VERTICAL SHAFT GENERATORS

*BY AKHTAR HUSSAIN

VERTICAL shaft generators are heavy pieces of equipment. A cross-sectional view of such a machine manufactured by the Canadian General Electric Company is shown in figures. The machine is composed of so many individual parts that they look like links of a chain. Each part has its own function and needs individual attention in the design office and also during manufacturing process in the workshops. It is after years of research work and experience that company has been able to produce such a machine in its present shape.

Such generators are invariably driven by Francis or Propeller-type turbines.

In an earlier issue of the Engineering News an effort has been made to give the details of construction and some design features of such a machine. All the important parts will be discussed one by one. These details relate to a conventional machine only.

ROTOR :—The rotor spiders are either forged and keyed to the shaft or are fabricated of steel plates and bolted to the shaft. The forged spiders are used where the inside diameter of the rim is smaller as compared to the shaft or the normal speed is higher. Stiffness and ventilation are the special features which are taken into consideration in its designing.

The purpose of the rotor rim is to hold the poles, provide the magnetic path and also to provide the WR^2 for the machine. It is usually designed to provide ventilation for the field and the stator.

In the rotor rim the maximum stresses are kept below two-thirds of the yield point when operating at a full runaway speed. The rim as a rule is composed of punchings made out of mild steel sheet one-quarter of an inch thick.

The rotor rim is held together by means of accurately ground studs driven hard into the holes of the rim, thereby ensuring that the rim will be held tightly together even if the friction between the rim segments should be inadequate. The rim is attached to the rotor by means of driving tapered keys inserted in slots in the inside of the rim and the ends of the rotor arm.

ASSEMBLING OF ROTOR

The spider, rim, poles and connections are all weighed before they are assembled together. Assembling is done in such a way that the rotor is automatically balanced.

The rim is generally heated before the keys are driven in the spider arms. The idea is to produce a preload in the spider and rim parts which will not be entirely cancelled out by centrifugal stress encountered at substantially higher than rated speed.

FIELD POLES: The laminations for pole pieces are made out of $\frac{1}{16}$th mild steel sheet having suitable magnetic properties alongwith sufficient strength to withstand mechanical stress. The laminations are riveted or bolted between end plates and have a fairly good oxide coat to serve as insulation between them. The poles are fastened to the rotor spider by means of dovetails held in the rotor rim slot by tapered keys. These keys are left *extended* so that they can be easily removed with a key puller. Thus we can replace a damaged stator coil without dismantling the generator.

*Assistant Director (Power Control).

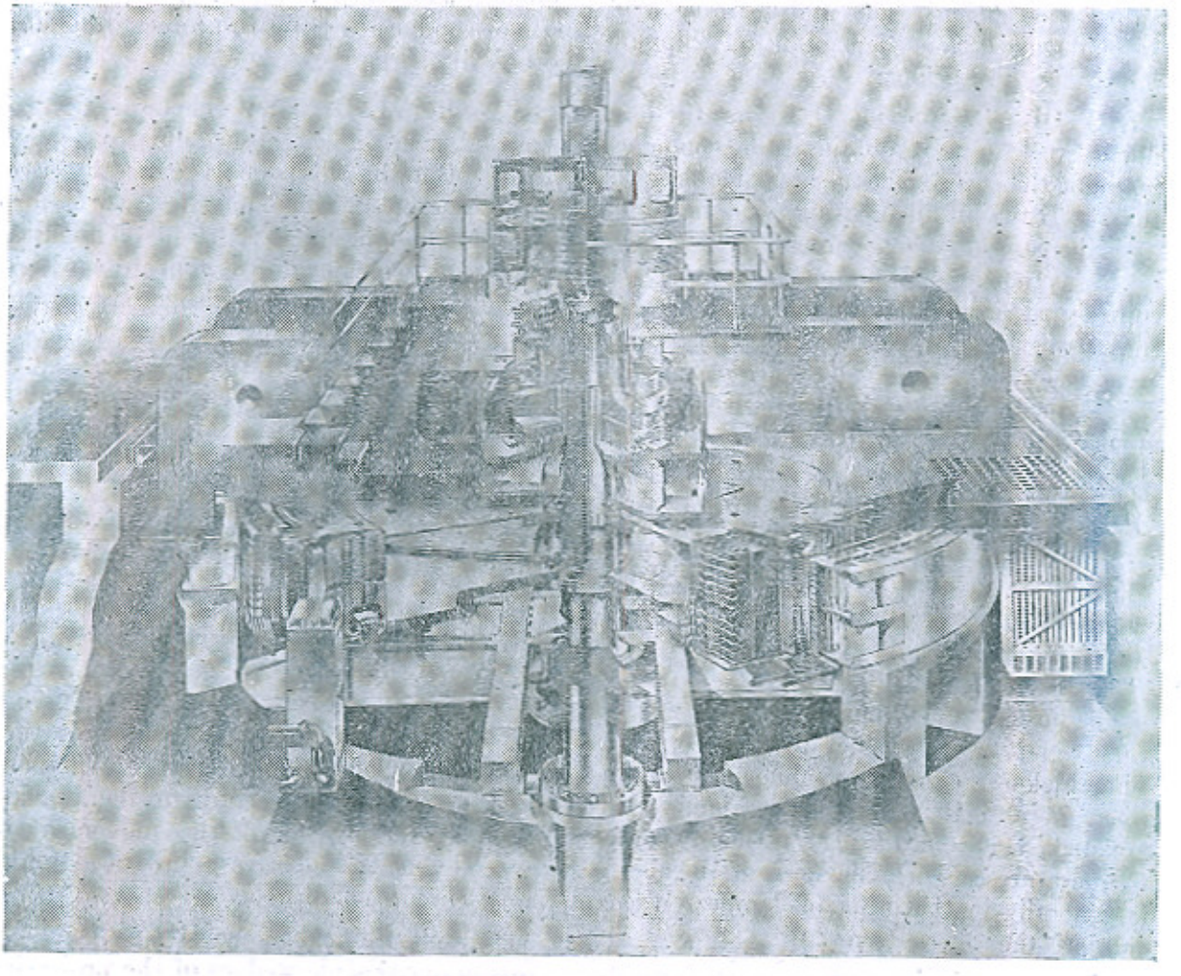
A non-continuous amortisseur winding is provided on the pole faces, which is composed of hard drawn copper bars *shorted* at the end by copper end plates.

FIELD COILS : There are two types of coils wire wound and strip wound. The wire wound coils are cheaper and are used on the smaller machines. In larger ones the size of the wire becomes too big and difficult to handle. However, to save expense either the coils are wound in two circuits or a higher voltage is adopted. The designers generally prefer strip wound coils.

The strip wound coils make a more compact field with better heat dissipation qualities. The conductor has to be of a reasonable physical size. The coils are essentially of bare copper. They are insulated between turns with asbestos insulation. They are insulated on the pole body by means of mica moulded onto the poles. They are insulated on the pole tips and the rotor body by Permali pole collars.

The coils are inter connected at the top ends. This makes the dismantling easier in case it becomes necessary to remove the poles in order to replace a damaged stator coil.

ROTOR SHAFT : The shaft is made of one-peace forged steel. It has two flanges for mounting the rotor spider and a half coupling. The shaft is designed for torsional



Vertical Shaft Generator.

stresses in the order of 5,000 to 6,000 pounds per square inch. The forged steel used for this purpose has the following strength and composition:—

Tensile strength, minimum.	75,000 lbs per sq. inch.
Yield point, minimum	37,500 ,, ,,
Manganese ..	0.4 to 1.0 P.C.
Phosphorous ..	0.05 P.C. max.
Sulphur	0.05 P.C. max.
Carbon	0.4 P.C.

STATOR FRAME: The stator frame is fabricated and welded out of steel plates. This is designed to give proper support to the stator core and the upper bracket. Mostly the structure is modified to provide proper ventilation. The stator frame may be made in sections depending on shipping and other limitations.

STATOR CORE: The C.G.E use the best silicon steel they can obtain at an economical price for the core. Silicon sheet steel has the characteristic of decreasing permeability with increase in silicon content. The change in losses per pound for increase in silicon content is large but decreases in effect as the percentage is increased. Therefore, after a certain percentage of silicon is added, the following methods are adopted to decrease the losses further.

1. Varying the thickness of the punchings.
2. Annealing and proper treatment of the material after punching.
3. Mill treatment such as using material with a definite grain alignment.

LOW-LOSS STEEL

The use of 2-3/4 percent silicon gives a very good low-loss steel for this purpose. The thickness of core punchings varies between 14 and 15 mills. These laminations are baked in insulating varnish at high temperatures. The thickness of insulation is generally in the order of ? miles on each side of the lamination.

The stator core is attached to the frame by means of cold finished drawn steel key ribs welded to the flange plates of the frame. The key ribs are welded in position during the process of stacking and the core thus matches accurately to the dovetail slots on the back of the punching. The individual laminations are stacked on keys in steps of approximately two inches; then a space block is provided to form a ventilating duct. The space blocks are kept in position by having them welded to the laminations. When all the laminations are piled, they are clamped between fingers by core bolts which also transmit the weight of the core to the frame.

The laminations are so lined up in the slot that they need not 'be filed to achieve a smooth slot and wedge groove. Before the coils are assembled in the slot, it is given a coat of conducting paint to protect it against corona discharge.

STATOR WINDINGS: There are several types of windings such as chain, frog, wave or lap. But the one which is generally used in the case of such machines is lap winding. The Canadian practice is based on making similar coils which can be used in any position in the armature. It is also easier and cheaper to manufacture them as only one winding form is used. The stator coils are usually wound with a fractional pitch and skewed to an extent to achieve the characteristics of an *infinitely* distributed winding. This construction minimises tooth ripple and improves wave form.

The inter-connection between the coils is made at the top. The bottom nose of the coils rests on a circumferential ring known as the "nose-supporting ring". This carries the weight of the coils. Separate rings are provided both at the top and the bottom which are called "bracing rings". The coils are lashed with glass cord to the bracing ring. These rings check the movement of the coil due to the stresses produced under short circuit conditions.

The coils are held in the slot by means of cross-grained maple wedges of the projecting air-slide type designed to enhance the ventilation of the core ducts and thus permit

the application of closed ventilation without the necessity of surrounding the end windings. This leaves the end winding open which makes the maintenance and inspection much easier and quicker. The connections between coils are made with inter leaved joints which are properly soldered. A number of thermocouples are provided in the stator coils which serve as temperature detectors.

STATOR COIL INSULATION: On machines having 11 KV as generator voltage, the class of insulation used is B. The requirements of the insulation are that it should have as small an organic content as possible; it should be free of voids; it should not be subject to shrinkage. The insulation should not be too brittle so that it may crack or fatigue after some time.

With these requirements in mind, Canadian General Electric insulate the strands of the coil with glass insulation. The turns are insulated with mica tape and treated with an asphaltic binder in the vacuum pressure process. The insulation over the coil consists of two separate applications, each of many layers of mica tape over the full length of the coil including the end connections. Each of these applications is followed with asphalt in the vacuum pressure process. The vacuum treatment removes all the *entrained* solvents in the asphaltic base varnish by which the tapes are applied.

A pressure treatment under asphalt then compacts and slides the mica flakes over each other. They adhere tightly to the conductors and are uniformly bent around the corners of the coil without cracking or damaging the individual flakes, making up the insulation. No mechanical pressure is applied to these coils in forming, as such pressure might crack the mica. This process results in a dense homogeneous insulation adhering tightly to the conductor.

The part of the coil which has to rest in the slot is then accurately sized by adding mica tape or scraping off high insulation. It is then finished with a slot armour consisting of fibre glass tape impregnated with a suitable conducting paint to protect it against corona. The end connections and other exposed parts of the coil are finished with glass tape and painted with glyptol varnish. The resulting insulation is thermoplastic. These coils are readily installed or removed when worn without damage.

UPPER BRACKET: There are two general types of brackets; parallel beam type and spider type (radial arm). The upper bracket takes the weight of the rotor and the hydraulic thrust and also locates the shaft radially. It also provides the support for the exciter. In the design of a bracket, stiffness and not the strength is the main governing factor. This is because of the direct deflection imposed upon it by the dead weight of the rotating parts plus the hydraulic thrust. Rapid fluctuations in the hydraulic thrust (sometimes known as runner sing) could set up undesirable oscillation under certain conditions.

BRACKET DESIGN

The upper bracket has also to take the side thrust, due to unbalanced forces which may be due to magnetic or mechanical imbalance. It has to take the side thrust in case of short circuit in the rotor field. These forces are transmitted to the bracket through the upper guide bearing. The design of the bracket has also to cater for the suitable reservoir of oil and cooling system and the enclosure for the bearings.

With these requirements in view, CGE designes the upper bracket of parallel girder type construction. The thrust bearing housing is mounted between the web of the girders. Care is taken that the stresses from the thrust bearing are transmitted evenly to the bracket. Radial gusset plates are provided to avoid any soft spot under the bearing.

The construction should be such that both the thrust bearing and the upper guide bearing can be attended to for the purpose of maintenance and inspection without dismantling any other part of the generator.

Side arms are also provided with the upper bracket to give it lateral stiffness.

LOWER BRACKET: The lower bracket is designed to contain the bottom guide bearing and to take the side thrust. It is also supposed to take the weight off the whole rotor when the jacks are used. It should be so designed that the air flow to the rotor is not disturbed. Provision is also made for initial adjustment of the bearings for alignment purposes. This bracket is usually made of eye-beam construction.

SLIP RINGS: These are mounted generally on to the top guide bearing and the thrust bearing which makes for easy maintenance and also avoids any access of oil or oil vapours to the slip rings. Usually a low carbon steel (carbon less then .05%) is used. It is in the form of hot-worked or annealed bars and forgings, and is a soft low-strength steel having excellent ductility and weldability. The brush holders are provided with a pressure measuring device that indicates compression of the holding-down springs.

THRUST BEARING: The CGE uses a spring-supported bearing which consists of a rotating ring and stationary segments, plus a supporting structure of springs and base ring.

The area of the thrust bearing is directly determined by the weight of the rotor, wheel and hydraulic thrust it has to carry. The working pressure is in the order of 300 to 400 pounds per square inch. The two most important points in the service of the bearing are the finish of the rotating ring on the runner plate and chamfering of the loading edges of the segments.

The spring assemblies are preloaded to approximately 120 % of their anticipated load. Taking the bearing as a whole, this supplies a firm foundation and yet prevents local over-loading in the bearing to occur since the springs will simply deflect once their preload is exceeded.

The bearing shells of these bearings are made of cast iron in small machines, but are made of fabricated steel in larger ones. These are made in two halves.

The upper guide bearing fits over the *journal* surface of the thrust collar. To prevent shaft currents and the resulting pitting of the bearings, the upper guide bearing and the thrust bearings are insulated from the supporting structure in the bracket. The thrust bearing has two layers of insulation above and below the bearing surface. One layer serves as a stand-by in case the other breaks down.

The habit used for both the bearings is of lead base and has the following composition:—

Lead	..	78 P. C.
Antimony	..	18 to 19 P. C.
Tin	..	1 to 2 P. C.
Arsenic	..	0.75 to 1.25 P. C.
Copper	..	0.15 to .5 P. C.

Other impurities 0.35 P. C.

The normal pouring temperature is 350°C.

All the bearings are of self-lubricated type, based on viscosity principle and do not require separate oil circulating system or pumps. The bearings are water-cooled. The cooling coils are built in the oil reservoirs of copper tubing. The bearings are open to the atmosphere through a small vent to take care of the changes in temperature and atmospheric pressure. The vent to the thrust bearing housing is provided with a water-cooled condenser which condenses the vapours and returns the oil back to the reservoir.

A common reservoir is provided for the thrust and upper guide bearing. The oil is pumped by centrifugal force through the holes in the rotating ring to grooves in the upper guide bearing and by other holes in the rotating to a closed chamber enclosing the thrust bearing. The oil circulation is so arranged that it passes over the cooling coils and is then pushed over the running surfaces and the stationary shoes of the thrust bearing at high velocity.

The lower guide bearing has its own reservoir and cooling arrangement. This bearing operates against a journal forged on the shaft.

VENTILATION: The ventilation of these machines is so arranged that the air passes through the ducts in the rotor rim directly, with complementary ducts in the stator core and re-circulates back through the coolers in the corners of the square sheet metal housing. This form of cooling provides uniform rise of temperature throughout the generator. This particular arrangement of ventilation is a speciality of GE machines and is very efficient.

FIRE PROTECTION: The insulation of the windings is such that it resists a self-sustaining fire. All the machines are provided, within the generator housing, with carbon dioxide ($C0_2$) fire extinguishing equipment Apart from this, sometimes the customers insist on having water sprinklers at the bottom of the stator windings. The supply of water is manually operated and the sprinklers are so situated that the spray is directed on the coils in case of fire.

BRAKES: The brakes are pneumatically operated under a pressure of 100 pounds per square inch. The shoes of the brakes are made of metallic base asbestos compound which are very durable and do not give trouble. The brake cylinders are electro-plated with corrosion resistant chromium and the piston packing is made of oil resistant neoprene.

LIFTING JACKS

These brakes can also be used as lifting jacks. A separate oil pump is provided for this purpose. After the rotor has been lifted up with jack and if it is desired to keep it at that height, the metallic wedges which are supplied with the brakes are placed between the brake cylinder and the brake shoe block.

MAINTENANCE: The special feature of the Canadian General Electric machines is the easy maintenance and quick accessibility to different parts with the least amount of dismantling. Not only this, they also require the least number of spare parts.

The stator and rotor coils, if damaged, can be easily replaced with the rotor in position. The field leads are disconnected, the tapered pole keys withdrawn and then the pole can be taken out. This gives enough space for replacement work. The damaged stator coils can be replaced in less than 24 hours.

Similarly, all the bearings can be removed, inspected or replaced by removing covers from their respective housings, without any dismantling of other component parts.

The auxiliaries used are fewer. There are no pumps, A.C. motors, D.C. motors and starters for the bearing oil circulating system.

All the above features do not only save labour cost on maintenance but also minimise the loss of revenue due to breakdowns. This definitely places the C.G.E. far above many of the manufacturers of similar machines in other countries.

SOME RECENT BOOKS OF ENGINEERING INTEREST

1. Soil and Water Conservation Engineering. by Mr. R. K. Frevert, G.O. Schwaab, T.W. Edminster, K.K. Barnes Published by John Wiley & Sons Inc., N. York, U.S.A. (In the U.K. from Chapman and Hall Ltd., 37 Essex Street, London.

2. Concrete Manual (Sixth Ed.). Published by U. S. Department of the Interior Bureau of Reclamation, Denver Federal Centre, Denver, Colorado.

3. Ingenieurgeologie und Geotechnik by Dr. Ing. Karl Keil. Published by VEB Wilhelm Knapp Verlag, Halle (Saale) C.2, Muhlweg 19, Germany,.

4. Engineering Metallurgy., by Mr. E.M.H. Lips. Published by Philips Technical Library. (Distributed by Cleaver-Huem Press Ltd., 31 Wrights Lane, Kensington, London, W.8.)

(*Continued on page* 68)

PRESTRESSED CONCRETE

By SALIM ULLAH KHAN*

Concrete can only resist a tensile stress of a few hunderd pounds per square inch without cracking. To overcome this weakness, concrete is reinforced with mild steel bars in the zones where tensions are expected. The weakness of concrete in shear is also very marked. Failure occurring due to the tensile component developed by shear above a certain limit, necessitates additional reinforcement in such zones. In a beam suitably designed for tensile stress, cracks are still bound to occur.

THIS may be due to accidental overloading that induces very high stress in the steel or due to abnormal shrinkage of concrete in the tensile zone. This cracking is usually provided for in designs by neglecting the concrete section below the neutral axis. But complete elimination of cracks is not quite possible. Such cracks are apt to absorb harmful elements that can weaken the reinforcing steel. Ordinary concrete structures reinforced with mild steel are, therefore, bound to remain weak and also heavy as about 60% of the total weight of the section in the tensile zone is of no value to the strength of the member. Means, therefore, had to be found to remove this inherent defect of concrete. This was achieved either by producing concrete capable of resisting great tension, or by devising external methods by which tensions could be entirely eliminated from concrete. The former being impracticable, engineers applied themselves to the latter and the idea of prestressed concrete was born.

When prestressed concrete was actually produced is difficult to say. But it is known, that the first patent was taken out in U.S.A. in 1886. In 1928, Eugene Freyssinet filed his fundamental patent in France and demonstrated for the first time that high tensile steel was essential to Prestressing. Since then prestressed concrete structures have been erected throughout the world, and gained a marked popularity by the end of World War II when it was found that prestressed concrete was more economical and could almost completely replace structural steel.

II. THEORY OF PRESTRESSING:

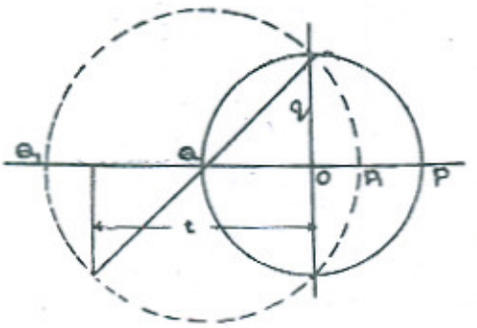
1. The general idea is to create in the various parts of a structural member permanent stresses in opposition to the stresses resulting from loads applied to the member. The magnitude of the applied negative' stress depends upon the stress that has to be overcome, and since it is only the tension that has to be reduced to zero, the prestressing force is a compression suitably applied.

In a homogeneous rectangular beam, the applied load causes compressive stresses in the top fibres and tensile stress in the bottom fibres. If a compressive force is now applied at a certain eccentricity from the neutral axis, it will cause a compression in the bottom and a tension in the top fibres i.e., entirely the reverse of the existing stresses in the beam due to applied loads. Quantities with opposite signs tend to cancel each other, and the prestressing can be so arranged that tensions are entirely eliminated.

Prestressing is of a definite advantage in shear. In an ordinary R.C.C. beam, failure in shear is caused by the maximum principal tensile stress due to the existing shear

* Executive Engineer, North Western Railway.

stress. It can be shown by Mohr's Circle diagrams that if an axial tension due to shrinkage of concrete, is compounded with shear, the principal tensile stress is greatly increased. If the axial stress is now a compressive stress, the principal tensile stress can be reduced. A further reduction is still possible if a vertical compressive stress is superimposed in addition to the horizontal one. This is obtained in a prestressed beam by curving upwards some of the reinforcing cables which introduce a vertical downward force at the ends. The following diagrams will make it clear:—



OP AND OQ ARE THE PRINCIPAL STRESSES DUE TO THE SHEAR q ONLY OQ BEING THE TENSILE STRESS

IF AN AXIAL TENSION 't' IS INTRODUCED, THE PRINCIPAL STRESSES DUE TO q AND 't' ARE NOW OP' AND OQ' SHWING THAT OQ HAS NOW INCREASED TO OQ'.

2. DESIGN.

The evaluation of the required prestressing force P can now be done as follows:—

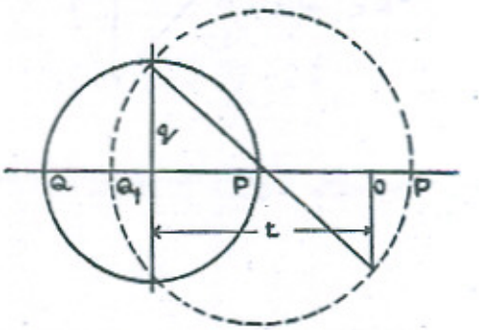
If Fc, Zc, Ac, are the permissible compressive stress, section modulus and area of cross section of the concrete respectively, & Fs, N and A, are the permissible working stresses of steel, the number of cables and the total area of steel in one cable respectively:—

Then Prestressing force, $P = N.A_s.F_s$

If eccentricity of P from the neutral axis is given by 'e', then

Stress in top and bottom fibres $= \frac{P}{A} + \frac{Pe}{Zc}$

The stresses due to applied loads having been evaluated, the force P can easily be found so that no tension exists in the bottom fibres.



OP AND OQ ARE PRINCIPAL STRESSES DUE TO SHEAR q ONLY.

INTRODUCING A COMPRESSION 'C' REDUCES OQ TO OQ'.

The shear, as a measure of diagonal tension, is normally reduced to negligible quantities due to the presence of the compression induced by the prestressing force, and can be further reduced by curving a number of cables in a parabolic shape.

3. LOSS OF PRESTRESS :—

The maximum elastic elongation of mild steel is practically equal to the strain in concrete due to compressive stress and creep and, therefore, it is evident that mild steel cannot be used to establish a permanent prestress. The stress—strain curve of the high—tensile steel now normally used for prestressing, however, does not show a definite yield as is the case with mild steel. The curve is linear practically upto the yield point of mild steel (E. being the same in both cases) and then gradually the line begins to curve away forming a hyperbola. There being no yield point, the strength of high-tensile steel is specified by 'Proof' strength. For example, the stress which on removal produces a permanent strain of one per cent will be called the 1 per cent 'proof stress' for that particular sample.

The steel generally used for prestressed work is usually in the form of cold drawn high tensile wires with diameters from

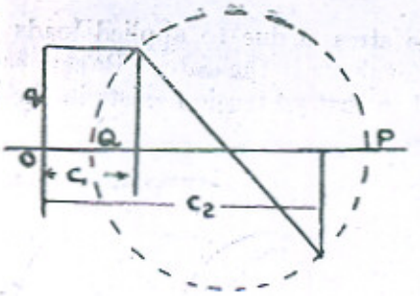


FIG. 3.

C1 AND C2 ARE THE TWO COMPRESSIONS INTRODUCED PERPENDICULAR TO EACH OTHER. q IS THE SHEAR STRESS.

PRINCIPAL STRESSES ARE NOW GIVEN BY OP & OQ.

0.06 to 0.276 inches. The ultimate tensile strength is greater for smaller wires, the values ranging from 150 tons per square inch for the smallest to 95 tons per square inch for the largest. During prestressing the maximum stress is not allowed to exceed 90% of the 1 % 'Proof Stress' which is about 90 tons per square., inch for 0.2" diameter wires with an ultimate tensile strength of 110 tons per square inch. This with a maximum permissible stress of about 80 tons per square inch the net working prestress available is about 70 tons per square inch on the assumption that the total losses do not exceed 10 tons per square. inch. The British Railways use a maximum limit of 67 tons per square inch and a working prestress of 50 tons per square inch. The latter limits are a bit on the conservative side.

Loss of prestressing force is also caused by creep in steel and slip of anchorage. Creep in steel is normally minimised during tensioning, maximum tension being applied for a short time. The anchorage or cone slip is measured by experiment or assumed to be about 1/16 inch and allowed for. Total losses in the prestressing force do not normally exceed 10 to 15 per cent of the maximum permissible tension that can be applied to the prestressing wires. A figure of 12.5 per cent is generally employed in working out designs.

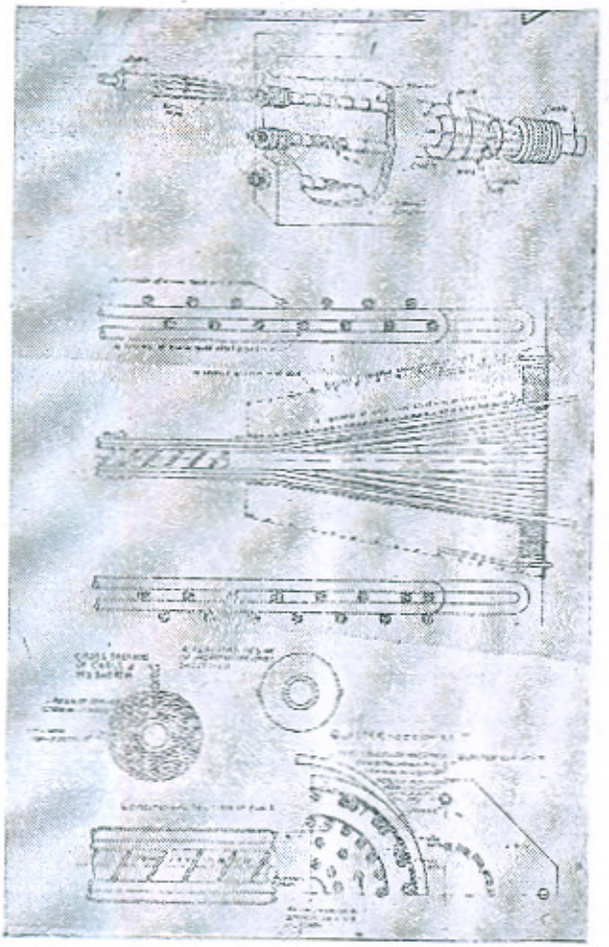
4. CONCRETE:

The quality of concrete must be high to withstand heavy compressions during and after prestressing. Continental and British constructional firms use cube strengths after 28 days equal to 6,000 lbs. per square inch for unbonded prestress and 8,800 lbs per square inch for bonded prestress. Concrete of this quality is now universally used. The minimum 28 days cube strength for unbonded prestressed concrete is generally fixed at 5,000 lbs. per square inch. This quality of concrete is capable of being attained is 'Situ' construction by careful grading of aggregate and vibration and presents no difficulties in the field. The higher strength of 8800 lbs. per square inch used in bonded prestress viz. Hoyer beams (explained later) can only be produced in factories under careful control. Firms dealing in the latter bonded prestress, utilise different methods; some depending on intense vibration, and some on physical compression of green concrete in presses. Many firms use steam curing at fairly high temperature to cut down curing time and enable quick release of moulds for faster production.

III. THE MEANS OF PRESTRESSING

For prestressing small beams and slabs the stress is applied to steel wires stretched across moulds and the concrete is placed while the wires are in tension. The wires are cut outside the ends of the moulds when concrete has hardened sufficiently. The tension in the wires is transmitted as a compression to the concrete through a bond between the steel wires and concrete, or by anchorage blocks welded to the ends of the steel wires. This method is suitable for precast beams and slabs of small size, particularly where a large number of a standard section are required and repetition of work is possible. The wires are stretched between abutments by means of jacks acting on yokes to which the wires are wedged by means of cast steel wedges. The yokes are then anchored and the jacks are removed.

The installation is costly and the method is only economical if the number of sections to be precast is fairly large. This method has been fairly successfully adopted for casting railway sleepers in France.



Prestressing Arrangement.

This method was originated by Preyssinet and first developed commercially by a German; Edward Hoyer, who used plain wire of $\frac{1}{6}$ th. to $\frac{1}{8}$ th. inch diameter with a tensile strength of 350,000 lbs, per square inch and a working limit of about 85% of this. Some designers are rather doubtful about the amount of load obtained because of the smoothness of the wire not withstanding its small size. The Hoyer beams are now widely used both in England and in the Continent.

Various improvements in this method have been carried out to suit particular types of work. In the manufacture of railway sleepers the wires are sometimes anchored to the mould itself, and are also crimped to improve bond. In the U.S., a method has been evolved entirely dispensing with the use of outside anchors. It would be interesting to know that the practice of tensioning steel bars by means of screwing nuts on threaded ends is still followed by some British firms.

Another method which is gradually becoming universal, is placing of cables inside ducts or pipes left in a precast section, and anchoring these cables after tensioning to the end blocks of the section. The main difference between the two methods is that in the former the steel is tensioned against exterior or interior anchors and then embeded in concrete and the steel released from anchors after the concrete has hardened. In this manner precompression is applied to the beam along its entire length through bond, but the exact distribution of stress is in doubt. In the latter method, the steel is tensioned against the hardened beam and the stress distribution is known at all times. In addition to this advantage, heavy exterior anchors are entirely eliminated.

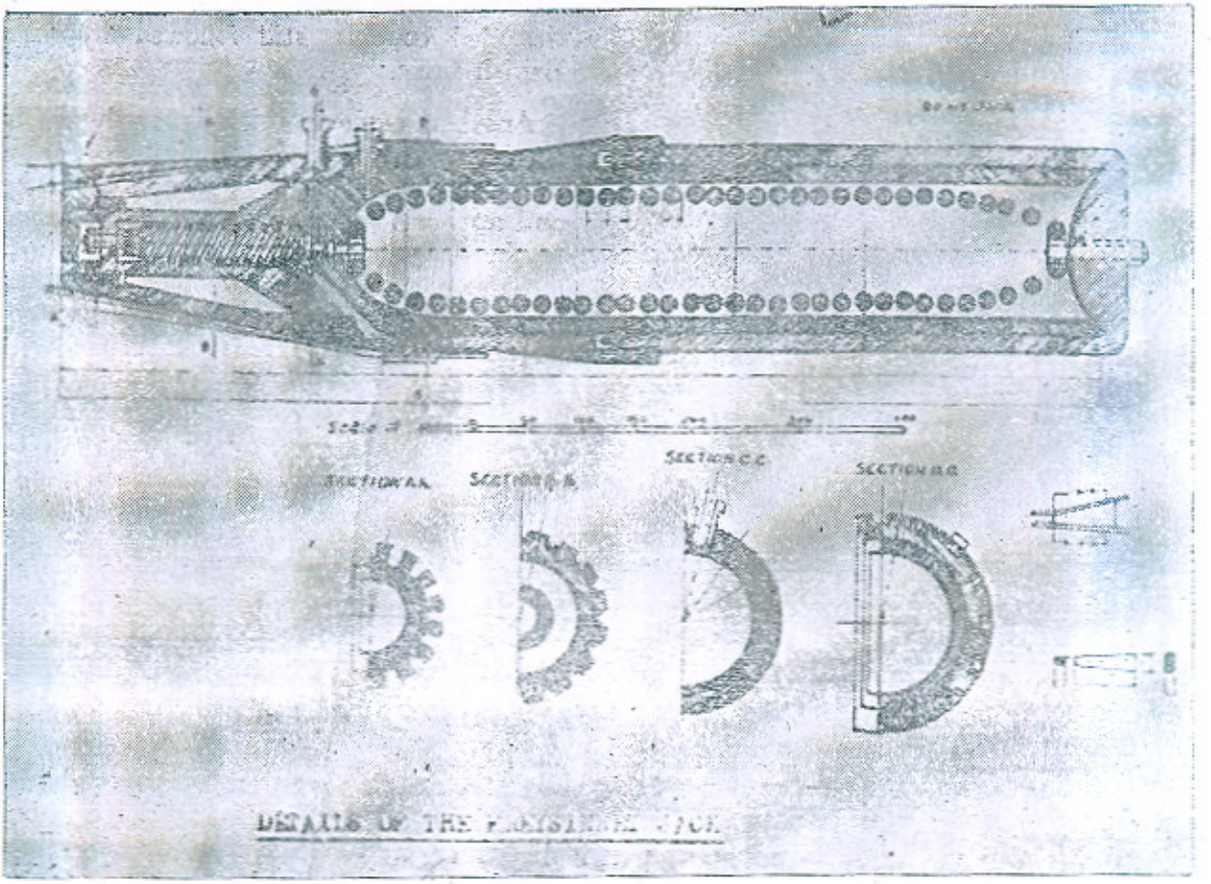
Tension is applied to the cables by means of jacks acting against the concrete, and then the cables are grouted to established bond. Different techniques have been developed on this principle and two schools led by Freyssinet (France) and Magnal (Belgium) have sprung up. The main difference lies in the method of tensioning and anchoring cables. The actual form of the cables and their method of placing is also dissimilar.

THE PREYSSINET SYSTEM

In the Preyssinet system hollow cylinderical shaped anchors are cast in the end blocks at the ends of the ducts or pipes cast in the member. The cables, formed of 0.2″ diameter, high tensile steel wires laid in concentric layers around a spiral former

are well greased and pushed in through the duct so that about 30 inches project beyond the anchors. The jacks are then placed and the projecting wires are wedged in pairs around a circular head. The pumps are worked and the tension is applied until the necessary stress is reached. The second piston of the jack, *then applies a*

The ducts for the cables in the beams are made in several ways. When cables cannot lie open as is the case in the prestressing of precast unreinforced concrete slabs for tanks or pavements, channels are made in the member at the time of casting by embedding a thin metal tube, or cables are placed in their correct position wrapped in a very



Preyssinet Jack

conical shaped grooved wedge, well smeared with mortar. The jack is then removed and the projecting wires are cut. The cone has a hole in the centre through which the whole cable is pressure grouted. The jack heads are inter changeable and one type of jack can be used to tension 8,10 or 12 wire cables; another for 14, 16 or 18 wires and a third for 32 wires although the larger sizes are seldom necessary. A 12 wire cable is commonly used.

thin iron sheet or several layers of a strong paper made watertight with a bitumenous substance. The latter method was evolved due to shortage of steel and has proved quite successful. There is yet another method in which a rubber tube is fixed in the correct position and pumped up. After casting the tube is deflated and withdrawn. This type of tube expands and contracts spirally and has been found very useful.

The injection of mortar under pressure is

done as a final operation to provide cover on the wires, prevent corrosion and improve bond. Some engineers have criticised the Preyssinet cable on the basis that the cover will not be 100 per cent due to the close spacing of the wires. The Preyssinet school, however, maintains that if proper proportions of mortar are employed, the grouting will be sufficient to maintain tension by bond only. The mortar is specified as one part by volume of sand upto 0.5 mm. grain, to one part of cement.

The sequence of operations for stressing a Preyssient cable is as follows :—

(*a*) Ends of the cable sticking out are freed, cleaned and fanned out in pairs along the conical internal face of the anchorage embedded in the concrete.

(*b*) In the interior of this conical space, is inserted the conical wedge (male part of the anchorage) coated with sufficient plastic mortar to embed all the wires finally.

(*c*) The hydraulic jack is lifted into position and the projecting wires wedged into the back part of the jack in pairs.

(*d*) Jacks having been placed at both ends, pumping is commended simultaneously. The wires are stretched and when the required pull (equivalent to a stress of about 80 tons per square inch, has been obtained, checked both by guages on the pump and by the elongation of the wires, pumping is stopped.

(*e*) Pumping is started into the tapered end of the jack, which actuates a piston, pressing home the conical wedge with a force of 50 tons. This force of 50 tons on the green coat of mortar is equivalent to an average compression of 12,000 lbs per square inch at which pressure the mortar,according to Preyssinet, behaves like a liquid and equally distributes itself around the circumference and over the 10 inch length of embedment of the wires. The friction between the wires and the mortar is sufficiently high to prevent slip, and the wedge is safely anchored. Jacks are then removed.

(*f*) Through the hole in the anchorage injected the liquid cement and watergrout.

(*g*) Projecting steel wires are then cut and bent, and the end of the cable sealed with rich cement mortar.

Magnel System.

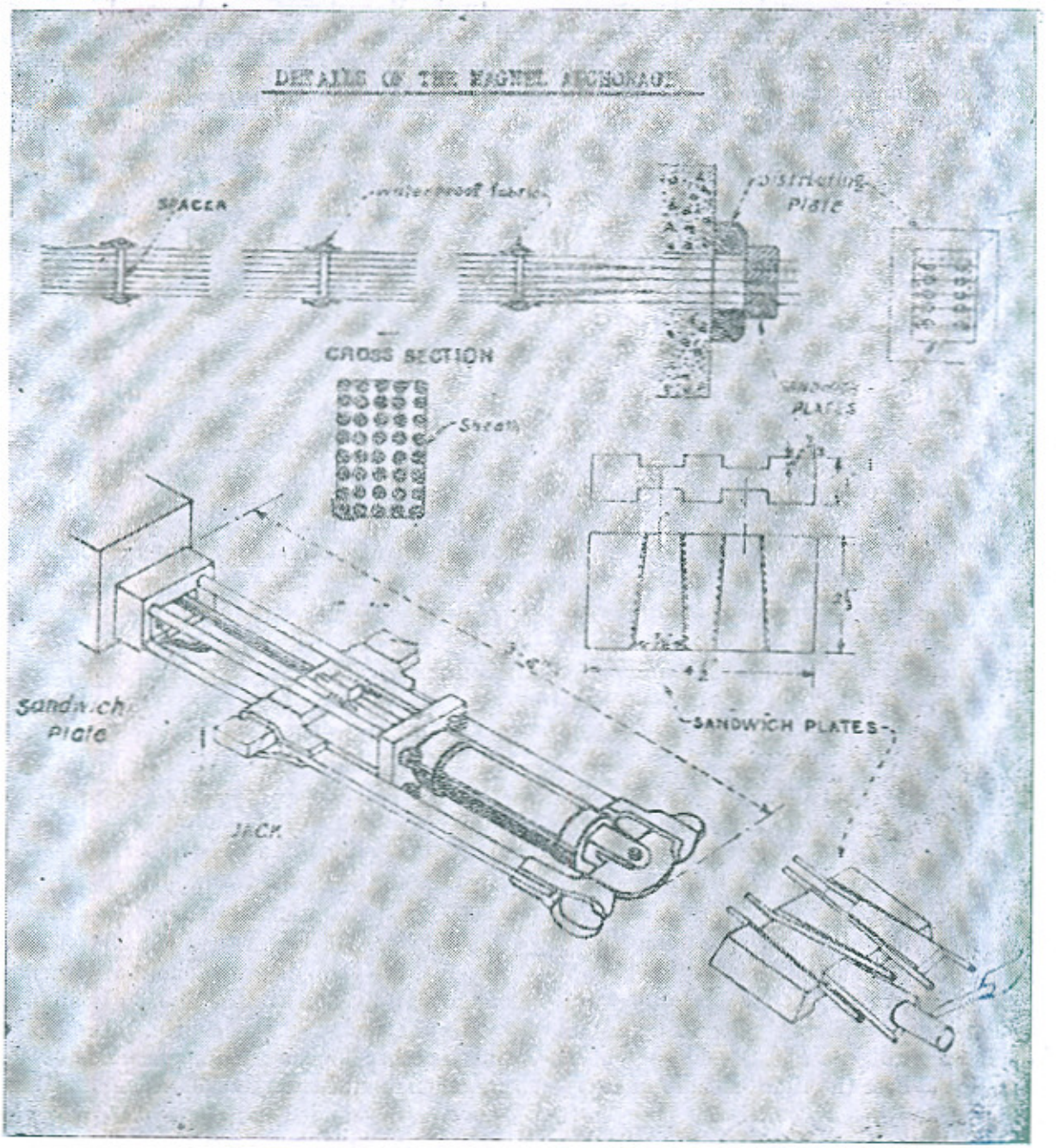
In the Magnel system, advocated by Prof. Magnel of the Brussel University, only two wires are to be tensioned at a time as it has been contended that stressing a greater number of wires does not result in equal tensioning of all wires. The jack used in this process has a capacity of only 10 tons. The wires tensioned in pairs, are anchored in the same sequence to a cast steel sandwitch plate which acts against a cast steel distributing plate. Each sandwich plate is provided with wedge-shaped grooves in each of which a pair of steel wires are secured by cast steel wedges. On completion of tensioning the cable is grouted.

The wires of the cable have to be arranged in a rectangular pattern because of the arrangement of sandwich plates. This is accomplished by sheet metal perforated spacers. The duct for the cable is rectangular in shape and is cast around a rectangular metal form, and the wires are placed in this duct after the concrete has hardened.

Both systems are equally effective The principle advantage of the Magnel system lies in the fact that the number of wires that can be used in one cable is not limited. The installation and the apparatus required for the Preyssinet system, however, is much lighter and simple and consequently cheaper.

(*iii*) A third system of inducing prestress in slabs and beam has been developed by the Roebling Co. of U.S.A. In this system the ends of wires strands are anchord at the ends of the slab by bond. The tension is applied by forked jacks at the centre. The jacks pull together opposing pairs of strands which are then connected by plates and bolts. Galvanised stranded cables are used and are said to be immune from creep. As the cables are not bonded to the concrete except at the anchorage, the cables are capable of

adjustment to compensate for volume changes of concrete or even to take greater loads. The cable stresses also can be checked. For slabs or beams in which thecables are practically straight, pipes or paraffined paper tubes are employed to prevent bond. For longer spans, hollow rectangular beams are used with parabolic cables resting on diaphrams on saddles between webs and bearing on anchor plates at ends. Tensioning the cables produces upward forces at the saddles, inducing moments and shears opposite in



Magnel Anchorage.

sign to those produced by the applied loads. In design the load is distributed between the cables and the concrete in the same manner as it is apportioned between cables and the stiffencing trusses in a suspension bridge. As compared with high tensile wires of 0.2 inch diameter, stranded bridge cables of any size can be employed in this method with permissible tensile stress of 1,00,000 lbs per square inch.

IV. ADVANTAGES OVER ORDINARY R. C. C.

(*i*) **Costs:-**

As already pointed out, prestressed concrere is generally cheaper than ordinary reinforced concrete, lighter and consequently much more convenient to handle.

The following figures are instructive for a prestressed concrete three span (50′,100′,50′ continuous slab road bridge constructed in West Germany in 1949.

(*a*) Total cost 17 percent below that for reinforced concrete.

(*b*) Steel used 46 percent below that for reinforced concrete.

(*c*) Cost of steel 11 percent above that for reinforced concrete.

(*d*) Cost of placing and prestressing steel 42 percent below the total cost for cutting, bedding and placing normal reinforcement for reinforced concrete.

(*e*) Quantity of concrete used 15 percent below the quantity for reinforced concrete.

(*f*) Cost of super-structure 26 percent below that for reinforced concrete.

For a similar work done in this country labour costs should be lower than in European countries.

(*g*) In a prestressed concrete member the concrete is protected against cracks and the variation of stress in the steel due to variation of live loads is also much smaller than in reinforced concrete members. Ordinary reinforced concrete beams subjected to rapidly varying loads frequently fail due to fatigue of steel and the failure of concrete in the tensile zone although the yield point of steel is never exceeded.

(V) Factors of Safety

(*a*) In an ordinary, un-prestressed reinforced concrete beam it is a common practice to use working stresses rather than factors of safety based on ultimate stresses. These working stresses are based upon the elastic limits to provide for possible variations in live loads, excessive loads, impact effects; variations and imperfections in materials, designs and construction; deformation stresses not allowed for in design such as those caused by unequal settlement of supports, shrinkage, temperature changes and plastic flow due to load and time effects and finally, due to the gradual deterioration of the structure working stresses in the steel reinforcement are usually taken as one-half of the elastic limit, giving a factor of safety of 2 with respect to a steel tension facture.

The factors of safety for ordinary concrete in-28 days strength are as under:—

Concrete in compression.	0.40 fc.
Concrete in bearing	-0.25 fc.
Longitudinal bars with proper anchorage and web reinforcement.	-0.12 fc for diagonal tension.
Longitudinal plain-bars with proper anchorage.	-0.06 fc bond.

The above factors of safety and the consequent evaluation of working stresses have been based upon the observed behaviour of beam under load. During early loading the concrete assists the steel in taking tension and the deflection is uniform. As the concrete fails in tension near the centre of the beam a readjusting stage occurs; the steel carries more and more of the tensile stresses.

(*b*) The behaviour of a prestressed beam under load is quite different. Deflections are generally much less than a similar R.C.C. beam upto the stage where prestress becomes zero due to increase in bedding stresses under increased loads. When the point is reached where the prestress is completely destroyed, the stresses in the concrete usually beocome zero in the tensile zone. A prestressed beam is fully elastic and returns to its original state on reduction of load. Cracks that open also close up and disappear on removal of load. Permanent deformations of a prestressed structure can only occur when an additional limiting load, beyond that required to completely overcome the prestress, is exceeded. This limit corresponds to an irreversible strain, either in compressive zone, concrete, or in the steel.

(*c*) In a prestressed structure a load in excess of the transformation load is very clearly indicated by an exaggerated deflection, which being completely reversible, does not endanger the structure in the least. The real safety limit beyond which permanent strain and final rupture becomes possible has yet to be reached and, at this stage, with a little control danger can be completely averted.

SOME RECENT BOOKS OF ENGINEERING INTEREST

(*Continued from page* 59)

5. Grundbau-Taschenbuch Vols. I and II. Edited by Dipl. Ing. H. Schroder, contributed by 25 authors. Published by Wilhelm Ernest & Sohn, Hohenzollerndamm 169. Berlin-Wilmersdorf, Germany.

6. Legal Cases for Contractors, Architects and Engineers by I.Vernon Werbin B.S. C.E.LL.B. Published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, 37 New York N.Y. (In U.K. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4.).

7. Elementary Engineering Mechanics by F.B. Thirlwell B.Sc. Eng. Published by Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W. I.

8. Mathematics for Engineers—Part I (Ninth Edition Revised) by Mr. W. N. Rose B.Sc. Eng (London) Published by Chapman & Hall Ltd., 37, Essex Street, London.

9. Grund und Wasserbau in Praktischen Beispielen. by Professor Dr. Ing. Otto Streck. Published by Springer-Verlag, Reichpietschufer 20, Berlin W 35, Germany.

10. Les Barrages en Voute Mince (Arch dams) by Mr. Fean Lombardi. Preface by Pierre Lardy. Published by F. Rouge & Cie S.A., Librairie de L'Universite, 6 rue Haldimand, Lausanne, Switzerland.

11. Materials of Construction (6th Edn.) by Mr. A.P. Mills H.W. Hayward and L.F. Rader. Published by John Wiley & Sons Inc., 440, 4th Avenue, New York. In U.K. from Chapman & Hall, 37 Essex Street, London.

12. Practical Design of Simple Steel Structures, Vol. 1 (4th Edn.) by Dr. David S. Stewart, M.I.C.E. Published by Constable & Co. Ltd., 10 Orange Street, London.

MINERAL RESOURCES OF PAKISTAN

By B. W. HOLMAN*

This illuminating talk on Mineral Resources of Pakistan was given by Prof. B.W. Holman, at a monthly meeting of West Pakistan Engineering Congress. The article gives an idea of mineral resources of this country which are being exploited at present.

PAKISTAN has main kinds of mineral resources, oil and gas, bedded deposits, and vein or lode deposits.

Oil and gas resources have been developed during the last few years, gas in considerable commercial quantities and the oil in encouraging amounts in the Attock area. New areas are being prospected for the bedded deposits. Large quantities of salt, gypsum, iron ore, limestone and coal have been known to exist here for a long time.

SALT :—Very considerable deposits of salt have been worked for many years. In the Salt Range (Punjab) there are seams of salt from 50 to 200 ft. thick; some are very pure and contain upto 99% of sodium chloride and very small quantities of impurities.

Before independence, the former province of Punjab alone produced upto 200,000 tons of salt a year. For example, in 1931 the output was recorded as 193,399 tons. Now the output is less than the half after independence. Recent restrictions on export of salt to East Pakistan have further reduced the market for West Pakistan. Very large supplies are available but the market is restricted.

GYPSUM :—The position is much the same with gypsum. High quality gypsum is found in a very large quantity but the market is restricted. Moreover, many deposits can be exploited by open working. At the western end of the Salt Range, close to the railway, there is a large outcrop of high grade gypsum estimated to contain 25,000,000 tons.

That the market is restricted is illustrased by the fact that in 1952 India was willing to buy £ 1,000,000 worth a year of gypsum from Egypt but not from nearby Pakistan. For the purposes of export overseas gypsum deposits are unfortunately rather far from the cost which cuts them off from the large Japanese market. The demand of gypsum for plaster boards used in building is now very great. About 1,000,000 tons a year are now used in the United Kingdom compared with about 15,000 tons a year before the last war.

IRON ORE :—Iron ore occurs in large quantities in West Pakistan but it is widely distributed and in most places distressingly discontinuous although near the surface. For example, in Baluchistan ore of high quality occurs containing 65% of iron compared with 45% contained in the widely publicised Assuan deposits of Egypt which are continuous but thin, whereas the Baluchistan deposits are scattered and thicker. These deposits are subject to occur over an area of much more than 100 sq. miles. The importance of these deposits in older times was due to smaller demand, when individual small deposits could be worked and smelted where they occurred and the iron sent to local centres for purification.

* Head of the Mining Department, Punjab College of Engineering and Technology, Lahore.

KALABAGH AREA

Expenditure on prospecting this ore will be stimulated by the success in working the Kalabagh area which is less scattered and much more accessible. There the ore is of good quality as regards harmful impurities, and contains about 45% of iron. These deposits are more accessible and less discontinuous. There has been systematic development under the guidance of Fred Krupp since 1953.

So long as metallurgical coke was required for smelting such ore the latter deposits were of no economic importance. Now Krupp-Renn process, which was such a great success during the last war overcomes this difficulty and saves the great expense of blast furnaces. Neither the blast furnace nor the Krupp-Renn Kiln produces steel as has been so often stated even recently on the radio in England. They produced metallic iron.

Limestone :—Limestone is reported to occur in unlimited quantities. in many instances deposits occur in the vicinity of railways in a quantity and of a quality considerable for the manufacture of cement and for use in the iron and steel industry. Large deposits of marble (crystalyine limestone) are also known to exist. They are not worked on a large scale although Pakistan is said to import over £ 1,000,000 worth of marble a year. This curious state of affairs is similar to that in Egypt where even the fine quality of green veined limestone occur close to the bank of the Nile. This variety of marble is much used as an ornamental stone in buildings in Cairo.

COAL :—It is reported that 2,300 outcrops of coal have been located. Much of this coal is of poor quality as regards its high ash and sulphur content. The ash content is often upto 15% and sulphur is subject to vary from 5% to 12%. In this connection it might be noted that at the present very high price sulphur would be worth much more money than the coal itself. The known resources of the geological, not mining places, have been estimated at 300,000,000 tons.

The two chief areas for coal mining are Makerwal and in the Trans-Indus area 50 miles S.S.W. of Jhelum and the Quetta area. The Makerwal mine is the largest producing mine in Pakistan. In the Quetta area the Degari coal is not of a high quality but some of it is good enough to be used on the railways. But the coal explored by Mr. Henchman to an inclined depth of about 400 ft., is of much better quality.

The coal seam was found 7 ft. thick at the lowest point of the incline. The colliery was taken over about a year ago and is being worked since. This is a bright semi-bituminous coal with about 6% of ash and 2% of sulphur. Sulphur content is rather high and the ash is white and powdery. The Geological estimate of the content of the basin is a minimum of 200,000,000 tons. Indian coal being used in the district is powdery and contains about 20% of ash.

DEPOSITS IN AZAD KASHMIR

BAUXITE:--This mineral is the main source of aluminium in the world. Fine deposits in Kashmir are too remote for exploitation but the deposits north of Rawalpindi and in Azad Kashmir area are accessible. Investigations of these latter deposits have been undertaken and a million pounds scheme has been drawn up for the reduction of the metal.

BENTONITE:—This mineral is very important in foundary work and for drilling mud in the petroleum industry.

A new man in Azad Kashmir is producing some hundreds of tons a month of this valuable mineral.

ALUM :—Alum and alum shales are known in one or two districts and are worked on a small scale for use in the carpet industry. Alum has many uses and could be worked on a large scale where its production is organised.

CLAYS :—Clays for brick making occur in many districts. Clays suitable for refractories bricks are considered to be in short supply but the clay used in Lahore is

used for open oil lamps is definitely refractory. Prof. Abdul Hamid of the Punjab College of Engineering and Technology has noted these in one of these little basins which indicates heat resistance to over 1,000°C. This clay also worked for pottery. A light yellow clay for manufacture of pottery and to wash buildings and for laundry purposes is produced to the south of Sekesar. The deposits of high quality clay are not known to exist in Baluchistan and Sind.

KAOLIN:—This has been reported in Pakistan but not worked.

GLASS SANDS :—Glass sands known to exist in Pakistan are of poor quality but there is a soft sandstone found between Kalabagh and Makerwal which might be processed into glass sand. The deposits of high-quality glass sands have been reported at Thal but so far they appear to be wishful thinking. Deposits of sand which produced a poor green glass with bubbles in it occurred in Syria and also very large deposits in 5 places in Egypt which also produced very green glass during the last war.

These deposits have been producing nice white glass since 1948 because both the countries wash the sands before using it. In Pakistan there does not appear to be even one laboratory containing the necessary apparatus for improving the quality of sands for glass.

For example, I have not been able to find even one magnetic separator for testing sands for the removal of iron compounds. One could buy such plant for a few hundred pounds but it is a waste of money unless one has a person with practical experience of such work to carry out the tests.

OCHRES :—Brown and yellow ochres are known to occur in the Punjab and are worked commercially. The firm which has thé latest and the best machinery installed for this purpose is in Lahore. This firm also grinds pyrites, talc, mica, and steatite (soap stone). Powder talc is much used for making face powders as also in D.D.T. and as a special insulator in Radar apparatus. Talc sufficiently pure for the latter process sells for over £ 20 a ton whereas for the less scientific purposes sells for 8 to 10 pounds a ton.

SODIUM SALTS :—Nitre is worked at one place to an extent of 50 tons a year and occurs in various other places. The occurrence of potassium salts has been proved at Khewra and reported in other area. Sodium carbonate is worked at a small scale in other places by primitive methods, for example in Khairpur.

BORAX :—Borax generally occurs as a beddy deposit or as a surface saline deposit.

VEIN AND LODE DEPOSITS :—Chromium in the Hindu Bagh area 70 miles northwest of Quetta, is the only metal worked on a large scale in Pakistan. Occurrences of most of the other metals have been reported. Antimony, copper, and sulphur appear to be the only three which have been worked but only at a very small scale. It is reported that mines for sulphur (pyrites) have been opened this year.

PROSPECTING :—The Geological Survey of Pakistan and the Pakistan government are reported to have spent Rs. 1800,000 over prospecting for oil and other metalliferrous and non-metalliferrous minerals. The Canadian Survey over a plane has recently been completed and is believed to have cost over £ 30,000. One or two other important surveys by foreign teams have been made over the last three years.

A very large number of deposits have been found, but there is no Pakistani engineer or geologist to determine commercial occurrences. Moreover, there is only one institution in the whole of West Pakistan for training youngmen for such work. It was actually proposed to close down in October this institution which is training 16 students at present.

It may be recalled that a similar attempt was made in Egypt to close down the Mining Department at the Cairo University. The authorities concerned had actually started reducing grant to the Department. It was slowly drawing towards complete closing down, when it luckily attracted the attention of President Nasser. He looked into the matter and stopped the rot. He went one step further and gave 20 scholarships for the students wishing to train in the Mining Department with its four or five years' degree course.

RECENT PUBLISHED PAPERS

TURBINE AND PUMPS

1. Hydraulic turbine deficiencies, by Mr. Parmakian John. Water Power Vol. 7, No. 7, July, 1955.
2. How impulse water turbines came to Canada, by Mr. Duport J. Modern Power and Eng. Canada Vol. 49. No. 11 Nov. 1955.

SOIL MECHANICS AND FOUNDATION

1. A survey of modern concrete technique, by Messrs, Bate E.E.B. and Stewart D.A. Proc. Int. of C.E. Vol. 4, No. 3, Dec. 1955.
2. Effect of modern constructional methods on tunnel design. by Mr. Rabcewicz L.V. Water Power Vol. 7, No. 12 Dec. 1955.
3. Strain-guage measurements on high lift storage pumps, by Mr. Martinaglia L. Water Power Vol. 7, No. 12, Dec. 1955.
4. An experiment in high speed tunnelling, by Mr. Alexandra H.J. Water Power Vol. 7, No. 7, 1955.

MATHEMATICS AND PHYSICS

1. Reactor Handbook Engineering by the United States Atomic Energy Commission McGraw Hill Book Co.
2. Reactor Handbook Physics. By the United States Atomic Energy Commission. McGraw Hill Book Co.
3. Research Reactor by the United State Atomic Energy Commission. McGraw Hill Book Co.
4. Neutron Cross Sections by Messrs Hughes, Donald, J. and Harvey, John A. McGraw Hill Book Co.
5. Principles of nuclear reactor engineering by Mr. Classtone, Samuel. McGraw Hill Book Co. 1955.
6. Reactor Handbook materials general properties by the United States Atomic Energy Commission. McGraw Hill Book Co. 1955.

GEOLOGY AND HYDROLOGY

1. Rainfall depth-duration relationship by Mr. Corn Herbert M. Proc. Am. Soc. C. Eng. Vol. 81, No. 84, 1955.
2. The 1951 Kansas City Flood by Mr. Barney, Keith R. Proc. Am. S. C. Eng. Vol. 81, Nov. 1955.
3. River Soundings by Helicopter by Mr. Holden, Otto. Water Power, Vol, 8 No. 1956. 1.

NEED FOR CONSERVATION OF WATER IN PAKISTAN

By S. MONAWAR ALI*

The Author, while speaking at the monthly meeting of the Institute of Engineers, Pakistan, states that the inequitable partition of this sub-continent has jeopardised our existence and it is not for our future progress but for our existence that we need conservation of our water resources.

THE history of dam construction is the history of development of civilization. The technique of masonry dams developed by Romans and improved by the Muslim rulers of Spain was taken to the West by the Spaniards. The science was introduced into America by Spanish Missionaries who constructed the Old Mission Dam on the San Diego River in 1770. Since then thousands of big and small dams have been erected in that country. Only California State alone can boast of more than 600 dams of all dimensions and denominations. It may not be far wrong to say that dams to a very large extent are responsible for the progress and prosperity of that country.

(The following are a few excerpts from his talk.)

Fire is man's best friend and his greatest enemy. The same is true of water. It turns barren lands into smiling meadows and moves the wheels of industry in man's service. Lakes, seas, rivers and glaciers are doubtless a boon for mankind. But if unharnessed and left to their own erratic ways they can cause extensive damage. After all who has not experienced or at least seen the devastation wrought by floods.

Like water, which exists in so varied forms and volumes, the subject of its conservation is also very vast and covers many fields of physical science and engineering. But this article deals in general terms with only one form of conservation of water i.e. by impounding it in artificial lakes and reservoirs.

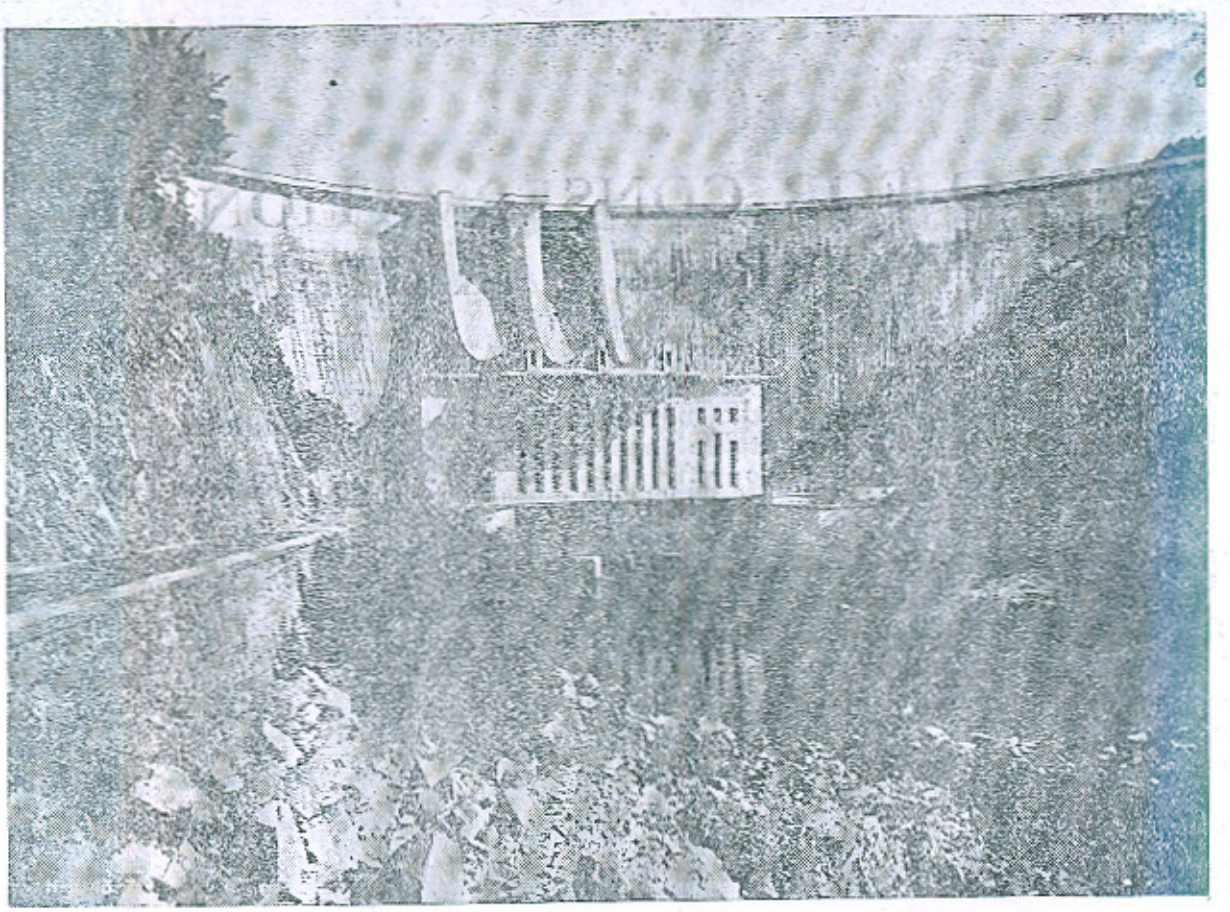
AS OLD AS CIVILISATION

A dam is probably one of the earliest structures devised by man. It has played a big role over the ages in providing food, water, power and protection from floods. Archaeological evidence places the date of construction of a well-planned dam much before 5,000 B.C.

The history of dam construction is the history of development of civilization. Technique of masonry dams developed by the Romans and improved by the Muslim Rulers of Spain was taken to the West by the Spaniards. This science was introduced into America by Spanish missionaries who constructed the Old Mission Damon the San Diego River as far back as 1770. Since then thousands of big and small dams have been erected in that country. California State alone can boast of more than 600 dams

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* Executive Engineer, Mangla Dam Project.



St. Etienne Cantales on Cere River.

of all dimensions and denominations. It may not be far wrong to say that dams to a very large extent are responsible for the progress and prosperity in that country.

ALLAH DIN'S LAMP

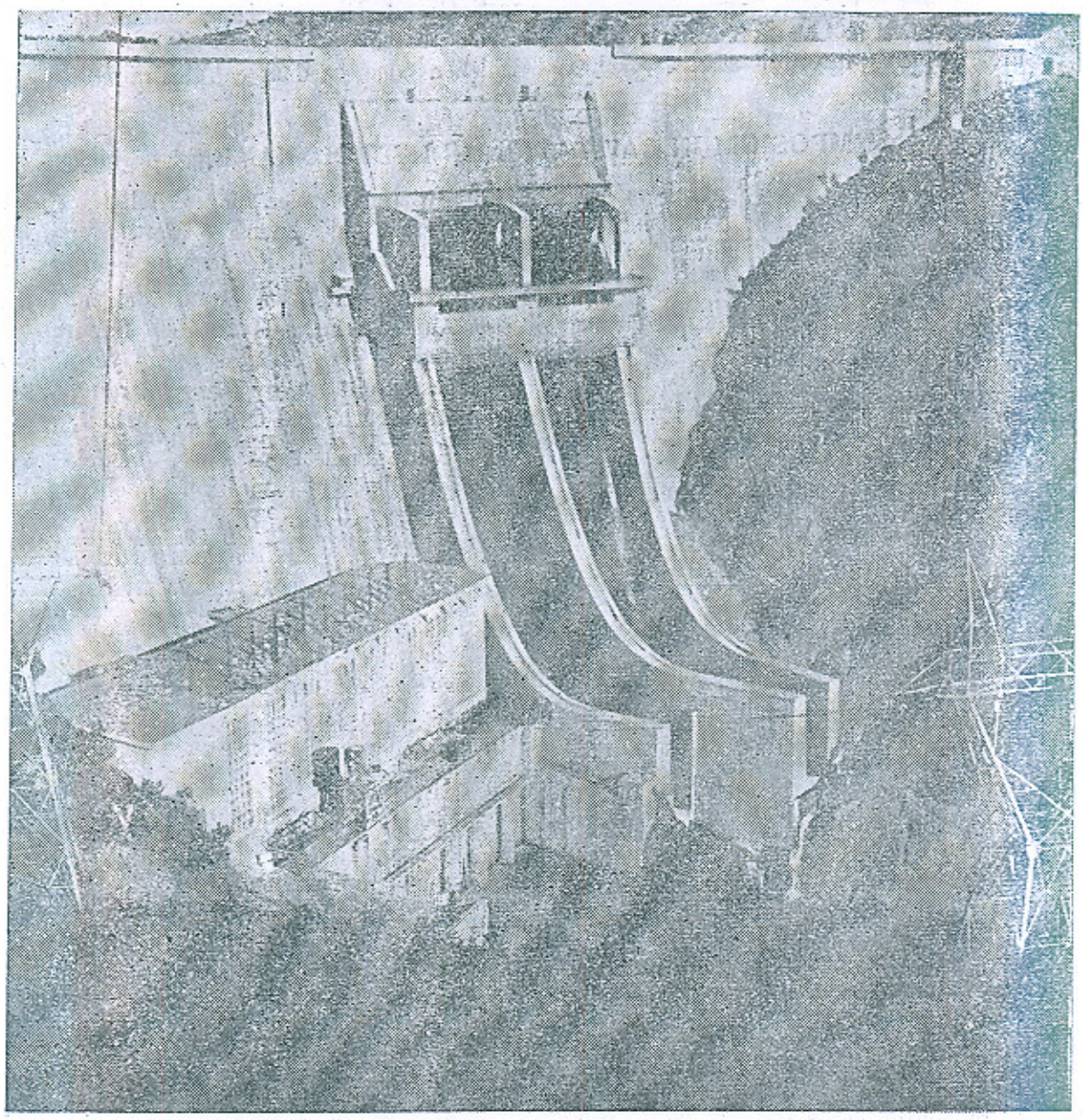
A dam is a veritable Allah Din's lamp that can capture this giant of water power and press it into the service of starving millions. That is exactly what every country is trying to do. Countries like Iran and Ethiopia have got dozens of projects under construction. Egypt has even risked its very existence and world peace for the sake of Aswan Dam. After all what is the background of this Suez crisis—Egypt's dream to build that colossal earthen dam costing more than six billion rupees. And that precisely is a crying need of this country.

Inequitable partition of this sub-continent has jeopardised our existence. And it is not for our future progress but for our very existence that we need conservation of our water resources. Nature has provided us with every thing that we need in this connection. It is now up to us to find out and develop suitable sites for building up dams.

DAM DESIGNS :—From functional point of view dams can be classified broadly under two major categories. Dam that provides protection against floods and the dam that stores or controls water. Structurally, modern dams can be divided into four categories such as earth-fill, rock-fill, a masonry and concrete. Each of these types are further sub-divided according to the mode of construction, arrangement of material or its design specifications.

PROGRESS IN DAM DESIGN

Early dam building was purely an art depending solely on experience. That art gradually gave way to science. The planning and design of a dam are now based on better physical and mathematical research although sound judgement and knowledge of fundamentals still play a vital role. In the field of earth dams, 390-foot Mud Mountain dam is already being surpassed by a 500-*foot* dam now being designed in the United State Bureau of Reclamation and even that is no longer considered to be the last word. The colossal Aswan Dam in Egypt is also proposed to be a zoned earth structure which will impound 105 miliion-acre feet of water (about 30 times that of Mangla reservoir) and will cost more than 6 billion rupees.



Castelo Do Dode Dam Zezere River, Portugal.

In the early days when earth was not favoured for construction of dams to retain great depths of water the apparent strength of masonry walls caught the imagination of the builders. But in its early days even a masonary dam, like an earthen embankment, was not made scientifically. Often a masonry structure had so enormous dimensions that the water flowing over them for centuries could cause no appreciable damage to this day.

Gradually the conception of resultant pressures, uplift, internal stresses, shear distribution, sliding, etc., were brought in and the designs were based more and more on physical and mathematical laws. The research in the fields of cement and concrete gave impetus to concrete dams and introduced a host of other problems.

Improvement in the concept and treatment of these problems still continues. The 726 feet high Hoover Dam is no longer a marvel and already stands eclipsed by 922 feet Grand Dixence Dam in Switzerland. Even this height by no means is the limit to which a concrete dam can be raised.

SYMPOSIUM IN CAVITATION IN HYDRODYNAMICS

The National Physical Laboratories, London recently held a symposium on Cavitation in Hydrodynamics in which a number of articles were read.

Her Majesty's Stationery Office, York Horne Kingsway, London, has published these articles. We reproduce below the subject of articles for the interest of the members.

1. A critical review of recent progress in cavitation research by Mr. Eisenberg, P.
2. Some factors affecting the inception of cavitation, by Mr. Williams E. E. Menulty, P.
3. Tensile Stresses in flowing water, by Mr. Ziegler, G.
4. Turbulence and boundary layer effects on cavitation inception from gas nuclei, by Mr. Daily J.W. Johnson, E.
5. The tensile strength of liquids under dynamics stressing., by Mr. Davies, R.M. Lewis, G.M. Trevena, D.H., Ress, N.J.M.
6. Undissolved air cavities as cavitation nuceli, by Mr. Strasberg, B.
7. Instrumentation for the measurement of fluctuating forces pressure intensities and velocities in studies of cavitation, by Mr. Appel, D.W.
8. Techniques for pressure pulse measurements and high speed photography in ultra source cavitation, by Mr. Ellis, A.T.
9. Instrumentation for the A.R.L. water tunnel and rotating beam channel, by Mr. Ritter, H.
10. The six-inch water tunnel at St. Authory Falls Hydraulic Laboratory and its experimental use in cavitation design studies, by Messrs Straub, L.G. Ripke, I.F. and Olson, R.M.I.
11. Some reflections on model scale formulae for cavitation phenomenon, by Mr. Gerber, H.
12. Air entrainment at the rear of steady cavity, by Mr. Cox, R.N. Clayden, W.A.
13. Preliminary observations on a geometrically similar series of model screws, by Mr. Silver, Leaf, A.
14. Ship propeller cavitation patterns, by Mr. Weeks, A.F.
15. Hydrofoils in non-cavitating and cavitating flow, by Mr. Plesset, M. S., Parkin, B. R.
16. Super cavitating flow past foils and struts., by Mr. Tulin, P.
17. Effect of static pressure differences on the cavitation characteristics of hydrofoil profile report A. The case of high static pressure, by Mr. Numachi, F.
18. A suggested mechanism of erosion damage, by Mr. Callis, G.T.

(Continued on page 78)

INVESTIGATION FOR GROUND WATER

GEORGE A. La ROCQUE JR.*

Conservation of water is a prime necessity for maximum agricultural production in West Pakistan. Conservation can be only through safe and wise utilization of all waters. Water must be used to conserve it because it is a renewable resource.

The first consideration in the conservation of water must be acceptance of the principle that all waters—ground and surface—are one and inseparable. The second consideration is acceptance of the principle and fact that the ground-water reservoirs are an integral part of West Pakistan's total water-facilities storage capacity.

A ground-water investigation is the measurement of the several hydrologic factors and determining the relationship of these factors one to another and to the geologic (including soils), topographic and physical characteristics of the area. At all times in a ground-water investigation the following should be the foremost in the investigator's mind:

1. Application of logic and logical methods.

2. That there are no "rubber stamp" methods to follow.

3. That 95 percent of the measurements made, maps and curves drawn and analyses run may be discarded, not because they do not fit in the investigator's pre-conceived of concept of conditions, but because the "hydrological balance-sheet" will not balance throughout. But if time and necessity warrant these, discarded measurements can be fitted properly into the picture.

4. Ground water has no magical properties and always follows natural physical laws,

(*a*) It cannot cross a divide or valley of the aquifer it is flowing through

(*b*) Always moves along the path of least resistance and all other things considered along the greatest hydraulic gradient.

INVESTIGATION'S END-POINT

The next thing to be kept in an investigator's mind is the reason for and end-point of an investigation, be it for :

1. General availability of water or,
2. Specific availability of water for:
   - (*a*) Municipal and industrial water supply ;
   - (*b*) Irrigation water supply.
3. Specific problems connected with :
   - (*a*) Drainage of agriculture lands, including salinity control
   - (*b*) Drainage of industrial areas and facilities :
   - (*c*) Intrusion of salt water into and aquifer,
   - (*d*) Flood protection, specifically protection or stability of levees, bunds and dams etc;

The general categories of an investigation to be considered are :

I. Soils and geology of the area
   A. Soils mapping and land calssification

* Groundwater Engineer, Project Advisor, West Pakistan Water Survey,

1. Soils chemistry.
2. Soils physical characteristics.

B. Geological mapping.

1. Aereal distribution, continuity and origin of deposits.
2. Sub-surface geology.

a. Depth and extent of aquifers and acquicludes.

b. Physical characteristics of the aquifer and aquicludes.

3. Geo-chemistry.

II. Hydrology.

A. Hydrologic investigations, including special studies, analysis, interpretation and basic research.

GROUND WATER		SURFACE WATER
Occurrence	..	Rainfall-runoff
Movement	..	Qualitative
Storage ..	..	Quantitative
Recharge ..	..	Storage
Natural Discharge	..	Distribution
Perennial yield	..	Losses and gains
Artificial discharge	..	Chemical quality
Chemical quality	..	Silty movement

B. Hydrographic investigations, including data collection, processing, review and publication

Stream flow, ground-water levels, ground water discharge, chemical quality, silt content.

Many of the factors may be grouped along similar activities and for specific purposes.

1. Determination of the physical character, distribution and continuity of the soils and water-bearing materials through soils, land-classification and areal and sub-surface geology.
2. Determination of the vertical and lateral extent of the waterbearing materials and their ability to transmit and store water, through geophysical explorations, test drilling, tubewell, drilling and aquifer tests.
3. Determination of the amount of and changes in the amount of ground water in storage through measurement of ground water levels.
4. Determination of recharge and discharge to and from the ground-water reservoirs, through measurement of gains and losses to or from rivers, canals and drains; evaporation, transpiration and consumptive losses; infiltration of rainfall and applied irrigation water.
5. Determination of distribution and chemical character of all waters.

When the factors are all related one to another and summed up into an adequate and pertinent reports, the necessary amount of applied water together with the numbers, capacity, type and density of the required facilities may be determined, in the case of West Pakistan for—salinity control, drainage control and optimum water development and distribution.

SYMPOSIUM ON CAVITATION

(*Continued from page 76*)

19. Further studies of the mechanics and damage potential of fixed type cavities., by Mr. Knapp Rober, T.
20. Some experiments on cavitation erosion in water mixed with air, by Mr. Rasussen, R.E.H.,
21. Mechanism of cavitation erosion, by Mr. Wheeler, W.H.

MORE PAPERS ON CAVITATION

Published recently by Tokyo University (Japan) Series B. (Technology) Vol, 5, 1955 are.

22. Cavitation tests on hydrofoil profiles suitable for arrangement in cascade.
    (*a*) 5th report on Effect of Minor Variation in profile dimension, by Mr. Numachi, F.Abe. S., Kawai, M.
    (*b*) 6th report on Effect of difference in water temperature, by Mr. Numachi, F and Chida, I.
    (*c*) 7th Report on three profiles belonging to types 1″ and 2″ of 8% thickness ratio, by Mr. Numachi, F. Chida, I and Kawashima, D.
    (*d*) 2nd Report, by Mr. Numachi, F. Abe, S. Tokee Un, Vol, 2, 1952.
23. Cavitation by Mr. Eggestad, I, Lovstad, C.D., Teknisk Ukeblad, Norway.

SOME MAJOR IRRIGATION SCHEMES IN FRONTIER

By SARWAR JAN KHAN*

As a brief descriptive note in the scope of this Project has already appeared in the earlier issue of the Engineering News, it is not intended to discuss it again in this article that is confined to the up-to-date progress.

Broadly speaking the project can be sub divided into the following two phases:—

Phase I.

1. Construction of weir across the Kurram river at Kurram Garhi.

Estimated cost	..	Rs. 2.5 M.
Capacity	..	1,50,000 cusecs.
Earth work	..	1.53 M. cft.
Rock cutting	..	0.113 M. cft.
Masonry work	..	0.58 M. cft.

This work is 100% complete.

2. Construction of canal head regulator.

Estimated cost	..	Rs. 0.64 M.
Capacity	..	3,800 cusecs.
Earth work	..	1.56 M. cft.
Rock cutting	..	0.374 M. cft.
Masonry work	..	0.284 M. cft.

The work is 100% complete.

3. Construction of 500 feet long lined tunnel (located immediately down stream of canal head regulator).

Estimated cost	..	Rs. 0.494 M.
Capacity	..	3,800 cusecs.
Rock cutting	..	0.32 M. cft.
Masonry work	..	0.153 M. cft.

The work is 100% complete.

4. Construction of lined Upper Main canal R.D. to R.D. 6350.

Estimated cost	..	Rs. 1.63 m.
Capacity	..	3800 cusecs.
Earth work	..	12.9 M. cft.
Rock cutting	..	0.106 M. cft.
Masonry work	..	0.13 M. cft.

The work is 100% complete.

5. Construction of lined Lower Main canal R.D. 0 to R.D. 5,000.

Estimated cost	..	Rs. 1.08 M.
Capacity	..	1,400 cusecs.
Earth work	..	9.9 M. cft.
Rock cutting	..	1.35 M. cft.
Masonry work	..	0.3 M. cft.

The work is 100% complete.

6. Construction of flood channel R.D. to R.D. 21,900 for feeding additional supplies into Kachkot during flood season

Estimated cost	..	Rs. 0.8 M.
Capacity	..	800 cusecs.
Earth work	..	9.86 M. cft.
Rock cutting	..	1.35 M. cft.
Masonry work	..	2.95 M. cft.

The work is 100% complete.

7. Construction of Kachkot feeder channel from R.D. 0 to R.D. 17,560.

Estimated cost	..	Rs. 2.91 M.
Capacity	..	600 cusecs.
Earth work	..	30.9 M. cft.
Rock cutting	..	0.331 M. cft.
Masonry work	..	0.56 M. cft.

The work is 88% complete and the remaining work is likely to be completed by the end of the current financial year.

8. Construction of feeder links to connect the existing civil canal to new Kachkot feeder.

* Deputy Chief Engineer, Irrigation Branch, Peshawar.

Estimated cost .. Rs. 1.5 M.

The average progress on these link channels is about 50%. The delay in completing the channels which are fairly *straight-forward* is due to the controversy regarding allocation of available supplies to the existing irrigated land. The case is pending with the Government for final decision.

9. Construction of power houses and inlet works.

The civil work portion is 90% complete and the remaining 10% will be completed after the installation of the machinery by the Electrical Department. The cost of the civil works of the hydel portion of the scheme is estimated at Rs. 1 million. The civil works have been designed and executed by the Irrigation Branch. The entire electrical machinery has already arrived at the site, and its installation is in hand. It is hoped that the work will be completed by the end of the current financial year.

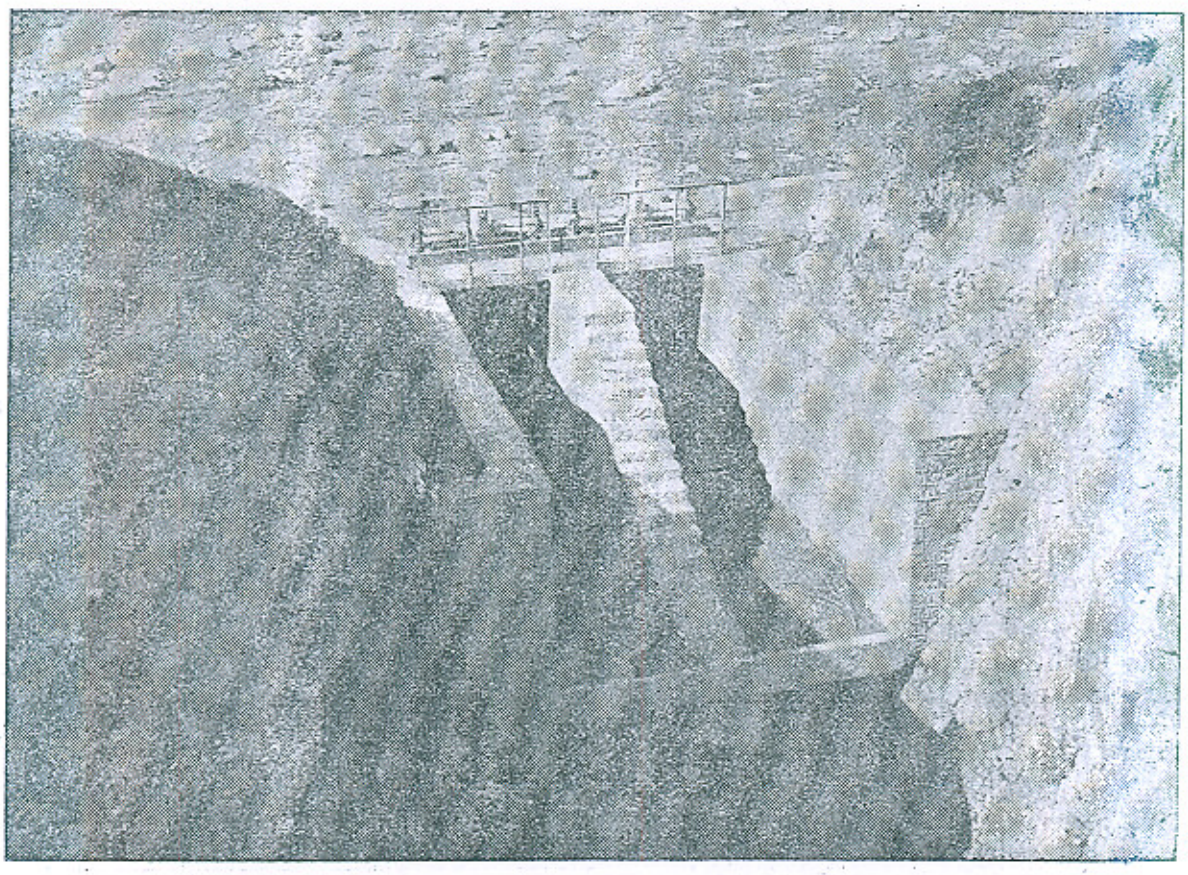
Hence that Phase I of the project will, unless something unforeseen happens, be completed by the end of the current financial year. The approximate cost of the Phase I is estimated to be Rs. 12.2 million.

PHASE II.

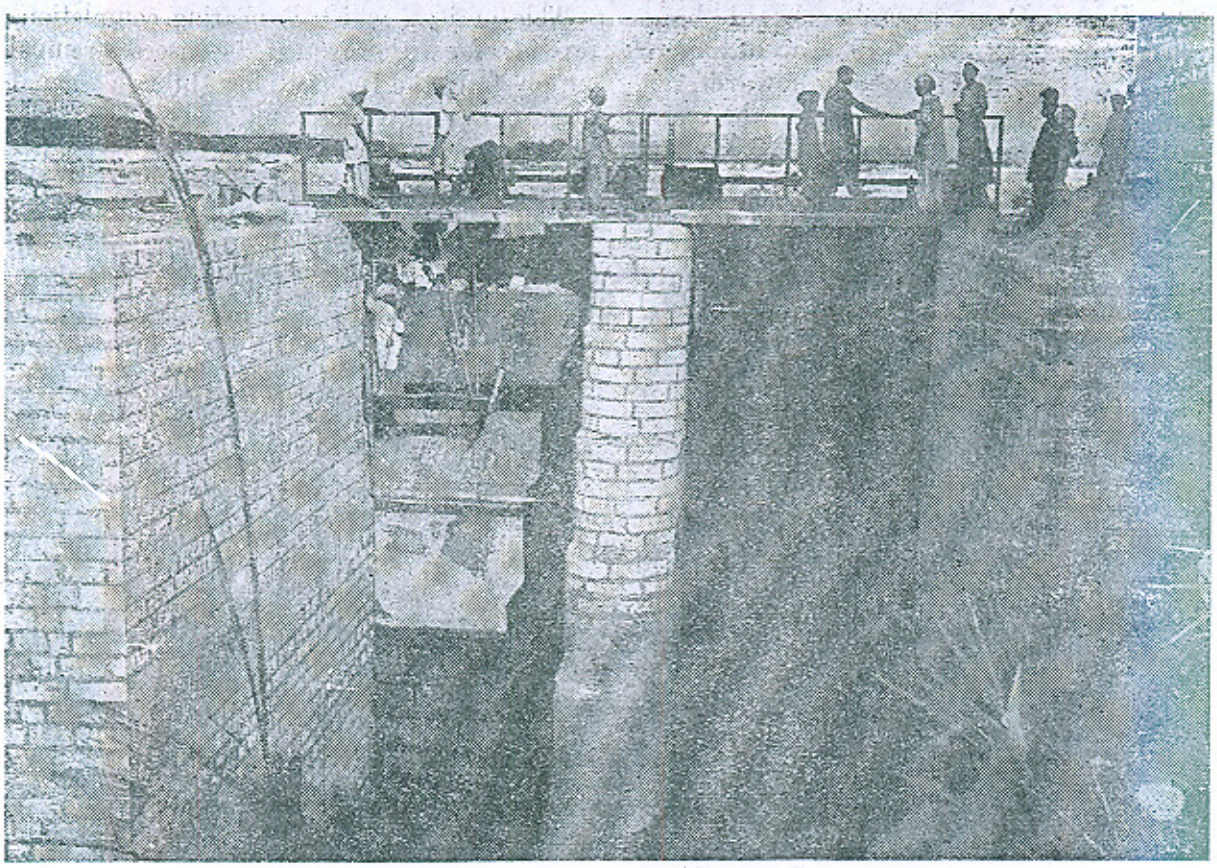
1. Lined Feeder channel to Baran Dam Reservoir.

Estimated cost	..	Rs. 1.7 M.
Capacity	..	1,600 cusecs.
Earth work	..	6.3 M. cft.
Rock cutting	..	2.2 M. cft.
Masonry work	..	0.23 M. cft.

The work is 100% complete.



Head Regulator of Siran Canal.



Head Regulator of Pehur Canal.

2. Construction of Baran Dam.

Approximate cost		Rs. 10.04 M.
Capacity	..	87,000 A. ft.
Length	..	3,300 feet.
Height	..	120 feet.
Total earth work		93.12 M. cft.
Up-to-date progress		40.33 M. cft.
Total rock cutting		2.8 M. cft.
Up-to-date progress		0.9 M. cft.
Total masonry work		13.2 M. cft.
Up-to-date progress		4.57 M. cft.

The overall progress of the work is 36%.

3. Construction of right bank canal R.D. to R.D. 217200.

Estimated cost	..	Rs. 10.05 M.
Capacity	..	800 cusecs.
Total earth work	..	113.9 M. cft.
Up-to-date progress		82.5 M. cft.
Total rock cutting	..	0.152 M. cft.
Total masonry work		4.00 M. cft.
Up-to-date progress		1.88 M. cft.

The overall progress is 34%.

4. Spill weir channel (capacity 40,000 cusecs).

The work is being designed by the Central Design Office, Irrigation Directorate, Lahore.

5. Construction of inlet tower and provision of control valve.

The order for this machinery has been placed with the Director-General, Supply and Development, after negotiations for it with a German firm.

6. Construction of subsidiary channels taking off from the Right Bank Canal.

Total estimated cost		Rs. 35.75 M.
Total earth work	..	25.13 M. cft.
Total masonry work		2.1 M. cft.

Up-to-date overall progress on these subsidiary channels is 62%.

7. Earth moving machinery worth about Rs. 30 lakh has been acquired for the construction of the Baran Dam.

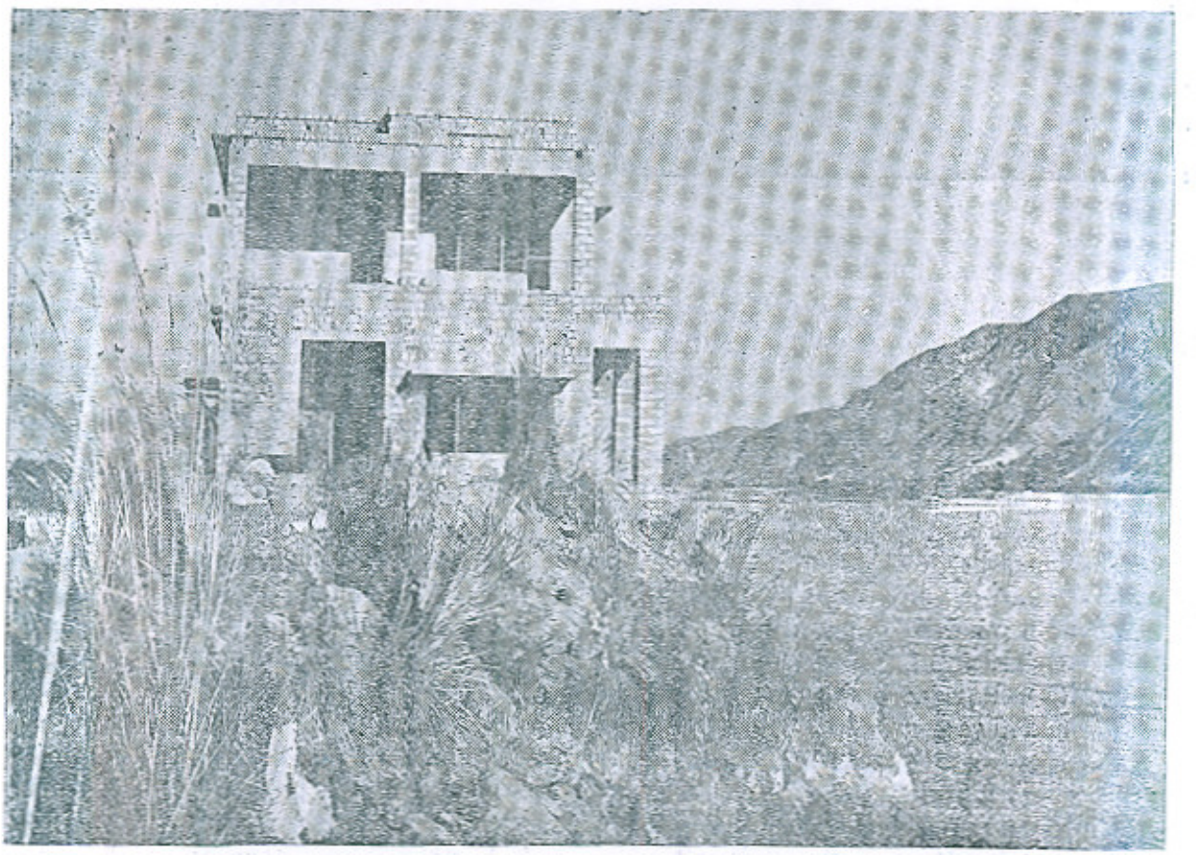
The Baran Dam actually should have been completed by kharif 1957 according to the original schedule.This would, however, not be possible, because, due to delay in the receipt of earth-moving machinery and the spare parts, the anticipated daily out-put of 1.5 lakh cft. could not be achieved. The average progress, due to breakdowns, has been of the order of 60,000 to 70,000 cft. Apart from the difficulty in getting the machinery, the order for the supply of inlet valve etc. has been delayed due to late supply of the design by the U.N. Expert. Nevertheless it is hoped that second phase of the scheme would be completed by the end of 1958 at the latest.

II. Pehur Flow Irrigation Scheme.

Pehur Flow Irrigation Scheme is located in Swabi Tehsil, Mardan District, Peshawar Division.

This project, which is nearing completion, provides for withdrawal of 250 cusecs perennial supply from the Indus River, through a canal aligned on the right bank. The headwork of the channel is located about 35 miles away from the Attock bridge. The cill level of the head regulator has been, so fixed that it would be possible to feed the canal, by gravity, even when the river is lowest. The total length of the canal is about 56 miles including 3 minors, and it will irrigate about 48,400 acres of existing Chahi and Barani area of Swabi Tehsil. The yield in this area, which is uncertain at present, is expected to rise to 10,000 tons with the regular supply of water.

The work on this project began towards the end of 1954, and was expected to be completed by the end of 1955. It has, however,



Pehur Rest House.

unfortunately not been possible to do so, due to unforeseen difficulties like appearance of hard rock in the first four miles of the channel, and the heavy flood damages during 1955-56 and 1956-57. It is, however, expected that the canal would be completed by the end of the current financial year i.e. in time for Kharif 1957.

The total estimated cost of the project is Rs. 70 lakh.

The construction of this channel involves the following quantities of work :—

(i)	Rock excavation ..	14.9 M. cft.
(ii)	Digging in hard soils ..	39.00 M. cft.
(iii)	Earth filling ..	8.5 M. cft.
(iv)	Masonry work (involving the use of 2,400 tons of cement & 300 tons of steel.) ..	0.663 M. cft.

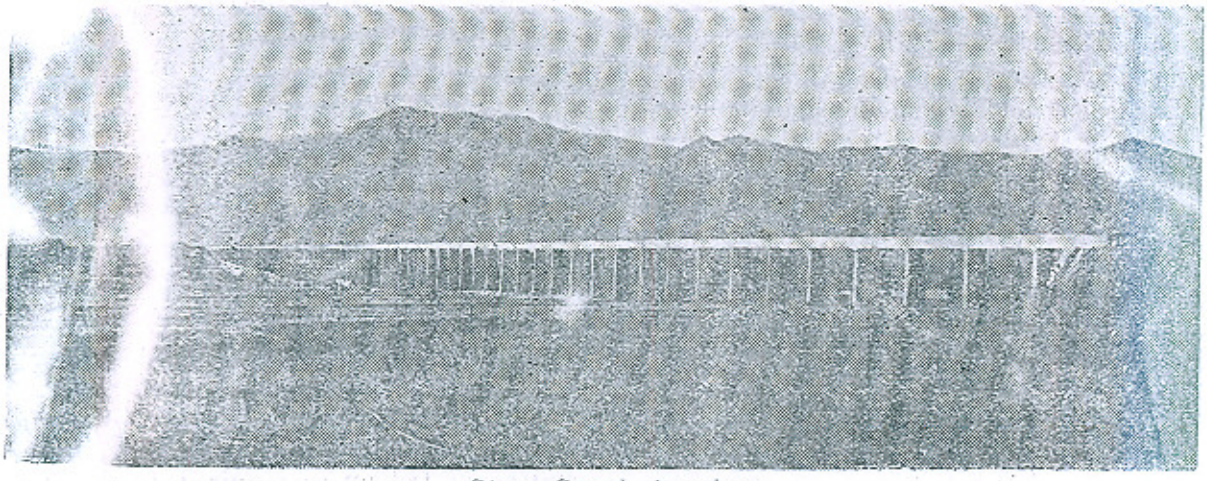
III. Siran Canal.

Siran Canal takes off from the River Siran in Hazara District of the Peshawar Division. This project, which is first of its kind in the irrigation *practice,* involved the construction of a contour channel, 17 miles long, including two minors. The channel, which has been completed in April 1956 at a cost of Rs. 9.2 lakh has a capacity of 30 cusecs, and will serve an area of 6,000 acres in the Pakhli plain of the Mansehra Tehsil. Although this area is situated at an elevation of 3,300 and has average rain-fall of 40", yet continuous droughts and erratic rainfall do a considerable damage to the crops.

The channel takes off from the left bank of the Siran river, at a point, about two mile sdownstream of Shinkiari Police Station. After winding its way round the precipitous hill spurs, over a distance of about 8 miles, it eventually debouches into the Pakhli plain area.

The river levels at a point of the off-take of the channel are such that it has not been considered necessary to provide a diversion weir in the river bed for feeding the channel. In winter season, when the river is low, it will be necessary to construct a temporary boulder diversion bund from local material for feeding the channel. The channel has, however, been provided with a proper head regulator with a view to control the entry of the water into the channel during summer season when the river is high.

The striking engineering feature of this channel is the raised aqueduct at RD 47,800 which is 2,500 feet long and carries the channel across the natural depression measuring 35 feet at the deepest point in the centre.



Siran Canal Aqueduct

GANGES - BRAHMAPUTRA MULTIPURPOSE PROJECT

The Institute of Engineers, Pakistan, has published a 56-page pamphlet describing the main features of Rs. 4,000 million Ganges-Brahmaputra Multipurpose Project. In this article the author, Mr. Mosharraf-ud-Din Ahmad, has summarised the main features of the scheme as under.

The main objects of the Ganges-Brahmaputra multi-purpose project in East Pakistan are:—

(A) Flood control, .. (B) Power production.

(C) Irrigation, .. (D) Reclamation of saline areas

and (E) Navigation.

(A) Flood control will be achieved by :—

(*i*) Prevention of spilling of the Brahmaputra river and its tributaries, the Teesta, Dharla, etc., and control of discharge of its branches, the old Brahmaputra, Dhalleswari, Lohajung, etc.

(*ii*) Reduction of the water level at Chandpur, thereby improving the slope of the Meghna, old Brahmaputra, Dhalleswari rivers and all other rivers discharging into them.

(*iii*) Flood escape for the Gumti floods.

To secure the above-mentioned conditions the following works are proposed.

1. Diversion of the Ganges by means of a cross-dam near Pabna and canalising its floods through its many old spill channels of the districts of Kushtia, Jessore, Khulna and Faridpur.

2. Containing the Brahmaputra floods within a reasrvoir to be created by two marginal embankments, starting from the northern border of East Pakistan and terminating at a barrage on the Padma near Bhagyakul.

3. Provision of a high-level flood escape canal for the Gumti river approximately two miles down-stream of the eastern border.

(B) Power production—At the barrage 75,000 causecs, at an effective head of 50 ft., is available for production of electricity. It will give 2.5 lakh K.W. for the industrial development of East Pakistan.

(C) Irrigation—The reservoir, will be able to supply any quantity of water for Kharif crop (seldom needed) and 22,000 cusecs for the second crop. This 22,000 cusecs will be augmented by another, 3,000 cusecs from outside the reservoir and will irrigate 30,00,000 acres for a second crop.

(D) Reclamation—Embankments are needed in the area lying in the south of the Khulna, Jessore and part of Barisal districts which cannot grow any crop due to attack of brackish water of the sea as a direct result of absence of pressure of upland fresh water. The Chandana, Gorai, Bhairab, Harihar, Mukteswari, Kobadak, Kholpetua, Kalindi, and Bhudder rivers, will be revived and connected up as required to divert the entire Ganges flood to the big estuaries lying in the south of the Khulna district.

(E) Navigation—The revived spill channels of the Ganges river and the Brahmaputra reservoir will provide more than 1,000 miles of new all-weather navigation channel for the country. The reservoir will be provided with a navigation lock for the purpose.

MAIN CHARACTERISTICS OF THE PROJECT.

1. Area of agricultural land in East Pakistan which is usually affected by the floods of the Brahmaputra, Ganges and Meghna rivers—79,06,560 acres.

2. Percentage of area brought under this flood control scheme—100%.

3. Water for second crop—30,00,000 acres.

4. Water for principal crop when needed. 79,06,560 ,,

5. Reclamation of saline area area 10,00,000 ,,

6. Hydro-electricity 2.5 lakh K.W
2,190 million K.W.H.

7. New lines of navigation—1,000 miles.

8. Important hydraulic structures,

(*i*) Sluices-5 Nos. total capacity 6 lakh cusecs.

(*ii*) Barrage 1 No.

(*a*) length 6,000 ft.
(*b*) Ht. over flood—88 ft.
(*c*) depth below floor—94 ft.
(*d*) 470 16 x 10 vents.
(*e*) concrete volume 5.2 m.c. yd. approx.
(*f*) excavation volume 3.0 m.c. yd. approx.

(*g*) Cost Rs. 1,250 million approx.

(*iii*) Flood escape (large) 1 No. capacity 5 lacs causecs.

(*iv*) Flood escape (small) over Gumti-1 No. capacity 13,000 cusecs.

Ganges spill channels to be improved. Chanadana, Gorai, Bhairab, Kobadak, Harihar, Mukteswari, Khopetua, Bhudder and some of their spill channels,

9. Estimate of the cost.

First phase.	.. Rs.	36.5 crore.
Second phase.	.. Rs.	144.5 ,,
Third phase.	.. Rs.	189.5 ,,
Establishment.	.. Rs.	11.0 ,,
Contingency.	.. Rs.	18.5 ,,
TOTAL	Rs.	400 crore (approx)

10. Estimate of revenue.

Annual expenses.	.. Rs.	9.30 crore.
Annual income	.. Rs.	16.04 ,,
Net revenue.	.. Rs.	6.74 ,,

11. Direct benefits :—

Total present requirement of foodgrains in East Pakistan are 19 crore maunds.

Extra food grains per year from :—

(*i*) Irrigation.		6,00,00,000 Mds.
(*ii*) Reclaimed saline lands.		2,00,00,000 Mds.
(*iii*) Flood protected lands		1,60,00,000 Mds.
Total.		9,60,00,000 Mds.
(*iv*) Value	Rs.	80 crore.
(*v*) Increased national income due to industrial development	.. Rs.	100 crore.
(*vi*) Security against flood damage	.. Rs.	25 crore.
Total(iv, v and vi)	Rs.	205 crore.

DACCA SYMPOSIUM

East Pakistan held its science conference on January 7 and 8, 1957, in which a symposium on Scientific and Technical development in East Pakistan was also held.

Dr. Annas Ali spoke on the role of man-power, river power and solar energy in the development of both small and heavy industries. Dr. S. D. Choudhary explained the progress in the field of jute research in East Pakistan.

Dr. Daud Ali discussed the prospects of soil survey for industrial use. Mr. Abdul Hakim spoke on Education and Psychology.

The conference later on split up into various sections. The sections of Physics and Mathematics, Medical and Natural resources by Prof Hussain, Col T.D. Ahmad and Dr. Qudrate Khuda respectively.

BRIEF INTRODUCTION TO PAPERS DISCUSSED IN THE 41ST SESSION OF THE CONGRESS

During the 41st session of the Congress held from February 14 to 16, 1957 five papers on various subjects of national importance were read and discussed and a symposium on housing problems in West Pakistan was held. In this article we have given a brief introduction to each paper and the main sub-heading of the symposium.

PAPER NO. 323.

Dr. A. G. Asghar and his colleagues read a paper on the "Use of Indigenous Sulphur for Lowering Soil Alkalinity". The paper is based upon the investigations carried out in the Land Reclamation Directorate laboratories on the semi-field scale. Sulphur and its compounds have long been used for lowering the soil alkalinity. In West Pakistan it was never used even on a small scale, due to its prohibitive cost and lack of adequate information on the subject with reference to the local soil conditions.

In other countries, apart from its use as a fertiliser and ameliorant, sulphur and its compounds are extensively used in reclamation of alkaline soils. Unfortunately in this country no attention has been paid to the use of sulphur for counteracting the menace of high alkalinity of soils having free sodium carbonate or where PH of the soil was very high due to the presence of sodium in exchange complex.

The effectiveness of sulphur is due to its oxidation and presence of calcium compounds in soils. The final stage of oxidation of Sulphur is sulphuric acid which acts on calcium carbonate and releases calcium for exchanging sodium from the clay complex. The action can be represented by the equation.

$$H_2SO_4 + 2CaCo_3 + 4Na + clay = Ca + clay = Na_2SO_4 + 2Na\,HCO_3$$

Considerably large quantities of native sulphur are available about 21 miles from Nakundi Railway Station in the Quetta Division on the Kol i-Sultan. Specimen of high grade sulphur were obtained from the site and used in the investigations.

The beneficial effects of the use of indigenous sulphur in the reclamation of non-saline alkali soils are described in the paper.

The paper contains a detailed bibliography on the subject and several tables showing the results of investigations.

PAPER NO. 324.

The second paper was on "Influence line for Continuous Concrete Bridges", read by Mr. A. A. Jamal-ud-Din, Superintending Engineer, B & R Branch. The author has put forth a simple method to design a continuous bridge in concrete that normally has not been adopted due to the intricacies of the design. Usually, the problems in continuous spans are solved on the determination of final moments at supports. But many variables are involved in the solution.

The ratio between the length of spans in a unit and the manner in which the moment of inertia of a member varies between supports greatly influences the final moments. The solution gets simpler if for a particular span ratio, the moment of inertia of a member

between supports is uniform; but with variable moment of inertia, the process becomes lengthy and laborious.

The time and labour involved in the design of continuous bridges with variable moment of inertia have thus deterred the designers from adopting continuous construction where it would have been a logical choice.

A set of influence lines for continuous spans in units of three or four for various combinations of span lengths having symmetrical or unsymmetrical members with variable moment of inertia has been drawn for final moments at supports. A design procedure based on these influence lines has been presented to afford the facility and ease with which continuous concrete bridges can be designed.

Several new methods have been developed in the past few years for the analysis of indeterminate structures making it possible to reduce greatly the labour involved in design. Some of these new methods are further explained by diagrams and tables. The set of influence lines presented here for the final moments at supports is yet another attempt in this direction. Continuous bridges in concrete may now be designed with a little more time than is required to design simple span structures.

PAPER NO. 325.

"Sedimentation of Reservoirs on Indus Basin River System" by Dr. Nazir Ahmad and Mr. Abdul Hamid present the basic data of the important rivers of West Pakistan. Four categories of rivers have been studied. These are: (1) mainly snow-fed (2) snow-fed and rain-fed (3) flashy streams and (4) Monsoon nullahs. Total suspended sediment content, classified into sand, silt and clay on monthly and yearly basis, sediment intensity and precentage of each constituent is given in the paper.

This basic information is most essential for any storage project. as siltation of a dam is of paramount importance for a country like Pakistan which has very few suitable sites. Probable rate of sediment deposition in the storage schemes that are already in hand i.e. Warsak, Kurram Garhi and Mangla, is also discussed alongwith comparision of the data of similar rivers of other countries, including India. It is hoped that initiation of this topical subject when the country is undertaking some storage schemes will be of great interest and importance.

PAPER NO. 326.

"Chuharkana Acquifer Test" by Sayyed Hamid and Mr. M. S. Minhas was the fourth paper read and discussed in the conference. This paper was based upon investigation which are in progress by Ground Water Development Organisation in co-operation with I.C.A. of America. For proper installation of tube wells to supplement canal supplies and as anti-water logging measures, estimation of thickness of aquifer, storage co-efficient and transmissibility constant is most important. The authors have described in this paper results of two tests conducted by them near Lahore-Sheikhupura road on Chichoki Mallian drain. As this was the first paper of its kind ever discussed in the Congress the theoretical aspect of the pumping tests was described in details.

SYMPOSIUM ON HOUSING PROBLEM IN WEST PAKISTAN

Housing and settlement aspect of national development has a vital importance to social political and economic life. The problem is limited not only to provision of some space for shelter but also concerns the over-all planning as it has direct bearing on the health and well-being of the people. Housing, therefore, has many aspects, each inter-linked, and requires careful analysis, The West Pakistan Engineering Congress, therefore, took up this problem by discussing some of the aspects through a symposium held in its annual session on 14th February, 1957 at the University Hall. Khan Muhammad Inamullah Khan, President of the Congress, was in the chair. Ten different aspects of the problems were presented at the symposium in the papers read by the engineers, town planners and officers of Social Welfare Department and Village Aid Administration.

THE nature, extent and magnitude of the housing problem in West Pakistan was presented by Mr. S.A. Rahim, Town Planner, Lahore Improvement Trust. The speaker laid great stress on preparation of statistical data to guide the country in assessing the number, type and standards of houses in the urban and rural areas of West Pakistan. Rapid increase in population, according to him, is becoming a problem as it works out to half a million person per-annum. In terms of accommodation it means additional 100,000 houses each year. The present population in urban areas in West Pakistan is estimated to be approximately 8,000,000.

The housing requirement on the basis of a family unit of 5 persons works out to 1.6 million dwellings. The data on the number of houses or their condition is not available. Even if it is assumed that 10% of the houses in the urban areas require re-building then, we would need another 160,000 houses. This percentage in view of the speaker was rather low and according to him it may be as high as 25 %. The rough estimate of the total shortage in urban areas of West Pakistan at present is between 500,000 to 600,000 leaving the requirement of 100,000 houses for normal increase in population. Assuming that a house may cost about Rs. 3,000/- including cost of land and development, it would mean an expenditure of Rs.1800,000,000. The housing problem for normal increase of population in the towns would claim another Rs. 300,000,000/- per year.

RURAL AREAS

In the case of rural areas, he said, there were about 38,000 villages in West Pakistan with an average of 150 houses in each village. Assuming every family in the village has some sort of a house the shortage of houses in the rural areas may not be very much but there was a greater need for improving environments and essential services. The villages as well as most of the urban areas were devoid of drainage, proper water supply and other social facilities. All this would cost Rs. 25,000/- per village or a total of Rs. 1,000,000,000/- for the whole of the rural area of West Pakistan. This amount, he said, did not include expenditure on improvement of houses.

APPROACH TO HOUSING PROBLEM

Suggesting a solution of the problem in the urban areas Mr. Rahims said since neither the Government nor individuals could

incure such a huge expenditure on house building. Suggesting a solution to the problem in urban areas, Mr. Rahim said, since, neither the Government nor private organisations could afford such a huge expenditure on house-building on a large-scale, the following procedure might be of some help :—

1. Improvement trusts should be set up to provide developed sites either on long-term lease or on instalment basis spread over a period of 10 to 20 years.
2. House-building Finance Corporation, banks, insurance companies and other organisations should advance loans.
3. Restrictions should be placed on the size of house in order to conserve material and prevent inflation.
4. To encourage private enterprise for building houses for low income groups, no property tex should be levied for 10 years on approved type of houses. Income from rents or instalments of such houses should not be taxed for the same period.
5. Evacuee lands should be available for building houses.

Concluding, Mr. Rahim stressed the need for drawing up the housing programme. It should be begun by setting up a department of housing and settlement for drawing up a programme and its implementation. The department would also canduct surveys to collect data of requirements of each area or community. All available resources of men, materials and money will be exploited. Targets will have to be laid down for the completion of the programme.

SOCIAL ASPECTS

Dealing with the social aspect of housing, Mr. M. H. Shah, Deputy Secretary, Social Welfare Department, said that in planning new housing schemes the planner should not only aim at providing adequate and healthy living conditions to the family but also provide services which would keep the people physically healthy, make people life richer and complete and full of creative activities for the benefit of themselves and the community. The development of areas where houses or settlements do not allow the formation of communities and where no community life springs up and people live as isolated families, social and political unstability are greatest. Mr . Shah also laid stress on encouraging the people to improve their environments by self-help.

Community activities can be explained and demonstrated to the people to give them an idea how their environments can be improved by working together. He gave instances of the community work now in progress in Dharampura and Misri Shah. Social work under trained staff was taken up. Quietly and slowly the social workers started livening up the community and bringing them closer together. After sometime the people saw the deficiency in their housing and their sorrounding not as something which could not be cured and so had to be endure but as problems which posed a challenge to them. These people now have taken concrete steps to make their life worth living. They are improving sanitation and drainage of the area, building roads and paths, organising clubs and opening schools. They have also decided to build with their own labour a community center.

OTHER ASPECTS

Khan Bashir Ahmad Khan, Under-Secretary, Social Welfare Department, discussed the financial and administrative aspect of the problem. He quoted satistics to point out that 90% of the population in this country earned less than Rs. 100/- per month per family. The cost of living had arisen from Rs. 100/- to 196/- and the cost of housing has gone up from 100/- to 400/-. The housing programmes and policies should, therefore, be formulated keeping in view these limitations. He was of the idea that the financial and administrative aspect of the housing problem are wedded to the economy of the country. The means in

this country are extremely limited. There is need for economy in the area under settlement. He compared the standard evolved for use of land in the country with those of U.S.A. and called for strict economy in the use of land.

Discussing the experience gained in developing satellite towns he stressed that in future planning more thought must be given to providing the amenities like underground sewerage. They cannot pay for the water required for flush system and according to him amenities which cannot be maintained by the people. does not deserve to be provided.

Mr. Bashir Ahmad also stressed on intensive land use to reduce the land acquisition cost. The multiple storied houses according to him merited serious consideration as the people like to reside near their business places.

SLUMS AND THEIR EFFECTS

Mr. Irshad Ahmad, Assistant Town Planner, Lahore Improvement Trust, speaking on "Slums Clearance" said that the problem had three aspects. Firstly ways and means to catch up with the arrears caused by under-building have to be evolved; secondly, to check recurrance of shortage or organising supply of new dwelling sufficient to house the annual increase of population; and thirdly to find out how to demolish and replan the slum areas of the city. Many factors lead to the creation of slums. Higher the fluctuation, the greater the complication in finding out housing shortage of the town. Recurrance of shortage is due to constant immigration of the population in a town where all industry and trade is concentrated He said that till the time economic conditions become favourable for slum clearance certain steps should be taken to improve the situation. He suggested that the people should be taught to develop spirit of self-help through propaganda and demonstration. The Government should extend assistance in the form of building material and labour to those who cannot execute essential repairs, white-washing or minor alterations. Dilapiated buldings should be demolished and the areas cleared should be reserved for final development. He further said that at this stage of our national development much stress should be laid on the durability of houses and controlled planning of the new areas as haphazard building and cheap constructions quickly turn these areas into slums.

URBAN DEVELOPMENT

Mr. Mazhar Munir, Assistant Provincial Town Planner, read a very illuminating paper on the urban development. The paper provides a useful data that may serve as guide for future planning. He discussed various town plans in West Pakistan and their short comings and suggested major changes in their formulations so that they can play an effective role in the development of new areas. Mr. Mazhar Munir recapitulated the activities from 1947 to 1950 and the period after 1950 in respect of the development urban areas. The creation of Urban Development Department in the Punjab and framing of urban development policies was discussedby him in great detail.

He also discussed about provision of back-lanes area and width of roads and streets and road-patterns, the density of population, land acquisition and the costs of the various satellite towns schemes. He said that a very important section of the administration connected with urban development advocated the view that the standard of public service should be lowered for the people of the lowest income group. But for the town planners, he said, it is quite clear that the lowering of the standards is a retrograde step and cannot be justified on financial grounds.

The economic spiral is such that if a piped water supply scheme costs. Rs. 100,000/- to-day, in another ten years the same system would cost Rs. 300,000/-. Therefore, provisions of public service would become more and more difficult as years go by even if the

financial position of the Government or local bodies improve.

PROPER HOUSE

Mr. Mazhar Munir discussing the cost of C & D class houses said that a proper house for a family must have two rooms, as one-room house cannot be justified on any ground, moral, hygienic or social. The C type houses that were built in the beginning for the lowest income group had two rooms and cost about Rs. 3000/- to 3500/- which do not include the cost of development and land. Later on the Urban Development Departments built a large number of D type single room houses leaving space for one or two more rooms.

These houses cost about Rs. 1500. Now a view is being expressed that the standard or specification should be so much lowered as to bring down the cost of one-room house to under Rs. 1,000/-. Mr. Mazhar Munir opposed this view as he considered that whatever was being built to-day should be durable enough to last for at least 30 to 40 years instead of crumbling into slum within a couple of years. Therefore, he said, that a planner would always emphasise quality rather than quantity.

RURAL HOUSING

No rural development scheme would be complete if it did not include within its purview the prospect of improving housing conditions in the rural areas. This point was discussed by Raja Muhammad Afzal Khan, Director, Village Aid Administration, who read a paper, on rural housing. According to his experience the villagers are generally convinced that the housing structure which has been in vogue for centuries is the only one suitable to village conditions. He gave several reasons and arguments, put forth by the villagers. In this context he suggested that the following important considerations should be kept in view:—

1. The new houses should not be more expensive than the hovels we aim at replacing.
2. They should be hygienic and meet the psychological needs of the occupants.
3. They should be simple, attractive and comfortable.

This problem calls for the services of engineers, architects, builders, educationists, public health experts, economists, psychologists, statisticians, publicity advisers and the people who know the village problems first hand. He suggested that the people should co-operate on definite lines to collect data, analyse it and provide the experts with correct facts and statistics on demand and also start designing low cost houses on the basis of first hand information of the village problems.

BUILDING MATERIALS ORGANIZATION

Production of building material has remained scattered and unplanned in this country. Mr. A. A. Jamal-ud-Din Superintending Engineer, Buildings and Roads dealing with this subject stressed the need for raising the building material production to the level of a small-scale industry to start research in developing new types of materials and fix their standard and quality He suggested immediate development of pre-cast concrete units for various structural purposes, improvement in the method of production of bricks and conserving coal by necessary change in the type of kilns at present in vogue.

Discussing the hurdles comings in the way of producing better and cheaper building materials, Mr. Jamal-ud-Din said that it was essential to have central building materials organisation for the formulation of problem and subsequently to translate the findings in a manner useful for the common man. The functions of this department will be :—

1. To the survey demand for building materials for various purposes and to make recommendations with regard to production, distribution and use of traditional and other building materials.

2. To develop methods for the most economical use of materials in short supply and to advise on the import of such materials.

3. To evaluate the suitability of substitute or new methods and help in the standardisation of material.

4. To organise wide publicity of materials and techniques and direct private enterprise into better use of resources.

5. To co-ordinate in the result of researches already made and to conduct investigations in the production of new materials and types and to improve on the existing methods of production.

6. To bridge the gap between research and its application.

7. To survey the quantitative and qualitative requirements of building labour for various purposes and to encourage training programmes.

LOW-COST HOUSES

Mr. Ghias-ud-Din Habib, Superintending Engineer, Buildings & Roads Branch, discussed the subject of low cost houses. He suggested introducing new system of prefabrication, hollow block, soil cement stabilised, and shell roof structures. Stressing the above types of construction, he stated that, organised research on an extensive scale should be taken in hand on new methods of construction using indigenous materials. To give practical shape to the out-come of research work, model colonies should be established in different parts of the country with different climatic conditions.

ESSENTIAL SERVICES

Mr. Mukhtar Ahmad, Assistant Director (B&R), dealt with the essential services and their effect on development cost. He said that the pattern of society had changed and social values were now keenly realised. The man wants that his house should be in a good hygienic sorroundings which is easily accessible to business and industrial areas and community centers by quick means of transport, that good water is available in plenty and there are means for the efficient disposal of waste water and excreta. Discussing how far these essential requirements are being provided for him, he gave a comparative account of the development that has taken place in the new satellite town schemes recently. He said that:—

(*a*) The utilization of net area for housing affects the development cost per kanal.

(*b*) The division of residential plots into small units increases the length of roads, water supply and sewerage distribution and increases the development cost, as will be apparent from Ghulam Muhammad Abad Scheme and Industrial Labour Colony.

(*c*) Where disposal works are situated at a distance from the scheme, greater length of the main sewer increases the cost as in the case of Montgomery Satellite Town Scheme and Multan Schemes No. 1 and 2.

(*d*) A balanced area with equal size plots above one kanal and below one kanal is most economical as in the case of Sargodha Satellite Scheme.

(*e*) Development cost ranges between Rs. 5,000 to 7,000 per acre.

(*f*) Provision of water supply and sewerage cost about 70% and the balance 30% is spent on roads and levelling of the area.

(*g*) The best distribution of land for various uses will be—roads 25%; open spaces and lawns 10%, community buildings 5%, residential areas 60%.

(*h*) Open spaces and lawns should be so located that water supply and sewerage distribution lengths are fully utilised and should not require detour around these areas.

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231. Theory and Physics of Seepage losses from Canals.—,K. R. Sharma.

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276. Engineering Economics of the design and construction of dams.—S. I. Mahbub and C. L. Handa.

277. Silting tanks on the Western Jumna Canal.—H. L. Vadera.

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292. Flood control investigation for west Pakistan—M. A. Rahim, I. A. AZafar and S. M. Niaz.

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310. Test of bs theory—Abdul Latif.

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312. Drainage of Irrigated soils in Arid Regions—Dr. A.G. Asghar & Dr. Nazir Ahmad.

313. Water allowance for Reclamation in High water table a Dr. A. G. Asghar and Ch. Mohammad Ata-ur-Rehman.

314. Planning of Tube well Projects—I.A. Zafar.

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317. The design and construction of Deg Supper Passage on Marala—Ravi Lilnk—S. M. Niaz & Nafis Ahmad.

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ABSTRACT OF RECENT PAPERS

1. Maritime and Waterways Division Meeting, Institution of Civil Engineers, March 20, 1956.

By Mr. N. A. Matheson, M.I.C.E., M.I. Mech. E.

In this Paper attention has been drawn to some aspects of the lay out and construction of dock roadways and railways, quayage, transit sheds and warehouses, with special regard to their effect on handling general cargo. Some of the requirements for efficient road, rail, and shed working are set out briefly. The figures given in the Paper are only intended to illustrate in a very general form the main features mentioned above.

(2) The Investigations, Design and Construction of Paya Lebar Airport, Singapore. By J. J. Bryan, B.Sc., M.I.C.E.

(Airport Division Meeting, Institution of Civil Engineers*. April 24, 1956.)

The paper deals with the investigations and survey of the site, giving physical properties of the soils encountered, the variation in depth of the water-table, and the methods used for determining the thickness of the runway and taxi-track pavements. A suggested method of determining, by direct measurement, the ultimate bearing capacity of a soil under a sealed pavement at a known height above the water table is described.

(3) The use of gunite as a Structural Material: A Survey of Developments, 1930—1955 By Mr. T. Whitley Moran, B.A., B.A.I., M.I.C.E., M.I. Struct E.
(Institution of Structural Engineers. February 9, 1956.)

The use of gunite began around 1925. It was at first chiefly used for maintenance work on concrete structures and for protecting corroded steelwork. Today the most important application lies in the systematic reconditioning of weathered reinforced concrete structures by restoring them to a state as good as new and thus avoiding reconstruction.

Gunite is composed of cement and sharp sand mixed together in a dry state, and projected from a cement gun through a delivery pipe. Hydration takes place at the discharge nozzle. The most useful structural properties of gunite are its density and the physical bond to a suitably prepared concrete surface.

(4) Hydrographic Surveying for Civil Engineering Development By Lieut.-Commander A. D. Margrett, R.D., R.N.R.

(Royal Institute of Chartered Surveyors, March 15, 1956.)

The purpose of this paper is to introduce a land surveyor to hydrographic surveying and, in particular, to its application to civil engineering, e.g., in new port location, submarine pipe-line laying, cable laying, dredging, wreck location, bridge construction, dumping of industrial waste, etc. The author briefly discusses the general aspects of each of these applications before proceeding to deal with the methods of survey employed.

(5) Use of Vibration for the Deep Compaction of Granular Soil by Mr. Frederick L. Cassel, M.I.C.E., M. I. Struct. E.

In many parts of the world there are large accumulations of relatively loose granular soil, mainly sand, often of aeolian origin, which have such low density that they are highly compressible and quite unsuitable for