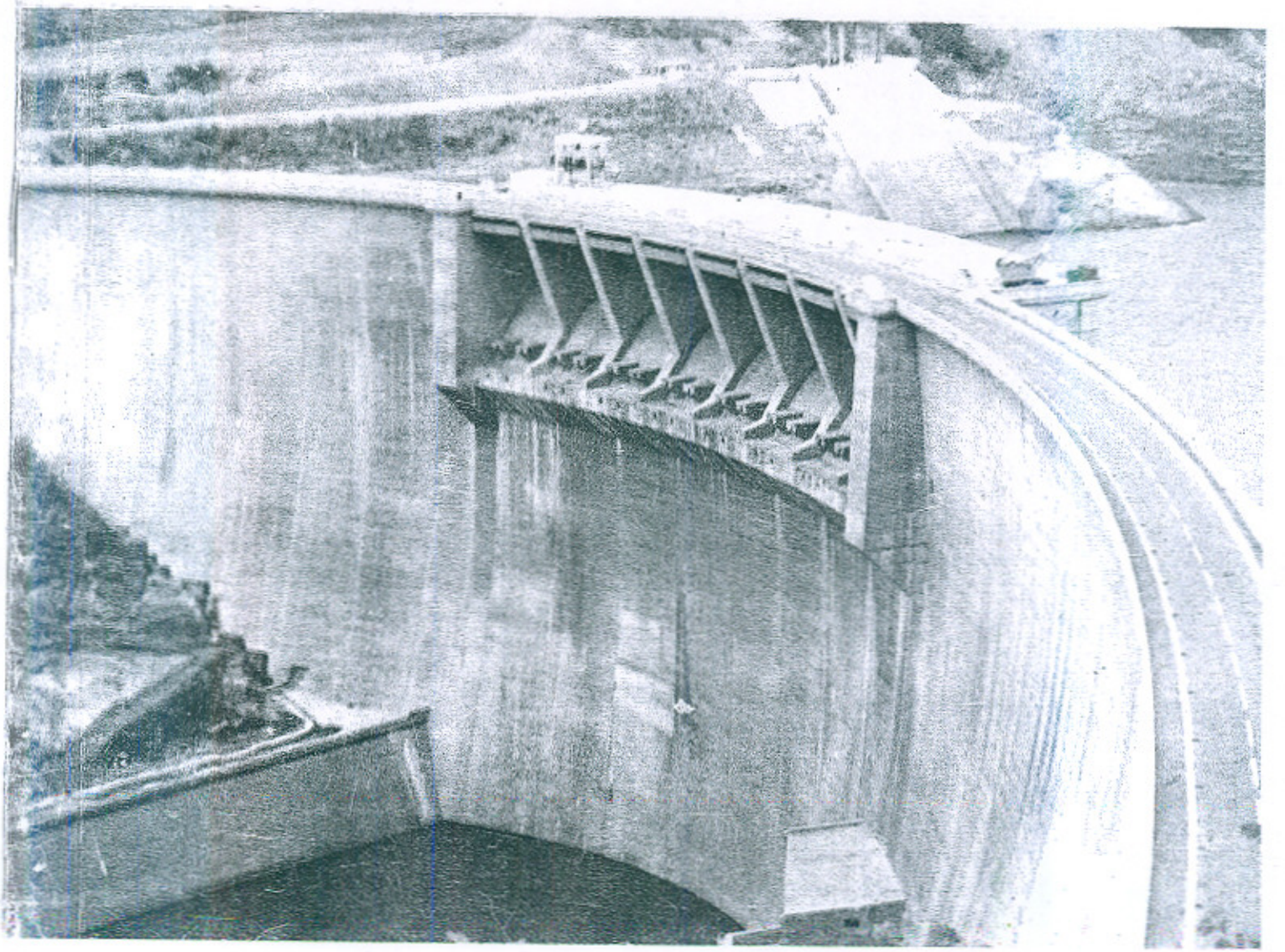
Engineering News

A QUARTERLY JOURNAL OF PAKISTAN ENGINEERING CONGRESS

Vol. XXX No. 3 & 4 Annual 1986

Victoria Dam – SRILANKA



CODE OF ETHICS

PAKISTAN ENGINEERING CONGRESS

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

In the name of God, the Beneficent, the Merciful

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

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

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

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

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

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

٣۔ وَلَا يَجْرِمَنَّكُمْ شَنَاٰنُ قَوْمٍ عَلٰى أَلَّا تَعْدِلُوْا اِعْدِلُوْا هُوَ أَقْرَبُ 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.

٤۔ أَوْفُوْا بِالْعُقُوْدِ ○

"Fulfil the obligations". v : 1

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

THIRTHIETH YEAR OF PUBLICATION

ENGINEERING NEWS

Quarterly Journal of the Pakistan Engineering Congress

Vol. XXX *Annual 1986* *No. 3 & 4*

EDITORIAL

TEAM WORK – THE SECRET OF NATIONAL PROGRESS

Making of honey by bees is an extemely difficult task. Countless bees work day and night on countless number of flowers to produce a sizeable quantity. It has been estimated that at certain places bees have to cover a cumulative flight of 300,000 miles to produce one pound of honey. No bee lives for more than a few months and therefore no one bee can make one pound of honey in her life span, even if she sits on flowers every moment of her life. The solution to this problem lies in "team work". What cannot be done by one bee, is made possible by the collective effort of hundreds of thousands of bees.

The Nature seems to teach us a lesson in this group activity. It was quite possible for Nature to have created springs of honey from under the mountains like those of petrol and water or to have made a suitable type of fruit giving honey as its juice like the pineapple.

There are certain kinds of work in human life that can be performed by individual effort and there are many others which cannot be done but by collective effort. The bee's methodology of work provides a guidance to the human beings in such cases. However, achievement by collective work is possible only when something is sacrified. These are the rebellious motives rising in the human mind, like emotions for glory, emotions for personal identity. Without crushing these motives, no group activity can be successfull. Patience, perseverence and humility simply known as "SABR" is the tool to control these emotions.

A 50,000 ton tanker is manufactured in American shipyards in 16 months. The same is prepared by the Japanese in 8 months. The secret of this miracle is team work. Group harmony is the distinctive feature of Japanese culture and the methodology of work. Their planners, managers and technicians work with such harmony that is unbeaten anywhere in the world. Willium Ouchi, an expert in Japanese ways of work, states:

> "Every activity in Japan is group activity and not a spring board to individual glory and personal advertisement".

This characteristic is the top secret for achieving heights in all fields of industry in Japan. It is due to this team work that the Japanese have captured all world markets in almost every field. Even American markets are flooded with Japanese goods. Americans who dropped atomic bombs on Hiroshima and Nagasaki, levelled the Japanese to the ground. The Japanese in return learnt "team work" and have defeated the Americans in the economic field. The greatest obstacle to the success of collective work is its negation of personal advertisement. Where persons want their individual glory, collective work cannot be successfull and therefore no major progress can be achieved. The

easiest way to greater achievements is collective work. Group activity multiplies human effort and progress achieved is in exponential proportions, but for this personal glory has to be sacrificed. This is the secret of national progress. Let us look into over own rank and file to find out whether we have created an atmosphere of team work or personal glory!

COMMAND WATER MANAGEMENT PROJECT

By
R.K. Anver*

Pakistan has the largest continuous Irrigation system in the World with a net work of Canal totalling about 40,000 miles with water courses, Farm Channels and Ditches running another one million miles in length. With inadequate uncertain and unevenly distributed rainfall, artificial Irrigation is the backbone of Agriculture in the country. The crops yields are low as compared to the other countries having similar resources. The basic concept of the Command Water Management Project is to increase the agricultural production with the integrated efforts of specialised line agencies involved in the irrigated agriculture. The major elements are to be dealt with by the public sector organizations of Irrigation, Agriculture, Credit/extension services and ofcourse the active participation of the farmers. The objective of the project can be summed up as below:

Objectives

a) Increase agricultural production sub-stantially through improved water management, alongwith efficient applying of agricultural services and non water inputs.

b) Develop Water Management techniques and programme replicable over a wide range of agroclimatic Zones.

c) Reduce inequities in water deliveries in the tail reaches as compared to the head reaches of branches, distributaries, minors and water courses.

d) Build within the provincial agencies a continuing capability for planning, implementing, operating and maintaining integrated and efficient programme of irrigated agriculture and

e) Strengthen farmer's participation in the form of water users Associations to improve their over all water and non-water input management and provide them a stronger voice in decision making.

The Command Water Management Project has been launched in all the four provinces of Pakistan with the financial/technical assistance of World Bank and US Aid.

It is a Pilot Project comprising 7 Sub-Projects of which 4 cover the sub commands of different canal systems in Punjab and one each in Sind, Baluchistan and NWFP. The total cultureable area under the command of the project is about 5.00 lac acres. The total cost of the project is about 82 million dollars (Rs. 1105 million) and extends over a period of 5 years starting from 1984-85 to 1988-89.

The break-up of cost for different components is as follows:

Chief Engineer Irrigation, punjab Lahore.

	(Rupees)
A. Canal Rehabilitation & Remodelling	= 350 Million
B. Drainage	= 123 Million
C. On-Farm Water Management	= 264 Million
D. Project Management, Monitoring and evaluation.	= 117 Million
E. Physical/Price contingencies	= 251 Million
Total	=1105 Million

The activities are involved under the above components are:

A. Canal Rehabilitation & Remodelling

The principle elements of Canal Rehabilitation and Remodelling are primarily to:

i) raise the height of the Canal Bank to secure required operating free boards for operating capacities

ii) Widen Canal Bank to improve safety of operation and provide an adequate canal road.

iii) Improvement of canal structures and lift facilities as well as installation of other water control structures in order to meet water Management requirements.

iv) Remodelling of Outlets :

Lining:

The project provide for lining certain Sections of Minors & Distys: to reduce current seepage losses and to improve command.

B. Drainage :

i. Sub Surface Drainage

The Sub Surface Drainage is provided only in 6-R Hakra and Shahkot Sub Projects in Punjab where 36,000 Acres in 6-R Hakra and 12,000 Acres in lower Shahkot Area are disaster areas with a ground water table of 0 to 5'. 60 Tubewells of 1.0 Cs capacity and 22 Tubewells of 2.5 Cs. capacity are proposed to be installed respectively in these Sub projects in addition about 25 miles of lined channels would be constructed to convey drainage effluent for disposal.

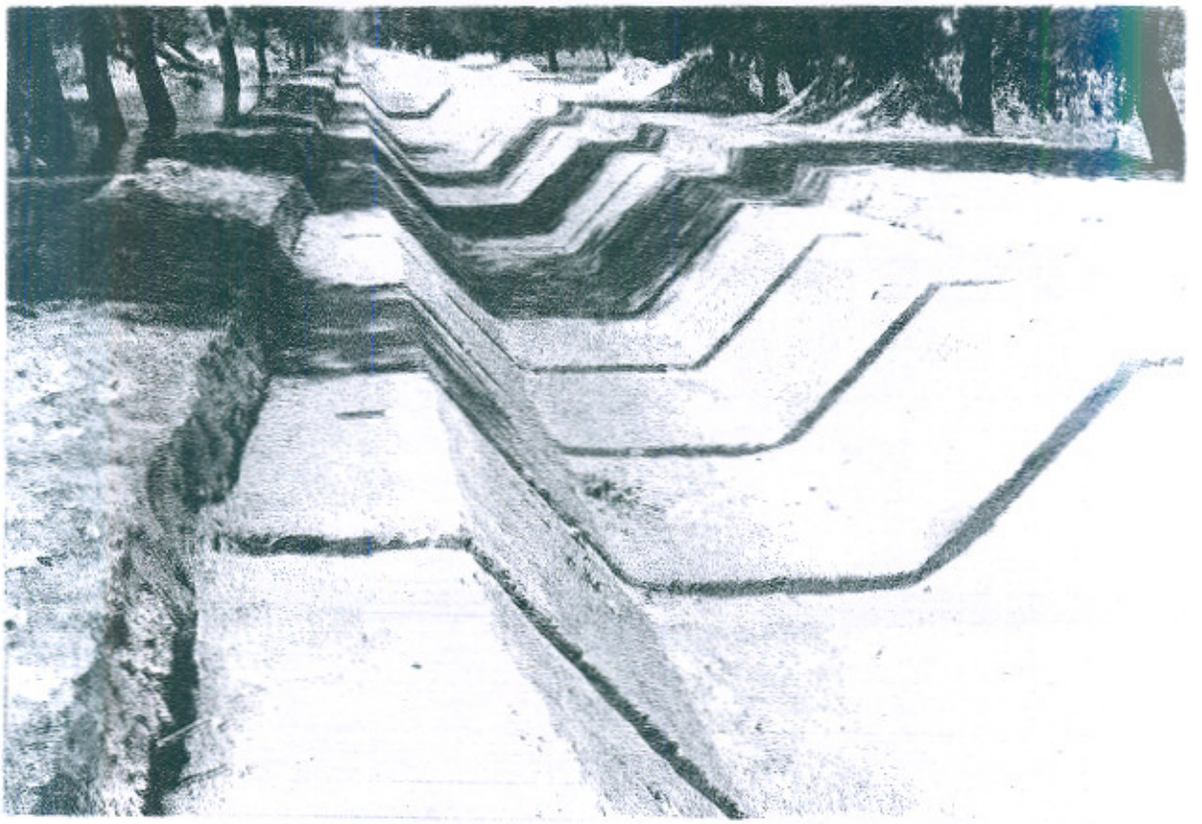
ii. Surface Drainage

Improvement of surface drainage system in the Shahkot, 6-R Hakra, Warsak lift and Las-Bela Sub Project. The surface drainage system would provide an Outlet to drain excess storm rain water in a timely manner and dispose of effluent from the Sub Surface Drainage system in case of 6-R Hakra and Shahkot Sub Project. The quantum of work has been indicated in the Table.

C. On-Farm Water Management :

The On-Farm Water Management Component consist basically of the

Completed section of lining of Niazbeg distrubutary under command water management program.



Dressed earthwork before laying of concrete lining.

The quantum of work involved Sub Project-wise is as under :

	C.C.A Thousand (Acres.)	Length Channel (Miles)	Canal Rehabilitation (Miles)	Canal Lining (Miles)	Drainage Surface (Acres)	Drainage Tube Well No.	Drainage Disposal Channel Miles
Punjab :							
1. Shahkot	49	33.7	23.5	10.2	12000	22	10.5
2. Niazbeg	41	44.3	11.4	17.5	–	–	–
3. Pakpattan	97	94.4	54.9	40.8	–	–	–
4. 6-R Hakra	104	84.3	25.9	38.5	36000	60	45.0
	251	256.7	115.7	107.0	48000	82	55.5
Sind							
Naulakhi/ Sehra.	164	178.5	115.7	67.2	–	–	–
Baluchistan							
Las-Bela	12	27.3	14.7	10.0	7900	–	–
N.W.F.P							
Warsak	43	45.8	Escapes 3 No. cover 800	11.3	4000	–	–
	510	508.3	246.1 cov: 800 Sec : 3 No.	195.6	59900	82	55.5

following elements

a) Water Course renovation with 15 to 50% of Lining and Pacca nakka.

b) Farm Irrigation and Surface Drain Ditches.

c) Precision Land levelling.

d) Demonstration Plots

e) Establishment of Water Users Association.

It is estimated that about 50,000 Acre ft. of water shall be saved by Canal Lining and 237000 Acre ft. by water course renovation/Lining. The intensities of irrigation shall be increased by 9 to 26%. The maximum impact shall be in Las-Bela Sub Project where cropping intensity would increase from 15% to 115% being a newly canal irrigated area.

The economic viability is reflected by the Economic Rate of Return which ranges from 12 to 36%.

Project Management :

A major constraint to achieve reasonable increase in irrigated agriculture production is the fragmented institutional arrangements which have proved in-efficient in delivering water and non water inputs to farmers on a timely and assured basis. The Project Management Organization has been structured to over come these deficiency and is responsible for inter agency coordination. A significant irvestment is being made in this component in the form of Technical Assistance, Training, Monitoring and evaluation to develop a Provincial capability for planning, implementing & maintaining a programme of Irrigated agriculture. On the experience of this project this knowledge could be re-deployed during the post project period and also to other areas carrying out similar programmes.

IRRIGATION IN SRI LANKA

By

S. Nazar Hussain Mashhadi*

Background

As a part of the Command Water Management Project, a senior level workshop-cum-study tour to Sri Lanka on social factors in Irrigation Water Management was arranged by the Ministry of Water and Power for which the arrangements were made and funds provided by United States Agency of International Development (USAID). The tour started on August 1, 1986 and concluded on August 13, 1986. The delegates, 20 in number, comprised officers from the Ministry of Water and Power, Government of Pakistan, Provincial Ministries of Irrigation and Power and Agriculture of the four Provinces of Punjab, Sind, N.W.F.P. and Baluchistan, Supervisory Consultants for the IDA Component and AID Components of CWM Project and representatives of USAID. The delegates met the irrigation authorities and Mahwali Project authorities and visited the Agrarian Research and Training Institute (ARTI) at Colombo, visited the major cities like Kandy, Anuradhapura, Kalawewa and Polonnaruwa etc., and inspected some of the major components of the "Accelerated Mahawela Programme" like Victoria Reservoir, System 'H' of Mahawela, Nachchaduwa Reservoir etc., and the International Irrigation Management Institute (IIMI) located in Digana village near Kandy. The writer, as a member of the official delegation carried several impressions from Sri Lanka which are being compiled in the form of a detailed report. However, for the information of the readers, a brief resume of the Irrigation in Sri Lanka as ascertained from the local irrigation authorities is given in the subsequent paragraphs.

Introduction

To understand and appreciate the Irrigation Development in Sri Lanka it is necessary to know and examine the climate and Hydrology of the country and at the same time have a knowledge of the role of Irrigation in the historical perspective and the development upto-date.

Sri Lanka, an island of 25,000 sq. miles is situated in the tropic region between latitudes 6^{o} and 10^{o} N. The central parts of the Island consist of hills and mountains which rise upto 8,300 ft. above M.S.L. The coastal plain, relatively narrow on the East, West and the South broadens out to a vast tract of land area in the northward direction. A large number of rivers,

* Project Manager, Command Water Management (IDA Component), and Managing Partner, National Development Consultants (Regd), 59-T, Gulberg-II, Lahore.

most of them orginating from the central hills, drain the land into the sea which surrounds the Islands.

The Island can be divided into 103 natural river basins and another 94 smaller coastal basins. The mean annual precipitation over the entire Island is of the order of 89 million acre-feet. Some of the river basins are comparatively large and carry large discharges. Few of them, however, have perennial sources. Stream guaging stations have been set up to measure the flow in the more important rivers. Hydrological records and climatic data are available over a long period.

The monsoons, the north-east monsoon – from November to February – and the south-west monsoon from May to August are responsible for a major part of the annual precipitation. These monsoon periods correspond to the traditional cultivation seasons namely 'Maha' and 'Yala' respectively. Due to the screening effect of the central mountains, during Yala, rainfall is unevenly distributed over the Island and there are large seasonal variations due to other factors as well. Irrigation is, therefore, more applicable in the Yala season compared to the Maha season which depends on rainfall to a greater extent. Annual average rainfall varies from 40 inches in the dry parts of the country to over 200 inches in the south-western slopes of the hilly region.

The Island has been broadly divided into a Dry Zone and Wet Zone by a line following approximately the 75 inches isohyet. The West Zone generally corresponds to the SW quadrant of the Island and covers 30 percent of land area. In the dry zone, agriculture is essentially based on Irrigation practices unlike in the Wet Zone where more favourable conditions exist for rainfed agriculture. Three crops cover most of the lands in Wet Zone under plantations and the lands are almost fully utilized in one way or another.

Any type of agriculture is, therefore, almost impossible without irrigation in the dry zone as the water resources available from seasonal rainfall have to be stored, regulated and applied where necessary. Irrigation had been traditionally practiced in these parts for centuries.

In the Wet Zone too, irrigation is again necessary to drain and reclaim lands due to excessive rainfall and effective flood control. In the southern and western coastal belts, alongwith drainage problems is associated the salt water intrusion into arable lands which again needs irrigation. The emphasis on the dry zone for irrigation development arises out of the situation that it is in this region that substantial extents of land area are still available and unexploited or untapped resources are found for systamatic agricultural activities.

It is no wonder, therefore, that irrigation had been termed the 'Lifeblood' of the country and this being essentially an agricultural country emphasis has been laid from times immemorial on irrigation development.

Historical Perspective

The early Indo-Aryan settlers, it could be concluded, purposely avoided areas of

A PART OF NACHCHIYADUWA DAM AND RESERVOIR
BUILT BY KING SENA-II IN 998 AD AND RESTORED
BY THE BRITISH GOVERNMENT IN 1906.
PHOTO - AUGUST 1986.

A GROUP PHOTO OF SOME PAKISTANI DELEGATES TO SRI LANKA
IN FRONT OF HOTEL AMALIAN NIWAS, POLONORUWA CITY IN
AUGUST 1986 (SECOND ANCIENT CAPITAL OF SRI LANKA)

heavy rainfall probably due to the dense forest cover and rocky terrain. They settled in the dry zones adjoining rivers where the lands were found fertile. The main population centres of the Island grew in such places. Where the early civilization sprang and flourished, an elaborate system of irrigation developed, which is regarded as a tribute to the Hydraulic Engineering skill of the ancient Sinhalese of a glorious past. This has earned the admiration and at times evoked wonder in many western observers. The ancient Irrigation Engineer of that by-gone era seem to have well understood and grasped the principles of a sound technology without which such attainments could not have been possible.

Cultivation of paddy, the staple diet of the people from those times needed irrigation waters. The growth of a large network of irrigation works, ruins of which are now found in abundance all over the dry zone, was the result of this demand. The disadvantages of periodic droughts and the irregular and uncertainity of rains was thus overcome to harness the fertilitity of the soils by this irrigation system.

Two different systems have been adopted in the long time. In one sytem the upper reaches of a valley were used to store water by embanking the outlets and lead the water to the plains below. In the other system, a more scientific and of greater undertaking large volumes of water were stored by constructing massive weirs or anicuts across rivers and diverting the water along man-made canals for impounding in large reservoirs or chains of reservoirs. These reservoirs called 'vapi' or 'wewa' released the water for cultivation through sluices. In modern terminology they are called 'tanks'. The earthen embankments, spills and the outlet works have attained perfection in design principles, their locations and construction. The advanced knowledge of the ancient engineers have earned reputation in other countries as well.

As one case of illustration, of particular interest, is the twin tanks kalawewa – Balaluwewa across Kalaoya, and the transbasin canal Jaya-gauge which supplied an adjoining basin and the Capital City, Anuradhapura. The transbasin canal, 57 miles long had a gradient of only 1/2 ft. per mile for the first 17 miles and an average gradient of 1 ft. per mile for the total length – a remarkable achievement by any standards.

Conservation of the water for irrigation and its distribution for cultivation had been looked upon as a first and foremost duty of the Kings of ancient Sri Lanka, and those Monarchs who excelled in this regard were held in high veneration. One such king – The great Parakramabahu who is reputed to have achieved the restoration or construction of 165 diversion dams, 3,910 channels, 163 major tanks and 2,376 minor tanks, has made the famous statement – "In this country let not even a drop of water obtained by rain go to the sea without benefitting mankind".

A clear example of a gradual build-up of a hydraulic civilization which achieved great heights is associated with the story of Irrigation in Sri Lanka. The intricate irrigation system that evolved

itself made a lasting contribution to that achievement. The agriculture produce from the vast tracts of lands generated an economic surplus which advanced the religious and social welfare of the time, in and around the seats of government, Anuradhapura and Polonnarwa. By the 12th Century A.D. very intricate and advanced irrigation system prevailed in the country. Of the large numbr of small tanks each tank was synonymous with the villages which depended on their existance too.

The vast irrigation system fell into decline and disuse after the 13th century, for which the reasons attributable are internal wars, foreign invasions, prepondense of malaria and the breaking away of central administration. The dry zone was virtually abandoned and together with the infrastructure of that ancient civilization the irrigation system suffered the same fate of neglect and decay for centuries.

It remained in this state until rediscovery during the last century by the British Colonial administrators, some of whom marvelled at the sight of the ruins and many of those explorers observed the great potential and scope that lay ahead if a revival could be made.

New Interest in Irrigation Works and Re-opening up of the Dry Zone

The interest generated by the observers during the exploration after the British occupation led to the investigation and partial restoration of some of the ancient irrigation works.

Towards the latter part of last century, the country depended on imported rice and a plantation economy centered around 3 export crops — tea, rubber and coconut. However, the improvised condition of the peasantry in the dry zone, who were but few, and the slump in the commodity price of export crops prompted some degree of interest in paddy production and investment in irrigation. However, the interest in self-sufficiency of paddy production on larger scale or larger investments in irrigation was slow to grow. It remained as such till the early parts of this century when greater emphasis in that direction was to be seen.

During the critical days, a Central Irrigation Board attended to the restoration works and by the year 1900, there was sufficient interest for systematic restoration of the ancient irrigation works to form a new Department of irrigation. Many enthusiastic British Irrigation Engineers contributed to this development in the initial phase.

When a complete topographical survey of the Island was done, the great potential that lay ahead in Irrigation Development was assessed and appreciated. To regulate the laws governing irrigation an Irrigation Ordinance was enacted.

Irrigation Development Upto the Present

With the reforms brought about after the Dononughmore Constitution, new emphasis was placed on further development of ancient irrigation works in the dry zone and resettling of people — they

were called colonisation schemes at that time. The Hon. Minister of Agriculture, Mr. D.S. Senanayake, who was to become the first Prime Minister of Independent Sri Lankia, took great interest in this direction and with lot of determination ventured into opening an establishment of many such schemes. The Minneryia Scheme in Polonnaruwa District was one such pioneering scheme, which was soon followed up by other schemes like Minipe, Parakrama Samudra etc. During the 2nd World War, when the sources of imported rice were cut off, further interest was generated in self-sufficiency in rice investment and irrigation activity achieved new heights in the Island, when large works and a greater number of construction works were undertaken.

The Irrigation Department expanded to keep to the tasks and the specialized personnel who were first obtained from abroad were later replaced by locally trained personnel towards the post-independence era. Advances in the science of Irrigation Engineering were made and activities such as the following commenced:

i) Scientific development of village irrigation works which traditionally had been the responsibility of the villages and investment in larger projects.

ii) Theoretical concepts in Channel Designs.

iii) Engineering surveys of large extents in collaboration with the Survey Department and preparation of blocking out plans for settlement.

The Department also established a Central Designs and Research Branch and gradually other specialized branches such as Soils, Engineering Geology, Hydrology and Hydraulic Research, Land Use etc., evolved. An Island wide organization to construct, operate and maintain the Irrigation Works was set up. The Department now functions under the Ministry of Lands and Land Department.

After the post-war period, new construction techniques have been developed especially in the construction of earthen dams. Heavy earth moving machinery was used in preference to organised labour for the first time in the 1940's, when Cat. D-4 Tractors were employed in the breach closure of Parakrama Samudra. Since then, especially after the construction of the Goal Oya Dam in 1950's this tend continued.

With time, the emphasis laid on restoration of ancient works have shifted towards other projects such as:

i) New Irrigation Projects
ii) River Basin-wise development to harness the full land and water resources in each river basin.
iii) Multi-purpose Projects.

With the completion of the topographical mapping, resource surveys were undertaken to assess the full potential in water availability, land-use etc., in each major River Basin. Need for catchment protection, water shed management and environmental protection had been felt and legislation introduced to effect such regulatory measures. It is the present policy and practice to

plan, design and utilize the Land and Water Resources in each Basin for optimum benefits.

The Gal Oya Scheme, the first multi-purpose project of this kind started in the early 1950's and it was undertaken with American assistance, being styled and influenced by the T.V.A Project, USA. A new statutory body, the Gal Oya Development Board was formed for implementing the project as it was considered too large an undertaking for the Irrigation Department alone. After, the completion of project the Irrigation System was handed over to the Irrigation Department for maintenance and after being in operation for over 30 years a rehabilitation and a water management programme is now underway in this Project. The Gal Oya Board has given rise to the formation of a River Valleys Development Board which is specialized in heavy construction work. The Uda-Walawe Project was the next major multipurpose project undertaken by this Authority. Both these projects have Hydro-power component.

Settlement

The story of Irrigation in Sri Lanka is not complete without reference to the settlement programmes necessarily associated with it. Almost all the schemes are intended to re-settle farmers in Agriculture and others in supporting services. An irrigation infrastructure is constructed for the farmer families to move in and the state assistance includes clearing of lands, providing for land preparation, building farm cottages and maintenance of famiies until the first crop is harvested together with the providing of other services. The general policy had been to establish the allottee on a unit of holding consisting of a wetland area and a highland area so that he could derive from the land an income sufficient to maintain himself and family in a reasonable standard of living. The highland, generally located close to the farm area, beside his house provides for cultivation of permanent tree crops and vegetables mainly for own domestic consumption.

A land policy had been evolved to effect the settlement and the land Development Ordinance enacted 50 years ago provides for the allottee's claims for the land holding.

In the earlier schemes, wetland area unit was 5 acres and high land unit 3 acres. With time, after taking into consideration prices of agricultural produce and the farm extent each holder could manage with family labour, this has been reduced to 2.5—2.0 acre wetland and 0.75—0.50 acre highland.

The present pattern is to group the highlands in clusters so that hamlets, villages and townships could be located within each major settlement area, making way for easy provision of common ameneties.

Investment and Foreign Collaboration

With the increases in the investment under Irrigation Projects, which forms a substantial component of the National Budget, and the advance made in the technology transfer, foreign assistance and foreign collaboration has taken place from the 1960's. Technical assistance and Foreign funding as grants and loans

has been made for a number of Irrigation Projects undertaken in the recent past. They are associated with the bilateral and multi-lateral aid programmes and financial agreements.

The Mahaweli Project

The largest multipurpose project associated with Irrigation and Hydropower undertaken in Sri Lanka is the Mahaweli Project. After a resources survey in 1960's with UNDP/FAO assistance, a master plan was prepared which estimated the potential of this river project to be capable of regulating nearly 5.6 million acre-feet annually which could be successfully utilized to irrigate 900,000 acres of lands and permit installation of 460 MW of hydropower. The first project Polgolla diversion, commenced in 1970's. Under the accelerated programme launched in 1977, major reservoirs such as Victoria, Randenigala, Kotmale, Maduru Oya have been commenced and completed and the work on the downstream irrigation system and infrastructure build-up is taking place. A statutory authority, the Mahaweli Authority of Sri Lanka (MASL) has been established to be in overall charge of the Project. The components of the Project are foreign funded.

The Present Position

The total extents of land provided with irrigation facilities under major schemes today stand around 770,000 acres. This compares with about 465,000 acres under minor irrigation works. Total extent of paddy gross under rainfed conditions is about 675,000 acres throughout the island. There are about 350 schemes defined as major irrigation schemes and the number of minor irrigation schemes consisting of village tanks, diversion anicuts, which are functioning today exceeds 12,000. There are over another 12,000 of minor works which are abandoned and not serving any irrigation purpose, scattered throughout the dry zone. Minor irrigation schemes are broadly defined as those benefitting less than 200 acres or those that are maintained by the villages themselves without governmental expenditure.

The Irrigation Department is responsible for the development of land and water resources for irrigated agriculture, flood control and provision of irrigation and drainage facilities including planning design and execution of all Irrigation projects in the Island (other than in those specified areas entrusted to other statutory bodies) and the operation and maintenance of major schemes. The maintenance of minor irrigation works have been entrusted to the Agrarian Services Department.

Some of the larger projects just completed or under implementation at present are,

- The Kirindi Oya Irrigation & Settlement Project.
- The Inginimitiya Irrigation Project.
- Gin Ganga Flood Protection Scheme.
- Nilwala Ganga flood protection scheme.
- The Major Irrigation Rehabilitation Project (MIRP)
- The Village Irrigation Rehabilitation programme (VIRP)
- The Gal Oya Rehabilitation Project.
- The Irrigation Systems Management Project (ISMP)
- The Irrigation component in integ-

rated rural development projects in the resp. districts.

With the resources in some river basins already exploited almost fully, the emphasis in recent times has been laid on water management and rehabilitation of the existing systems in older schemes.

A water management programme was commenced by the Ministry from the early 1980's and this has extended to an integrated approach towards management of the system taken as a whole. The INMAS or the Integrated Management of Irrigation and Settlement projects programme was launched in 1984 to realise those objective fully. Full time Project Managers have been appointed for selected major projects. Project committee have been formed in these projects with the officials drawn from the line departments. A project approach towards management is being introduced to and coordinate the activities at project level, in terms of inputs, optimizing benefits, marketing etc. Coordination is also affected at district level by the project staff through the district agricultural committee in the districts agricultural programmes. A new division, the Irrigation Management Division has been formed at the ministry to manage this programme at national level and to guide and formulate policy matters.

Collection of operation and maintenance costs from the farmers, to partly contribute to the expenditure required to run the system is another programme introduced recently.

An important aspect in the new outlook in the emphasis placed on the farmer, who is the beneficiary, as the most important link in the whole system, and the formation of farmer organisations and involvement of the farmer community in the management of the system.

Acknowledgement

The author acknowledges with thanks the painstaking efforts of Mr. Senarath, Deputy Director Irrigation Department, Ministry of Land and Land Development, Government of Sri Lanka in supplying the above information during a lecture to the delegates.

DIAGNOSTIC ANALYSIS OF IRRIGATION SYSTEM

By
R. K. Anver*

Diagnostic analysis is an investigative process that examines an Irrigation system in its physical, technical, agronomical, Socio-economical and Organizational perspective in order to identify constraints impeding the Agriculture production. The basic object of the Diagnostic analysis is to:—

1. understand an Irrigation system as it actually operates — both its strength and its constraints.

2. Identify the major physical, Biological, agronomical, Socio-economical and Organizational constraints to the system.

3. Rank the identified constraints and their causes according to the magnitude of their effect on the system in order to arrive at possible solution.

The Diagnostic analysis examines the Irrigation system as it actually operate, not as it is assumed or perceived to be operating. There are three primary characteristic of Diagnostic analysis which singles it out from other methods. First it involves a system perspective which recognizes the complexity inherent in the Irrigation system, 2nd, it uses an inter-disciplinary approach and 3rd, it acknowledges the need for the Farmers involvement within the process.

The basic Diagnostic analysis process can be divided into 3 phases which are broadly as under:

1. Background research is done to provide a preliminary understanding of the system to be studied. This understanding should be sufficient to describe the system physically, Organizationally, Operationally and Socio-economically, as it is assumed or perceived to exist and operate.

2. A reconnaissance of the system is conducted after gaining an insight of the background research. During this reconnaissance observations are made concerning the actual condition and operation of the system. Based upon both the background research and the observation made during the reconnaissance, the constraints to increase productivity are hypothesized.

3. Detailed studies are planned and carried out to define the information needed to support or disprove the hypothesis made and determine the required measurement to provide that information. Once the required parametres are determined, the methodology to be used to make those measurements can be specified in respect of each discipline.

After the detailed studies are completed, the information that has been collected is analysed and then synthesized. The net result is an inter-disciplinary perspective of the existing condi-

*Chief Engineer Irrigation, Punjab Lahore.

tion of the system and how the system is actually functioning. This inter-disciplinary perspective spells out the strength as well as the constraints in the system that limit the level of agri-cultural production.

The areas covered by the Diagnostic analysis as applied to our Irrigation system involve the resources, tradi-tions and socio-economical factors typical to our rural society. The agri-culture production is low as compared to the international standards consider-ing the area under Irrigation. Broadly speaking the Diagnostic analysis is to cover the following compartments for ascertaining the constraints and then evolve an inter-disciplinary approach to increase the agricultural production:

A. Water:

i. Water distribution system upto the Outlet level.
ii. Outlet to Farm Water distribu-tion.
iii. Irrigation within the Farms inclu-ding water application practices land levelling etc.
iv. Ground Water potential/quality.
v. Drainage
vi. Soil Salinity.

B. Non Water Inputs:

i. Seeds, Fertilizer their availability and scientific application keeping in view the soil characteristics.
ii. Pesticides

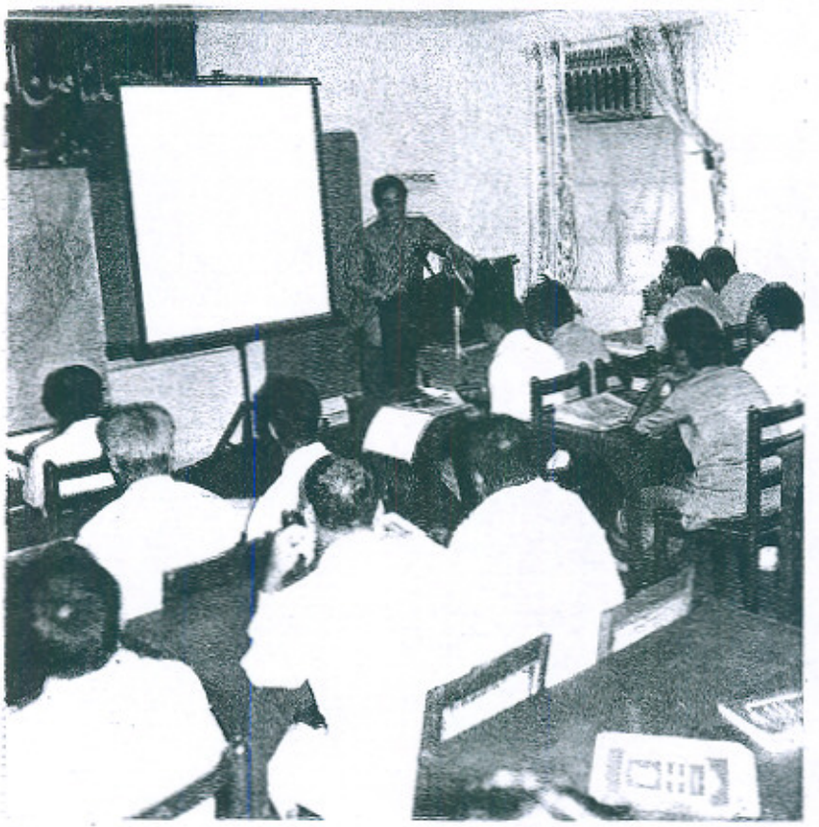
C. Services:

i. Credit facilities
ii. Information to Farmers about the use of water and non-water inputs, cropping pattern/Farming practices.
iii. Energy
iv. Communication
v. Marketing.

D. Farmers Involvement:

i. Water Users Association
ii. Co-operatives and community Development.

A Diagnostic analysis workshop on Irrigation System was carried out under the auspices of USAID in July–August, 1985. The workshop has yielded some important results which would prove very fruitful in planning and operation of the projects.



R.K. Anver adressing a workshop on diagnostic analysis arranged under auspices of U.S. Aid.

Some of the audiance at a lecture on Diagnostic Analysis of Irrigation System.

INTRODUCTION OF OPTICAL FIBRE CABLE IN PAKISTAN T & T DEPARTMENT-T.

By

Engg. Sheikh M. Afzal

The local optical fibre links are being established by Telegraph and Telephone Department in Karachi, Lahore and Islamabad for local junction network. The fibre cable and related equipment has been procured from M/s. GEC England. 7 K.Ms optical fibre cable have been laid in Karachi between Marston Road, Exchange and Pak. Capital Exchange. 8 K.Ms optical fibre have also been laid in Lahore between Central Telephone House-II Exchange and Garden Town Exchange, while 21 K.Ms optical fibre cable have been laid between Rawalpindi City Exchange and Islamabad-I Exchange.

34 M bit/second system is being installed on this optical fibre cable links in Karachi, Lahore and Islamabad. This system will be capable of providing 480 channels between two local exchanges for inter-exchange working. However, 565 M bit/second system can be installed on this monomode optical fibre without installation of any regenerator.

16 PCM system will be installed in Pak Capital Exchange Karachi for extension of 480 circuits to the local exchange while 34 M bit/second stream will be brought down to two M bit/second stage at Marston Road Exchange and will be directly extended to Digital Exchange at Marston Road without bringing it down to the channel stage and therefore, no PCM system will be installed in Marston Road. All the 480 circuits will be utilized as outgoing circuits from Digital Exchange at Marston Road. Similarly, 16 PCM systems will be installed at Garden Town Lahore and 2 M bit/second, stream will be extended to Digital Exchange in C.T.H. Lahore. All 480 circuits will be utilized as outgoing from Digital Exchange. 16 PCM systems will be installed in Islamabad Exchange and 2 M bit/second stream will be extended to Digital Exchange in Rawalpindi City. 240 circuits will be utilized each as outgoing and incoming from Digital Exchange.

These links are being extended on experimental basis to introduce fibre technology in the T&T Department.

HORIZONTAL VS VERTICAL DRAINAGE

By

*Dr. Izhar-ul-Haq**
*Abdul Haq***

Introduction

Indus plains are spread on an area of nearly 80,000 square miles. These are flat lands nearly 900 miles in length. About 160 MAF of surface water has continued to flow through these lands since thousands of years. The underground formation consists of alluvial deposits mostly silt and sand. Ground water of different qualities is found in the formation. In general in the areas near the perennial rivers and their flood-plains, the ground water is fresh possessing low percentage of salts. The areas away from the rivers possess ground water having high percentage of soluble salts. Pakistan has one of the most extensive irrigation systems in the World with practically non-existant natural drainage. Drainage has been held in abeyance because of the financial problems till the water table started rising close to the surface.

The drainage requirements in the canal command areas of Indus Basin consist of both surface and sub-surface drainage. Surface drains are needed for areas with frequent flooding from storms and for rice areas in the southern region. Sub-surface drainage is required in all irrigated areas, except rice commands, where the groundwater table has to be controlled at a depth from which it would not affect crop growth. 11.51 MAc. area, where sub-surface drainage has been indicated, is underlain with 7.8 MAc. area of usable groundwater and only 3.91 MAc. area of unusable groundwater. Out of 3.91 MAc. the area in Sind is 2.61 MAc. (excluding the rice growing areas) as compared to 1.3 MAc. in Punjab Province.

Selection of Drainage System

In order to provide effective control of the water table, the two alternate methods which can be used are :

i) Vertical drainage, by means of tubewells.
ii) Horizontal drainage, by means of either open channels with field drains or sub-surface horizontal tile drains with collector pipes and open disposal channels.

Uptil now only tubewell drainage has been applied on large scale in Pakistan, except East Khairpur Tile Drainage Project which has recently been completed and Mardan SCARP where construction is in progress. However, the monitoring results of tile drainage method are not yet available. Hence there is not much experience about

* Director International waterlogging and Salinity Research Institute.
** Deputy Director Planning Division WAPDA

the tile drainage in Pakistan, whereas, presently many of the tubewell drainage projects are working in addition to large number of private tubewells. The higher capital cost of the tile drainage projects had been the major hinderence to opt this method. The annual operation and maintenance cost of this method is expected to be very low as compared to tubewell drainage. Horizontal open surface drains have been used generally for disposal of surface runoff or saline effluent from tubewells. However at some places, these are constructed deep enough to intercept sub-surface flows especially in areas of high groundwater table. In such cases, though technically feasible, deep open drains require 10 to 15% land to accommodate the flat side slopes. Movement on the farms is also obstructed. For this reason the farmers do not construct field drains. These require heavy maintenance to clear the choking on account of side sloughing and weed growth. Due to the high cost and social implications, deep open drains do not offer viable choice for sub-surface drainage.

The selection of any system, however, depends upon the conditions of the aquifer, groundwater quality and effluent disposal modes. In usable groundwater areas with favourable aquifer conditions tubewells are the obvious choice for the dual purpose of supplementing the irrigation water supplies and controlling the rise of the groundwater levels. It is only in case of saline groundwater areas that tile drains can be considered as an alternative to tubewells in certain locations.

Expected salinity of the tile and tubewell drainage effluents.

The mineralization of the ground water in the Indus Plain increases with distance and depth from the recharge sources, mainly the rivers and large canals. The effluent in the horizontal drains is drawn from 50 to 100 feet deep flow lines (figure-1) depending on the drain spacings, aquifer conditions and differece in head including the horizontal flow towards the drain, while tubewells of 3 to 4 cusecs generally will extract water from a depth of about 100 to 300 feet. It may, therefore, be concluded that the effluent of horizontal drains, on the average, contain only half to one third of the salt contents compared to that of large drainage tubewells. The salt content of the effluent of shallow wells will also be higher than that of horizontal drains.

The quality of the effluent from horizontal drainage will equal the average quality of the recharge after the saline water has been flushed from the aquifer. Based on Carlson's test referred to in IACA's studies the time required to flush the aquifer would be from 25 to 35 years. The final salt content of the drainage effluent is estimated to be 1500 ppm.

NESPAK-IACO Consultants to WAPDA for SCARP VI (Punjab Abbasia) in 1983 estimated that Electrical Conductivity gradually decreases from 6.4 mS to 2.4 mS. Some 5—10 years after installation of the drains the water could be used for irrigating relatively salt resistant crops (e.g. cotton) and only after 10—15 years does the water seem fit for use for medium salt tolerant crops. If it is mixed with canal water the potential for the reuse is greater.

FIGURE-1. TILE DRAIN FLOW NET

Upper soil layer only

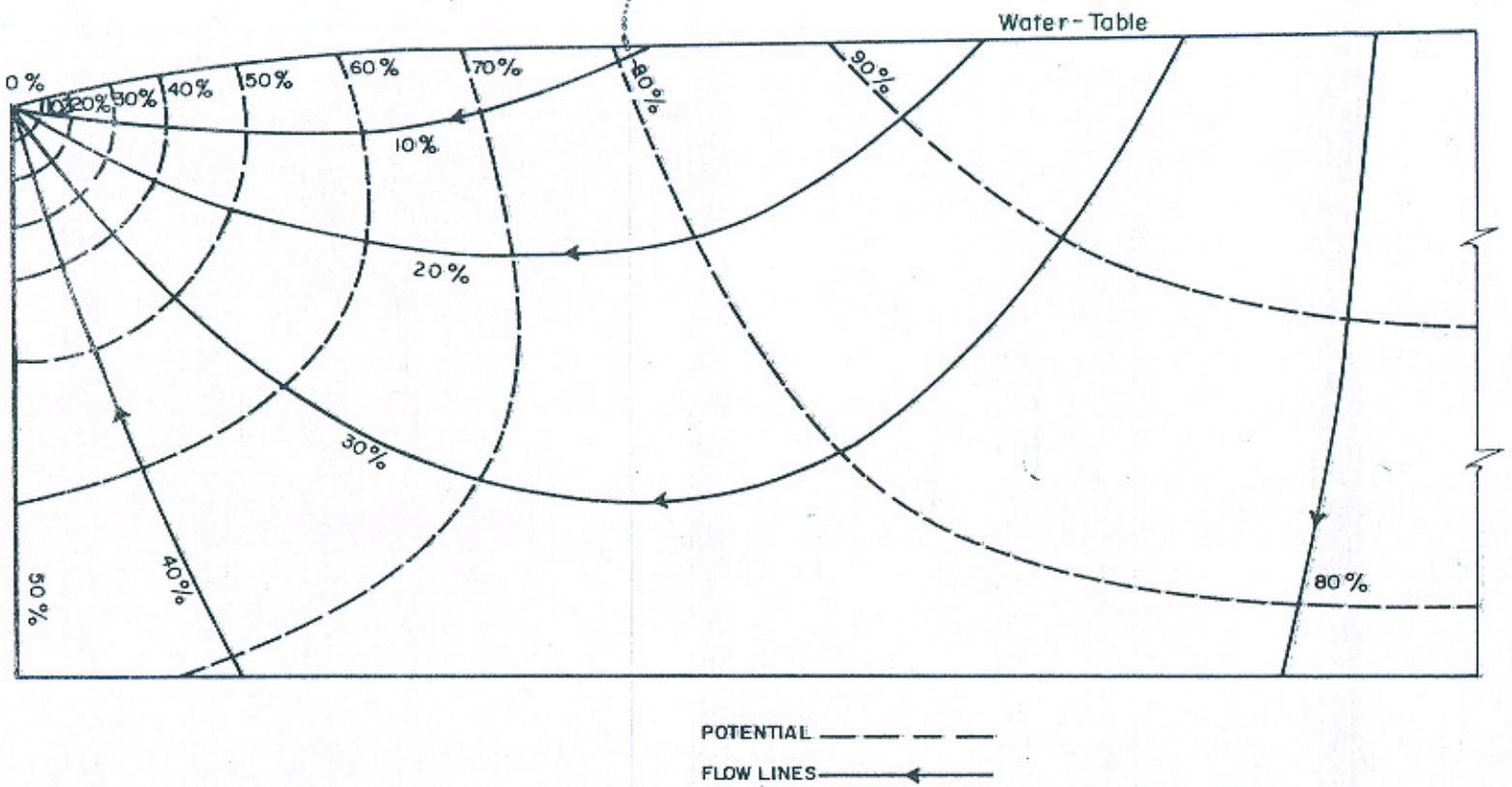
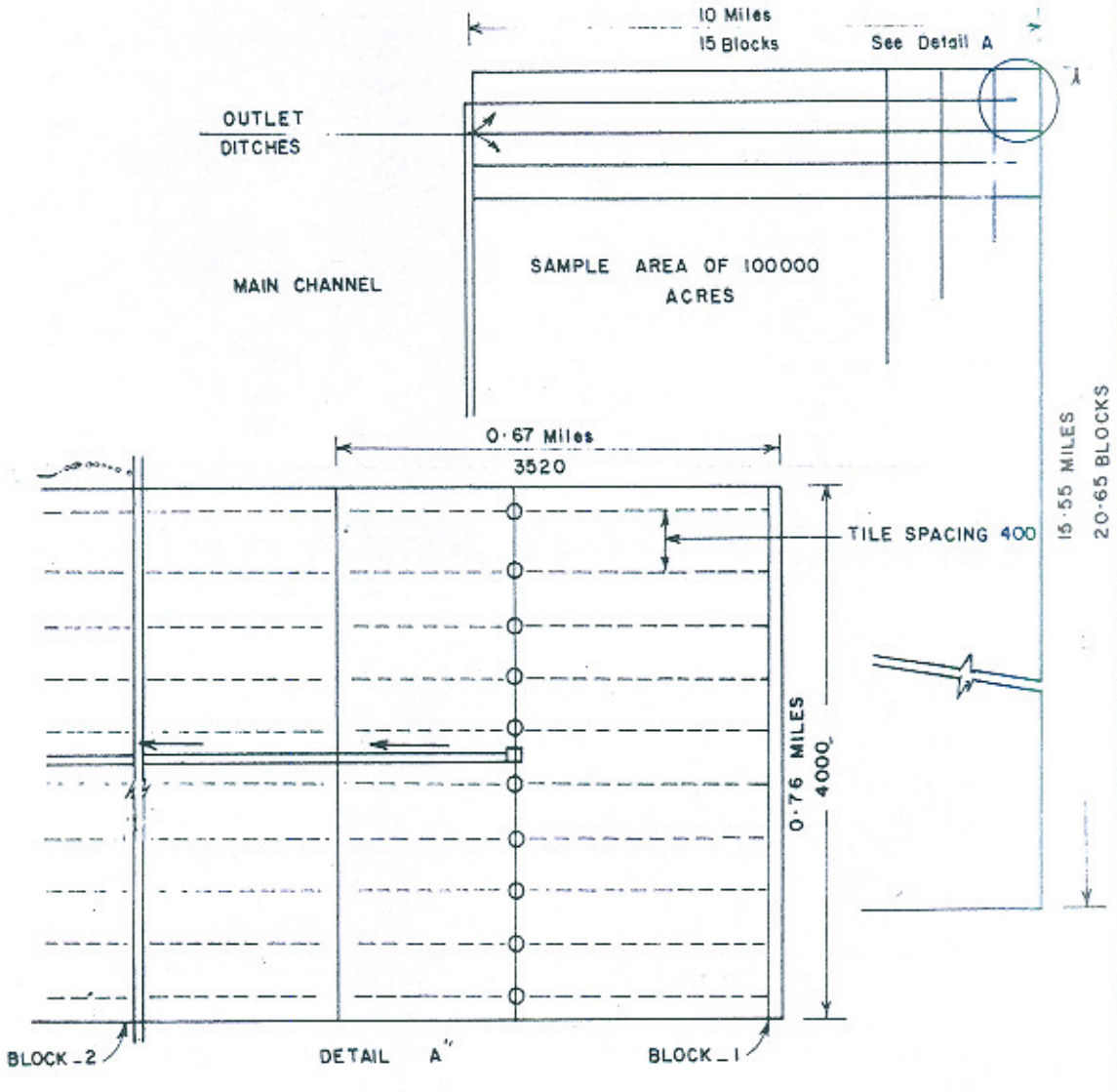


FIGURE 2. LAYOUT OF A TYPICAL TILE DRAINAGE SYSTEM

(NOT TO SCALE)



LEGEND

LATERAL / COLLECTOR — Slope 1 in 1000

PUMP & SUMP

MAN HOLES

OUTLET DITCH

BLOCK AREA = 325 AC

TILE SPACING = 350 FT

No OF BLOCKS = 310

Inspite of all the uncertainties it is clear that quality of groundwater in case of horizontal drainage system is improved with the passage of time. On the other hand ground-water quality in a vertical drainage system may further deteriorate due to mining of deep saline water if the necessary measures are not adopted to control the upconing of the highly saline water from the aquifer layers.

Tubewell Drainage

a) Advantages

i) The cost analysis shows that capital cost of tubewell drainage, where technically possible with favourable aquifer conditions, is about one fourth the cost of tile drainage.

ii) There is vast experience available in both private and public sectors for the installation and maintenance of tubewells.

iii) Drainage is achieved in a large area by installation of only one tubewell.

iv) With the operation of tubewells, groundwater storage at the door step of the farm can be managed for providing adequate and timely for crops (in case of fresh ground water areas).

v) The disposal can be controlled by using the aquifer as a storage. Tubewell can be operated to depress the saline groundwater level so as to create room for obsorption of part of the surface runoff during the above average rainfall years and improve the water quality in upper stratum.

b) Disadvantages :

i) The drainage effluent from tubewells is of much higher salinity and effects the life of screen and machinery. It may also create problems of slainity in the adjoining areas of the outfall channels in certain reaches which may be of hundreds of miles of length if direct disposal facilities to the sea or to the desert are not available. Removal of salts in the evaporation ponds may also create problem of salt disposal.

ii) The drainage by tubewells is not selective and water table will be lowered in all parts of the area lying in the influence of the well.

iii) In the long run, the re-cycling of the salts leached down will cause greater mineralization of the groundwater.

iv) Disposal of saline effluent to rivers is possible in the flood months which decreases the utilization factor thereby increasing the number of tubewells and hence the initial cost as well as the O&M cost of the project.

v) From the existing tubewell drainage projects it is experienced that even the recovery of O&M cost of the project is not possible from the beneficeries. Therefore, these projects have proved to be a permanent burden upon

the government.

vi) Deep drainage by tubewells encourages upconing of saline water thereby deteriorating the quality of aquifers.

TILE DRAINAGE

a) Advantages :

i) The tile drainage, with the year round water application produces an effluent of lower salinity with the passage of time. Deep saline groundwater layers remain undisturbed.

ii) Pumping of the effluent from tile drains if required, will be only from a shallow depth compared with the tubewells and the total power requirements shall be much less as compared to well drainage.

iii) Tile drainage requires less pumping than tubewells and with the rising cost of energy and difficulties in maintenance of longoutfall drains, tile drains may prove more useful inspite of the initial heavy capital outlay.

iv) The area served by each unit of a drain is small and the tiles need to be installed only in those areas, actually cultivated and requiring drainage.

v) Leaching of the soil in the root zone is done effectively and the salts are exported from the drained area.

vi) Tile drains installed as interceptor drains along the main canals and distributries in saline groundwater areas shall reduce the saline drainage effluent in areas having disposal problems especially in northern Indus regions.

b) Disadvantages :

i) The drainage has to be affected concurrently with water applications round the year. Due to high water table there is danger of salts coming in the root zone and to the surface due to capillary action in fallow lands.

ii) As the drainage effluent keeps flowing constantly, contnuous pumping has to be done. Therefore, disposal of saline effluent to rivers during low flow periods may cause salinity problem downstream.

iii) Tile drains can only work in areas of high water table as maximum recommended depth is 10 feet.

iv) Initial capital cost is much higher as compared to tubewell drainage system.

v) Presently there is a little experience of tile drainage in Pakistan. Khairpur Tile Drainage Project has recently been put into operation while Mardan Project is under construction. Tech-

nology being newly introduced in Pakistan, a lot of foreign exchange component is needed for completing a project.

.Cost comparison of tile drainage system and tubewell drainage system

So far many agencies have tried to give the cost comparison between tile and tubewell drainage systems. A brief description of the same is given below.

a) IACA in their Comprehensive Report Vol. 6 (1966) made a cost comparison of two systems in Punjab and Sind. Their analysis shows that :

i) Capital cost of tile drainage is Rs. 585/Ac in Punjab (Spacing 750 ft.) and Rs. 700/Ac in Sind (Spacing 350 ft.) as compared with the cost of Tubewells Rs. 430/Ac in Punjab (35% utilization due to restricted pumping) and Rs. 290/Ac in Sind (75% utilization) respectively.

ii) Annual cost for both the systems for all practical purposes is the same at Rs. 50/Ac.

b) M/s. Tipton and Kalmbach Inc. (T&K) have discussed both the drainage methods in their Regional Plain of Northern Indus Plains Vol. II (1967) and have analysed the cost as follows:-

i) Capital cost of Tile Drainage is Rs. 546/Ac as compared with the cost of Rs. 65/Ac (excluding electrification) for Tubewell Drainage.

ii) The initial cost of tile drainage system plus the present worth of operation and maintenance cost, including the cost of energy required for pumping, over a 45-year period, is approximately Rs. 655/Ac. The corresponding cost of accomplishing the same objectives by means of tubewells is approximately Rs. 327/Ac. Thus, the horizontal drainage is twice as costly as tubewell drainage.

c) M/s. Hunting Technical (1966) carried out a study to compare the cost of drainage by Tile and Tubewells as follows :

i) Capital cost of Tile Drainage (spacing 450 ft.) is Rs. 836/CCA as compared with the cost of Rs. 186/CCA (including electrification) for Tubewell Drainage.

ii) Annual cost (for forty years assumed life) in case of Tile Drainage is Rs. 61/CCA and for Tubewell Drainage is Rs.27/CCA.

d) Master Planning and Review Division of WAPDA in its supporting Report of Revised Action Programme (RAP) for Irrigated Agriculture in 1981 worked out cost comparison of tile and tubewell drainage systems keeping in view the two alternatives that the tubewell effluent a is disposed to evaporation pond/sea (70% utilization) or b) to the river (30% utilization factor due to restricted pumpage during flood season)

The analysis shows that :

i) Capital cost of Rs. 4265 per acre for Tile Drainage (spacing 450 ft.) is four times the cost of Rs. 1065/acre for Tubewell Drainage with 70% utilization and more than double the cost of Rs. 1845 for Tubewell Drainage with 30% utilization.

ii) Annual cost of Rs. 375 (includes O&M at Rs. 18) per acre for Tile Drainage is about three times the cost of Rs. 128 (includes O&M Rs. 39) per acre for Tubewell Drainage with 70% utilization and is more than one and a half times the cost of Rs. 218 (includes O&M at Rs.64) per acre for Tubewell Drainage with 30% utilization (due to restricted pumpage).

e) M/s. NESPAK-ILACO consultants to WAPDA for SCARP VI (Punjnad Abbasia) in April 1983 in their supplement to the final plan Prefeasibility Study on Tile and Tubewell Drainage for Unit-V have worked out the cost as follows :

Capital cost of tile drainage (average spacing 260 ft.) is Rs. 4000/acre. Annual O&M cost of tile drainage is estimated at Rs. 20/acre of which 75% is cost of energy.

Alternatively, cost of tubewell drainage was worked out at Rs.750/acre. Operation and maintenance cost was estimated at Rs. 69/acre of which 2/3rd is the cost of energy.

Cost of surface drains and electrifications being the same was not included in both of the above systems.

Present value of costs of tile and tubewell drainage systems was evaluated including the present worth of operation and maintenance cost and the cost of energy required for pumping over a 30 year period.

Conclusions/Recommendations

1. Capital cost of the Tile Drainage System is very high (generally 3 to 4 times) as compared to Tubewell Drainage System.

2. Annual cost of Tile Drainage System is generally 1.5 to 2 times as compared to Tubewell Drainage System.

3. If the Tile Drainage effluent is considered (the quality of which is likely to improve with time) to supplement the irrigation supplies, the economic analysis shows that cost difference between the two systems is not significant.

3. In Tile Drainage System consumption of energy (if needed) is about 1/3rd as compared to Tubewell Drainage System.

4. Rising cost of energy and difficulties in maintenance of long outfall drains, tile drains may prove more useful inspite of initial heavy capital outlay. Specially in Northern Region of Indus Plain where disposal of saline water is a permanent setback.

5. With the construction of more tile drainage projects it is expected that material and technology being used for the construction system

shall become cheaper. If the local contractors are encouraged to participate in the construction of such projects, the foreign exchange component of tile drainage projects shall also reduce to a minimum.

STRATEGY FOR 'SPEED UP' PLANNING OF PAKISTAN RAILWAYS

By
*Mian Ghias-ud-Din**

Introduction

In the present day of acute competition and rivalry from other transport modes a Railway system has to continuously improve and 'Speed Up' its operations. The Railway operations can be speeded up either directly by increasing the speed or indirectly by improving the time table and curtailing existing stoppages etc. In this chapter strategy for 'Speed Up' planning will concern only the methodology in increasing the operational speeds directly on a Railway system.

I - Essentials of a long term 'Speed Up' Plan.

The Railway system has to frame a long term speed up plan which may be termed as 'Target Speed Planning' or 'Perspective Plan for Speed Up' or 'Corporate Planning for Higher Speed'. Irrespective of the terminology, the aim and the object for this long term planning is always to achieve the projected speed increases which are fixed to-day and are to be attained after the passage of a period of say 20 to 25 years. With this aim all the branches and disciplines within a Railway system have to act in perfect co-ordination and unison for performing various tasks assigned to them in a manner that at the end of the perspective plan period all the sectors of the Railway do not lag behind in any manner and are fully ready to meet the target speeds prescribed for the various sections of the Railway system. In nutshell, this is a purpose oriented planning for which all the Railway men belonging to all the departments have to come up and make the achievement of target speeds possible without severe hold ups and fiasco.

Investigation and methodology for fixing target speed

Basic elements and essentials which are required to be surveyed and examined for planning attainment of higher speeds on the existing lines are as under :-

(i) Track - Its location and structure.

(ii) Traffic—Its forcasts and time table improvements.

(iii) Rolling stock—Capability and Riding characteristics of Locomotives and Carriages/Wagons.

(iv) Signalling/Interlocking—Equipments at stations/Block Sections and Level Crossings.

(v) Safety Installations.

A brief description as to how the investigations are to be carried out in respect of the above sectors is given below :-

(i) TRACK

* General Manager, Pakistan Railways.

(a) **Location**

Under this heading a scrutiny of the existing curves will be carried out to assess the actual condition and provision of the following variables.

(i) Degree/Radius of curve and existence of transitions at both the ends.

(ii) Amount of super-elevation available.

(iii) Existing cant deficiency and excess of cant.

The incidence of above characteristics of the cure will give an indication as to what extent the speed increase is possible keeping in view the existing condition of track and the proposed improvements in the standard of track structure and Rolling stock structure during the perspective plan period. It may be mentioned here that it has been establised after research and studies on the technically advanced and developed railways of the world that speeds of the order of 100 MPH/160 KMH for passenger train and 60 MPH/100 KMH for goods trains are possible and economically feasible on the existing main lines of the various Railway systems of the world without involving any substantial reconstruction of the lines from the stand point of curve characteristics. In order to introduce the above speed limits what is required is to redesign and re-align the existing curves in such a fashion that comfort and safety of the passenger and goods trains is ensured.

(b) Structure

Under this subject an assessment of the condition of existing items of track structure viz. rail section, kind and density of sleepers, design and adequacy of fittings and fastenings and ballast cushion/subgrade, will have to be made judiciously to decide as to whether these existing standards and items of the track structure will successfully absorb the effects of the projected increases in speed. It may not be out of the way to point out here that moderate speed increases of the order prescribed above can be introduced from the view point of track structure and its design considerations even without strengthening it. The main requirement in such cases is to improve the level of maintenance and the raising of the technical level of the maintenance supervision. It is but logical that this is the only feasible course left for the developing railways of the under-developed countries of the world due to extreme resource constraints on the one hand and non-readiness to assimilate the sophisticated technologies in the real of design, construction and maintenance of most modern track structures on the other.

(ii) TRAFFIC

(a) Forecasts

The projected increase in direct speed will increase the capacity of a line subsequently and more traffic can be passed. It is, therefore, but natural that increased traffic should be avail-

able in respect of both categories viz. passenger and goods, facilitating the effective utilization of this increased capacity. Thus, after the necessary study of the projected increase in speed, by the Track sector, to be attained at the end of the perspective plan period, the result is required to be forwarded to the Traffic Specialist for assessing the projected traffic increase which will be generated to avail of the capacity created by the projected increase in speed. It is not the aim of this article to explain the intricate methodologies and techniques for traffic forecasts now developed by the technically advanced Railways. In fact, traffic forecasting is a science in itself now. However, the main broad elements involved in the traffic forecasts are enumerated as under :-

1. Existing population centres alongwith projected population area to be developed, as a result of the over-all development of a country or region in respect of industries to be set up, agricultural facilities and infra-structure to be created or provided and minerals to be explored/extracted, are to be identified. The above information will facilitiate the preparation of census and reasonable estimates in respect of population growth and availability of marketable/transportable goods.

2. From the information gathered above a scientific/judicious analysis will be made as to the approximate estimates of passenger and goods traffic that will be flowing each way.

3. Based on the above assessment and estimates for the potential passenger and goods traffic available, a clear cut division and sharing of the potential traffic, to be carried, will be made between the various modes of transport including Railways.

4. It is clear from the above that the Railway will thus be ensured of the requisite traffic for which additional capacity will be available by the projected speed increases on the Railway system at the end of the perspective plan period. The full and economical utilization of the increase in capacity will make the planned speed increases viable and feasible.

(b) Time table improvements

Simulataneous to the traffic forecasting study, time table studies will also be carried out to make the railway travel competitive and comfortable for its customers and clientele. The result of these studies should be available within time, prior to the introduction of the projected increases in the speed, as these are time consuming and need comprehensive pre-planning.

(iii) ROLLING STOCK

(a) Locomotives

A study involving design work and field trials will be needed to arrive at the correct characteristics of the locomotives which will be required to haul the trains and loads at the projected speed increases. In the case of locomotives following considerations will have to be kept in view :-

1. Rated Horse Power-Availability of

adequate adhesion and the draw bar horse power, feasible axle load and number of axles. Centre of gravity, height and wheel diameter to rated power ratio etc.

2. Suspension characteristics—Brake gear etc. It may be noted that the view points of locomotive designer/manufacturer are in conflict with the track structure designer and hence a viable compromise is the ultimate solution of the problems involved. Braking capability has direct relation with the Signalling and Block distances and hence require a further compromise between a Loco man and a Signal man. Another pertinent aspect from suspension point of view is the extent of sprung and unsprung masses. The unsprung mass has to be kept as low as possible to reduce dynamic effects injurious to the track.

(b) **Carriage and Wagons**

The design and manufacture of the new carriages/wagons or strengthening of the existing fleet to meet with the projected increases in speed is another very important subject which will have to be studied most carefully involving extensive field trials and workshop experimentation, besides calling in know how of design/construction technologies prevalent in the World.

The main considerations to be kept in view for making the worthwhile studies can be summed up as under:—

1. Adequacy of wheel assemblies including axle and their journals.
2. Suspension systems vertical as well as lateral.
3. Incidence of sprung and unsprung masses.
4. Draw gear.
5. Truck and bogie design and their components.
6. Buffing gear.
7. Centre of gravity height and wheel diameter.
8. Tare weight.

It is worth mentioning that on the technically advanced and developed railways the emphasis has now shifted towards improvement of rolling stock structure rather than improving and strengthening the track structure. The novel suspension and tilting body coaches and locomotives manufactured and put in service on those railways do not entail the strengthening of the existing track structure or improving its maintenance level. However, on the Pakistan railways, in the foreseeable future such monumental advancement in the technological fields is hardly possible and PRs railway men hve to abide by the conventional and traditional methodologies i.e. equal stress will have to be laid for keep up of the maintenance of rolling stock structure and maintenance of track structure simultaneously.

(iv) SIGNALLING/INTERLOCKING

(a) **Equipments at Stations/Block sections:**

It may be appreciated that high speeds and signalling-cum-interlocking are interdependent and inter-woven and either of them cannot be seen in isolation. If high speeds are to be achieved, improved signalling and interlocking systems have to be created and put into commission.