it is massive where galvanic attack may occur, and then it is installed on a copper conductor the electrolytic current density across the large mass of aluminium, connector is low, and any pitting which may occur is confined to an area on the connector where it has no effect on joint resistance or mechanical strength. Furthermore, when a properly proportioned connector made of aluminium is installed on an aluminium conductor, there can be no attack of the aluminium conductor as the result of galvanic action.

Thermal Expansion

The design standard under which BICC-BURNDY tin-plated copper alloy connectors are created specifies that their clamping elements must have sufficient resilience to compensate for all factors involved in differential expansion. As a result the connector and the the conductor expand and contract as a unit without exceeding the pressure originally obtained upon installation to a point where additional flow of the conductor will take place.

When proportioned aluminium connectors are installed over copper conductors, the expansion difference is such that a reduction in the pressure applied by an aluminium connector on the copper conductor might be expected. However, BICC-BURNDY connectors of this type are massive in proportion to the conductor, and because of its mass, the connector runs appreciably cooler than the copper conductor within it. The lower temperature of the aluminium connector compensates for its greater expansion coefficient, and the original pressure is maintained.

General Section

Modern Techniques of Project Planning and Management

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INTRODUCTION

In the earlier days of construction or manufacture, little attention was paid to the project planning or management, because little capital investment was needed for many of the projects, labour was cheap and speed of transportation very slow. These factors ensured a low cost of time. Comparative success of the managers in those days depended largely on their ability to drive men, mules and equipment in order to complete a project at the lowest total cost. The changes which have occurred since then have, however, increased the cost value of time manifold. Modern techniques of planning and methodology of construction/production offer tremendous opportunities for increased efficiency. Old pratices are, therefore, giving way and in many cases have already been replaced by modern methods of project planning, execution and control, in which each step is very carefully planned before the work on the same is actually started. Capital resources of all kinds—cash, loans, stocks and equipment etc. are selected with meticulous care for use for a specific purpose and for the shortest possible time.

Signing of Indus Waters Treaty in 1960, and the gigantic programme of works that it brought in its wake, together with the time limits imposed for the execution of these replacement works, and the financial implications involved, if the same were not carried out in time, perhaps made us realise, for the first our in our country, the high cost value of time. Our subsequent increased contacts with foreign consultants and contractors in the past few years, during the implementation of the Indus Basin Project replacement works made us further realise the cost value of time and the need for training and switch-over to modern methods of planning and execution. In the present-day circumstances when pressure on our limited resources is very high and Govt. determined to undertake as many development projects as possible in every field to better the lot of the common man, it has become increasingly necessary to understand these new techniques and to keep abreast with the rapidly changing (developing) art of planning, organising and control of various types of projects.

To accept the challenge, take up new responsibilities and to become good project

managers, it may be interesting to state here that the new methods of project planning and management do not require specialization and expertise in one subject *i.e.*, engineering only (though its importance is not intended to be underrated) but require an integrated study and use of economic, technical and human aspect of the problem; and their action and interaction etc. The roles that experts from various contributing disciplines, engineers, economists, accountants, psychologists and sociologists etc., can play have to be understood and made use of by the project managers to the best advantage of achieving the given objective.

Management Problems—Subdivisions

Management problems can be subdivided very roughly into two classes :

(*a*) Problems of Policy; and

(*b*) roblems of Execution, which include designing, planning and control over the project operation.

Typically a policy problem is concerned with deciding as to what is to be done, to what time scale and with what resources. Once a decision has been made the problem of its execution arises. Here again the executives in higher position may be faced with policy types of problems to some extent. However, at the lowest levels the management is entirely executive.

Engineers in our country are already taking care of the 2nd category of problems. But since they are endowed with the creative ability and are also equipped to find solution to problem with some training are ideally suited to take charge of the policy-making also—particularly concerning the Development Programmes.

Here, however, we shall confine ourselves to the method of Project Management, after a policy decision, to undertake a project, has been made.

Project Management : (General)

It is very helpful for the understanding and use of management methods to distinguish three phases of supervision :

(*i*) Project Planning.
(*ii*) Project timing and Scheduling.
(*iii*) Project control.

The first two should be completed before the work on the project actually starts. Project control is in fact aimed at overcoming the difficulties that may be encountered during the execution of the project.

During the planning stage the first step is to clearly understand and define the project; and the way it is to be carried out. This is very important as the success of the plan is largely dependent on the accuracy and effectiveness of this initial definition.

In the second phase "Project timing and scheduling", the datailed control information is calculated. This will include the latest starting time of all activities and the identifications of those operations of which timings may be crucial for completing the project on schedule. Consideration of resources (skilled and technical manpower and capital equipment etc.) is an important item of this phase. The managers must be concerned especially with those resources whose availability is limited and which might impose some sort of constraint. The allocation and timing of such resources is called scheduling.

The final phase of project management is controlling the project activities when they are being carried out. This will include not

only ensuring that the schedule originally laid down is adhered to but more especially it will comprise the whole management service needed to keep a check on the time table, on all delays and their effects on the remainder of the project time. The project managers will evaluate the consequences of any delays and of possible counteractions which will bring the project back on time.

MODERN TECHNIQUES

Bar Chart, PERT and Critical Path Method

(*i*) Bar Chart

The bar chart, in its simplest form, consists of thick lines showing on a regular time scale the start and finish dates of all activities in a project. This is usually employed as a management tool for project control. The chart depicts the schedule of activities of various items involved in a project. However, as interrelationship between various activities cannot be shown on the bar chart; and logic and sequence of activities are of greater importance than their duration, in the initial but crucial first stage of planning the project so the bar chart is of least use at this stage.

(*ii*) C.P.M.

In this method project net work or arrow diagrams depicting the logical sequence of activities to reach an objective are drawn. Starting and completion dates are shown. Bottlenecks are pin-pointed beforehand and remedical measures taken in time to avoid costly delays.

Critical path method of analysis was first introduced by Great Britain about 1960 and it has been used on a rapidly-increasing scale since then. In fact the essential elements of the method had been discovered independently in at least two British Organizations, before the end of 1955, who had realized the importance of parallel sequences and logical interrelationships (other than sequential ones) of various activities that generally occur in large projects. This was followed in U.S.A. by the chemical firm E. I. Du, Pout deNemours & Co. which developed the critical path method in 1957 and applied it to the construction of a new plant in 1958.

(*iii*) PERT

PERT (Programme Evaluation and Review Techniques) which is identical to C.P.M. was developed in 1958 for the U.S. Navy to facilitate supervision of construction of the Polaris Missile system. Nearly 7,000 subcontracting firms were involved in the project and the success of the system had an immediate and widespread effect such that U.S. Deptt. of Defence began to require firms to use PERT/Cost on Government Contracts.

Project-Management by Network diagrams

(A) Project planning

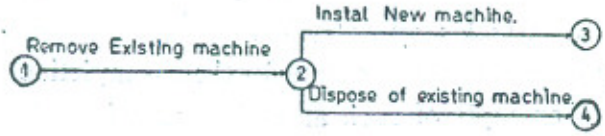
The first step when planning a project by the new technique of network analysis is preparation of an "Activity List" in which all constituent operations or jobs for the completion of the project are noted for reference. The size of these activities will, however, depend upon the nature and scale of the project. But, generally, these activities shall be small enough and well defined. It may be noted that usually activities are those operations which require time for their completion and on which resources are expended. However, sometimes there are certain activities which may not consume any resources though may require time for their completion. An example of such an activity can be "ob-

taining approval of "designs" or "proposal"; or "schemes" (PC-I forms etc.) from the competent authority.

After the activities have been defined, the sequence in which they are to be performed has to be established. Frequently, there is only one possible sequence but in projects where several methods of carrying out the activities are possible, the sequence chosen may be the result of a prior management decision or general policy of the organi ation or the Government.

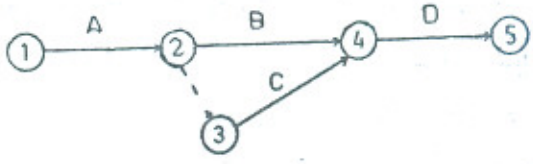
This chosen sequence is then represented on a network diagram. There may be several forms of such diagrams but the type most frequently used at present is known as the "Arrow Diagram" in which each activity is represented by an arrow and the sequence in which the activities are performed. The general direction of time flow is from the tail to the head of arrow. The junctions between activities are termed as "Events", which usually indicate that certain activities have been completed and others are about to be started. These events are often given reference numbers. The following is an example :—

The activities of the above sequence where first activity must be fully completed before second can be started are known as "serial activities;" but the activities which can take place at the same time are known as "parallel activities".

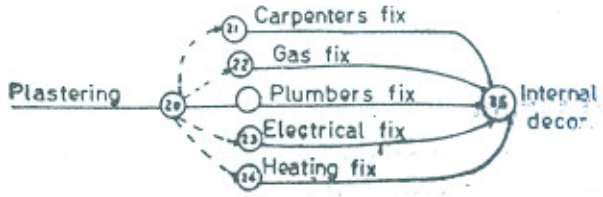


Note that at each event all activities represented by incoming arrows must be completed before any activity represented by outgoing arrow can start.

In some networks the logic allows several activities to proceed completely in parallel, all entering and leaving the same event. In order to remove this ambiguity it is necessary to insert a "dummy" as shown here:—



The uniqueness dummy is activity (2,3). This acitivity was not in fact essential but the ability to refer uniquely to each activity is often desirable and is essential when computer is to be used for analysis of the network. An example of the use of the uniqueness dummy in practice is illustrated by the following typical house-building project :—



When a large project is to be planned, it may sometime contain more than even two or three hundred work operations which need to be represented. Success in such cases lies in the use of "hierarchy" or family of networks of increasing details (and avoiding including large number of activities in one single network). The number of stages in the hierarchy may reflect not only the complexity of the project but also the structure of the company management and the systems of

control, and reporting that are in use. The preparation of overall network should therefore be carried out by someone familiar with organization of the company or management as a whole. Naturally he will be assisted by the representative of various divisions, so that inter-departmental constraints are inserted correctly as early as possible. The more detailed sub-networks can then be prepared by staff of the various divisions who need not have detailed understanding of the work of the other departments but only information concerning the activities leading to and from interface events.

(B) Project Timing:—Duration of Activities:

The next phase in preparing a network analysis involves taking account of the timing of the stages of a project. Since the activities are to be performed in future the periods involved can only be estimated. If the activities be of unusual nature as in a project of exploratory or speculative nature estimates of duration may be subject to considerable error. However, very often prediction of a duration is not so much impossible, or even difficult as inexpedient. The man in charge of a particular job is usually in the best position to make an estimate of its duration, but he may not be willing to commit himself perhaps because he knows better than anybody else that he cannot guarantee to live up to his expectations. One way out would be to incorporate a hidden contingency allowance but this method is not satisfactory as it may defeat the very object of project timing and each superior must, therefore, make a realistic estimate of the likely duration of the job for which he is responsible.

A trick which is usually recommended for new comer to network techniques is the use of three "time estimates"—an optimistic estimate, an estimate of most likely duration; and pessimistic estimate : which he may collect from various opinions that perhaps can be given more freely eliminating the element of committing oneself. The estimator then simply takes a weighted average of the three figures to obtain the expected duration. For example if the optimistic reasonable and pessimistic estimates be 5,7 and 10 days respectively then the expected duration can be calculated as :—

$$\frac{(1\times4)+(4\times7)+(1\times10)}{(1+4+1)} = 7 \text{ days.}$$

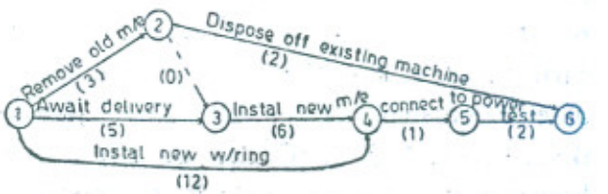
Network diagram analysis

When the network diagram has been prepared and duration of individual activities estimated the network can be "analysed". The purpose of this analysis is determination of the total duration of the Project.

Analysis procedure

(*i*) **Annotation of duration**

The time required for the completion of each activity is written on the network alongside the job to which it may refer. This is usually written below the arrow and in round brackets as shown here :



Note the zero duration assigned to dummy, for it takes no time to perform.

(*ii*) **Calculation of earliest dates**

The earliest date on which each activity can be started is worked out with the help of

network. For this purpose it is more convenient to work in terms of "periods" (say day or week numbers) than in actual calendar dates. A separate conversion calendar can then be used to determine the actual dates, in which week ends and other holidays can be reckoned. The project is started on day 0 and each activity leaving the initial event can also start on this day. The earliest start date for succeeding activities can then be calculated by adding the 'duration', which the activity concerned may require, to earlier calculated dates for the preceding event. These dates for each event are written above the particular-event to which they belong. In cases of activities with more than one predecessor (as for example for event Nos. 3 and 4 in the above network) the required start date is the highest of the values calculated from the various inward path. Thus for event No. 3 the earliest date is 5 and for event No. 4 it is 12.

(*iii*) Calculation of latest dates

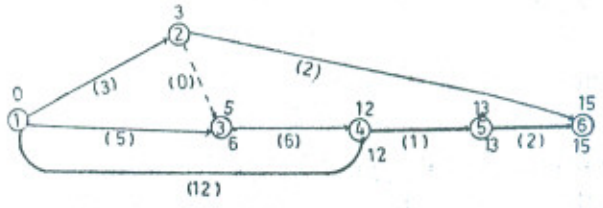
The latest times by which various activities must be finished in order to complete the project in time or schedule are calculated to determine the critical paths. The latest dates are worked out on the basis of a reverse pass through the network. As a first step the project completion date is established. This may be determined by contract conditions or by other external factors. This date may be earlier than or later than the earliest finishing date calculated earlier. In many applications of the C.P.M. (Critical Path Method), however, the required date is expressed as identical to the earliest possible date and any reductions in project duration are made later. This date is written *below* the final event (as compared to earliest date where they are written above the event). The calculation for latest finishing dates are then made for each event on the basis of a reverse pass on the network. For example, in the network shown if project is to be completed on day 15, 'Connect to power" must be completed by day 15—2=13. Likewise installation of power and new machine has to be completed by day 13—1=12 and so on.

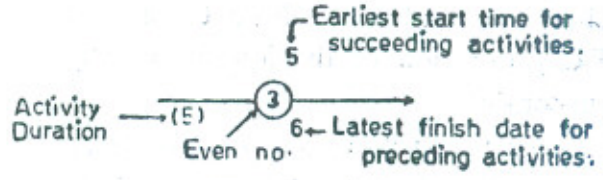
Where one activity has many successors the latest possible finishing time is the lowest of the values calculated from the various outgoing arrows. The final calculation is made at event No 1 to determine the latest date by which the project must have started, if it is to be completed in time.

The critical path can now be marked easily on the network as *it passes through all events for which earliest and latest dates are equal.* It may however be remembered that :

(I) Not all activities between these events are critical.

(II) Unless care is taken when marking up the critical path activities may be wrongly included. This can be avoided by preparation of a table which shows the earliest and latest dates. (Additional parameters can then be calculated more easily from this table than from the diagram).





TABLE

Activity	Duration	ESD	EFD	LSD	LFD	TF	Critical?
Remove machine	3	0	3	3	6	3	
Await Delivery	5	0	5	1	6	1	
Instal new wiring	12	0	12	0	12	0	Yes
Dispose	2	3	5	13	15	10	
Dummy	0	3	3	6	6	3	
Instal new machine	6	5	11	6	12	1	
Connect	1	12	13	12	13	0	Yes.
Test	2	13	15	13	15	0	Yes.

ESD = Earliest Start date
EFD = " Finish "
LSD = Latest Start "
LFD = " Finish "
TF = Total Float = The difference between earliest and latest start dates. It is also known as the period by which an activity can be delayed without affecting the project completion date.

Within the limits of total float, activities can be performed at any time, in order, for example, to make most efficient use of the available resources. For example, in the network shown "dispose of existing machine" which can start on day 3 need not be started on that day but may be taken up at any time till day 13 and it will not cause any delay in the completion of the project.

In addition to the "total float" there are other floats whose knowledge is also essential for project adjustment *e.g.* interfering float is the float which is shared among activities on a chain or path. If it is utilized by the first activity in the chain, then although the project as a whole is not delayed, the subsequent operations which originally had the same period of float will have no float remaining. Thus the interfering float can be utilized by only one of the activities (An example of such activities is activity (1-3) & (3-4) in the network shown).

The float for the final activity of the path (or for a single activity, which does not lie on a chain of operations of equal float) is termed as free float. An activity which has free float can more readily be arranged to be performed at different times than one which is subject to interfering float as the effect on succeeding activities has not to be considered.

As a result of above network analysis and determination of more critical path the planner will know how the job is to be carried out, how long it will take and the time at which all activities can or must be started. He will also know if total duration of the project calculated from the duration of all activites is greater than allowed by contract condition or desired by top management. Then it is the activities on the critical path which have to be examined for possible reduction in duration. It may be noted, however, that although in principle it may be possible to reduce the duration of any critical task, in practice the choice may be limited; for example, it may

not be possible to expedite work to be carried out in a confined space.

The cost of reducing the activity duration need always to be considered to determine which operations are to be shortened.

(C) Resource Management, Scheduling and Levelling

No manager has all necessary resources available in unlimited quantities. Most resource limits are not very serious, but experience has shown that certain constraints are quite fundamental. For projects of many types the most important consideration is to complete the project in the shortest possible time and cost is less important, because the value of profits lost due to any delay in the timely completion of the project may be very much greater than extra expense incurred in accelerating the project or averting any cause of delay. However, only if time is worth money (or some other valuable resource) it is worth minimising.

Supervisory, technical, and skilled manpower, also capital investment are usually the other resources (than time) that have to be allocated most carefully. The help which network methods afford in the resource management of projects is probably their most valuable advantage.

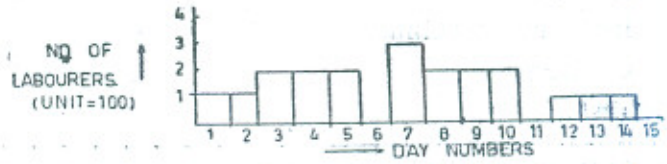
There are two main groups of resource management methods.

(*a*) Straightforward method of accounting for the use made of resources at different times.

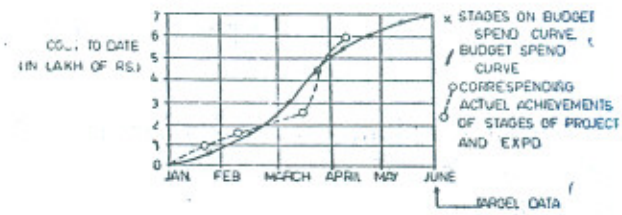
(*b*) The other method is concerned with the allocation of both time and resources.

(*i*) Resource Aggregation

Having found out the critical path, the earliest starting times for all activities and knowing the duration of each activity of the project as also the number of units needed of various resources involved, it is simple to record separately for each resource the number of units needed in every time unit. The resource usage profile is then obtained by adding the number of units in each vertical section. These profiles are also called 'histogram' and are usually plotted for important resources (about 8-10 resources).



The cost control system PERT/cost makes use of this procedure but instead of giving the sum of money expended in each time period the total amount spent up-to-date is plotted.



(*ii*) Resource Scheduling

The term scheduling is used to establish the starting dates of the resources needed for every activity of the project. The project manager will allocate the recources within the limits of their availability and in such a way as to obtain their best utilization. If the resource usage profile indicates a gap between the needed availability he will try to arrange those activities which have some 'float' such that starting times of some of them might be delayed within their floats to reduce the resource levels needed for those occasions when they exceed the limits.

(*iii*) Resource Levelling

It frequently happens that it is not possible to keep within resource limit by manipulating the floats and an absolute limit on one or more resources may result in increasing

project duration. The problem of calculating the best schedule when such limits have been set is quite formidable. The problem though appear to be of a kind that can be solved by linear programming, but in practice it is difficult to solve; because the resource allocation problem for any realistic project is far too large to be solved numerically even with the largest Computers. Practical method, therefore only make use of the general outline of the project.

(*iv*) Resource allocation

It is not possible to describe in detail the method of resource allocation. A great deal of, though simple but repetitive computations are involved. Except for simple projects with few resource limitations it is rarely possible to perform the work manually and use of computers have to be made. The methods used by the computer programmes consists of tentative allocations, using a number of decision rules, and systematically improving upon these until criterion of effectiveness is fulfilled.

(*v*) Resource smoothing

Even if all resource usage profiles are within the required limits they still show another undesirable feature. For example, a project may require employment of 200 labourers in some weeks, whereas none may be needed next week and then again 300 labourers, in the following week as indicated by the usage profile shown before. It is not possible to make effective use of these 200 men elsewhere just for one week but resource smoothing may require their continuous employment. The effective resource usage profile therefore often differs from the calculated form.

(D) Project Control and Method of recording Progress

Having planned the project by network techniques it is necessary that the effect of the planners' decisions must be explained to all those involved (in its execution and control also); and later when the profile is in progress, any deviations from the plan must be recognised and corrected as quickly as possible. For this purpose the following actions are usually adopted :—

(*i*) The practice of holding periodic conferences with key personnel to discuss plans, procedure and results. Such conferences should result in better understanding and moral among staff members engaged in various operations.

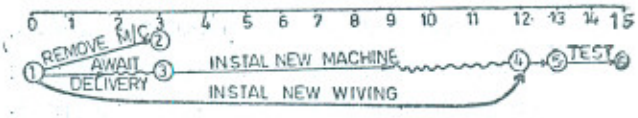
(*ii*) Payment of bonus to key personnel and staff for production in excess of a specified rate.

(*iii*) Considering the desirability of contracting/subletting specialised operations.

For explaining the project the network diagrams are not suitable, for it is not drawn to time scale. Instead, the system, which has been used for many years is the bart chart or Gnatt Chart. A bart chart can be drawn up from any network. The planned start and finish dates of all activities are shown, after due allowance for resource allocation. If no indication of activity float is given the production staff will follow the programme as strictly as possible and project planners themselves shall be expected to attend any project alternations that may become necessary due to any reason. If some day-to-day control over the project parts is however desired from the site supervisor it will be advisable to show the 'float' on various operations in the bart chart. This practice may be good for morals, in addition to being more efficient.

Working schedules of separate gangs of various tradesmen can also be prepared on the above principle, but in these 'Trade bar chart' floats are not indicated because the interaction between various gangs are not normally shown, and if the float be an interfering float the delay in one trade may cause a similar but unforeseen delay to another.

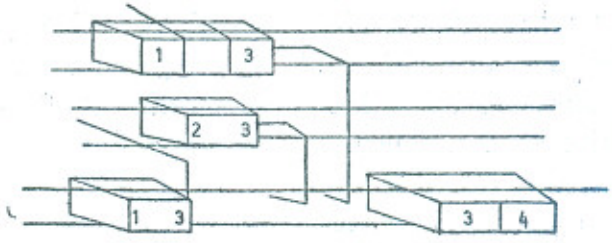
Sometimes the entire network is drawn to scale to combine the advantages of the network and bar chart : showing activity sequence more clearly. But it should be borne in mind that any attempt to combine these benefits may also share the faults of both methods.



Presentation during project control stage

The initial plan though can be shown to scale but during running of the project any variation in the duration of any activity will require that arrow to be redrawn, and may lead to redraughting the complete network. A project may contain a hundred or more operations, however, of which several may be in progress at any time. Continual alternation of diagram is, therefore, time consuming and wasteful. It is, however, essential that current status of the project should be monitered and presented in some form.

The usual method is to prepare time-scaled diagrams of different sections of the project, while retaining the basic network of the entire project. These "sections" may be "periods of specific duration" or may be separate 'stages' of the work process. As each stage is approached the corresponding part of the network drawn to scale is used to assist in day-to-day control. Some mechanical systems, which aim at overcoming some of the disadvantages of the time scaled displays, are not fool-proof and tend to overlook one aspect or another of the project. For a completely fool proof system (once the initial plan has been placed on the chart) a suitable system might consist of beads sliding in grooves or between wires and linked by means of stiff wire to the other beads which are affected by their progress. If such a system is set up correctly interfering and free float can be represented. The resources needed by each activity can be marked on the beads so that at any time the total resources required on site can be calculated. In this way alternative schedules can be compared in a short time to make best and effective use of available resources. Since this frame does not suffer the disadvantages of time scaled network drawn on paper it can be set up for a complete project rather than a section.



Information retrieval

The network or bar chart can only be used to indicate the current status of a project, but the project can only be controlled successfully if the information about the progress of various activities is reported to the network managers as quickly as possible. Decisions can then be made and communicated to the production staff with minimum delays. Activities may be reported at fixed intervals, say weeks or months. As activities are completed a record of their duration must be kept to update the network and to compare the actual and estimated progress.

Feedback is one of the most crucial affairs in the project management. If the manager is not certain of the correctness of information there is very real risk that project control may fail altogether.

There may be considerable administrative problems of ensuring reliable reporting but efforts must be made to solve them before the project to be controlled is started and if necessary the feedback must be tried and perfected beforehand.

Benefits of Network Techniques to Management

The following are some of the main advantages of network method which will accrue to the management.

1. Network representation is easily understandable and it is much easier to discuss alternatives and to choose the best way of carrying on the project.

2. Realistic timing of all activity starts, however, along ahead, simplifies administration problems.

3. Resource allocation method can bring about reduction in the cost of the project.

4. The identification of the critical activities and stages of project. The fact that all activities on the critical path are equally critical is in marked contrast with the usual but mistaken idea that only delays near completion of the project are detrimental.

5. Subordinates/Labourers who would usually see only part of the project can be involved much more effectively, or otherwise they would be unable to identify the effort put in by them with the end product. This method may, therefore, reduce at least sectional strikes in mills/factories. Because if effort of all will go to waste by strike/closure of one section at a crucial time they will persuade their colleagues to deesist from going on strikes.

Introduction of network techniques on selected Projects

In the end I hope that, to start with, the methods of project management by network techniques will be introduced on some selected projects and encouragement and backing by top management shall not be lacking. The backing by top management is very essential, at least in the start. Because effective project management will have repercussions in many departments, divisions and sections, this involvement of top management (those making policies) must, therefore, be an active and real one, not only of encouraging the necessary changes in organisation and practices but also by allowing sufficient time and resources for thorough preparation, and also by a keen interest in the results achieved and its possible extension to other fields.

ACKNOWLEDGEMENT

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(*i*) Prof. Dr. Syed Nazir Ahmad, Head Civil Engg. Deptt.
(*ii*) Mr. W. A. Khan
(*iii*) Mr. Ijaz Sadiq.
(*iv*) Mr. Mukhtar Ahmad Khan.

Thanks are also due to M/s. Saleem and Saqlain for typing from my notes.

REFERENCES

(*i*) Methods Engg. by Krick.
(*ii*) Construction Planning Equipment & Methods by Peurify.
(*iii*) Project Network analysis and critical paths by Affrod G. Simms & John R. Britten.

NEWS AND NOTES

Use of Earth Satellites for Snow Surveys under a Remote Sensors Control Program now being planned in Pakistan

Northern parts of West Pakistan are blessed with high mountains snow covered peaks and glaciers; to a lesser extent solid precipitation falls in parts of Baluchistan also. Rivers in the north thus depend considerably during the critical flow period, on the snow-melt. Advance and ablation of glaciers and the snow cover play an important part in the water budget of not only the mountain regions but also of the plains. The critical flow period during April and May depends entirely on the snow-melt and adequate knowledge of snow-cover and its characteristics is thus a must. The USA has two earth satellites in the orbit at the moment and their photographs can be obtained from NASA. These photographs combined with the ground control of stream-gauging, can give all the knowledge we want about snow and glaciers. The Outer Space Affairs Division is willing to co-operate actively on this issue and has offered help.

Location of Groundwater Springs into the Sea with the help of Infrared Photography

Sometimes it so happens that sweet water springs quietly emerge into the sea without warning. If such emergence can be located particularly in the coastal area of Makran District, it would be a boon to the economy of the area. During recent years it has become possible to locate such springs with the help of Infrared photography. Pakistan must catch on this opportunity and do something for the sweetwater shortage areas.

West Pakistan University of Engineering and Technology

A new subject 'elementary hydrology' has been introduced into the curriculum of the third year B.Sc. class in Civil Engineering. It is proposed to start a Post-graduate Course in Water Resources Engineering in 1972-73. This course will consist of subjects like water resources investigation and development, groundwater hydrology, surface water hydrology, statistics and probability, numerical analysis, soil water plant relationship and sediment transport. The Department of Civil Engineering has set up a Hydrology Field Station adjacent to the departmental building on the G.T. Road, Lahore. The station is equipped with Thermometers, Class—A Pan, Sunken Pan, Thermograph, Actinograph, Barograh, Barometer, Non-recording and Autographic Rainfall Gauge, Wind Vane and Anemometer. Research is being carried out to study the effect of climatic elements on evaporation. Two 7x7x7 feet R.C.C. Lysimeters have recently been added to the station to study actual evapotranspiration of different crops and correlate it with climatic elements.

INTERNATIONAL CONFERENCES

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Schedule of Proposed FAO Conferences, Sessions, and Seminars

Conferences and Sessions

Date	Place	Title	No.	Off. Responsible
4-9 Sep. 1972	Sopron (Hungary)	FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers (9th Session)	FO 804	Chauvin
4-9 Sep. 1972	Rome	Expert Consultation on Crop Water Requirements.	AGL 808	Doorenbos
12-18 Sep. 1972	Dudapest	Codex Committee on Methods of Analysis and Sampling (7th Session)	CX 819	Kermode
Sept/ Oct. 1972	Vienna	FAO/IAEA Panel of Experts on the Radiation Preservation of Food	AGE 810	Fawi Abdu
5-13 Oct. 1972	Wageningen	Expert Consultation on "Land Evaluation for Rural Purposes"	AGL 804	Smyth
6-12 Oct. 1972	Seoul	Asia and Far East Commission on Agricultural Statistics (4th Session)	ESS 807	Narain
9-Oct. 1972	Rome	Working Group on Use of Plastics in Agriculture Industry Cooperative Programme	DDI 816	Bertrand
9-Oct. 1972	Rome	Working Group on Farm Mechanization; and Working Group on Forestry and Forest Industries, Industry Cooperative Programme (Joint Session)	DDI 817	Friedrich

Date	Place	Title	No.	Off. Responsible
22 Oct. 1972	Bari	FAO/IAEA Panel of Experts on Methods of Production and Use of Mutations in Plant Breeding	AGE 807	Micke
30 Oct. 3 Nov. 1972	Bangkok	IRC Working Party on Rice Soils, Water and Fertilizer Practices (13th Session)	AGL 895	Hauck Tsutsui/ Loerbrock
13-15 Nov. 1972	Bangkok	International Rice Commission (12th Session)	AGD 802	Loerbrock
17 Nov. 1972	Rome	Meeting with countries contributing to the Associate Expert Scheme	DDA 802	Markham
27 Nov. 1. Dec.	Kandy (Sri Lanka)	FAO Regional Commission on Farm Management for Asia and the Far East (5th Session)	AGS 801	Kristjanson
Sep. 1973	Ghent (Belgium)	ECA Working Party on Soils Classification and Survey (9th Session)	AGL 803	Pecrot
1973	To be determined	Symposium on the Use of Isotopes and Radiations in Soil Physics Irrigation and Drainage Problems.	AGE 812	Fried
5 days 1973	Nicosia (tent).	Regional Commission on Land and Water Use in the Near East (Fourth Session)	AGL 812	Hauck/ Massoud
1 week Spring 1973	Rome	IHD Working Group on "The Hydrology of Carbonate Rocks or the Mediterranean Basin" (4th Session)	AGL 811	Burdon
1st Half 1973	Lahore Pakistan (tent).	First FAO Conference on Cereal Improvement and Production in the Near East.	AGP 804	Tahir
5 days 1973	Nairobi (tent.)	Expert Consultation on Traditional Forms of Land Tenure in Africa	ESR 807	Posada
5 days 1973	Bangkok (tent.)	Expert Consultation on Establishment of Guidelines for Rural Youth and Agricultural Extension in Asia and the Far East.	ESR 812	Wilson
2-14 Oct. 1972	Tokyo	Seminar on Water Management and Control for Agriculture	AGL 817	Houston/ Tsutsui
27 Nov. 2 Dec. 1972	Cairo	FAO/UNDP Regional Seminar on Reclamation and Management of Calcareous Soils.	AGL 820	Massoud

NEW PUBLICATIONS

1. "River Mechanics," ed. by H. W. Shen, 1971. Available from Water Resources Publications, P.O. Box 303, Fort Collins, Colorado 80521, U.S.A.

2. An annotated bibliography on "The Design of Water Resources Systems", by H. Asfur and W. W. G. Yeh, for OWRR., Mar. 1971, Paper No. PB-201, 005. Available from National Technical Information Service, USDC, 5285, Port Royal Road, Springfield, Va. U.S.A. 22151.

3. "Isotope Hydrology", 1070, Proc. of Int. Atomic Energy Agency Symposium 71. Available from 'Unipub', Inc., P.O. Box 433, New York, N.Y. 10016.

4. "Irrigation and Drainage in the World —a Global Review" by K. K. Framji and I. K. Mahajan (2 volumes), 1969. Available from International Commission on Irrigation and Drainage, New Delhi, India.

5. "Planning for an Irrigation System". Available from American Association for Vocational Institutional Materials, Engineering Centre, Athens, Ga. 30601.

6. "Ground Water"—a selected bibliography published by Water Information Centre, Inc., Dept. 5P, Water Research Bldg., Manhasset Isle, Port Washington, N.Y., U.S.A., 11050.

7. "Conflicts in Water Resources Planning", ed. by E. F. Gloyna and W. S. Butcher. Available from Centre for Research in Water Resources, Balcones Research Centre, Route 4, P.O. Box 189, Austin, Texas U.S.A., 78757.

8. "Effects of Watershed Changes on Streamflow", ed. by W. L. Moore and C. W. Morgan. Available from Centre for Research in Water Resources, Balcones Research Centre, Route 4, P.O. Box 189, Austin. Texas, U.S.A., 78757.

9. "Urban Runoff Characteristics"—quantitative and qualitative information of run off from a one-year study of a 2380-acre combined sewer-watershed in Cincinnati Ohio, by Division of Water Resources, Department of Civil Engineering, University of Cincinnati. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. U.S.A., 20402.

10. "Probability and Statistics in Hydrology", by Vujica Yevjevich, 1972. Available from Water Resources Publications P.O.

Box 303, Fort Collins, Colorado 80521, U.S.A.

11. "Stochastic Processes in Hydrology" by Vujica Yevjevich, 1972. Available from Water Resources Publications, P.O. Box 303, Fort Collins, Colorado 80521, U.S.A.

12. "Sedimentation", ed H. W. Shen, 1971; available from the source as in 11.

13. "Systems Approach to Hydrology", prepared by V. Yevjevich, 1971. Available from Water Resources Publications, P.O. Box 303, Fort Collins, Colorado 80521, U.S.A.

14. "Synthetic Rubber Canal Lining : Laboratory and Field Investigations of Synthetic Rubber Sheeting for Canal Lining Open and Closed Conduit Systems Program", No. PB-200 533. Available from the National Technical Information Service, Springfield, Va. U.S.A., 22151.

15. "Water Well Manual", a practical guide for locating and constructing wells for individual and small community water supplies, covers fundamentals of groundwater movement and design and construction of wells. By U.P. Gibson, Premier Press, P.O. Box 4428, Berkeley, Ca. 94704. Available from the National Fire Protection Association, Publications Service Department, 60 Batterymarch St., Boston, Mass. U.S.A., 02110.

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A general view of WAPDA Colony Kot Adu constructed in 1965

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