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THE NEW IRRIGATION ERA

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RHYME AND REASON

“ Whonever you are wrong, admit it
whenever you are right, keep quiet.”

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UNION MINISTER FOR IRRIGATION & POWER VISITS CHEPAUK LABORATORIES

The Madras Public Works Department hails the appointment of Dr. K. L. Rao as Union Minister for Irrigation and Power which is an unprecedented honour to an Engineer in the country. We wish that he may rise to greater eminence in his new assignment.

Dr. Rao graduated in Engineering with Honours from the Madras University. He was also the first recipient of the Research Degree in Engineering (M.Sc.) of the Madras University.

He worked in the Cauvery-Mettur Project for more than 8 years and later as Assistant Professor in the Engineering College, Guindy, Madras. He went to U.K. for higher studies and took his Doctorate in Engineering from the Birmingham University of the United Kingdom. Dr. Rao was the first Indian to hold a research scholarship and later Senior Lectureship in an Engineering Institution in the U.K. He was a lecturer in the Loughborough College of Technology. It was while he was in U.K. he wrote the well-known standard text-book on R.C. Concrete.

Even while he was in England he was deputed by the Madras Government to the United States of America to visit the various Dams and meet the experts in connection with the proposed Ramapadasagar Dam across the Godavari.

On his return to India Dr. K. L. Rao was appointed as Designs Engineer in the Madras P.W.D. He formed the Concrete and Soil Mechanics Laboratories and organised the Central Designs Office, Madras. They started with the preparation of the plans, specifications and designs for the Ramapadasagar Dam. Subsequently, detailed designs and specifications for

the Lower Bhavani and Tungabhadra Dams were also prepared under his guidance.

In December 1950, Dr. Rao joined Central Water and Power Commission as Director and later became Chief Engineer also. From 1st October 1953 he came to be borne in the cadre of the New Andhra State. From March 1956 to December 1961, when he retired from the service he was the Member of the Central Water and Power Commission in charge of designs and research. He was responsible for the design of many river valley projects such as Hirakud, Kosi, Chambal and Nagarjunasagar.

He served many Institutions. He was President of the Institution of Engineers (India) for two years, President, Indian National Society of Soil Mechanics and Foundation Engineering, President of Central Board of Irrigation and Power and Vice-President of the International Society for Soil Mechanics and Foundation Engineering. He has visited different parts of the World including U.S.A., U.S.S.R., China and Europe.

He is the recipient of the President's prize on three occasions for the best papers published in the Journals of the Institution of Engineers (India). He was awarded the Honorary Degree of D.Sc. by the Andhra University. The President of the Indian Union conferred on him the National honour of 'Padma Bhushan' on the Republic Day (1963) in recognition of the meritorious service rendered by him.

In March 1960, as President of the Central Board of Irrigation and Power and Member, Central Water and Power Commission in charge of design and research, Dr. Rao visited the Concrete and Soil Laboratories and discussed with the staff here the progress on the various

items of Research being carried out in these Laboratories under the auspices of the Central Board of Irrigation and Power. The guidance and advice of Dr. Rao have been instrumental in the furtherance of research in this State.

Recently as Union Minister for Irrigation and Power, Dr. Rao paid a visit to the Irrigation Research Station, Poondi on 1st October 1963 and to the Concrete and Soil Laboratories, Madras on 2nd October 1963. The member (Planning and Progressing), Central Water and Power Commission accompanied the Minister. At Poondi the Minister evinced keen interest in the model studies for sediment exclusion from Grand Anicut Canal. The details of the studies on control of evaporation from open water storages were explained to the Minister at Budheri. The Minister was very much impressed with the research activities of the Station. In the Concrete and Soil Research Laboratories, he appreciated the work that is now being done. The encouraging sentiments expressed by Dr. Rao will go a long way in enhancing the initiative and enthusiasm for further research work.

Later in the evening the Officers of the Public Works Department were 'At Home' to

Dr. K. L. Rao, in the P.W.D. Buildings, Madras.

Retired Chief Engineers of the P.W.D. Sri N. Padmanabha Ayyar, Sri T. S. Venkatarama Ayyar, Sri J. M. Frederick and Sri U. Ananda Rao were present at the function by special invitation. The party and the meeting were largely attended by the Chief Engineers and other officers of the P.W.D.

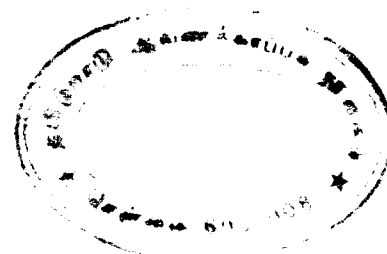
Sri J. G. Abraham, Chief Engineer (General) welcoming Dr. K. L. Rao traced briefly the achievements of Dr. Rao in the academic and Engineering field. He pleaded for better status for Engineers in the society and State and stressed the early introduction of the All-India Service of Engineers.

Dr. Rao in his address expressed deep appreciation for the great talent and high professional standards of Madras Engineers and exhorted every one to be more aggressive so that their talents will be better recognised at the centre.

Sri K. V. Ekambaram, Chief Engineer (Irrigation) concluding said that the very presence of Dr. Rao in the midst of the P.W.D. staff is a matter of inspiration to the engineers.

"If eternal vigilance is the price of liberty, endless effort is the price of progress."

Dr. K. L. Rao.



Dr. Rao arrives at the P.W.D. Offices.



Dr. Rao discussing in the Concrete Laboratory regarding the use of Sapindus Emarginatus as an air entraining agent.

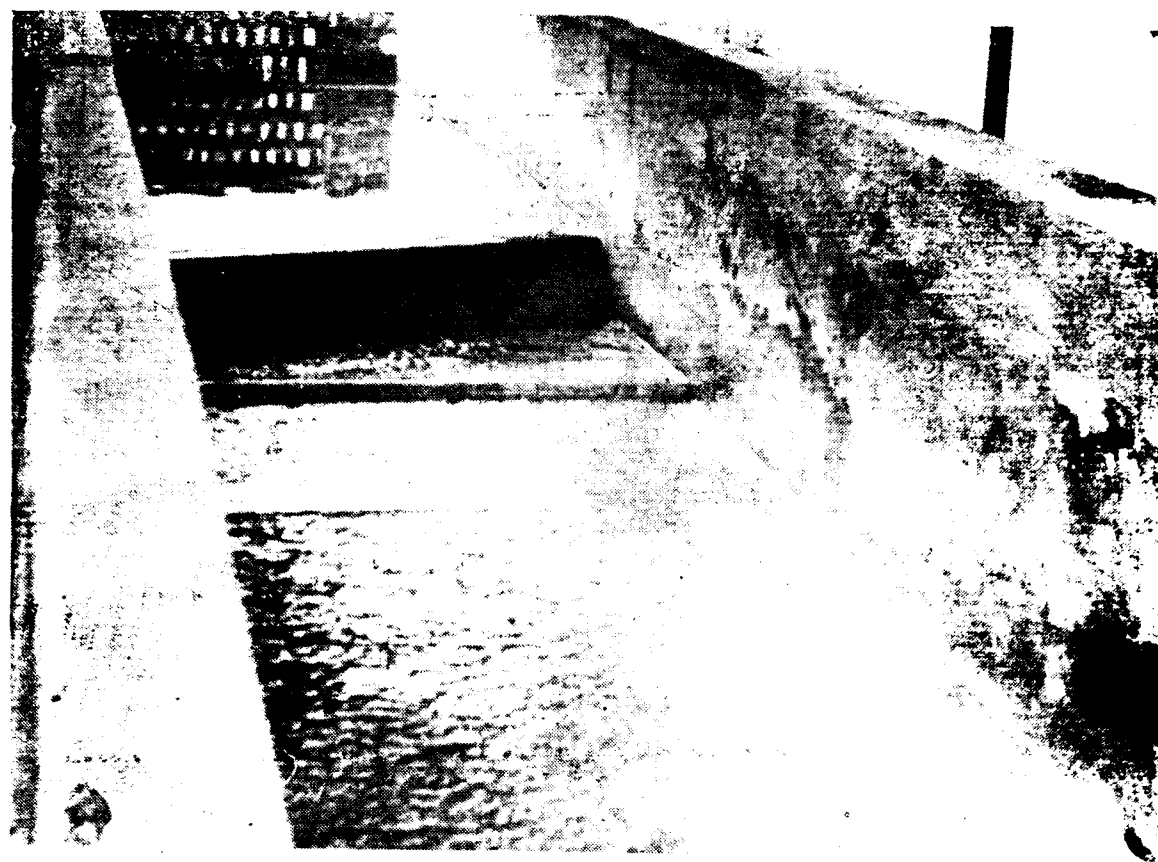


Photo 1: Dry Model Anicut.

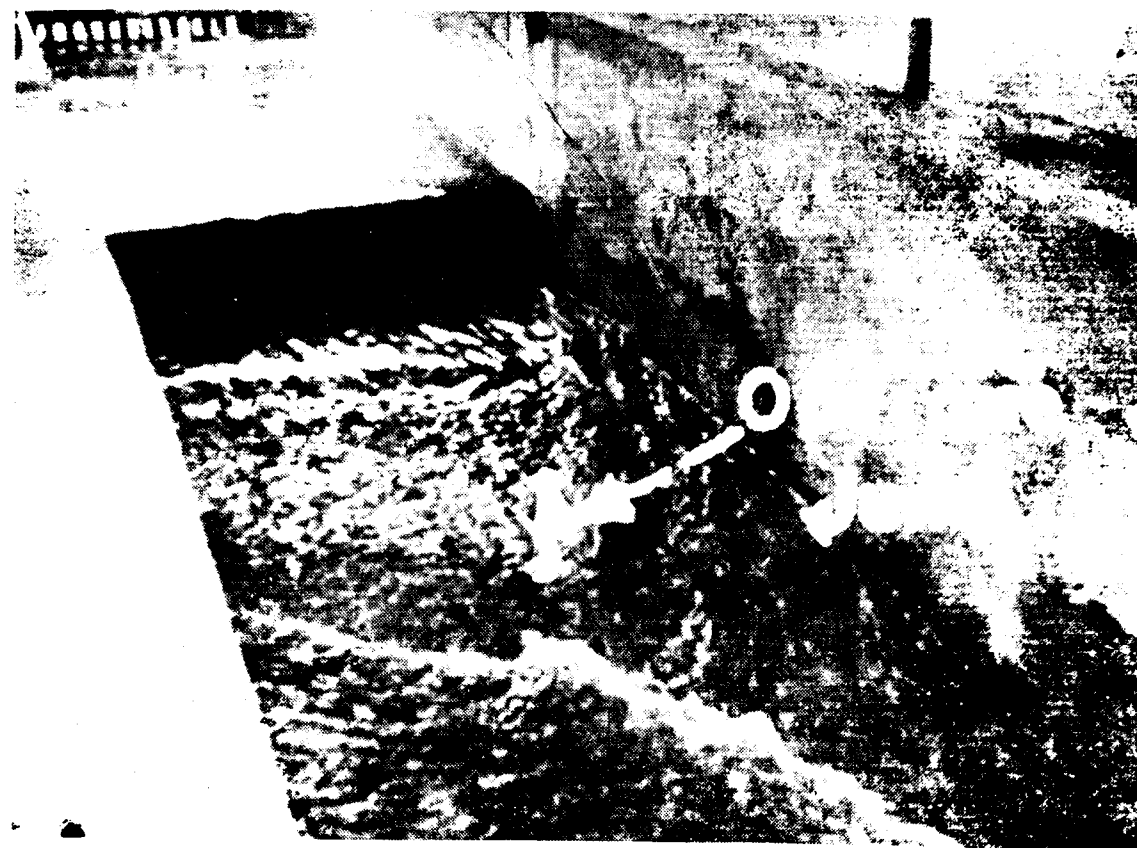


Photo 2: Anicut with Oblique Jump.

DISCHARGE CHARACTERISTICS OF OBLIQUE ANICUTS

By

SRI K. T. Ganapathy, B.E. (Hons.)*

SRI Albert Nathaniel Raj, B.E., **

SRI V. Ramanathan, B.E., ***

Synopsis.

The flow characteristics of oblique anicuts have been observed in a model. Studies have been conducted on the co-efficient of discharge of the same. Procedure to assess the co-efficient for any obliquity of the anicut is indicated. Method of assessing the net increase in discharge is also suggested. A practical example has been worked out.

Introduction.

Anicut is a primary structure in a minor irrigation system and is meant for diversion of flow for irrigation purposes. Quite often field officers decide on the adoption of an oblique anicut on account of economy indicated by the favourable foundation details. It is known that with an oblique anicut even though the total discharge over the whole length may increase, the co-efficient of discharge decreases. Another disadvantage in the case of oblique anicut will be that there will be parallel flow along the upstream face which may damage the upstream talus and thus call for cross groynes upstream of and at right angles to the anicut. Unfortunately there is no definite information regarding co-efficients to be adopted in the case of oblique anicuts. A short term study was made on the flow performance and co-efficient of discharge of oblique anicuts and this paper presents the result of this.

Experimental set up.

Experimental set up consisted of a long flume 4.344 feet (1.324 metres) wide across

which anicuts with different obliquity can be constructed with end contractions fully suppressed. Anicuts with obliquity of 15° , 30° , and 45° were tested, the last mentioned being considered as almost the upper limit of obliquity (vide photo-1). Necessary stilling arrangements on the upstream consisting of honeycombs, baffles, etc., and measuring arrangements in the downstream in the form of a right angled 'V' notch were made. Water levels were read with the aid of a foot gauge with a least count of .001 ft. (.03048 cms.). Standard anicut profile as adopted in one of the anicuts here was used. Oblique anicuts were constructed always with the profile at right angles to the line of anicut.

Experiments and observations.

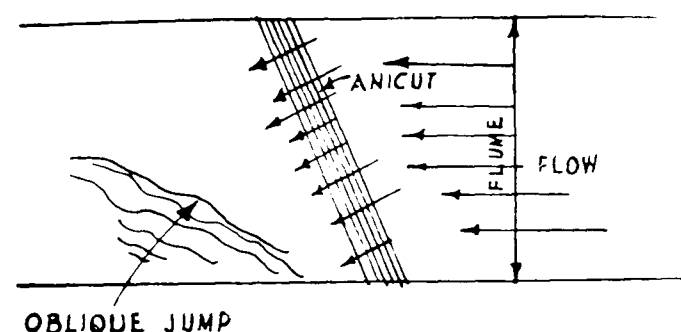
Experiments were conducted as follows.—A low constant inflow was first maintained. After conditions settled, the head of overflow over the weir and that over the 'V'-notch were noted and recorded. The inflow was slightly increased and when constancy was attained the two readings were again noted down. Thus pairs of readings for head of overflow and head over 'V'-notch were noted for progressively increasing inflow up to a maximum value. Standard tables were used for obtaining the discharge for head over 'V'-notch. Co-efficient of discharge (C) in the general formula $Q = CLH^{3/2}$ was calculated for each pair of observations and a graph was drawn for co-efficient (C) Vs head of overflow (H).

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First set of observations were made for a weir, normal to flow. Next, weirs with obliquity of 15° , 30° and 45° with the normal anicut were experimented upon successively.

Observations of flow characteristics.

In the case of oblique anicuts it was observed that for all heads of overflow up to the maximum of 0.30 ft. (9.144 cms.) the flow became almost still at the upstream pond and the flow over the weir took place normal to the alignment of the weir and not parallel to the flume (see sketch below).



This is considered to be due to the lack of sufficient overflow over the crest of anicut, in excess of the height of the model anicut. On account of this turn given to the flow direction, there was a concentration of flow on the left side thereby giving rise to an oblique jump on the left half of the flume as shown in the same sketch referred to above. (Vide photo 2).

It is felt that in the field this concentration of flow may endanger the bank connections on that side. The effect of cross flow (shown in arrows parallel to the anicut in the sketch) was clearly visible by the undulated nature of the nappe falling over the weir.

Co-efficient of Discharge.

Computations for finding out the co-efficient of discharge were made based on the actual (oblique) length of the anicut. These curves are shown in figure-1. It can be seen that reduction in co-efficient of discharge over that of a normal anicut increases as the obliquity increases.

Increase in total Discharge.

Computations were also made to arrive at the increase in total discharge as percentage increase over that of a normal anicut. The curve of percentage increase in discharge Vs percentage increase in length is shown in figure-2. It can be seen that the percentage increase in discharge is not proportional to percentage increase in length but gradually falls.

The variations of percentage reduction in co-efficient with obliquity is shown in figure-3.

Conclusion.

As a result of the studies it is confirmed that the co-efficient of discharge will be reduced in the case of oblique anicut and the reduction in co-efficient increases with increase in obliquity. This is to be expected as in the case of the oblique anicuts there will be cross flows across the falling nappe the severity of which is likely to increase with increase in obliquity.

Eventhough there is reduction in co-efficient indicating reduction in discharge per foot width there is a net increase in discharge due to the increase in length of anicut which reduces the head of overflow for passing a given flood discharge. This will in consequence reduce the cost of flood banks and other bank protection works upstream.

Figure-3 can be used to arrive at the co-efficient of discharge for any obliquity up to 45° provided, the co-efficient over a normal anicut can be reasonably assessed.

Figure-2 can be used to arrive at net increase in discharge for any obliquity provided the discharge over a normal anicut can be computed.

Example.

An anicut has to be constructed across a river to pass a maximum flood discharge of 2,095 cusecs (59.32 cumecs). The head over crest of anicut should not exceed 3.0 feet (0.9144 metres). Width of the river = 100 feet (30.48 metres). The co-efficient of discharge (C) of the

designed anicut section in the formula $Q = CLH^{3/2}$, is 3.50 (=1.932). Find out the angle of obliquity that is required to pass the above flood discharge and the co-efficient of discharge of the anicut, in its oblique position?

$$Q = C L H^{3/2}$$

When Q is the discharge in cusecs (cumecs).

C = Co-efficient of discharge.

L = Length of anicut in ft. (metres).

H = Head over crest of anicut in ft. (metres).

$$L = 100 \text{ ft.}, C = 3.50; H = 3 \text{ ft.} \\ (30.48) (1.932) (0.9144).$$

Maximum discharge that can pass through with 3 ft. head (0.9144) for the normal anicut. $Q_1 = 3.5 \times 100 \times 3^{3/2} = 1819$ cusecs (51.50 cumecs.)

Maximum flood discharge in the river = 2095 cusecs (59.32 cumecs.)

Percentage increase in discharge

$$= \frac{2095 - 1819}{1819} \times 100 = 15.20 \text{ per cent.}$$

From figure 2.—Percentage increase in length of anicut, required for this increase in discharge = 18.90%.

Length of oblique anicut = $100 + 18.9 = 118.90$ ft. (36.24 metres).

$\therefore$ angle of obliquity required = $32^\circ - 45'$ (1)

$$\left[\cos \phi = \frac{100}{118.9} \therefore \phi = 32^\circ - 45' \right]$$

From figure 3.—Percentage reduction in 'C' due to obliquity = 3.20%. Hence co-efficient of discharge 'C' for the oblique anicut,

$$\text{designed} = 3.5 - \frac{3.5 \times 3.2}{100} = 3.388 \text{ or say } 3.39 (1.872) \quad (2)$$

Thus, maximum discharge $Q = C \times L \times H^{3/2}$
 $= 3.39 \times 118.9 \times 3^{3/2} = 2095$ cusecs (59.32 cumecs.)

NOTE.—(1) For solving this problem, either figure-2 or figure-3, may be used. Both the curves need not necessarily be used.

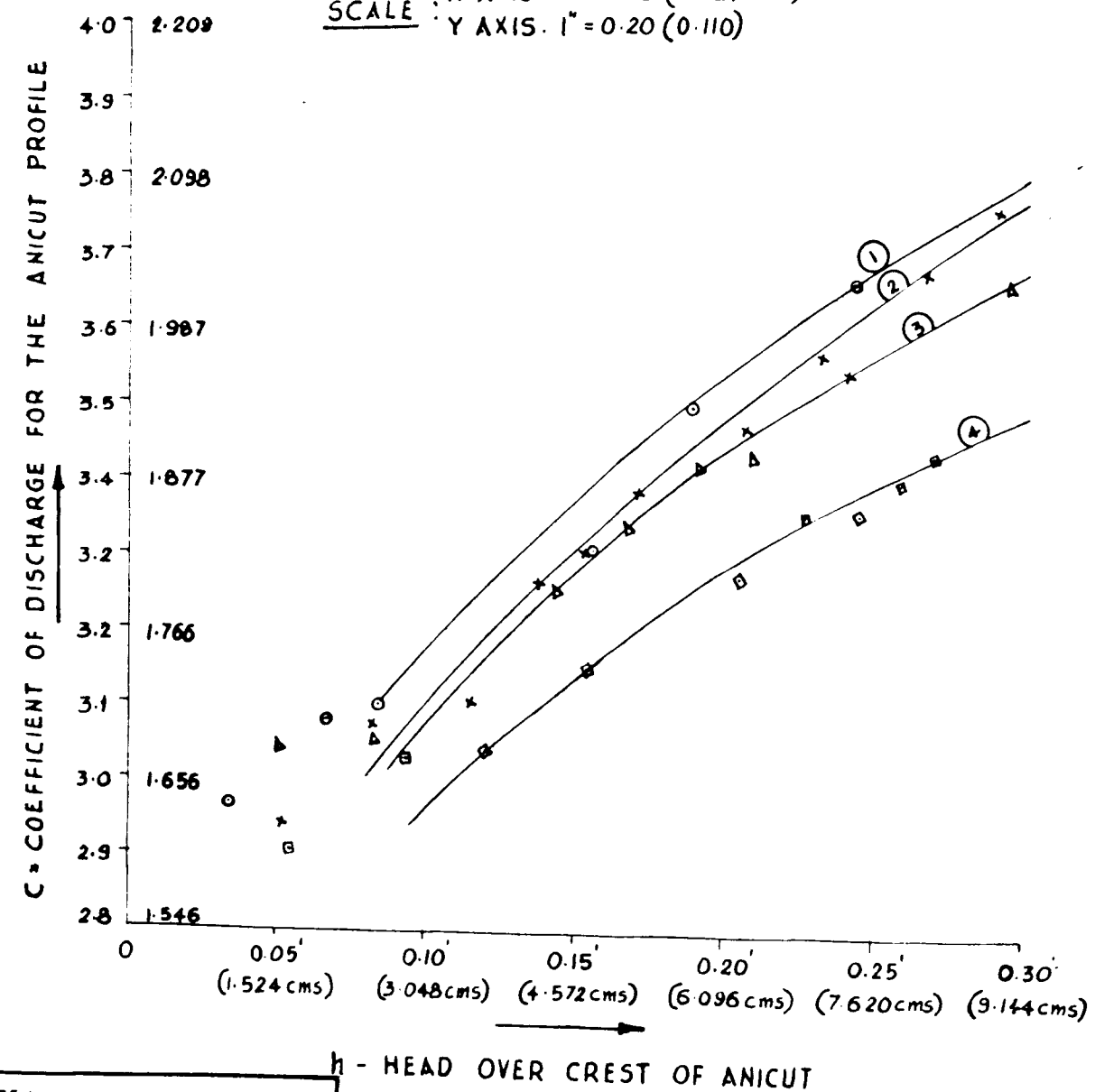
(2) The figures within the brackets indicate the corresponding values in metric units.

Acknowledgment.—The study was suggested by Sri P. C. Varadaraj, Research Officer, Irrigation Research Division. The writers wish to acknowledge the keen interest evinced by the Research Officer during the studies and his many suggestions during the preparation of the article.

OBLIQUE ANICUTS
DISCHARGE CHARACTERISTICS
COEFFICIENT OF DISCHARGE VS HEAD OVER CREST

FIG...1

SCALE : X AXIS. $1'' = 0.05' (1.524 \text{ cms})$
Y AXIS. $1'' = 0.20 (0.110)$



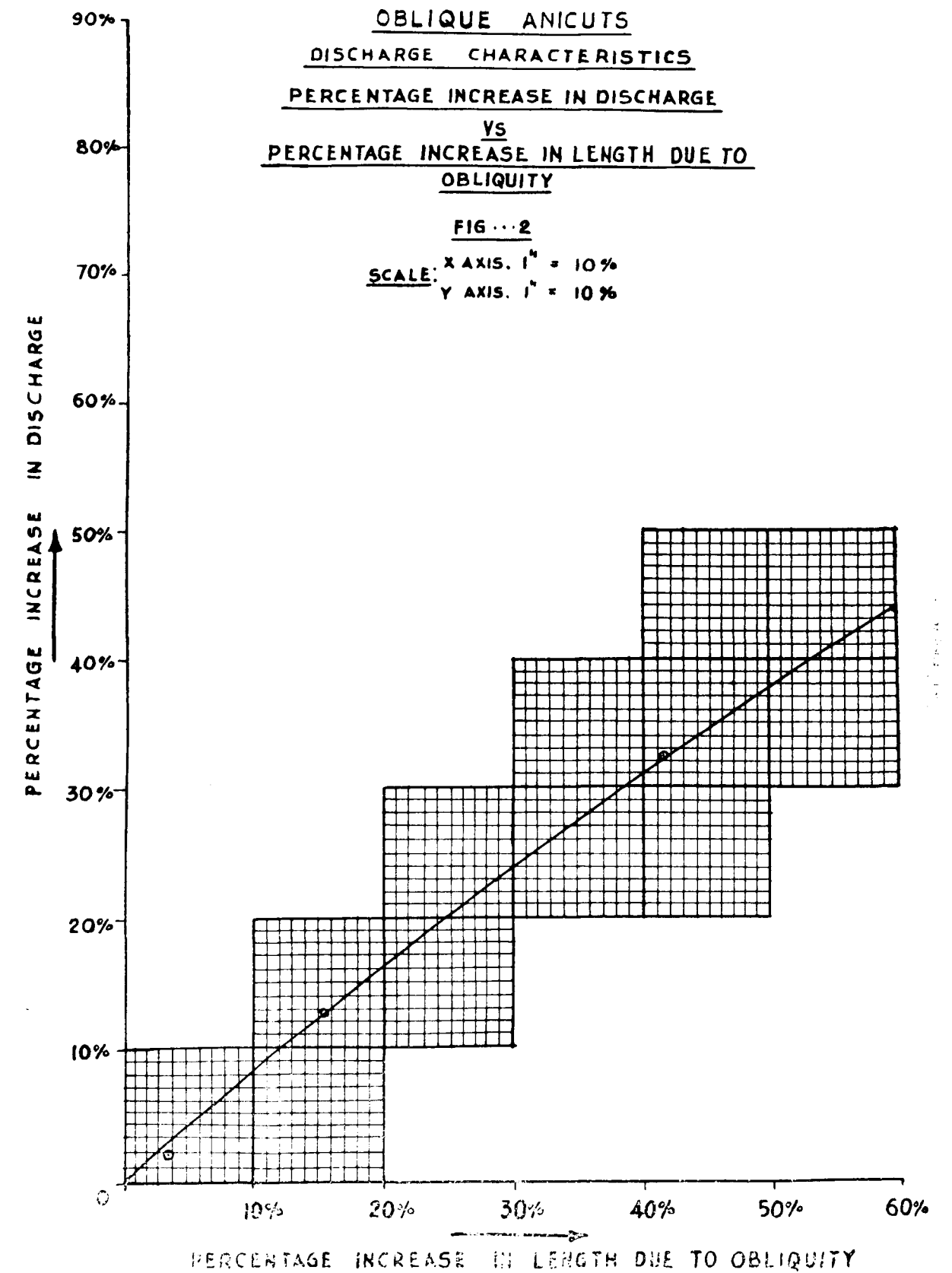
NOTE :-

- ① NORMAL ANICUT
- ② ANICUT WITH 15° OBLIQUITY
- ③ ANICUT WITH 30° OBLIQUITY
- ④ ANICUT WITH 45° OBLIQUITY

OBLIQUE ANICUTS
DISCHARGE CHARACTERISTICS
PERCENTAGE INCREASE IN DISCHARGE
VS
PERCENTAGE INCREASE IN LENGTH DUE TO
OBLIQUITY

FIG...2

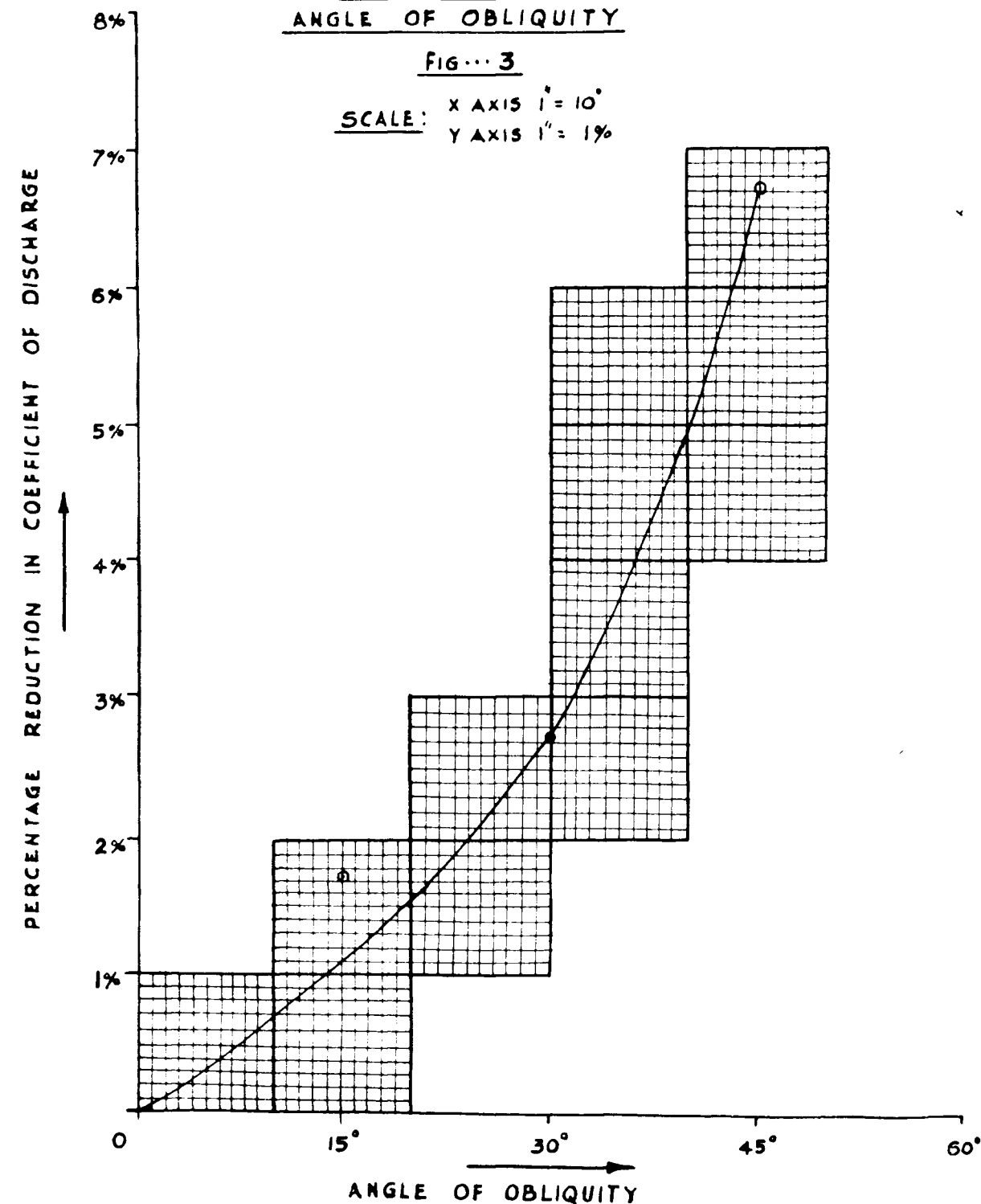
SCALE: X AXIS. $1'' = 10\%$
Y AXIS. $1'' = 10\%$



OBLIQUE ANICUTS
DISCHARGE CHARACTERISTICS
PERCENTAGE REDUCTION IN COEFFICIENT
OF DISCHARGE VS
ANGLE OF OBLIQUITY

FIG. 3

SCALE: X AXIS 1" = 10°
Y AXIS 1" = 1%



NOTE ON TAKING AND SENDING SOIL SAMPLES TO THE LABORATORY FOR ROUTINE SOIL EXAMINATION

By

SRI C. F. MARTIS, B.E.*

1. General.

Soil samples are usually obtained for tests in order to determine their suitability for use in embankment constructions or as foundation material. Whereas disturbed samples are quite sufficient for carrying out tests in connection with embankment suitability, undisturbed samples are necessary for foundation studies. Methods for taking, packing and sending disturbed and undisturbed samples are detailed below.

2. Disturbed samples for embankment construction.

2.1. The region in the neighbourhood of the proposed embankment, especially on the upstream side, should be inspected carefully with a view to find out suitable areas in which different distinct types of soils are available. Differences in the types of soil can be judged superficially with reference to their colour and texture.

2.2. In each area, containing one type of soil, atleast two or three trial pits should be put in. The trial pits should be distributed uniformly throughout that area. If minor variations of soil types are observed within the area, the trial pits may be so distributed as to have atleast one pit for each such subsidiary area. The trial pits should be atleast 3 feet square so that a man can get into it easily. They should be dug to atleast 6 to 8 feet depth or down to the depth of the disintegrated rock layer, whichever is less.

2.3. Each pit should then be examined for the different layers of soils exposed. One soil

sample for each distinctive soil layer should be taken by scarping a vertical side of that layer in the pit excluding preferably the top and bottom 6 inches of the layer. For example if one type of soil is available in a pit from 2 feet to 5 feet below ground level, the 3 feet thick layer of that soil should be scraped from 2½ feet to 4½ feet below ground level, in order to get the samples of that soil. Care should be taken to scrap only about 25 lb. of the soil. All the scrapped up soil should be gathered on a large sheet of paper, carefully spread underneath, at the bottom of the pit. A sheet of newspaper or any other material can be used for the purpose.

2.4. For preliminary estimate of suitability, about 25 lb. of soil in each sample is necessary. This quantity alone should be scrapped and the whole of the collected quantity should be gathered and packed and sent to the laboratory.

2.5. If large stones greater than 1 inch size are present in a soil sample, they can be removed before the sample is despatched. In this case the number and the weight of such stones removed should be estimated roughly and recorded as a percentage of that total weight of the sample. This percentage of removed stones should invariably be furnished when sending the samples.

2.6. The soil samples can be sent, packed in cloth or gunny bags lined inside with a double layer of stiff packing paper. Alternatively, the soil samples can be put in paper covers made out of stiff and strong paper. Each soil

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sample in its paper cover should be then put in second paper cover and finally enclosed in a polythene or cloth or gunny bag stitched tightly over the covers. A paper cover 15 inches wide and 20 inches long will contain the necessary quantity of soil. The object of the double paper cover is to ensure that the fines are not lost during transit. The object of the cloth or gunny over the paper cover is to give the necessary strength.

2.7. With each sample sent, should be enclosed a slip giving particulars of

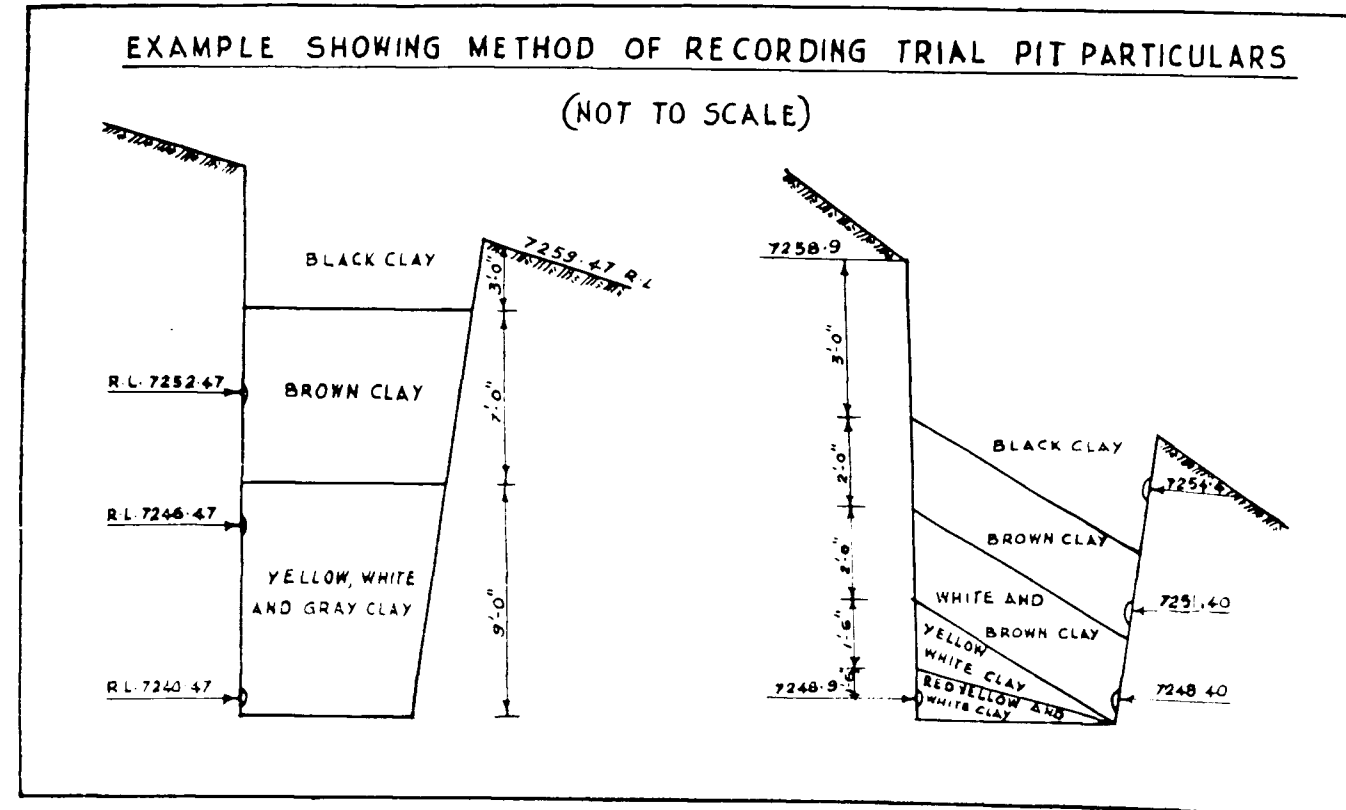
1. Name of the scheme or project.
2. Pit No.
3. Sample No.

4. The depth at which the sample is taken. This slip should be put inside the respective sample packet along with the soil. The same

details should also be written on the outside of the gunny cover of the sample packet.

2.8. The sample packets should be packed either in gunny bags or more preferably in dealwood cases and sent to the Concrete and Soil Research Laboratory, Chepauk, Madras-5, freight paid, if sent by rail. Every care should be taken in packing, to see that the sample packets do not get damaged during transit and mix together.

2.9. The details of soil layer in each trial pit should be noted and diagrammatically represented. The ground level at the pit should be indicated as well as also the thickness of each soil layer. The soil need be described only with respect to its colour (dark-brown, yellowish brown, yellow, black, grey, etc.) and in terms of its texture (fine sandy, clayey mixed with Kankar, mixed with stones, etc.). The pit details should be recorded something as follows which is only an example.



3. Undisturbed samples for foundation studies.

3.1. Undisturbed samples are taken when foundation conditions are to be investigated through laboratory tests. Along with the undisturbed sample as described below a quantity of the disturbed sample should also be taken and sent to the laboratory. A method of taking undisturbed samples without complicated equipment is described below.

3.2. Samplers are to be made out of thin walled 2 inches G.I. Pipe 8 inches or 10 inches long. Each sampler is to be provided with a cutting edge at one end by grinding and levelling the outside at that end. The inner surface of the sampler should be a continuous smooth cylindrical surface for the whole length of the sampler.

3.3 For taking undisturbed samples a trial pit is put in at the required place to the required depth. One side of the pit, after it is freshly cut vertical, is smoothed plane. Through this surface at the required depth below ground, the sampler is driven in, in the horizontal direction. The samplers are driven in with a 7 lbs. hammer using a wooden block over the end of the sampler tube in order that it may not be damaged by the hammer impacts. The tubes should be well greased both on the outside and inside before being driven in.

3.4. After the tube is completely driven into the side, the soil round the outside of the tube

should be scooped out and removed. The sampler tube, with its core of soil inside, will now be released and can be taken out.

3.5. Soil to a thickness of $\frac{1}{2}$ to $\frac{3}{4}$ of an inch is then removed from inside the tube at both ends. These empty spaces are then filled with melted paraffin wax. The object of the paraffin plugs at each end is to conserve the moisture content of the sample during transit.

3.6. Samples for each distinctive layer of soil exposed may be taken and sent to the Laboratory or samples may be taken at intervals of 1 foot or 2 feet vertical. It is necessary to send 2 tubes of samples from each sampling point. The following particulars should be written in white paint on each sample tube. Alternatively the particulars can be written on paper and pasted to the sample tubes.

1. Name of scheme or project.
2. Pit No.
3. Sample No. and
4. Depth of sampling.

3.7. The sample tubes with the two moisture tight wax plugs at either end and sample particulars written or pasted over, should be then packed carefully and nailed in dealwood box, using moist hay as packing material. The box should be then sent to the Concrete and Soil Research Laboratory, Chepauk, Madras.

METRIC SYSTEM AND MODULAR COORDINATION

(By the Metric Cell Wing of Madras P.W.D.)

Introduction.

The Metric system is in practice for a long time in several countries of the world with the exception of U.S.A., U.K., and commonwealth countries. Having realised the importance and simplicity and easy working of the system, the Government of India have passed the Standard Weights and Measures Act in 1956, which allowed a period of 10 years for the complete change over to the metric system. This means that after 1966, adoption of any system of weights and measures other than metric will be illegal throughout the country.

The Government have recommended the creation of a metric cell wing in each of the P.W.D. and other departments to undertake the revision of specifications, designs, schedule of rates, data, etc., and to assist, in general, the department in the smooth change-over through a phased programme. Accordingly the metric cell of the Madras P.W.D. is entrusted with this important task.

Module and Modular Coordination.

The Metric system envisages the adoption of "Modular Co-ordination" which claims to economise the cost of building construction as also help in high productivity. The word 'Module' comes from the Latin 'Modulus' which means a small dimension. By "Modular Co-ordination" is meant "the co-ordination of dimension using a module to enable components to be used together in a building with modification". The module is the common unit of measure internationally agreed upon for the co-ordination of dimensions. The module forms the basis of a three dimensional rectilinear frame which when used in buildings, ensures that standard materials and components can be used

together and they will fit into the general design layout.

Thus sizing of the components on the basis of a 'Module' helps us in the reduction of construction and production costs of buildings by eliminating the variety of building components and unnecessary modifications at site. The adoption of module simplifies and rationalizes the dimensions and details to such an extent that even drawing office costs are reduced. The modular co-ordination when adopted both by the Architect and the building industry would mean better planning and would result in lesser number of component parts that are to be manufactured. This would ensure better co-ordination between the standard industrial supply and individual design demand, which does not exist at present. With industrialised production of standardised building components this would be more significant in that it would result in an appreciable decrease in building costs.

It may thus be seen that the main object of the modular coordination is to have a basis module on which the dimensions will be co-ordinated. This would help to have the least possible number of component parts in the building industry and which would in its turn, allow advanced standardization of the production of building parts. A concept has already been developed that dimensions of materials and equipment which are assembled for the construction of building shall be coordinated with one another and with the dimensions of the building. The main advantage would be that the parts could be fabricated in any factory outside the building site, conditions at the latter site for production being generally unfavourable. The lesser number of component parts would also help great efficiency being maintained in the production as also the best quality control can be achieved. The basis of

modular co-ordination should be such that the component parts can be fitted in a number of different combinations and thus give room for original and creative designs. It is thus a system of prefabrication and interchangeability of parts that minimizes the amount of skilled labour and at the same time increases the speed of construction and efficiency.

History.

'Modular co-ordination' is nothing new to the building industry. Dimensions of bricks have exerted considerable influence in the planning, design and construction of buildings. Multiples of dimensions of bricks, viz., 3, 4½ and 9 inches have governed dimensions of rooms as well as location of openings, height of rooms, height of sills, lintels, etc.

In its earliest use, as a basis for dimensioning architecture, the module was taken as the semi-diameter at the base of a column and divided usually into five parts. The various parts of the buildings were then related to each other by the use of this module, the main dimensions being simple multiples. But the disadvantage was that each building used its own module depending on its overall size and importance. This system had therefore a proportion within a building only and the construction of building components could not be universalised to fit in any other building which was based on different module.

Fred Heath, an engineer experienced in masonry products originated, in 1925, the idea of co-ordinating building materials through a 4 inch grid.

Later on, Albert F. Bemis, a manufacturer, improved the basis of the concept by introducing the 4 inch cube. He had also proved that, if any building could be made up of a series of the basic 4 inches cubes or its multiples, and if the construction materials were also standardised on the basis of the 4 inches module, there would be no waste in the construction materials.

The American Standards Association (A.S.A.) have also agreed to the 4 inch module as suitable for dimensional co-ordination. Ultimately

several countries have taken up this module, have known the advantage and ease of working with the same.

Size of module in metric system.

The module recommended for the metric system is 10 cm. and this may be applied to width, depth or height of any material or the building itself as a whole. The module, besides being the basic modular size, simplifies and inter-relates the component sizes and is also the basic increment of size. Thus the basic increment of size in planning and component manufacture are identical and this ensures co-ordination between the design and the industrial supply.

The 10 cm. module selected is large enough for turning out a lesser number of standard sizes and small enough to allow ample scope and flexibility in design and layout.

It may be of interest to the readers to know that Belgium, France, Germany, Italy, Netherlands, Norway, Sweden, have all adopted the 1 dm. or 10 cm. module. The international union of Architects, the European Productivity Agency and the International Organisation for Standardisation have also recommended the 10 cm. module where metric system is used and 4 inch module where the foot lb. system is used.

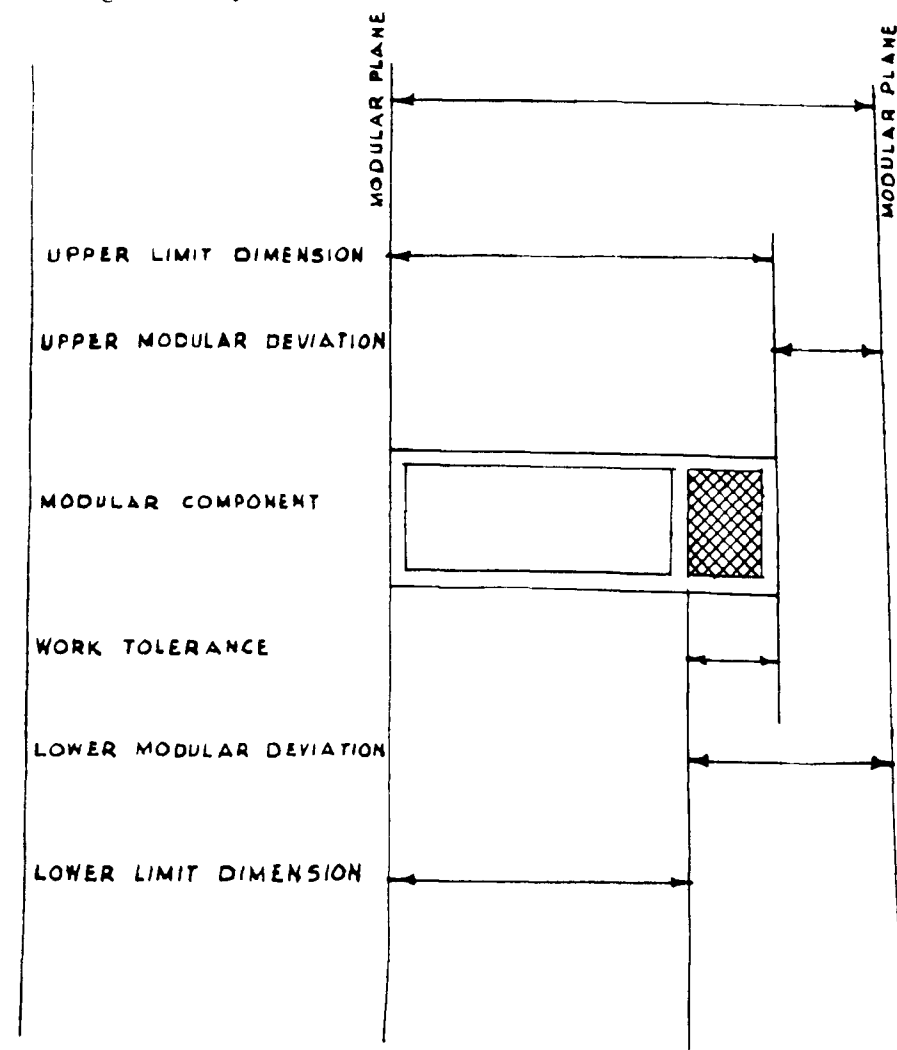
However the possibility of dimensions other than simple multiples of the module is not eliminated because either custom or manufacturing and assembling methods may require a dimension smaller than the module in one or more dimensions. For these to be of useful modular size, two or more components may be joined together to total a dimension which is equal to the module or multiple of a module. However this cannot be taken for all cases except where it would be absolutely necessary. This comes to us handy in the case of fixing a smaller thickness for the ground moulded bricks where we are proposing to have an intermediate thickness between 4 and 9 cm. such that 3 courses may be a double module. A thickness of 5.7 cm. satisfied this condition.

Modular System of Tolerances.

The modular dimension of a component includes the dimension of the component as well as its joint. For this purpose, a modular system of tolerances has been devised. The components are to be dimensioned for manufacture before their actual position in any building. So the dimensions are to be related to modular planes and not to adjoining components. In fixing up the dimension of a component, the gap required for the joining material should be taken into consideration. Thus the size of modular bricks is actually 19 by 9 by 9 cm. though the nominal size is 20 by 10 by 10 cm. so as to fit in into the modular co-ordination, where the module is 10 cm. Here the width of joint between bricks is assumed to be 1 cm. It has been considered after extensive investigations by the I.S.I. that

irrespective of the type of brick the bed joint should not be less than 10 mm. for effective dispersion of load in the masonry. But for this consideration it would be possible to adopt the thinner joints in the case of better shaped bricks, viz., wire-cut bricks, etc. Even in the specification of some foreign countries, the minimum joint thickness is given as 10 or 12 mm.

Similarly the actual size of flooring tiles are to be 19.85 by 19.85 cm. though the nominal size is 20 cm. by 20 cm. the thickness of joint being here 1.5 mm. It is thus obvious, that in actual application, the manufacturers of materials and components will not normally supply articles to dimensions exactly equivalent to a module or to a multiple or a sub-multiple thereof, but to dimensions, which, when the articles are



installed will permit a building as a whole, to conform to a modular layout.

This can be further illustrated by the following definitions and sketch:—

Modular Plane is the reference plane in a modular reference system. The *upper modular deviation* is equal to the necessary minimum of joint thickness. The *upper limit dimension* will be the modular dimension minus the upper modular deviation. *Work tolerance* is the difference between the limits within which the component can be manufactured. The *lower limit dimension* is equal to upper limit dimension minus work tolerance.

The *lower modular deviation* will be the sum of upper modular deviation and work tolerance; in otherwords, it is the distance of the lower limit from the modular plane. It will be not more than the maximum permissible joint thickness.

Application

All buildings are to be so dimensioned that the size of rooms, floor, doors, windows, etc., height of room, etc., are to be co-ordinated by an imaginary modular grid in all directions.

Regarding the length and breadth of rooms or in general the horizontal dimension in case of walls whose nominal thickness is a multiple of the module must be such that the modular grid should be laid so as to coincide with the modular surface of the unfinished wall. In the case of walls whose nominal thickness is not a multiple of the module, the grid should be so laid as to coincide with the central lines of the walls.

Partition walls should be placed on a centre line basis so as not to disturb the grid arrangement. Doors, windows and other openings are so located as to fit into the modular reference system.

In the vertical plane the grid will be laid such that it coincides with the modular surface of the unfinished structural floors. The height of the storey, measured from top of floor to top of

floor will be modular. In the placing of doors, etc., a clearance of 4 cm. should be provided for floor finish and the height of shutters adjusted accordingly.

Some of the dimensions of principal building materials standardised by the I.S.I. are given below:—

Material.	Modular dimension.	Work dimension.
Building brick. (I.S. 1077/57)	20 × 10 × 10 cm. 20 × 10 × 5 cm.	19 × 9 × 9 cm. 19 × 9 × 4 cm.
Stones (I.S. 1127/ 57 and I.S. 1128/ 57).	20 × 20 × 20 cm. 40 × 20 or 30 × 20 or 30 cm. 150 × 150 × 5 cm.	19 × 19 × 19 cm. 39 × 19 or 29 × 19 or 29 cm. 149.5 × 149.5 × 5 cm. or
Tiles. (I.S. 1237/59)	20 × 20 cm. 30 × 30 cm.	19.85 × 19.85 cm. 29.85 × 29.85 cm.
Metal doors and Windows. (I.S. 1033/57)	210 × 60 cm. 90 × 60 cm.	207.5 × 57.5 cm. 87.5 × 57.5 cm.
Timber doors and windows. (I.S. 1003/57)	190 × 80 cm. 210 × 90 cm.	187.5 × 77.5 cm. 207.5 × 87.5 cm.

Advantages of Modular Co-ordination—To Engineers

The system of modular co-ordination makes the design practice much easier and simpler, so much so, the engineer may be able to utilise his time for creative work and improved methods of construction. Co-ordination of materials and components, if modular system is adopted, result in quicker, easier and accurate quantity surveying. The field erection is also easier and economical.

To Architects

Modular co-ordination simplifies architectural design and reduces drafting time, which the architect can gainfully employ in creative architecture and better planning services. When this modular system is adopted and used by drawing office staff, the preparation of plans and working drawings are much simplified. Also, it is not necessary to fully dimension such drawings since the reference grid would indicate the sizes and position of various components. This system permits easier substitution of alternative materials and changes in specification without replanning.

To Contractors

Modular practice ensures easier and economical field erection with a reduction in field cutting. Since the materials will be obtained from mass production, the difficulty of building components at site is eliminated. Further modular materials will be cheaper and will have better quality due to mass production. This system minimises the high salaried skilled labour needed for assembly purposes at building site.

Modular co-ordination holds waste of materials to a minimum by reducing (i) cost of purchase, (ii) cost of labour used in cutting off waste and (iii) the cost of disposing waste. Engineering layout time is reduced to 35 per cent and productivity of labour is increased. It has been found in America that the cost of labour is reduced by 10 per cent by using the modular system.

It therefore means more efficient methods on job and less construction time with consequent lower cost.

To manufacturers

Once the production of building components is standardised on the modular system, there will be an uniformity on a national basis and we could be able to have the least number of stock sizes and still satisfy the demand. This, in turn, simplifies the manufacture process and at the same time raises the efficiency of production and quality control. Further, this results in reduced ware-house space, reduced packaging costs, etc.

Conclusion

It may thus be seen that the modular co-ordination plays an important role in the building industry, resulting in reduction of construction costs. In view of the present national emergency, the economy achieved by using modular dimensioned materials will be very significant and also considerable.

However it has been natural that any change is resisted, and it is difficult to make the old ideas vanish to give room to new, unless a strong campaign is launched.

Hence nothing except a vigorous propaganda can popularise the modular co-ordination among the public as well as engineers, architects, manufacturers and builders. With this in view, the P.W.D. proposes to construct a "Metric modular block", which would be planned completely on modular system and built with modular materials. This would help the public to get an "on the spot" idea of the advantages of the modular system and modular materials, besides enabling the P.W.D. to collect data and other vital statistics regarding the modular system of building construction.

References.

1. Recommendation for modular co-ordination of dimensions in the building industry - I.S. 1233 1958.
2. Metric Measures - July 1962.

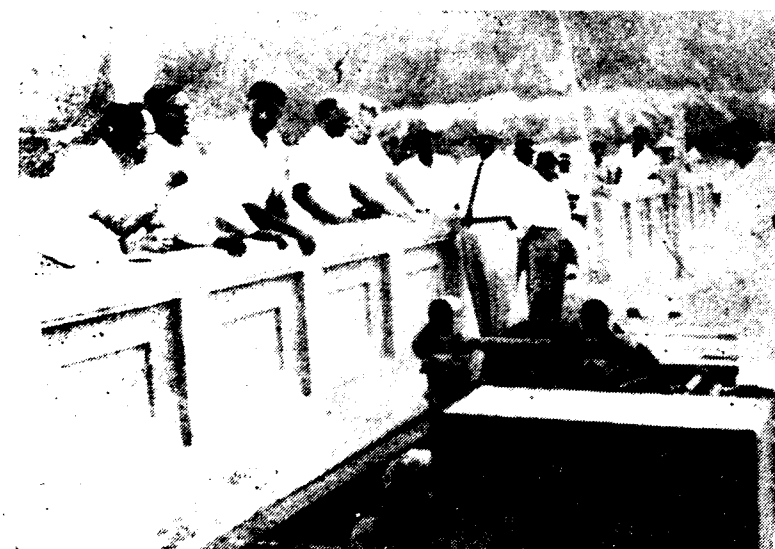
Art Supplement



World Bank Team inspecting masonry work in progress at Sholigar Dam.



Mr. Mitchel examining the soil in the proposed cultivable area.



World Bank Team on the Spillway Bridge of Aliyar Dam.



*World Bank Team being shown
round the Designs Office.*



*Final round of discussion with the
World Bank Team*



*Member of the World Bank Team
discussing with officers of the P.W.D. at
the Central Library Hall.*

OPTIMUM REQUIREMENTS AND UTILISATION OF WATER FOR IRRIGATED CROPS

By

* SRI J. WALTER, B.A., B.E., M. IRR. ENG. (Colorado).

The back bone of any country is its agricultural prosperity and this depends on 'water', the most important limiting factor for production of crops. The natural source of supply for all vegetation in the country is of course 'The rainfall', but wherever this is scanty and or out of season, human enterprise has effected the requisite regulated supply of the available water by forming dams and barrages, etc., across valleys and rivers and conserving the waters otherwise running waste, for raising the crops.

Many such storage reservoirs have been taken up and completed in our country. In Madras State almost all the existing sources of surface waters have been tapped and we are at the tethers end. Utmost economy in the use of water with maximum production shall be the criterion, or in other words maximum utilisation of the waters available for raising the maximum crops, shall be the aim of all irrigation and agriculture engineers. To achieve this, the existing irrigation works must be well maintained and operated with the highest degree of efficiency.

The irrigation requirement of any crop depends upon (1) the soil composition, (2) soil moisture, (3) surface topography, (4) the duration, (5) climatic conditions, (6) method of irrigation, (7) design of delivery system. Psychology, stamina, intelligence and skill of the farmer, possible maintenance of soil fertility, etc., are some of the other factors, which govern the yield or the harvest.

Experiments conducted at the Paddy Breeding Station at Coimbatore for two seasons 1932 to 1934 for determining the quantity of water required for different stages of growth for Vallaisamba (white rice—one special quality) ripening in 160 days and a duty of 84.8 acre inches of water revealed the following:—

Stage of crop.	Acre— <i>inches</i> (including irrigation and rainfall).
1. From preparation of plots to planting.	25.63
2. From planting to flowering ..	48.27
3. From flowering to last irrigation.	10.89
Total ..	<u>84.79</u>

Water requirement of crops.

The water requirement of an irrigated crop is the amount of water needed for crop growth. This may be met entirely by precipitation in humid regions, by precipitation and irrigation in semi-arid regions and by irrigation only in arid regions. The irrigation requirement of a crop is denoted by 'duty' which may be defined as the area of a particular crop that can be successfully raised to maturity, with a flow of one cusec of water during its growth including rainfall.

Optimum Requirements.

A correct estimate of the optimum requirement of water for a crop is essential for getting the maximum yield with economical use of water. Many additional acreages could be developed if water supplies could be used more economically. Still further extensions in irrigated areas could be made if all unused stream flows could be stored, delivered to the lands as actually needed and applied with high irrigation efficiency. The

* Superintending Engineer (Designs), Chepauk, Madras-5.

supply of water more than the optimum requirement not only gives very little increase in yield of most crops but also decreases the quality of the product.

Optimum water requirements of different crops are the seasonal depths of water that result in maximum yields where the depths include soil moisture supplied by precipitation as well as water delivered by irrigation.

Soil moisture plays an important role in the study of the optimum requirement of water for a crop. The hygroscopic water in a soil is not available for plant growth and hence disregarded in considering irrigation needs. Only when the soil moisture increases beyond 50 per cent above its content of hygroscopic water it is taken by the plant. When the water content increases further, more and more water is available for the plant growth. When the water content increases beyond the maximum capillary capacity of the soil, the excess water flows off the soil particles under the action of gravity and drops to lower level or drier soil or passes down to the water table as gravity water. When the soil moisture decreases below a certain limit, the plant is not able to take up the available moisture, it begins to show signs of distress, wilt and die (Figure 1). The soil moisture at which the wilting begins in any soil is called the wilting co-efficient of that soil.

For economic utilisation of water, water must be delivered to the field in such a manner that the water content of the soil within the root zone at any time shall never fall below the wilting co-efficient of the soil and shall never exceed the full load capillary capacity of the soil.

Utilisation of water.

For maximum utilisation of available waters, the minimum should be the losses. The losses may be broadly classified as (a) transmission (b) transpiration.

(a) *Transmission losses*.--To study the transmission losses in canals and field channels

experiments were conducted in fields in Aradiarpalai, Kugalur Arakankottai and Thadepalli channels. The results obtained indicated that 8 cusecs per square foot run of water may be safely assumed as transmission losses.

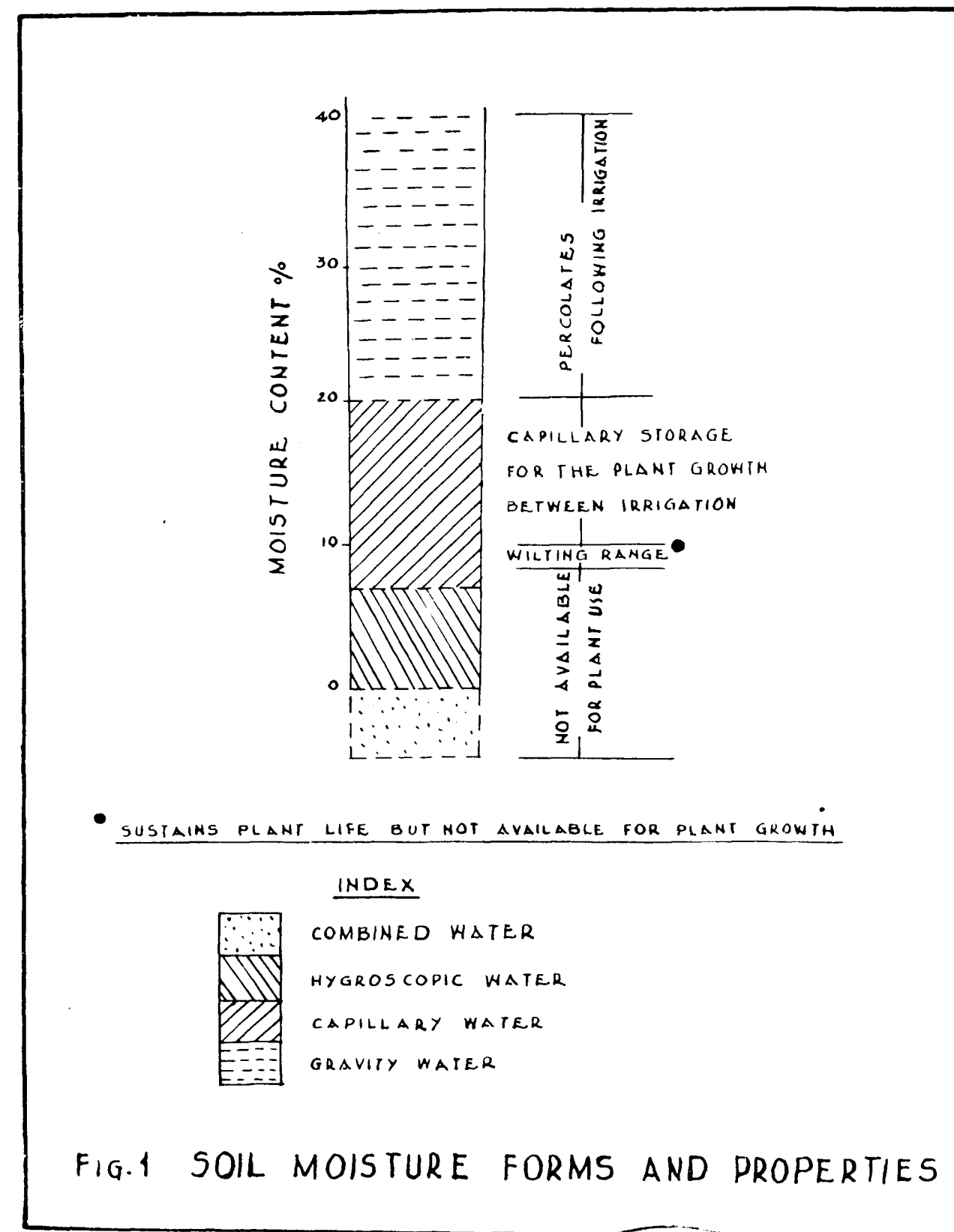
(b) *Transpiration losses*.--The transpiration losses for the important crop rice were studied in Aduthurai and Maruteru research units. The results obtained indicate that the total loss due to transpiration by the crop, evaporation from the surface and seepage from the soil can be safely assumed as 1.10 inch per day per acre in the deltaic areas.

In the interests of the country, attempt should be made to get the maximum production with the available water. It is the duty of the engineer to minimize the loss of water through the bunds, loss during transmission through canals, distributaries and field channels and evaporation loss. Seepage loss can be minimised by careful selection of site for the reservoir, proper selection of materials and quality control in forming the bund, lining of canals, etc. Loss of water in the field can be controlled by proper methods of water delivery and proper method of cultivation. Experiments are under way for reducing the evaporation losses, as well.

When more water is supplied to the field than the optimum, the surplus water drains away and carries with it plant food in solution and impoverishes the soil. But when the water is not drained, then it descends down below the reach of crop roots by gravity, escapes to the water table and causes an increase in the water table. This increase in water table curtails the root zone through which plants can be fed and hence limits production. In addition, it may cause water logging under certain conditions and serious drainage problem.

Measures of Economy.

The measures for securing the best use from the available water supply depend mainly upon the farmer himself and can be controlled by methods of water delivery. Inadequate cultivation is one of the reasons for not achieving



maximum results even with adequate supply of water. It has been shown that soil kept in a thorough state of cultivation with the surface thoroughly pulverised at frequent intervals loses water much less rapidly than uncultivated ground.

Experiments have shown that a small quantity of water supplied to the plants during the earlier stages of growth gives better yield than the same quantity of water supplied at the later stage. Farmers must accommodate each other and meet the demands of the system concerning the time of application of water. Rules must be rigidly enforced forbidding wanton waste of water, such as allowing it to run at night without benefit. On account of the inconvenience of night work farmers allow to waste water in large quantities from the lower end of fields into the roads or waste ditches and other similar practices.

Rotation System.

Better results can be had by delivering water at intervals in large volumes than by delivering a constant flow for a definite period. Much higher economy both in time and water can be obtained by turning on a large quantity at once so as to cover the ground several inches in depth and while the water in contact with the soil is being absorbed, the surface water is run rapidly towards the lower end of the field. The entire surface is thus soon wet and the irrigation of a certain area is soon over and the water is carried to additional fields. Larger heads of water may be used for irrigation on a pervious soil than upon impervious soils which require some time to absorb the requisite amount of water. The system of allowing water to a farmer for one week double the amount of water which would be required for constant flow and then one week without any water delivery may be tried. This rotation system of delivery is reported to have been found to be reasonably economical and satisfactory in America.

Some field studies have already been undertaken in our country soilwise and climatewise to determine the optimum requirement of water

considering the soil moisture for each crop during the various stages of the plant growth for the economical utilisation of water.

The Utab Agricultural College has done some experiments in the economical use of water and has concluded as follows. Deep and thorough ploughing enables the soil to absorb and retain the rain water. The more the rain water stored the less will be the irrigation water required. Thorough and frequent cultivation will reduce the loss of water by evaporation from the surface of the soil. The correct method of irrigation may have to be adopted depending upon the type of crop, soil and climatic conditions.

An experiment with the following eight treatments and four replications was conducted for a period of five years commencing from 1938-1939 at Coimbatore.

- (i) Two inches depth of water once in 3 days.
- (ii) Two inches depth of water once in 6 days.
- (iii) Two inches depth of water once in 9 days.
- (iv) Four inches depth of water once in 6 days.
- (v) Four inches depth of water once in 12 days.
- (vi) Four inches depth of water once in 18 days.
- (vii) Normal (i.e., standing water of 2 inches depth always maintained) for 4 weeks and afterwards 4 inches of water once in 12 days.
- (viii) Control normal—2 inches depth of standing water always maintained.

The general trend of results was that the control viz., 2 inches of water maintained always, recorded as good a yield as 2 inches in

3 days and 4 inches in 6 days. Experiments 1938 onwards for some of the plantations and were also conducted at different stations from the results are furnished in the table below:—

Serial number and name of the station.	Crop.	Duty of water.	Remarks.
1. Maruteru	Sugarcane	107	
	Bananas	136	
	Rice (first crop)	81	June-December.
	Rice (second crop)	54	February-May.
2. Aduthurai	Kuruvai rice	68	First crop.
	Thaladi rice	80	Second crop.
	Samba rice	76	Single crop wet lands.
3. Pattukottai	Kuruvai rice	37	
	Thaladi rice	37	
	Samba rice	37	
4. Central Farm, Coimbatore ..	Sing'e crop rice	51	Average of four years.
	Ragi	130	May-September.
	Sorghum	120	March-June.
	Cotton	190	6 months duration.
5. Siruguppa	Sorghum	163	June-September.
	Cotton	265	August-March.
	Ragi	126	July-October.
	Wheat	234	November-March.
	Korra	103	June-September.
	Groundnut	156	July-October.
	Rice	60	Single crop.
	Sugarcane	90	

The mean duty of dry irrigated crops worked out to 175, whereas the approximate duty for rice is 60. It will be seen therefore that the duty of dry irrigated crops is roughly three times that for rice.

From the experiments conducted by the Madras Agricultural Department, it is inferred that smaller quantity of depth of water delivered at short intervals produced better yields than larger quantities at longer intervals and that 2 inches of standing water maintained always gave the maximum yield for rice cultivation.

The returns of the irrigation can be increased by economic handling of water. Field studies for determining the optimum requirement of

water for every crop during various stages of growth soil-wise and climatic-wise will help irrigation with high efficiency. Irrigation should always be applied before the soil moisture reaches the wilting point throughout the root zone. Loss and waste of irrigation water must be reduced to a minimum by proper method of water delivery and cultivation. It may not be out of place to mention for optimum utilisation of available water evaporation from water surfaces may be reduced wherever possible by the application of monomolecular layer on the basis of experiments done at Irrigation Research Station, Poondi and transpiration through crops is also reduced by suitable application as is reported to have been successfully practised in Japan.

“....Any mule can kick down a barn door.
But it takes a good carpenter to make one.”

LYNDON B. JOHNSON,
President of U.S.A.

WELCOME ADDRESS ON THE EVE OF THE INAUGURATION OF CHITTAR PATTANAMKAL SCHEME

BY

* SRI K. V. EKAMBARAM, I.S.E.,

Hon'ble Chief Minister

Hon'ble Minister for Public Works

Ladies and Gentlemen

1. On behalf of myself and the Officers of Public Works Department, I extend my hearty welcome to one and all assembled here for to-day's function. We are very grateful to the Hon'ble Chief Minister of Madras who amongst his multifarious duties and particularly when he is engaged at the moment in taking a leading part in guiding the destinies of this country, has found time to be present here to inaugurate the Chittar-Pattanamkal Scheme. It is also fitting that the Hon'ble Minister for Public Works has consented to preside over the function.

2.1 Ever since this Kanyakumari area was transferred to Madras State in 1956, the Madras Government have been concentrating their attention on this area through every Department of the Government. This area was the granary of the old Travancore State and it was the aim of the Madras Government to still further enrich this. Pechipara Dam which serves this area was constructed in the early years of the century. Because of the age and methods of construction adopted in those days, it was leaking rather badly. No doubt, the Travancore Government took steps to grout the dam with an idea of stopping the leakages. After we took over, we speeded up the work and we completed the same with the result the leakage from the dam now is very insignificant. The dam and its vicinity have been considerably cleaned up and made attractive to the tourists who may care to visit. The canal system has also been considerably improved by doing lining and revetment work wherever necessary. With the water so saved, it has been possible to extend some of the channels of the

system to irrigate approximately an area of 4,350 acres.

2.2. The Neyyar Project of the erstwhile T.C. State was expected to benefit this area also, but no work had been commenced till we took over. We have since then excavated the Kanyakumari Branch and the other allied works and our Chief Minister inaugurated the same on 25th April 1963. The system is now ready to irrigate an extent of about 7,000 acres.

2.3 Some portions of Vilavancode taluk do not have even drinking water during the summer. There are numerous small tanks which are very often dry. To benefit this area, we executed Vilathurai Lift Irrigation Scheme. It is a very costly scheme where pumping over a head of 200 feet has to be done. I doubt if such a high lift has been attempted elsewhere in our country. Even then the work was undertaken to benefit the people of the area.

2.4 The numerous ponds which irrigate the Yelas in the area are also being repaired in the interests of food production.

3.0 There are still areas in Vilavancode and Kalkulam Taluks which do not have any irrigation facilities. The former Travancore Government thought of constructing dams across the two Chittars which fall into the Kodayar below Pechipara dam and to take their waters into the Left Bank Canal of the Kodayar System and excavate a new canal from this to irrigate this area. The extent proposed to be irrigated was 15,000 acres. After the Madras Government took over, detailed investigations were made. To bring down the cost, only a dam across one of the Chittars was proposed and the channels taking off from the Thirupparappu weir were proposed to be extended. Thus, through

the existing irrigation system and with the new proposals the whole of the commandable area of Kanyakumari district was expected to be covered by irrigation.

4.0. During one of his visits, our Chief Minister enquired whether every water that the rivers carry in Kanyakumari district will be used up by the time we complete the Chittar-Pattanamkal Schemes envisaged by us. He was told that this area was similar to all the other areas in the western side of the Ghats, where there is plenty of water due to the never failing South-West Monsoon, and a good bit of it goes into the sea. Immediately, our Chief Minister questioned as to why the water that is wasted could not be diverted to the southern portions of the Tirunelveli district which notoriously lack in rains being in the rain shadow of the Western Ghats. Of course, he was anxious to do this, after fully covering all the possible areas in Kanyakumari district. Our Chief Minister's first question was as to why a tunnel should not be drilled and water taken to the other side. We went on examining the various possibilities of utilising the surplus waters, to the best advantage. As the quantity to be diverted was not big, and as a tunnel through the hills is a costly proposition, it was found that the various alternatives were costing a great deal. Finally, the idea of improving the existing irrigation canals so that they can carry more water and taking a branch canal from the Nilaparai channel to irrigate the southernmost portions of the Tirunelveli district came into being.

5.0. We have been ourselves requesting the Kerala Government for sparing us some waters from the west flowing rivers so that we could improve the drought-stricken areas on the Madras side, to some extent. Our aim is, that water should not be allowed to be wasted into the sea when we have a vast extent of land over which we are not able to raise anything at all. As we strongly believe in this philosophy, it gives us great pleasure that we have set an example ourselves to divert some of the surplus waters on the western side towards the east though at some considerable cost. Now, we feel

that we have carried out a sacred duty by so doing.

6.0. The present Chittar-Pattanamkal Project which our Chief Minister will be inaugurating consists of the following works:—

(i) Raising the F.R.L. of Pechipara Reservoir by 6 feet and increasing its storage by 840 M.cft.

(ii) Raising the F.R.L. of Perunchani Reservoir by 6 feet and increasing its storage by 590 M.cft.

(iii) Construction of two dams across the two Chittars to form two reservoirs one on Chittar-I with a gross capacity of 555 M.cft. and the other on Chittar-II with a capacity of 964 M.cft.

(iv) An interconnecting channel between the above two reservoirs to use the storages of both.

(v) A feeder channel from the reservoir on Chittar-I to the existing Left Bank Canal of the Kodayar system.

(vi) Improving and lining the Left Bank Canal of Kodayar system to take in the additional flow diverted from the two Chittar reservoirs.

(vii) Excavation of the new Pattanamkal channel from mile 6¼ of the Left Bank Canal of Kodayar system to irrigate 10,000 acres of double crop through a net work of distributaries.

(viii) Extending the existing two channels taking off from the Thirupparappu weir (the Left Bank Canal by 16 miles and the Right Bank Canal by 5½ miles) to benefit 5,000 acres of double crop including the existing irrigation of 1,543 acres.

(ix) Improvements and lining for the Pandiankal up to mile 1¾, Thovala channel up to the branching off of Nilapara channel and also for the first one mile and two furlongs of the Nilapara channel.

(x) Excavating a new channel from mile 1¼ of Nilapara channel for a length of 20 miles 4 furlongs up to Radhapuram, tailing into Mahendran tank to benefit 17,000 acres.

* Chief Engineer (Irrigation), P.W.D., Madras-5.

7.0. The cost of the project is estimated as Rs. 680 lakhs. The total area benefited by the Project will consist of 15,000 acres which will raise two crops in Kanyakumari district and 17,000 acres of single crop in Tirunelveli district. Thus, the gross area will be 47,000 acres. While the area in Kanyakumari district will raise wet crops, only dry crops are proposed for irrigation in the Tirunelveli area, like Cholam, Ragi, Chillies, etc. The sub-soil water level in the present dry area of Radhapuram sub-taluk may improve and with the assistance of wells, coconuts and plantains which are already grown will be encouraged.

8.0. The dams across Chittars will submerge about 2,000 acres of plantations and Government lands, of which 950 acres consist of rubber plantations. This is inevitable. In view of the larger benefits accruing from the project this small inconvenience to the rubber industry has to be put up with. As our Chief Minister once said, the rubber area can be replaced, but the water lost cannot be recovered and is lost for ever. Also, 40 acres in Kerala State limits will be submerged. It is hoped that the Kerala State with the good neighbourly relationship we have, will kindly consent to acquire them with suitable compensation.

9.0. It is hoped that the people of the area who have already welcomed the project will extend their wholehearted support for the early implementation of the scheme and also utilise the potential fully and quickly. A special responsibility devolves on the ryots of Radhapuram sub-taluk. It is proposed to give irrigation to dry crops only in this area, instead of to paddy which is the usual way, so that the benefit can be spread over a larger area. Also recent studies have revealed, that while the productivity of one acre inch of water is 115 lb. of Ragi, it is as low as 30 lb. of paddy. So, it is believed the irrigation of dry crops besides benefiting a larger area will produce greater wealth than a wet crop

can do. For taking to this type of irrigation the co-operation of the ryots is quite essential and it is hoped it will be forthcoming. The raising of coconuts and plantains on a large scale is also visualised.

10.0 I feel I am not expressing adequately when I say that our Chief Minister has taken an extraordinary interest in this project from the beginning. It became keener, when the idea struck him that the surplus waters of the western side could be used for the drought-stricken areas on the east. This is due to his intense interest in improving the condition of our masses. Practically, he has been watching our progress in the investigation from day to day. Here, I must express that the staff engaged in the investigation rose to the occasion and tried to carry out the huge volume of field work, as speedily as possible. The Chief Minister expressed his idea in October 1962, and I am glad to say that we would submit a concrete project to the Government in May 1963. Because of the keen interest shown by our Chief Minister, the project also has been got sanctioned very speedily. Today, on which he has kindly consented to inaugurate this, is to be considered a red letter day in the annals of irrigation in this State. Not only do we expect to cover whatever area that can be commanded in the Kanyakumari district but also we expect to use the surplus waters to bring relief to the drought-stricken areas in the southern portions of the Tirunelveli district.

11.0. On this occasion, our thanks are due to the Collectors of the two districts and Officers of the Revenue and Agricultural Departments who have bestowed great interest in the investigation and finalisation of the project.

12.0. I now request on behalf of the Public Works Department the Hon'ble Minister for Works to preside over and conduct today's proceedings and the Hon'ble Chief Minister of Madras to inaugurate the Project.

THE PUBLIC WORKS WORKSHOPS AND STORES

BY

* SRI S. SHANMUGASUNDARAM, B.E., M.S.A.E.

The Introduction

1.1. Ranking as the earliest and perhaps as the largest of the undertakings of the Government of Madras are the Public Works Workshops and Stores, Madras, which play a vital role in the development projects carried out by the State with ever increasing tempo. A wide variety of articles and equipment, ranging from small badges and seals to huge steel gates and overhead cranes, is turned out by the Workshops. True to their avowed purpose, the Workshops and Stores seek to serve as a convenient and ready source from which the Public Works Department to a major extent and the other Government Departments to a lesser extent, obtain a majority of their requirements.

The Workshops

2.1. The Public Works Workshops are an old Institution, whose history can be traced as far back as to the days of the East India Company. It was in the eighties of the last century that the Workshop came into existence, having been established by the East India Company to serve as a Gun Carriage Factory. Subsequently, when the Gun Carriage Factory had to be moved inland--to be precise, to Jabbalpore for strategic reasons, the East India Company seemed to have handed over the Workshops to the Public Works Department of the Government of Madras. For several years in the beginning, the department seemed to have utilised the Workshops only as a maintenance workshop for carrying out repairs to the Irrigation equipments, though some of the shutter equipments installed in the Cauvery delta at the turn of the century are believed to have been actually manufactured in this Workshops. It is only in recent years, however, that

the Workshop came to be equipped and developed to undertake large scale manufacture of irrigation and flood control equipments as well as other structural and mechanical equipments needed for the various projects in the State. Just prior to the last war, the annual outturn of the Workshops was hardly Rs. 3 lakhs, with less than 300 workmen on the rolls. During the war and post-war periods and more particularly, after the advent of independence, the alround launching of various development projects in the State brought upon a heavy demand on the Workshops. To meet the growing demand successfully, sustained efforts were made to develop and expand the Workshops whose annual outturn now stands at Rs. 30 lakhs, with nearly 1,000 workmen on the rolls.

2.2. Primarily, the Public Works Workshops are intended for catering to the multifarious needs of the Public Works Department in respect of mechanical, structural and other equipments for the Irrigation, Building and General Works. But these apart, the Workshops also undertake works needed for various other departments of the Madras State as well as of other States, and under certain conditions, works of quasi-public and private bodies also. Extending over an area of about four hectares (about ten acres), the Workshops consist of different shops and sections carrying out a variety of works. The structural shops undertake the fabrication of roof trusses, columns and beams, doors and grills, collapsible and ornamental gates, sluice and spillway gates, deckbridges, aqueduct and penstock pipes, transmission and aerial towers, steel tanks and trestles, etc. The machine shop is well equipped with a variety of general purpose machines. The shop commands an impressive array of heavy duty lathes, drilling machines, planing machines,

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shaping machines, milling machines, plate-bending machines, etc. All the machined parts required for the flood control and irrigation equipment, etc., are turned out in this shop. Hoist gear assemblies and overhead travelling gantry cranes required for the irrigation projects are made in this shop. The machine shop is also equipped with sand-blasting equipment, metal spraying equipment and heat-treatment plant. A carpentry shop, a foundry and a smithy also form an important part of the Workshops. The sheet metal shop makes steel furniture, racks and shelves, steel boxes, and safes, etc. The instrument shop undertakes repairs on levelling instruments, theodolites, prismatic compasses and other scientific instruments. This shop also makes badges and seals, dating stamps, embossing and punching machines, levelling staves, etc. The machine repair shop carries out repairs on engines, pumpsets, motors, vibrators, concrete mixers, etc. The irrigation machinery section maintains a fleet of transport vehicles, which move the finished goods and equipments to their respective destinations all over the State. This section also procures and supplies earth-moving machineries, pumps and motors and other heavy tools and plants to the various projects and divisions of the department. This section also maintains a P.W.D. pool, in which all the surplus inspection vehicles of the department are received, reconditioned and re-issued. Repairs to transport vehicles and heavy machinery are also undertaken by this section to a substantial extent. The erection and maintenance of various mechanical installations outside the Workshops are the functions of the outdoor section. On an average about fifty workmen are on deputation to outdoor work every day, to carry out the erection of and periodical repairs to the various mechanical installations, including flood control and irrigation equipments all over the State.

2.3. At the time of the construction of the Lower Bhavani Project, the first large scale irrigation project taken up in the State after Independence, sufficient design and manufacturing facilities were not available in the Public Works Workshops. The sluice equipments required for

the project had, therefore, to be imported from abroad. Since then, however, the Workshops have acquired extensive knowledge and experience in the design and manufacture of such equipments, with the result that in the case of all projects taken up after the Lower Bhavani Project (with the exception of Amaravathi Project), the sluice gates, hoist gears, overhead crane, etc., have entirely been designed and manufactured in the Public Works Workshops. It may perhaps be mentioned here that in the case of the Amaravathi Project, the sluice equipments had to be imported in view of the time factor involved. The spillway equipments, such as gates, bridges, hoists, etc., for almost all the existing dams in the State have been designed and manufactured by the Workshops. Similar equipments have also been designed and manufactured by the Workshops for certain other projects such as Sandynallah Dam of the State Electricity Board and Cheerakuzhi Weir, Enamakkal Regulator and Manjankuzhi Weir of the Kerala State. At present, the Workshops are engaged in the manufacture of equipments for the Sathanur Dam (Second Stage Scheme), Parambikulam-Aliyar Project and two other projects of the Kerala State, namely, Pothundy Dam and Chulliar Dam.

2.4. The varied nature of works undertaken in the Workshops will perhaps be evident from the following list of structures and equipments recently manufactured by the Workshops:—Roof trusses for the Polytechnics and Junior Technical schools at Nagercoil and Vellore, for the buildings of the Institute of Leather Technology, the Central Polytechnic and Engineering College, Guindy, for the godowns at Orathanad and Chinnasalem, and for the Agricultural Implements Workshops at Thiruvavur, mooring buoys for Colachel and Royapuram, conical buoys for the Tuticorin Port Trust, steel cupboards and wooden furniture for the Veterinary and Medical Colleges, structures for the bus stand-cum-waiting shelter of the State Transport Department at T. Nagar, mechanical mixer for the Quinine Factory of the Cinchona Department, various component parts for the printing machinery of

the Government Press, perforating machines for the Panchayat Union Councils, overhead water tanks and trestles for the Ambattur Industrial Estate, man-hole pipes and elliptical lids for the tunnel adits of the Kundah Hydro-Electric Scheme, etc.

The Stores

3. Attached to the Workshops, but forming a separate and distinctive unit, as it were, are the Stores, which procure, stock and issue a variety of materials, required not only by the different divisions of the Public Works Department, but by other departments of the State as well. The materials extend over a wide range—hardware stores, pipes and pipe fittings, structural steel, fuels and lubricants, paints and accessories, building materials, various kinds of small and heavy tools and plants, valuable metal, scientific instruments and various other miscellaneous stores. In addition, various special tools and plants are maintained by the Stores and lent on hire to various projects and divisions for use in their works. The Stores hold in stock as many as 8,000 items of materials worth more than Rs. 70 lakhs. Over the years the demand on the Stores had increased enormously. The value of the materials issued by the Stores to various divisions amounted to less than Rs. 15 lakhs in 1949-50, whereas last year it stood at more than Rs. 60 lakhs.

The Workmen Welfare

4.1. Various welfare schemes are in operation in the Workshops for the benefit of the workmen. The specially appointed Labour Officer of the Workshops looks after the welfare of the workmen and maintains a liaison between the workmen and the management regarding grievances of workmen. The workmen have their own Unions through which they make their representations to the management. In addition, a Works Committee consisting of the representatives of the workmen as well as of the management, is functioning for the past several years. The Works Committee holds its meetings periodically and discusses among other matters, the suggestions for improvements of the Workshops

and all matters relating to welfare and working conditions of the workmen. A Safety Committee, consisting of representatives of the workmen and the management has also been constituted recently, to periodically inspect the Workshops and the equipments, to make appropriate recommendations for improvement of conditions as regards safety and hygiene and to watch over the carrying out of measures adopted and their efficiency. Since 1961, the workmen of the Workshops and Stores have been covered by the Employees' State Insurance Act by which, all the workmen are "Insured" by making contributions both by the workmen and by the management. By virtue of this, the workmen become entitled to various sickness benefits, disablement benefits, dependants' benefits, medical benefits, etc., sanctioned by the Act.

4.2. In the interest of benefiting the workmen as well as in the interest of fostering healthier relations between the workmen and the management, a number of amenities are provided for the workmen. A canteen and a recreation club are run within the premises of the Workshops. The workmen are provided with facilities for free medical examination by an authorized Medical Officer. Facilities are provided for the workmen for buying handloom cloth and khadi, on credit, from the Madras State Handloom Weavers' Co-operative Society and the Madras State Khadi and Village Industries Board. A Co-operative Loan and Thrift Society is also run by the Workshops for the benefit of the workmen. Loans are granted to the members of the Society at a low rate of interest and recoveries are made in easy instalments. Thrift money is collected from the members every month and is repaid at the end of their terms, while the interest on the thrift money is paid off annually. At the instance of the Government, plans are afoot now to organize a Consumer Co-operative Stores for the workmen, with a view to help them to obtain essential commodities at reasonable prices and also as a measure of stabilization of prices in the present context of National Emergency. With a view to provide residential accommodation to the workmen, the department is now constructing quarters

at Tondiarpet within easy reach from the Workshops.

The Finance

5. The operation of the Workshops, in terms of the financial results also, is satisfactory. The outturn of the Workshops during the past several years is steadily on the increase. The outturn during 1960-61, for instance, was Rs. 28.07 lakhs, which is more than twice that of 1953-54. During 1961-62, the outturn increased to Rs. 29.36 lakhs and it has further increased to Rs. 30.19 lakhs during last year. A steady profit of over Rs. 3 lakhs has been registered by the Workshops for the past several years, after allowing for all the depreciation charges, pension and audit allowances, interest, etc., apart from the actual working expenses. From the standpoint of assets and liabilities also, the Capital Balance Sheet of the Workshops reveals a steady increase year by year in their capital value, that is, in the excess of their assets over liabilities, thereby testifying to the sound financial structure of the Workshops.

The Future

6.1. Though there are good grounds for the Public Works Workshops and Stores to take a legitimate pride, as it were, in their remarkable success and utility, there are still scopes and needs for remodelling and reorganizing the Workshops and Stores, in order to enable this institution to serve the interests of the State more

intensely, more abundantly and more economically. In this context, it is indeed heartening to know that various proposals are now being actively considered by the Department and the Government to fulfil the long-felt needs for modernizing the Workshops and Stores. Bifurcation of the Stores and Workshops, finding more room for the working of the Workshops and Stores, streamlining and strengthening of the technical and administrative personnel, mechanisation of handling and movement of materials and jobs in the Workshops, modernizing the operational methods, affording intensive training to the workmen and technical personnel of different cadre, in the modern methods of operation, production, production planning and control, quality control, management, etc., are some of the basic and essential improvements, which this institution looks forward to have in the not too distant future.

6.2 As for the works in the future, it is expected that the Parambikulam-Aliyar Project, the Gomukhi Nadhi Reservoir Scheme, the Sathiar Odai Scheme and other irrigation schemes of the Third and Fourth Five-Year Plans, various minor irrigation works and building works, not to mention the multifarious development projects of the different departments of the State will bring forth a heavy demand on the Public Works Workshops and Stores, which as always, can be depended upon to rise up to the occasion and put up their best and utmost.

THE VARIABLES IN CHANNEL DESIGN AND THEIR LIMITATIONS

BY

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From time immemorial, rivers and torrents have been flowing down the hills and mounds, carrying large quantities of sediment, washed and scoured on the way. On approaching the plains, which they themselves have built in the course of ages, their velocity gets slowed down and the coarser fraction of the sediment carried, gets deposited on the bed and the sides, with the finer portion, sustained in the suspended state throughout reaching the Sea. The laws governing the stable sediment transporting rivers in a odible material are highly complex and various theories have been put forward from time to time dealing with the precise manner in which a river or stream transports its sediment.

The irrigation canal which draws its supplies from these rivers draws along with the water, its proportion of sediment. Such an artificial channel in its turn flows along, depositing silt in some places, scouring down in other places, scarcely maintaining the section given to it initially, arbitrarily. This presented continuous problems to the Irrigation Engineer in maintenance and set him thinking as to why not the section of the channel as it is originally made, be made to induce flow in regime, i.e., flow which neither scours nor deposits silt.

This is the crux of the problem of channel design.

The design of regime channels has been the object of considerable research during the past six decades. Any design theory must recognize the effect of the many variables involved in the problem. Originally only single equation of the Chezy or Manning type, was utilized and having

obtained the velocity of flow, the cross-section which gave the required waterway was arbitrarily fixed. In recent years, however, various investigators have concluded that width, depth and slope are all variables in alluvial channels and that this implies mathematically the necessity of at least three design equations. The problem appears even more complex when one recognizes that sediment transport also affects channel stability with the result, to date no theory has been conceived capable of adequately considering all the several variables that influence channel behaviour and the problem of channel design remains as yet to a certain extent unsolved.

A list of the major variables involved in the problem is as follows:—

- (1) Discharge conditions—
 - (a) Steady discharge.
 - (b) Variation of discharge with crop needs.
 - (c) Periodic operation.
 - (d) Design discharge exceeded.
- (2) Slope.
- (3) Shape of channel.
- (4) Boundary material—
 - (a) Cohesive material.
 - (b) Non-cohesive material, sand range.
 - (c) Non-cohesive material, larger than sand.
- (5) Water temperature.
- (6) Magnitude and range in size of total sediment load.

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- (7) Berms—
- (a) Deposition of wash load ;
 - (b) Shape of channels possessing berms;
 - (c) The influence of berm formation on bank vegetation.
- (8) Bank stabilization.
- (9) Secondary circulation or transverse flow.
- (10) Seepage inflow or outflow.
- (11) Effect of wind action on stability of channels—
- (a) Estimate of tractive shear exerted on the bed of a channel due to waves ;
 - (b) Effect of percolation caused by waves on the stability of a permeable bed ;
 - (c) Effect of waves on bank stability ; and
 - (d) Wind effect during the non-operating season.

The required carrying capacity of a canal under design is determined by the area to be served and the duty during the period of maximum use. Irrigation channels for distributaries are likely to flow at full discharge throughout the season. Even in the main canals the variation may not be considerable and frequent and all designs and calculations are generally made for discharge at full supply level.

It is customary to attempt to follow the slope of the topography for the canal slope wherever feasible and where the grade available is excessive, the grade that would promote flow in regime is determined by the use of the various formulæ developed.

A semi-circle open at the top is hydraulically the most efficient of all channels, but it is not a practically feasible shape especially in earth channels. If a polygon, it should be circumscribed about a semi-circle, having its centre in the upper water surface for best efficiency. If a rectangle the depth should be equal to half its width. If trapezoidal it should have side slopes of 60° which cannot be easily maintained in

unlined earthen channels. But hydraulically efficient shape does not necessarily give a stable cross section for the channel. It has been realised from the large studies made that for a given discharge flowing in the canal, the width, the depth, slope are all fixed by nature, the channel thus self-adjusting its dimensions.

The boundary material decides to a large extent the freedom for the flowing channel to adjust its shape and thus affects the regime conditions being set up. The grain-size distribution and the composition of this material influence the maximum permissible velocities that can be all-owed without fear of scouring the bed and banks.

The water temperature directly affects its viscosity and with the ordinary turbulent flow that prevails in the open irrigation channels, viscosity is a factor that cannot be disregarded. Certain ranges of temperature promote vigorous weed and moss growth which blocks the flow cross section and increases resistance to flow, reducing the discharge to even as much as one-fourth the capacity sometimes.

Above all, the sediment in transport, in suspension as well as rolling down along the bed, influences the flow characteristics in the channel and ability of the channel section to retain its original shape. The laws of sediment transportation are highly complex and even though much work has been done in recent times in their investigations, complete knowledge cannot be said to have been gained.

Berms are sometimes placed at the original ground surface where the canal runs partly in fill and partly in cut. The width of the berm is made equal to the depth of water, the side slope below the berm being 1:1 and above 1½:1 or 2:1. It has been felt that the berms assist the channel in adopting its shape to permanent sections by providing the necessary material if needed or affording possibilities for the quick deposition of the wash load. But the use of berms in this position are not favoured by many as it provides the fertile ground for vegetation to spread. Sometimes berms are placed at the free board height when the canal is all in deep cut with the water surface several feet below the

ground. In such a position they are very useful—

(i) to receive the material which may wash down from part of the bank above it preventing its falling into the canal ;

(ii) to lessen the pressure of the earth above the berms on the material below which has a tendency to slip into the canal especially in moist conditions ; and

(iii) to facilitate repairs and inspection of the canal. The width of the berm in such cases may be equal to the depth of the water subject to a minimum of 3 feet.

The effect of the other factors detailed are secondary and much work is yet to be done before sufficient knowledge can be gained for a detailed treatment of those in relation to the problem of channel design.

Steady uniform flow is obtained when the following conditions exist:—Constant cross-section, uniform roughness and constant slope ; these imply a constant velocity with the water surface grade parallel to the grade of the bed of the canal. In practice especially in earthen channels, there are more or less variations and steady uniform flow conditions are seldom attained. Nevertheless this type of flow is commonly assumed for design purposes. The velocity of flow in irrigation channels is maintained far below the critical stage with the Froude Number ranging around 0.3.

The problem of channel design hence reduces to this ; “For a specified discharge, and for the given conditions of the channel material, sediment in transport and climate, to design the channel cross section and grade which will maintain steady uniform flow in tranquil stage without either scour or objectionable deposits of sediment on the bed and sides”.

SOME GLIMPSES OF PUNJAB IRRIGATION

BY

* SRI K. V. EKAMBARAM, I.S.E.

Foreword

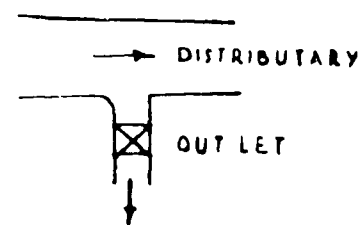
The author took advantage of his recent tour to Delhi to attend the Annual Session of the Central Board of Irrigation and Power to visit a small length of the Delhi Branch and the Delhi tail end Distributary which form parts of the Western Jumna Canal Irrigation. The various details noticed are given below. Even though the author visited only a small extent of the irrigated area of the Punjab, yet, it may be considered as typical of Punjab irrigation.

The area irrigated by the Western Jumna Canal is a vast alluvial plain. The area that can be irrigated is, so to say, very large. So, to spread the benefit over the maximum number of people, the ayacut that is fixed under each outlet (sluice) of the distributary is in the order of 400 acres for every cusec. For Delhi Tail Distributary in any one year, 50 per cent of the area only is expected to be irrigated. The rest usually grows crops with the help of rains or by thrifty use of irrigation water. Out of this 50 per cent half the area is expected to be irrigated in Kharif season (from 1st April to 30th September) and the other half in the Rabi season (from 1st October to 31st March). Thus, water is provided for one-fourth of the area in an outlet chak in one crop.

It is noticed that the cultivators in these parts own comparatively large holdings. Some consolidation of holdings was also carried out in past years. This has helped irrigation considerably. Under each outlet, a time-table for irrigation has been fixed up according to which, each cultivator gets water over a limited number of hours, in a period of 8 days. So it is left to

him to use the water as carefully as possible and irrigate the area he likes with the water allowed. It was noticed that even though the original intensity was fixed at 50 per cent, it has now gradually increased to 70 per cent on Delhi Tail Distributary.

The distributary was generally seen to run in embankment, and hence discharges through the outlets are free. So, it is constant whatever field is irrigated. The outlets have no shutters; they are either adjustable proportionate modules or open flumes. Their wing walls also are designed as shown in the sketch to give a smooth



hydraulic flow into the outlet. The irrigation authorities have to only see that they maintain F.S.L. in the channels all the time. Irrigation is practically automatic, and it was noticed that complaints about water supply, are very few. The demand for more water is, of course, there.

The assessment of water cess and the issue of demand notices are made by the irrigation authorities. It is claimed that this sort of control over irrigation enables the irrigation authorities to watch that every land that uses irrigation water is assessed and also enables the efficient utilisation of water. This method prevails in the Punjab, U.P. and Maharashtra States. So, to each Executive Engineer, a revenue staff is attached. A Deputy Collector is the head of this

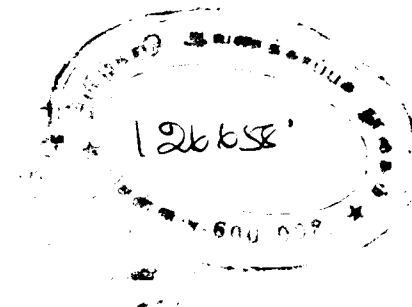
Organisation and there is one under each Executive Engineer. His immediate subordinate is called the Zilladar under whom works the Patwaris who are now called Irrigation Booking Clerks. Each Patwari has a jurisdiction of about 5,000 acres. Each field in this area has got to be visited at least once in 15 days. Of course, the collection of water cess and land revenue is done by the Revenue Department.

By a recent order, the trees on the banks of the irrigation channels have been handed over to

the Forest Department. The advantages of this change in control are yet to be seen.

At the time of my visit there were only sugarcane, and wheat crops in the fields. It is understood in the Kharif season, rice, jowar and millets are grown. The soil is uniformly alluvial and appeared to contain about 10 per cent of clay.

The channel banks are being maintained well and neat and are motorable. On the whole, irrigation seemed to be automatic and efficient.



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NEWS ROUND UP.

1. *Manjalar Reservoir Scheme.*—The Manjalar Reservoir Project, estimated at a cost of Rs. 65.80 lakhs, was inaugurated by the Chief Minister of Madras, Sri K. Kamaraj, on 18th September 1963 and was presided over by the Minister for Works Sri V. Ramaiah. On the occasion, the Chief Engineer (Irrigation) welcomed the gathering and gave a brief account on the Project. This is another land mark in the history of irrigation of Madurai district.

The proposed reservoir site is at about 3-1/2 miles north of Devadanapatti village of Periakulam taluk. The scheme will give assured supply to the existing ayacut of 3,249 acres, bridge a gap of 113 acres and will bring in a new ayacut of 1,200 acres which will result in an additional food production of 728 tons of rice every year.

2. *Chittar Pattanamkal Scheme.*—The Chittar Pattanamkal Scheme in Kanyakumari and Tirunelveli districts, at a cost of six hundred and eighty lakhs of rupees, was inaugurated by the Chief Minister of Madras, Sri K. Kamaraj on 19th September 1963 to the great jubilation of thousands of villagers deriving the benefits of the project. Minister for Works Sri V. Ramaiah presided over the function and Sri K. V. Ekambaram, Chief Engineer for Irrigation who welcomed the gathering said that this new scheme would benefit an area of 15,000 acres of double crop and 17,000 acres of single crop.

3. "The Central Public Health Engineering Research Institute will hold a symposium on PROBLEMS IN WATER TREATMENT during November 1964. Interested people may send 2 copies of full papers by July 31, 1964, to Dr. N. U. Rao, C.P.H.E.R.I., Nehru Marg, Nagpur-3. Exact dates will be announced later.

" . . . There will always be dissident voices heard in the land, expressing opposition without alternatives, finding fault but never favour, perceiving gloom on every side and seeking influence without responsibility."

—Extracted from the speeches of late Mr. John Fitzgerald Kennedy, Late President of U.S.A.