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In this Issue

TITLE COVER

A Dual Carriageway in Islamabad (Courtesy Highway Department)

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Road to Prosperity

People, it is said, are the common denominator of all progress and the improvement of their lot is the only valid test of prosperity. So long as the wealth of a nation keeps piling into a few hands, widening the gulf between the rich and the poor, no progress can be real or lasting.

The coveted objective of prosperity for the common man in Pakistan is linked with the development of Agriculture, Natural Resources, Industry and Commerce-the four main props of our economy. Their overall development, in turn, requires a comprehensive and efficient system of transportation to link together the remotest areas and people of the country.

Unfortunately, like many other things, the development of transportation facilities in our country has been lop-sided. The road, rail and air transport facilities are not only limited but confined to certain privileged areas. The original reasons for this uneven development were historical but, later, short sighted planning aggravated the problem. The result is that today, 28 years after Independence, there are many places in Pakistan which are practically cut off from the main country. Such places virtually cry out for a link-any sort of link-that will facilitate movement of men and materials either way.

A road system, therefore, has to be evolved quickly that will give ALL our citizens the mobility they desparately need-a road system that will bind the people of the four corners of Pakistan into one, inseparable whole—a road system that will ensure an equitable distribution of national wealth and the benefits of progress—a road system that will help us to guard and protect our frontiers.

Long life provides the most important single element in highway economy, calling for construction to the best designs. Best design standards contradict the factor of available resources and this highlights the importance of proper maintenance. However, when aspirations are high, needs are urgent and varied but resources are low, compromises have to be made. One only hopes that such compromises are made in a sensible manner, in the best overall interest of the country.

It is a harsh fact that poor performance of our roads is not entirely due to compromises in design and maintenance standards. Negligence, lack of supervision, and corruption, all make their undesirable contribution. It would be a fatal mistake to deny or ignore the element of malpractices. In fact, even the compromised standards are not faithfully maintained. All that is specified, and available, does not necessarily go into the construction or maintenance of a road, and certainly not in the manner specified.

We can go on holding seminars, fill libraries with scholarly expositions on modern theories and practices of planning, design and construction of roads and highways, talk convincingly of traffic surveys, stage construction, compaction, sub-grades and sophisticated machinery, and discover intelligent and practical ways of raising requisite funds for highway construction, such as toll taxes, sale of special bonds or special levies on various automobile items, but what we need most, is a foolproof system, that will ensure that all the engineering decisions taken on the drawing board are faithfully implemented and translated into reality, out there in the field.

To be able to achieve this ideal, we need to go beyond engineering and educate ourselves in the concepts of freedom, nationhood, sincerity, honesty and integrity. There is no reason why we cannot partly make up with a sense of responsibility and dedication what we obviously lack in resources.

In a manner of speaking, a thousand roads lead to progress and prosperity provided they are intelligently planned, carefully designed, faithfully constructed and diligently maintained. There are straight, expeditious roads and, also, rough, long, dreary, twisting and winding roads that go uphill all the way. With the vast accummulated experience of advanced nations of the world at our disposal, it should be a relatively simple matter to avoid the obvious pitfalls and select a road for ourselves that will, one day, lead to prosperity.

Highways, Railroads, Airways, Factories and other signposts of progress must not detract us from the real objective- the betterment of our people. We have immense manpower, which needs to be effectively mobilized to compensate for any lack of other resources. If only we can impart proper education to our masses and elite - not just technical education but political, ideological and moral education as well-giving them a strong sense of unity, motivation and duty, then we are cerainly on the right road and prosperity is just round the corner.

Buildings Bridges and Highways Section

SEMINAR

on

HIGHWAY CONSTRUCTION

Foreword

A seminar on Highway Construction was held at Hotel Inter-Continental, Lahore, on 26th May, 1975, under the auspices of Pakistan Engineering Congress.

Syed Fayyaz Ali Shah, the Chief Engineer, Punjab Highway Department, convened the seminar. Dr. Mohammad Sadiq Malli, Minister for Communication and Works, Punjab, was the chief guest.

Four papers were presented on different aspects of road construction. In addition, Brig. Aftab Ahmad Khan, Director General Frontier Works Organization, gave a resume of the activities of his organization relating to the development of road communication facilities in various parts of the country. A film was also shown depicting different stages of work on the Karakuram Highway.

Engineering News brings to you the highlights of this Seminar.

Address of Welcome by S. Fayyaz Ali Shah

Syed Fayyaz Ali Shah, presenting his address of welcome, said that to develop the natural resources of the country, to promote industry and agriculture, to raise the standard of living of people and to meet the defence needs, the necessity of an efficient road network needed no emphasis.

He recalled that a seminar on the Highways was held in Lahore in 1972, by CENTO, on the subject of "Highway Planning and Administration." Again, last year, a seminar on "The Structural Design of Bitumen-Surfaced Roads in Tropical and Sub-Tropical Countries" was conducted by CENTO at Ankara. Based on the inferences, the Punjab Highway Department was carrying out field experiments for effecting economy in the pavement design. The CENTO had further agreed to hold another seminar on "Road Maintenance and Maintenance Techniques" in early 1976 for which necessary arrangements were being made by the Government.

He said that a number of countries had about one mile of road length per square mile of the area. Pakistan had less than 25% of this value. Keeping in view the financial resources, it was difficult to provide a network of metalled roads to cover up all existing deficiency.

In his opinion, staged construction was an aspect which could be high-lighted in regard to development of roads in Pakistan. Another important aspect was the proper lay-out and compaction of embankments and, consequently, the sub-grades. The role of machinery in its various forms in road making was also important.

Finally, he enumerated some factors hampering the implementation capacity and suggested various remedies :

(a) Inadequate capacity of contractors to handle large scale programme of road construction due to lack of resources and means to procure machinery.

(b) High prices of construction equipment.

(c) A limited stock of machinery at the disposal of the department which could not cope with the large scale requirements.

Problems (a) to (c) could be solved if a construction equipment industry was developed with the help of Government subsidy. It would reduce the capital investment of the Highway Department and promote high efficiency.

There was also a need for cutting down the import-duty and taxes on road construction equipment.

(d)Another problem was the scattering of finances over a large number of projects which caused tremendous delays in completions. One solution was careful selection of fewer projects for implementation every year, and sizable allocations of funds to achieve accomplishment within a year or two.

(e) The selection of projects could be made at least a year ahead of the implementation to allow sufficient time for effective planning.

(f) Very few trained engineers in this field were available within the country. Some experienced men had already left in pursuance of more lucrative jobs abroad. The Government could provide proper incentive to stop this drain.

Gist of the Reply by Dr. Mohammad Sadiq Malli, the Chief Guest

Mr. M. Sadiq Malli, in reply to the address of welcome, said that the People's Government was committed to alleviate the lot of the common man, to establish a just social order and bring prosperity to the country as a whole. The development works of great magnitude were being taken up in every sphere that had never been attempted before. The roads, no doubt, played a key role in national development. The existing network of roads was grossly inadequate and the need for improvement was obvious.

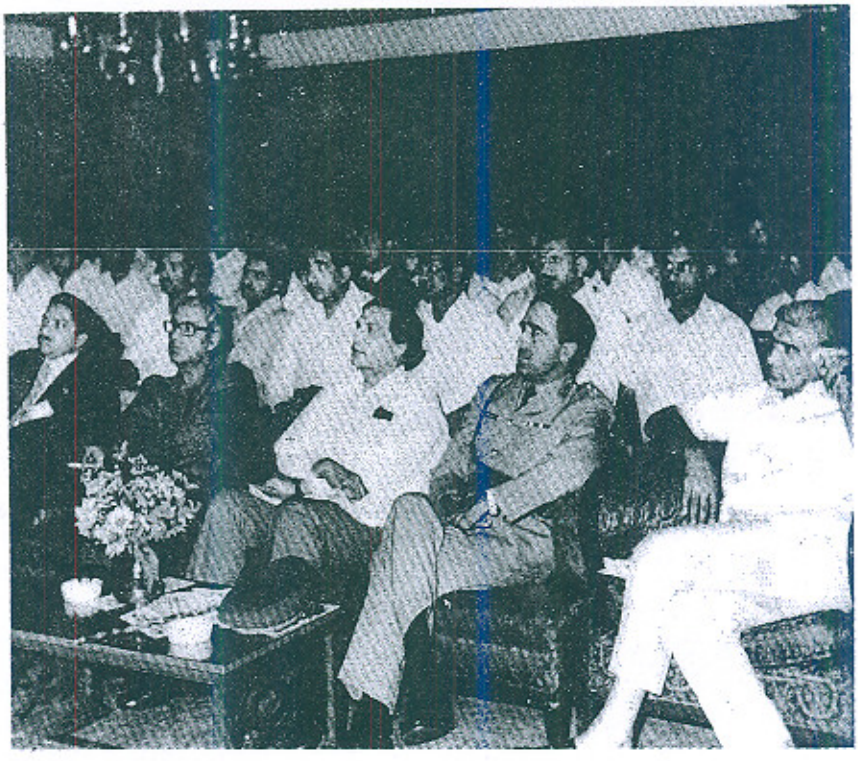
Mr. Malli appreciated the role of Pakistani engineers and the work being done by CENTO. He said that problems and suggestions highlighted by the convenor will receive his personal attention as they aim to make improvements in existing conditions.

The Address of Dr. Mubashir Hassan

The 2nd session of the seminar was addressed by Dr. Mubashir Hassan, President, Pakistan Engineering Congress. He congratulated the Congress on holding the seminar and said that presentation of 4 papers in mid-session was a proof that engineers had come a long way.

He said, the main problem in road construction was compaction. While irrigation engineers had known & tackled this problem for a long time, the building engineers in Pakistan had been a little negligent. The basic principles of compaction were easy to understand and could be applied without much difficulty.

Mr. Sadiq Malli, the guest of honour addressing the delegates at the Seminar on "Road Construction" held in Lahore on May 26, 1975



A section of the delegates who participated in the Seminar on "Road Construction"

Dr. Mubashir Hassan, President of Pakistan Engineering Congress addressing the afternoon session of the Seminar

Dr. Mubashir lamented the fact that the feudal society of Pakistan did not understand the language of the engineer. This was one of several reasons why the Pakistan engineer was unable to give his best to the society. He said, the engineer should go beyond the text book and look at the social forces which affect his work - the social forces that prevent him from acting professionally. He said that the real problems hampering the efficient working of engineers should be pinpointed and all the forces that were acting to oppose, retard or nullify his efforts must be dealt with firmly. There was need to bring about a social change in the country and engineers as a class should help to bring about this change by making common cause with the workers and the farmers.

Replying to criticism on the specifications and design criteria of Indus Super Highway, he said that the proposal for a 4-lane highway was based on a quantitative change in outlook. Roads do more than just carry people and goods from place to place. They help to break barriers. There was no reason why Pakistan should have to go through all those stages of development in this field as was done in Europe, America or Japan.

The prime necessity in Pakistan was parallel and equal development of all regions to partially undo the wrongs of the past. We must have a breakthrough on the right bank of Indus and provide modern means of communication. The decision was politically as well as strategically inspired.

On the way to progress, we must skip as many intermediate stages as possible and go to the most modern technology. This required a completely new outlook and a change in mentality.

Summaries of the Papers presented at the Seminar

Development of Road Communication System in Pakistan
A Case for Stage Construction

by

TAJAMAL HUSSAIN QURESHI,* *FASCE*

Inadequate Road System

The area of Pakistan is approximately 3,10,000 sq. miles and the approximate figures of different types of roads are as follows :

Type of Roads	Highway Depts:	District Councils	Municipal committees, Town committees, Cantonments.	Total
1. All types	12,000	27,000	2,800	51,800
2. Metalled	12,000	1,500	2,300	15,800
3. Unmetalled.	10,000	25,500	500	36,000

The above figures would indicate gross inadequacy of the road system. In advanced countries, the average figure as related to the area is usually one mile per sq. mile of area, collectively, for all types of roads. The need, therefore, is to provide as much mileage as possible within the shortest possible time to extend the much needed facilities to all areas.

Even the existing bituminous surfaced road system maintained by the Provincial Highway Departments, which consists of mostly single lane roads, needs rehabilitation and improvements to cater for the growing requirements. The following figures would indicate the gross inadequacy of the capacity of the existing roads to cater for the rapidly growing traffic requirements :

Average daily traffic. (Motor vehicles only) carried by the roads.	Percentage of paved roads (high type)	Mileage.
1. Upto 500	52%	6240
2. 500 to 1000	32%	3840
3. 1000 to 2000	13%	1560
4. Above 2000	3%	360
	100%	12000

Why Stage Construction

The task before us, therefore, is formidable and unless we closely relate our programmes with the actual requirements, we cannot make much headway due to the limitation of the financial resources and the implementation capacity. All the new road schemes that are being undertaken by the Provincial Highway Departments envisage construction of bituminous surfaced roads straightway and the position is more or less the same with regard to the schemes being undertaken under the Peoples Works Programme. In case of all those roads, the scope is almost uniform

*Director, Road Research Institute, Lahore.

and the actual needs have not been closely related by proper analysis of the traffic requirements. On many of the roads, it is anticipated that appreciable vehicular traffic would grow over a period of years which could justify a bituminous surfaced road. Even in the case of a very advanced country like United States of America, out of a total of about 3½ million miles of roads, over an area of 3 million sq. miles, only about 300,000 miles are of high type roads, although, the motor vehicles using these roads exceed 100 million. The development of road communication systems in every country has taken place in a process of stage construction whether planned or unplanned. The principle of stage construction is not new and, in fact, most of our existing roads represent a form of stage construction. Take, for example, the case of Bahawalpur Civil Division which, at the time of integration in 1955, had only 53 miles of metalled roads, whereas, the rest of the roads were either katcha or brick paved. This mileage of metalled roads has now grown to nearly 1000 miles since then by a process of gradual improvements.

Stage Construction of New Roads

The greatest virtue of stage construction is that it provides the roads that are needed NOW with the resources that are available NOW and defers till tomorrow the construction that will be needed THEN with the resources that will become available THEN. By this process, stage construction can provide a longer mileage of roads sooner, and at less cost.

Two Forms of Stage Construction

Stage construction can be accomplished in two ways. The stage construction in depth would mean building bridges, culverts and an embankment with a shingle or brick paved surface and returning later, at a future date, to add a base course with bituminous surfacing, or bituminous carpet, depending upon the needs. There is also stage construction in width i.e. building to-day the lanes which are surely needed now, while reserving the necessary right of way for additional future lanes. In all this process, however, the future requirements of geometric standards regarding curves, longitudinal grades, etc. should be catered for right from the beginning.

Exception

Lest it be understood that this policy is being advocated for each and every road, it appears necessary to clarify that in case of roads where the traffic requirements are estimated to be over 100 vehicles a day, bituminous surfaced roads should be built right from the beginning, in accordance with the anticipated requirements as determined by actual analysis. Where actual requirements so warrant, we must also build high speed highways or improve the existing roads to modern standards. The emphasis is actually on relating the construction needs with the actual requirements, to eliminate the danger of over spending on a certain facility at the cost of other projects and, thereby, also to prevent retardation of the speed of development of the road system.

Stage Construction for improvement of the existing Roads

Much of the network of roads in Pakistan has only a single lane pavement with a width varying between 9 to 12 ft. While such single lane roads are suitable for low traffic counts upto 100 vehicles per day (as per standards followed in developed countries), vehicle operating cost tends to rise rapidly on such roads as traffic increases. The maintenance cost for such roads also increases with increase of traffic and it becomes physically impossible to keep the road in reasonable condition, when the traffic exceeds about 750 vehicles a day, without widening the paved surface. The use of the shoulders of narrow roads increases in passing or overtaking manoeuvres which, besides adversely affecting the safety of traffic, makes maintenance and vehicle operation cost prohibitive.

When to Widen an Existing Road

According to some studies carried out elsewhere, the cost of operation of vehicles on single lane roads at a traffic count of 1000 vehicles per day is about the same as the cost of operating the vehicles on earthen roads. Based on this assumption, in a paper on "The Economics of Widening of Existing Paved Roads in West Pakistan" by Mr. F.H.P. Williams, the then Adviser on Road Research and Mr. R. E. Burns, formerly Transport Adviser to P&D Department, it had been worked out that it is economical to widen a road to 20-24 ft. when the traffic volume reaches about 300 per day. From the table of the existing roads with the volume of traffic thereon given in the foregoing paragraphs, it will be apparent that there is a need of widening of a huge mileage of roads straightaway. It can be easily realised that the present implementation capacity and other resources would not permit achieving this objective unless, again, the principle of stage construction is followed. To start with, much relief can be provided to the traffic by providing 4-6 ft. of brick paving on either side of the narrow roads. In the second stage, the brick paving can be removed and broken into brick ballast and mixed with about 25% sand to bring it to required gradation and can be used as a very good sub-base material. Alternatively, the brick paving can be laid at a level 3 to 4 in. lower than the existing pavement and the edges of the pavement can be sloped to join with the brick pavement to permit smooth maneouvres of traffic. In that case, in the second stage, base course can be laid directly on this brick pavement with bituminous surfacing. The enormous speed that can be attained with brick paving will provide a very speedy relief to the traffic, while the second stage of the provision of base course and surfacing can follow. The existing surface of the roads can be kept patched up and surfaced periodically till it becomes possible to provide overlays. By following this policy it would also be comparatively easier to work on the roads with running traffic.

However, in case of major roads or where traffic volume is in excess of 800-

1000 vehicles per day, widening and strengthening of the existing roads with bituminous pavements would be justified in the initial stage.

SAVING IN COST OF CONSTRUCTION OF ROADS IF ONLY BRICK ON EDGE PAVING IS DONE AND CONSTRUCTION OF BASE COURSE AND BITUMINOUS SURFACING IS LEFT TO BE DONE AT A SUBSEQUENT STAGE.

(i) Cost of brick on edge paving, sand grouted over 1" sand cushion. Rs. 150 per % Sft.

Cost per mile of 12 ft. wide road.	Rs. 95,000 (approximately)
(ii) Cost of sub-base course.	Rs. 150 per % Sft.
Cost of base course 4" thick.	Rs. 200 per % Sft.
Cost of surfacing.	Rs. 100 per % Sft.
Cost of sub-base, base course and bituminous surfacing.	Rs. 450 per % Sft.
Cost per mile of 12' wide road.	Rs. 2,85,000
Saving in cost per mile.	Rs. 1,90,000

Role of Sub-grade Soils in Road Construction

by

HASHMAT ALI and MOHAMMAD SIDDIQ*

Introduction

The nature of sub-grade soils and environmental conditions have a prominent effect on the design, construction and maintenance of highway. Complex physical process develop in the sub-grade soil on account of moisture and soluble salts during the annual wet and dry cycles. The sub-grade soils with high volume change and elasticity, excessive moisture content due to adverse ground water fluctuations and detrimental soluble salts, can damage the road performance in the absence of suitable remedial measures.

The paper deals briefly with the probable damages to the road performance due to natural agents like variable soils, salinity, water-logging, sand drifts and flood wash outs. It also discusses in detail the remedial measures to be adopted, which are briefly discussed as under :—

Sub-Grade

The sub-grade is a foundation layer of the structure which ultimately bears all the loads applied on the pavement. It is, therefore, very desirable that the structural design of the flexible pavement begins with the design of the sub-grade upon which the pavement is to be constructed.

Following are the desirable properties which the sub-grade should possess.

(I) **Strength and Stability :**

It can be achieved through proper selection and compaction of sub-grade soils at optimum moisture contents for a given compactive efforts.

(II) **Sub-grade Drainage :**

When highways are constructed on flat terrains, formation should be raised above the natural ground level so that it is at least 4-5 ft. (for silty and clayey soils) above the uppermost water-table level depending upon the height of capillary rise for a particular soil. For surface drainage, the sub-grade should be finished with proper camber.

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(III) **Compaction Equipment :**

The soil is compacted by applying energy in one of the three ways i.e. by (a) Rolling (pressure), (b) Ramming (impact) and (c) vibration.

(a) **Rollers :**

(i) **Smooth Wheel :**

Suitable for gravelly soils where crush-action is required. Unsuitable for sands.

(ii) **Pneumatic tyred rollers :**

Compaction achieved through kneading action from the contact pressures of pneumatic tyres. It is suitable for wide range of soil including gravelly to sandy silts and sandy clays.

(iii) **Sheep's Foot or Tamping Rollers :**

The compaction is achieved through kneading action of feet and is most suitable for fine grained cohesive soils.

(b) **Impact Rammers :**

The compaction is done through impact forces of the dropping weights. Their main application lies in compacting back-fill, bed trenches for drainage structures and soils behind bridge abutments.

(c) **Vibrators :**

Compaction is done by pressure under vibratory impulses. Most suitable for non-plastic gravelly soils and silts with appreciable amount of sand.

(Iv) **Compaction Control :**

The usual method of compaction control during construction is to determine the dry density of soil so as to achieve the specified degree of density. A rigid control can be exercised by determining the in-place moisture content and density after the embankment/sub-grade has been compacted. The main methods of in-situ density measurement are core-cutter and sand replacement methods. The limitations of each method should be properly evaluated before it is adopted for use as a routine control measure.

Table I

Compaction by Smooth Wheel Roller

Soil Group	Weight Group (Tons)	Pressure (weight per linear in-width of rear wheels).
Clean, well graded sands uniformly graded sands, and some gravelly sands having little or no silt/clay.	Cannot be rolled satisfactorily with three wheel rollers.	
Friable-silt, clay sand soils.	5 - 6	150 - 250
Intermediate group of clayey silts and lean clayey soils of low plasticity (10)	7 - 9	225 - 300
Well-gravel sand, gravels with sufficient fines.	10 - 12	300 - 400
Medium to heavy clayey soils.	10 - 12	300 - 400

Table II

Compaction by Pneumatic Tyred Roller

Soil Type	Contact pressure
Cleaned sand and some gravelly sands.	20-40 psi inflation pressure the greater pressure with the layer size tyres.
Friable-silty and clayey sands.	40-65 psi inflation pressure.
Clayey soils and very gravelly soils.	65 psi and up, inflation pressure.

Table III

Compaction by Sheep's Foot or Tamping Roller

Soil Type	Contact Area (Sq in)	Contact Pressure (psi)	
Friable silty and clayey, sandy soils.	7-12	75 - 125	Much heavier contact pressure with increased contact areas are necessary if higher field densities are to be produced.
Intermediate group of clayey silts, clayey sands and lean clay soil with low plasticity.	6-10	100-200	
Medium to heavy clayey.	5-8	150:300	

Earthmoving Road Construction and Ancillary Equipment Requirements for Indus Super Highway

by

MR. MUHAMMAD ABDULLAH*

1. Introduction

Indus Super Highway connecting Karachi with Peshawar will be running along the western bank of river Indus throughout its length. The Highway will be a modern four lane divided highway having two carriage-ways separated by a median strip, each carriage-way providing two lanes. The Highway will have a total length of about 1220 kilometres (758 miles) and, in the first 55 kilometres (34 miles) length from Karachi, it will run parallel to the existing Karachi - Hyderabad Highway. In this stretch, single two lane carriage-way is planned, the existing Karachi - Hyderabad Highway providing the second carriage-way.

Construction equipment costs have recently risen very sharply and continue to rise. In order to keep investment in construction equipment as minimum as possible, the use of machinery in various construction processes involved in construction of the Highway calls for very careful planning. Simultaneously, there is an urgent demand for reduction in construction period of the Highway and tightening of the specifications and controls. These objectives can only be achieved through thorough planning of various construction operations and selecting the right types and sizes of construction and ancillary equipment. Above all, the controls, operation and maintenance of construction machinery should be placed in the hands of qualified, experienced and competent personnel.

In order to determine the relationship between equipment costs and construction time, the requirements of construction and ancillary equipment have been planned for varying construction periods and priced at present day estimated costs. Proportionate part of the economic life of equipment exhausted over different construction periods has been assessed. Optimum construction period which will completely exhaust the economic life of most of the construction machinery on completion of the Highway, and will involve minimum investment in construction plant and equipment, has been worked out. Requirements of construction and related ancillary equipment alongwith broad specifications have been detailed for the optimum construction period.

2. Construction Sections

A project of the size of Indus Super Highway is too large for a single contractor to handle, particularly when local labour & local contracting organizations are to be encouraged. It seems, therefore, advisable

*Chief, Equipment Division, NESPAK Ltd.

to divide the Highway in appropriate sections for construction purposes. Keeping in view the volume of work involved in different construction operations of the Highway, it is planned to split the Highway into seven construction sections of about average length of 170 kilometres (105 miles). For the purposes of planning construction equipment requirements, 170 kilometres section of the Highway has, therefore, been taken. Actual equipment requirements in any particular section will depend upon the local conditions of the terrain through which that section is passing, and the design criteria adopted in view of these conditions. Construction equipment requirements in different sections, therefore, will vary, but, overall requirements for the total Highway may average out to about seven times the requirements of one section. If, in view of some constraints, the construction of the Highway has to be phased, construction equipment requirements could be staggered and planned according to the priorities assigned to different sections.

3. Construction Operations

The sequence of operations involved in construction of the Highway will be as follows :

(a) Arrangement of water for camp use, construction machinery and construction processes.

(b) Construction of sub-grade which would involve :

  (i) earthen embankment to be laid and compacted to given specifications.

  (ii) rock-excavation which may include drilling of two tunnels, 550 metres (1805 ft.) each, near Kohat, excavation of boulders etc. from within the right-of-way.

(c) Construction of pavement would involve laying specified layers of :

  (i) sub-base course,
  (ii) base course,
  (iii) priming coat, and
  (iv) surfacing.

Appropriate choice of construction and ancillary equipment for each of the above operations is highly important. Progress and quality of any one operation in any phase of construction depends upon the proper selections, application and production of 'key' machines. In view of high costs of construction equipment, requirements of various categories of equipment, viz earthmoving, compaction, road construction and ancillary units, must be planned on the basis of maximum use of equipment. The various work groups or equipment fleets must be balanced so that no wastage of machine-hours occurs and all unnecessary delays eliminated. Where equipment fleets are working in conjunction with each other, and output of one fleet is dependent upon the other, proper scheduling of work must be done in order to eliminate any possibility of adverse effects on production of individual fleets or on the overall progress. Furthermore, it is visualized that construction will proceed in a telescopic fashion and shifting of machinery from one phase or

operation to the other will not be permitted as that will result in unbalancing one or the other equipment fleet. On the basis of these considerations and the basic assumptions given under para 4, requirements of various categories of construction and ancillary equipment have been planned for the above operations in the following pages.

4. Basis of Planning Construction and Ancillary Equipment Requirements

For planning the requirements of earthmoving, road construction and ancillary equipment for various phases of construction of Indus Super Highway, following basic assumptions have been made :

(i) The construction of the Highway will proceed in a telescopic fashion.

(ii) The construction machinery will be operated in two shifts of 8-hours each.

(iii) At the start of each shift, one will be devoted to refuelling, preventive maintenance, routine adjustments and minor repairs etc. If conditions so warrant, some of these operations will be carried out in the third so as to ensure that a minimum of 14 production hours per working day are obtained.

(iv) 45 minutes/hour efficiency for estimating production of 'key' machines.

(v) 25 working days in a month and 10 working months in a year, two months being lost due to rains, unfavourable weather conditions, labour management problems etc.

(vi) Work on surfacing requiring high degree of precision and accuracy will be carried out from sunrise to sunset only i.e. an average of 8 hours per day.

(vii) Economic life of scrapers, tractors and other related equipment will be about 12,000 hours.

(viii) Construction equipment will become due for complete strip-down and rebuilding after having worked for 5,000 - 6,000 hours.

(ix) Job-management-efficiency of 75% for all construction operations.

(x) Swell factor of 40% for clay, dry or wet or mixed with gravel and 25% for loamy soils.

(xi) Speeds in excess of 8 kilometres per hour (5 mph) will not be permitted on sheep's foot tamping rollers for compacting cohesive soils and 2.5 kilometres per hour (1.5 mph) on vibratory rollers for compacting granular, sub-base and base materials.

(xii) Specified degree of compaction on earthen embankment (sub-grade) for average conditions will be attained by 12 passes of sheep's-foot/tamping or other type of compaction equipment and on sub-base and base course, by 4-7 passes of vibratory compactors, depending upon thickness of the fill.

(xiii) Estimated equipment costs are based on the latest (April, 1974 or earlier) purchases made by the Defunct Machinery Pool Organization of WAPDA. A reasonable allowance for escalation for the period elapsed since the last purchase has been made. Where possible, present day equipment costs have been obtained from the local agents of the equipment manufacturers.

(xiv) Rupee expenditure on custom duties, sales tax, port trust charges, inland transportation etc. on imported equipment will be about 30% of the foreign exchange cost.

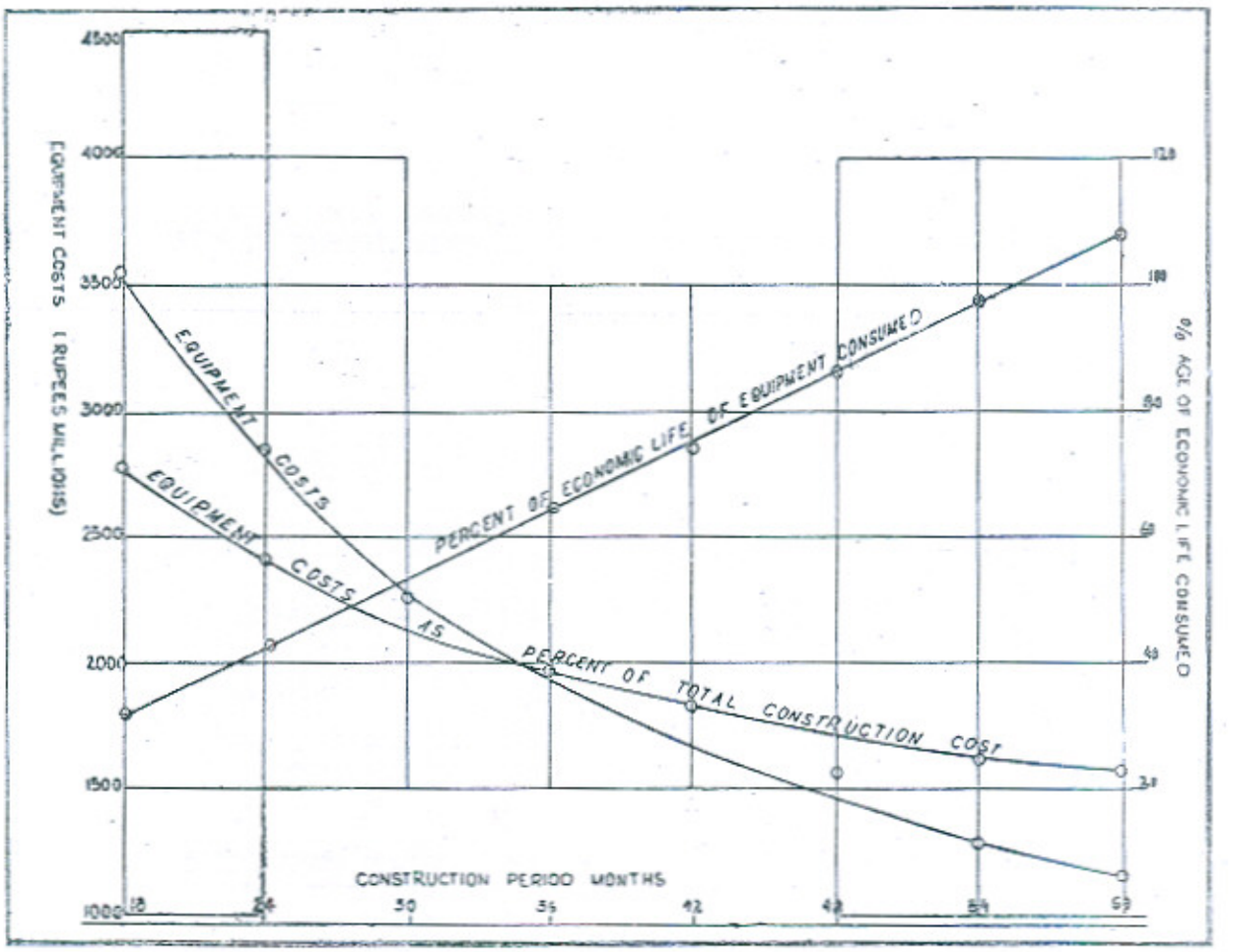
(xv) For determining the relationship between equipment costs and construction time, following construction periods for the Highway have been assumed :

18, 24, 30, 36, 42, 48, 48, 54 and 60 months.

(xvi) Where estimated quantities of different items of work are available, equipment requirements have been planned on their basis. Where estimated quantities are not available, equipment requirements have been worked out on the basis of experience on similar projects or works and will be firmed up when estimated quantities become available.

5. Factors affecting selection of Construction Equipment

In selecting most suitable construction equipment for any particular project, the general practice is to go in for "standard



equipment" unless the project definitely justifies the purchase of "special equipment". "standard equipment" has the following definite advantages over "special equipment" :

(i) It is commonly manufactured and is generally readily available "off-the-shelf". It can, therefore, be procured quickly.

(ii) "Standard equipment" may also be available in good second-hand condition, offering opportunities for quick availability.

(iii) Initial investment in "standard equipment" will be less than in "special equipment" which is specially designed and manufactured for a single project or a special type of operation.

(iv) "Standard equipment" can be used economically on more than one project.

(v) On completion of the project, "standard equipment" can be easily and economically disposed of.

(vi) Another positive advantage which "standard equipment" offers over "special equipment" is the availability of repair parts. Any equipment for which repair parts are not obtainable easily and quickly must not be purchased in a country thousands of miles away from the equipment manufacturers. It is always wise to go in for equipment which offers easy and quick availability of repair parts even though other considerations may make it look less desirable.

(vii) Easy availability of trained operators and mechanics which will offer considerable savings on training programmes.

While selecting the types and sizes of equipment for the construction of the Highway, above considerations have been kept in view. "Standard equipment" in preference to "special equipment" has generally been proposed. Careful consideration has also been given to the size of the Project and the local conditions of the terrain through which the Highway is to pass. Experience of major organizations owning and operating construction machinery in Pakistan has also been kept in view. Following additional factors resulting from these considerations have affected the choice :

(i) The Highway is likely to encounter high sub-soil water conditions in substantial reaches, and the equipment proposed should be of the type and size which can operate and run under such conditions. In certain high water-logged areas, rubber-tyred equipment may have to be provided with special wide tyres for improving its performance and production.

(ii) For most part, the Highway will be running through alluvial soils and it is expected that borrow material for construction of the sub-grade will be available without much difficulty. Long leads may, however, be involved particularly because digging of borrow pits within the "right-of-way" of the Highway is not permitted. In some sections, sufficient good quality borrow material may not be available in the vicinity of the Highway and may have to be hauled over long distances. Taking all these factors into account, it is estimated that average hauls, one way, including effect of grades, if any, for embankment material will be of the order of 600 - 800 metres.

(iii) Standard equipment already in operation with major construction agencies such as, Mechanized Construction of Pakistan Ltd., C.D.A., A.D.A. etc., has generally been proposed. This will assist in procurement of trained operators and mechanics and also help in availability of repair parts and repair facilities.

(iv) Locally manufactured equipment of reasonable quality, meeting or near to the specifications, should be utilized to the maximum.

(v) It will be profitable if construction equipment, on completion of the Highway, can be used on other development projects of national importance. If the Highway has to be built in 36 months' period, the equipment will still be having sufficient economic life on completion of the Highway and this factor will weigh heavily in favour of "standard equipment".

6. **Standardized Makes of Construction Machinery**

Earthmoving and construction equipment is manufactured in many countries of the world and numerous makes of the same type of construction machinery are available in the world market. Only a few of the many makes available today have proven credibility, performance and production. Messrs Edzublin, a German construction firm, who built Marala Barrage, preferred to use caterpillar motorized scrapers in preference to German equipment because caterpillars are proven machines. T.J.V. is using caterpillars 631 Model scrapers for earthmoving operations, and there are many more such instances. At least two organizations, namely M.P.O., WAPDA, (now known as Mechanized Construction of Pakistan Ltd.), and the Pakistan Army have evaluated and standardized different makes of construction machinery. The selection of equipment for the Highway should be keeping in view the evaluation of different makes of construction machinery done by M.C.P., the Pakistan Army and other agencies engaged on construction activity. Soft loans or barter protocols should not allure us for going in for construction equipment of inferior quality, unproven credibility, performance and production.

7. **Construction Equipment Requirements**

On the basis of assumptions given in paragraph 4, equipment fleets have been planned for each phase of Highway construction separately. These have then been priced on the basis of current estimated costs. Investment in construction machinery for varying construction periods and the proportionate part of the economical life of construction equipment exhausted at the end of different construction periods plotted on the graph at page 17. This graph shows that the optimum construction period which will involve minimum investment in construction machinery is around 55 months.

Shear Strength of Soils and Compaction Equipment

by

CH. MANZOOR AHMAD*

Introduction

Soil compaction is achieved by applying a compressive load which induces shearing stress of more than some critical value when bond between soil particles fail. If applied stress is not high enough, the soil will not fail. Compaction process is, therefore, a means of producing higher shearing strength than before. If shearing strength of a soil cannot be increased by compaction to a level higher than the required loading, the soil is not suitable for embankments and fills.

Compaction Due to Shear

Shear failure will occur when applied shear stresses are greater than the resisting stresses, which are due to cohesion and friction.

Friction is directly proportional to the force squeezing the particles together and increases with increase of compaction.

$$\frac{\text{Shearing stresses}}{\text{Pressure}} = \tan \phi$$

tan $\varnothing$ is co-efficient of internal friction and ϕ is the angle of friction and is characteristic of the material and its condition.

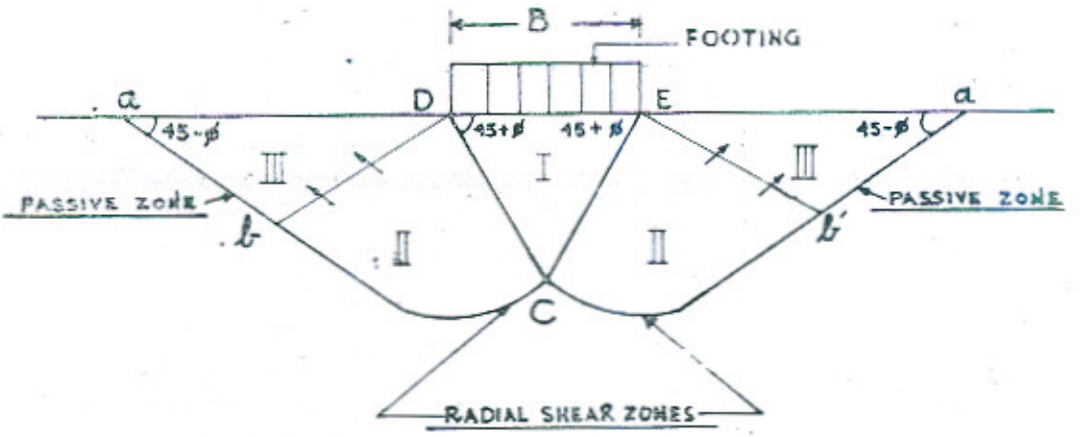
Cohesive materials such as clays, greases will hold together, even though slowly moving with time. Pure frictional material like dry sand will separate unless confined. Cohesion and friction also vary with temperature and moisture.

Based on analysis of stress conditions for plastic failure of soil, Prandtal, Tarzaghi and Housel have developed theories for finding out maximum load that a soil is capable of supporting. This analysis is also helpful in understanding the action of compaction equipment for making stable sub-grades of highways, air fields and other embankments.

Shear Compaction under a Footing

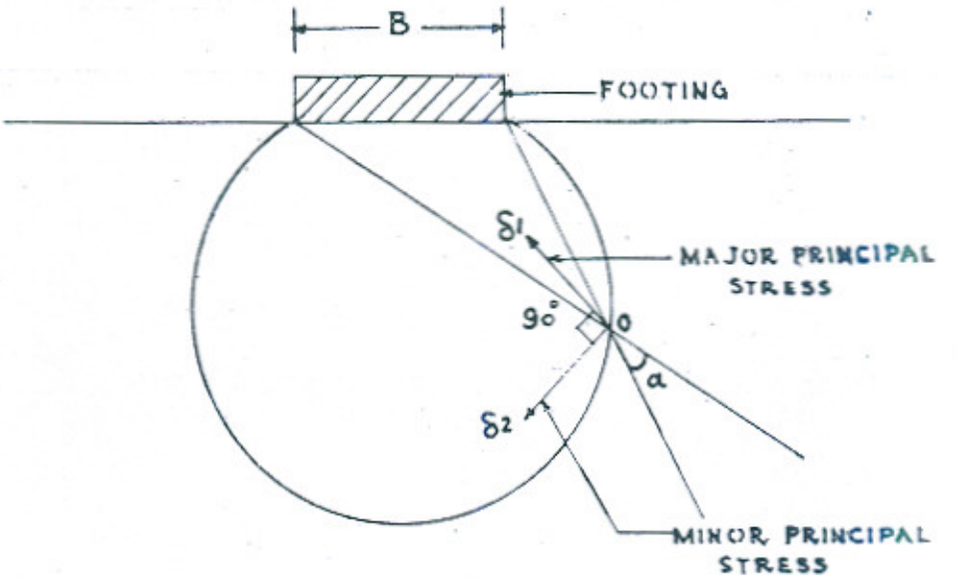
Directions of shear stresses under a loaded footing are shown in Fig. 1. In

* S.E. Highway Mechanical Circle, Lahore



SHEAR ZONES UNDER A FOOTING

FIG-1



MAJOR (δ_1) AND MINOR (δ_2) PRINCIPAL STRESSES AT a POINT O

FIG-2

7·50 × 15 COMPACTOR TYRE

CONSTANT INFLATION PRESSURE
VARIABLE WHEEL LOAD

3000 Lbs — 55 PSI — AREA - 50 SQ·INCHES

GROUND PRESSURE = $\frac{3000 \text{ Lbs}}{50}$ = 60 PSI

4000 Lbs — 55 PSI — AREA - 60 SQ·INCHES

GROUND PRESSURE = $\frac{4000 \text{ Lbs}}{60}$ = 66 PSI

CONSTANT WHEEL LOAD VARIABLE
INFLATION PRESSURE

4000 Lbs — 55 PSI — AREA - 60 SQ·INCHES

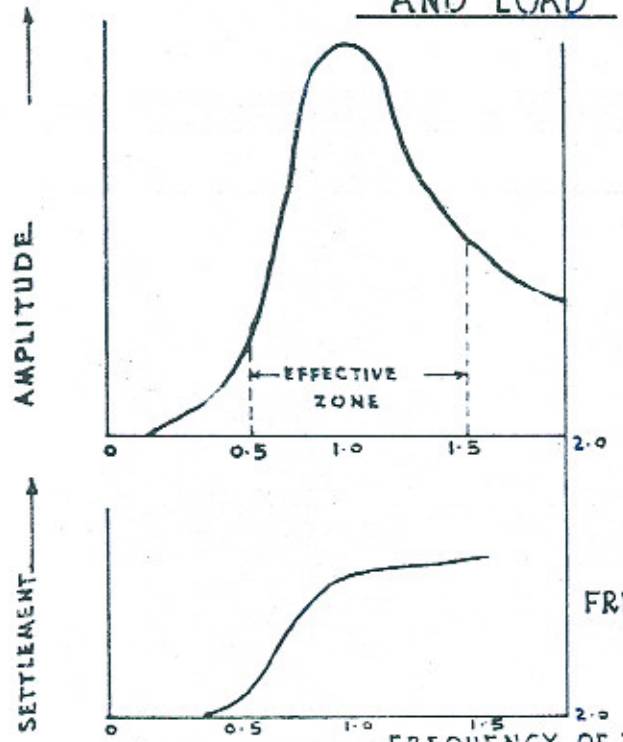
GROUND PRESSURE = $\frac{4000 \text{ Lbs}}{60}$ = 66 PSI

4000 Lbs — 80 PSI — AREA - 48 SQ·INCHES

GROUND PRESSURE = $\frac{4000 \text{ Lbs}}{48}$ = 83 PSI

PNEUMATIC TYRED ROLLER AT VARIABLE TYRE PRESSURE AND LOAD

FIG-3



FREQUENCY RATIO = $\frac{\text{FREQUENCY OF THE ROLLER}}{\text{NATURAL FREQUENCY OF THE SOIL}} = \frac{f1}{f0}$

FIG-4

case of local shear failure, movement in the radial shear zone is limited and effect the passive zone in a manner so as to raise it. Since the net volume of all the effected soil has decreased, compaction has occurred.

When compaction has taken place, the soil becomes stable, then combined effect of all forces is balanced and no shear slip movement takes place.

Compaction can be achieved on those soils whose friction can be increased by combination of shear slip under compression.

Compressive Stresses at a Point under Surface

Major principal stresses (δ_1) and minor principal stresses (δ_2) at a point 0 under the footing are shown in Fig. 2.

$\frac{\delta_1}{\delta_2}$ is called principal stress ratio. When this is not more than 5 - 8, compactive shear failure takes place.

Maximum shearing stress $\delta max = \frac{\delta_1 - \delta_2}{2}$ and bisects the two principal stresses.

As per Coulomb's equation, shear resistance δ_r of the soil subject to shear failure is expressed in the equation :

$$\delta_r = C + \delta_1 \tan \phi$$

Where C = constant dependent on cohesion.

δ_1 = normal stress on sheared face.

ϕ = angle of internal friction.

If maximum induced shear δ_{max} is more than the resisting shear in the passive zone, loosening will occur and there will be no compaction. If compacting machine sinks far enough that weight of the soil on the passive zone prevents loosening, compaction will take place.

Pure plastic materials (frictionless) are not compactible. In practice such materials are avoided and are "Stabilized" to increase the internal friction.

For purely granular materials where cohesion is zero, δ_{max} is greater than $\delta_1 \tan \phi$, friction angle is generally 24°-34°. Compaction will take place at depths of only one-fourth to one-half of the width of the load. Therefore, large contact areas are recommended.

Shear Compaction under a Roll

Since prismoidal body DEC (Fig. 1) acts as a part of a footing, it makes little difference whether the bottom of the footing is curved or not. The chord of the arc of contact is equivalent to flat bottom of the footing DE.

Compacting roll should be loaded to the extent that any further significant increase in weight would cause the undesirable general shear failure of the soil. This would provide maximum compaction per pass. As stability of the soil increases with more passes, weight of roll can be further increased.

Rolls of Different Diameters

Rolls of different diameters will produce the same size of prismoid but the larger roll will not "dent" the soil as deeply as the smaller roll. Thus for larger rolls, the angle of inclination of the prismoid will be less, the rolling resistance will be less and there will be less distortion of passive zones. The result will be that

there will be lesser tendency for general shear failure.

During first pass, there is a likelihood of general shear failure, but if the speed of the roll is more than the speed of propagation of passive zone shear failure, compaction takes place. Subsequent passes should be made at a slow speed so that sufficient time is allowed for local shear to occur. The second pass is the most important in compaction and maximum possible advantage should be derived from it.

Sheep's Foot Rollers

Sheep's Foot Rollers compact soils in layers and depth of compaction is nearly equal to the length of the pad.

Pneumatic Tyred Rollers

Plastic equilibrium theory explains equally well the compacting effect of this type of roller. Most important characteristics of a Pneumatic Tyred Roller are the tyre inflation pressure and area of contact of the tyre. Gross weight of the roller is not important, since it is a function of number of wheels, area of contact and inflation pressure.

Ground pressure produced by a pneumatic tyre is not equal to its tyre pressure, because, side walls of the tyre carry considerable portion of the load. Average ground pressure can be obtained by dividing the wheel load by area of the "foot print" of the tyre. Fig. 3.

Vibratory Rollers

These rollers do an excellent job of rearranging soil particles by reducing friction between them and eliminating air voids thus bringing particles to their tightest arrangements.

Working of a Vibratory Roller mainly depends upon four factors :

1. Vibration frequency.
2. Vibration amplitude.
3. Centrifugal force.
4. Travel speed.

If Roller is run at a frequency which is equal to the natural frequency of the soil, resonance will take place. At this frequency, the roller is most effective and maximum settlement (compaction) will take place. The most effective range of frequencies is $\frac{1}{2}$ to $1\frac{1}{2}$ times the natural frequency (Fig. 4). Natural frequency depends upon density and moisture contents. These two factors are continuously changing as the compactor travels.

The greatest vertical distance through which the roll moves from its equilibrium position is called amplitude of the roller. Amplitude is maximum when roller is in resonance. The amplitude ranges from 0.1 inch to 0.05 inch.

The force applied to the soil depends upon the mass of the unbalanced weight, its eccentricity, speed of rotation and upon physical soil properties. Physical properties are its spring rate and damping co-efficient depends upon cohesion and moisture.

Unbalanced centrifugal force F can be expressed as :

$$F = \frac{W}{g} w^2 r$$

where W = Mass of the unbalanced weight
w = Angular motion
r = Eccentricity
g = Acceleration due to gravity.

Ratio of machine weight to centrifugal force cannot be less than 0·31. Below this ratio, the vibrating motion is no longer harmonic and roller does not touch the ground at each impulse.

Travel speed should range within 1-2 miles per hour :

Energy dissipated per cycle at resonance in soil can be determined :

$E = \pi F. x_{max}$

where x_{max} is the maximum amplitude at resonance, and F the centrifugal force.

From this relationship, power expended in the soil can be determined.

When a vibration force is applied to the soil, the compression is propagated as pressure wave and shear as shear wave. Pressure wave moves at the speed of sound while shear wave moves at approximately one-half the speed of sound.

Frontier Works Organisation in the Northern Region

BRIG. AFTAB AHMAD KHAN*

Brigadier Aftab Ahmad Khan, Director General Frontier Works Organisation, presented a paper on the various road construction projects being handled by his organisation in the Northern Region. The salient points from this paper were later summarized with the help of Director Public Relations, HQ, FWO.

Location

Gilgit and Baltistan collectively make the Nothern Region. Flanked by China in the North and Afghanistan in the West, the area has unique geological features. Fourteen of the 20 highest peaks in the world, all above 25,000 ft, are crowded in this area, including the famous, 28,250 feet high, K2. The heavily glaciated areas include the 36 mile long Batura glacier. Hunza, Astore, Punial, Yasin, Chilas, Shigar and Khaplu are the important valleys in the area, and the mountain passes include Mintaka (15,450 feet), Khilik (15,600 ft), Babusar (13,685 ft) and Khunjerab (16,188 ft). Generally, the area is of undulating rocky nature with vegetation in the valleys and nowhere on the bare rocky mountains. The weather conditions are extreme and the temperature may go upto 50°C (122°F) at places. such have been the conditions under which the Frontier Works Organisation has taken up the challenge of carving roads out of rocks.

Early Work

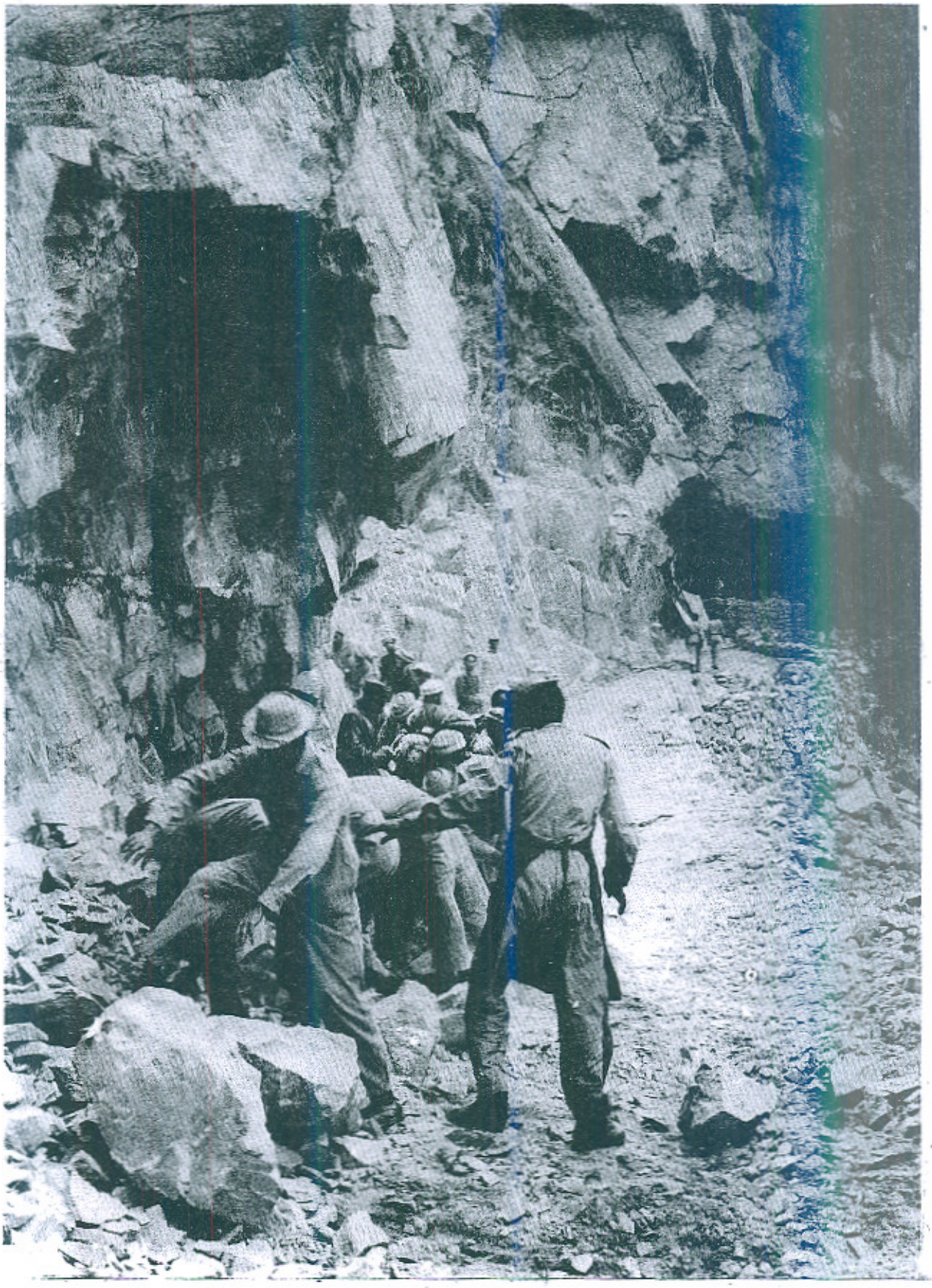
The first move in the road construction work was taken up in 1949. A jeep track was constructed through the Kaghan Valley of Hazara District via Babusar Pass upto Chilas which, unfortunately, remained closed for 9 months in a year due to snowclad Babusar Top.

Karakuram Highway (KKH)

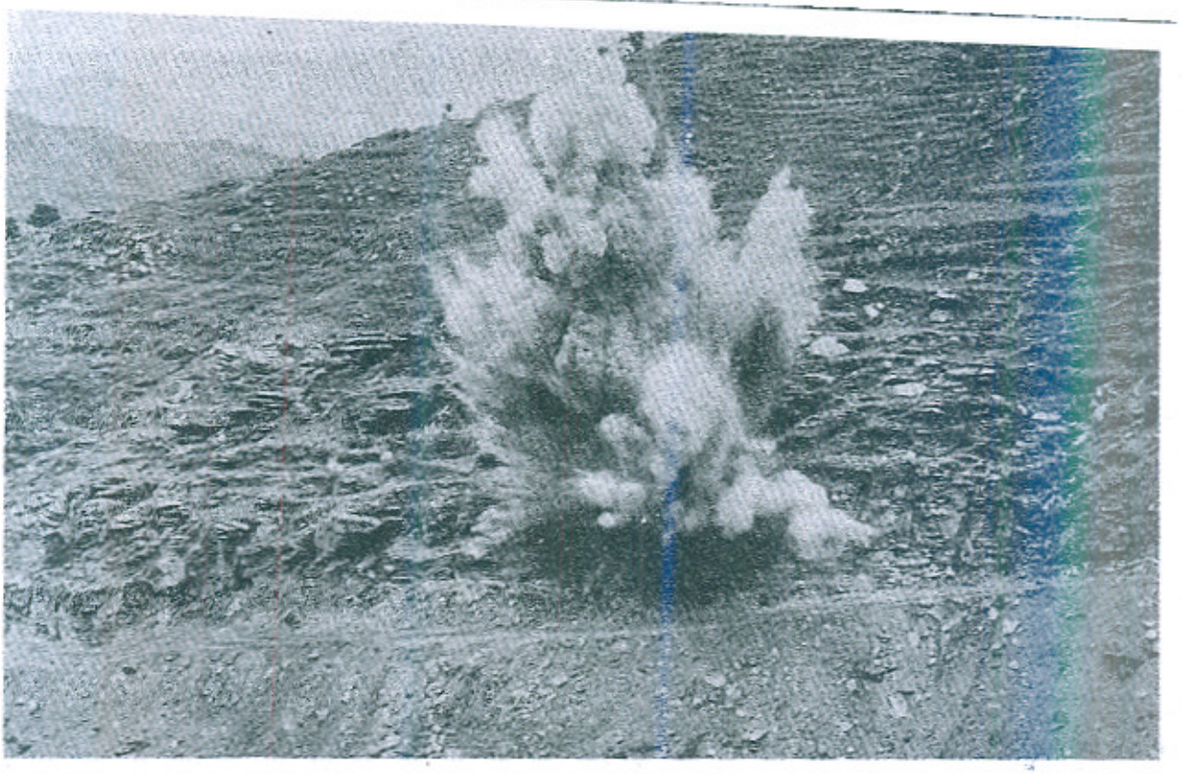
In order to provide an all-weather

*Director General, Frontier Works Organisation

Drilling work in progress on Karakuram Highway



Jawans of the Engineers Corps clearing the rock debris after blasting



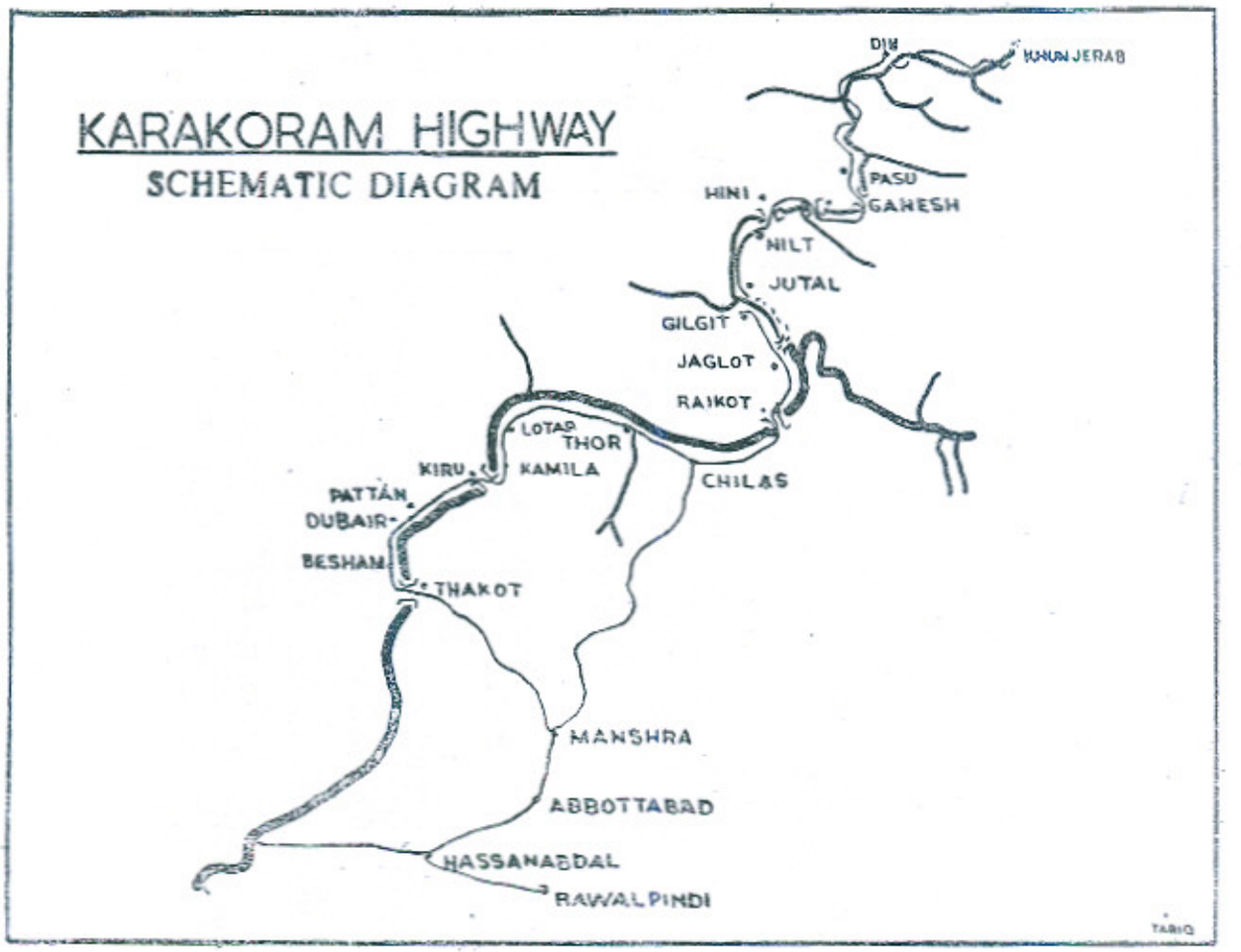
Army Engineers blasting a huge mountain for the construction of Karakuram Highway

A portion of Shahrah-e-Karakuram being built by Frontier Works Organisation

road to the Northern Region, Government of Pakistan embarked on the construction of Indus Valley Road (IVR) in 1958. The Army Engineers lined the area upto Gilgit with the country below, through Karora in Swat by IVR of 237 miles length meandering along the Indus River gorge under sheer precipices. IVR was further lined up at Besham Qila with Abbottabad via Thakot to shorten the distance between Rawalpindi and Gilgit by 70 miles. In 1966, the Government of Pakistan raised the level of the above road to that of a Highway-the Karakoram Highway. Initially, the KKH was 237 miles in length, it is now 485.8 miles. It has largely been carved out of the Karakoram range. Almost every inch of the road has been chiselled through, The terrifying gorges and cliffs took a heavy toll of human life but now we have an all weather road linking the entire northern region with the rest of Pakistan.

Khunjerab-Thakot Road

Strictly speaking, it is the extension of the Karakoram Highway to the borders of our friendly neighbour, the People's Republic of China. The construction of this road, which is nearing completion, will open the northern parts of Asia which remained proverbially inaccessible so far.



Thakot-Havelian Road

Next to the Karakuram Highway, link roads were given due priority. The work on the link road between Thakot at KKH and Havelian in the Hazara District was started in 1972 and involved construction of several culverts and bridges. The road has been successfully completed and opened to traffic.

KKH-Skardu Road

Skardu is being linked up with KKH by an all weather road and the task has been assigned to the Frontier Works Organisation.

Chakdara-Chitral Road-Lowari Tunnel

Chitral is connected through a seventy-five miles fair-weather road with Dir which in turn is connected by an all weather road via Chakdara and Malakand with the rest of the country. Between Dir and Mirkhani, the existing road climbs up to Lowari Pass and then descends into the Chitral valley along excessive steep slopes and through a large number of hairpin bends. Because of the high elevation encountered, the road around Lowari Pass remains closed to vehicular traffic for about eight months in the year. The only means of communication during this period is by air, which again is not dependable due to bad weather. An era of prosperity will be ushered in Chitral alongwith Dir valley when a new tunnel to be known as "Lowari Tunnel" will be constructed by Army Engineers to provide an all-weather road between Chakdara and Chitral. The two-lane road tunnel which would be more than five miles in length at an altitude of 7,880 feet will probably be the first of its kind. Not only would it add new dimensions to the tourism activities in Pakistan but also revolutionize the economy of Chitral and Dir. Mining activity will receive due impetus which would go a long way in developing the area and raising the standard of living of the people of Chitral.

DISCUSSIONS

Comments by Mr. Abid
of National Oil Refinery, Karachi

(i) A case for Bulk supply of Asphalt

National Oil Refinery is spending a huge amount of foreign exchange every year on importing equipment for the delivery of asphalt in barrels. To save this huge expense, the Government has directed the company to look into the possibility of distribution of asphalt in bulk. The company has taken steps in this direction and, as a matter of fact, supplies near the Karachi area are already being made in bulk. During the construction of Superhighway from Hyderabad to Karachi, the supplies of asphalt were made in bulk. It is accordingly suggested to the Highway Departments which are handling large scale road development programmes that they must consider very seriously the question of bulk supplies of asphalt. The Highway Departments must equip themselves to switch over to receiving bulk supplies of asphalt.

(*ii*) *Asphalt Institute*

For close contact between the manufacturers and the users, a technical body known as Asphalt Institute on the lines of the one in U.S.A. should be established in Pakistan. Bulk of the roads in Pakistan during the last ten years have been built with asphalt from National Oil Refinery but, unfortunately, there has been no feedback of technical matters from the concerned user departments. It is, therefore, strongly felt that an Asphalt Institute consisting of the manufacturers and the users should be establised.

(*iii*) *Advance Information*

If the requirements of asphalt for Indus Super Highway are determined and given to the National Oil Refinery, it will help them to make plans in advance to meet the asphalt requirements of Indus Highway.

Replies by Mr. Tajamal Hussain Qureshi, Director, Road Research & Material Testing Institute, Lahore.

(i) Bulk distribution of asphalt would definitely save a lot of money both in foreign exchange and local currency to the manufacturers and also the users, but bulk distribution on the basis of the past experience has its own drawbacks. To streamline the methodology to be adopted in this respect, National Oil Refinery can sort out the details with the concerned Highway Departments.

(ii) The suggestion regarding setting up of an Asphalt Institute in Pakistan is useful but it would be known to the National Oil Refinery that in U.S.A., such an Institute has been established and maintained by the asphalt producers themselves, by charging a small cess on every barrel of bitumen produced. The initiative in this regard, therefore, must be taken by the National Oil Refinery to set up such an Institute from their own resources which could keep a close liason with the asphalt users.

Comments of Mr. Abdus Salam, Director, Planning & Design of Highway Departments, Lahore.

(*i*) *Thickness of Brick Soling*

In the general application of stage construction in the context of pavement designs, we have generally been depending upon a design period of five to ten years instead of twenty years. Regarding the suggestion made in the paper that in the case of lightly trafficed roads i.e. for traffic less than 100 vehicles a day, initially 4½" thickness of brick soling should be provided and, subsequently, base course and surface course added when the funds are available. I have made certain calculations and have found that with an initial road traffic of 50 vehicles a day and a C.B.R. value of 10, with 5% per annum growth rate of traffic, the thickcess of the pavement for a design life of five years comes to about 9". So, if we are going to provide 4½" thickness against a design thickness of 9", I am afraid that the road will not stand very well and, in a couple of months, the pavement is likely to get corrugated under traffic.

(*ii*) *Flexible Design Standards*

The main problem is of limited resources and, within the limited amount

of funds available every year, we must construct greater mileage of roads and open out more areas. In order to be able to do this, I very strongly feel that we must adopt realistic design standards. In other countries, the lane width, the width of road formation and the roadway on bridges vary with the traffic requirements, whereas, in our country, more or less uniform standards are adopted. In Australia, a very large mileage of 12 ft. wide road has been built with a road formation of 28 ft. against our road formation of 32 ft. It may be said that conditions in Australia are different from ours. In India, where the conditions are very much like ours, the Indian Road Congress has laid down much more flexible standards. The roads which carry about 50 vehicles a day with a pavement width of 12 ft. have a formation width of only 24 ft. The roads which carry 80 vehicles a day have a formation width of 28 ft. and where the traffic is more than 100 vehicles a day, the formation width is 32 ft. In the context of 2-lane roads, the earthen shoulders are 8-10 ft. Wide. 8 ft. being the minimum and 10 ft. being more liberal. In our case, the shoulders width is always about 11 ft. I think, we can possibly cut down the cost to a great extent by adopting realistic standards. The pavement width on some of our roads is 28 ft. and the roadway at bridges on various roads are 28 ft. wide. This really conflicts with the international practice. A 28 ft. pavement width is 3 lane road which has a very high potential of accidents and thus we are building unsafe roads. The design standards must, therefore, be reconsidered.

Comments of Mr. Mazhar Ali, Chairman, Cement Board

Resources :

(i) *Financial vs Human*

I am not a road specialist by profession and will not be making appraisal of the papers from that angle at all. I have, however, a few comments and suggestions on whatever has been said in the papers in a lightly broad perspective. Massive effort is required if we want to take to the doorsteps of the masses any semblance of civilization. The prosperity of the cities has to be taken to the villages if we do want to make any progress. We have been trying to make some effort and progress in this direction for the last twenty years. Each public sector has been critical of lack of funds, support, subsidy, lack of attention etc to the desired degree in order to achieve the desired objective. The basic question is, "Are we going to achieve everything possible within the financial means?" If the answer is yes, then we will never have the financial resources to achieve the desired results. The entire planning so far is directed to achieve physical targets through financial means. The Peoples Works Programme and the roads being built under this programme, mentioned by Mr. Tajamal Hussain Qureshi, was in fact an effort in the dynamic direction to make a departure from the old system to provide the badly needed facilities in various sectors by association of the masses rather than depending on the financial

resources. Unfortunately, we, in the Government services, feel that we are the wisest and have the monopoly of patriotism. This, unfortunately, is not the case. Our own thinking is in a certain perspective and the result is that we end up with a lot of paper work and we are not able to do anything because of the financial means. Mr. Tajamal Hussain Qureshi has pointed out very correctly that we do not have the resources to spread the benefits of the roads all over the county and we talk of intermediate solutions.

(*ii*) *Thin paved Roads or Brick Paved Roads*

The present position is that if you go out and look around to see the roads which were built with thin pavements or brick paving, you will find that they are terribly wavy. The bricks are by far the poorest specifications. They are badly dented and you cannot make a speed of more than ten miles. You will probably go on katcha lane on brick paved roads for fear of tearing of your tyres. If that is the reality, how do you propose a parallel solution when the quality of bricks is not being controlled.

(*iii*) *Designer's Dilemma*

It has been advocated by Mr. Abdus Salam to change the design standards. I have been a designer myself and know the spirit that goes behind the designs. Instead of adopting very economical design to spread the benefits over a larger area, the designs are kept heavy to safeguard against enquiries, as enquiry committees would forget that the designs were deliberately kept low to affect economy.

(*iv*) *Use of Machinery*

The double shift use of machinery has been advocated but I am afraid that even the existing machinery is not being put to optimum use. When this is not being properly used even in a single shift, it is not understood how efficiency can be promoted in a double shift arrangement.

Comments of Mr. Munir of P.W.R.

(*i*) *Flexible Specifications*

The specifications adopted for a certain facility should be governed by the requirements.

(*ii*) *Encroachments*

At present, because of reckless encroachments, the roads are not being put to the maximum use.

Reply by Mr. Tajamal Hussain Qureshi

I have never said in my paper that brick paved surfaces would be an ideal solution for all situations. The idea is to bring home the necessity of providing a larger mileage of roads within the available resources, by closely relating the requirements with the construction needs. Where only nominal traffic is expected, the practice of providing brick paved roads or shingle roads can give the required facilities quickly in larger areas. These facilities will definitely be of an inferior quality but the question is of having a facility or no facility at all. During the last three years, a lot of investment has been made in the

road sector but it would be an interesting study to find out how many roads or how many miles have been added during this period. Mr. Abdus Salam talked about the design criteria. Actually, 100 vehicles a day have been mentioned in the paper as a stage at which the road should be metalled. This is only a suggested figure. It can be reduced to 50. While proposing brick paved or shingle roads, I have actually in mind several of the roads which are in hand at the moment where we do not expect, in the coming four to five years, more than 10 - 20 vehicles a day. It would definitely not justify bituminous surface roads straightaway. Regarding design criteria, I must emphasize again that, while adopting stage construction to spread the benefits over a large area, we must be prepared to accept some inconvenience in the matter of the facility being of a lower category. Mr. Abdus Salam has suggested a minimum of 9" thickness of pavement for a road with 100 vehicles a day, whereas, we know that even a highway like Lahore - Multan Road is about 8" thick and, in certain sections, it is carrying over a 1000 vehicles a day although with periodical maintenance and repairs.

As an example of stage construction, by providing brick paved roads, I would like to point out that in Bahawalpur region, at the time of integration in 1955, there were only 53 miles of metalled roads. Even our highway, from Punjnad onwards, had only brick paved trackways which, though with inconvenience, made it possible for the traffic to move on. While talking about the condition of the old brick paved roads, as expressed by the speakers, one should bear in mind that these were built at a time when there was no concept of proper compaction standard and drairage etc. Furthermore, it is the amount of traffic on which the condition of these roads would depend. Under low volumes, as I have mentioned before, they would give a reasonable surface and the moment they show signs of distress, the stage of metalling would automatically be indicated.

I would definitely agree with the suggestion of Mr. Abdus Salam that we should reconsider our design standards to match with the actual requirements and affect economy where possible. The specifications which only include the standards of materials and workmanship should remain the highest but the design and scope should be closely related with the actual requirements.

A very important point has been made by Mr. Munir with regard to the improper use of the available road space due to encroachments and other activities on the available road space and the land on either side. It is true that much relief can be provided if the available road space is put to optimum use by eliminating encroachments etc.

The whole purpose of presenting this paper is to recognize the necessity of providing facilities at a faster rate so that the impact of developments in this sector is felt quickly.

Replies by Mr. Mohammad Abdullah from NESPAK

There has been a question about the quantity of bitumem required for Indus Super Highway. This is given in the paper on page 43*.

While dealing with Mr. Mazhar Ali's comments, regarding my recommendation for working of the machinery in two shifts, I would like to point out that all the machinery on Indus Basin Project, Mangla dam and Tarbela dam has been working in two long shifts, and I may say that the operators were all Pakistani. What we lack is the managerial quality. In the post rehabilitation and reconstruction programme following the floods in August, 1973, we were very short of the machinery. We approached the Army, the first organization in the country who had imported scrappers from Zchekoslavakia. I saw those scrappers and found only one in working order and talked about it to Brigadier Nadir. He said, "what can I do? All the operational manuals are in Zchek language". He said he would get in touch with the Zchekoslavakian embassy, and it took one and half year to get the operational manual in English language. If we are going to purchase some such sort of machinery, I think we will be wasting money. It is time that we should standardize these things. Again, I contacted the Capital Development Authority for scrappers and they had about eight to ten units but none was in working order. All had broken down in less than 500 hours. Finances are the major constraint in the purchase of machinery but, at the same time, we should be very careful in purchasing the machinery and equipment so that it does not break down soon after its arrival in the country. I have already made a suggestion that some authority should be constituted which could evaluate the performance of different makes of machinery before we could purchase them.

**This refers to the original paper and not the summary reproduced in this journal—Ed.*

University of Engineering & Technology

in the field of consultancy

Engineering News Reporter

University of Engineering and Technology extends advisory services to Government, Semi-Government and other agencies This is being done so as to benefit the society with the highly qualified knowledge and skill available with the University.

The University, among other works, is handling two sizeable projects, namely, Gomal University, D. I. Khan and Punjab Medical College and Hospital, Lyallpur. In both these projects, the University of Engineering and Technology has been engaged to act as Consultant on all the architectural and engineering aspects of the problems. The main features of the design projects are as under :-

1. Punjab Medical College and Hospital, Lyallpur

The Problem

The Hospital and the College Campus present a complex problem in space relationships. It is expected that there may be about 5 to 6 thousand people on the site at any one time. This includes patients, visitors, hospital staff and all the population expected in the college and the colony. The solution proposed attempts to base itself on the fundamental problem of circulation and traffic.

Traffic Analysis

The traffic analysis and design attempts to :—

(i) Ensure a smooth access to all buildings.

(ii) Segregate the pedestrians and the vehicular traffic.

(iii) Prevent any cross traffic in the site (no road is provided to link the main roads on the periphery).

(iv) provide pedestrian areas, walkways and parks to ensure that vehicular traffic does not become a menace.

Land use

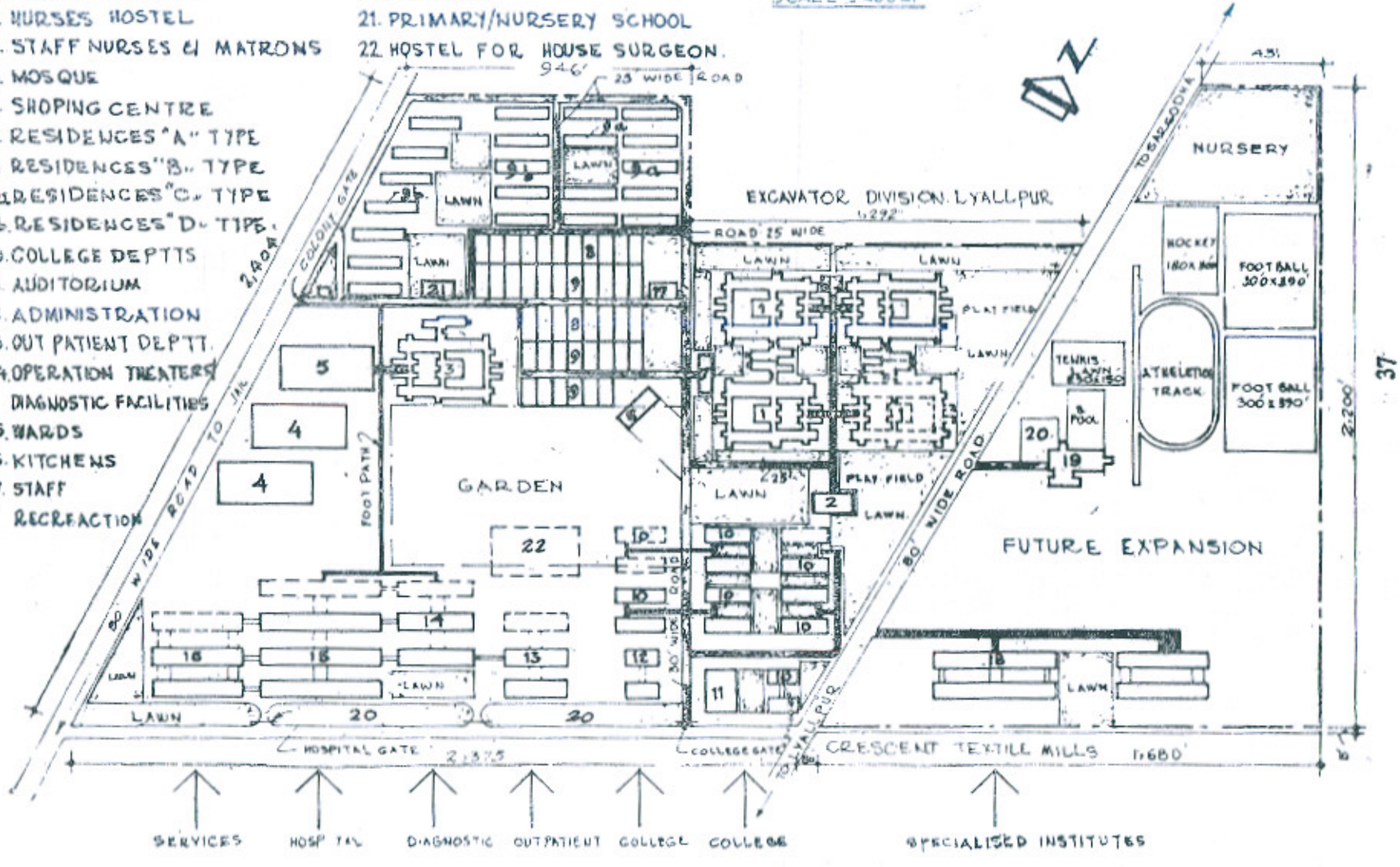
The site of the hospital is in two parts. The division of the site poses problems as well as presents certain advantages in so far as it lends the possibility of having certain autonomous and self sufficient research or specialised institutes away from the main campus. The main part of the site, approximately 105 acres, lying on the South West of Sargodha Road, will constitute the main campus. The South West corner of this site, which is also the nearest to the town centre, is being earmarked for the hospital proper. This corner of the site will have most of the public dealing and general public shall enter this particular corner and leave without disturbing the rest of the campus. The South

LAYOUT PLAN OF PUNJAB MEDICAL COLLEGE LYALLPUR

SCALE : 400' = 1"

REFRENCES

1. BOYS HOSTEL
2. R.T. HOUSE
3. GIRLS HOSTEL
4. NURSES HOSTEL
5. STAFF NURSES & MATRONS
6. MOSQUE
7. SHOPING CENTRE
8. RESIDENCES "A" TYPE
9. RESIDENCES "B" TYPE
9a. RESIDENCES "C" TYPE
9b. RESIDENCES "D" TYPE
10. COLLEGE DEPTTS
11. AUDITORIUM
12. ADMINISTRATION
13. OUT PATIENT DEPTT.
14. OPERATION THEATERS DIAGNOSTIC FACILITIES
15. WARDS
16. KITCHENS
17. STAFF RECREACTION
18. T.B. & OTHER INSTITUTE
19. GYMNASIUM
20. PARKING
21. PRIMARY/NURSERY SCHOOL
22. HOSTEL FOR HOUSE SURGEON.



East of the site is devoted to the college campus.

The road taking off from the link road will travel from South to North of the site. This road will act as the main artery serving the campus. The college, in the main, will lie on the East of this road and the hospital on the West. The road then leads on to the boys hostels which are on the North Eastern part of the main campus. These hostels have been so placed as to be near the college as well as the play fields which are proposed on the site lying on the South East of the Sargodha Road. On the West of the main artery road is the housing colony for the hospital and the college. This colony will also act as buffer between the Boys Hostel and the Nurses and Girls Hostel, placed in the Western part of the site.

The main campus has been so arranged as to encircle the existing garden. This green patch will serve as a garden and buffer between the hospital and the colony. Some portions of this park may be used later on for future expansion purposes.

The second part of the site lying on the South of Sargodha road will have Sports and Cultural Centre in the Northern portion and some Specialised and Research Institute in the Southern part.

2. Gomal University, D.I. Khan

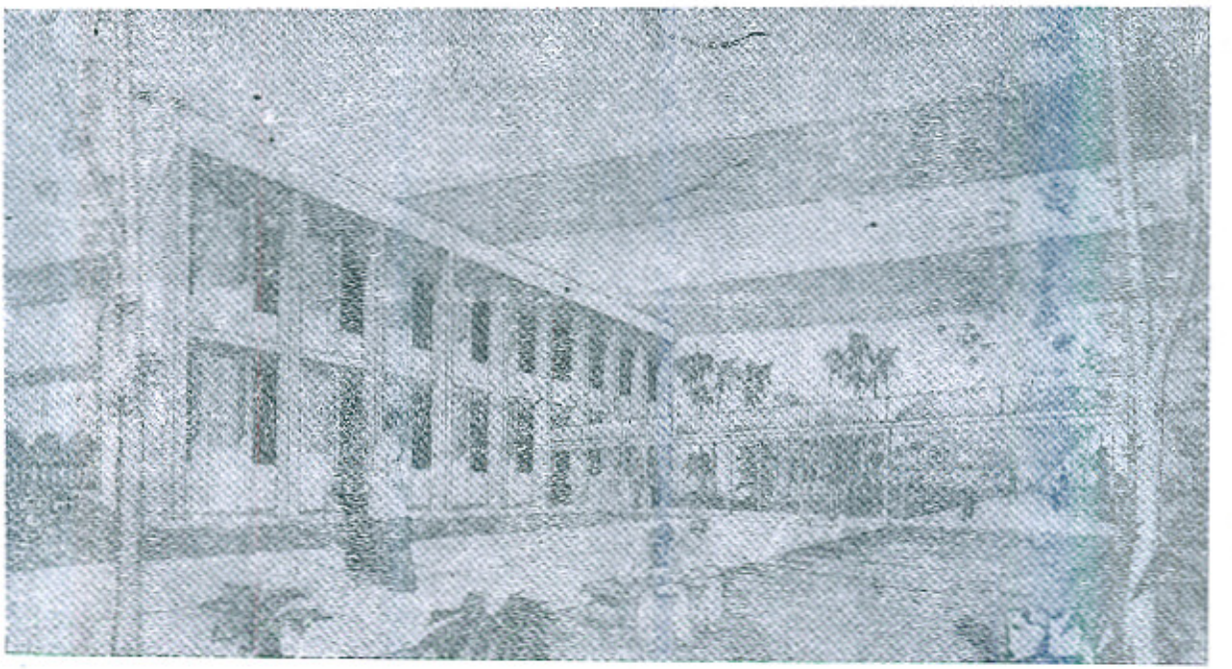
The Fountain Head

The fountain head of the University comprises the Grand Mosque, Administration Building, Multiple Purpose Hall and the Library. These four have been arranged in a square from which the rest of the campus takes off.

Flexibility

The master plan provides a design that is flexible and yet gives a complete

Contd. on page 62



Perspective view of Arts Block, Gomal University, Dera Ismail Khan

Irrigation and Power Section

The Concept of Thal Reservoir Project

BARKAT ALI LUNA*
S. NAZAR HUSSAIN MASHHADI**

Necessity of more stored water

Although Pakistan is blessed with the unique system of the Indus river and its tributaries, occupation of a major portion of Jammu and Kashmir territory by India has deprived us of the facilities of storing the water of these rivers for use on our fertile plains. In addition to that, the three Eastern rivers were taken away by India under the Indus Waters Treaty and we were left with only the Chenab, the Jhelum and the Indus rivers to meet our growing needs of food and fibre. Under this Treaty, two Dams, namely, Mangla and Tarbela, have been constructed alongwith numerous links and barrages to transfer supplies to the commands of the three Eastern rivers, viz., the Ravi, the Beas and the Sutlej.

Apart from other problems of immense magnitude, financial and technical, which the Treaty has brought in its wake, two problems stand out very significantly :

(1) The rapid depletion of the capacity of Mangla and Tarbela Reservoirs, and the urgent necessity of building new storages to replace the silted storage capacities.

(2) The depletion of subsoil water over considerable distances along the banks of all of our rivers, due to daming up the normal and flood flows at the Dam sites.

Tarbela's live storage will be depleted at the average annual rate of 0.12 MAF for the first 20 years and 1.07 MAF for the following 30 years corresponding to an average annual silt load at Tarbela of 440 million tons. The live storage would decline from 8.48 MAF in 1975 to 1.1 MAF in the year 2025.

Mangla similarly depletes at the rate of 0.02 MAF a year.

The storage at Chasma barrage being small does not carry major significance in this context.

So far, the storage capacities built under the Indus Waters Treaty are of the order of 15.14 MAF (Mangla 5.34 ; Tarbela 9.30 and Chasma 0.50).

The conclusion drawn by the World Bank Study Group headed by Dr. P. Lieftinck in their report presented to the Government of Pakistan in July, 1967 was as follows :

> "An analysis of the hydrological factors affecting the Indus Basin produces one inescapable conclusion : control of the Indus river itself will ultimately be essential to control of the surface water supply. This follows from the simple observation that the Indus river carries 63 percent of the total surface water that is

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**Partner, Engineering and Technical Consultants.

available to West Pakistan for development under the terms of the Indus Waters Treaty 1960, and that 72 percent of its flow occurs during the four month period, June to September. Without storage, some large proportion of Indus water must inevitably run waste to the sea."

It was estimated that the mean demand for stored water after the construction of Tarbela would grow to 26.5 MAF by the year 2000 A.D. It is evident that we are to go a long way in supplementing our storage capability by constructing additional storage reservoirs wherever possible. After Tarbela, the World Bank Group identified future storage projects as follows :

(i) Kalabagh, (ii) Side Valley storage, (iii) Upper Indus Sites ; and (iv) Thal Off-stream storage scheme.

Besides, one minor storage scheme of 1.8 MAF at Mancher was also suggested.

The construction of Thal Reservoir came to focus in the light of this programme. M/s T&K, Consultants to Wapda, also proposed in their "Regional Plan for the Northern Indus Plains" that a large shallow reservoir can be created in the barren lands of Thal Doab as an off-channel storage with a gross capacity of 21 MAF. This reservoir was meant to store the surplus flows of the mighty Indus river which normally flow down to the sea during the summer season.

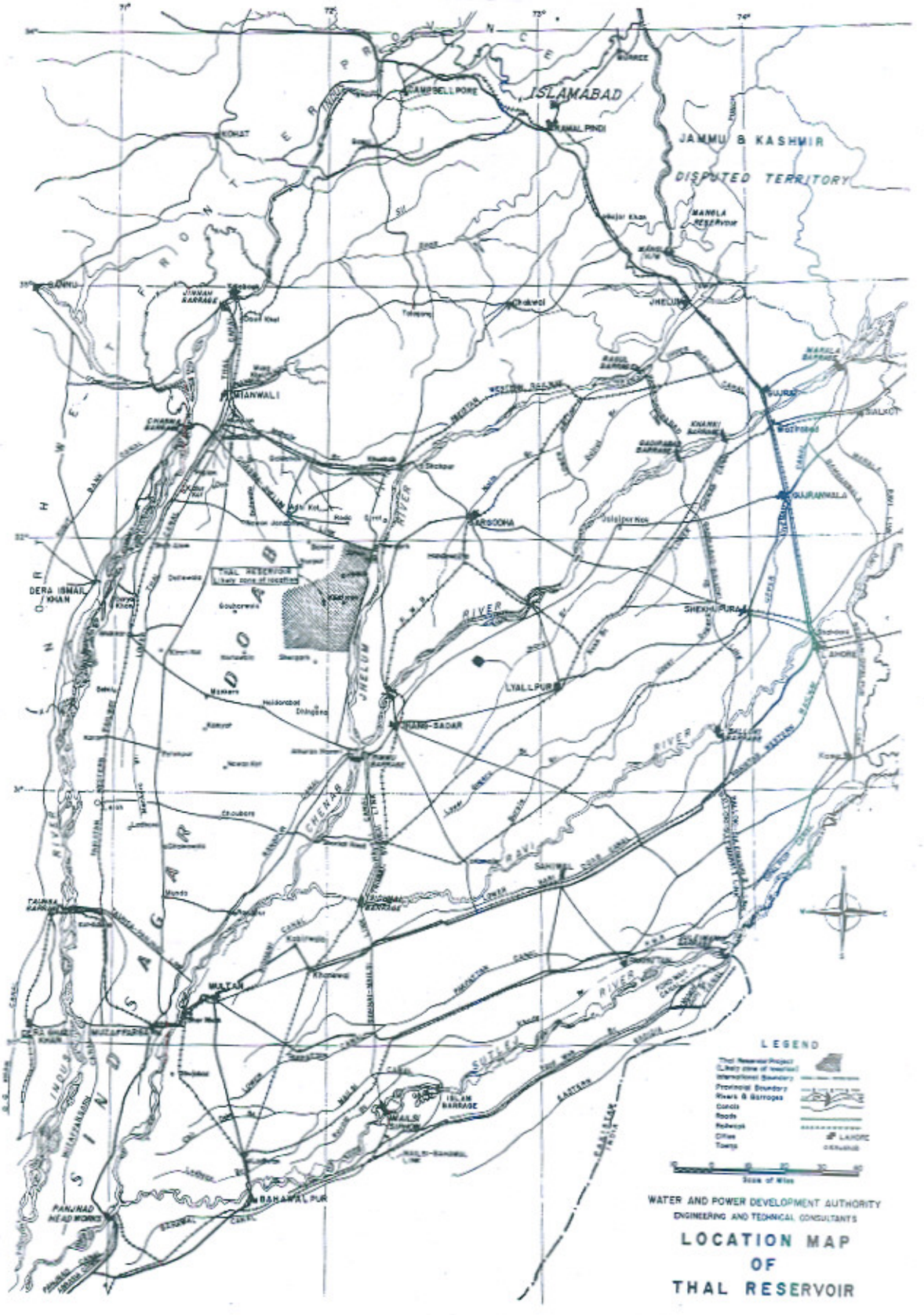
After subsequent studies, it was, however, considered that this large reservoir would submerge a substantial tract of the Thal Doab which is already developed or is planned to be developed. As such it was decided to investigate the feasibility of a small storage of about two MAF as a pilot project.

It has already been recognised by all experts that the rapid spread of salinity in our country is the direct result of short supplies which we provide to our irrigated areas. As a matter of fact, irrigation supplies should be enhanced considerably to the level practiced in U.S.A. and other countries so that excess supplies can be used for leaching down the salts which have reached the ground surface as a result of short irrigation supplies. The Government of Pakistan have already embarked upon an accelerated programme for salinity control which has been given top priority in order to save our irrigated agriculture from extinction. Looking from this angle, the more the availability of stored water, the more successful would be our accelerated programme of reclamation.

Very Economical Storage in the Thal Reservoir

(i) Chasma versus Thal Reservoir

A small reservoir with 0.8 MAF capacity was created in the year 1971, upstream of Chasma Barrage on the Indus river. This has proved very useful, as an intermediary storage before the commissioning of Tarbela Dam Project. Although the storage capacity is very small, it has submerged an area of 0.9 lac acres. The riverain belt which it has submerged upstream of Chasma is very fertile and more thickly populated than the area of


ISLAMABAD
JAMMU & KASHMIR
DISPUTED TERRITORY
MANGLA RESERVOIR
JHELUM
MIANWALI
KHUSHAB
SARGODHA
GUJRANWALA
SHEKHUPURA
LYALLPUR
JHANG-SADAR
MULTAN
BAHAWALPUR
DERA GHAZI KHAN
DERA ISMAIL KHAN
THAL RESERVOIR
Likely zone of location
INDUS
JHELUM
CHENAB
RAVI
SUTLEJ
SIND SAGAR DOAB
CHAJ DOAB
RECHNA DOAB
JECHNA DOAB
RIVER
CANAL
LEGEND
Thal Reservoir Project
Likely zone of location
International Boundary
Provincial Boundary
Rivers & Barrages
Canals
Roads
Railways
Cities
Towns
LAHORE
Scale of Miles
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING AND TECHNICAL CONSULTANTS
LOCATION MAP
OF
THAL RESERVOIR

Thal reservoir, where only one village of importance viz. Jamali would be submerged. Almost the entire area coming under this reservoir is a barren waste, as would be seen from the map on page 41.

The following table would give a comparative picture of the reservoir at Chasma and that in the Thal area :

Item	Chasma Reservoir	Thal Reservoir
(a) Gross Storage	0 8 MAF	2.3 M.A.F
(b) Area Submerged	0 8 lac acres	1.8 lac acres
(c) Nature of submerged area	Fertile and thickly populated	Barren Waste
(d) Population affected	62,000	23,000
(e) No. of Villages affected	30	8

(ii) **Cost of Storage**

It is also interesting to note that the cost per acre foot of storage at the prevalent price index in the case of Tarbela Dam is Rs. 1044 ; at Mangla it is Rs. 1674 ; while at the Thal reservoir it would be Rs. 690. Apart from this huge economy of stored water, the life span of Thal reservoir would be about 275 years against only 53 years of Tarbela.

(iii) **Favourable factors responsible for low cost of storage**

The following factors contribute towards the low cost of storage in the Thal reservoir :

(a) No costly barrage or a new canal would be needed, because the reservoir can be fed through the existing C-J Link taking off from Chasma Barrage.

(b) The work would be carried out in dry conditions. Unlike in-channel storages, no diversion works, costly pumping and deep cut-offs below the dam would be needed.

(c) Cheaper to build with labour intensive methods.

(d) Major construction materials are locally available.

(e) No hazards like Tarbela are involved.

(f) The land to be acquired is all barren waste.

(g) No interception and relocation of existing utilities like railways, roads, or canals etc. are involved.

Brief Description of the Thal Reservoir Project

The proposed Thal Reservoir would be located just south of the tail reach of Chasma-Jhelum Link along the West bank of Jhelum river as shown in the Location Plan attached. Supplies to the Reservoir shall be routed through the existing Chasma-Jhelum Link taking off from Chasma Barrage during the months of July and August when there is excess flow in river Indus and Chasma-Jhelum remains closed because Trimmu demand can be met with from Chenab supplies. The maximum supply to be drawn at head equals 26,000 cusecs which can be run in Chasma-Jhelum Link after allowing a rise of 1.5 ft. in the free-board of the Link Canal. The Reservoir would be enclosed by an earthern dyke of 74 miles with the maximum height of 47 feet including 12 feet free-board. The gross storage capacity of the Reservoir would be 2.3 M.A.F. and utilizable storage equals 2.15 M.A.F. The total estimated cost of the Project works out to Rs. 158 crores. The common man's fear that there would be excessive

seepage loss through the sandy bed of the Reservoir is unfounded, because the area of the Reservoir is capped by a 10-12 feet thick layer of clayey/silty sand with a reasonable coefficient of permeability. The reservoir would be emptied generally during September, October and early November and would provide very valuable supplies for Kharif maturing and Rabi sowing. The supplies of-course can be utilized anywhere in lower Punjab or Sind areas.

Enormous Benefits of Thal Reservoir

(i) It hardly needs any elaboration that our irrigation system suffers from chronic shortage of supplies during the low flow periods and as already explained in this Note, the only course to improve the situation lies in storing the surplus flood flows of the rivers. The quicker we build our storage potential, the earlier we shall be able to achieve self-sufficiency in food for our overgrowing population.

(ii) As stated in the World Bank Mission Report, we are in need of 26.5 MAF stored supplies. The storage at Mangla and Tarbela are fast silting up and there is emergent need to compensate for the loss of capacity at Mangla and Tarbela. The Thal Reservoir which will be storing the relatively silt-free water of the Indus river shall have a very long life (275 years) and the benefits of the stored water would produce results over a much longer period than Mangla and Tarbela.

(iii) The Government have already initiated an accelerated programme for salinity control for which supplementary water inputs play the major role. The Thal Reservoir can certainly help this accelerated programme to a substantial degree.

(iv) The Thal Reservoir being planned will provide stored waters during late *Kharif* and early *Rabi* during the period of keen demand and in this manner would substantially improve the agriculture output.

(v) The Thal Reservoir would provide more economical storage as compared to huge dams on the Indus; because it would be constructed in absolutely dry conditions on barren waste lands where no problems like river diversion, pumping and foundation cut-offs are involved. It would also provide opportunities for labour intensive methods which in the case of large dams are not practicable.

(vi) The proposed reservoir is located in the northern region at such a location where-from it can command any problem area in the lower regions of Pakistan. Since it would store water from the Indus Main, its advantages can rightfully be shared by the Provinces of Punjab, Sind and Baluchistan.

(vii) There will be a drop of about 60 ft. at the outlet from the Thal reservoir and this provides a potential site for generation of cheap hydroelectric power which would help us mitigate the energy crises during the critical winter months. Of course, this power would be fed into the national grid for use anywhere in the country.

(viii) The Thal Reservoir being planned would be depleted in the early *Rabi* period and as such it would be possible to cultivate the area within the reservoir for bumper *Rabi* crops.

(ix) After the construction of Mangla Dam, the spill level of River Jhelum D/S of Mangla has gone down and all the sailaba and well irrigation along the banks is fast decreasing. Government is already considering schemes to provide water for such adversely affected areas through tubewells. A scheme for development of riverain areas has been prepared by WAPDA. The Thal Reservoir would certainly help this effort in the reach of Jhelum river between tail of C-J. Link and Trimmu Barrage by providing a good source of recharge of aquifer feeding the future tubewells in the sailaba areas, so that the intensities of irrigation could be kept up.

(x) Last of all, the Thal Reservoir would provide us useful data and experience for planning our future recharge projects in the country. The working of the innumerable tubewells in the private sector and in the SCARP areas are lowering ground water table at a fast rate of 1 to 2 ft. per annum and we are already threatened with a fast approaching failure of our tubewell projects. The necessity of recharging the ground water reservoir has already been seriously felt and in the near future we shall have to plan recharge reservoirs similar to the Thal reservoir at numerous places along the various rivers for recharging the ground water reservoir in order to save our tubewell projects from extinction. This is by far the most important advantage of the Thal reservoir.

New Dimensions in Satellite Hydrology*

Water Budget Concept Atmospheric Components

An important element of the water budget is the amount, location and movement of water in the atmosphere. Through the mechanisms of evapotranspiration, condensation and precipitation, vast amounts of water are transported over large distances. Satellites with a synoptic and repetitive view over large areas have always permitted the observation of clouds and, at least indirectly, other forms of atmospheric moisture. Studies using early Tiros satellite data showed that atmospheric humidity could be usefully estimated, particularly over remote regions where conventional measurements are very sparse (e.g. McClain, 1966 ; Raschke and Bandeen, 1967 ; Fritz and Rao, 1967 ; Smigielski and Mace, 1970). The distribution of atmospheric water vapour has been delineated (Nordberg et al., 1966 ; Smith and Howell, 1971 ; Hanel and Conrath, 1970) by monitoring upwelling radiation in the 6.3 μ_m absorption regions through Nimbus satellites. These observations have been related to dynamic features in the atmosphere by Beran et al. (1968), Martin and Salomonson (1970) and Rodgers et al. (1973). A review of atttempts to estimate the distribution and depth of precipitation from satellites is given by Martin and Scherer (1973).

The improved spatial resolution on the NOAA 2 VHRR permits much more detail to be observed in the configuration of convective cloud tops. This improvement may be useful in delineating the extent and intensity of rainfall. The microwave spectrometer (NEMS) and the electrically scanning microwave radiometer (ESMR) on Nimbus 5 apparently allow improved satellite estimates of precipitable water and precipitation, particularly in cloudy regions (Wilheit, 1973; N.C. Grody, personal communication, 1972). Over-all, however, much remains to be done before satellite measurements of horizontal and vertical liquid and water vapour fluxes are sufficiently accurate to be used in studies of the atmospheric water balance.

Flood Detection

The accumulation of excess amounts of water in the land surface and near-subsurface will in some cases result in flooding. Because of the ability of the ERTS 1 near infra-red channels to detect surface soil moisture changes, the satellite can be used to distinguish areas that are accumulating water, nearing saturation

*A Rango "New dimensions in Satellite Hydrology" Water Resources Journal, September, 1974, Economic and Social Commission for Asia and the Pacific (ESCAP).

Explanations : ERTS Earth Resources Technology Satellite
NOAA National Oceanic and Atmospheric Administration.
VHRR Very High Resolution Radiometer.

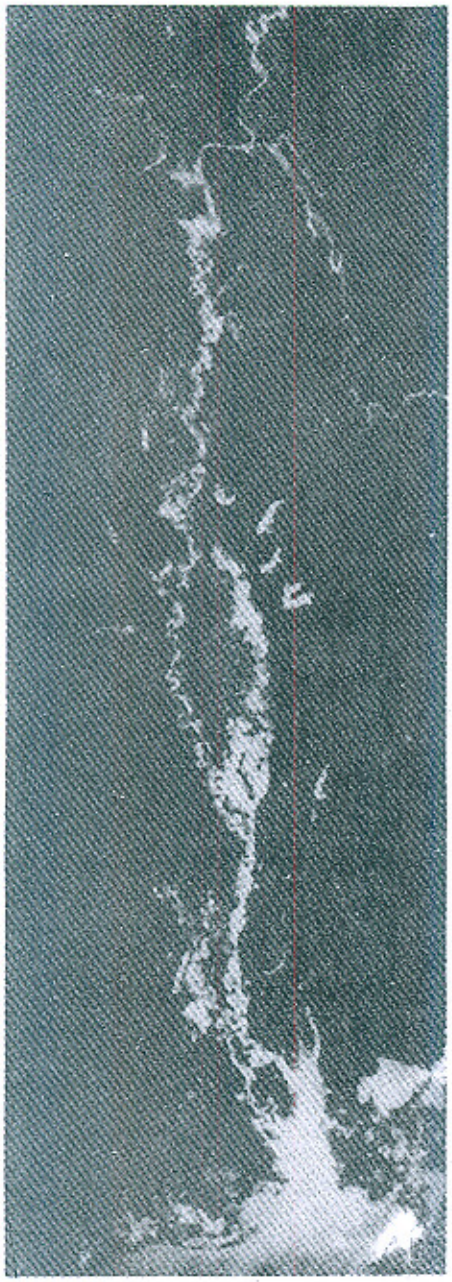


Fig. 5. Mississippi in flood from southern Illinois to the gulf of Mexico, enhanced by sun glint portion of NOAA 2 VHRR visible image orbit 2516, 1554 GMT May 4, 1973

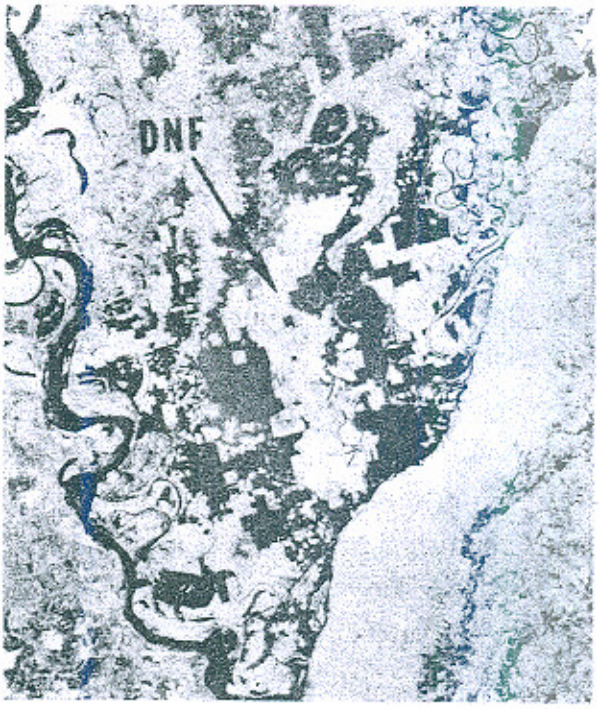


Fig. 6. Backwater flooding in the Delta National Forest (DNF) area as observed by Erts 1 (0.8 - 1.1 μm) on May 5, 1973.

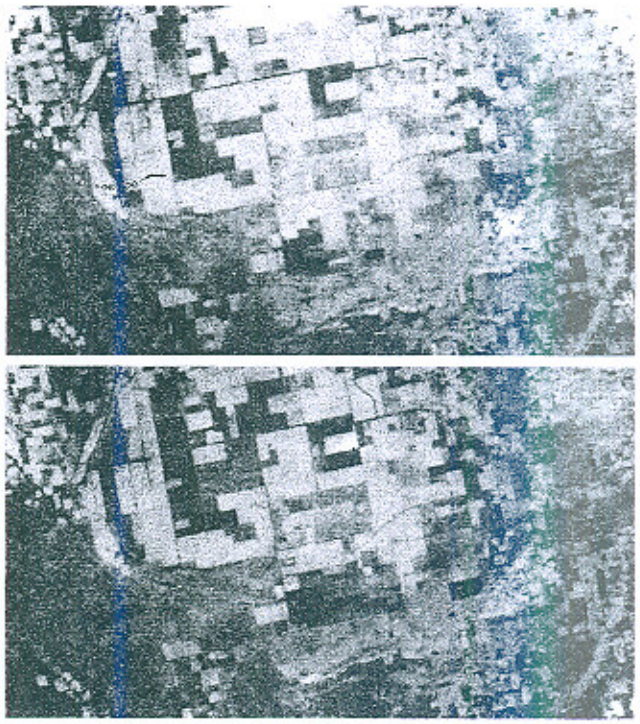


Fig. 7 Changing irrigation patterns in the Tulare lake bed near Bakersfield, California, as imaged by Erts 1 (0.8 - 1.1 μm) (top) on August 11, 1972 and (bottom) on August 29, 1972

and producing potentially dangerous flood situations. The 18-day repeat period associated with Erts 1 is a great drawback in such situations ; weekly coverage, although still not optimal, would be significantly more useful, Noaa 2 observation frequency is excellent, but it does not possess the desirable near infra-red (0.7-1.1 μ_m) sensors.

Both Noaa 2 and Erts 1 can be used during and after flooding to survey the extent of flooding effects. Figure 5 is an unusual picture taken by Noaa 2 showing the extent of flooding in the entire Mississippi Valley below Cairo, Illinois, on 4 May 1973, enhanced by sun glint. Severe flooding, in which Cairo was inundated, is readily apparent at the junction of the Mississippi and Ohio rivers. The series of filled reservoirs east of the Yazoo River in northern Mississippi are accentuated by the sun glint. The mouth of the Mississippi River has been saturated (overexposed) by the glint, obscuring the true extent of the flooding. A region of particular interest is the area of extensive flooding lying between and just north of the confluence of the Mississippi and Yazoo Rivers. The dark north-south band within this flooded region is the Delta National Forest. The simultaneous thermal image (not shown) shows the area between the rivers to be almost isothermal. A possible explanation is that the bases of the hardwood trees are flooded, but the foliage remains above the water.

The area shown in the Erts 1 high-resolution image (figure 6) taken the following day (5 May 1973) is just a small portion of the NOAA 2 scene, centred over the delta region of northwest Mississippi, that was inundated by backwater from the Yazoo and Big Sunflower rivers. The highly reflective area labelled DNF in the Erts 1 image is the Delta National Forest. Closer inspection of the image reveals that, wherever a forest clearing exists, water is visible ; this image confirms the Noaa 2 hypothesis that the entire forest has been inundated with only the crowns of the trees standing above water. The advantage of Erts 1 in flood assessment lies in its high resolution and resultant ability to cartographically delineate the specific areas inundated. In addition, it has been shown that Erts 1 near infra-red observations as late as two weeks after flooding will still show the areas that had been flooded as regions of low reflectivity (Hallberg et al., 1973 : Morrison and Cooly, 1973).

Subsurface Water

Soil moisture measurement is one of the more difficult problems in solving water balance equations for river basins. The development of techniques for assessing soil moisture from satellite observations would provide a real breakthrough in hydrology. The Erts 1 multispectral approach, in theory, should enable at least semi-quantitative estimates of soil moisture based on the differential spectral response of wet and dry soils ; this response is more pronounced toward the near infra-red Erts 1 bands. Soil mapping by Erts 1 has been effective in certain areas, generally where vegetation is sparse.

Variations in reflectivity of these areas appear to be related to moisture in the near-surface soil. Figure 7 shows portions of two Erts 0.8-1.1μ_m scenes over the Tulare lake bed irrigated area between Bakersfield and Fresno, California. Those fields under irrigation or recently irrigated are easily distinguished. In particular, note the large field in the lower centre of the right image. This field was under irrigation at the time when the satellite passed over, and the wetted area in the northeast half of the field sharply contrasts with the drier southwestern half of the field.

NOAA 2's VHRR, which senses in the thermal infra-red, can also be utilized for detection of soil moisture variations where the moisture content is inversely proportional to the temperature. The effect of vegetation is largely an unknown factor that must be evaluated by further research efforts. The NOAA 2 thermal data may also provide a possible means of detecting groundwater discharge into lakes, reservoirs and large rivers. Care must be exercised so that thermal anomalies caused by upwelling in response to surface wind stress are not mistaken for groundwater inflow. Such upwelling has been routinely observed on imagery of the Great Lakes by personnel of the NOAA National Environmental Satellite Service.

In December 1972, NASA launched the Nimbus 5 satellite carrying on board the electrically-scanning microwave radiometer (ESMR). The capabilities of this experimental instrument, when combined with those of Erts 1 and NOAA 2, provide for relatively complete monitoring of the hydrologic cycle in various portions of the electromagnetic spectrum. This passive microwave instrument, sensing at the 1.55-cm wavelength, provides a capability for detection of hydrologic features at and just below the soil surface because of the penetrating properties of microwave radiation. In an initial study using early Nimbus 5 ESMR data, the microwave brightness temperature fluctuations were compared with a number of known hydrologic parameters. The correlations were best with precipitation indicating that the ESMR monitors soil moisture changes in a layer just beneath the surface. Such observations may provide an index of the susceptibility of a particular area to flooding.

General Section

News and Notes

Tarbela-Lyallpur Transmission Line, inaugurated on 29th May, 1975 by Mr. Khattak

Work on the construction of 206-mile long 500 KV Transmission line from Tarbela to Lyallpur was started on 29th May, 1975 after formal inauguration. In this connection, Wapda has awarded two contracts amounting to a total of Rs. 13.11 crore to two Pakistani power construction firms, to construct the high voltage transmission lines from Tarbela to Khushab (Northern section) covering a distance of 114 miles and from Khushab to Lyallpur (Southern section) covering a distance of 92 miles. The construction work on both the sections will start simultaneously and completed within a period of 2 years.

The Tarbela-Lyallpur 500 KV single circuit transmission line, the first high voltage line of its kind in Pakistan, is being built with financial assistance from the Canadian International Development Agency (CIDA) to carry Tarbela power from Northern to the Southern Region. Canada will supply all the material for transmission towers, which will be assembled locally, and also the conductors, hardware and insulators.

The long distances involved, difficult topography and presence of a chain of rivers here dictated the development of 500 KV transmission system in preference to the existing 220 KV, 132 KV and 66 KV lines. Pakistan will thus be the first country in Asia and fifth in the world to have this extra high voltage Power transmision system. At present only the USA, USSR, Canada and Egypt have 500 KV lines. This project is being implemented by the Extra High Voltage (EHV) Design and Construction Department of Wapda, which had carried out its studies, conceptual design, preparation of specifications, detailed designing, preparation of schedules and construction of the transmission system. Messrs EHV Consultants of Canada with their Pakistani counterparts are providing consultancy and engineering supervision on this project which is being-constructed by hundred percent Pakistani engineers, technicians and technical know-how. Canada has provided an interest free loan of forty-one million dollars for this project.

Tarbela Irrigation Tunnel-85% Construction Work Completed

85% percent work on the construction of 5th Tunnel, called Left Bank Irrigation Tunnel at Tarbela Dam Project has been completed, Mr. M. I. Chishti, Chief Resident Engineer of Wapda Consultants, Messrs NESPAK, stated in an interview at Lahore on June 17, 1975.

Being constructed by Wapda contractors, Messrs Pakistan Tarbela Consortium (P.T.C.), under the supervision of NESPAK, this tunnel is expected to be completed on schedule by the end of May next year at a cost of Rs. 60 crores.

Work on the construction of this tunnel was taken in hand in July 1973.

On completion, this tunnel will ensure irrigation supplies during early kharif season when Tarbela reservoir is at low level. The four tunnels at the right bank would not be able to meet the demand of farmers in the Punjab and Sind during this period.

Mr Chishti particularly mentioned that the design and supervision of this 36-foot diameter tunnel was being carried out entirely by the Pakistani crew. About 1600 Pakistani personnel including engineers, engineering geologists, technicians and workmen are busy round-the-clock to complete this tunnel on time, he added.

Mr Chishti pointed out that in the design of 5th Left Bank Irrigation Tunnel, certain improvements have been carried out by the Wapda Consultants, Messrs NESPAK, on the basis of experience gained from the defects which had occured in the right bank tunnels.

Bara Canal opened
50,000 acres to be irrigated

The Rs. 5.23 crore Bara River Canals Scheme in the Khyber Agency was formally opened on April 28, by the NWFP Governor, Maj-Gen. (retired) Sayad Ghawas.

The Scheme will help irrigate about 50,000 acres of barren land including 38,000 acres in the Tribal areas and remaining 12,000 acres in Peshawar district. The land hitherto had no other source of water supply. About 280 cusecs of water has been diverted through a 9,000 feet long tunnel dug through the hills on the left bank of Bara River. The irrigation will be done through the right and left bank canals.

The scheme, it may be added, is one of the few big irrigation projects in the country which was conceived, planned and executed entirely by the engineers of the Frontier Province and at very competitive rates.

Speaking on the occasion, the Governor said that the completion of the project was a big step forward towards the economic uplift of the tribesmen.

In the presence of a large number of tribal Maliks, elders and other tribesmen, as the Governor pushed an electric button, lifting the steel gate, water gushed out from the river and entered the canal.

Later, addressing a representative tribal Jirga participated by tribal elders, Maliks and tribesmen from Khyber, Mohmand, Kurram and other Agencies, held to mark the occasion, the Governor said that the promotion of economic well being of the tribesmen had always occupied and would continue to occupy a prominent place in the development policies of the present Government. The massive development programme initiated by the Government vindicated its policy, he declared.

The Governor revealed that a total of 310 development schemes in all sectors was at present at various stages of implementation to usher in an era of progress and prosperity in the tribal belt. These schemes envisage construction of roads, opening and construction of educational and health institutions, provision of irrigation and drinking water facilities,

development of minerals and agriculture and setting up of industrial units.

He expressed confidence that with the rapid implementation of these schemes, the tribal areas would not only be at par with the developed regions very soon, but would also serve as a model of development for the rest of the country.

He, however, underlined the need of deriving full advantages of the development by the tribesmen making good use of the educational, health and other facilities being extended to their areas. He observed that peaceful settlement of mutual disputes amongst various tribes was a pre-requisite to reaping full benefits.

Inland Waterways Plan Under Study

Two feasibility studies are underway to examine the possibility of opening inland waterway routes for the first time in Pakistan, to supplement the transport facilities.

A feasibility study being carried out by the Planning Division is in respect of a navigation route between Port Qasim and Sukkur, and the other feasibility study sponsored by the Federal Communication Division is for surveying the Indus river from Tarbela to Sukkur for navigation purposes.

This was disclosed by the Federal Communications Minister, Mr. Mumtaz Ali Bhutto, in a prepared speech delivered by the Sind Education Minister, Mr. Pyar Ali Allana, at the opening of a two-day Transport Advisory Council meeting here this morning. The Communications Minister was stated to be indisposed.

"Besides being the cheapest means of transportation, this offers a possibility of carrying over-sized consignments with ease and safety," he said.

The Minister said that future planning about the development of inland waterways would be based on the results of these two studies.

Referring to the development of the road network in the country, Mr. Mumtaz Bhutto disclosed that negotiations were under way for a loan from the World Bank to improve 865 miles of the country's major highways, where the density of traffic was beyond the scope of the existing facilities.

In the Railway sector, he informed the meeting, considerable progress was being made to fully cater for long-distance movement of goods.

Tube Railway for Karachi

Karachi will have an efficient and rapid public transportation system including tube railway, wherever necessary.

Disclosing this at the opening session of a two-day Transport Advisory Council meeting, the Federal Communication Minister, Mr. Mumtaz Ali Bhutto, said that some progress in this connection had been made.

In his prepared speech, delivered by Sind Education Minister, Pyar Ali Allana, he told the meeting that a Japanese experts' team visited Karachi in December last to help plan a rapid transport system. Preliminary report of this team would be made available by June this year, he said.

A Great Loss

MIAN IFTIKHAR-UD-DIN, a distinguished member of the Pakistan Engineering Congress died in Lahore on May 17, 1975, after a prolonged heart ailment. May Allah grant peace to his soul. Originally from the Building and Roads Department, his experience extended to planning, design and construction, and also to teaching and management. He served as a lecturer, head of department and acting Vice Principal of the Government School of Engineering, Rasul.

He was a good orator and prolific writer. His paper on "Streamlining of Public Services for the task of National objectives" presented at the Annual session of Engineering Congress in 1972 brought him a gold medal award from the President of Pakistan. He served the engineering profession relentlessly, even at the expense of his health. He had specially worked on the Engineer's role in the administrative structure of the country. His contributions in the cause of emancipation of the engineering profession will always be remembered. His honorary commitments variously included general secretaryship of the Pakistan Engineering Congress and the Punjab Gazetted Engineers' Association. Professionally, he was engaged as Manager, Training, NESPAK. The Pakistan Engineering Congress passed a condolence resolution for the bereaved family at their mid-term session held in Lahore on 26th May, 1975. The delegates also offered 'Fateha' for the departed soul.

During the period, Nature took away another outstanding Engineer in MR. GHULAM AHMAD, General Manager, Mechanised Construction of Pakistan. May Allah grant peace to the departed soul and fortitude to the bereaved family.

Introducing Pakistani Consulting Engineers

2. Engineering & Technical Consultants (ETC)

History and Background

Engineering and Technical Consultants (E.T.C) Lahore, were established in year 1973 under the chairmanship of Mian Masud Ahmad, a retired professional engineer with over 40 years experience in various engineering projects. Before his retirement from Government service in 1969 he served as Chief Engineer Development and Coordination and Incharge of Design and Planning Cell, WAPDA, Head of WAPDA's Task Force (M.P.O.T.P. Link), Chief Engineer Purchase and Inspection WAPDA and Deputy Chief Engineer Irrigation and Power Department, Government of the Punjab, West Pakistan. In 1973 he invited several experienced fellow engineers to pool their knowledge and resources and established consultancy services.

Range of Services

E.T.C. enjoy the services of qualified and experienced technical personnel to handle any engineering problem and offer services for field surveys and investigations ; collection, processing and evaluation of data ; preparation of project planning reports, project preparation, detailed design of works, preparation of contract documents, construction drawings and all related works for the successful completion of engineering works and projects.

Specialized services provided by the firm include :

1. **Irrigation**
   - Hydraulic Structures.
   - Gravity Flow Irrigation.
   - Lift Irrigation.
   - Basin Irrigation.
   - Flood Control and Flood Protection.
   - Training of Rivers and Streams.
   - Land Reclamation, Drainage and Tubewells.
   - Storage and Hydro-electric Schemes.
   - Remodelling of Existing Irrigation Channels.
2. **Highways**
   - Precise Surveying and Mapping.
   - Soil and Material Exploration and Testing.
   - Design of Pavements and Structures.
3. **Factories**
   - Architectural and Structural Design.
4. **Architectural and Related Fields**
   - Buildings.
   - Landscape Architecture.
   - Urban Development.
   - City Planning.
5. **Educational Institutions**
   - Master Planning.
   - Architectural, Structural and Services Design.
   - Laboratory Layouts.
   - Auditoriums.
   - Students Hostels and Services.
   - Sports Facilities.

6. **Water Supply and Sewerage**

- Municipal and Industrial Water Supply.
- Sewerage Planning and Design.

7. **Hospitals**

- Architectural and Structural Design.

8. **Sports Complex**

- Planning, Design and Layout.

9. **Townships**

- Planning, Design and Layout.

However, services are also rendered for :

(i) Construction supervision of large engineering works, writing of completion reports and catering for other aspects of construction management.

(ii) Inspection of engineering works, materials, plants and machinery.

(iii) Afforestation for raising shelter-belts.

(iv) Soil conservation and prevention of land erosion.

(v) Geological, geohydrological and geomorphological investigations and mapping.

(vi) Planning of livestock farms and agrovillas.

Current Assignments with the Firm

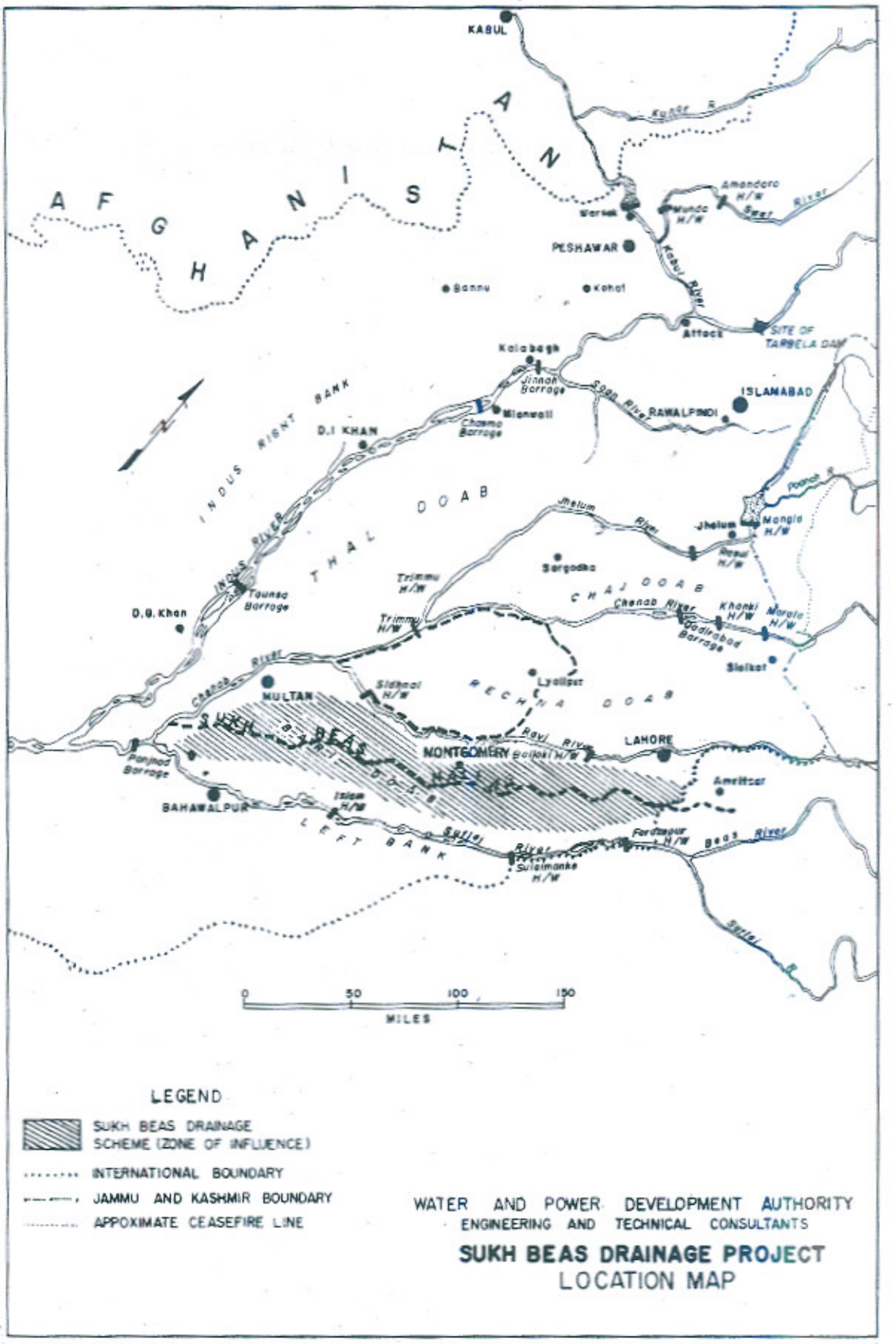
In a short period of existence, the Engineering and Technical Consultants have been able to achieve a respectable position in the realm of Consultancy Service. Projects mentioned below will give a brief account of their current commitments.

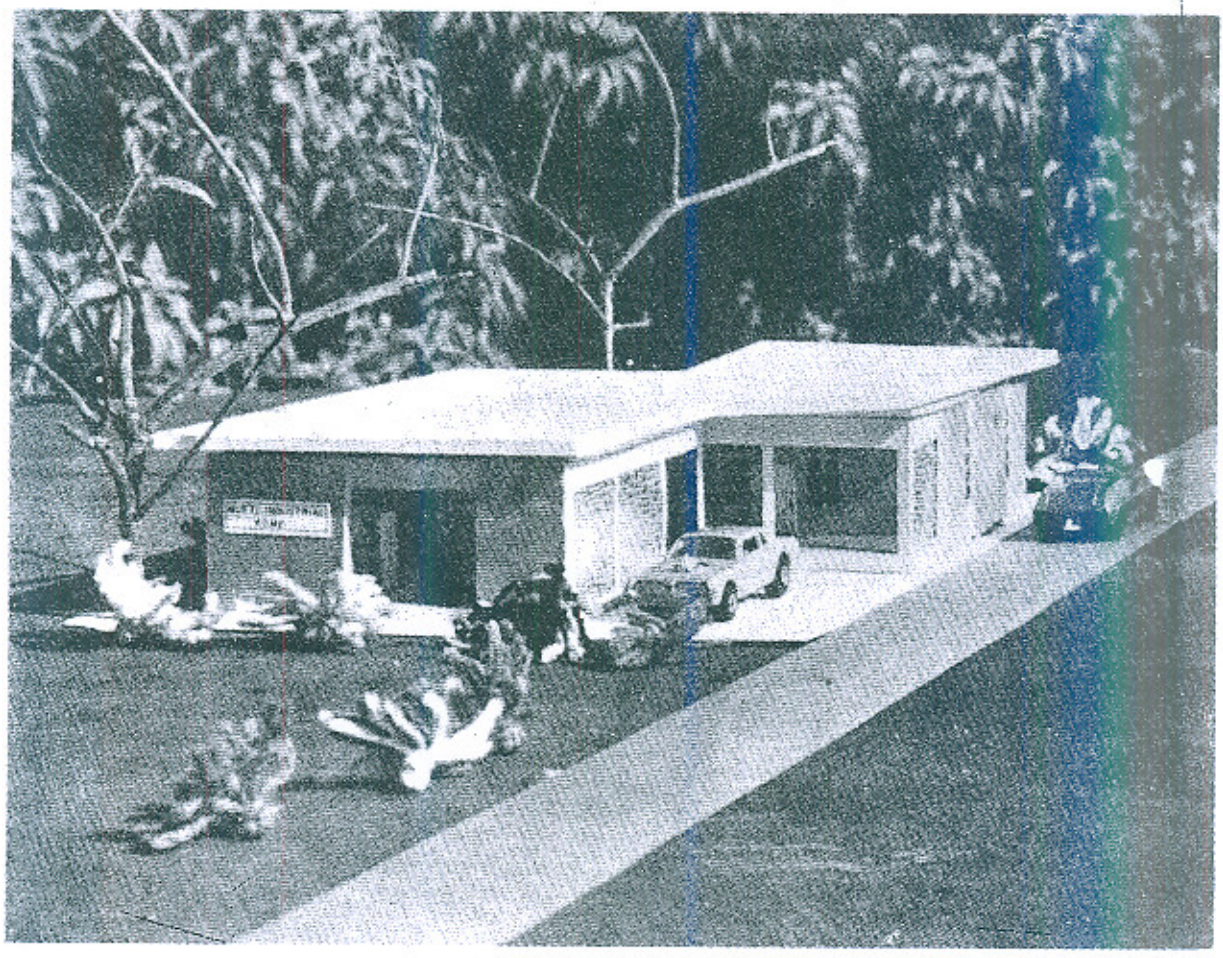
1. **Thal Reservoir Project - For WAPDA**

The project, to be located in the central Thal Doab on the western bank of Jhelum river and south of Chasma-Jhelum Link Canal, envisages the preparation of feasibility report of the proposed project with an estimated open-surface storage capacity of over 1.5 million acre feet to conserve the surplus flood waters of Indus river. The assignment entrusted to the firm by the WAPDA involves reconnaissance, topographic, contour, resistivity, geodetic and other related surveys, including geological and soil investigations in an extensive area of 300-400 square miles. It also includes preparation of feasibility designs, specifications, bill of quantities and cost estimate. Eventually, the aim is to prepare the feasibility or project planning report in a period of 30 months. The project, if implemented, is estimated to cost about two hundred crores of rupees.

2. **Sukh Beas Drainage Project - For WAPDA**

This is another project for which the firm has been appointed as consulting engineers by the WAPDA. The project shall embrace the canalization of the old meandering bed of Sukh Beas river, traversing the extensive tracts of developed land in Lahore, Sahiwal and Multan districts for a length of about 500 miles, to a properly planned and designed drainage system with tributary and spine drains and their appurtenant structures. This project, on implementation, will provide drainage relief to over 3 million acres of land against surface runoff and is


KABUL
AFGHANISTAN
Kunar R.
Warsak
Amandara H/W
Munda H/W
Swat River
PESHAWAR
Bannu
Kohat
Kabul River
Attock
SITE OF TARBELA DAM
Kalabagh
Jinnah Barrage
Soan River
ISLAMABAD
RAWALPINDI
Mianwali
Chasma Barrage
D.I KHAN
INDUS RIGHT BANK
THAL DOAB
Jhelum River
Jhelum
Mangla H/W
Rasul H/W
Sargodha
Trimmu H/W
Taunsa Barrage
D.G. Khan
CHAJ DOAB
Chenab River
Khanki H/W
Marala H/W
Qadirabad Barrage
Sialkot
Lyallpur
Sidhnai H/W
MULTAN
RECHNA DOAB
Ravi River
LAHORE
MONTGOMERY
Balloki H/W
Panjnad Barrage
BAHAWALPUR
Islam H/W
Amritsar
LEFT BANK
Sutlej River
Suleimanke H/W
Ferozepur H/W
Beas River
0 50 100 150
MILES
LEGEND
SUKH BEAS DRAINAGE SCHEME (ZONE OF INFLUENCE)
INTERNATIONAL BOUNDARY
JAMMU AND KASHMIR BOUNDARY
APPOXIMATE CEASEFIRE LINE
WATER AND POWER DEVELOPMENT AUTHORITY
ENGINEERING AND TECHNICAL CONSULTANTS
SUKH BEAS DRAINAGE PROJECT
LOCATION MAP



A view of Widow Home and Industrial Workshop, Lahore

anticipated to cost about 60 crores of rupees.

3. **Roads in Indus Kohistan - for Kohistan Development Authority**

E.T.C. have been appointed as consultants to the Kohistan Development Authority for survey and mapping of roads. The assignment includes marking of alignment, carrying out preliminary and detailed surveys and geometric designs for the roads to be constructed in the hilly areas of Swat and Hazara districts which were rocked and devastated during an unprecedented earthquake in 1974.

4. **OSSEIN Plant at Kala Shah Kaku - For P. Leiner & Sons, Chemicals & Feeds (Pakistan) Limited**

The firm is also engaged by M/S. P. Leiner and Sons Treforest, Glamorgan, U.K. on the planning, designing and construction supervision of a big Ossein factory to be constructed near Kala Shah Kaku. The overall planning includes factory buildings, administration blocks, tubewell, overhead reservoir, residential buildings and other appurtenant works.

5. **SOS Children Village - For SOS Villages International, Vienna, Austria**

E.T.C. are working as consulting engineers to SOS Villages International and their scope of services includes planning, designing, preparation of tender documents and construction supervision of an SOS town near Lahore consisting of dwelling houses, hospital, community centre, school and other support facilities.

6. **Commercial Centre, Jail Road, Lahore**

The firm is also working on the planning, designing and ultimately construction supervision of a commercial centre proposed to be constructed on Jail Road, Lahore. It shall involve construction of show rooms and offices with an approximate cost estimate of Rs. 50 lacs.

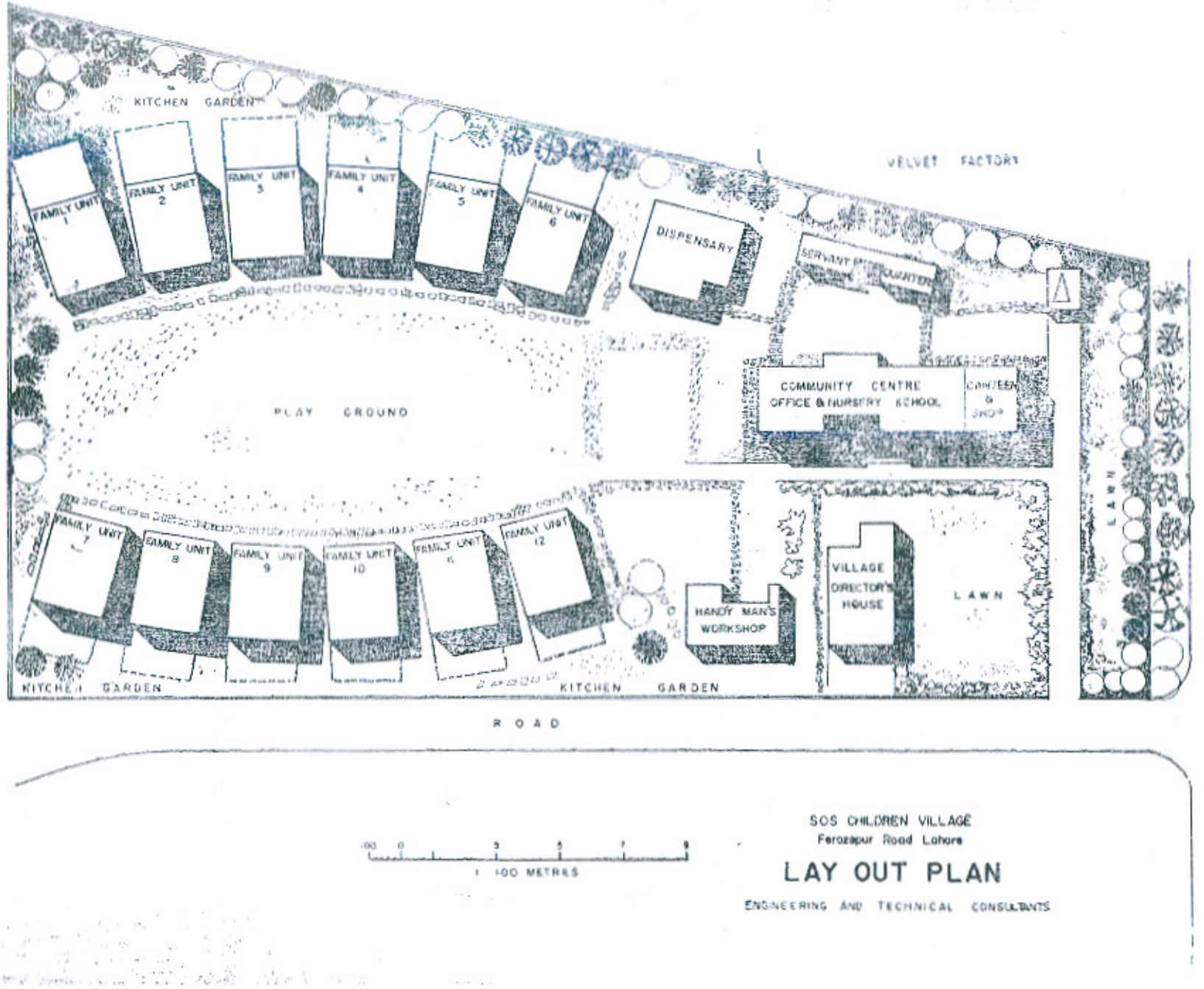
7. **A Food Complex (Sherrys) Lahore**

ETC have been appointed as consulting engineers for a restaurant combined with a motel. The scope of services includes planning, design, construction supervision, interior decoration, furniture designing and central air-conditioning. The complex shall include Chinese cousine ; barbeque ; snack bar ; ice cream parlour and a dance floor.

Approximate cost of the project shall be Rs. 20 lacs.

8. **Indus Super Highway Tunnel near Kohat - For I.S.H. Board**

The Indus Super Highway Board invited E.T.C. alongwith some other firms to submit proposal for the design of a tunnel near Kohat on the proposed Indus Super Highway. The firm has submitted a detailed proposal containing discussion on site investigations, field surveys, design considerations for the tunnel, methodology of work, estimates of the job to be done together with remuneration to be paid to the Engineer.



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1 100 METRES

SOS CHILDREN VILLAGE

Ferozepur Road Lahore

LAY OUT PLAN

ENGINEERING AND TECHNICAL CONSULTANTS

Organization

The firm is managed by four partners who are all experienced engineers and have planned, designed and afforded construction supervision of many well known projects some of which are delineated against each.

1. **Mian Masud Ahmad**
   Chairman and Chief Dams and Barrages
   C.E. (Roorkee) India
   F.I.E. (Pak.), M.E.C. (Pak)
   (i) The Lahore Wapda House.
   (ii) The 10-Lac cusecs capacity Taunsa Barrage on Indus river.
   (iii) The 10-Lac cusecs capacity Guddu Barrage on Indus river.
   (iv) The Tanda Dam. of N.W.F.P.
   (v) The Gujranwala Hydel Power Station.
   (vi) The 10,000 - cusec capacity lined Bhakra-Nangal Canal with scores of cross-drainage works (India).

2. **Mian Bashir Ahmad**
   Vice Chairman and Chief Contract Management B.Sc. Engg (Civil) Punjab A.S.T.E.F. (France), M.I.E (Pak.), M.E.C. (Pak.)
   (i) The 32,000 - cusec capacity river sized Sidhnai Spill Channel.
   (ii) Remodelling works for Depalpur canal from 8000 - cusec capacity to 2000 - cusec capacity.
   (iii) Flood Control Plan for Ravi and Chenab Rivers.
   (iv) Construction of Structures on Jaranwala Main Drain.
   (v) River Training Works in Sind-Sagar Doab on Indus river.

3. **S. Nazar Hussain Mashhadi**
   Partner and Chief of Designs,
   B.Sc. Engg. (Mech.) Punjab, B.Sc. Engg. (Civil) Punjab, F.I.E. (Pak.), M.E.C. (Pak.)
   (i) Design, Construction and Maintenance of the12,000-cusec capacity and 38-mile long Taunsa-Panjnad Link Canal with 28 structures, the only project designed and constructed under the I. B. P. solely by Pakistani engineers.
   (ii) Designs for the Radical Remodelling of Depalpur Canal from a large channel of 8000-cusec capacity to a small channel of 2000-cusec capacity alongwith its structures.
   (iii) Schemes for Remodelling of L.B.D.C., Mailsi and Fordwah canals.
   (iv) Review of I.B.P. works comprising Q.B. Link, T.S. Link, R.Q. Link and Sidhnai Barrage.

4. **Ch. Niaz Ahmad Enver**
   Partner and Chief Protocol and Public Relations.
   (i) Nandipur Hydel Station, Spillway, other allied works and residential colony.
   (ii) Construction and repair of the lined Haveli Canal.
   (iii) Remodelling and repair of numerous irrigation works.
   (iv) Compilation and Preparation of the Revised Schedule of Rates for Wapda.

Perspective view of the Proposed Commercial Building at Jail Road, Lahore

KEY PERSONNEL

1. **Mian Barkat Ali Luna,**
   Chief Water Resources & Hydel Projects
   B.Sc. Engg. (Civil) Punjab, C.T.H.D (Canada), C.T.L.D. (Holland), M.E.C. (Pak).

2. **Mr. Kushhal Khan,**
   Assistant Chief Water Resources
   B.Sc. Engg. (Civil), M.E.C. (Pak).

3. **Mr. Mehtab Khan Usafzai,**
   Assistant Chief Dams & Soil Mechanics
   B.A. (Hons) Punjab, B.Sc. (C.E.) with ditinction, Aligarh (India).
   Diploma in Aeronautical Engg. with distinction Aligarh (India)
   Post-Graduate, Studies in University of Austin-Texas (U.S.A.)
   Specializations-Soil Mechanics, Earth Dams, Hydraulic Channels and Architecture.

4. **Mr. Maqsood Ahmad Malik,**
   Assistant Chief Hydraulic Structures
   B.Sc. Engg. (Civil) Punjab
   M.E.C. (Pak)

5. **Mr. R. R. Shariff,**
   Assistant Chief Materials and Meterology, B.Sc. Engg. (Civil) Aligarh (India),F.I.E. (Pak.), M.E.C. (Pak.)

6. **Ch. Sultan Ali,**
   Assistant Chief Field Surveys and Investigations, Diploma from Government School of Engineering, Rasul, Pakistan.

7. **Dr. Nazir Ahmad,**
   Hydrologist and Soil Scientist.
   M.Sc. (Physics) Aligarh (India)
   Ph.D. (Hydraulic Sc.) Punjab
   D.Sc. (Water Conservation Engg.) Punjab
   Fellow of Pak. Academy of Sciences
   Life Member of Pak. Ass. for Advancement of Science
   Member of Academic Council of Engg. Un. Punjab
   Member of Equivalence Committee, Engg. Un. Punjab
   Member Physics Board of Studies, Punjab University
   M.E.C. (Pak.)

8. **Kh. Aziz Ahmad,**
   Principal Engineer Field Surveys, Data Collection and Estimation.
   Diploma from Govt. School of Engg. Rasul, Punjab, M.E.C. (Pak.)

9. **Mr. M. Aman-ul-Haque Enver,**
   Principal Engineer Reports & Contract Management.
   B.Sc. Engg. (Civil) Punjab
   M.E.C. (Pak.)

10. **Ch. Ghulam Mohy-ud-din,**
    Principal Engineer Public Health Engg.
    B.A., B.Sc. Engg. (Civil) Punjab.
    Higher Training in Water Supply and Sanitary Engg. Barkley (U.S.A.)

11. **Mr. M. A. Bhutta,**
    Principal Engineer Highway Structures
    B.Sc. Engg. (Civil) Punjab
    M.I.E. (Pak), M.E.C. (Pak.)

12. **Mr. S. A. Khilji,**
    Principal Engineer Soils and Surface Hydrology.
    B.Sc. Engg. (Mechanical) Punjab
    M.I.E. (Pak). M.E.C. (Pak).

13. **Ch. Mohammad Riaz,**
    Principal Engineer Field Surveys and Construction
    B.Sc. Engg. (Civil) Punjab.

14. **Mr. Fayyaz Ahmad,**
    Principal Architect
    B. Arch (P.U.E.T.) Punjab
    APAEP., AIAP.

15. **Mr. Anis A. Abbasi,**
    Chief Geologist
    M. Sc. (Geology) Syracuse (U.S.A.)
    M.A. (Geography) Punjab
    Corressponding Member of Commission of Quaternary Stratigraphy of the International Association of Quaternary Research.

16. **Dr. Mohammad Afzal,**
    Chief Agronomist
    Ph. D. (Agronomy) Nebraska (USA)
    M.Sc. (Agriculture) Punjab
    Sigma XI-Gamma Sigma Delta
    Member Pak. Biological Society
    Member Pak Science Association
    Member Distt. Development Committee. Member/Secy. Distt. Agri. Advisory Committee.

17. **Mr. M. A. U. Sumbal,**
Chief Economist
M.Sc. (Forestry Economics) New York (USA)
M.Sc. (Agriculture Economics) Punjab.
LL.B. Punjab.
B.Sc. (Agriculture) Punjab.
Diploma in Forestry (A. P. F. C.) Abbottabad.
Member of Society of American Foresters

18. **Agha Ali Hassan,**
Revenue Officer
B.A., (Political Science) Punjab
Received training in Judiciary, Revenue, Settlement Relief Work and Publicity.

Contd. from page 38

Unit at any one time. When the University expands, all the three components i.e. academic building, students hostel and staff housing will expand correspondingly. The University is so designed as to have a core of the academic building with student hostel and the teaching staff colony placed on either side. Expansion, therefore, in one direction is possible. Each of the buildings put up is also expandable.

Segregation of Traffic

The Master Plan is designed to ensure the separation of the different traffic types. Roads and fast moving vehicles are kept up to a maximum and, within the roads, pedestrian walkways and pedestrian activities are encouraged. Maximum walking distance for any one activity has been calculated to be about 8 minutes of walk. Majority of the walking distances will be about 5 minutes of walk.

INDEX TO ADVERTISERS

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Special Feature

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 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 الْكَيْلَ وَالْمِيْزَانَ بِالْقِسْطِ وَلَا تَبْخَسُوا النَّاسَ اَشْيَاۗءَهُمْ وَلَا تَعْثَوْا فِي 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 incit you not to act equitably. Be just ; that i nearer to observance of duty". v :

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

۴۔ اَوْفُوْا بِالْعُقُوْدِ ۭ ○

"Fulfil the obligations". v :

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

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

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

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

٦- وَقُولُوا قَوْلًا سَدِيدًا ۝

"And speak straight words." xxxiii : 70

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

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

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

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

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

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

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

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

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

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

١٠- وَأَمْرُهُمْ شُورَىٰ بَيْنَهُمْ ۖ

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

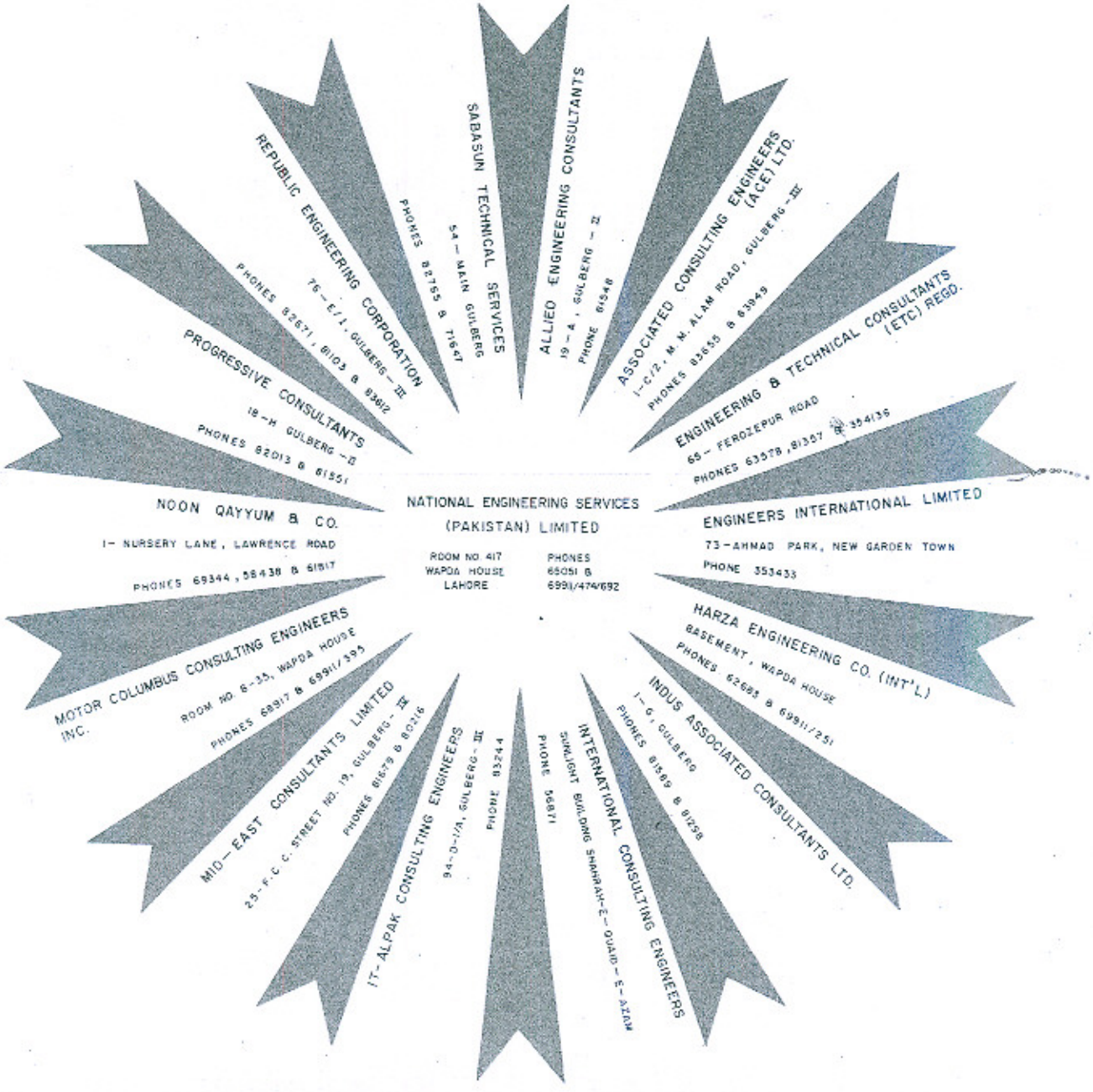
10. You shall decide matters of common professional interest by mutual consultation

١١- وَاعْتَصِمُوا بِحَبْلِ اللَّهِ جَمِيعًا وَلَا تَفَرَّقُوا ۚ

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

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

CONSULTING ENGINEERS IN LAHORE



NOTES :-

1. Consulting Engineers not listed above are requested to send their particulars to the Chief Editor "Engineering News" for publication in the next issue of the Magazine.
2. Any change in the name, address or telephone number of any firm may also be promptly notified for carrying out a correction in the next issue.