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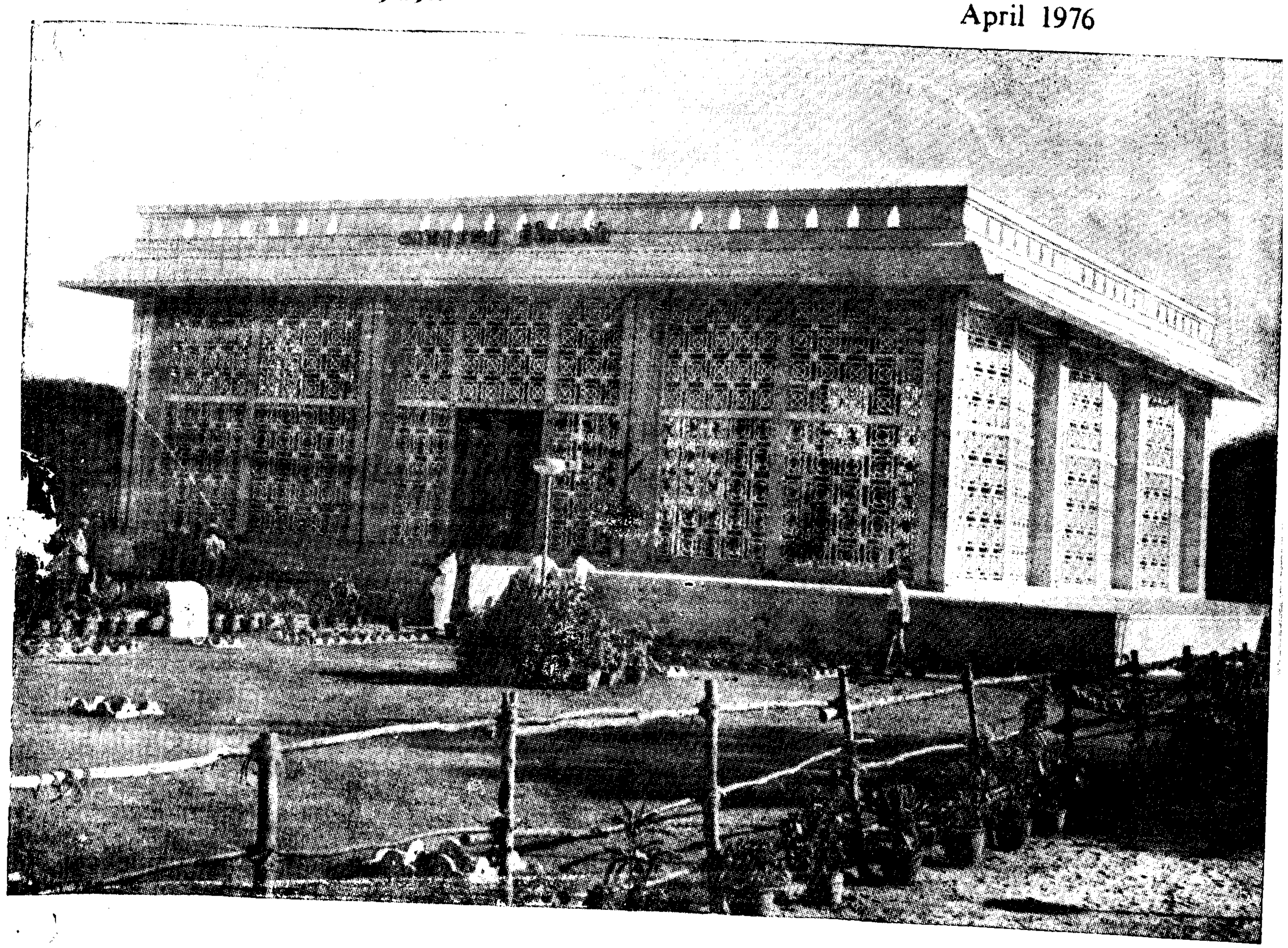

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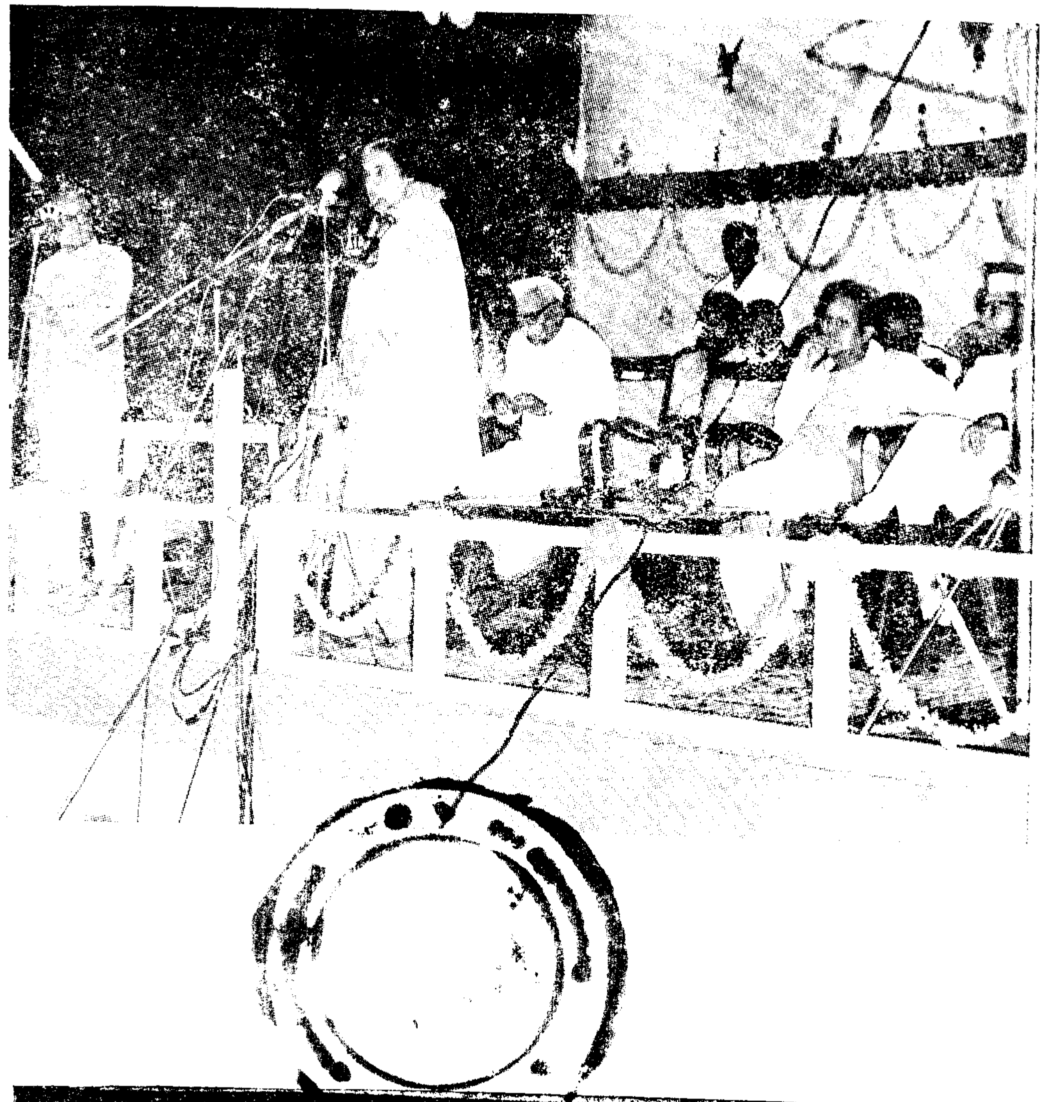

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THE NEW IRRIGATION ERA

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EDITORIAL.

It is presented with pride that this issue of the Journal namely Volume XIV—Issue 2 contains more articles on 'Water and its management practices'. Major use of water is in Irrigation. Hence a study on water and its management practices must be more useful to Engineers like us dealing with Irrigation practices. The articles adorning this issue covers the following useful information namely Distribution of water in the World, World's demand of water, Assessment of water, Various uses of water, Water Management in an Irrigation Project, Water Management in the fields, Economic and efficient use of water, Multipurpose reservoirs, Artificial rain, Disalienation of sea water, Pollution of water. In this total water resources and their utilization, research need for improved water management, seepage, losses, etc.

This issue also carries the information about 'Foundation Problems in Swelling Soils and its possible solutions, etc.' This has also got the quite interesting photographs of the various Irrigation Projects in Tamil Nadu. Hence the Editorial Board is happy to present before its readers this valuable journal, the carrier of useful information on water.

CHARACTERISTICS OF FLOW OVER TERMINAL WEIRS AND SILLS

by

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Iowa Institute of Hydraulic Research, State University of Iowa.

Synopsis.

Generalised experimental results are presented to show the variation in both the discharge coefficient and the nappe profile for two-dimensional flow over a vertical sharpcrested weir at the end of a horizontal channel as the ratio of head to depth of flow changes continuously from zero to unity.

Abstract.

Whereas most existing weir formulas lose significance as the ratio of head to height of weir becomes great, it is known that the rate of flow overa sill at the end of a channel can be estimated from the basic weir equation by assuming the velocity of approach to have its critical magnitude. This gives rise to a discharge function for sills which meets that for weirs in a sharp peak when the head is about ten times the weir height. There are related indications that the nappe attains a maximum elevation and thickness at the same head-height ratio. Laboratory tests to determine quantitatively the variation in discharge coefficient and nappe profile over the entire range are described, and the experimental results are presented in generalized form for design purposes.

Historical Background.

Poleni (1), in 1717, was the first to publish an equation for weir, discharge obtianed by integrating over the outlet section an expression for the velocity in terms of the square root of distance below the free surface. Although he neither took account of the nappe contraction nor explicitly introduced the gravitational acceleration g, Poleni's name continues to be associated with the elementary discharge equation.

$$q = \frac{2}{3} C_c \sqrt{2g}\, h^{3/2} \qquad (1)$$

in which q is discharge per unit width of flow section, Cc the coefficient of contraction, and h the head of the crest. Contraction of the nappe was taken indirectly into consideration by Du Buat (2) sixty years later in setting as arbitrary limits of integration the crest level and a level the distance h/2 above the crest; it was also Du Buat who introduced present-day methods of estimating the effect of submergence. Bidone (3), better known for his study of the hydraulic jump, appears to have been the first to show an interest in expressing alegebraically the geometry of the weir nappe.

Not until about the middle of the 19th century was attention focused upon the velocity-of-approach "correction" for weir discharge, which was to dominate certain branches of the literature for another century. In 1845 Weisbach (4) published the familiar integral form

$$q = \frac{2}{3} C_c \sqrt{2g} \left[\left(h + \frac{v_0^2}{2g} \right)^{3/2} - \left(\frac{v_0^2}{2g} \right)^{3/2} \right] \qquad (2)$$

Since the solution of this equation has to proceed by successive approximation because of the implicit presence of the approach velocity V0 on the left side of the equation, the impression has persisted that this velocity is independently variable. Weisbach himself appreciated the fact that a unique solution existed for any ratio of head h to depth of approach h + w, as he proposed an empirical formula for its evaluation ;

$$q = \frac{2}{3} (C_c)_{h=0} \left[1.041 + 0.3693 \left(\frac{h}{h+w} \right)^2 \right] \sqrt{2gh} \qquad (3)$$

Bazin (5) in 1888 adopted the same form of function, with specific evaluation of the limiting co-efficient of contraction,

$$q = \left(0.405 + \frac{0.003}{h\ (m)} \right) \left[1 + 0.55 \left(\frac{h}{h+w} \right)^2 \right] \sqrt{2g}\, h^{3/2} \qquad (4)$$

the dimensional term 0·003/h being introduced to compensate for low-head effects now attributed to surface tension and viscosity. In a series of investigations extending over the next ten years, Bazinalso went deeply into such varied aspects of weir flow as the distribution of velocity and pressure throughthe nappe, and the effects of incomplete ventilation, submergence, weir inclination, and geometry of the crest, his nappe-profile measurements are still used as the basis of spillway design.

Bazin's formulation of the discharge coefficient soon led others to attempt further improvements by slight changes in the type of algebraic expression used. From 1911 to 1928 Rehbock (6) proposed a number of variants, the most pertinent of which was

$$q = \left(0.605 + 0.08 \frac{h}{w} + \frac{1}{305\ h\ (ft)} \right) \frac{2}{3} \sqrt{2g}\, h^{3/2} \qquad (5)$$

Comparison of Eq. (5) with Eq. (4) will show that the primary distinction lies in the use of the ratio h/w in place of h/(h + w) as the geometric parameter. The remaining term of Eq. (5)—which, like the corresponding one of Bazin, is not dimensinally homogeneous with the others–again reflects capillary and viscous effects at low heads. If the latter factors are ignored and if the basic weir equation is written in terms of a discharge coefficient C_d,

$$q = \frac{2}{3} C_d \sqrt{2g}\, h^{3/2} \qquad (6)$$

it will be seen that the essential aspects of the Bazin and Rehbock formulas may be reduced for comparison to

$$C_d = 0.608 + 0.334 \left(\frac{h}{h+w}\right)^2 \qquad (7)$$

and

$$C_d = 0.605 + 0.08 \frac{h}{w} \qquad (8)$$

which are plotted against h/(h + w) in Fig. 1. The two curves evidently differ by little more than 1 per cent for heads as great as twice the height of weir.

When Mises (7), in 1917, determined the co-efficient of contraction analytically for various two-dimensional forms of conduit outlet, he noted that the values for a symmetrical slot in a normal plate at the end of a consuit would—in combination with Eq., (2)—duplicate the trend of the Rehbock formula very closely over a considerable range if the ratio of slot dimension b to conduit dimension B were used to represent the ratio h/(h+w). His curves for C_c and Cd are also shown in Fig 1. To be notec in particular is the limiting theoretical value $\pi/(\pi+2) =$ 0·611 in comparison with the empirical values 0·608 and 0·605 chosen by Bazin and Rehbock. One of Mises, students, Lauck (8), nearly a decade later approximated not only the discharge coeffient but also the entire nappe profile for the weir of infinite relative height, by means of Cauchy integral theorem.

Inspection of the Bazin and theRehback formulas will Indicate that the latter must approach the limit $Cd_0 = \infty$ as the relative hight of the weir apprcaches the limit zero, (i.e., the free overfall), a trend that is necessarily shared by the orifice function of Mises, whereas the Bazin function has the finite limit Cd—0.942. Now it is obvious that dis charge over the free overfall is finite rather than infinite Since the effetive head is the critical depth. However it was noted by Boss (9) that the critical stage of flow is already estzablished upstream from terminal stills well before they attain zero height, which would yield a trend contrary to that of Eq. (6). That is, following the procedure of Rouse (10), the dicharge co-efficient for such conditions can be determined by introducing into Eq (6) the crirical depth relationship

$$h + w = y_c = \sqrt[3]{\frac{q^2}{g}} \qquad (9)$$

Thus,

$$C_d = 1.06 \left(1 + \frac{w}{h}\right)^{3/2} \qquad (10)$$

which is plotted at the upper-right of Fig. 1. Evidently, the discharge characteristics of terminal sills follow quite a different functional relationship from that of even moderately low weirs, with an intermediate maximum value of the discharge coefficient. Now the coefficient of contraction Cc can be determined from simultaneous solution of Eqs. (10), (6), and (2) and plotted as at the lower right of Fig. 1. If, after Rouse, this coefficient is assumed to approximate the relative thickness of the nappe at its highest point, then this plot indicates that the flow profile will also attain a maximum stage at the borderline between weirs and sills.

In order to investigate these aspects of the problem the recond author undertook in 1931–33 in the River Hydsaulic Laboratory of the Department of Civil and Sanitary Engineering at M.I.T. a systematic series of profile (as well as velacity and pressure) measurements on the nappe of a weir that was successively reduced in height until the overfall limit was reached. The results of the profile tests were reflected in a subsequent book (11), but they were found to cover the transition range inadequately and hence were never published in their entirety. Similar measurements over a less extensive range of the parameter h/(h+w) were undertaken later by the Bureau of Reclamation and published (12) for purposes of spillway design. Because it was believed that certain characteristics of the weir-sill range were nevertheless of technical interest, generalized plots of the M.I.T. data showing a parallel between the discharge-coefficient and nappe-profile functions were included in the Proceedings of the Fourth Hydraulics conference (13) of the Iowa Institute of Hydraulic Research.

Continued efforts have since been made at the Iowa Institute to complete both the analytical and the experimental phases of the weir and sill problem. The relaxation method has already been applied to the improvement of Laucks approximation of the nappe profile for the infinitely high weir (14) and at the time of writting the study is being extended to other values of h/(h+w). However since numerical integration is not as readily applicable to low weirs and sills as to high, the gaps left in the M.I.T study were in 1956 filled in experimentally by the first author (15) under the direction of the second to the end of providing a basis for both design and further theoretical analysis. It is to the presentation of the composite results that this paper is devoted.

Experimental Procedure.—

The M.I.T. experiments were conducted in a 50 cm. glass-walled flume the rate of flow through which was measured with a ventilated sharp-crested weir 40 cm. high in accordance with Eq. (5). The experimental weir was initially of identical characteristics, but its effective height was changed by the addition of successive false floors on the upstream side. These were constructed of troweled cement mortar over sand and each consisted of a 6 feet level section preceded by a very gradual rise from the original floor of the flume. Three weir heights—40, 20 and 10 cm.—were produced in this way. The 40-cm. weir was then removed and still another false floor was added at a height of 37·5 cm. above the flume floor with a brass-angle end to simulate the free overfall. A supplementary weir crest could be attached to the end with wingscrews to produce additional weir heights of 5, $2\frac{1}{2}$ and $1\frac{1}{4}$ cm. Full ventilation was provided below the nappe in all instances.

Profile measurements were made at 1 cm. sections upstream and downstream from the crest with point and hook gages reading by vernier to 0·1 mm. For each of the seven weir heights the same nine rates of discharge were investigated; these corresponded to heads on the measuring weir ranging by 2 cm. increments from 2 to 18 cm. Supplementary measurements of pressure distribution along the floor, up the weir plate and through the nappe as well as checks upon the constancy of the total head at various points, were also made but neither the experimental techniques nor the results are pertinent to the present discussion.

The tests conducted at the Iowa Institute employed the same type of free-overfall structure as the one finally constructed at M.I.T. except that it was built of brass plate and angles and mounted in a 1 foot flume. The level portion was 4 feet in length, its height above the floor of the flume was 1 foot and the approach curve had the form of a quarter ellipse with an axis ratio of 3·5 : 1. The adjustable weir plate was machined to a sharp upstream edge, the top surface originally having a width of about 1/32 inch. To minimise capillary distortion of the lower surface of the nappe at small weir heights, the crest surfaces were rubbed with parafine. For the very smallest height (0·005 foot) the crest was remachined to a knife edge. The test procedure was essentially the same as that at M.I.T., although the range of head was limited to 0·1 foot < h < 0·5 foot and the range of weir height to 0·005 foot < w < 0·05 foot. Discharge measurement was effected by means of a 90° elbow meter in the 6 in supply line that had been previously calibrated against a 12 in sharp-crested weir mounted in the flume itself, the Rehbock formula being used as reference just as in the M.I.T. experiments.

Discussion of results.—As has long been realised, the head on a weir must be measured a considerable distance upstream from the crest, where the effect of the curvilinearity of flow upon the surface elevation is still negligible. A distance equal to three or four times the head is generally considered to suffice. Unfortunately, with relatively low weirs the effect of channel resistance becomes appreciable, so that the nappe profile is a symptotic to a sloping rather than a horizontal line. In other words, the head measurement then is subject to two types of error, the one increasing with proximity to the crest and the other with distance from it.

In order to determine that section at which the net error would be a minimum so that the heads for different weir heights could be determined consistently, a composite dimensionless plot was made of all profile measurements up stream from the crest for the most extreme case—the free overfall—as shown in Fig. 2. Since the computed critical depth was used as the reference length, and since the critical section has been shown to be the last at which hydrostatic distribution of pressure (i.e., absence of curvilinearity) can be assumed to prevail (10), the abscissa of the desired section should be that having an ordinate value of unity, or x/h = 4. In as much as this value for the free over fall agrees with that commonly used for weirs of great relative height, it was adopted for all subsequent evaluations in the intermediate range as well.

From the experimental determinations of discharge and surface profile for the various heights of weir and sill the co-efficient of discharge was evaluated according to Eq. (5) and plotted as in Fig. 3. Herein the Rehbock parameter h/w is used as abscissa in the weir range, because of the linearity of the resulting function. Its reciprocal w/h then logically serves as the abscissa in the still ranget the relative scales of the two being so chosen as to yield, approximate agreement in the intermediate range. All of the Iowa data are shown, together with a comparable number from M.I.T. (i.e., all at the heigher heads). Inspection of the diagram will indicate that Eq. (8) for weir applies with good approximation over the range 0 < h/w < 6, and Eq. (9) for sills over the range 0 < w/h < 0·06. Although some discrepancy between the two sets in the zone of overlap is apparent, a smooth transition between the two functions can readily be drawn.

In Fig. 4 are superposed a systematic series of nappe profiles extending through the weir range to the case of maximum co-efficient, h/w = 10. Figure 5 shows the, corresponding family of profiles for sills. Like the coefficient plot of Fig. 3, the profiles (except for the owe surface of the weir nappe) are seen to be characterized by similar trends, the case h/w = 10 or w/h = 0·1 evidently representing a maximum for both the discharge coefficient and the nappe deflection.

As had previously been noted by the second author and used as the basis of the generalized profile diagrams already mentioned (13), plots of z/h as functions of h/w w/h with x/h as parameter bear a striking resemblance to the coefficient function shown in Fig. 3. Revised in accordance with the sill data now at hand, these diagrams, are presented as Figs. 6 and 7, together with measured points for two representative values of x/h. The confocal rectilinear portions of the curves below h/w = 5 are identical with those previously published, but the remainder will be found to differ appreciabaly. Similarity with the coefficient curve is maintained well into the sill range however, except in the very neighbourhood of the over fall limit.

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Although the foregoing experimental data were obtained with heads of relatively small magnitude and hence can be expected to apply only approximately to conditions at larger scale, it is believed that the degree of approximation will not be appreciably lower than the experimental precision evident in the figures. The Rehbock equation, for example, indicates that capillary and viscous effects change the discharge by about 1 per cent at a head of 0·3 foot. Since this is representative of the heads that were investigated, there is no reason to expect scale effects of a higher order to be present in the results.

Conclusions.—

Though the combination of experimental measurements made at considerably different times and places, information is now at hand for the co-officient of discharge and the form of the nappe profile as the relative height of a ventilated, sharp-crested weir at the end of a channel varies over its complete range from infinity to zero. In the range 0 < h/w > 6 the coefficient of weir discharge is given approximately by the formula.

$$Cd = 0{\cdot}61 + 0{\cdot}08 \frac{h}{w}$$

In the range 0 < w/h < 0·06, the coefficient of discharge is given approximately by

$$Cd = 1{\cdot}06\left(1+\frac{w}{h}\right)^{3/2}$$

In the intermediate zone there is a continues transition between the two functions with a maximum at approximately h/w = 10; the latter might hence be regarded as the borderline between weir flow and sill flow. This value of h/w also marks the condition of maximum nappe deflection, the nappe for both weirs and sills gradually rising the thickening as this common value is approached. Nappe profiles for design purposes may be determined either by interpolation of the profile curves or by direct reading of the generalized profile co-ordinates presented in the paper.

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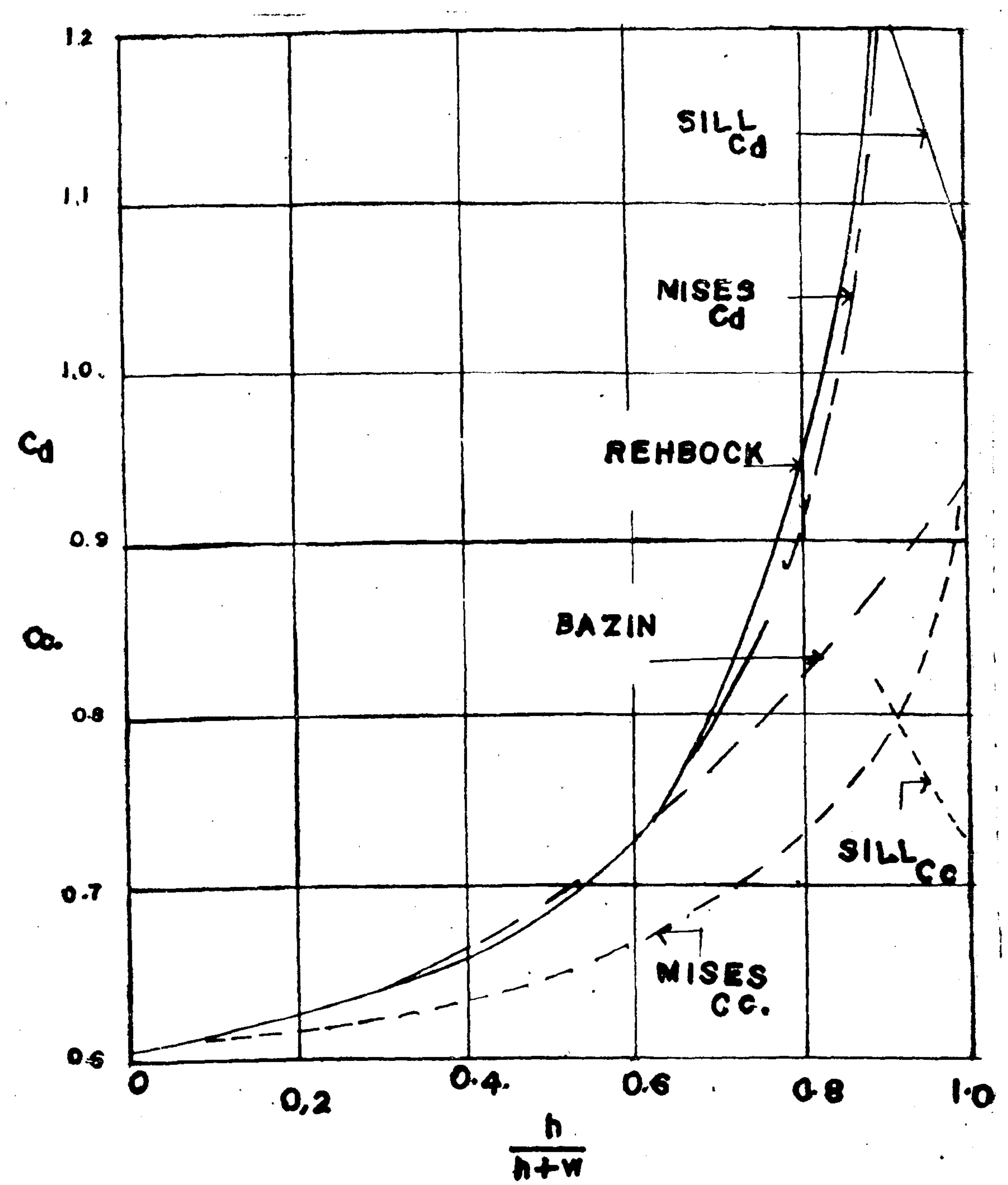

FIG. 1. COMPARISON OF DISCHARGE FUCTIONS FOR WEIRS AND SILLS

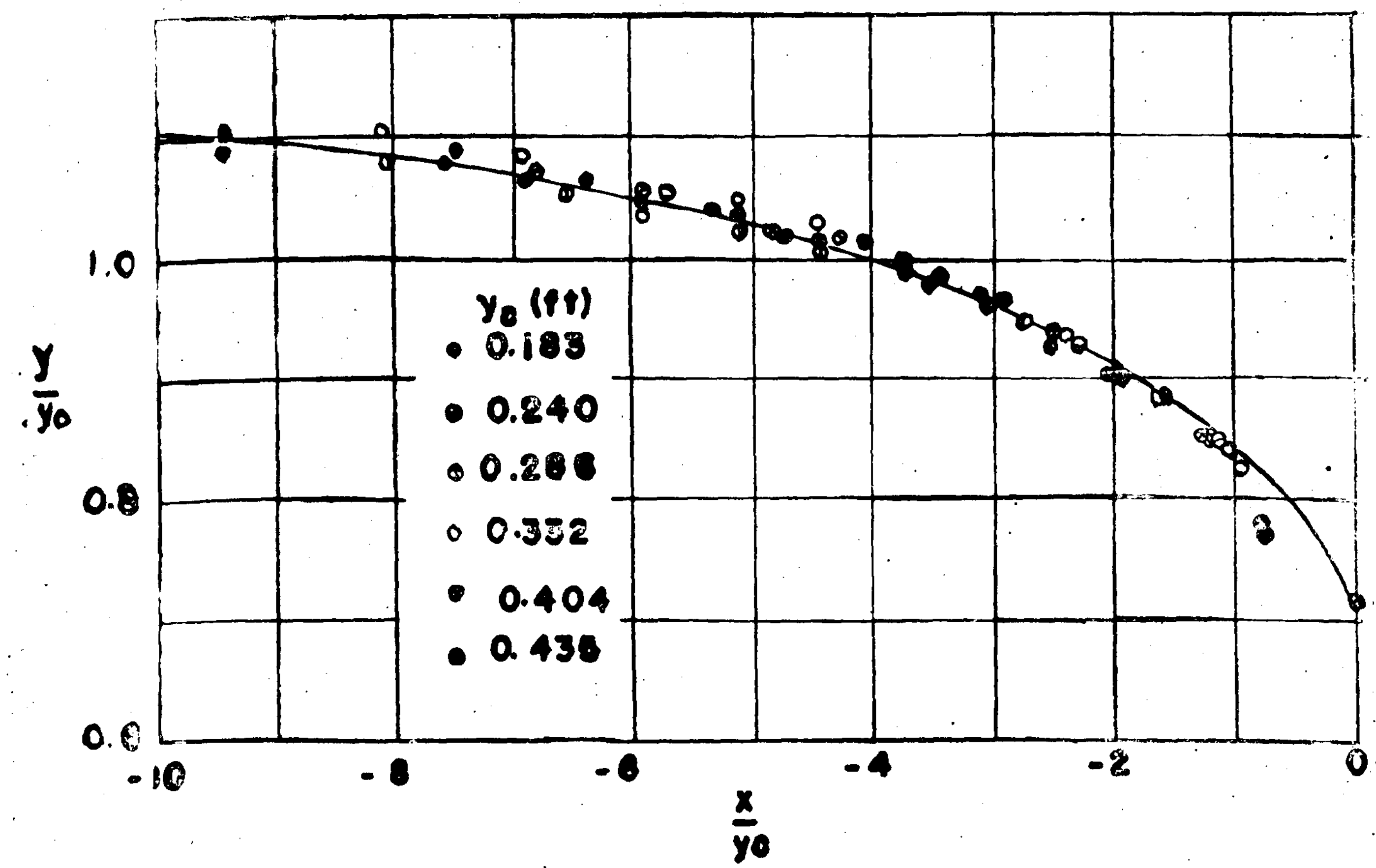

Fig 2. Location of critical section upstrem free over fall.

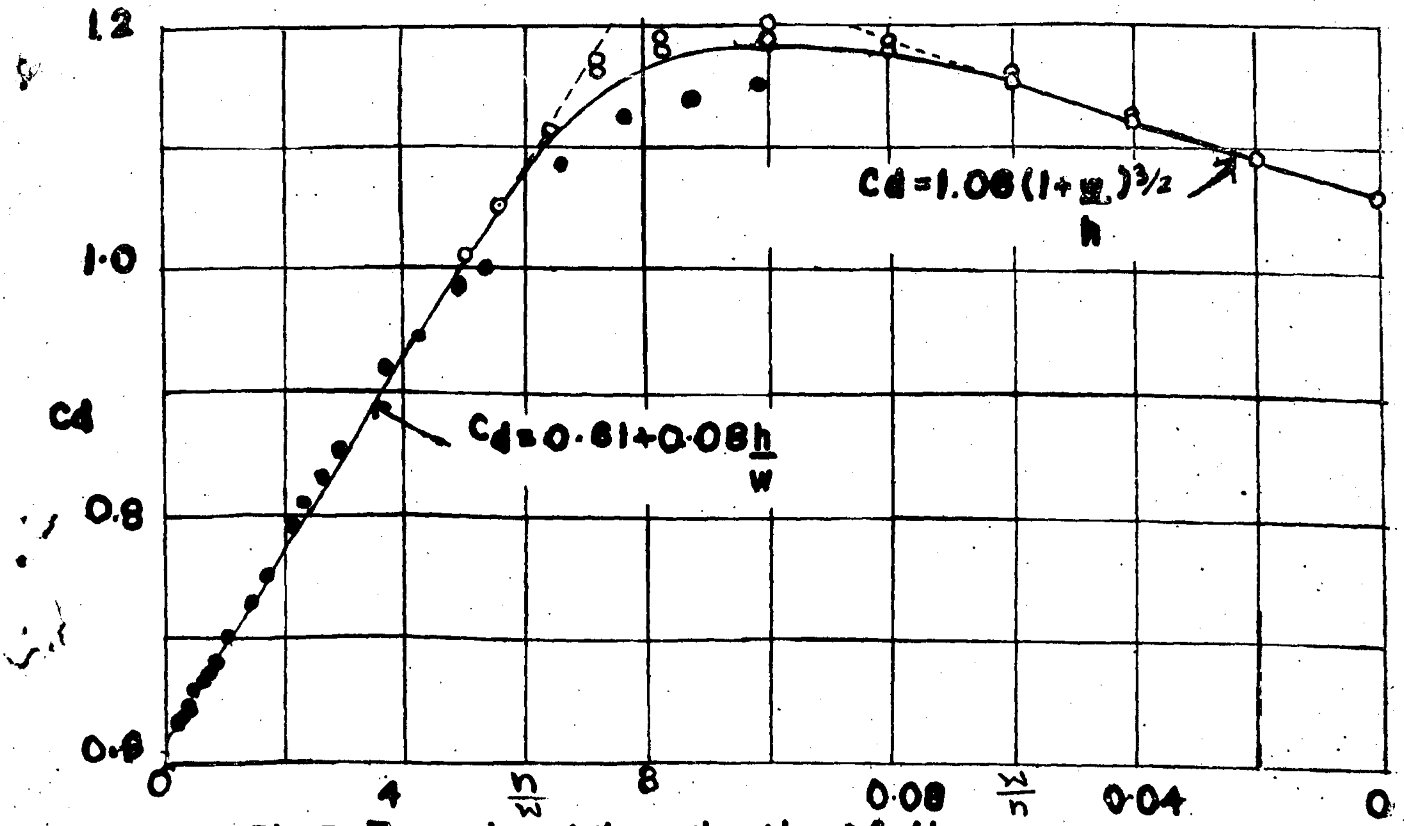

Fig 3. Experimental evaluation of discharge coefficient for entire weir-sill range

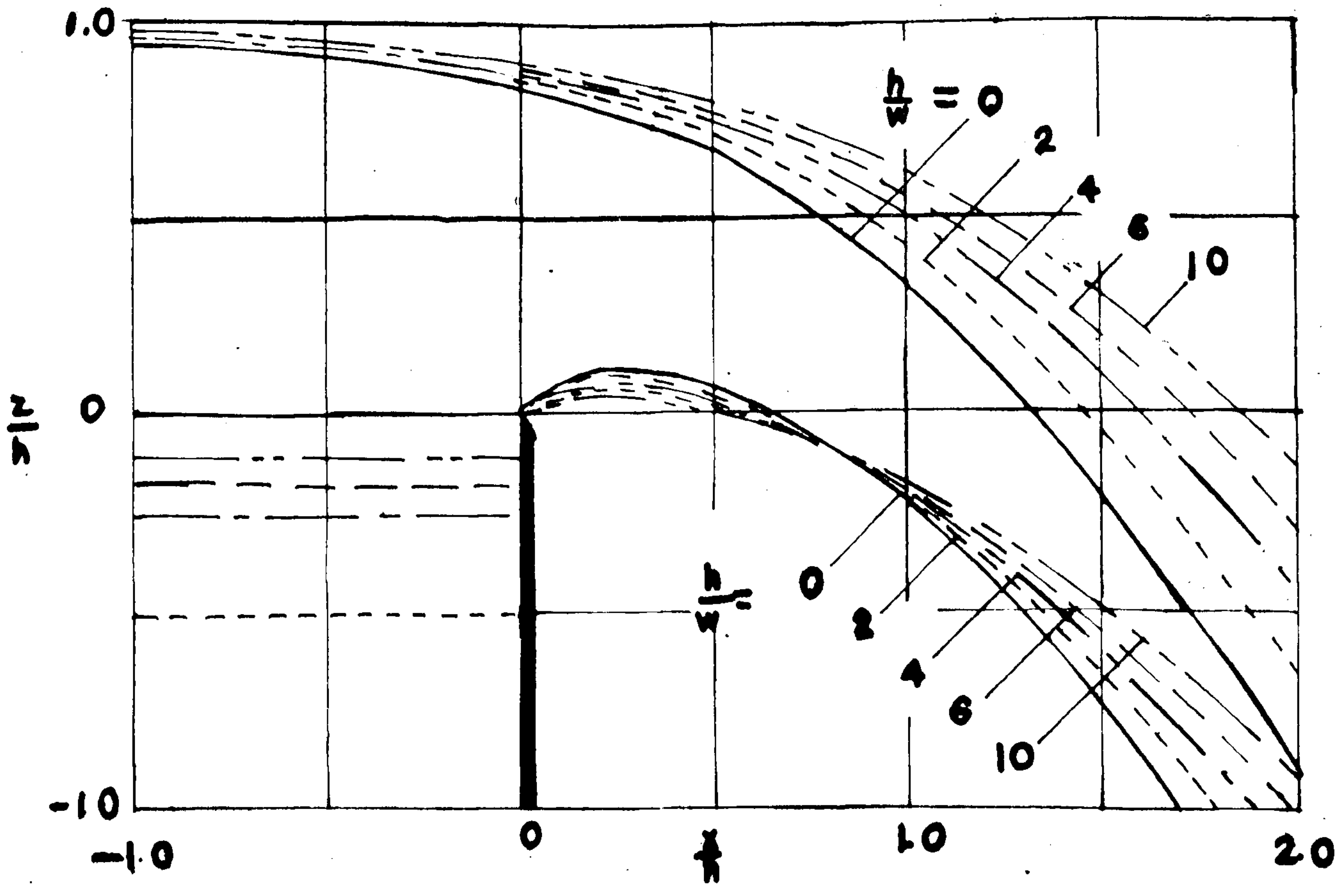

Fig. 4. Variation of nappe profile with relative height of weir

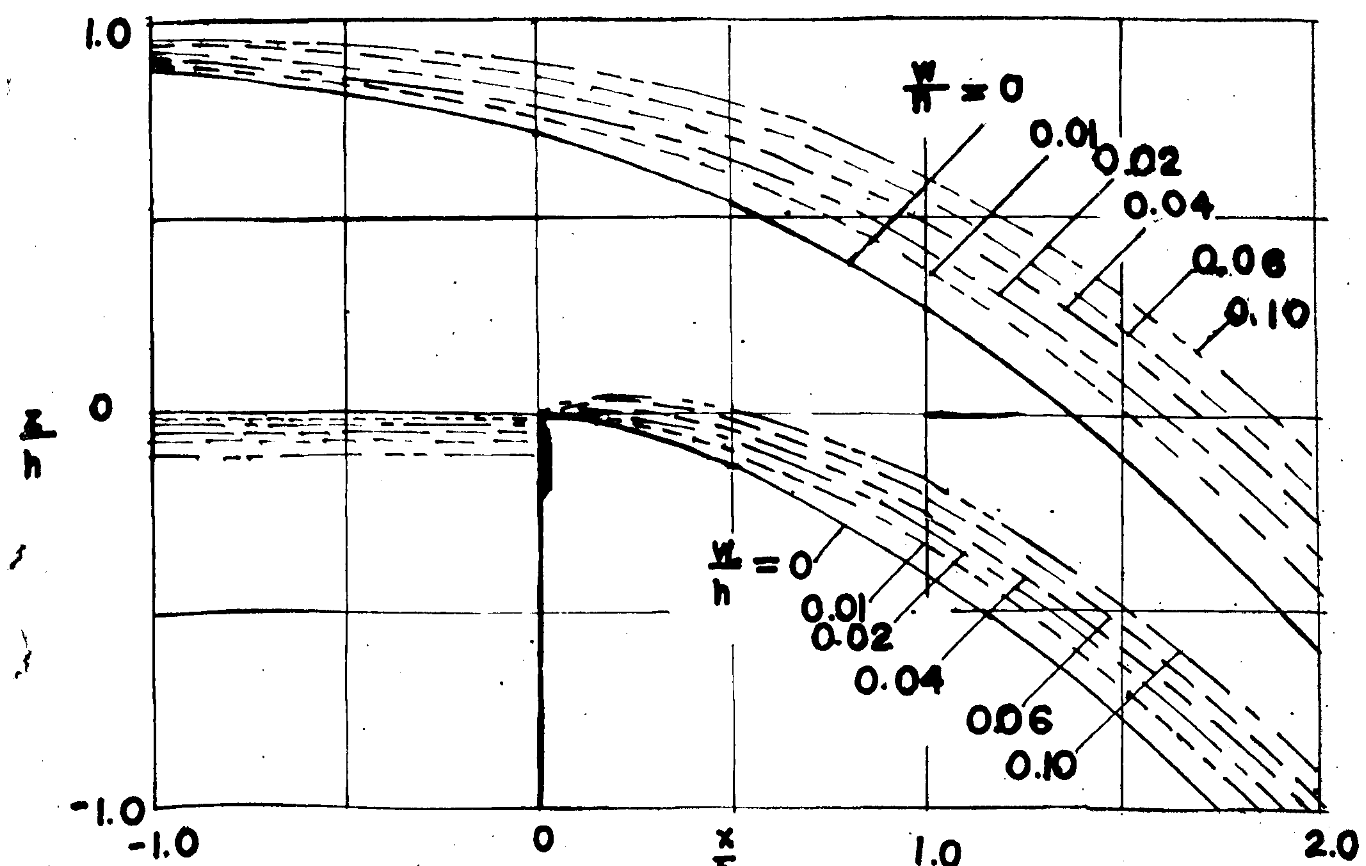

Fig. 5 Variation of nappe profile with relative height of sill

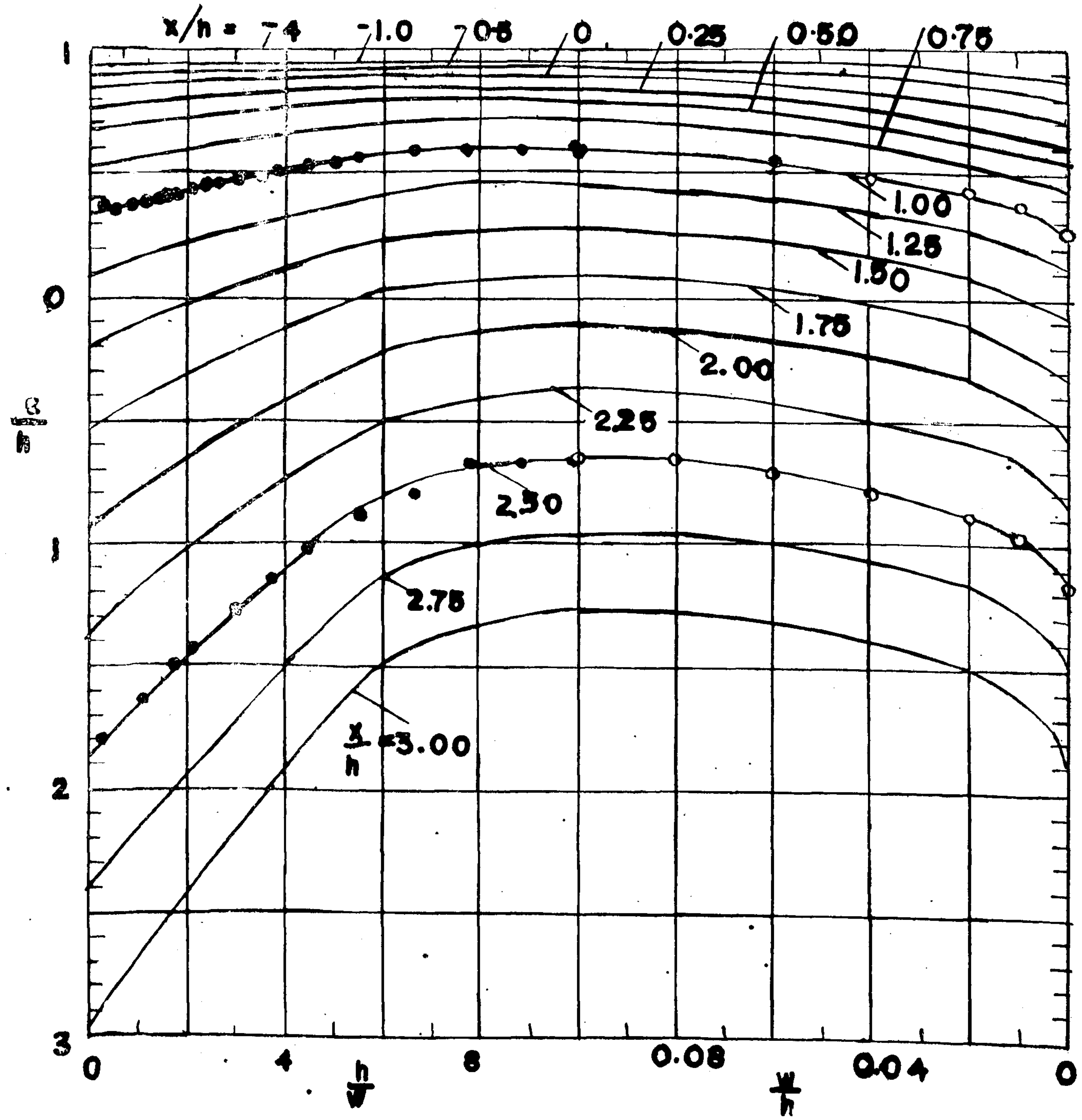

Fig. 6. Generalized coordinates of upper nappe surface for terminal weirs and sills.

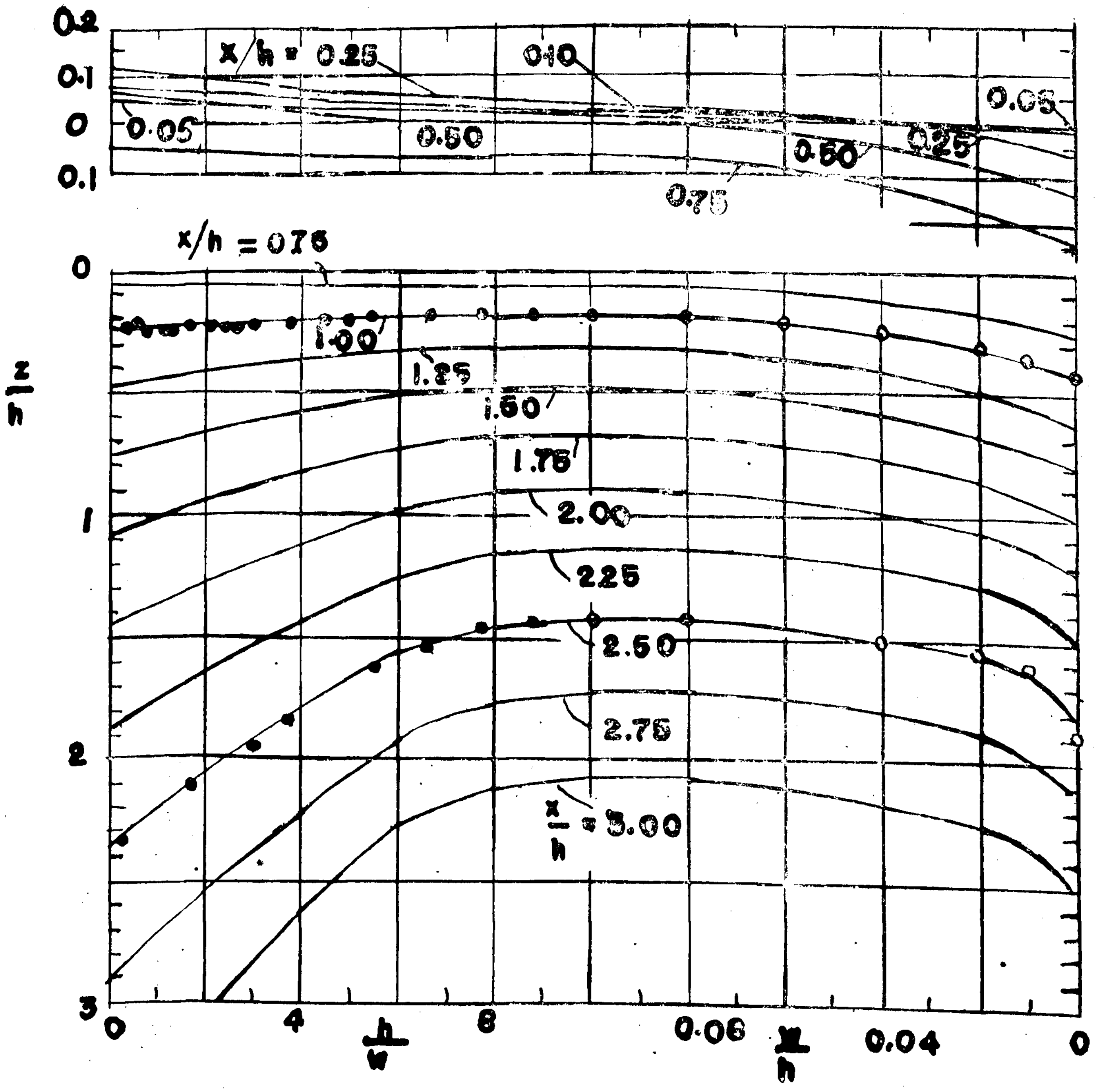

Fig.7. Generalized coordinates of lower nappe surface for terminal weirs and sills.

நூல் ஆய்வு.

நூலின் பெயர் : **நீரளவைகள்.**

எழுதியவர் : **மு. துரைராசன் முன்னாள் தலைமைப் பொறியாளர், தமிழ் நாடு குடிநீர் வடிகால் வாரியம்,** சென்னை.

வெளியிட்டோர் : **கீதா பதிப்பகம்,** 16, கிராண்ட் சாலை, செனாய் நகர், சென்னை-30.

தமிழ் மொழியில் அறிவியல் சம்பந்தமான நூல்கள் போதுமான அளவு வெளிவரவில்லை, என்பது பெருவாகக் கூறப்படும் குறையாகும். இப்பொழுது இத் துறையில் புதிய முயற்சிகள் தொடங்கப்பட்டுள்ளன என்பது வரவேற்கத் தக்க செய்தியாகும்.

உலகில் உயிர் வாழ்க்கைக்கு நீர் இன்றியமையாதது. நீர் இல்லையேல் உயிர் இல்லை " நீரின்றி அமையாது உலகு" என்பது குறள் வாக்கு. நீர் இன்றேல் எவ்வித முன்னேற்றமும் இல்லை.. நீரைப்பற்றி ஆராய்வது நீரியல் எனப்படும்.

இந்த நூல் நீரியல் துறையில் ஒரு கன்னி முயற்சி. வரவேற்கப்படவேண்டியதுங்கூட. இம்மாதிரி நூல்களை எழுத இதன் ஆசிரியர் மிகவும் தகுதியுடையவர். தமிழ் நாடு பொறியியல் துறையில் நீண்ட காலம் பணியாற்றி அதன் தலைமைப் பொறியாளர் நிலை வரை உயர்ந்து ஓய்வு பெற்றவர்.

இந்த நூலை நல்ல தமிழில் சரளமாக எழுதியிருக்கும் முறை மிகவும் பாராட்டத்தக்கது. பொறியியல் வல்லவரான நூலாசிரியர் அறிவியல் கருத்துக்களை எளிய, இனிய தமிழில் தருவதிலும் வல்லவர் என்பது புலனாகிறது.

குறட்பாக்களை போன்று ஆங்காங்கே, ஈரடி செய்யுட்கள் சில இயற்றப்பட்டு பொருத்தமாக அமைக்கப் பெற்றிருக்கின்றன.

நீரின் பலப்பல தன்மைகள், குணங்கள், அவசியங்கள் முதலியவற்றைவிட நீர் எப்படி அளக்கப்படுகிறது என்பதற்கு இந்த நூலாசிரியர் முக்கியத்துவம் கொடுத்திருக்கிறார். பொதுமக்கள் நீரின் அவசியத்தை, உபயோகத்தை அன்றாட வாழ்க்கையில் உணர்கிறார்கள். ஒவ்வொரு காரியத்திற்கும் அக்காரியத்திற்கேற்ப நீர் தேவைப்படுகிறது.

குடிநீர் வழங்கும்பொழுது இத்தனை லிட்டர் தண்ணீர் விடப்படுகிறது என்று கூறப்படுகிறது. இவ்வாறே பல வேலைகளுக்கும் கொடுக்கப்படும் தண்ணீர் எப்படி அளக்கப்படுகிறது என்பதை சாதாரண மக்களும் தெரிந்துகொள்வதே இந் நாலின் நோக்கமாகும்.

இந்நூலில் நீர் அளவுகள் மட்டுமின்றி அதற்குத் தொடர்ந்த பல விஷயங்கள் கொடுக்கப்பட்டிருக்கின்றன.

ஆசிரியர் குடிநீர் வழங்குவதற்குக் கட்டணம் ஏன் வசூலிக்க வேண்டும் என்று பாமரருக்கும் நன்கு விளக்கும்படி எழுதியுள்ளார். இப்பகுதி எல்லோராலும் படித்து உணரத்தக்கது.

நீர் வேளாண்மை அத்தியாயம் ஒரு தனிச் சிறப்பு. இதில் பல சிந்தனைக்குரிய செய்திகள் பரவலாக இருக்கின்றன. (1) நீர் பங்கீடு ஒரே சீராக ஏன் இருக்க வேண்டும், (2) தொழிற்சாலைகளில் நீருக்கு ஏற்படும் தூய்மை கேடு, (3) தண்ணீர் மண் தரையில் உறிஞ்சப் படுவதை ஏன் தடுத்தல் அவசியம் முதலியன நன்றாக எழுதப்பட்டிருக்கின்றன.

குழாய் மூலம் தண்ணீர் வழங்குதலில் எப்படித் தண்ணீர் வீணடிக்கப்படுகிறது என்பதை விளக்குவதுடன் வீணடிப்பு மாணி எப்படிச் செயல்படுகிறது என்பதையும் ஆசிரியர் விளக்கியுள்ளார். எந்த அறிவியல் கருத்தையும், தமிழில் எளிதாக எழுத முடியும் என்பதற்கு இந் நூல் ஒரு சான்றாகும். தொழில் நுட்பக் கல்வி இயக்குநர் திரு. வ. செ. குழந்தைசாமி அவர்கள் இந்நூலுக்கு நல்லதொரு அணிந்துரை வழங்கியுள்ளார்.

மொத்தத்தில் இந்நூல் பயனுடைய, படித்து உணரத்தக்க, புது செய்திகளைத் தெரிந்துகொள்ள உபயோகமானதாகும். பொறியியல் துறைக்கு மட்டுமின்றிப் பொதுமக்களுக்கும் பயன்படக்கூடிய வகையில் நூல் அமைந்துள்ளது தனிச்சிறப்பாகும். இது போன்ற இன்னும் பல அறிவியல் நூல்களை இந்நூலாசிரியர் எழுதித் தமிழ் உலகுக்கு வழங்குவது பயனுடைய பணியாக இருக்கும் எனக் கருதுகிறோம்.

FOUNDATION PROBLEMS IN SWELLING SOILS.

By

Thiru R. PALAYAAN NADAR, B.E.

1. Types of Swelling Soils and their Identification

Clayey soils which contain minerals like illite and motmorillonite undergo substantial changes in vloume due to the expansive property of these minerals as well as due to variation in capillary stresses.

Bentonite is one of the ultrafine clays found in various Ports of India and is mainly composed of montomorillonite group of clay minerals. The colour of bentonite clays varies from white to light green or light blue. When a dried bentonite is immersed in water it swells mcre than any other dried clay. Calcium bentonite absorbs 200 to 300 per cent of water while sodium bentonite absorbs 600 to 700 per cent of water. The predominent mineral found in Indian Black cotton soils is however Kaolinite, which is less active compared to montmorillonite (Jumikis 1962).

The range of general characteristics of swelling soils according to Sundararaman and Nagarajan (1960) are as given below :

Fine sand	3 to 10 per cent.
Fraction passing through sieve No. 200.	70 to 100 per cent.
Liquid limit	40 to 100.
Plasticity Index	20 to 60.
Base exchange capacity ..	40 to 50 ml/100 gms

According to Seed, Richard and Reymand Lundgren, (1962) a low swell potential corresponds to a plasticity Index (P. I) of about 30 or less, and medium Swell potential corresponds to a P. I of 30 to 40. The swell potential is high when the P. I. is 40 to 70 and very high, above 70. However, the depth of active zone in soils subject to swelling is from 1.5 metre to 3 metres according to Sowers Leonard (1962).

A simple laboratory test to identify swelling soils is the differential free swell test. The test is performed by slowly pouring 10 cc. of the dry soil passing through 420 micron sieve into a 100 cc graduated jar filled with water, and another 10 cc. of the same sample in another 100 cc graduated jar filled with kerosene. The swelled volumes in each jar are noted after 24 hours. Then, the differential free swell (DFS) is obtained as follows :

$$\text{DFS} : \frac{\text{Soil volume in water—Soil volume in kerosine}}{\text{Soil volume in kerosene}} \text{x100}$$

The classification based on DFS values is as follows :—

Degree of Expansiveness	DFS
Low ..	Less than 20.
Moderate	20 to 35.
High	35 to 50.
Very high	grater tiban 50.

2. *Problems in swelling soils :*

Buildings in regions where such conditions exiist tend settle or heave depending on the season in which they are built. Expansive soil while shrinking badly cracks the structure built on them. In many cases trees are planted near houses and along streets underlain by montmorillonite clays. As the trees mature, they withdraw more soil moisture than replenished by nature, there by drying out the soil and shrinking it. The resulting soil movements disrupt houses, driveways and streets. Concrete and other rigid slabs in canal or reservoir linings and in swimming pools are very vulnerable to expansive soil damage. Underground sewer, water and gas pipes are stretched or bent causing them to break or leak. High way pavements built on expansive soils usually break up or become wavy inconveniencing the public and increasing the cost of repairs.

The problems is also encountered in arid climates where the surface evaporation is larger than rainfall In such cases, the ground under the building is shielded against evaporation, whereas the ground outside is not protected. The result is a migration of moisture to the soil beneath the building, an increase in soil moisture content and a resulting heave. Moisture from leaking pipes will also produce the same effect. These effcets are more pronounced only with light bulidings having a single or two floors. For heavy buildings which impose a heavy intensity of load on the soil, the swelling phenomenon is not of much consequence, as the downward pressure of the weight effects the swell pressure.

3. *Possible solutions;*

Problems of foundations on swelling soils are solved by minimising the change in moisture content or its effect. This is done by :

(i). Carrying the footings down deep enough to get below the active zone in the soil.

(ii). Using short bored under reamed piles (IS : 2911 (Part-1)—1964].

(iii) Removing the Clayey soil to the depth of active zone and replacing it with a coarse grained inert fill, like sand.

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In any case peripheral areas around the building should be paved as far as possible and the site should be graded to provide positive drainage away from the building Downspouts from roof should discharge well away from the footings. The trees planted near the house shall be away from the house by a distance equal to the probable height of the tree when nature, prewetting of site will also minimise the adverse effects due to the extreme changes in moisture content.

Paul J. Wright (1973) has suggested a relatively in expensive and promising solution to render the soil les- active. According to him, lime slurry pressure injection (LSPT) is an economical way to deep treat foundation soils in place to reduce their volume change potential This method can be used either to stabilize a foundation soil before the structure is built or to remedy a soil instability problem on the existing structure. Accordirg to P. J. Wright, this method has been successfully used in extensive areas of America. Lime slurry pressure injection is done to a depth of about 2.1 Metres. The slurry is pumped into the soil under injection pressures of 4 to 15 Kg/Cm² (50 to 200 p. s. i.) depending on the soil condition. The slurry follows the path of least resistance, moving along fractures, bedding planes, root lines, sand lenses, etc. The slurry is deposited in a net work of horizontal sheet like seams interconnected with vertical or angular venis. With injection spacings at 1.5 M centres, there is an overlapping pattern, and the net work of lime seams deposited throughout the soil mass, thicken and grow through calcium iron exchange. As a result there is a continued gradual improvement in the soils shrink-swell behaviour. In conventional stabilisation, lime is mixed into the soil to reduce its plasticity and increase shear strength. But in the new method, the sheet like seams serve as individual moisture barriers, tending to stabilise the moisture content by eliminating serious moisture fluctuations. Immediately following injections, lime slurry left on the surface from the injection is mixed into the top 15 cm of the soil and recompacted. This creates a bridge effect to help distribute small pressures in the event of differential movement in isolated expansion.

It is also possible to construct a stiff building capable of riding up and down with the heave and settlement without damage.

Another solution is to proportion the foundation so that the bearing pressure exceeds the swell pressure.

Foundation beams or preferably plinth beam may be used to provide a stiff foundation.

4. *Design of plinth beam or foundation beam :*

The elastic formulae suggested by Schleicher (1965) can be used for finding out the bending moment on foundation beams due to swelling

$$M : \frac{\pi}{16} E \Delta J\lambda\, b^2 \text{ Kg Cm.}$$

Where E : Young's modulus of the soil to be determined by experiment (kg/Cm²)

Δ : Total anticipated heave (cm)

J λ : An influence factor, related to

Where λ : L/b

b : Breadth of footing (cm)

L : Length of footing (cm)

The approximate E values for various types of soil S. Boominathan) 1974 (b) are given below :

Type of soil	Value of E (kg/cm)²
Very soft clay	3 to 25
Soft clay	15 to 40
Medium clay	40 to 80
Hard clay	70 to 175
Silty clay	280 to 420

The approximate heave for various swell potential are given below [S. Boominathan, 1974 (a)].

Swelling potential	Heave in cm/30 cm height of soil.
Low	0 to 0.64
Medium	0.64 to 1.27
High	1·27 to 2.54
Very high	2·54 to 3.80

The value of J λ can be read from figure for known values of λ. It is suggested that for the purpose of estimating total heave, the thickness of the dangerous layer may be restricted to the depth of active zone. Height of any other inert layer within the active zone may be deducted.

Further it is suggested that the most vulnerable footing will be the interior one which connect the peripheral walls, as this will be subjected to maximum differential heave and resulting bending movement. Hence, the length foe the purpose of calculating the bending moment will br the maximum length between any two cross walls.

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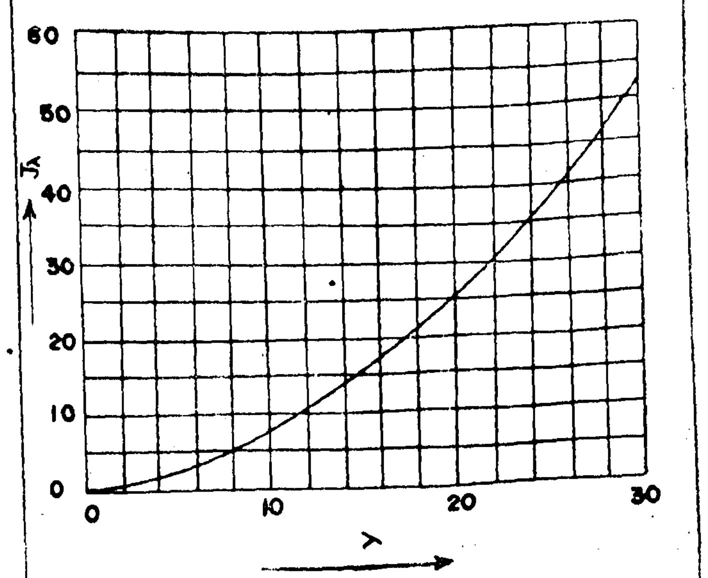
SCHLEICHER'S CURVE TO FIND MAXM. VALUE OF INFLUENCE FACTOR Jλ.



$\lambda = \frac{\ell}{b}$

ℓ = LENGTH OF FOOTING

b = BREADTH OF FOOTING

FIG. 1

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WATER MANAGEMENT PRACTICES IN THE FARM

By

Thiru R. K. SIVANAPPAN

1. *Introduction.*

Water is a vital natural resource. Its wise use must be the concern of every citizen of the country.

Though many technological developments have been attained in various fields over the past several years, man is still facing the challenge of producing more food to feed the growing population. To over come this, irrigation agriculture will have to be undertaken in a big way. Therefore, irrigation development is very essential and it is an integrated part of the national plan of economic development.

In Tamil Nadu, over 95 per cent of the surface water and 60 per cent of ground water have been harnessed. Still the area under irrigation is only about 43 per cent. The possibility of getting more water to increase the area of irrigation in Tamil Nadu is very remote unless we get it either from the neighbouring states or from Ganges through linking Ganges and Cauvery. The same condition prevails in many states in the country. Hence water mangement is the most significant factor that would affect the pattern of Agriculture in the years to come. Further it is quite necessary to plan not only for conservation and use of surface water but also conjunctive use and management of both surface and ground water.

To understand water management, it is necessary to understand the soil that is cultivated. Different soils have different characteristics. Since the clay soil can hold more water and evapotranspiration is the same for a particular type of crop in the same location, we need longer intervals between irrigation in clay soil than in sandy soil. Hence information on physical and chemical characteristics of the soil such as the texture, depth of the soil, permeability; weather data, crops to be grown and other details need be known before deciding irrigation practices.

The following are some of the research findings on economising the use of water for various crops:—

2. *Paddy.*

The water requirement of high yielding Paddy crop is varying from 100-120 cm. It is estimated that the amount of water utilised (Evapotranspiration) is about 60-80 cm. and the loss of water by percolation is about 20-40 cm. By adopting water saving method of irrigation, it is possible to save about 30 per cent of water without affecting the yield. In this method the soil is saturated or thin layer of standing water is maintained just before flowering and then submergence to a depth up to 5 cm.

3. *Cotton.*

Cotton irrigation is done in different methods namely by check basin, border and furrows in different places. It is found that there is saving in water by adopting the furrow irrigation without sacrificing the yield. Further the weed infestation was also significantly less in this method. The experiment conducted on skip furrow method at Tamil Nadu Agricultural University, Coimbatore has Indicated that water use efficiency can be increased to nearly100 per cent without affecting the yield. Further some short duration crops like pulses can also be grown in the vacant space between the cotton rows thereby the productivity of the land can be increased.

4. *Fruit crops.*

The present practice of big basins provides around the fruit crop are luxury for the plant. The experiments conducted at Tamil Nadu Agricultural University has indicated that small size basin (say 2 to 3 m. diameter for Anab-e-Shahi grapes, 1m., dia. for Banana), will do, to get the normal production and thereby more than 50 per cent of water could be saved. It is noticed that by reducing the basin size, the yield of the crop was not affected.

5. *Sprinkler irrigation.*

Sprinkler is an advanced method of irrigation which is in operation from 1900 in U.S.A. This method is used in many parts of the world for irrigating nurseries, vegetables and plantation crops. Sprinkler gives greater savings in water, labour, increased yield in certain crops improved quality of production and more profits. The experiments conducted abroad and in India have demonstrated the advantages of sprinkler irrigation over the surface method. The work done at Tamil Nadu Agricultural University, Coimbatore on cotton has shown that about 12-40 per cent of water could be saved by this method without sacrificing the yield. The cost of this system works out to Rs. 2,000 to 2,500 per acre including the cost of booster pump.

6. *Drip Irrigation.*

In this method water is taken by tubes and is given at the root zone of each plant. The experiments conducted on various vegetables and fruit crops, it was observed that the water used in this method is only about 1/3 to 1/4 of the regular surface irrigation and the yield was not affected. This method of irrigation is very

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suitable for wide spacing row crops and tree plants including banana, grapes, etc. The cost for this system is vary from Rs. 3,000-4,000 per acre for different crops. For light and sandy soils water can be applied without any wastage in this method.

7. *Prevention of Seepage losses.*

It is calculated that the loss in conveyance of water in the field channel is about 20 per cent. We cannot afford to loose this water especially if the water is got by pumping since the cost of pumped water works out to Rs. 3-5 per hectare cm. when the water table is 80-100' deep. This amount of water could be saved by lining the field channels with cheap lining materials. The precast cement concrete, or soil cement lining can be used to convey the water without wastage!

The cost of this channel to carry upto 10,000 gph may work out Rs. 2 to 2·50 per running foot. This can be fabricated by farmers by engaging local artisans and laid in their fields.

Lack of appropriate farm distribution facilities such as field channels, control structures, measuring devices have resulted in uneven distributions while the absence of drainage channel has caused water logging in the canal and tank irrigated lands. In some cases the lands turned into saline or alkali patches. It also leads to over irrigation in the head reaches and shortage of water in the tail ends. It is possible that with good water management at the form level through controlled irrigation and drainage and other appropriate management practices, higher yields can be produced.

7. *Research need for improved water management.*

A prerequisite for the practice of good water management is information concerning crop water requirements and the application of water in quantity and time. Though much work has been done in advanced countries, it is not possible to use same information in other countries. Hence it is necessary to conduct applied studies to acquire the exact knowledge applicable to local conditions. The studies may be on the following lines :—

1. Water soil plant relationships.
2. Applied research to be taken in various regions.
3. Studies on timing and amount of irrigation.
4. Studies on method of water application
5. Studies on optimum water crop yield ratio.

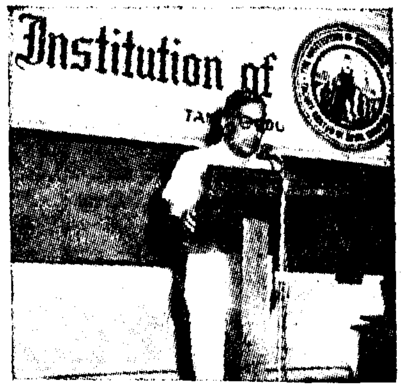
8. *Conclusion.*

It is reported that more than 50 per cent of the water drawn from reservoirs is not reaching the field and more than 50 per cent of the water applied to the field is not used by the plant. Hence by suitable water management and conservation practices it is possible to save large quantity of water. The practices mentioned are only few and much more information is required to solve the water scarcity in the future. Hence research on water use must be undertaken in a big way to enable us to tackle the problem.

PLANNING FOR WATER.

by

DR. K. BHARATHAN



Water-General:—

1·1. Life originated in the universe in water. probably in oceans. It is yet to be known whether life was driven to land due to pollution of water in the ocean Man is the most advanced creature and he cannot survive without fresh water. He may live without food for say 30 days but he will not survive for even 3 days without water. Water is his basic need next to air and he needs water for his other daily uses also. 65 per cent by weight of man is water. Thus water plays a very important role in man's life. It is no wonder that in the olden days, civilisation grew along rivers In history we read that whole cities or nations perished because of lack of water or rain. A place becomes useless for human habitation if there is not sufficient supply of water. Serious mass starvation and mass epidemic result for want of water.

1·2. Let us see how use of water is referred to in ancient vedas and older civilisation. It is known that Indians practiced the art of raising crops by artificial irrigation as early as during 4000 BC. The Indus civilisation, the most extensive civilisation of the preclassical world, extended from Rupar on river Sutlej to Sutkavendar near the shores of the Arabian sea and also on the banks of Narmada and Tapti rivers. It is almost certain that the people of that civilization designed and constructed channels in the flood plains to grow foodcrops and cotton. Some people qualify this type of civilisation as 'hydraulic' as it is based on water.

1·3. In the Rigveda, the most ancient book of Hindu, and also in the later Yajur and Atharvana Vedas, mention is made of wells, canals and reservoirs. The story of Bhagirath who by his herculean efforts brought water for the welfare of the people, is well-known. It can be seen that India's development closely followed the development of water resources.

1·4. Water is the only common substance which we seen in all the three states-solid, liquid and gas, in nature. In the case of water, because of its structure, the energy required to produce these changes is very high. It is because of this property, that water remains in sufficient quantities on the earth's surface. Another odd property of water is that it expands when it is cooled from liquid to solid ice. It is the oddity of water that prevents lakes and rivers from freezing solid. Even when the top layers of water in river freeze to ice the bottom remains water and sustains life. Water moderates weather by absorbing and storing large amounts of heat.

2. *World supplies of water*—

2·1. An assessment of the total water resources in the world is a difficult problem. Several people have tried to make some assessment, based on available data. Seven tenth of earths surface is covered with oceans. It is estimated that 97·6 per cent of the total water resources of the world is in the oceans. Out of the remaining 2·4 per cent major portion is locked up in ice caps. One estimation is that only 0·65 per cent of the total quantity of water is potable. This quantity is also not readily available for use as a major portion is in the form of ice. Only about 0·027 per cent is available in fresh water rivers, lakes and ground water.

2·2. Over the ages, this quantity of water has remained practically the same. The sun's rays help the atmosphere to absorb moisture from the sea. Precipitation spreads the moisture as fresh water on the earth's surface. This water gradually makes its way back to the sea; in the meanwhile perhaps going through some factories. animals or plants. This inevitable route of a drop of water is known as the water cycle. The portion available in rivers as channel storage is estimated by certain persons, to be as low as 0·0001 per cent while the fresh water lakes contain 0·0094 per cent. Balance quantity, which is the major quantity is available as ground water. Here also the position is not encouraging as it is considered that 50 per cent of the ground water is available in zones below half a mile depth from the earth's surface. Approaching from another angle, it is estimated that 77 per cent of the total rainfall in the earth, falls directly into the oceans. 16 per cent of the rainfall is lost from the land portion as evaporation. Thus only 7 per cent of the total world average annual rainfall of about 80 cm. is available as run off. All these figures, even though they may be quite approximate, indicate how small is the portion of fresh water available in the world.

2·3. It is estimated by the famous hydrologist Vente Chow that the total quantity of fresh water available in the world as surface water and ground water together is 3·8 million cubic kilometres. He has warned that, in the light of the fastly increasing population, scarcity for fresh water will be felt within a short period of 300 years, through out the world.

3. *Distribution of water in the world*—

3·1. When averages are worked out, it may appear that the availability of water resources all over the world ies satisfactory. Asia is the richest in water resources and South America is the second; the two countries possessing about 34 per cent and 26·5 per cent of the total water resources respectively.

3·2. Most of the Asian countries are fortunate to have high rates of precipitation with annual average precipitation of about 300 to 500 cm. in Malaysia 250 cm. in Indonesia and Philippines, 125—500 cm. in Bangaladesh 250 cm. in Taiwan, 100 to 500 cm. in Sri Lanka, 112 cm. in India, 120 to 250 cm. in Thailand, etc.

3·3. In Africa also the precipitation is comparatively heavy as in Tanzania where the average annual rainfall varies from 100 to 200 cm. in different localities. The rainfall in the European countries are still less for example the rain fall in Norway is 140 cm. and that Poland and Sweden is about 70 cm. Whie in South America there

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a good rain-fall as in Brazil where the average annual precipitation is 200 cm. in the North America precipitation is as low as 75 cm., as in U.S.A. It is understood that one sixth of the total fresh water discharged from all the rivers to the oceans in the world, is from the Brazilean rivers.

3·4. The potential of water resources in the Middle East countries is very miserable. In places like Kuwait, there is no surface water at all; here the average annual precipitation is only about 13 cm. The average annual precipitation in some other countries are Iran—25 cm., Iraq—15 cm., in most of the area, Isreal—2·5 to 5 cm. in the inhabited area (there are places with 100 cm. rain fall also), Jordan—10 to 20 cm. There, some of these countries are depending entirely on desalinised water.

3·5. In spite of such large quantities of water available in the world, it is well known that many regions in the various continents experience acute shortage of water because of great variation of run off with respect to time and location. The time variation in run-off can be successfully tackled by constructing storage reservoirs, but variation in location can be compensated only by interbasin transfers.

4. *World's demand of water*—

4·1. The major quantity of water resources in any country is utilised for agriculture. It is found that about 70 per cent of the total demand of water is for irrigation. This is inevitable as the production of food grains is the basic requirement for the existence of man. Paddy is a semi aquatic plant which require standing water to a small depth. Research studies are in progress all over the world to find out methods to reduce the quantity of water required for irrigating paddy. Revolutionary changes have been effected in irrigating dry garden crops. Sprinkler irrigation, for example is adopted widely as it requires only small quantity of water compared to occasional flooding methods. But evaporation lossess are considerable. Now drip irrigation is found to be most economic as the minimum required quantity can be available at the root zone without losses.

4·2. Another important utilisation is for the production of hydro-electric power. This is the cheapest in-put for the production of power as the source is inexhaustible. There is the added advantage that the water utilised for power production can be utilised for other purposes also, eventhough not in full.

4·3. Due to vast industrial progress achieved during the 19th and 20th centuries the demand for water has increased considerably in industrialised countries. As a matter of fact, the demand of water for industries is much more than the demand for drinking purpose. For instance, the manufacture of one litre of petrol requires 10 litres of water one tone of cement 3,500 litres of water; one tone of steel 20,000 litres of water and one motor car 162,000 litre of water. This will show the big demand of water, for some common industries. With giant strides being made in industrial progress, this demand is sure to increase alarmingly.

4·4. The demand for drinking water supply is increasing day by day. About one billion or one third of the world population lived in urban centres in 1960. By the year 2,000 A.D. about 3·1 billion or half of the then world population are expected to live in urban areas. A survey in an undeveloped country during 1967 showed that about 35 per cent of the urban population had some form of municipal water source; Twenty-three per cent were provided with piped but inadequate supply and 12 per cent were served with public faucets. The remaining 65 per cent derived their water from water ways, irrigation canals and private wells. To illustrate this point let us take the case of Madras City itself. This city had experienced acute scarcity of water for drinking purposes last year and there was even a threat of evacuation of the city.

4·5. Navigation is another field where water is required in large quantities. In most of the countries, especially in developing countries inland water transport is a major and cheaper method of transportation. To maintain navigable draft in rivers, lakes, canals. etc., especially during dry months, a continuous supply of water has to be maintained.

4·6. Water is required in large quantities to prevent salinity in fresh water sources. In states like Kerala, which has a long coast line and vast areas of low lying fields near the coast, rivers and lakes have to be depended greatly for irrigation and for other needs and once fresh water supply is reduced, salt water intrudes from the sea. To prevent this and to protect the fields and also industries, a continuous flow of fresh water has to be maintained in rivers.

4·7. One peculiar phenomenon noted in vast areas of low lying paddy fields in Kerala is the presence of acidity which rises up from the lower strata containing decayed organic materials. This happens when fresh water depth is reduced in the surface. This acidity has to be washed away periodically failing which the paddy crop will wither away. Considerable quantity of fresh water is required for periodical flushing and washing.

4·8. It can be seen that in all fields whether it is in the field of irrigation, hydro-electric power industry, wates is drinking water supply,. or in other fields, the demand of increasing rapidly. Every body has felt the necessity for the planning of water. Such planning calls for action several years in advance. This is necessary because it takes time, effort and money to plan for water and obtain this in required quantities from wherever it is available and use it to the best advantage. In any Government, several departments deal with water and therefore this planning calls for co-ordinated work so that the necessities of water for all concerned are provided for. This is how the water resources planning came into existence.

5. *Assessment of water*—

5·1. In planning for water the first and foremost requirement is the assessment of the available and utilisable quantity of water. The world's available fresh water is found either as surface water or ground water. Hydrology is that branch of science which deals with the water as it occurs in the atomosphere, on the surface of the ground and underground. It is not yet possible to call hydrology an exact science because, when given a factor such as rainfall, one cannot accurately deduce the resulting disposition of the water in scientific and mathematical terms. This inaccuracy is due to the great complexity of the hydrologic cycle, the lack of accurate observational data and the almost innumerable combinations of hydrologic phenomena that occur in nature.

5·2. Rainfall and run off are to phases of water cycle and all over the world, efforts are made to assess the quantities of both. While somewhat accurate data may be available about these two factors in limited areas, much remains to be known. In hydrology we cannot expect exact answers but only best estimation depending upon the length of period for which reliable data is available. At present widespread data is available regarding surface water, but comparatively very little is known about ground water. Of course in countries where water is a scarce material as in Israel, the knowledge about ground water may be more comprehensive, but this is not the case in most of the other countries. In India itself where we have got a very long history of the utilisation of water resources much remains to be known about ground water resources.

5·3. One of the principal projects of the International Hydrological Decade, (1965-74) which is continued into the post decade period as part of international Hydrological Programme (I.H.P.) is the assessment of the world water balance or the gross distribution and movement of water in the total earth atmospheres system. To assess the amount of water in its various environments over the earth, requires monitoring and measurement over the globe at frequent intervals in space and time. These data have to be collected in a uniform and as constant a manner as possible. In the present system, the observations are often incomplete and non-uniform and very long time is required to get the data. There is ample evidence to indicate that remote sensing technology applied from satellities and aircraft can be a very useful tool in obtaining observations that permit rapid and continuing assessment of the world water balance.

5·4. Using spectrometric instruments flown in meteorological satellities, usefull data can be collected to estimate precipitable water in the atmosphere. Similarly snow and ice falls can easily be monitored from space making it possible mapping of snow and ice. The feasibility of delinating, mapping and measuring the areal extent of surface water has been demonstrated in several instances. Mapping water depths in shallow water was found possible utilising the property of penetrating the water by the light in the visible wave lengths. Thus estimation of the surface storage is feasible. Geological interpretation of high altitude photography and by infrared measurements, the detection of the presence of ground-water and some quantitative assessment is possible, but assessment of deep ground water may not be possible. Anyhow, we can expect a more correct estimation of world water balance, in the near future. Till then we have to depend upon conventional methods. Most of the countries are gauging the important rivers and rainfall data is collected extensively. A correlation is made between these two and the water resources is assessed now. Kerala State has done the evaluation of its water resources sometime back and it is found that this is very useful for all development works.

6. *Various uses of water*—

6·1. Some of the major water uses are listed below:—

6·1·1. *Nature.*—Water used for all natural purposes, Evaporation and transpiration by natural vegetation, transporting the products of the geologic weathering processes to build the rich alluvial valleys and maintain their fertility by transporting the dissolved salts to the sea, etc.

6·1·2. *Culinary uses.*—Drinking, bathing, washing, cooking, etc.

6·1·3. *Agriculture.*—Growing agricultural crops. This is the major use. From 500 to as much as 5,000 tonnes of water are required per ton of crop.

6·1·4. *Industry.*—Cooling, processing, washing, etc.

6·1·5. *Power.*—For hydro power, steampower, and atomic power.

6·1·6. *Navigation.*—Waters of high seas, lakes, rivers, and canals are used for navigation, including shipping and national defence.

6·1·7. *Transportation.*—Many materials including hydraulic dams, sewage and pollutants are mixed or suspended in water are transposted·

6·1·8. *Flood-control.*—Reduction of flood by diversions, water spreading storage.

6·1·9. *Municipal.*—Fire fighting, parks, sewage disposal, lawns and shrubbery, street washing and house hold uses.

6·1·10. *Recreation.*—Swimming, boating, water sports, fishing.

6.1.11 *Mining.*—In hydraulic mining and material transport.

6·1·12. *Acquaculture.*—Culture of fish and other marine life.

6·1·13. *Land building*—Changing land use, controlling erosion, revegetation, urbanisation, etc. These cause changes in the water routing.

6·1·14. *Pollution and quality control.*—Storage or receiving waters are used for detection, mixing, oxidation and sedimentation.

6·1·15. *Aesthetics.*—Water used for beauty such as natural or artificial lakes or pools, water-falls, fountains, etc.

6·2. Many of the above mentioned uses overlap in specific use functions. Most of them conflict with other uses in one way or other.

7. *Water management in an irrigation project*—

7·1. In a major irrigation project, water is stored, conveyed and supplied to the field. I have already said that the major use of water is in irrigation. Hence to effect any economy in the utilisation of water special attention has to be given in the field of irrigation by way of water management. Water management is defined by A.A. Bishop as spacetime-quantity: quality alteration of the water resources in and between various water uses to meet societal goals." Let us see how we can have water management in irrigation. There is loss of water in the reservoir by way of evaporation and sometimes by seepage also. There is loss in canals due to evaporation and mainly due to seepage and there is loss in the field due to excess supply, etc. Of these, the losses in the distribution system, i.e., in the canals form the major part.

7.2. For designing new earth canals in project we have got certain standards regarding the allowance to be made regarding seepage losses such as 8 cusecs per one million square feet of wetted perimeter for main canel 6 cusecs per one million square feet of wetted perimeter for branch canals, etc. When quantified the losses may work out to 15 to 20 per cent of the irrigation requirement. But in actual practice it has been noted that the seepage losses is 30 to 40 per cent in several cases. Several reasons may be attributed for this, such as, the property of the soil, poor quality of construction, presence of several embankments, inefficient management, etc. By lining a canal, the losses can be reduced considerably and it will be proved finally that lining is economical if a lined canal is properly designed. Reduction in size of the canal an consequent savings in land acqusition, savings in annual maintainance cost and reduced chances of pilferages are extra benefits in addition to the savings in water by seepage. The height of the dam and thus the capacity of the reservoir can be reduced if the canal is designed as lined, as the requirement of water is reduced. Thus the modern trend is to design the canals lined canal only as is the trend in the construction of modern highways where always a dustless surface is provided in any new important highway.

7.3. Another aspect to be considered is the depth of water to be maintained in canal. When a canal is running half full, the quantity of water lost will be less than in the case when it is running full. But the percentage loss will be less when the canal is full, as the increase in wetted perimeter is comparatively small. Hence if an intermittant system of supplying water is adopted, it may be possible to keep full level in most of the canal. This aspect requires more study.

7.4. The modern trend is to utilise more and more ground water, and where a surface water distribution system is available, conjunctive use is recommended to effect huge savings in water. Earth is a porous medium and even lining materials are not water tight. Hence there is huge losses from canals. There is also considerable losses due to evaporation. The Irrigatior Commission has pointed out several instances of huge losses in the existing canal systems throughout India. It seems that in certain cases, the losses exceed actual utilisation. In undulating terrains as is available in Kerala, the present system of distribution poses several problems.

7·4.1. Losses will be more as the canals have to be taken through very high terrain.

7·4·2. The canals are costly as land is very dear and large areas of occupied garden lands have to be acquired for the construction of canals.

7·4·3. A large number of costly structure such as aqueduct are necessary to cross each valley which are numerous, not only in the case of main canals, but also in the case of branch canals.

7.5. In any case, it is essential to effect economy in the case of utilisation of water. In olden days when demand was less it might have been possible to divert any quantity of water to the field whether it is used by the plant or not. But as demand increases availability reduces correspondingly and hence the only alternative is to modernise the canal systems and adopt modern methods of water management so that the irrigation potential can be retained.

8. *Water Management in the fields*:—

8.1. Apart from the economy of water in canals, economy of water is to be effected in the fields also. When water is let into a field for irrigation, it is used up in three different ways.

8·1·1. Evapo-transpiration which includes the actual requirement of the crop, and also evaporation from the field and from the plant.

8.1.2, Seepage, to either a lower field or to the sub-surface water table or by deep percolation to the lower strata.

8.1.3, Wastage from the field either by spilling or by flowing outside the field through outlets.

8.2. Water management in the fields attempts to reduce the quantities utilised in items 1 and 2 above and to avoid item 3. Wastage in evapotranspiration is caused by weed growth. This can be controlled by removing weeds in time either manually or by applying chemicals. This will limit evapotranspiration to the actual minimum quantity for the irrigated crop alone.

8.3. Seepage in the field depends on the nature of soil and also on the depth of standing water in the field. Standing water is required for crops such as paddy and sugar cane. Hence it is essential that these crops should not be raised in soils having excessive seepage rate, say more than 8 to 10 mm. per day. In highly porous soil, dry crops can be raised which require only occasional wetting of the top soil in the rootzone. Porous soil can be used for raising paddy and sugar cane without wasting much water if there is some impervious layer just below the root zone. In Kerela there is an area known as Onattukara, where the soil is sandy and highly porous, but paddy is raised in this area for the past several years depending on rainfall. When detailed soil survey was conducted in connection with an irrigation project is was discovered that there is a thin layer of clayey zone at a depth of about 1 to 1-1/2 metres which reduces the seepage considerably. If such a condition can be created artificially in porous soils, the seepage losses can be reduced considerably.

8.4. In another coastal region in Kerela where the soil is purely sand, a novel method is adopted by the local people to raise paddy in limited areas. They remove the top sandy layer for a depth of about one metre and clay brought from distant places is spread for a thickness of 20 to 30 cm. Paddy is cultivated in the clayey soil. But here the advantage is that the water table is very high and hence, the crop gets assistance from the ground water, without any pumping.

8.5. At least in some places, impervious trays with concrete and other materials are built and paddy is cultivated after filling the tray with suitable soil. This is done to prevent seepage, and also to prevent entry of salt water in to the field in marshy areas. Wherever feasible and economically viable, such methods can be adopted to save precious water.

8.6. The depth of standing water in the field is an important factor. People want to maintain higher depths of water in their fields mainly to reduce growth of weed and also due to the fear that water at shallow depths will get heated up quickly and may adversely affect the plant. Research Studies have been done at several stations regarding the optimum depth of water to be maintained and it has been found that the optimum depth for paddy is 2.5 cm. to 5 cm. Maintaining a depth above 5 cm. will reduce the yield and at the same time increase seepage loss. Anyhow this is a field where experts on agriculture can do lot in research studies and in educating the cultivators.

8.7. Field efficiency depends on supplying the exact quantity of water required for irrigation to a field. But several people prefer to have running water in their fields i.e., to have a continuous flow at a low rate. This they want except during the period of manuring. But once the cultivator understands that there is considerable outflow from the field by way of seepage and inflow from the irrigation canal, he may be satisfied with standing water alone. Where field to field irrigation by flooding is practised instead of direct supply to each field, some losses and inefficiency are unavoidable.

9. *Economic and efficient use of water :—*

We have already seen now that fresh water is not plentiful in this world and its demand is increasing every day. One of the methods of conserving water is to use it economically and efficiently in all its uses. In water supply systems we have all learnt the various methods employed to reduce the amount of water being used and also losses in supply. We use the intermittant suppy in some cities and you are all familiar here about this in Madras. The losses in transit are avoided as much as possible and non-leaky taps are to be used in distribution systems. In Kerala in the olden days a brass vessel (Cheppukutam) with a narrow neck was used for taking water for personal needs. By this vessel water is used most economically. I understand that Arabs introduced this vessel in Kerala as in Arabia, water is very scarce. In Irrigation and Agriculture, we have already seen how we can economise on the use of water Regarding industry, one of the methods now employed, is to use water again and again after purifying it each time. A number of industrial plants in America operate on such ''closed water cycle''. This not only reduces the demand but also prevents pollution of streams as there is no waste of water. In all other uses of water also, various methods can be found out for economical and efficient use.

10. *Multipurpose reservoirs :—*

10-1. Reservoirs are only artificial lakes formed behind dams for storing water for a variety of uses. These uses are irrigation, hydro-electric power, municipal uses, industries, navigation, flood control recreation, etc. A reservoir when used for several purposes is known as a multipurpose reservoir. In the planning for water, reservoirs play a very important part as the construction of reservoirs for various uses is the main method of conserving water. Though this is known to everyone what is not commonly understood is that unless the reservoir is designed to suit the various purposes, it will not fulfil these purposes. Therefore, before a reservoi is designed, the various uses of it must be detailed out and a complete study made and the reservoir designed to fulfil these purposes. The storage space for each purpose must be calculated and allocated and this is known as reservoir storage allocation. Though it is a fact that a reservoir may serve several purposes there are some conflicting characteristics in their use. Power and Irrigation reservoirs are of greatest value when full, while flood reservoirs are of greatest value when empty as long as possible in order that their entire capacity may be available when needed. From this it will be clear that the allocation of reservoir storage becomes a subject of serious study and judgment.

10-2. While planning for reservoirs, one thing to be taken into account, is that these reservoirs can be constructed economically only in the upper reaches of rivers. Therefore when a reservoir is planned at a particular site then this should be designed in such a way that the entire flow available at the site at least can be stored here for their various uses round about the reservoir. If this is not done, then after some years if it is found that more water is needed here then it will not be possible to construct one more reservoir here or nearabout economically. Therefore each river basin must be examined for the various uses of water and the number of reservoirs and capacity necessary in each basin predetermined so that all the available waters in the river are impounded in these reservoirs in a certain period of time for the maximum use for all purposes.

10-3. In the planning for reservoirs what we are familiar is designing the capacity of the reservoir for an average year's flow and using this water in one year. But rich nations plan reservoirs with ''Carry over Storage'', by which the capacity of a reservoir is designed much more than an average year's flow and the surplus flow in one year is impounded in the reservoir to be used in the second or third years. While I was in U.S.A. in 1958, I happened to see 4 reservoirs constructed in Missouri river in which the entire average flow of 4 years can be impounded without a drop of water being let down in any year. Such planning can only be done by rich nations. There is therefore difference in the planning of rich and poor nations. It is like a millionaire planning for wealth for his children and grand children and an ordinary man planning for wealth for his children alone and a poor man planning for himself only.

11. *Trans-basin diversion of water :—*

11-1. Civilization first developed in an environment requiring irrigated agriculture. Most of the arable soil in the Humid region are used for crop production. The world population is growing at a rate of 2-1/2 per cent per year. FAO has estimated that food supplies must increase at a rate of 3-1/4 to 3-3/4 per cent per year to maintain a slight improvement in the general nutrition situation. To increase further food and fibre production we are moving to the arid and semi arid lands that comprise over 50 per cent of the earth's land surface. The majority of the developing countries are located in the arid or semi-arid ones.

11-2. The total water supply of this planet is essentially fixed. But the demand for water as population has increased and uses have multiplied has risen tremendously. It has been estimated that between 70

and 80 per cent of the water developed by man is consumed in agriculture. Thus man must find ways to increase food production by more efficient development and use of the world's limited supply.

11-3. Water resources problems arising because of uneven distribution of run off with respect to space are more complex and challenging and have to be handled in a manner somewhat similar to the transportation problems of other resources. Transportation of water within a drainage basin and distribution is practised extensively all over the world. But interbasin diversions are not so common, but there are many in developed countries as in United States. Many of the major water transfer systems have been constructed for supplying water to urban areas and not for agricultural use. In India and in certain other countries transfer of water from one basin to other has been made for agriculture. Several countries are planning such projects recently. Australia, Middle East countries, Great Plains of United States of America are some of the countries in addition to India planning such extensive water transfer.

11.4. One major factor to be reckoned with is the emotional aspect of water transfer. People will encourage resource development such as oil, timber and metals but will stubbornly resist the transfer of water a source which nature replenishes every year. Once metals are mine or oil is pumped, the resource is gone; whereas the annual rains replenish the water supply. Legal battles have lasted several years 20, 30 or even 40. Once public emotion is removed from water transfer many of the water transfer projects will move forward. A significant factor is an adequate supply of food for the world population and if transfer of water will help developing additional area it should be encouraged.

11-5. The position of India with regard to the water transfer can be examined. India has substantial water resources but their distribution over the land is uneven. The uncertainty of occurrence of rainfall marked by prolonged dry spells and fluctuation in seasonal and annual amount is a serious problem for the country. Large parts of the country comprising areas in the States of West Bengal, Bihar, Uttar Pradesh, Haryana, Rajastan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Mysore and Tamil Nadu are not only deficient in rainfall but also subject to large variations. There are a total of 160 million hectares of drought affected areas in these States. About ⅓ of the people in India live in this area. It is common sense that we cannot evacuate the people from the drought affected areas but we can take water to these areas. In order to increase the area under irrigation in these drought areas it is necessary to consider schemes for importing water from outside the basin. Interbasin transfer of water is not a new concept in India. Many such schemes have been constructed already, the important of which are :

1. Periyar Diversion Scheme.
2. Kurnool-Cuddapah Canal.
3. Parambikulam Aliyar Project.

Rajasthan Canal, Beas Sutlej Link, Diversion from Ramganga into Ganga are some of the important schemes under construction.

11-6. Ganga Cauvery link is a mighty proposal to link, Ganges in the north to the Cauvery river in the south. This is the main project in the proposed National Water Grid of India. Connecting the Sone, Narmada, Tapti, Godavari, Krishna, Pennar and Cauvery basins this link is more than 3,600 km in length involving a lift of about 350 m; this link will handle a discharge of 1,700 cumecs. I had the good fortune to preside over a seminar on the national water grid in 1972 at Delhi where the top most Engineers in Irrigation and Power attended. As is the case with any other major water project, Ganga-Cauvery link has a long history. This scheme was first suggested by Arthur cotton (1803—1899) about 150 years ago. Later Sir M. Visweswara Ayya (1861—1962) studied this project in detail and tried to gather popular opinion in favour of the scheme. Dr. C. P. Ramaswamy Iyer, Dewan of erstwhile Travancore State strongly supported this project but he was also not in a position to create interest among concerned authorities at all India level and thus the project remained in cold storage. Recently when the engineer-states man Dr. K. L. Rao became a minister in the Union Government of India, he took personal interest in the project. The Government of India associated the UNDP in the studies and a team of U. N. experts visited the area during 1971 and 1972 and submitted its report during 1972. Even if the project is taken up in full earnestness, the preliminary investigation will take 3 to 5 years, and the detailed investigation will take another 5 years. The cost of investigation alone is estimated to be about Rs. 300 million. The execution of the project is estimated to cost Rs. 29,000 million and may take 20 to 30 years' period. perhaps we may have to wait for better times to see that the project is taken up. Meantime other smaller projects of trans-basin diversions can be taken up to increase production of food crops, production of power and other amenities.

12. ***Artificial Rain :***

12.1. Weather modification is a new phase of hydrology, of which artificial rain making is an important item. There are two general categories of clouds in the context of weather modification (1) cumuliform cloud with horizontal and vertical dimentions roughly equal, often of the order of 1 to 10 km and (2) Stratiform clouds or layer clouds which have a horizontal dimention hundreds or thousands of times the vertical. While the vertical dimention is less than 1 km (some times only a few hundred metres), the horizontal dimention may be of the order of hundreds of km. Cloud seeding have better chance of success with cumuliform clouds then with layer clouds.

12.2. For the formation of rain, existence of four mechanism is necessary.

(1) A mechanism for cooling the water (this is provided by the adiabatic reduction of pressure in the upward motion of the air).

(2) A mechanism for condensation (this is provided in the atmosphere by condensation nuclei consisting of small particles, having affinity to water).

(3) A mechanism for droplet growth

(4) A mechanism of sufficient intensity to produce, accumulation of moisture to cause rain fall.

12·3. Previously presence of ice-crystals was considered to be a pre-requisite for commencing precipitation processes, but precipitation has frequently been observed to fall from clouds which are entirely in region warmer than 0°c. A large number of attempts were done with seeding the super cooled clouds with ice-crystals in the hope of initiating the growth of water drops. The experience in Australia and in America has not definitely proved that rain fall increased due to cloud seeding and further observations are considered necessary. But Israeli artificial rain experiment gives consistant increase of 18% in precipitation. In India experiments were conducted with warm cloud seeding at Delhi, Agra and Jaipur earlier. The seeding was accomplished by spraying dilute salt solution or by blowing up finely powered salt and soapstone mixture into the air, using ground based generations. It is considered that the precipitation increased up to 40% in these experiments.

12·4. Recently some experiments were done at Madras and at Nilgiris by American experts. They sprinkled silver iodide from an aeroplane in the clouds which cooled the clouds quickly causing precipitation.

12·5. During its passage over the Arabian sea and Bay of Bengal, the monsoon current picks up copious moisture but precipitates only about 20% of it as rain over India. If it is possible to tap just another 10% of the incoming moisture during the monsoon season by artificial means, the total rainfall in the country could be increased by 50 per cent with consequent gain in run-offi.

12·6. Artificial rain making has ill effects also. It is reported that cloud-seeding has become so common in the United States that 23 States now have laws against it, since the precipitation of rain in one state may effect its neighbour. There is no scientific basis or proof to the belief that the artificial rain in an area will be followed by a drought next year. There is the danger that manipulation of the weather can be used as a weapon in warfare. It was flashed in news papers that during the Vietnam War, the American seeded clouds to prolong monsoon and make the movement of the enemy supplies difficult. In spite of such dangers, all experiments in weather modification for peaceful purpose are to be welcomed.

13. *Desalination of sea water*:

The oceans form an inexhaustible source of water. Some 1·38 billion cubic kilometers of water is available in the oceans. By desalination, this water can be made available for our needs. Desalination has been adopted now in practice in many countries though the methods remain quite costly. Already Kuwait is using desalinated water for its water supply schemes. This method has also been tried in U.S.A. and Australia. However, at present, use of this method is limited to countries adjacent to the sea and is still costly. Yet in the near future, we will have to depend more on desalination to meet our requirements.

4. *Pollution of water*:

14·1. In the hydrologic cycle in nature, we get fresh water continuously, but once it reaches earth's surface it starts polluting. On its way to the ocean or to the groundwater source, the water dissolves salts, minerals and various waste materials. The river course is the naturaldrain for any locality. The man knowingly or unknowingly allows all waste to be drained to the river which pollutes the river water. In most of the countries, industrial wastes pollute the river waters such that it is not fit to use for any other purpose. The industrial and other wastes sent to the sea have made the sea water unfit for even marine life. Applying in huge quantities in the fields, pollutes the water reaching the river as return and regeneration flow. Pesticides is another source of pollution. Waste disposals in the under-ground area pollutes ground water. Mining operations, especially coal produce huge quantities of acids which pollute the water resources of the neighbouring area considerably. The degree of pollution is increasing in such rapid rates that many believe wild life will soon be extinct. Marine life is threatended. Man will drown in his own wastes, Planet is doomed. Time is running out".

14·2. In industrialrised countries pollution of water has become a very serious problem and severe measures are taken to improve the situation. In the industrial field, manufacturers are made responsible to prove that the product or the waste is not harmful to the environment. Water quality standards are fixed in several cities and severe action taken against those who violate the standards. The use of D.D.T. and similar substances which are found polluting the water are controlled or even banned in several places. In countries like U.S.A. the restrictions have become so complex that it is feared that further development of water resources for various purposes have become very difficult.

14·3. Fortunately in India we have not reached such a level of water pollution except in certain crowded cities. But we have to think of various specific courses to keep our water resources as clean as possible, some of which are ;—

(1) Maintaining public awareness of both the short and long range consequences of water pollution and the cost of its control.

(2) Adequate research and development activities have to be done to provide technical solutions to pollution problems.

(3) Reuse of waste water to be encouraged and application of advanced waste treatment technique to be popularised.

(4) Comprehensive, long range, river basin wise plans should be prepared for the development and utilisation of water resources.

15. *India's total water resources and their utilisation.—*

15·1. Lastly, let us examine the water resources of our country and its utilisation, India is fortunate to have rich water resources compared to many other nations in the world. The average annual rain fall is estimated as 112 cm. It varies however from year to year and from area to area. While it is as high as 800 inches in one place, it is evenless than 20 inches in other places. More than 75 per cent of the annual rainfall is received during South-west Monsoon season (June—September) in most parts of the country. The total water that falls on the surface of India is about 3,704 billion cum (3,000 million acres feet), on an average. Of this athird is lost by evaporation; over a fifth sinks into the soil and the

balance of about 1,678 billion cum (1,360 million acre ft.) is the suface run off. It is assessed that 40 per cent of the total water i.e. about 671 billion cum (544 million acre ft.) can be utilised for irrigation. Broad ground water surveys have been done for many of the areas in the country and it is estimated that the utilisable ground water resources is about 270 billion cum (220 million acre ft.) The abudance of this source in the Gangetic basin is revealed by the fact that some of the deep bore holes yield as much as 150,000 gallons an hour.

15·2. The development of irrigation has not progressed much to cope up with the demand or in accordance with the availability. At the time of independence (1947) the net irrigated area in the country was about 19.4 million hectares which corresponded to about a fifth of the cultivated area at that time. The first Five Year Plan started in 1951. At that time. the total gross irrigated area was 22·7 million hectares and the production of food grain was about 50 million tonnes which was in sufficient for the then population of 361 millions. By the end of the Fourth Five Year Plan i.e. by 1973-74 the total irrigated area increased to 31·5 million hectares and the production of food grains increased to 104 million tonnes. By this time the population increased to about 550 million, but the food grains producted per each person was much more than that was during 1950-51. In other words India has almost reached the stage of self sufficiency, which will be completely achieved quickly

15·3 The total quantity of water utilised by 1971 for various purposes such as irrigation, power generation and domestic and industrial purposes is estimated to be 369·9 billion cum (300 million acre feet) including the utilisation of ground water. This is about 40 per cent of the total utilisable quantity available in this county. It is estimated that by 2,000 A.D. all our utilisable water resouces will be utilised and we will be looking all out for additional resources.

கருப்பா நதி திட்டக் குறிப்புரை

1. முன்னுரை.

கருப்பாநதித் திட்டம் தென்காசிதாலுகாவில் தாம்பிர பரணியாற்றின் (பொருனை) கிளை ஆருகிய சிற்றாறில் விழும் கருப்பாநதியின் குறுக்கே கட்டப்படும் ஒரு நீர்த் தேக்க மாகும். இதன் கொள்ளளவு 185 மி.க. அடி. கருப்பா நதி அணையின் கிழ் கருப்பாநதியில் 6 அணைக்கட்டுகள் உள்ளன. ஆறு அணைக்கட்டுகளின் கீழ் 9 பொதுப்பணித் துறை குளங்கள் மூலமாகவும் 66 ஊராட்சி ஒன்றிய கண் காணிப்பிலுள்ள குளங்களின் மூலமாகவும் பாசனம் நடை பெறுகிறது. கருப்பாநதி அணையின் மூலம் 1,552 ஏக்கர் நேரடி பாசன நிலமும் 7,963 ஏக்கர் குளப்புரவு நிலங் களும் பயனடையும். இத்திட்டத்தால் ஏற்படும் உணவு உற் பத்தி 5,903 டன்களாகும். ஒரு டன் அரிசி விளைச்சலுக்கு திட்ட முதலீடு ரூ. 2,372 ஆகிறது.

கருப்பாநதி ஆற்றின் ஏந்துகை (நீர்ப்பிடிப்பு) தென் மேற்கு, வடகிழக்கு ஆகிய இரு பருவ மழைகளாலும் பயன்பெறுகிறது. எனவே, இவ்வாற்றின் பாசனத் திற்குட்பட்ட ஆயக்கட்டின் பெரும் பகுதியும் இருபோகம் விளைகின்றது.

2. அணை அமையும் இடம்.

அணை மேற்கு தொடர்ச்சி மலையில் தென்காசி மதுரை சாலையிருக்கும் சொக்கம்பட்டியிலிருந்து 8 கி. மீ. தொலைவி லுள்ளது. சொக்கம்பட்டியிலிருந்து அமைக்கப்பட் பட்டிருக்கும் சாலைவழி அங்கு செல்லலாம். அணை ஆற்றின் இருமருங்குமுள்ள இரண்டு பாறைகளை இணைப்பதாகிய மண்ணணையும் கொத்துவகை (கல்லணை)யும் இணைந்த அணையாகும்.

3. செயற் குறிப்பு.

கருப்பாநதி அணை 890 மீட்டர் நீளம் உடையது. இந்த அணை இடது பக்கத்திலிருந்து 40 மீட்டர் கல்லணையாலும் மீதி பாகம் மண்ணணையாலும் ஆனது. இந்த அணையின் உயரம் ஆழ்பகுதி அஸ்திவாரத்திலிருந்து 34.44 மீட்டர் (126 அடி) அணையின் மேல் பாகத்தில் 6.1 மீட்டர் வீதியில் இரண்டு மலைகள் இணைக்கும் சாலை போடப்படும். அணையின் இடது பக்கம் ஆற்றுமடை அமைக்கப்பட்டிருக்கிறது. மடை யின் கண்மாய் அளவு 1.525×1.83 மீ. உபரித்தண்ணீரை இரண்டு கண்மாய்களால் வெளியேற்றுவதற்கான ஏற்பாடு செய்யப்பட்டிருக்கிறது. இதன் கண்மாயின் அளவு 9.14 மீ. 4.57 மீ.

கருப்பாநதித் திட்டம் அரசு ஆணை எண் 75. பொ.ப.து. நாள் 1971-ம் ஆண்டு ஜனவரி மாதம் 7-ந் தேதியில் ரூபாய் 140 லட்சம் அங்கீகாரம் கிடைக்கப்பெற்று, தலைமைப் பொறியாளர் (பாசனம்) 154 லட்சம் ரூபாய்க்கு ஒப்புதல் அளிக்கப்பட்டது.

திட்ட வேலைகள் 1976-ம் ஆண்டு பிப்ரவரி மாத முடி விற்குள் முடிக்க திட்டமிடப்பட்டுள்ளது.

4. நீர் சார்ந்த குறிப்புகளும், மற்றும் முக்கியமான அமைப்புகளும்.

1 நீர் பிடிப்பு நிலம்	11.33 சதுர மைல்கள்
2 மொத்த நீர் வரவு	312 மில்லியன் கன அடி
3 கூடுதல் வெளியேற்றத்திலிருந்து வெள்ளத்தின் அளவு	12,600 கனஅடி/விநாடி
4 மண் அணையின் நீளம்	850 மீட்டர்கள்
5 அடிமட்ட அஸ்திவாரத்திலிருந்துஅணையின் உயரம்.	34.44 மீட்டர்கள் உயரம்
6 அணையின் மொத்தநீளம்	890 மீட்டர்கள்
7 அணையின் கொள்ளளவு	185 மில்லியன் கன அடி.
8 நிரப்புதல்கள்	1½ நிரப்புதல்கள்
9 அணையின் முழு நீர்பிடிப்பு மட்டமும் கூடுதல் நீர் பிடிப்பு மட்டமும்.	253.00 மீட்டர்
10 அணையின் மேல் பாகத்தின் மட்டம்.	255.44 மீட்டர்
11 நீர் பரப்பு	0.5 ச.கி.மீ.
12 அணையின் மேல் பாகத்தின் அகலம்.	6.1 மீட்டர்கள்
13 நீர் வழிந்தோடி (2 கண் மாய்க்கள்).	9.144 மீ×4.572 மீ.
4 மடையின் அடித்தளத்தின் மட்டம்.	231.00 மீ.
15 மடையின் கண்மாயின் அளவு.	1.525×1.83 மீ.

வைகைக் கால்வாய்கள சீரமைப்புத் திட்டம்

சு. தண்டபாணி, பி.இ. டபிள் யூ.எம்.யு.எஸ்.பி' ஆர்.

.0. வைகை நதியின் சிறப்பும், உற்பத்தியும் :

வைகை : நினைத்தாலே நெஞ்சமெல்லாம் இனிக்கின்ற கவினுறு நதி, தமிழர்களின் வாழ்வில் இரண்டறக் கலந்து அவர்களின் வாழ்வில் ஒளியேற்றி வைக்கும் ஒப்பற்ற நதியே வைகை நதியாகும். ஏழை, எளியவர்க்கு இறைவனாய், கவிஞர்க்கு காவியமாய். பொறியாளர்க்கு பொற்குவியலாய் விளைந்து வரும் வைகை இறைவனுக்கு இடர் சேர்த்திட்ட பெரு நதியாகும். "புலவர் நாவிற் பொருந்திய பூங்கொடி, வையை என்னும் பொய்யாக் குலக்கொடி" என்று இளங் கோவடிகளாலும் "முழங்குகால் பொருத மரம் பயில் காவின் இயங்கு புனல் கொண்ட" வைகை என மாங்குடி மருதனாராலும் "தமிழ் கண்டதோர் வையை" என்று பாரதியாலும் சிறப்புறப் பாடப்பெற்ற வளமிகு நதியே வைகை யாகும்.

வைகை நதி வளம் மிகு மேற்குத் தொடர்ச்சி மலைகளில் சுமார் 1,525 மீட்டர் உயரத்தில் உற்பத்தியாகி, கிழக்கு நோக்கிப் பாய்ந்து, இடையில் தேனியாறு, சுருளியாறு, மஞ்சளாறு, வராகநதி போன்ற துணை நதிகளை தன்னுள் இணைத்துக் கொண்டு, மதுரை, முகவை மாவட்டங்களில் ஓடி, இறுதியில் இராமநாதபுரம் பெரிய கண்மாயில் சங்கம மாகிறது. இக்கண்மாயின் உபரி நீர் வங்காள விரிகுடாவில் கலக்கிறது.

2.0. தற்போதைய பாசன அமைப்பு :

வைகை நதியில் இருமருங்கும் சுமார் 115 கால்வாய்கள் பிரிந்து செல்கின்றன. வைகை நீர் இக்கால்வாய்களின் வழியாகச் சென்று சுமார் 414 கண்மாய்களை நிரப்பி, அவற்றின் கீழ் உள்ள ஒரு இலட்சம் ஏக்கருக்கும் அதிகமான நிலங்களுக்குப் பாசன வசதி நல்குகிறது. இது தவிர, "வைகை நீர் பெறும்" கண்மாய்களின் உபரி நீரை நம்பி 5,047 ஏக்கர் ஆயக்கட்டைக் கொண்ட 62 பி. குரூப் எனப்படும் கண்மாய்களும் வைகை நீரை நம்பியுள்ளன. முன்பு, வைகையின் குறுக்கே போரணை தவிர மதகு அணை எதுமில்லை.

3.0. பெரியாறு மற்றும் வைகைத் திட்டங்கள் :

"வைகைக் கால்வாய்கள் சீரமைப்புத் திட்டத்தைப்" புரிந்துகொள்ளுமுன், "பெரியாறு திட்டத்தையும்", "வைகை அணைத்திட்டத்தையும் பற்றி அறிந்து கொள் ளுதல் நலமாகும். 18ஆம் நூற்றாண்டின் ஈறுதியில் கட்ட பட்ட அணையே "பெரியாறு அணையாகும்", இவ்வணை மேற்கு முகமாகச் சென்று வீணக அரபிக் கடலில் கலந்து வந்த நீரை கிழக்கு முகமாகத் திருப்பி விடப்பட்டது. பெரியாறு நீர், பேரணை என்ற இடத்தில் கட்டப்பட்டுள்ள மதகு அணையின் மூலம் பெரியாறு பிரதானக் கால்வாய் மற்றும் திருமங்கலம் பிரதானக் கால்வாய்களில் திருப்பி விடப் பெற்று மதுரை, முகவை, மாவட்டங்களில் சுமார் 1,68,800 ஏக்கர் நிலங்கட்கு நிரந்தரப் பாசன வசதி நல்கு கிறது.

பேரணை மதகு அணைக்கு மேலே 32 கிலோ மீட்டர் தூரத்தில் 1954-ஆம் ஆண்டு ஆரம்பிக்கப்பட்டு, 1959ஆம் ஆண்டு முடிக்கப் பெற்ற வைகையின் குறுக்கே கட்டப் பட்டுள்ள அணையே "வைகை அணையாகும்". இது ஒரு சமன்பாட்டு நீர்த்தேக்கமாகும். பெரியாறு அணையின் உபரி நீர் மற்றும் பெரியாறு நீர் மின் நிலையத்தினின்று வெளிப் படும் நீரையும் தேக்குவதே வைகை அணையின் முக்கிய பங்காகும்.

பேரணை மதகிற்குக் கீழே வைகையின் இருமருங்குமுள்ள கால்வாய்களே வைகைக் கால்வாய்கள் என அழைக்கப் படுகின்றன. இக்கால்வாய்களை நம்பியுள்ள ஆயக்கட்டு I வைகை ஆயக்கட்டு" என அழைக்கப்படுகிறது.

4.0. வைகைக் கால்வாய்கள் சீரமைப்புத் திட்டம்—ஏன் ?

பேரணை மதகிற்கும், இராமநாதபுரம் பெரிய கண்மாய்க்கும் இடைப்பட்ட 128 கிலோ மீட்டர் தூரத்தில் வைகையின் இருமருங்கும் 115 கால்வாய்கள் பிரிகின்றன. இக்கால்வாய் களின் நீரோட்டத்தைக் கட்டுப்படுத்திட மடைகள் எதும் இல்லாமல் இருந்தது. இக்கால்வாய்கள் பல தேவைக்கு அதிகமான நீரை வைகையிலிருந்து எடுத்துக் கொண்டன.

மேலும் வைகை தனது நீண்ட நெடிய பயணத்தில் பெரும் பகுதி நீரை மணலுக்கும், வெப்பத்திற்கும் பலி கொடுத்துவிட்டு, சிறிதளவு நீரையே கடைமடைப் பகுதி களுக்கு இட்டுச் சென்றது.

மேற் சொன்ன இரு காரணங்களினாலும் வைகையின் கடை மடைப் பகுதிகளில் ஆண்டு தோறும் சுமார் 10,000 ஏக்கர் தரிசாகப் போடப்பட்டது.

நீரோட்டத்தைக் கட்டுப்படுத்திட மடைகள் எதுமில்லாத காரணத்தால் அதிகமான நீர் கால்வாய்களில் புகுந்து, கால்வாய்களையும், கண்மாய்களையும் பெருமளவில் சேதப் படுத்தி முகவை மாவட்டமக்களுக்கு சொல்லவொண்ணாத துயரத்தை அளித்தது.

பல கால்வாய்கள் மராமத்து எதுமில்லாத நிலையில் வேண்டிய அளவு நீரைக் கடத்திச் செல்லும் திறனற்றதாக இருந்தன.

இந்த நிலை மாறிட வேண்டுமென்றும், வைகை நீரை வழங்குவதில் ஒழுங்கு முறை வேண்டுமெனவும், கால் வாய்களைச் சீர்திருத்தி மடைகள் கட்டி, கீழ்கோடியிலுள்ள ஏழை விவசாயிக்கும் சம உரிமை வழங்கிட வைகைக் கால்வாய்கள் சீரமைப்புத் திட்டம் வேண்டுமென முகவை மாவட்ட விவசாயப் பெருங்குடி மக்கள் பன்னெடுங் காலமாக வேண்டி வந்தனர். தமிழக அரசு தனது ஆணை எண். 555-ன் மூலம் 7—3—68 அன்று வைகைக் கால்வாய்கள் சீரமைப்புத் திட்டத்திற்கு அனுமதி வழங்கியது. தமிழக அரசின் கனிவான இச் செயல் கண்டு குளிராத நெஞ்சங் களே இல்லை. இவ்வாணை கேட்டு முகவை மாவட்ட மக்கள் சொரிந்த ஆனந்தக் கண்ணீர் வைகையில் புது வெள்ளமாய் ஓடியது.

5.0. திட்டத்தின் நோக்கம் :

(அ) மதுரை மாவட்டத்தில் விரகனூர் அருகே வைகையின் குறுக்கே மதகு அணை ஒன்றைக் கட்டுதல்.

(ஆ) விரகனூர் மதகு அணையின் கீழ் வைகையின் இரு புறமும் பிரதானக் கால்வாய்கள் (இரண்டு) வெட்டி, அதன் மூலம் வைகை நீரைச் செலுத்தி பாசனத்திற்குப் பயன் படுத்துதல்.

(இ) முகவை மாவட்டத்தில் பார்த்திபனூர் அருகே வைகையின் குறுக்கே மதகு அணை ஒன்று கட்டுதல்.

மேற்பார்வை பொறியாளர் பொதுப்பணித்துறை திட்டங்கள்வட்டம். மதுரை.

(ஈ) பார்த்திபனூர் மதகு அணையின்கீழே வைகை நதியின் இரு புறமும் கால்வாய்கள் (இரண்டு) வெட்டி, அதன் மூலம் வைகை நீரைச் செலுத்தி பாசனத்திற்குப் பயன் படுத்துதல்.

(உ) பிரதானக் கால்வாயிலிருந்து பிரியும் துணைக்கால் வாய்கள் அனைத்திற்கும் மடைகள் கட்டி நீரோட்டத்தைச் சீர்படுத்துதல்.

6.0. திட்டத்தின் பொறியியல் விவரங்கள் :

(அ) விரகனூர் மதகு அணை ஒவ்வொன்றும் 12.20 மீட்டர் நீளமுள்ள 18 கண்களை உடையது. இவற்றில் 1.98 மீட்டர் உயரமுள்ள இரும்புக் கதவுகள் பொருத்தப்பட்டுள்ளன. இக்கதவுகள் வைகை நீரைக் கால்வாய்களுக்குக் திருப்பிட உதவும். வைகையில் மிக அதிகமான வெள்ளம் வரும் பொழுது, கதவுகள் மின் வசதியால் திறக்கப்பட்டு, வைகை யிலேயே வெள்ளத்தைத் திருப்பிட வசதி செய்யப்பட்டுள்ளது.

(ஆ) விரகனூர் மதகு அணைக்குக் கீழேயுள்ள இடது பிரதானக் கால்வாய் 30 கிலோ மீட்டர் நீளமுடையது. இக்கால்வாய் வினாடிக்கு 8.40 கன மீட்டர் நீரைக் கடத்திச் செல்லும் திறன் பெற்றது. இக்கால்வாயின் மூலம் 14,195 ஏக்கர் நிலப் பரப்பு உறுதியான, நிலையான பாசன வசதி பெறும்.

(இ) விரகனூர் மதகு அணைக்குக் கீழேயுள்ள வலது பிரதானக் கால்வாய் 46 கிலோ மீட்டர் நீளமுடையது. இக்கால்வாய் வினாடிக்கு 19.60 கன மீட்டர் நீரைச் சுமந்து செல்லும் திறன் பெற்றது. இக் கால்வாயின் மூலம் 27,217 ஏக்கர் நிலப் பரப்பு நிலையான, உறுதியான பாசன வசதி பெறும்.

(ஈ) பாத்திபனூர் மதகு அணை ஒங்வொன்றும் 12.20 மீட்டர் நீளமுள்ள கண்களை உடையது. இதன் இருபுறமும் தலை மதகு ஒன்றும், மணல் வாரி மதகு ஒன்றும் கட்டப் பட்டுள்ளது. மதகுக் கண்களில் பொருத்தப்பட்டுள்ள 1.83 மீட்டர் உயரமுள்ள இரும்புக் கதவுகள் கால்வாய்களில் நீரைத் திருப்பிட உதவும். வைகையில் அதிக வெள்ளம் வரும் பொழுது கதவுகள் மின் வசதியால் திறக்கப்பட்டு நதியிலேயே வெள்ளத்தைத் திருப்பி விட வசதிகள் செய்யப் பட்டுள்ளன.

(உ) பார்த்திபனூர் மதகு அணையின் இடது புறமுள்ள பிரதானக் கால்வாய் 45 கிலோ மீட்டர் நீளமுடையது. இக் கால்வாய் வினாடிக்கு 50.40 கன மீட்டர் நன்னீரைக் கடத்திச் செல்லும் திறன் பெற்றது. இக் கால்வாய் மூலம் 31,872 ஏக்கர் நிலப்பரப்பு உறுதியான, நிலையான பாசன வசதி பெறும்.

(ஊ) பார்த்திபனூர் மதகு அணையின் வலப்புறமுள்ள பிரதானக் கால்வாய் 43 கிலோ மீட்டர் நீளமுடையது. இக் கால்வாய் 43 வினாடிக்கு 47.60 கன மீட்டர் நீரைக் கடத்தித் செல்லும் திறன் பெற்றது. இக் கால்வாயினால் 32,598 ஏக்கர் நிலப்பரப்பு உறுதியான பாசன வசதி பெறும்.

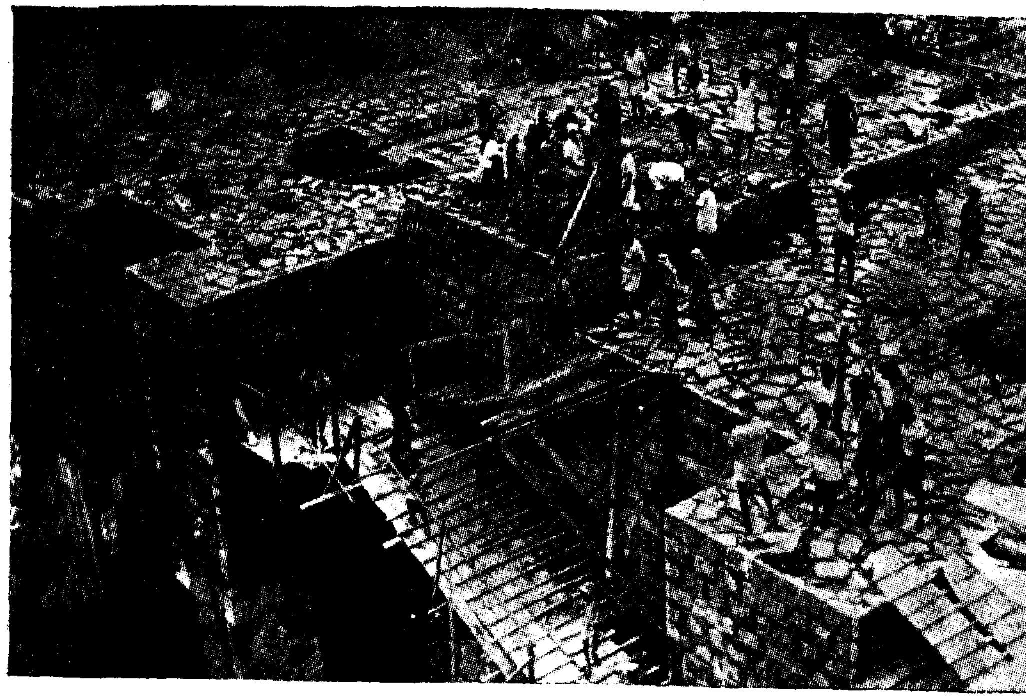
7.0. திட்ட மதிப்பீடும், திட்டத்தின் நன்மைகளும் :

வைகைக்கால்வாய்களின் சீரமைப்புத் திட்டத்தின் மொத்த மதிப்பீடு ரூ. 823 லட்சங்களாகும்.

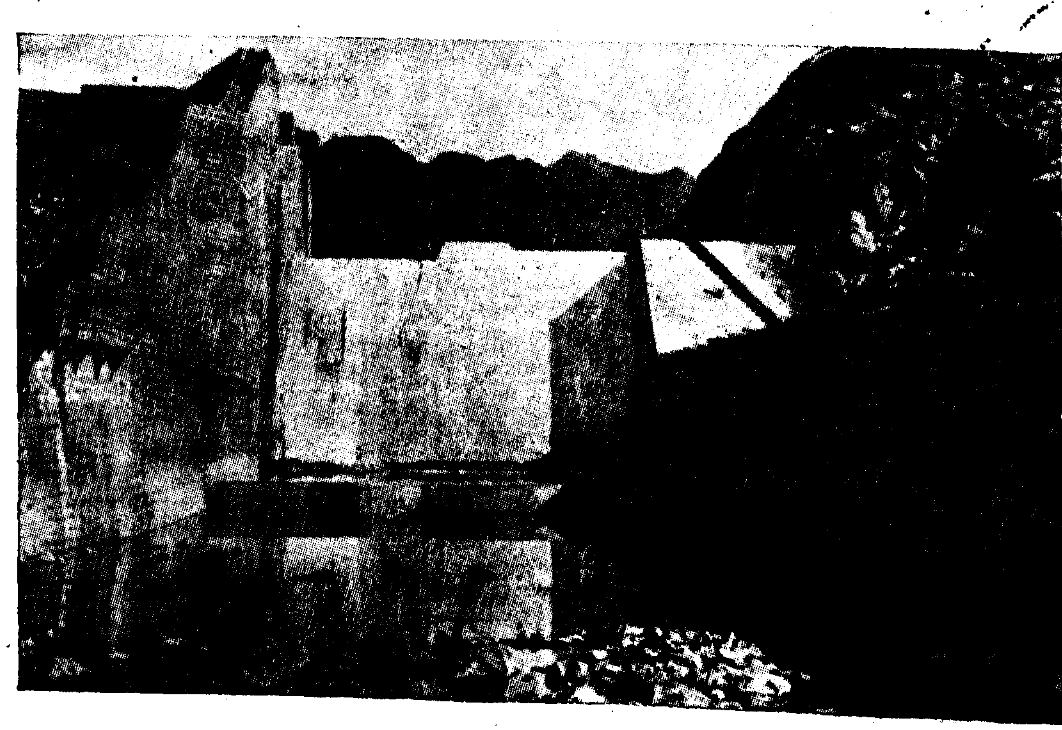
இத்திட்டத்தினால் மதுரை, முகவை மாவட்டங்களில் 1,05,882 ஏக்கர் நிலப் பரப்பு உறுதியான, நிலையான பாசன வசதி பெறும். இத்திட்டத்தின் பயனாக ஆண் டொன்றுக்கு சுமார் 55,940 டன் கூடுதல் உணவு உற்பத்தி யாகும். இத்திட்டம் நிறைவேற்றப்பட்டதன் பயனாக ஏறத்தாழ 5,000 தொழிலாளர்களுக்கு 3 ஆண்டுகள் தொடர்ந்து வேலை வாய்ப்புக் கிட்டியது. குறிப்பாக நடப்பு ஆண்டில் ஏற்பட்ட கடும் பஞ்சத்தைத் தணிக்க இத்திட்டம் பெரும் பயனுள்ளதாய் அமைந்தது.

8.0. முடிவுரை :

முகவை மாவட்ட மக்களின் நெடுநாள் கோரிக்கை இன்று நிறைவேறுகிறது என்னும்போது பெருமகிழ்ச்சி யாக உள்ளது. வறட்சிமிகு மாவட்டம் என்ற பெயர் மாறி, முகவை மாவட்டம் வளமிகு மாவட்டம் என்ற பெயர் பெற இந்த மாபெரும் நீர்பாசனத் திட்டம் வகை செய்யும் என்பதில் எள்ளளவும் ஐயமில்லை. முகவை மாவட்டத் தில் நிறைவேற்றப்பட்ட மிகப் பெரிய நீர் பாசனத் திட்டம் என்பதை எண்ணி முகவை மாவட்ட மக்கள் பெருமை யடையலாம். முகவை மாவட்ட மக்களின் பல நூறு தலைமுறைகளுக்கு இத்திட்டம் நல்ல பயனைத் தந்திடும் என்பதில் ஐயமில்லை



கருப்பா நதி திட்டம்.



கருப்பா நதி திட்டம்.

UPPER NIRAR WEIR (P.A.P)

MAXIMUM HT. OF DAM.	85	26·91	MAXIMUM HT. OF DAM
MASONRY QUANTITY	4100 C-FT	11603 C-METRE	MASONRY QUANTITY
EARTH DAM QUANTITY			EARTH DAM QUANTITY
COST	310·00 LAKHS		COST

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SHOLAYAR DAM (P.A.P)

MAXIMUM HT. OF DAM	345	105·16	MAXIMUM HT. OF DAM
MASONRY QUANTITY	193600 C-FT.	547888 C.METRE	MASONRY QUANTITY
EARTH DAM QUANTITY	[illegible]00 .FT.	[illegible]400 METRE	EARTH DAM QUANTITY
COST	1115·00 LAKHS		COST

PARAMBIKULAM DAM (P.A.P)

MAXIMUM HT. OF DAM	240	73·15	MAXIMUM HT. OF DAM
MASONRY QUANTITY	81000 C-FT.	229230 C METRE	MASONRY QUANTITY
EARTH DAM QUANTITY	16340 .FT.	46242 .METRE	EARTH DAM QUANTITY
COST	347·00 LAKHS		COST

TRD. BY: N.N.G