Engineering News

A QUARTERLY JOURNAL OF WEST PAKISTAN ENGINEERING CONGRESS

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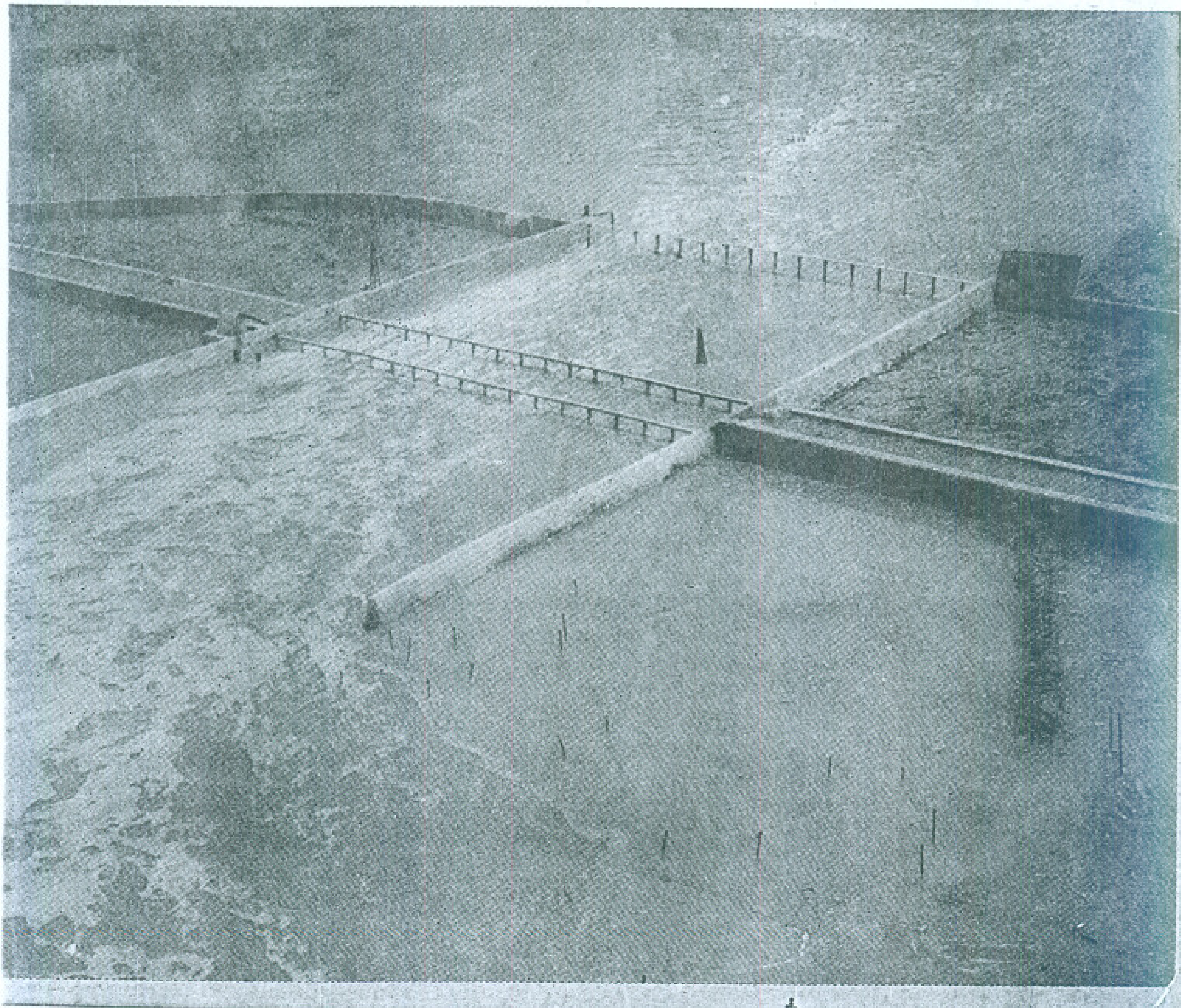


Attention Members Please:

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.

CODE OF ETHICS

WEST PAKISTAN ENGINEERING CONGRESS

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

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

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

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

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

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

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

۱- اِنَّ اللّٰهَ يَاْمُرُكُمْ اَنْ تُؤَدُّوا الْاَمٰنٰتِ اِلٰٓى اَهْلِهَا ۙ وَاِذَا حَكَمْتُمْ بَيْنَ النَّاسِ اَنْ تَحْكُمُوْا بِالْعَدْلِ ؕ اِنَّ اللّٰهَ نِعِمَّا يَعِظُكُمْ بِهٖ ؕ

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

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

۲- اَوْفُوا الْمِكْيَالَ وَالْمِيْزَانَ بِالْقِسْطِ وَلَا تَبْخَسُوا النَّاسَ اَشْيَآءَهُمْ وَلَا تَعْثَوْا فِى الْاَرْضِ مُفْسِدِيْنَ ۝

"Give full measure and weight justly and defraud not men of their things, and act not corruptly in the land making mischief". xi : 85

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

۳- وَلَا يَجْرِمَنَّكُمْ شَنَاٰنُ قَوْمٍ عَلٰٓى اَلَّا تَعْدِلُوْا ؕ اِعْدِلُوْا ۫ هُوَ اَقْرَبُ لِلتَّقْوٰى ۫

"And let not hatred of a people incite you not to act equitably. Be just; that is nearer to observance of duty." v : 8

3. You shall not injure maliciously, directly or indirectly, the reputation or employment of another Engineer, nor shall you fail to act equitably while performing professional duty.

۴- اَوْفُوْا بِالْعُقُوْدِ ؕ

"Fulfil the obligations." v : 1

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

۵- وَلَا تَأْكُلُوا أَمْوَالَكُمْ بَيْنَكُمْ بِالْبَاطِلِ وَتُدْلُوا بِهَا
إِلَى الْحُكَّامِ لِتَأْكُلُوا فَرِيقًا مِّنْ أَمْوَالِ النَّاسِ
بِالْإِثْمِ وَأَنْتُمْ تَعْلَمُونَ ۝

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

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

۶- وَقُولُوا قَوْلًا سَدِيدًا ۝

"And speak straight words." xxxiii : 70

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

۷- اجْتَنِبُوا كَثِيرًا مِّنَ الظَّنِّ إِنَّ بَعْضَ الظَّنِّ إِثْمٌ
وَلَا تَجَسَّسُوا وَلَا يَغْتَبْ بَعْضُكُمْ بَعْضًا

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

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

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

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

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

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

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

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

۱۰- وَأَمْرُهُمْ شُورَىٰ بَيْنَهُمْ

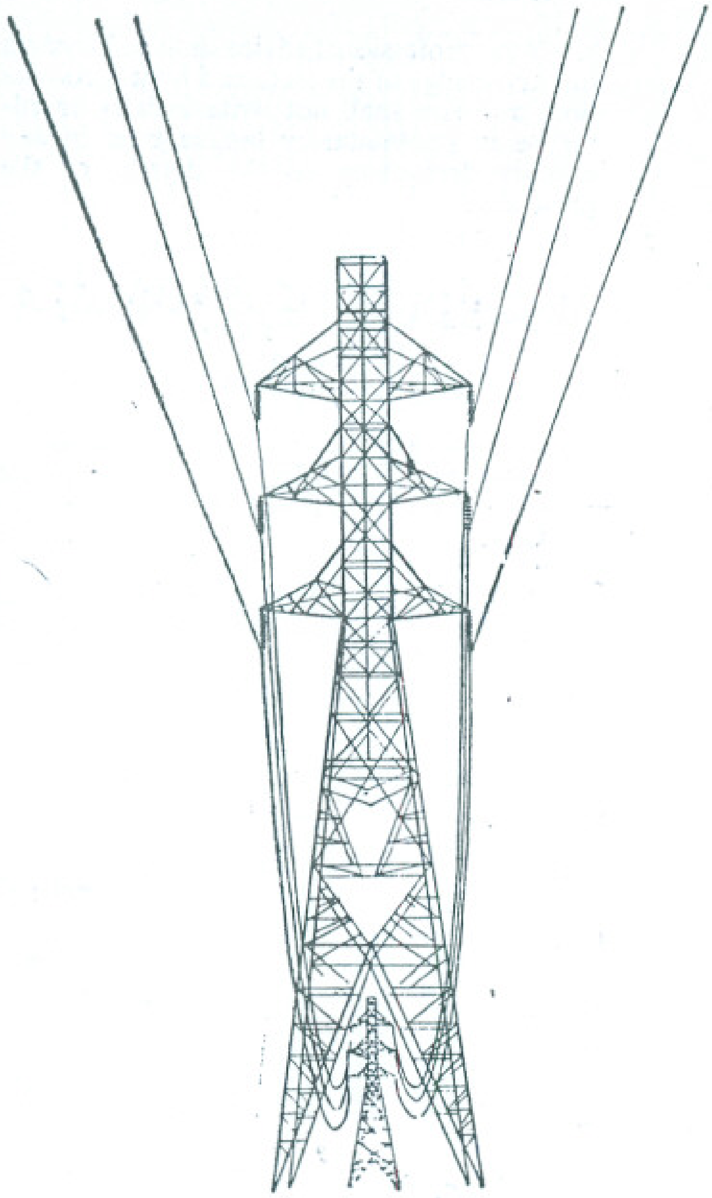
"And whose affairs are decided by counsel among themselves." xlii : 38

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

۱۱- وَاعْتَصِمُوا بِحَبْلِ اللَّهِ جَمِيعًا وَلَا تَفَرَّقُوا

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

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



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

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SEVENTEENTH YEAR OF PUBLICATION

ENGINEERING NEWS

Quarterly Journal of the West Pakistan Engineering Congress

Vol. XVII DECEMBER, 1972 No. 4

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TITLE COVER

A view of Model Studies of New Road Bridge on River Chenab near Wazirabad carried out at Hydraulic Research Station Nandipur

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

Harnessing the Mighty Atoms

'Why Nuclear Power?' The question has been repeatedly asked and convincingly answered in all its controversial aspects. It is not simply because other countries are doing it but because, for Pakistan, there is no other viable alternative.

In Pakistan, the per capita power consumption at present is only 130 kwh as compared to an Asian average of 300 kwh & 8000-9000 kwh in many highly industrialized countries of the world. This is considered by economic experts to be a fairly representative index of the progress gap we must bridge in our desperate struggle for prosperity and equality with the advanced nations of the world.

The oil finds in Pakistan so far are hardly significant and the coal reserves are either unsuitable for power production or their contribution will be small.

Natural gas is a tempting substitute, but it would be unwise to use it entirely for power production in view of its utility for petrochemicals and fertilizer production. In any case the total fuel reserves in Pakistan are equivalent to 800 million tons or 13 tons per capita as compared to the world average of 1250 tons.

Theoretically, Pakistan has substantial water-power resources and it is estimated that allowing for the ever-rising costs of dams and long transmission lines, a target of about 800 MW can be achieved by the end of this century. This will still be seasonal in nature and subject to the vagaries of the weather.

The conclusions of the present Government have been made manifest by our President Zulfiqar Ali Bhutto in the following remarks:

> "In no other country of the world the need to supplement conventional energy resources by nuclear power is so pressing as in Pakistan where the supplies of fossil fuels are so limited. Even at present the Northern part of the country is short of 300 MW of power.
>
> We must, therefore, accelerate our nuclear power programme and pursue

it with greater vigour and momentum. It is only by producing abundant and at reasonable cost electricity for enhancing our industrial productivity and agricultural growth that we can improve the lot of the common man."

The position is quite clear and non-controversial. The emphasis right now is on supplementing the conventional power resources and not replacing them in order to produce enough electricity at reasonable cost to possibly reach the present average of the developed world by the end of the century.

On the 28th November, 1972 the President inaugurated the 125-megawatt Nuclear Power Plant at Karachi to mark the beginning of our first step in that direction.

The possibilities from now on are limitless. The reported reserves of uranium around D.G. Khan should provide ample raw material for the production of Nuclear Energy and KANUPP with PINSTECH will provide the necessary initial facilities for training research and experimentation for future ventures. More nuclear power plants must follow but the activities must be extended from the simple power production to cover all the remarkable uses of atomic energy for peaceful purposes.

Harnessing Nuclear Energy for any purpose is an expensive exercise in itself and doubly so if one has to rely entirely on foreign help at all levels.

Here is a big challenge for the scientists and engineers of Pakistan. We have to face this challenge not for any false sense of glory but for our very survival in the 21st century. We must move heaven and earth to achieve absolute self reliance in this field.

The Chairman of Pakistan Atomic Energy Commission recently spotlighted some of the possibilities within our grasp in the near future. Production of better quality crops with short cycles, high yields (as much as 40-50% above normal for vital, crops like cotton and wheat) and better resistance to disease, fruit preservation through radiation, tapping and utilizing underground flows in Sind and Punjab, desalination of Sea Waters to cultivate the virgin soils of Baluchistan, were some of the possible targets he mentions. There are other equally important possibilities in the field of medicine, engineering, science and even domestic utility.

The prospects are indeed limitless but shall we, the scientists and the engineers, live up to the expectations of the common man? That is the crucial question and the answer lies in a realistic re-appraisal of our role in the past and a drastic change in our attitude.

For the common man, the mention of an engineer brings to mind a host of nightmares. The tricky hole dug on any street in Pakistan that is never filled level with the ground again. There is always a pit or a mound to mark the place for posterity. The teams of diggers and builders that follow one another with a monotonous regularity on a given spot. The transmission line that crashes to the ground with the first signs of a dust storm. The building and the road that cracks up before it is completed. The telephone that connects all the numbers in the directory except the one you wish to dial a host of other 'teasers'.

The general impression amongst the masses is that the engineers in our society have completely failed to solve the most fundamental and the most obvious problems. The reasons for failure notwithstanding the opinion is not ill-founded.

This image must be erased at all costs and a better and healthier image built instead.

So let us have a quick look at the possible factors contributing to our tragic failure.

Is it due to a basic lack of knowledge and technical skill?

Is it lack of planning and co-ordination?

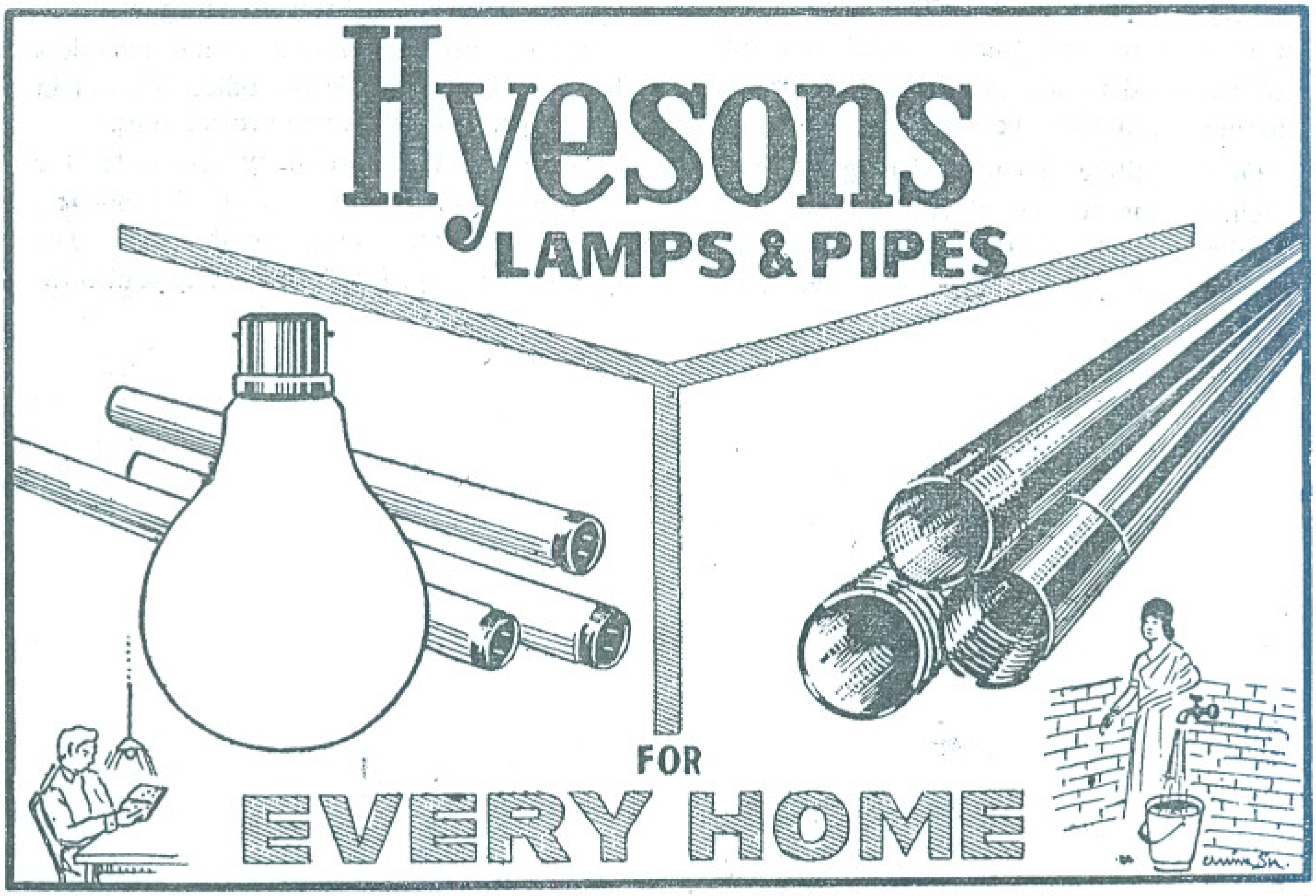
Could it be the result of corruption and malpractices or a confused mixture of all these?

Perhaps the biggest single contributory factor is sheer lack of will. The lack of will which is the hallmark of dependence and slavery. The will to strive and struggle, to work hard, to survive and to excel; the will to aspire and to achieve; the will to live as honourable and free people.

Our destitute country has given the engineers (as to the other educated and qualified people of the country) the rare privilege to acquire knowledge and skill that can be a decisive factor in the future betterment of our society. The engineers can translate the nation's dreams of comfort, better living and general economic uplift into a reality. These potential mighty atoms of our country have an obligation which cannot be discharged by sitting in air-conditioned offices, getting in and out of conferences, meetings or tea parties and leaving the linesmen and the overseers to do the jobs. Their mental genius will never reach the 'critical stage' if they let themselves be bogged down by office routines, red tape or intrigues.

The answer lies in honest and relentless hard work both inside the office and out in the fields, workshops and project sites.

Of course, there are many substitutes for hard work: for instance slavery, dependence, humiliation and even annihilation. The choice is wide open and it is entirely your own.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Irrigation and Power Section

Evaluation of Design and Operation of the Taunsa-Panjnad Link Canal

By

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INTRODUCTION

Taunsa-Panjnad Link Canal constitutes the last unit of the eight Link Canals constructed under the Indus Basin Replacement Plan. This Link Canal, as identified by its name, transfers the Indus waters, available at Taunsa-Barrage, into the Chenab River about 19 miles upstream of Shershah Bridge at a point 92 miles (along river course) upstream of the confluence of the Chenab-*cum*-Jhelum-*cum*-Ravi and Sutlej Rivers, to meet the historic requirements of the Panjnad and Abbasia Canals, offtaking from Panjnad Headworks, which were formerly dependent for their supplies on the Sutlej River.

Taunsa-Panjnad Link Canal offtakes from the Head Regulator, already constructed at the time of construction of Taunsa Barrage and earmarked to serve a future link canal, and it extends 38 miles to the Chenab River. After running almost parallel to the Muzaffargarh Canal for the first seven miles, the link turns in a south-easterly direction and after traversing the lower Thal Doab along a straight route outfalls into the Chenab River, through a Tail Structure located on the Western high bank of the river. This link has a full design capacity of 12,000 cusecs at Head, with provision in structures to pass 14,000 cusecs to permit future increase in capacity.

The construction of Taunsa-Panjnad Link was carried out through two separate Main Contracts, *i.e.*, one mainly for Earthwork and the other for the construction of Structures. Work under Structures Contract were substantially completed on 15th July, 1969. Its period of maintenance, which began on 16th July, 1969, consisted of a one year period, following the issuance of the Completion Certificate, during which the Contractor completed all outstanding minor construction works.

Inasmuch as the Earthwork Contract was not completed till that time, the link was not ready for operation and hence the structures could not be subjected to staunching, seasoning, and testing during all the twelve months period of maintenance.

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** Junior Engineer, Taunsa Panjnad Link.

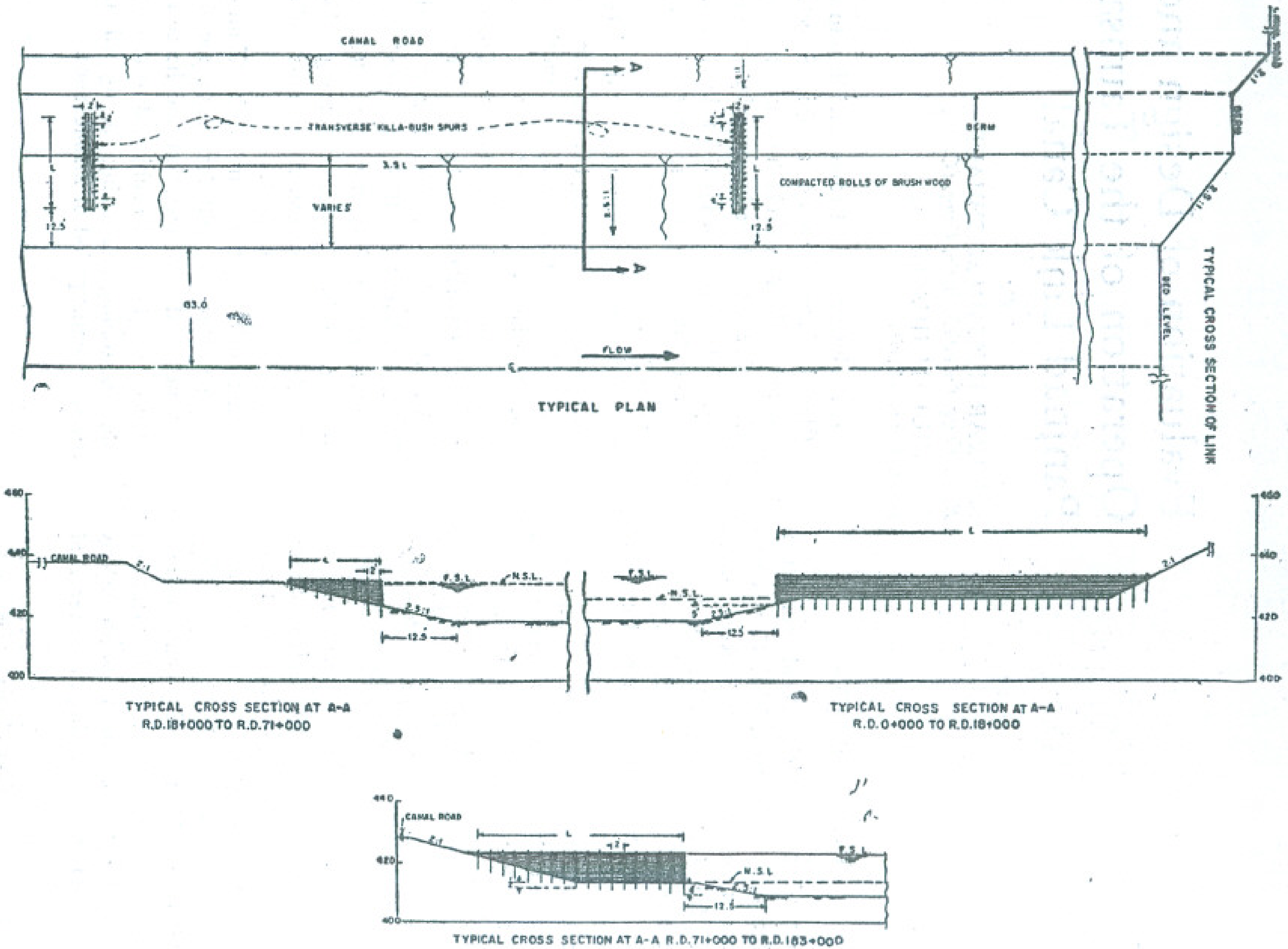


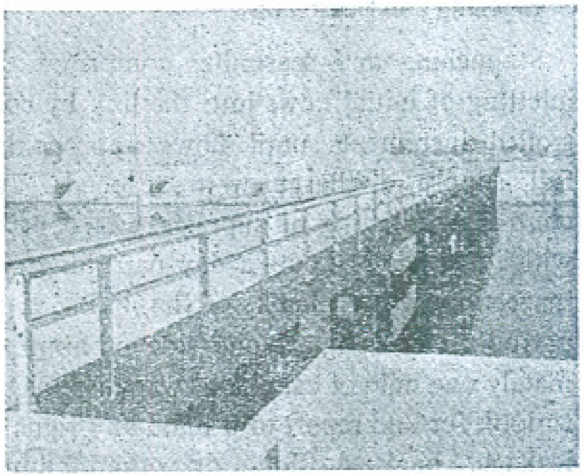
Fig. 1. Typical Plan and Sections Showing Killa-Bush Spurs.

Excavation of canal prism, under Task Force, Contract, had been completed by the end of April, 1970, but because of minor incompletions outside the prism, substantial completion certificate could not be issued before 30th September, 1970. The period of maintenance, which began on 1st October, 1970, consisted of the one year period, following the issuance of the Certificate of Completion, during which the Contractor completed all outstanding minor construction works to make the link completely fit for discharging its design obligations. Unlike the phase-I links, WAPDA elected to carry out most of the routine maintenance work on the Taunsa-Panjnad Link with their own forces. The Contractors were, therefore, notified that they would not be required to do the normal routine maintenance work, but were reminded of their continuing responsibilities for any major repairs that might be required. The Contractors were also advised that they might be called upon by WAPDA to carry out remedial works or to assist WAPDA in doing the routine maintenance work. During his maintenance period the structures contractor was required to extend the stone-pitching on the left bank of link in the reach R.D. 0+630 to R.D. 2+040, instal the water level gauges, construct the discharge sites, and to carry out other minor project finalisation works through variation orders. During the period of Maintenance Task Force Contractor was required only to furnish vehicles and maintain the air-strip etc.

PREPARATORY WORKS

(*a*) Construction of Killa-Bush Spurs

In order to protect the sandy side-slopes against side erosion, sloughing, and to encourage the formation of silt berms, transverse killa-bush spurs were installed all along the link on both sides at longitudinal spacings equal to three and a half times the length of each spur along its axis. Each spur consisted of two rows of killas, with two feet centre to centre distance of every driven stake, tightly filled in with the compacted rolls of pilchi or sheesham brush-wood. In normal Irrigation practice, killa driving is done in running water and green brush-wood from canal plantation is constantly filled in between the rows of killas. However, in view of the none-existence of canal plantation along a newly constructed channel traversing a desert terrain, the required number of killas and brush-wood had to be prearranged and stock-piled all along the link. Later on, killa-bush spurs were installed through WAPDA's own labour engaged departmentally. Construction of killa-bush spurs was started during the end of 1969 and completed by April, 1970. Provision was also made for replenishment and strengthening of the spurs during operation of the link. Details of killa-bush spurs, installed along the link, are shown in Figure-I.



Village Road Bridge R.D. 39+380
Killa-Bush Spurs in the background

(b) Stock-Piling of Revetment Stone

Taking advantage of the experience on other link canals, revetment stone in reserve was provided at different structure sites on Taunsa-Panjnad Link, possibly requiring stone dumping, to meet the future requirements of filling up scours downstream of hydraulic structures which occur during operation of the link or restoration of damages to stone pitchings and aprons. The quantity of the revetment stone in reserve stock-piled at various structures was as detailed herein :—

Structure and Location	*Quantity (Tons)*
Head Regulator and Divide Wall R.D. 00+000	4,500
Railway Bridge R.D. 30+580	500
Control Structure R.D. 59+600	1,000
Control Structure R.D. 131+300	1,000
Tail Structure R.D. 183+000	3,000

The revetment stone at each site was stacked judiciously on upstream and downstream and both right and left sides as close to the areas requiring dumping as possible to avoid extra rehandlings in future.

Staunching and Seasoning

Staunching and seasoning comprised the inletting of initial flows into the link by controlled increments until flows approaching full supply discharge were reached. The controlled inletting of supplies was coupled with intensive 24 hours a day patrolling and inspection of both banks of the link. Each patroller was assigned one side of approximately one mile of canal and was responsible to look for and report to a mate any signs of leakage, bank erosion, or other failures, or signs of incipient failure. Each mate supervised about eight to ten patrollers over a long reach of canal. Overseers and Junior Engineers also patrolled the link on jeeps at frequent intervals during day and night. Surprise checks on the watching establishment were also exercised by the Executive Engineers and the Deputy Project Director. Patrollers and other staff employed on night watching were provided with lanterns and torches etc. Three of the vehicles with the officers in charge of the operation of link were equipped with wireless sets for rapid transportation and communications with the main camp but such an equipment was rarely used since an efficient telephone system connecting all key points on the link with the main camp had been installed well before starting the operation of the link.

In the event of a trouble, the mates or the overseers informed the main camp by telephone and arranged for any necessary action to be promptly taken. The overseers in charge of various reaches of the link were provided with pick-ups for promptly carrying the materials like killas or brush-wood to the different sites of actions.

Under-water scour at bridges was measured using plumb bobs, while bed scour below canal regulators and the tail structure was measured by using sounding rods or plumb bobs from boats anchored to wire-ropes stretched across the width of the channel. To facilitate early staunching of the channel, supplies in the various compartments of the link, formed between every two gated control structures, were ponded up to the design full supply levels, even during partial supplies of 5,000 cusecs to 8,000 cusecs, with the help of gates provided on the Control Structures at R.D. 59+600, R.D. 131+300 and the Tail Structure at R.D. 183+000. This also helped in the formation of good silt-berms within the initial six months of link operation and establishment of natural vegetation on the berms.

INITIAL OPERATION

First Flow Season

Taunsa-Panjnad Link canal was first opened on May 31, 1970 at 1100 hours with an initial discharge of 1,000 cusecs which was gradually raised to 8,000 cusecs by June 17, 1970. Because of sudden fall in the supplies of the Indus River at Taunsa, the link had to be closed as an emergency shut-down on June 26, 1970. With improvement in the river supply the commissioning of the link was restarted with effect from June 27, 1970 and the flow in the link from the head regulator was gradually increased to 10,500 cusecs by July 16, 1970 which after touching the figure of 11,000 cusecs on July 24, 1970 was again reduced to 10,000 cusecs on July 29, 1970 which remained constant up to September 17, 1970 when gradual reduction had to be carried out to counteract the menace of water-logging resulting from heavy seepage from the link. Moreover, supplies in the Chenab River downstream of Trimmu Headworks had improved considerably and hence running of high-flows in the link simply for testing and staunching, at the cost of standing crops, public utilities and properties being affected by waterlogging, was not considered advisable and accordingly discharge at Head was reduced to 5,000 cusecs on September 18, 1970. The link was completely closed on December 31, 1970.

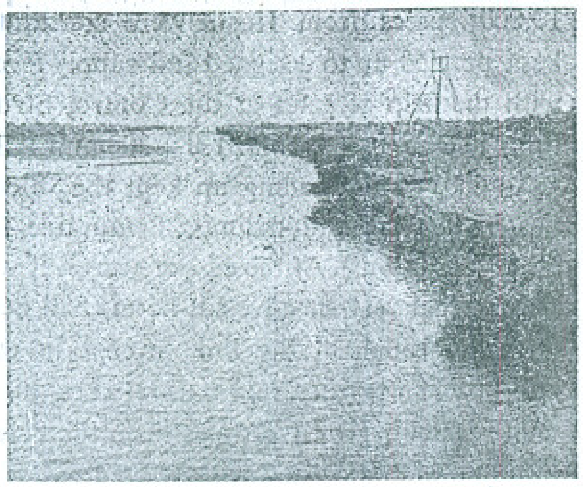
Berm Formation

During this operation period the link behaved satisfactorily except the problems briefly narrated herein. Although full supply discharge of 12,000 cusecs could not be run during this operation season, supplies with 10,000 cusecs from Head were constantly kept ponded up to designed full supply levels with the help of gates at the Control Structures R.D. 59+600, R.D. 131+300 and R.D. 183+000. This heading up kept the velocities in the link within limits favourable for berm formation. At the end of season it was noticed that very effective silt-berms had been formed throughout the link, except in certain problem reaches, and natural vegetation, mainly pilchi, grown profusely on the berms fertilized and stabilized with fine silt.

Sloughing of Banks

No significant damage to berms and banks was noticed as long as the supplies were kept ponded by artificial heading-up at the Control Structures at R.D. 59+600, R.D. 131+600, R.D. 131+300 and the Tail Structure at R.D. 183+000. The moment an attempt was made to raise the gates of these Control Structures, to attain free-flow conditions in the link, both the banks were considerably damaged due to side erosion and sloughing in the reaches R.D. 120 to 124 and R.D. 142 to 162. The apparent reasons of these erosive actions were the accelerated flow velocities, resulted due to the free-flow conditions in the channel. This trouble could also be partly attributed to the overloaded berms in these reaches which received a surcharge, after completion of construction, of loose sand drifted during severe wind storms. Although supplies were again ponded up by lowering the gates, some minor attacks, here and there, persisted due to poor nature of the soil in these reaches.

Suitable remedial measures like construction of longitudinal killa-bush spurs, floating-tree spurs, and unloading of surcharged berms were carried out to counteract the



Side erosion at R D. 142 right as viewed from A.R. Eridge R.D. 141+847

vagaries of the current in the channel. Similar measures were adopted in the other reaches at isolated locations to check the advance of side erosion. Replenishment of settled brush-wood and redriving of the loose tail-end killas in the killa-bush spurs continued throughout the season by gangs specially detailed for this purpose.

During peak operation of this flow season it was noticed that at certain locations in the reach R.D. 140 to 170, where the link was in high fill and the soil forming banks being "Kalarish", there was some slipping of the toe of the canal bank. It was found that due to bad nature of the soil the normal bank width in this reach was not sufficient to cover the hydrualic gradient. In order to avoid further deterioration, during full supply running of the link, earthen pushtas were constructed to cover the flatter hydrualic gradient. Further slipping of banks was adequately arrested and no trouble was noticed during the year 1971.

Abnormal Afflux

During the period of peak operation in this season, with 10,500 cusecs at head, an abnormal afflux of about 1.5 ft. in water elevations was observed in the reach R.D. 60 to 95. After recession of supplies in the link, detailed hydrualic surveys revealed a constriction in the waterway caused by accumulation of silt by wild growth of reed-mace and bulrush which did not perish despite initial cutting from the bed before commencement of operation, and throve on the sides where it was deliberately retained for the protection of newly excavated side slopes and the berms. This afflux posed a threat to the precast concrete trough aqueduct at R.D. 78+800 which was subjected to a submergence of about 1.5 ft., even with a discharge of 10,500 cusecs at head, against the anticipated design submergence of 0.5 ft. with the full supply discharge of 12,000 cusecs.

To guard against any possible damage to the aqueduct due to floating or lateral thrust of flowing water, especially during windstorms, the trough was suitably anchored, by M.S. rod U-bolts and nuts, with the RCC caps of the pilebents. Furthermore, the clearance of silt deposits was also done from the sides during the periods of low supplies, in the flow season of 1971, to widen the restricted waterway to as near the original conditions as possible. Since a complete closure in the link was not available, deposits in the bed could not be removed. However, whatever could be done proved quite effective and, as noticed during runnings of full supply discharge of 12,000 cusecs, there was no problem of passing the designed discharge or the submergence of the aqueduct at R.D. 78+800.

Behaviour of Structures

Just after the peak operation in July to September 1970 it was noticed that the brick masonry transition walls of the Drainage

Inlets at R.D. 123+400, 157+500 & R.D. 175+500 developed some vertical cracks due to differential settlement of the foundations. One possible cause of this settlement could be that these inlets had been constructed on very bad soil foundations and under dry conditions since, at the time of their design and construction, the subsoil water table was sufficiently below the bottom slabs of the transition walls and after running of the link the subsoil water table considerably rose due to which the bottom soil became boggy and surffered a loss in the bearing capacity and consequently resulted in settlements. The damaged portions of the walls were dismantled and rebuilt by the Structures Contractor. Similarly some brick-paved regulation platforms, on the berm near the slide gate hoist-column, of the inlets mentioned above, also cracked due to settlement of the subgrades underneath and had to be repaired by grouting.

Soundings were also taken at all bridges but no significant scour was noticed at any site.

Soundings were also taken downstream of Head Regulator, Control Structures at R.D. 59+600, R.D. 131+300 and the Tail Structure R.D. 183+000 and it was noticed that there was no settlement of the concrete block aprons or the stone-aprons. In certain canal Regulators of Q-B. Link, the concrete block aprons had settled by about two feet during first period of link operation. This settlement had been attributed to the 3-inch wide spaces between the concrete blocks from which the foundation material under the block apron had apparently worked out. Taking advantage of this experience the spaces between the concrete blocks on all control structures of T.P. Link had been reduced to 1/2 inch during construction and hence no settlement of concrete block aprons was noticed on any of the control structures, but in certain cases there was rather silting on the downstream aprons during low supplies, which of course was washed away during subsequent peak operations. Setting of the downstream floors, aprons, transition walls and the energy dissipation devices, proved sufficiently correct and there was no scouring or erosive action on the sides during the first flow season.

Second Flow Season

During the year 1971, the link was reopened on 15-1-1971 with an initial discharge of 1,000 cusecs. The discharge in the link was gradually raised to full supply discharge of 12,000 cusecs on 1-7-1971 and was kept constant up to 31-7-1971. Discharge was decreased to 8,000 cusecs on 1-8-1971. Because of the heavy silt concentrations in the Indus water, floods in the Chenab River, and also to give a relief to lands and public utilities threatened by serious waterlogging, discharge in the link was gradually decreased and ultimately reduced to nil on 11-8-1971. The link was reopened with a discharge of 2,000 cusecs on 2-9-1971 which was maintained up to 10-9-1971 and then gradually raised to the full supply of 12,000 cusecs on 21-9-1971 which was maintained for only 5 days whereafter a reduction in the link supply was initiated and by 27-9-1971 discharge at head was 8,000 cusecs. This flow was maintained up to 6-10-1971 and then reduced to 6,000 cusecs on 7-10-1971 which remained constant up to 15-10-1971. Supplies in the link were further reduced to 2,000 cusecs by 17-10-1971 which were maintained up to 31-10-1971. A low discharge of 1,500 cusecs was maintained from 2-11-1971 which was further reduced to 900 cusecs on 1-12-

1971, to 800 cusecs on 11-12-1971, to 600 cusecs on 14-12-1971 and finally reduced to nil on 22-12-1971 for the annual winter closure of Taunsa Barrage and its offtakes.

During this operation period, the canal was tested for the full supply discharge of 12,000 cusecs and behaved satisfactorily except the problems briefly described herein :

During running of full supply discharge, lot of silt movement was noticed in the canal bed and formation of longitudinal bed bars at certain locations resulted in concentrations of flow and erosive actions on sides. When the discharge was increased beyond 10,000 cusecs the link started giving some trouble due to actions on sides at different locations, especially in the tail reach. Accordingly, ponding had to be resorted to at the tail structure. The gates at R.D. 59+600 and R.D. 131+300 were, however, kept free throughout the flow season. Side erosion during this year was pronounced at R.D. 142 to 162 right and left and R.D. 176 to 181 right and left. Suitable remedial measures like construction of longitudinal killa-bush spurs and floating tree spurs or a combination of the two were adopted to keep the situation under control.

Scouring of Bed Downstream of Head Regulator

During detailed hydraulic survey of the link, carried out after running of full supply discharge of 12,000 cusecs, a deep scour of the order of 22 ft. below the designed bed was noticed on the left of the divide wall downstream of the Head Regulator. At the deepest point, about 15 ft. of the 40 ft. wide stone apron was launched into the scour hole. Just opposite to this scour on the right half of canal prism, there was a heavy silt deposit on the left half. The above phenomenon could be attributed to any one or all of the following factors :—

(*i*) Against the original proposal of providing a S-curve of 1350 ft. radius in the link alignment downstream of the Head Regulator, a curve with a shorter radius of 600 ft. had to be introduced to incorporate certain suggestions of the Irrigation Deptt : with the result that a sharp curved flow was generated and resulted in silting on the convex side of the channel.

(*ii*) Waterway in this reach was decreased after creation of a high silt-bar as described under (*i*) above and obviously resulted in concentrated flow on the right side which caused the scour.

(*iii*) Running of the link with full supply discharge during the month of September with comparatively silt-free water, which could pick up more silt from the troubled reach, might have aggravated the situation.

To safeguard the divide wall against undermining sufficient stone; from the reserves already stockpiled on both banks, downstream of the head regulator was dumped into the scourhole during early months of 1972 which proved quite effective in attaining the desired objective. With this, concentration of flow was increased towards the left bank and the silt bar also vanished, at least for the time being.

Testing and Evaluation of Designs

Soon after the Taunsa-Panjnad Link Canal was placed in operation, the collection of hydraulic and other data required to evaluate the performance of the link was taken in hand. Most of the data were collected by a special crew organised for this purpose by Harza

International, General Consultants to WAPDA. Additional data, such as daily measurement of water elevations at all the structures and observations of bed profiles and cross-sections of the link were collected by WAPDA. The following data were obtained during the testing period of the link.

1. Stage-discharge relationship of Taunsa-Panjnad Link at Head and other Control Structures.
2. Measurement of water-surface elevations.
3. Velocity measurements of Taunsa-Panjnad Link.
4. Bed profiles of Taunsa-Panjnad Link.
5. Cross-sections of Taunsa-Panjnad Link.
6. Bed material samples.

The data have been analysed to evaluate the hydraulic design and operation of the link as described in the following sections :—

Sediment Transport

The various sources of the sediments that can affect the operation of Taunsa-Panjnad Link are as follows :—

(*a*) River inflow sediments that enter the link through the head regulator.

(*b*) Sediments that enter the link waterway from the erosion of the link banks and bed.

(*c*) Coarser materials that are blown into the link from the surrounding sand dunes.

(*d*) Sediments that enter the link through drainage inlets.

The greatest quantity of silt entered the link through head regulator from Taunsa Barrage pond and from the erosion of the bank and bed of the canal.

(*a*) River Sediment Inflow

The Indus River during the initial period of operation, from June, 1970 through December, 1971, of the link maintained nearly a normal pattern of river flow. The sediment concentration was also normal during this period of operation of the link. The approach of the Indus River to the Taunsa Barrage is, hitherto, oblique and curved. The head regulators of Taunsa-Panjnad Link and Muzaffargarh Canal fall on the outer or concave side and the head regulator of Dera Ghazi Khan canal lies on the inner or convex side of the curve. Since the water flowing along the outer periphery of the curved river course is charged, due to acceleration of velocities caused by the centrifugal forces, with comparatively smaller volumes of silt and, accordingly, relatively sediment free water entered the link during initial operation period. After the completion of corrective works, the construction of which has already been taken in hand by the Irrigation Deptt., necessary for the straightening of the river approach upstream Taunsa Barrage, which is of substansive significance to preclude excessive sediment entries into Dera Ghazi Khan Canal, the discharge carrying capacity of which has already been considerably reduced by the heavy silt deposits within the canal prism in the head reach, a greater volume of coarser river sediments can be expected to enter the link in future. Nevertheless, by the time the straightening of the river approach upstream of Taunsa Barrage would be executed, the discharge pattern of the Indus River above Taunsa will be greatly changed due to the operations of Chasma Reservoir which has, hitherto, been completed and was placed in operation in July, 1971 and Tarbela Reservoir anticipated to be completed in 1976. The operation of these reservoirs will not only result in the reduction of the peak discharges but also most of the Indus River sedi-

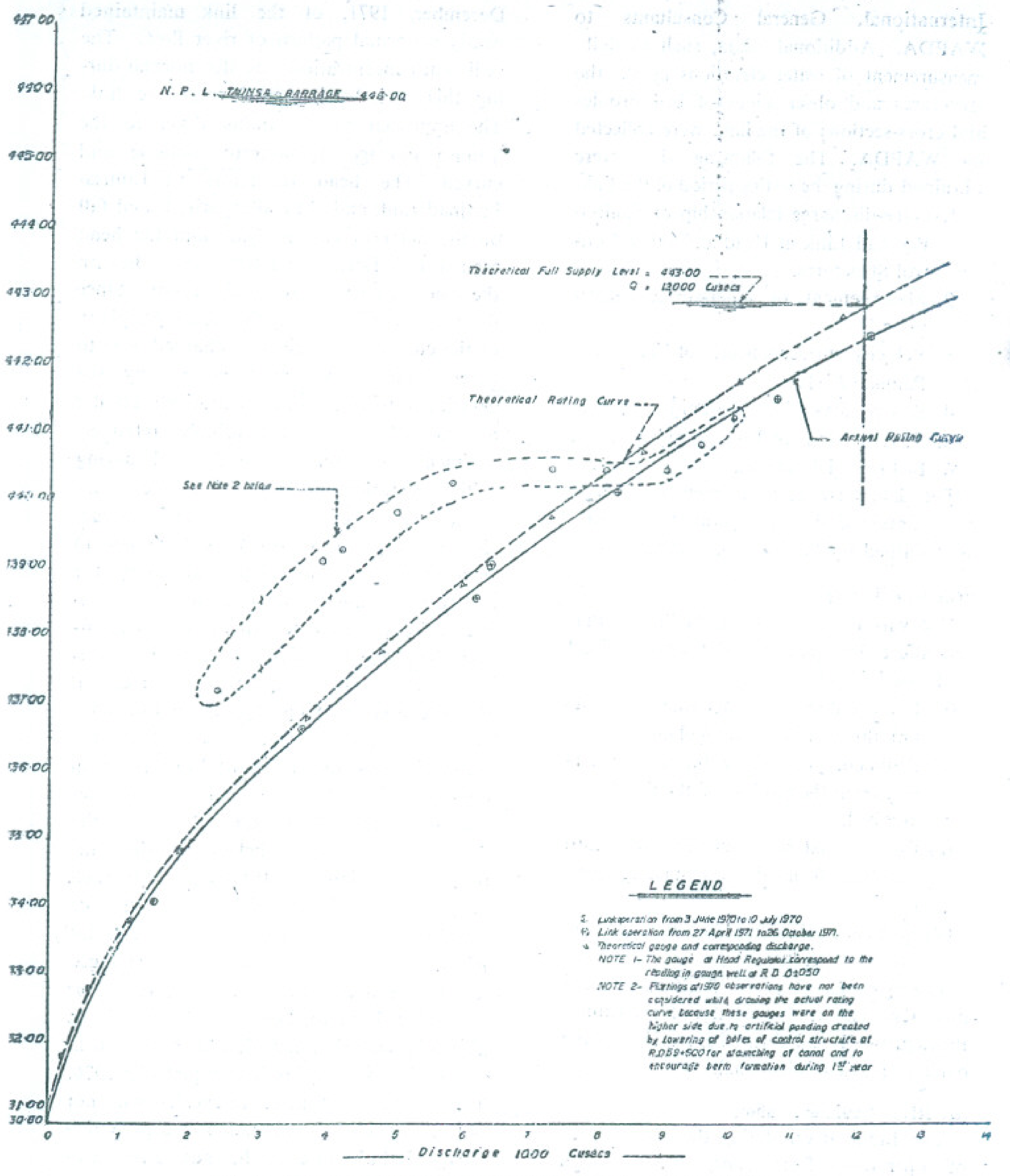


Fig. 2. Stage-Discharge Relationship at Head of Taunsa-Panjnad Link.

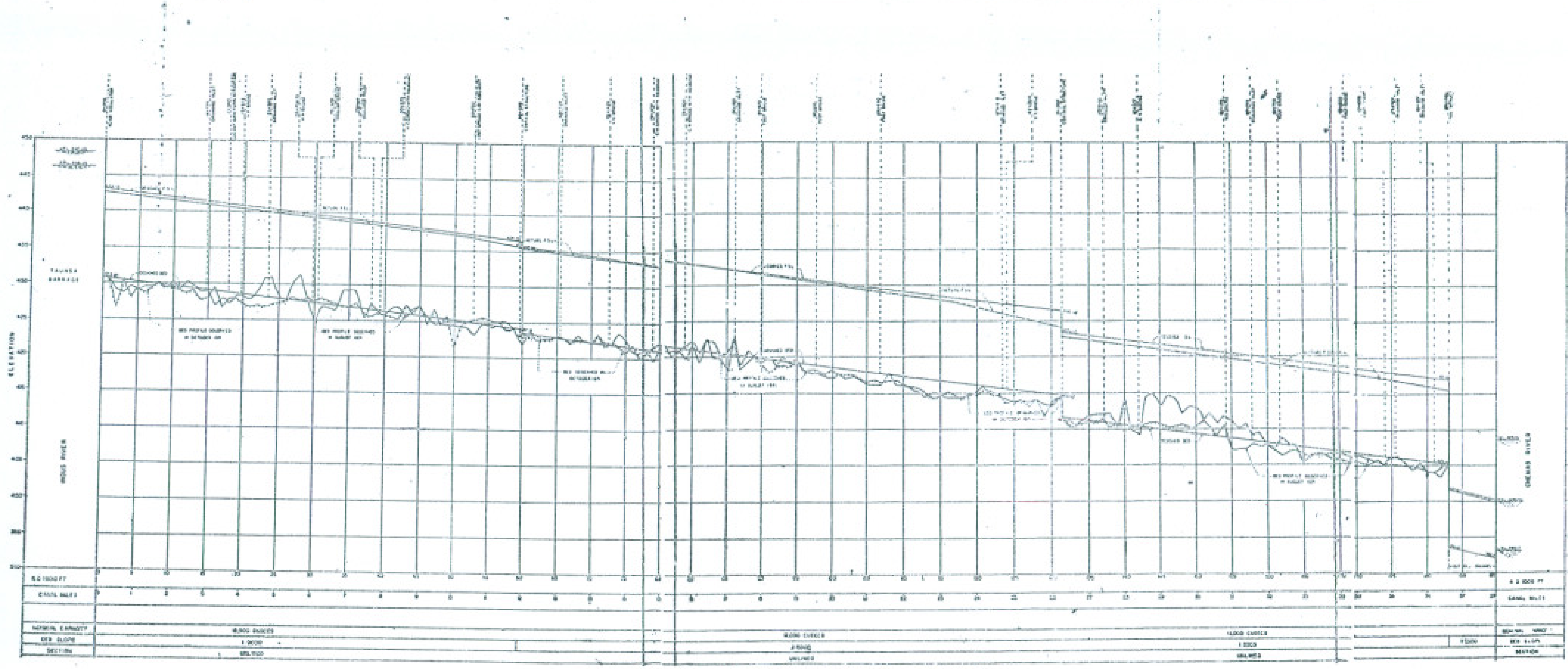


Fig. 3. Profile of the bed and Full supply of the Taunsa Panjnad Link.

ments would also be trapped in these reservoirs and, accordingly, large size river sediments are not apprehended to enter the link in future.

(*b*) Eroded Materials

The materials that enter the waterway from initial canal bank and bed erosion, are different from those that enter through the head regulator. These materials are the natural alluvial materials in which the canal is excavated. The natural materials normally contain coarser materials than water-borne materials that enter through the head regulator. The coarser materials are particularly significant because they do not go into suspension in the link, but move along the waterway bed. The finer fractions of the bank materials, nevertheless, go into suspension and pass rapidly through the channel.

The formation of the longitudinal bars in certain reaches are the result of coarser materials that enter the waterway because of the erosion of the canal banks and bed. The initially eroded materials from the banks and bed of the link probably contain a large proportion of medium and coarse alluvial materials than the water-borne materials brought into the link through the head regulator. When the newly eroded materials enter the flowing water, the finer materials go into suspension and rapidly carried through the link without any apparent adverse effect. The coarser materials, however, accumulate on the bed as large slow-moving longitudinal bed bars. These bars reach heights up to one half the canal depth and may be thousands of feet long. They move slowly down the link at the rate of a few miles per year, and cause high local water velocities which probably account for otherwise unexplainable local scour phenomenon. The adverse effects of the bars in a link can be expected to last for many years because of their slow movement. The self-perpetuating cycle of erosion, agglomeration of sediments into large longitudinal bed bars, high local water velocities, and further erosion has been successfully halted by stabilizing newly constructed link banks with killa-bush spurs and plantation. These bed sediments, if not controlled, will affect the link hydraulics for a number of years.

A huge longitudinal bed-bar at R.D. 149

(*c*) Wind-Blown Materials

The addition in the sediment concentration due to the wind-blown materials, from the sand dunes surrounding the link, was given special attention in designing the parameters of the link. In order to increase the sediment transport capability of the link, a steeper slope of 1 in 8,000 was contemplated suitable for reaches below R.D. 59+600. But the apprehension of the entry of the drift sand in the waterways has been appreciably reduced because of the plantation developed on the spoil banks of the link. However, the link has the potentiality of transporting the small fractions of sediments expected to be increased due to the entry of the wind-blown materials into the waterways in future.

(*d*) Drainage Sediment Inflow

Insignificant quantity of fine silt is expected to enter the link through the drainage inlets, as most of them have not operated hitherto, because of the low precipitation in this area.

Bed Material Sizes

The bed material size is an important variable in the design of stable channels in alluvium, and the 'silt factor" for the Lacy's design equation is a function of the bed material size. To compare the values assumed in the design with actual values, nine bed material samples were taken from the link at R.D. 20, R.D. 91 and R.D. 143. These samples were found to have median diameters ranging from 0.125 to 0.25 millimeter with an average of 0.19 millimeter. These median diameter bed materials closely approach to the design value of 0.20 millimeter, and are not expected to change significantly in the future.

Conclusions

Taunsa-Panjnad Link is capable of transporting the sediments expected to enter the channel without sediment ejection. Erosion of the banks of the link should be effectively controlled to preclude eroded materials from entering the water ways in excessive quantities.

Capacity of Link

The stage-discharge measurements for Taunsa-Panjnad Link were carried out during its operating periods. Since artificial pondings were maintained upstream of the control structures during the initial operation period of 1970, these measurements could not be relied upon for evaluating the performance of the link. The stage-discharge measurements, carried out during 1971 with free flow conditions, near its Head Regulator, are shown in Figure 2. It will be seen that measured water elevations on Taunsa-Panjnad Link are generally lower than the designed water elevations, with only sporadic exceptions at low discharges, for a given discharge. Water surface elevations were noticed on Taunsa-Panjnad Link almost daily by recording hydraulic gauges installed at suitable points of all the Control Structures, bridges and drainage inlets. Representative profile for full supply discharge at Head as shown in Figure 3, manifests that full supply water elevations attained by the Link, at its maximum designed capacity of 12,000 cusecs are generally lower than the designed full elevations and issues in the conclusion that the link is capable of conveying about 1,000 cusecs more than its maximum design capacity.

Flow Velocities

Figure 4 shows the mean velocities observed in the Taunsa-Panjand Link for various discharges and also indicates the theoretical mean velocities for the designed cross-section using Manning's n-=0.022. Velocities at some points are consistently higher than the design velocities while the velocities in certain reaches are slightly lower than the design value. Some variation in velocity from place to place was expected because of the formation of dunes and other irrigularities in the bed of the channel.

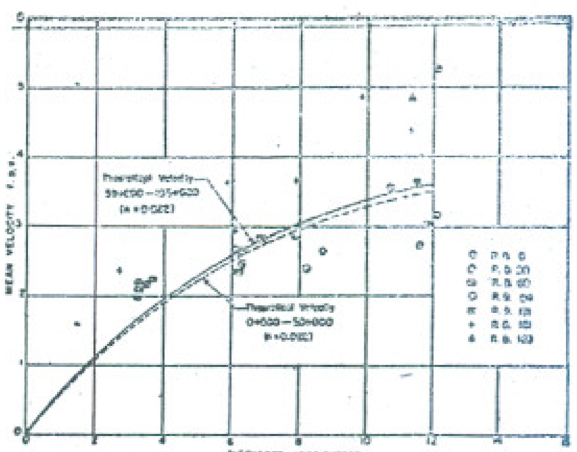


Fig. 4. Velocity Measurement of Taunsa-Panjnad Link.

Of particular interest, however, were the measurements of the unusually high velocities in the tail reach. This phenomenon, which undoubtedly contributed to bank erosion in some areas, is attributable primarily to the fact that the newly excavated sections were relatively smooth and had not fully developed the "ripples on dunes" bed-formation that is characteristic of a regime channel in alluvium. The other chief reason of the higher velocities and low water elevations, as illustrated earlier, may be the steeper bed slopes of 1 : 9000, which corresponds to a silt factor of 0.98, in reach from R.D. 0+000 to R.D. 59+600 which was further steepened to 1 : 8000, to increase the potentiality of the flow to carry the increased silt concentrations because of the sand blown into the link from the surrounding Thal area where sand storms are quite a frequent phenomenon, in the reach R.D. 59+600 to R.D. 183+000. The low sediment concentration and small sediment sizes, as compared to design values, *inter alia*, substantially contributed to the condition which caused the link to flow at higher velocities, and water elevations, significantly less than the design, in the tail reaches. The slightly higher water elevations and lower mean velocities in reach R.D. 60 to R.D. 95, as compared to the design values, were probably due to the effect of increased friction, as substantiated by the measured Manning's n of 0.'229 against 0.022 adopted in the design, and constriction in the waterway caused by the aquatic growth within the prism of the link in this reach as described in a foreoging paragraph.

Profiles and Cross Sections

The bed profile (Fig. 3) and cross-sections of the link observed during October, 1971 exhibited that the link has a general tendency, except in Reaches R.D. 60 to 95 and R.D. 140 to 160, to scour in the bed and, consequently, is issuing in flattening the bed-slope of the link which ultimately would result in minimising this tendency of side-erosion and bed scour. The greatest depth of scour that occurred was downstream of the Head Regulator in the right half of the prism, adjoining the Divide Wall. The reason of this scour, as explained earlier, was the constriction in the waterway caused by the heavy silt deposits accumulated on the left half of the prism of the link.

The consistent tendency of scouring upstream of the control structures is due to the reason that they are constructed for a maximum capacity of 14,000 cusecs to cater for a possible future increase in the capacity, and, *ipso facto*, give rise to higher velocities in the link immediately upstream of these structures. Initially, the link has been built with a capacity of 12,000 cusecs against the requirements of the order of 13,942 cusecs. The scouring potentiality which has developed by the combination of circumstances previously mentioned, namely, low sediment concentration, flow at sub-normal elevation with attendant higher velocities, because of flexibility in the design of control structures less roughness of the new channel, would gradually be dwindled with progressive approach of the canal towards its regime conditions.

During initial operating period of 1970, heavy sediment deposits were formed, which had to be physically removed during winter low supplies of 1971, on the bed and side slopes of the link because of the thick aquatic growth, like bulrushes and reed maces, in the reach R.D. 60 to 95. The comparison of the bed profiles, nevertheless, observed during August and October, 1971 and shown in Figure 3, indicates that sediment deposits in

Reach R.D. 60 to 95 and R.D. 140 to R.D. 160 were of transitory nature and are moving down the canal.

The widening of the outfall channel, which is extended to the river at about R.D. 191+700 from a point below R.D. 183+000 of the link, is also of a peculiar interest. The outfall channel was initially excavated with a bed slope of 1 : 5000, for a discharge of 3,000 cusecs and it was conceived that the channel would subsequently develop to its full section during the operation of the link. As anticipated, marked deepening and widening of the outfall channel occurred during the initial running of the link and initial running of the link and this development continued till it safely attained the requisite section to pass the F.S. Discharge of 12,000 cs. during peak operation in 1971.

In so far as the structures are concerned, no damage, like displacement of stone-pitching, brick pitching, and stone apron or settlement of any other part etc., to any structure has been experienced except that of the scour adjoining the divide wall as related in preceding sections. Concisely, the structures operated quite successfully and up to the design expectations.

Overall Performance

The overall performance of Taunsa-Panjnad Link was quite statisfactory during initial commissioning periods and it is expected to operate satisfactorily in the future. This general conclusion is well substantiated by the following :—

1. Taunsa-Panjnad Link successfully carried sustained flows up to maximum of its design capacity at water surface elevations generally lower than the design elevations during its initial operating period June, 1970 through December, 1971.

2. The head available for operating the link is adequate. The measured stage discharge relationship, velocities and slopes conform reasonably well with the design, being in most of the cases on the conservative side thus providing adequate allowance for adjustment to the final stable condition which the canal will need.

3. The link has shown little tendency of meandering; the radii of the already unprotected curves are adequate and require no special protection. The bank protective measures adopted are performed well.

4. Flow conditions were generally good and there were no abnormal conditions of backwater, head loss through structure, or other evidence of constrictions. Unusual scour occured only near Head Regulator adjacent to the Divide Wall. The scour area has been stabilized in such a manner that the possibility of excessive turbulence or other erratic flow conditions have been adequately minimised.

5. Due to the circular and oblique approach of the Indus upsteam of Taunsa-Barrage, and fall of less blown sands into the link, the sediment concentration in the link has been relatively small; the bed material closely approximates to the size of the material for which the link was designed. This bed material is apparently derived by resorting o the materials in which the link was excavated. The bed material in the link is not expected to change significantly in the future.

6. The canal is expected to have sufficient sediment transport capability to carry maximum sediment volumes that are likely to occur when the Indus River approach upstream Taunsa is possibly straightened and due to the accumulative increase of wind-blown sand into the link.

(Continued on page 22)

New Road Bridge on River Chenab Near Wazirabad

CH. MOHAMMAD ALI

In view of the poor condition of super-structure and the ever-increasing intensity loading of vehicular traffic, the Highway Department has proposed to construct a new road bridge on the River Chenab, near Wazirabad.

There are one railway bridge and one roadway bridge about 2400 & 200 ft. respectively, upstream of the proposed new road bridge site. The railway bridge whe originally built in 1870-1876 consisted of 64 clear spans of 132 ft. each, giving a clear waterway of 8448 ft., an exceptionally long structure. After introduction of Bells Guide Banks and other training works higher up, the number of spans was reduced to 17 spans in 1919.

Director (Bridges) proposed a new 18 span bridge about 2000 ft. downstream and parallel to the existing Road Bridge to be model tested for the following aspects :

1. Optimum waterway of the bridge.
2. Shape and length of Guide Banks.
3. River Training works if any required.

To fix the most suitable length depth scale ratios, to give dynamic similarity of flow and similarity of sediment transport in the model and prototype, we have to simultaneously choose another flow equation in addition to Froude law which is equally applicable to both the model and the prototype. Manning, lacey and some sediment transport relations if simultaneously satisfied with Froude's scale give in each case a different relationship for distortion.

All the features of existing works and river course after 1970 flood were accurately represented on a distorted model on 1/200 horizontal and 1/36 vertical scales. One of the fundamental accepted principles of dynamical similarity for open flow fluvial model work is the application of Froude law.

The model test with the proposed bridge (18 spans of 155 ft. each from centre to centre of the pier incorporated at a distance of 2000 ft. downstream of the existing road bridge and the right and left guide bank lengths equivalent to 750 feet and 1200 feet respectively, showed that the deepest scour levels occur along the left guide bank of the new bridge which was due to right-handed approach resulting in a high degree of concentration in left bays of the three bridges. There was no scour on the back side of head of left guide bank, and the left guide bank was captured partially. To minimise the scour action along L.G.B. and left piers of new bridge, one additional span was added in left flank in each test and it was observed that to attain the objective, 2 more spans were required to be added which was not economical. Subsequently the following alternative proposals were tested :

1. 18 spans bridge with two guide banks was made diverging out and connected to the approaches of existing bridge, similar in shape to the ones tried on New Road Bridge at Shahdara, to avoid :—

(*a*) Impregnable guide bank head.

(*b*) Armouring of guide bank head on the back side.

The test showed that the flow impinges on the left guide bank and the point of impingement shifted down-stream with stage in flood and an eddy formed upstream of the point of impingement. The extent and the strength of the eddy increased with stage in the river. Still the scour due to forward flow, and back eddy was confined to a length of about 1,000 of left guide bank.

2. A 16 bay bridge with straight and continuous guide banks showed that the max. scour depth along the continuous left guide bank was lesser in depth but more in area as the scour was along the full length of the guide bank.

3. The water level recorded with continuous guide banks were recorded higher than the other tests, but increase in water level was of the order of 2 to 5 depending upon the flood stage.

As a result of model study it was concluded and recommended that the hydraulic performance of 16 spans bridge with straight guide banks is nearly comparable with 18 span bridge with diverging out guide banks extended to approaches of existing road bridge. One of the two alternatives was recommended to be adopted from economic stand-point.

(*Continued from page* 20)

The hydraulics of the link may be expected to continue to change for a number of years. The initial slow progressive scouring of bed upstream of the structures will continue. This action is self-limiting, and may be expected to cease when the canal reaches an equilibrium depth or when more of coarser sediment enter the link. On the basis of the performance and adjustment of the Trimmu-Sidhnai Link Canal, and unlined portion of the Sidhnai-Mailsi Link Canal over a period of five years and that of the Qadirabad-Balloki Link Canal over a period of four years, it is confidently expected that Taunsa-Panjnad Link will continue to operate as designed.

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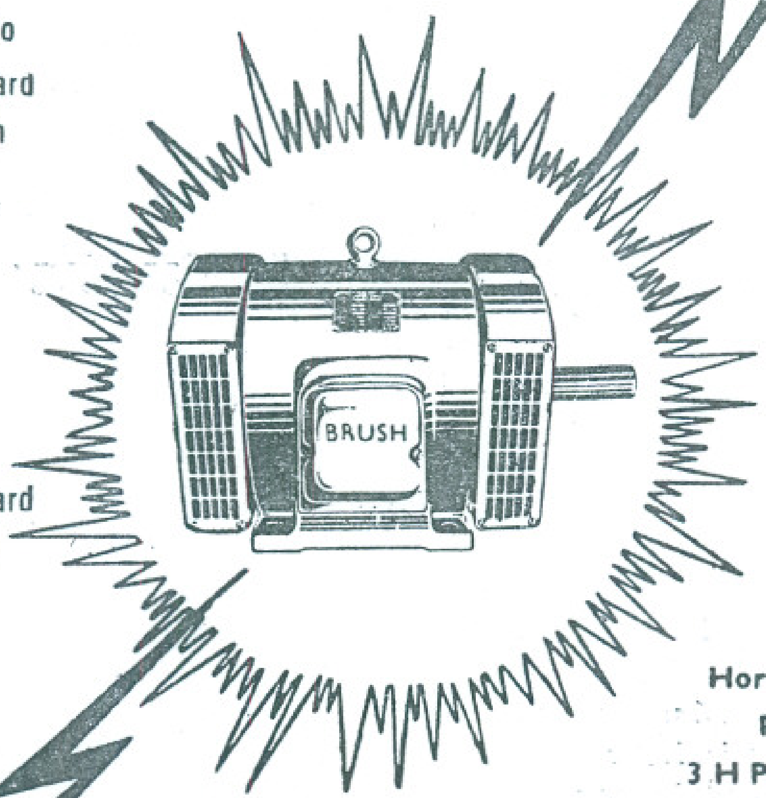

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Crescent

Use of Aluminium as Conductor*

By ISMAIL M. GHADIALI,
Offg. Additional Chief Engineer (Transmission, Distribution & Services), Karachi Electric Supply Corporation Ltd.

Use of Aluminium as Conductor

Copper is one of Nature's great gifts to mankind. It is an extremely useful material, seemingly created mainly for the electrical industry. Section for section, it has the highest electrical conductivity of all commerical metals. Its mechanical properties—tensile strength, hardness, fatigue strength etc.—are in the upper medium range for structural metals, and it posesses fair resistance to corrosion. It is easily worked and jointed.

Small wonder, then, that the red metal has long reigned supreme in the electrical industry. Some 50—55% of all copper produced goes into electrical uses under normal conditions. But its price is never stable and at near past it sky-rocketed far beyond £700 per ton.

With ever-rising cost of copper in the world market it is becoming more and more costly to distribute Electricity to power starved masses for domestic, commercial and industrial uses. We had, therefore, naturally been on look out for a proper substitute which besides being economical, would also give reasonable span of service in Karachi area, where climatic conditions, as most of you know very well, are extremely unfavourable from corrosion and contamination point of view. Naturally choice fell on using Aluminium Conductor in our low tension and high tension overhead network. Specimen conductors of ACSR, pure Aluminium as well as alloy was strung upon experimental basis at few selected sites around Karachi where atmospheric condition was most conducive to corrosion. The stringing was carried out in the same manner as a normal low tension line is constructed. The conductor was strung on poles spaced about 200 ft. apart and was tied to the porcelain insulators by means of copper binding wire. However, on inspection, after short period of one year their condition was found to be extremely hopeless. The corrosion had eaten deep into the conductor core, reducing that portion to a mere powder. The cause of the corrosion was found to be due to salt deposits which gradually penetrated between the strand of the conductor and started corroding the metal resulting in bulges caused by the growth of the products of corrosion and destruction of conductor.

* This article was presented on a symposium held at Karachi in July 1972 and is being published with the courtesy of Institute of Engineers, Pakistan.

The Chief Engineer of M/s. Canadian Hoosier Engineering Co. Ltd., contacted us to know our views about the use of Pure Aluminium, ACSR and Aluminium Alloy Conductor in their Transmission line connecting Karachi with Hyderabad. We had shown him corroded specimen of Aluminium Conductors as well as corroded copper conductor but it appears that he was skeptical of our findings. He himself carried out experiments by putting 3 samples of different types of conductors on test in different locations around Karachi, and he had to concede in his report that, "Such severe locations as Karachi are relatively uncommon and, therefore, we must treat these locations with caution. In the absence of evidence to the contrary, from these tests we would not recommend all aluminium conductor for location A & B" (i.e. KANUPP at Buleji).

We append herewith a report bearing Ref. No.: K/T. 80 by the Central Research Division of M/s. British Insulated Callender's Construction Co. on corrosion of copper overhead lines in Karachi which throws light on corrosive climate of Karachi and its effect on copper conductors.

Experimental Line

In-spite of our initial adverse experience we continued experimenting with Aluminium Alloy. We have recently constructed a double circuit loop line connecting our Gulshan Grid Station with our Valika & Malir Grid Stations. No doubt this line is far away from Sea-shore humid climate and, therefore, so far has not shown any deterioration in its structure. If this line stands test of the time we would be encouraged to use Aluminium Alloy conductors in our rural distribution network.

Use of Aluminium in Cables

In the letter circulated by the acting Convener of this Seminar inviting the members to participate in this symposium it is stated that by using Aluminium cable the expenses on the cable be reduced by about 40%. With due apology to the acting Convener. I beg to differ with this view. Since the conducitivity of E.C. Grade Aluminium Conductor is 61% of equivalent copper but the insulation and armouring required to be provided on Aluminium Conductor of equivalent copper conductivity would be $d^2 \times \pi/4$, in other words, several times more than for copper conductor. This and salvage value of copper after its useful life would leave very little difference in price between the ultimate cost of Aluminium and copper conductor cable.

Use of Aluminium in Internal Wiring

So far no worthwhile attention has been paid by the manufacturers of Aluminium Conductor to popularise use of insulated Aluminium Conductors in Residential, Commercial & Industrial Installations in place of Copper Conductors. Successful use of Aluminium Conductors in these installations depends on care being taken in laying, jointing and termination of insulated Aluminium Conductor and, therefore, manufacturers have to educate wiring conductors and their workmen by publicity materials in all vernacular languages and demonstration by actual working.

Comparative cost of Aluminium & Copper

As is generally known by now, long range price trends in metals generally favour aluminium. In 1940, for example, Aluminium was sold for an average price of Re. 1.00 per lb. while Copper averaged about Re. 0.60

per lb. Even at these prices, Aluminium was cheaper than copper in some electrical applications because in some instances one pound of Aluminium can do the work of two to three pounds of Copper. Present price of Copper is Rs. 5.00/lb. against Rs. 2.00/lb. of Aluminium.

On an equal conductance basis, aluminium enjoys a substantial cost advantage over copper in most applications. There is no overall formula to calculate the relative position of two metals, but one example will illustrate the point.

With one lb. of copper we can make a 20 ft. length of No. 8 solid conductor. But one lb. of Aluminium will yield a solid No. 6 conductor 41 ft. long and both will have the same conductivity per foot of conductor. In other words, volume to volume you can have more than double length of line with Aluminium condcutor with lighter supports.

Problem of Corrosion

With such an alluring prospects in sight, putting up cheaper mains by replacing copper by Aluminium conductors in our overhead lines was not lost on us. But our initial experience in the use of bare Aluminium Conductor did not encourage us to introduce the same in our system. Our experiments had established that if the Aluminium Conductor is properly covered with some sort of weather and moisture resisting material, it remains unaffected even exposed in contaminated atmosphere. Encouraged with this experience we approached local manufacturers of Aluminium Conductor to investigate the possibility of supplying us with thinly covered Aluminium Conductor by some weather resisting compound for use in our overhead service but so far we are still awaiting for their reply and comparative cost of covered E.C. Grade Aluminium Conductor to enable us to compare it with the cost of equivalent copper conductor. It is needless to impress that so far as KESC is concerned, it will not take the plunge unless we are fully satisfied with the quality and performance of covered Aluminium Conductor in climatic conditions existing in Karachi.

Use of Aluminium core Cables

It will not be out of place to mention that since last couple of years we are using dry, cross linked ployethelene insulated cables, known as PEX Cable, in High Tension & Low Tension underground system with aluminium conductor and we do not expect any trouble as all necessary precautions have been taken in letter and spirit of Maker's instructions, for jointing and termination. However, I cannot let go one incident when we were persuaded by one of the leading manufcturers of cables to go for aluminium sheathed cable. The cable was purchased and laid by the supplier but within 2 years cable started developing fault and had to replace entire length within 5 years. Inspection of faulted pieces revealed severe corrosion of Aluminium sheath and penetration of sub-soil water in paper insulation.

Jointing Precaution

Before closing I would like to give a brief resume of the various processes used for making electrical connections to aluminium and to comment on some of the properties of aluminium which are of importance in jointing.

The making of electrical connections to aluminium, and design of accessories for overhead lines, is influenced by many of the properties. The types of joints used in different classes of electrical work may vary considerably, and the engineer concerned should have an understanding of the funda-mentals involved to select the best design. The three most important factors are :—

(*a*) The joint surface.

(*b*) The joint pressure.

(*c*) Dissimilar metals.

The most important property of aluminium to be remembered when jointing, and one which is common factor to all joint process, is the oxide film. This film is extremely hard and tenacious and has a high electrical re-sistance. To obtain good electrical contact this oxide film must be removed or penetrat-ed, and prevented from reforming between the contact surfaces. This task is not such formidable one as it may sound and does not require the use of any special joint compound.

The oxide film is usually removed by cleaning the joint faces in the same manner as connections in any other metal, but it is more important that the cleaning be done properly. This can be done by scratch brushing with a wire brush or using emery cloth. The oxide film can be prevented from re-forming by application of a film of neutral grease or petroleum jelly before applying compression force on the joint.

It is almost impossible to obtain a perfect surface to surface contact. If two flat sur-faces are lightly placed together, contact will be at three places only. If the pressure on the joint face is increased these initial points will enlarge into small areas and contact will also be made at other points. The joint surface will thus be made up of a relatively small number of high spots or load bearing area, where there is pure metal to metal contact, and a small quasi-metal load bear-ing area surrounding each "High Spot", covered with a mono-molecular layer of alien matter but which is nevertheless fully conducting. The remaining and greater portion of the joint area is covered with a multi-molecular alien film of oxide etc. and does not carry any load or pass any current.

The interstices of this large non-load bear-ing area should be filled with a film of grease to prevent the entry of air or moisutre, which may result in tarnishing or corrosion. Many failures in our country where aluminium conductor is used in overhead mains can be attributed to failure of taking proper steps as stated above while making joints. The principal of abruding the metal surface under a film of grease should be employed whenever bolted connections are made. Joint area should be calculated on the basis of about 75 to 100 Amps. per square inch.

The other principle used in making mech-anical connections is that of compression or crimping. In a compression joint intensities of pressure are very high and there is cold flow and deformation of the metal. This causes the oxide film to split and direct metal to metal contact can take place along fissures so produced. Intimate contact is thus obtained over a relatively large portion of joint surface. It is nevertheless recom-mended that a suitable substance be used to fill the interstices to prevent the entry of moisture. A neutral grease may be used if the joint is not under great tension, but it is usually more convenient and cheaper to use a paste made up of 70% Zinc Chromate and 30% Raw Linseed Oil by weight.

In view of what has been said about the relatively small number of load bearing and current carrying points between two sur-faces, it is not surprising that means have been devised to increase these artificially.

The obvious thing to do is to mix hard, small metal particles into the joint compound with the idea that these will pierce the oxide film in numerous places when the joint is bolted up tightly. Such compounds are now available and are useful if the workmen cannot be relied upon to clean the joint surface thoroughly.

Adequate joint pressure is extremely important in all types of mechanical connections. It is also most important that this pressure be evenly distributed over the joint face and that no relaxation should occur during the life of the joint. It is difficult to give pressure figures, but the miniumum joint pressure should be in the order of 750 to 1500 lbs./sq. in.

To obtain and maintain joint pressures of this order, bolts should be as large as possible, and properly tightened during installation. Large flat washers should be used under bolt and nuts. Strong spring washers should be used under all nuts to maintain joint pressure.

Bimetal Connection

The foregoing recommendations apply equally to electrical connections between aluminium and aluminium or between aluminium and another metal. Where connection must be made between dissimilar metals, the need for additional protective measures have to be taken where possibility of moisture being present in the joint area. Due to presence of moisture electrolytic corrosion take place between the dissimilar metals and, therefore, the following factors to be kept in mind when making a joint between dissimilar metals in a corrosive environment are as follows :—

(1) Electrolytic corrosion cannot take place without an electrolyte. Thus, joints can be protected by keeping them dry by painting, wrapping with non-hygroscopic tape such as PVC etc. It is important to use proved materials of good quality which will remain waterproof over long periods. Inferior wrapping materials can do more harm than good if they deteriorate and act as a wet sponge, which retains moisture in the joint area.

(2) Electrolyte corrosion is an electrochemical phenomenon. When two metals are electrically connected in an electrolyte a simple electric cell is formed and an electric current flows. This current passes from the anode through electrolyte to the cathode. The rate at which anode is consumed, is directly proportional to the current flowing.

Conclusion

In a paper of this nature it has only been possible to touch rather superficially on the main characteristics of aluminium which are of interest to the Engineers and other users of Aluminium as electrical conductor in overhead mains or for interior wiring system for homes, cinemas, shops, restaurants, etc.

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BY THE CENTRAL RESEARCH & ENGINEERING DIVISION OF BRITISH INSULATED CALLENDER'S CONST. CO.

Ref. K/T. 80

Sub : *Corrosion of Copper Overhead Lines in Karachi (Pakistan)*

Following reports of severe corrosion of copper overhead lines in Karachi, samples of corroded conductors have been examined. Corrosion rates were found to be very high, up to 0.5 mil/year on the 66 KV line, and probably still higher on the lower voltage lines in the city area. Severe grooving of the latter is considered to be due, not to sand abrasion, as has been suggested, but to the corrosivity of the Karachi area, and to the radial growth of very thick oxide layers on conductors of a small diameter. This led to longitudinal radial cracking of the protective oxide, locally renewing attack. This type of attack has not previously been reported at normal atmospheric temperatures.

The corrositivity of the Karachi area is due primarily to the combined effects of salt-laden winds, little rainfall and high humidity, which produce moist, corrosive, saline deposits.

The use of a large diameter or segmental strands and periodic greasing are suggested as ameliorative measures, for polyethylene might give useful protection.

General Section

First 1,25,000 kw Nuclear Power Station Inaugurated by President of Pakistan

Inaugurating Pakistan's first-ever nuclear power station overlooking the Arabian Sea, about 15 miles from here, before a big gathering of scientists including 125 guests from 45 countries, the President said :

Pakistan believes in using atomic energy for peaceful purposes and as an instrument for development and progress. We have placed our nuclear facilities under the safeguards of the International Atomic Energy Agency (IAEA). We would like to see other countries in our region to do the same. The most menacing problem in the sub-continent of the South Asia is that of poverty and misery of its peoples. For this reason we will welcome if the entire sub-continent by the agreement of the countries concerned, can be declared a nuclear-free zone and the introduction of nuclear weapons banned.

President Bhutto described the inauguration of KANUPP as historic occasion for Pakistan. It symbolises our people's determination to keep pace with modern technology to be part of the nuclear age and in harmony with the march of time, he added.

Pakistan, he said, was irrevocably committed to the creation of an egalitarian society, free from poverty, ignorance, economic and social injustices. This society is in the making and calls for a ceaseless action on the part of every citizen, he said.

He gave an assurance that the requirements of the Ministry of Science and Technology, which I set up earlier this year, would be given the highest priority and attention. He welcomed the broad-based atomic energy programme which the Commission had chalked out and which his Government, enthusiastically supported.

President Bhutto said : "I believe that Pakistan's survival lies in using nuclear research, nuclear technology and nuclear power for the betterment of its people. The Government will give the fullest support to the programme of the Atomic Energy Commission and this country will make the necessary resources available to bring the promise of atomic energy to the people of Pakistan at the earliest possible time."

Third World Welcome

President Bhutto further declared that developing countries would be able to share Pakistan's experience in the field of atomic energy. He said Pakistan would welcome their scientists and engineers to work here.

After the inaugural speech President Bhutto was presented a model of KANUPP by the Chairman of the Pakistan Atomic Energy Commission.

Later he unveiled the KANUPP plaque to mark the inauguration of Pakistan's first nuclear power reactor. The President then took a round of the project.

Earlier on arrival President Bhutto was welcomed by the Chairman of the PAEC, Dr. Munir Ahmad Khan.

After recitation from the Holy Quran and its English translation Dr. Munir presented his inaugural address.

Prof. Abdus Salam, Chief Scientific Adviser to the President, also addressed the audience. He said, "Today is a momentous day in our lives, as it is indeed in the nation's life. We are proud and grateful to Allah that the Atomic Energy Commission's first essay into this most complex of modern technologies, designed and executed by Pakistan scientists, engineers and technicians in collaboration with their Canadian colleagues has functioned so beautifully with no teething trouble of the type which often beset plants of this size and sophistication.

Prof. Salam said: We are proud that in Pakistan, too, in a symbolic sense we have mustered for peaceful purposes that ultimate of energy sources which fuels the sun and the stars.

He said that there was no question but that in the long term Pakistan's energy requirements will have to be met by using non-fossil fuels.

Prof. Salam appreciated the personal interest President Bhutoo had taken for the development of science and technology in the country, particularly in the KANUPP.

He said : 'Given the national will for development, there is no question but that there is no instrument of change more potent for a developing country than a massive use of modern science and technology.'

Not Enough

He added : 'But in this context an isolated achievement like KANUPP does not mean very much if it is not part of a sustained self-reliant growth of indigenous scientific and technological skills both in the atomic as well as other related fields.

Prof. Salam appreciated President Bhutto's decision to create a separate Ministry for Science and Technology.

He said the Western countries, the Soviet Union and Japan had all understood the importance of this for a long time. For the developing countries this message was spelled out for the first time in its fullest force by our great and friendly neighbour, the People's Republic of China.

He referred to the Government's endeavour in forging technological and scientific alliances with other countries. He said that besides the agreements which already existed with France, Canada, USA, UK., USSR, Belgium, Italy and Spain, specifically for atomic energy, the Government were about to sign wider scientific agreements with West Germany and other friendly nations.

Prof. Salam said : 'These alliances may prove of far greater significance than even military alliances, for the future of Pakistan.

The PAEC Chairman, Dr. Munir Ahmad Khan, in his address of welcome said that the completion of the KANUPP would generate self-confidence and provide experience neces-

Contd. on page 40

Adaptation of Technology in Under-Developed Countries

By S. NISARUL HAQUE,* *B.Sc.* (*Engg.*), *AMIE.*, (*Pak.*) *AMBIM.*

Ours has been described as Age of Technology. Technology has been defined as application of knowledge to the means of production. This process of application of knowledge to the means of production has been going on from time immemorial. The invention of wheal and plough, domestication of animals., invention of steam engine and Atomic Energy are milestones on the road of technological progress of Mankind. However, with the discovery of scientific method in the 15th century more and more of human knowledge was employed in a systematised manner from day-to-day affairs with the results that the technologies developed at a much faster rate. Since the beginning of the present century there has been virtually a "Technological Explosion". This 'technological explosion' has created problems for all of us in social, economic and political spheres.

Economists like Kaynes, Boulding, Peter Drucker have pointed out that during the last 10,000 years or so, excluding the last 2 or 3 centuries no large human society has produced more than equivalent to 200 dollars per year/capita nor dropped below $50 per capita per year. But today most of the advanced countries have a G.N.P./Capita of much above this (Appendix-I). Thus it has become possible for the first time in human history to banish poverty. This has been achieved by technological revolution which was sparked in 18th century England by the invention of steam engine and spread to France and U.S.A. in the early 19th Century, to Germany and Russia in the last quarter of 19th Century and to India, Canada, S. America and Brazil after 1940. Since the end of 2nd World War nearly 88 new countries have come on the Map of the world. Most of these countries have to meet the "Rising Expectations" of their masses and to preserve their hard-earned freedom. The salvation of these under-developed countries is by adoption of modern technology as this is the only way for them to develop. Thus all over the underdeveloped world there is big urge to modernize and to adopt the technologies of the developed countries.

In the second half of the 20th Century, the backlog of technology available to the developed world today has changed profoundly both in content and range from the technologies of the first Industrial Revolution. New and sophisticated technologies are being

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developed which in the words of Peter Drucker represents a shift as great as the one that occurred between 1890—1914 when centre of economic gravity shifted from the industries of Industrial Revolution *viz.*, Coal, Steam, Textile and Machine Tools to new and different industries, steel, electricity, organic chemicals and I.C. Engine. "These new technologies are different in structure, in their knowledge, foundation and their sociology. They represent a qualitative rather than quantitative shift". These new technologies are in the field of :—

1. Nuclear Energy.
2. Weapons of War.
3. Electronics, Computers, Automation, and Information Processing.
4. Holography.
5. Biological Manipulation of Man.
6. Lacers.
7. Exploitation of Sea and Space resources.

Not only the range of technology is expanding at a fast rate but also the speed with which new technology are coming into being is fantastic. In fact the increments of advance in present-day devices over their predecessor is fantastically larger than it used to be. Take for example Computer. In 1946 the first generation of Computer had a speed of 200 times man's speed in simple addition. Today the Computer *vs.* man differential is in millions. Similarly B 47 Bomber which came nearly 50 years after the Wright Brothers' Plane, represented a great advance in aviation technology, but it took 10 years for B 58 Bombers to get as far ahead of B 47 Bomber as the latter was ahead of Wright Brothers' Plane. Electric Components have an average life of 9 months before these get obsolete. Every 3 years the transistor technology changes.

These new dimensions in the technological growth have made it imperative that the adoption of technology by the under-developed countries should be very carefully planned and executed in the shortest possible time. The first industrial revolution which was sparked by the discovery of steam engine in Britain in early 18th Century, it took 150 years for fruitation. It took U.S.A. nearly 50 years and Russia about 30 to achieve the same level of technological development.

In the under-developed world, time is the essence of change, because of the Revolution of rising expectations; these countries must build as quickly as possible. For this an overall plan and strategy is required to achieve maximum results in the shortest possible time.

Gilbraith has pointed out that before under-developed countries can adopt a modern technology they have to fulfil certain pre-requisites. These prerequisites as enumerated by him are :—

1. A well organized and efficient public administration system.
2. A small, educated elite.
3. An open society.

Every under-developed country, which wants to adopt technology, has to make a choice :—

(*a*) where to get the technology.

(*b*) which sectors of economy to modernise first.

(*c*) how to pay for the technology, through AID, Loan or trade.

The backlog of the technology that is available for adaptation by the under-developed world runs along quite a wide spectrum, for we realize now, thanks to Rostow that economic development is a process and as such societies at various stages of development are at various levels of technological development. The developed and under-developed countries can, therefore, thought of a beads being moved along a string. Therefore, the most advantageous transfer shall take place between the countries adjacent to one another on this string. However, in actual life what is best is usually not feasible so a developing country has to look for technology in the countries which are willing to give it. Thus the choice of the countries from where technology can be obtained on political and ideological factors.

As regards the choice of developing countries about sectors of economy which should be modernized first. Here again there is a difference between the Western and Eastern Bloc. Most of the Western Economists believe that the agriculture sector must be developed before industrial sector. On the other hand in Eastern Bloc more emphasis is laid on the industrial sector, especially the heavy industries.

The third choice the developing countries have to make is about mode of transfer of technology. In the countries where the first industrial revolution took place, the adoption of technology took place on private basis. Countries like France, U.S.A. got the technology through private enterprise. It was the British private capital which developed railway system in America, India and many South American countries. But in post-War era, the climate for foreign private investment was not good, so the technology had to be obtained by borrowing at Government to Government level. Apart from political strings the choice of borrowing countries was limited by foreign or internal policies of the lending country. The borrowing country had no choice but to buy steel, instead of a steel mill. If there was a over-production of steel in the lending country or food production had to be curtailed if lending country had excess food supply. Apart from economic and political strings, the flow assistance for developed to developing world has not been enough. From the early days of 1950 when largesc ale assistance was given by the U.S. to war ravaged economy of Western European (nearly $17,000 million under Marshal Aid) and other under-developed countries $47,000 million under Technical Assistance Programme between 1952-65, the climate for aid has changed with the result that today in the early 70's the flow of assistance has virtually stopped. For its Decade of Developments U.N.O. laid down that the developed countries must give 1% of their G.N.P. to under-development works. But in fact actual transfer has been 0.8% in 60 and 0.7% in 65. On the other hand, the developed countries have been transferring back to themselves 1/5th of Foreign Assistance, these countries gave to under-developing countries, through adverse terms of trade.

Basically there were only two model available for the developing countries in fifty and sixty for adopting modern technologies of the developed countries. One is that of Russia or Socialist Bloc and other of the free market economics of Western Europe and U.S.A. India and Pakistan, Egypt, Indonesia have resorted to the Western Model of borrowing on a large scale, whereas Cuba, Ghana, Czechoslovakia etc., have followed the socialist way, but none of these countries have been able to achieve technological break-through. On the contrary, according to a survey prepared by Rand Corporation of U.S.A. by the year 2,000 most of the under-developed countries in the world be the technological colonies of the developed countries. Thus after an age of political subjugation followed by an era of economic exploitation, under-developed countries will be heading for an era of technological colonization. According to another survey carried out by the Hudson Corporation of U.S.A., nearly 40% of the world population will be living in industrial societies, which would be mainly concentrated in the "Temperate North". Rest of the populations of the world will be living still in the pre-industrial stage of $50 to $200 G.N.P./Capita per year. Thus the gap between the developing and the developed countries will widen abysmally. This, of course, is not a very happy prospect and only those of the countries will escape this fate which have the courage, vision and the will to adopt new path. The concept that we should follow the same road which developed countries took to reach their present stage of development is bound to fail. It will only make us slaves of the developed countries. We must, therefore, give up the beaten track and evolve our own strategy of Development. This strategy must be tied to the technologies of today and tomorrow and not of yesterday. In recent times only two countries, Japan and China, have achieved rapid technological growth by adopting this policy. Nearly 26 years ago, at the end of the last War, Japan lay prostrate and completely ruined economically and politically. In the late 1940 any one could bet on Britain doing better than Japan in post-War economy but 20 years later it was Japan that had forged ahead while Britain had fallen behind. Why this happened? The basic reason for this Japanese miracle in the words of a Western Economist is "The real difference is one of fundamental attitude, outlook and policy. What the Japanese realised 20 years ago was they had to make sure that their productive resources would go into new technologies rather than into yesterday's work. They have pushed aggressively the importation of new and latest in technology, in electronic, in optics in pharmaceutical industry and so on".

However, to be able to achieve this, is no mean task. It will require effort in a new direction and on a gigantic scale. It requires, first of all, a nation-wide effort. In the words of Maurice Zinikin, "In the long run, economic development if it is to be rapid, requires the co-operation of the whole people". A wise, sagacious and dedicated leadership can channelize the energies of masses into constructive channels. Secondly, there must be universal education. Increasing knowledge is a key factor in a country's international economic strength. "In the modern world, the formal education has replaced experience as foundation for productivity, capacity and performance. There is a close correlation between the ability of economy to grow and to complete in the world today and the rate of the increase of its population at school beyond 15". Thirdly, the developing country must create a just social order; for "man is not so constituted that he will lend his best energies for enrichment of some one else. As education is economically efficient so is social justice".

In the Brave New World which is just over the horizon, new and developed, Appendix-II shows 100 technologies which are just across the horizon and will become a reality by the year 2,000. These new technologies will give mankind :—

(*i*) increased transportation capabilities.

(*ii*) increased mastery over energy.

(*iii*) Greater ability to alter the characteristics of materials.

(*iv*) Growing mechanization of physical and intellectual activities.

(*v*) extend man's sensory capabilities and lead to growing control of human life.

New Industries will be based on advances in communication technology (computer tolstons) and exploit sea and space resources. In this world only those will survive who will be able to bring new technologies to the market place of the world and exchange with the technologies of other nations. We are heading for an age when we will talk of balance of technology as we talk of balance of payments today. It is, therefore, very essential that the under-developed countries must invest in development of technologies of tomorrow. For this it is necessary at 1% of the G.N.P. of developing countries is spent on Research and Development.

In the circumstances of Pakistan today, it appears that this change in strategy of technological development can be implemented effectively for the most of the steps listed above are already taken. The present People's Government is quite aware of the need of the nation-wide efforts for development. A dedicated leadership is trying to channelize the energies of our masses into constructive channels and steps are being taken to ensure social justice. The agriculture development has been gives due priority. Above all, it appears that the Government is serious. The setting up of Ministries of Science and Technology & Production is a very timely and wise step. It is now possible to have a technological plan for Pakistan. However, merely setting up of a Ministry and Institution will not solve problems and achieve objective for which these institutions were set up. In my opinion we must take the following steps :—

1. In order to make these Ministries effective the bureaucratic control will have to be minimised. Full participation of the societies of Engineers and Scientists in decision-making is necessary. There are quite a large number of scientific and technical institutes in the country, which are running on voluntarily basis. These institutes will have to be strengthened by giving them financial aid for setting up Libraries, Auditoriums etc., for holding the Seminars and to act otherwise as 'Thak-Tanks' for their particular discipline.

2. Technology has to be given pride of place in our education. We must revise our syllabus and devise modern methods of teaching. The present emphasis on language philosophy and history in our schools must be shifted on to the learning of science and technology.

3. To create consciousness in our masses our media of masses communicated must be fully utilized and project need for technological foundation of our society.

4. We must set up separate technical cells in our selected foreign missions which will not only collect information about new technologies in the developed world but will serve as exchange houses and help export technologies in which we have an edge over others.

APPENDIX—I

	GNP Per Capita (1965 U.S. $)
Sweden	$ .. 2497
Canada	.. 2464
West Germany	.. 1905
East Germany	.. 1574
France	.. 1924
United Kingdom	.. 1804
Czechoslovakia	.. 1554
Japan	.. 857
Israel	.. 1334
Australia	.. 2009
U.S.S.R.	.. 1288
Italy	.. 1101
Poland	.. 962
Romania	.. 757
New Zealand	.. 1932
Argentina	.. 492
Taiwan	.. 221
U.A.R.	.. 166
Thailand	.. 126
China	.. 98
S. Africa and S.W. Africa	.. 503
India	.. 99
Brazil	.. 280
Pakistan	.. 91
Mexico	.. 455
Nigeria	.. 83
Colombia	.. 277
Indonesia	.. 99

APPENDIX-II

One Hundred Technical Innovations very likely in the Last Third of the Twentieth Century.

1. Multiple applications of lasers and masers for sensing, measuring, communiction, cutting, heating, welding, power transmission, illumination, destructive (defensive), and other purposes.
2. Extreme high-strength and/or high temperature structural materials.
3. New or improved superperformance fabrics (papers, fibers and plastics).
4. New or improved materials for equipment and appliances (plastics, glasses, alloys, ceramics, intermetallics and cermets).
5. New airborne vehicles (ground-effect machines, VTOL and STOL, superhelicopters, giant and/or supersonic jets).
6. Extensive commercial application of shaped-charge explosives.
7. More reliable and longer-range weather forecasting.
8. Intensive and/or extensive expansion of tropical agriculture and forestry.
9. New sources of power for fixed installations (*e.g.*, magnetohydrodyna thermionic and thermoelectric, and radioactivity).
10. New sources of power for ground transportation (storage battery, fuel-cell, propulsion (or support) by electromagnetic fields.
11. Extensive and intensive worldwide use of high altitude cameras for mapping, prospecting, census, land use, and geological investigations.
12. New methods of water transportation (such as large submarines, flexible and special purpose "container ships" or more extensive use of large automated single-purpose bulk cargo ships).
13. Major reduction in hereditary and congenital defects.
14. Extensive use of cyborg techniques (mechanical aids or substitutes for human organs, senses, limbs, or other components).

15. New techniques for preserving or improving the environment.

16. Relatively effective appetite and weight control.

17. New techniques and institutions for adult education.

18. New and useful plant and animal species.

19. Human "hibernation" for short periods (hours or days) for medical purposes.

20. Inexpensive design and procurement of "One of a kind" items through use of computerized analysis and automated production.

21. Controlled and/or super effective relaxation and sleep.

22. More sophisticated architectural engineering e.g., geodestic domes, "fancy" stressed shells, pressurized skins, and esoteric materials).

23. New or improved uses of the oceans (mining, extraction of the minerals, controlled "farming" source of energy, and the like).

24. Three-dimensional photography, illustrations, movies and television.

25. Automated or more mechanized housekeeping and home maintenance.

26. Widespread use of nuclear reactors for power.

27. Use of nuclear explosives for excavation and mining, generation of power, creation of high temperature high pressure environments, and/or as a source of neutrons or other radiation.

28. General use of automation and cybernation in mangement and production.

29. Extensive and intensive centralization (or automatic interconnection) of current and past personnel and business information in high-speed data processors.

30. Other new and possibly pervasive techniques for surveillance, monitoring, and control of individuals and organizations.

31. Some control of weather and/or climate.

32. Other (permanent or temporary) changes or experiments with the overall environment (*e.g.*, the "permanent" increase in C-14 and temporary creation of other radioactivity by nuclear explosions, the increasing generation of CO_2 in the atmosphere, projects—Starfire, West Ford, and Storm Fury).

33. New and more reliable "educational" and propaganda techniques for effecting human behaviour—public and private.

34. Practical use of direct electronic communication with the stimulation of the brain.

35. Human hibernation for relatively extensive periods (months to years).

36. Cheap and widely available central war weapons and weapon systems.

37. New and relatively effective counterinsurgency techniques (and perhaps also insurgency techniques).

38. New techniques for very cheap, convenient, and reliable birth control.

39. New, more varied, and more reliable drugs for control of fatigue, relaxation, alertness, mood, personality, perceptions, fantasies, and other psychobiological states.

40. Capability to choose the sex of unborn children.

41. Improved capability to "change" sex of children and/or adults.

42. Other genetic control and/or influence over the "basic constitution of an individual.

43. New techniques and institutions for the education of children.

44. General and substantial increase in life expectancy, postponement of aging, and limited rejuvenation.

45. Generally acceptable and competitive synthetic foods and beverages (*e.g.* carbohydrates, fats, proteins, enzymes, vitamins, coffee, tea, coca and alcoholic liquor.

46. "High quality" medical care for undeveloped areas (*e.g.* use of medical sides and technicians, referral hospitals, broad spectrum antibiotics, and artificial blood plasma).

47. Design and extensive use of responsive and supercontrolled environments for private and public use (for pleasurable, educational, and vocational purposes).

48. Physically unharmful methods of overindulging.

49. Simple techniques for extensive and "Permanent" cosmetological changes (features, "figures", perhaps complexion and even skin color and the physique).

50. More extensive use of transplantation of human organs.

51. Permanent manned satellite and lunar installations—interplanetary travels.

52. Application of space life systems or similar techniques to terrestrial installations.

53. Permanent inhabited undersea installations and perhaps even colonies.

54. Automated grocery and department stores.

55. Extensive use of robots and machines "slaved" to humans.

56. New uses of underground "tunnels" for private and public transportation and other purposes.

57. Automated universal (real time) credit, audit and banking systems.

58. Chemical methods for improving memory and learning.

59. Greater use of underground buildings.

60. New and improved materials and equipment for buildings and interiors (*e.g.* variable) transmission glass, heating and cooling by thermoelectric effect, and electroluminescent and phospherorescent lighting).

61. Widespread use of cryogenos.

62. Improved chemical control of some mental illnesses and some aspects of senility.

63. Mechanical and chemical methods for improving human analytical ability more or less directly.

64. Inexpensive and rapid techniques for making tunnels and underground cavities in earth and/or rock.

65. Major improvements in earth-moving and construction equipment generally.

66. New techniques for keeping physically fit and/or acquiring physical skills.

67. Commercial extraction of oil from shale.

68. Recoverable boosters for economic space launching.

69. Individual fixing platforms.

70. Simple inexpensive home recording and playing.

71. Inexpensive high-capacity, worldwide, regional and local (home and business) communictions (perhaps using satellites lasers, and light pipes).

72. Practical home and business use of "wired" video communications for both telephone and TV (possibly including retrieval of taped material from libraries or other sources) and rapid transmission and reception of facsimiles (possibly including news, library material, commercial announcements, instantaneous mail delivery, other printouts, and so on).

73. Practical large-scale desalinization.

74. Pervasive business use of computers for the storage, processing, and retrieval of information.

75. Shared time (public and interconnected ?) computers generally available to home and business on a metered basis.

76. Other widespread use of computers for intellectual and professional assistance (translation, teaching, literature research, medical diagnosis, traffic control, crime detection, computation, design, analysis and to some degree as intellectual collaborators generally).

77. General availability of inexpensive transuranic and other esoteric elements.

78. Space defence systems.

79. Inexpensive and reasonably effective ground-based BMD.

80. Very low-cost buildings for home and business use.

81. Personnel "Pagers" (perhaps even two-way pocket phones), and other personal electronic equipment for communication, computing, and data processing program.

82. Direct broadcasts from satellites to home receivers.

83. Inexpensive (less than 20) long lasting, very small battery operated TV receivers.

84. Home computers to "run" households and communicate with outside world.

85. Maintenance-free, long life electronic and other equipment.

86. Home education *via* video and computerized and programmed learning.

87. Stimulated and planned and perhaps programmed dreams.

88. Inexpensive (less than one cent a page), rapid high-quality black and white reproduction, followed by colour and high-detailed photography reproduction, perhaps, for home as well as office use.

89. Widespread use of improved fluid amplifiers.

90. Conference TV (both closed circuit and public communication system).

91. Flexible phenology without necessarily using prisons (by use of modern methods of surveillance, monitoring, and control).

92. Common use of (long-lived ?) individual power source for lights, appliances, and machines.

93. Inexpensive worldwide transportation of humans and cargo.

94. Inexpensive road-free (and facility-free) transportation.
95. New methods for rapid language teaching.
96. Extensive genetic control for plants and animals.
97. New biological and chemical methods to identity, trace, incapacitate, or annoy people for police and military uses.
98. New and possibly very simple methods for lethal biological and chemical warfare.
99. Artificial moons and other methods for lighting large areas at night.
100. Extensive use of "biological processes" in the extraction and processing of minerals.

(*Cont. from Page* 30)

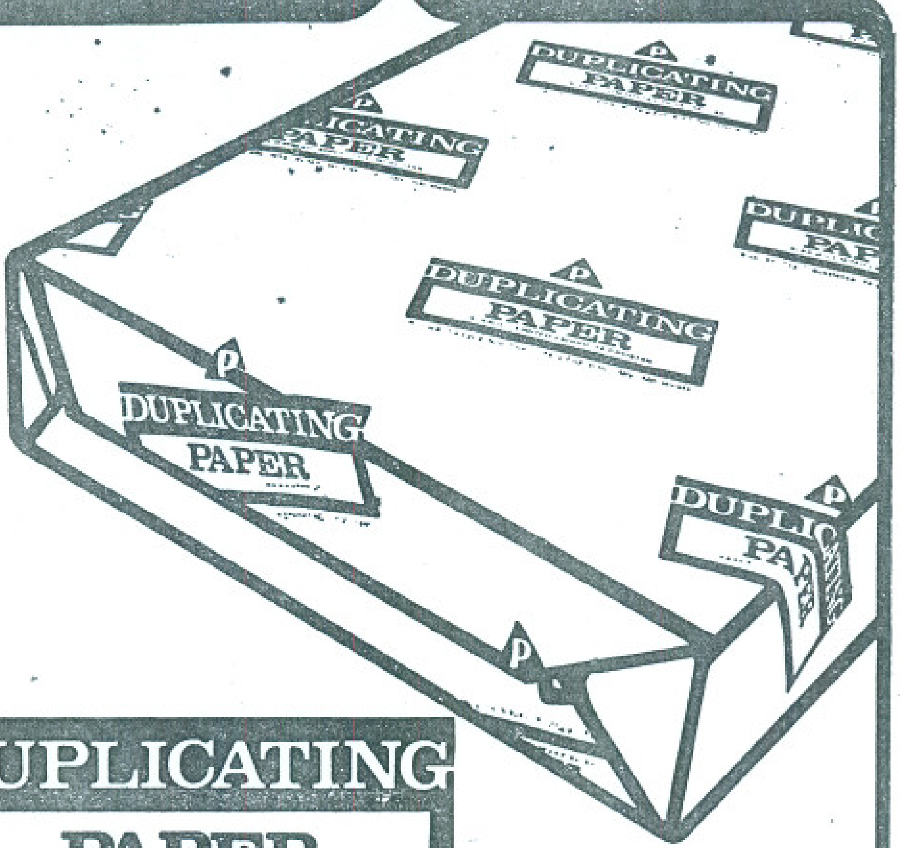
sary for launching a bold nuclear power programme.

Our object is to bring the benefit of atomic energy to the people of Pakistan and to accelerate the economic and industrial development of Pakistan, he added.

He said no country can advance without adequate supply of electricity at a reasonable cost. Giving comparative figures he said Pakistan's per capita consumption of 130 kilowatt hours per year was only 2 per cent of that in advanced countries. 'We have therefore no alternative but to turn to nuclear energy. Nuclear energy can help transform this country from north to the south and east to the west, increasing productivity of our labour, bringing light to the rural areas, making deserts green and open, arid regions to accommodate our growing population.

The PAEC Chairman said, 'We visualise that before the end of this century one third to one half of total electric power produced in the country will be from nuclear energy.'

In this connection he said that after KANUPP, the PAEC was planning two more power reactors for the country. One of these—500 megawatt capacity—is being planned for the northern areas and would be commissioned before the end of the current decade. The other—400 megawatt desalination plant for Karachi area—would be established in the next decade. This plant will also convert one million gallons of sea water into fresh water per day.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