FEASIBILITY OF USING BAMBOO AS AN IRRIGATION SIPHON TUBE OR SPILE IN INDIA

by

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INTRODUCTION

Agriculture has always been the primary and chief industry of India even from the early days, and nearly 75 per cent of the population depends directly on agriculture for food, shelter, and clothing. Therefore, agricultural development is intimately connected with the joy and happiness of the people in this country.

Agriculture is also the basis for a number of important Indian manufacturing industries. It represents 80 per cent of the Indian exports. The purchasing power of Indian people depends largely upon it. Their capacity to buy both domestic and industrial products depends on agricultural development. The finances of the Government of India depend upon successful tilling of the land. In short, it is the foundation of the economic prosperity of this country (4).

Increasing agricultural production is essential for feeding the rapidly growing population of the country, for the health and the efficiency of the vast masses of the population who live at subsistence level, in order to provide raw materials for the expanding industries, for securing exportable surpluses, and for creating conditions favorable to increasing the standard of living of the bulk of the population. The attainment of self-sufficiency in food should be a desirable aim for every country, but it assumes particular significance for a country like India which is making serious efforts for the economic uplift of the people. In fact, self-sufficiency in agricultural production shall be the decisive factor in the success of our plans for economic progress. The battle of Indian economic development shall be fought on the front of agricultural production and particularly food production (4).

The success of agriculture depends greatly upon the adequate and regular water supply. Better seeds, more manure, and scientific methods of cultivation play their part in increasing crop yield; but without adequate, timely, and a measured supply of water, effective results can not be produced. In any scheme for increasing food production, therefore, the provision for irrigation facilities is of prime importance (19).

History of Irrigation in India

The value of irrigation as a means of making the land more productive was recognized even in ancient times, and there remains evidence of its use in India.

India was an agricultural country from the very beginning and continues to be so even today. References are available about irrigation works in the oldest records of the Vedas and coming to the period of recorded history.

In Northern India, Chandragupta Maurya created facilities for irrigation in his empire, and in Southern India, Chola Emperors created facilities for irrigation during his reign. Then during the Muslim rule, Emperor Ferozshah Toghlak, in the 14th century, constructed canals from the rivers, Sutlej and Jumna, for the benefit of the people, and it was found that Akabar and Shahajahan improved these canals and opened new ones also. In Mysore during the 18th and 19th centuries, a good number of tanks were built and important weirs, Chikkaderaraj-Sagara, Madhavamanthin were also constructed. In the 19th century, the British remodeled the old canals in Northern India and in the Cauvery delta; and constructed new canals such as the Upper Bari Doab Canal, the Ganga Canal, and the canals in the Godavari delta.

An Irrigation Commission was appointed in 1901 to examine the possibilities of improving the irrigation in the country. This gave good impetus and as a result, many irrigation works in the shape of dams, barrages, diversion-weirs, and canals were developed.

Quite recently, the Union Government has established a body of experts called the Central Board of Irrigation and Power, and the Central Water and Power Commission. These organizations are authorized to look after the development of irrigation and to advise and help the State Government. As a result, many of the multipurpose projects have been prepared and at the present time, they are in different stages of progress.

Again a good number of research stations have been established in many states and finally the Planning Commission has included all important irrigation works in the Five-Year Plan. Topmost priority has been given to irrigation works.

Today, India leads other countries in irrigation. It cultivates 266 million acres of which 68 million acres are irrigated (2). India is the oldest and largest irrigated country, and one can find all types of irrigation works in it.

During the first Five-Year Plan, 16.3 million acres of additional land were brought under irrigation through minor and major irrigation works. The total area of irrigated land increased from 51.5 million acres in 1950-51 to 67.8 million acres in 1955-56. This area was divided as follows (2):

Irrigated by government canals	32.0	million	acres
Irrigated by private canals	3.3	"	"
Irrigated by tanks	10.1	"	"
Irrigated by wells	16.4	"	"
Irrigated by other sources	6.0	"	"
Total	67.8	"	"

India has been using either wells, tanks, pumps, tube wells, and channels or canals, dams, and reservoirs to irrigate the fields. The former are known as "Minor" and the latter "Major irrigation works."

Necessity of Irrigation in India

Although 25 to 26 per cent of the area under cultivation receives irrigation, the remaining 74 to 75 per cent (4) depends entirely upon the mercy of rain every year, for the successful cultivation of various agricultural crops. In India the monsoon sets in in June and spreads over almost all the country by July and August. During this period, 75 per cent of the total rainfall is received.

Indian agriculture is a gamble in "monsoons." The spectacle of the Indian farmer looking at the sky on the eve of the onset of the rainy season presents a picture of his great dependence on rainfall. The rainfall, though on the whole abundant, often fails on an average once in a decade. The normal annual rainfall varies from 460 inches in the Assam hills to less than 10 inches in Western Rajputana. The chief characteristics of the Indian rainfall are its non-uniform distribution over the country, its irregular distribution throughout the season, and its liability to failure or serious deficiency.

In the southeast part of the peninsula, where the heaviest precipitation is received from October to December, by far the greatest portion of the rainfall occurs during the southwest monsoon, between June and October. During the winter months the amount of rainfall is comparatively small, the normal amount varying from half an inch to two inches; while during the hot weather, from March to May or June, there is practically no rain. Consequently, it happens that in one season of the year the greater part of India is deluged with rain and is the scene of the most wonderful and rapid growth of vegetation; while in another period the same tract becomes a dreary sunburned waste. However, from the agricultural point of view, undoubtedly the most unsatisfactory feature of the Indian rainfall is its liability to failure or serious deficiency.

The effect of these variations, as productive of famine and scarcity, differs considerably from the average rainfall of the tract, being least in those parts where the average is either very high or very low. Where the average rainfall is high, a large deficiency can be experienced and yet sufficient water remains to insure a successful agriculture; where the average is very low, ten inches or less, cultivation without irrigation becomes, in any case, practically impossible, and agriculture consequently ceases to depend upon the rainfall and relies wholly upon water obtained from other sources.

Successful cultivation cannot be assured for any long period unless facilities are available for watering crops artificially when necessary.

Therefore, irrigation facilities and irrigation equipment are absolutely essential if Indian agriculture is to be insured against the vagaries of the weather (4).

OBJECTIVE

The major purpose of this study was: (1) to try to solve the considerable difficulty experienced by the Indian irrigators when diverting water from unbuilt water channels where properly built channels have not been provided, and (2) to investigate the possibility of using bamboo, which is cheap and a readily available material in India for carrying water.

REVIEW OF LITERATURE

According to Ivan D. Wood (33), siphon tubes were first used for irrigating in the United States. A farmer near Kearney, Nebraska used a form of siphon made of tin pipe about 1920. A few years later other farmers were bending metal, electrical conduit to form a very practical type of tube for furrow irrigation.

Siphon tubes are now made of rubber, plastic, or aluminum. The diameter varies from one-half inch to 10 inches or larger. Small-diameter tubes are used where slopes are extreme, or for vegetable irrigation where rows often are short. Large-diameter tubes are used for water control in irrigation or border strips or for other flooding practices where larger flows of water are needed.

In the year 1948, Dubois (6) studied the effect of end flares on the capacity of irrigation siphon tubes to determine the most efficient angle and length of flare which can be applied to irrigation siphon tubes. Aluminum tubes were used for the tests.

Dubois found that flaring only the inlet end of a siphon tube will increase its capacity by 9 to 15 per cent. A flare angle of either 3 or 10 degrees with a length of 6 inches, gives an increase of 15 per cent. Flaring only the outlet end of a siphon tube will increase its capacity by 3 to 15 per cent.

He also found that flaring both the inlet and the outlet ends of a siphon tube will increase its capacity by 12 to 39 per cent. A flare with an angle of 10 degrees and a length of 6 inches gave an increase of 39 per cent. When the flare length was 3 inches, an angle between 10 and 20 degrees gave optimum flow.

Some Important Species of Bamboos

Bamboo, the popular name for members of the Bambuseae, contains numerous species, and occurs throughout the tropical zone.

It is distributed unevenly, extending into the sub-tropical and even into the temperate zone. Tropical Asia is richest in species (10).

The natural distribution of bamboos in the Western Hemisphere extends from the southern part of the United States southward to Argentina and Chile, and from sea level to elevations of more than 12,000 feet in the tropics. Gaps occur principally in the arid regions or in places where agriculture has destroyed the natural forest cover. Species of Arundinaria and Chusquea are the most cold resistant of the western bamboos; the former grows farthest north and the latter farthest south and highest above sea level.

It is well known that in parts of the Far East the utilization of various species of bamboo has been highly developed, and greatly diversified species of Guadua, Chusquea, Arthrostylidium, and Autonemia are found in the eastern countries. These, according to their natural occurrence and physical properties, supply the principal or preferred material for houses, fences, bridges, basketry, and so on. Bamboos are of great importance economically, particularly in Asia (21).

Some important species of the bamboo are:

1. Bambusa vulgaris. It has been the most common bamboo under cultivation in the American tropics, and is utilized in many areas in the absence of more suitable species for general farm purposes, including house construction, fences, shades, and posts for nursery plants. The extreme susceptibility of its wood to invasion by powder-post-beetles, however, sometimes means

severe losses to its users.

2. Bambusa multiplex. This species and several of its horticultural forms, are less tender than the tropical species and are suitable for landscaping. They have, therefore, become perhaps the most familiar bamboos of the warmer parts. The culms of the parent species, which attain a height of 30 feet and a diameter above one inch, provide structural elements for low-cost houses. They also work as a good paper pulp and water pipe.

3. Bambusa tulda and B. longispiculata. These closely related to Indian species have proved to be outstanding for making furniture and split-bamboo fishing rods. They are also especially suited for use as structural elements in low-cost houses for tropical conditions.

4. Dedrocalamus strictus. From India, a species with thick-walled, strong culms has found special use in the bamboo furniture industry and as irrigational pipe (21).

Some Observations on Bamboos

Bamboo Sets. The bamboo stock is made up of a series of joints separated from each other by the nodes, and it is usually hollow. The node is often of greater diameter than the internode and may be very much swollen in some cases. The distance between joints or internode varies a great deal in the stalk for different seasons. It increases from the bottom upwards, the longest joint being about one third to one half the distance from the base of the stalk (16).

Bamboo Stems. The stems are jointed like those of other grasses, very hard but light and hollow, containing only a light spongy pith, except at the joints or nodes, where they are divided by strong partitions. This spongy pith or siliceous deposit was once valued for its supposed medicinal virtues. The partitions in between nodes can be removed. Stems are therefore readily converted into water vessels of various sorts and are used as pipes for conveying water.

Bamboos for Farm Use

Its use as a supplementary crop and source of material for farm and home use is interesting. The development of bamboo for such uses has only just begun.

Groves of bamboo on the farm can be useful as chicken runs and bird refuges. They can also supply edible shoots, supplemental winter forage for livestock, and poles for a hundred other uses: tree props, poles for harvesting nuts and Spanish moss, fishing poles, fishnet handles, chicken fences, garden stakes, lining out poles for fence buildings, and for staking off lands in plowing, to name only a few.

Once a grove is established, farm boys and girls can soon learn to supplement their incomes by selling poles in town for use in window displays, for interior decoration, vaulting poles, javelins, musical instruments, handles for insect-collecting nets, and material for basketry and other manual training and handicraft needs (21).

On farms in India and in many Eastern countries, bamboo stems are used for the posts and rafters of farm houses. Either whole or split lengthwise into strips, they provide material for walls, floors, and roofs. Narrow strips are woven into mats, chairs, cages, and curtains. Split bamboo is also used for chopsticks and fan ribs. Some farmers in India remove the partitions in between nodes with a red hot rod and use those pieces of bamboo as seed drill tubes (2).

Commercial Use of Bamboo

Bamboo now promises to offer to the technical world another basic raw material, cellulose, so that the bulk of vast paper requirements is being met. The paper is already being made by machine, on a commercial scale, from bamboo pulp in Trinidad, Burma, India, and France. The Forest Research Institute at Dehara Dun, India publishes reports on machine-made bamboo paper which seems to be the equal of the best book paper made from wood pulp.

The rapidly mounting rayon industry is now being added to the paper industry. For the rayon industry also, certain bamboos have been found well suited by virtue of superior physical properties, including high alpha cellulose content. So, the use of bamboo for cellulose is no longer in the experimental stage. In March 1947, a company was organized in Travancore, India for the commercial production of rayon from bamboo (21).

EQUIPMENT AND PROCEDURE

The following equipment and procedure were used in studying the performance of siphon tubes.

Preparation of Siphon Tube

A 6-foot bamboo pole having an even overall diameter was selected for making a siphon tube in this study.

Length and Diameter of Tube. Bamboo pieces 24, 16, and 12 inches long and 3/4 inch inner diameter were used to make a siphon tube 52 inches long, as shown in Plate I. The length of the tube can vary from 4 to 6 feet, according to the height of the ditch (20).

The rate of flow through a siphon tube depends upon the tube diameter and the pressure head (31). It is essential that the bamboo tube have a uniform diameter over its entire length.

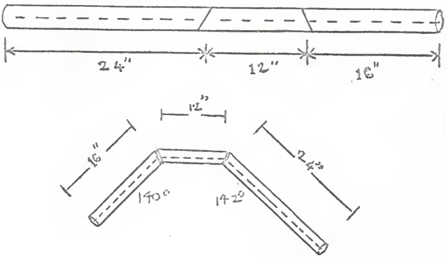
A farmer may require different sizes of siphon tubes. Hence, different sizes of bamboo should be available. In India there are certain species of bamboo having uniform diameter up to a certain length, which can fulfill the requirements of an irrigator (26).

Angles of Tube. Since the slope of the ridge of the ditch varies from 1:1 to 1:1½ (24), angles A and B will vary from 120° to 135° as shown in Plate II. This is satisfactory when side slopes are properly maintained. To be on the safe side, wider angles of the siphon tube than the ones mentioned above will be necessary. Hence, in the present study, the angles of 140° to

EXPLANATION OF PLATE I

Steps followed in making the siphon tube. Bamboo cut to lengths shown, and inside hole drilled with 3/4-inch drill bit. Joints were glued with epoxy glue. Angles of 140° and 142° were used.

PLATE I



EXPLANATION OF PLATE II

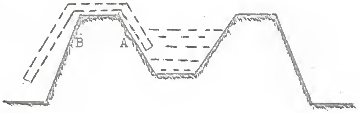
Sectional view of an irrigation ditch.

Angle A = 132°

Angle B = 135°

Slope of sides $1\frac{1}{2} : 1$

PLATE II



142° were selected as shown in Plate I.

Drilling the Hole. Different sizes of bamboo tubes will require different sizes and lengths of drill bits to make the hole through the tube. In this study a 3/4-inch diameter and 9-inch long drill bit with a 12-inch extension was used to make the hole in the tube.

In India, bamboo tubes are used on the farm in seed drills (26). The length of the tubes in seed drills is from 4 to 5 feet. The farmer uses, as mentioned earlier, a red-hot iron rod to make holes in these tubes. The red-hot iron burns the spongy partitions in between nodes, and thus a hole is made. This method is not scientific, and seed drills do not need the uniform hole throughout the length of the tubes; however, this is desirable for the siphon tube.

If some improvement can be made by this method, it is possible that this method of drilling the hole could be used to make holes in bamboo tubes for irrigation.

Method of Fabrication. Type of Glue. It is desirable to use a glue with waterproof qualities. If waterproof glue is not available, the user can make glue waterproof by adding a small quantity (about 1%) of ammonium or potassium bichromate to the glue liquid. Upon hardening, the glue then becomes waterproof. Adding a small quantity of formaldehyde to the liquid glue will help it to resist the action of water after it has dried for some time (30).

Another method is dissolving glue in an equal quantity of water and adding about as much linseed oil as water. Heat is added until a jelly is formed. This mixture is said to be practically waterproof (30).

Necessary Precautions to be Taken in Preparing Glue. As glue deteriorates quickly if allowed to stand, prepare only what is needed for a single day's work. It is even better to prepare it twice or oftener during the day.

If glue is dissolved at the proper temperature and kept at the same temperature after melting, no noticeable deterioration results during the course of the working day. But if allowed to stand overnight, its value decreases, and it should not be mixed with fresh glue, primarily because it is not of the same consistency (30).

Preparation of Surface for Gluing. The surface must be entirely free from dirt, dust, grease, and oil. Anything of a greasy or oily nature is particularly bad, as such materials soak into wood and can not be removed by lightly sanding or scraping the surface (17).

Clamps and Pressures. After gluing, the work should be kept under pressure for a sufficient length of time to insure perfect adhesion. The time varies with variations in the glue, condition of gluing surfaces, and temperature in the room. Pressure should be distributed as evenly as possible. It forces air out of the joint and glue into the pores of the wood (30).

Epoxy Glue. In this study, for joining the tubes, epoxy glue was used. The following method was used for preparing the glue:

1. Squeeze equal amounts of each tube (A and B) on a disposable piece of foil and mix thoroughly to a uniform (egg shell) coloring.

2. Apply a thin, even coat to each clean, dry surface. Keep glued surfaces in contact. Use paddle end of spatula for even spreading. The tube was kept overnight for hardening at 75° F. room temperature.

Procedure of Tests

Equipment as shown in Plate III was used for this investigation. The water level in the constant level tank and the flow through it was kept constant while making the tests. A bamboo siphon tube was clamped to the tank to hold the readings of C, constant. The head of the water in the tank was adjusted by controlling the flow of water into the tank. The height of the water in the tank was read on the manometer. C, constant was measured from the center of the discharge end of the siphon tube to the upper end of the constant level tank. Distance C was determined with the carpenter's square and spirit level. Discharge from the siphon tube was weighed on the scale. The time required was recorded for each 100 pounds of water discharged at one specific head. Rate of flow through the siphon tube was determined for the several different heads which are tabulated in Table 1.

Outer surfaces of the bamboo pieces were smooth, and there were no cracks. They were joined with epoxy glue, keeping the angles of 140° and 142° as shown in Plate I. It was noted that one hour of time was required for setting the joints and eight

EXPLANATION OF PLATE III

Sectional view of the equipment used for measuring rate of flow through the siphon tube.

M = Manometer reading (height of water column in pan).

dp = Depth of pan.

C = Constant.

H = Head.

$H = M + (C - dp)$.

PLATE III

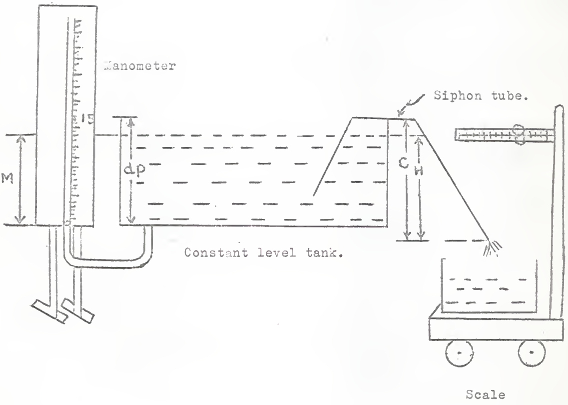


Table 1. Flow rates obtained through the bamboo siphon tube at different heads.

Head in inches, H_2O	Discharge in gallons per minute
1.70	2.26
2.10	2.50
4.50	3.71
5.50	4.11
7.40	4.74
10.25	5.58
12.50	6.15

hours were required for drying, after which the siphon tube became ready for use.

It was tested for priming and for any leakage, 10 hours after joining. It was observed that the tube was primed without any leakage. But swelling was observed after use, and cracks were seen on the siphon tube after four hours. It seems that these cracks were due to the swelling and shrinkage property of bamboo.

The siphon tube was again used for priming water and to see if any more cracks developed two days after the first priming. It was observed that previous cracks were widened and no more new cracks were seen, and no leakage.

The curve in Fig. 1 shows that flow through the bamboo siphon tube increases uniformly at an increasing rate as the head of the water increases.

Coefficient of Discharge

When water is diverted from a ditch using a siphon tube, the

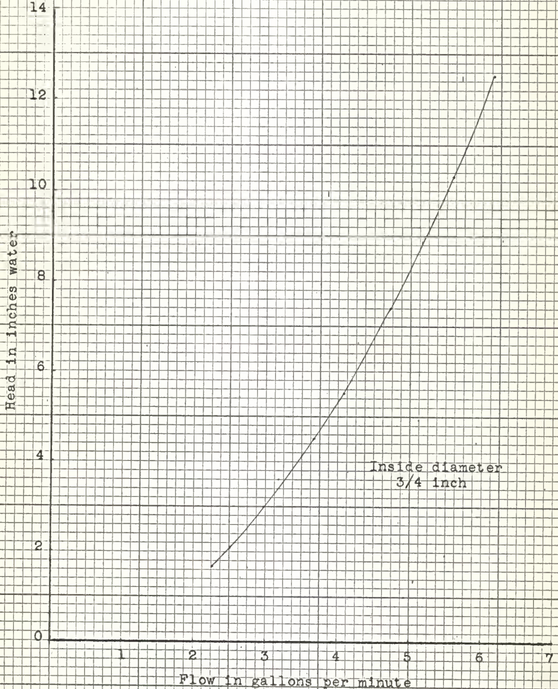


Fig. 1. Flow through bamboo siphon tube.

head of the water and the diameter of the tubes are used to estimate the discharge, with an accuracy of 5 to 10 per cent (15). In essence, the orifice-discharge equation applies to this type of flow with the discharge coefficient depending upon the length of the siphon and entrance and exit conditions of the flow. The following equation can be used for estimating flow through the siphon tube.

$$Q = CA\sqrt{2gh}$$

$$C = \frac{Q}{A\sqrt{2gh}}$$

C = Coefficient of discharge

Q = Quantity of flow, cfs.

A = Cross-sectional area of orifice in sq. ft.

g = Acceleration due to gravity which is 32.2 ft. per sec./ per sec.

h = Pressure head in feet.

Sample calculation of a coefficient of discharge:

$$A = \frac{\pi \times 0.75^2}{4} \times \frac{1}{144} \text{ sq. ft.}$$

$$C = \frac{2.26}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{1.7}{12}}} = 0.5415$$

Average C = 0.545

The coefficient of discharge, C, in the aluminum siphon tube ranges from 0.6 to 0.8 (15). This depends upon the degree of the roundness of the edges of the orifice, length of the siphon tube, and entrance and exit conditions of flow.

In this study, the coefficient of discharge is less than the aluminum siphon tube. It shows that losses of head in the bamboo siphon tube are more than in the aluminum tube.

COMPARISON OF BAMBOO AND ALUMINUM SIPHON TUBES

Losses of Head

Total losses of head in the bamboo siphon tube are more than in the aluminum siphon tube. They are as follows:

1. Frictional loss. Frictional loss of head in the bamboo siphon tube will be more than the aluminum siphon tube due to internal surface characteristics of the bamboo tube.

2. The loss of head by non-uniformity of the overall diameter throughout the length is prevalent in the bamboo tube.

3. The loss of head due to contraction and sudden enlargement occurs in the bamboo tube, while in the aluminum tube there is no dimensional change.

4. The loss of head due to a sharp bend occurs in the bamboo tube. In the aluminum tube there is no such sharp bend. Hence, loss of head in the aluminum tube is less than in the bamboo tube.

5. The loss of head at entrance. Losses of head in the bamboo siphon tube can be minimized by careful fabrication, selection of material, drilling hole, increasing angle, and careful gluing.

Table 2 shows the relationship of head and flow rate through the aluminum siphon tube.

Table 2. Data for flow through a 3/4-inch aluminum siphon tube.#

Head in inches Water column	Discharge in gallons per minute
1.70	2.50
2.10	3.00
4.50	4.50
5.50	5.00
7.40	6.00
10.25	7.00
12.00	7.50

Source of data: Irrigation, Texas A and M College, Extension Engineering Department, Leaflet 358.

Flow through a 3/4-inch aluminum siphon tube is more than that in a 3/4-inch bamboo siphon tube as shown in Fig. 2.

Cost

The cost of a 3/4-inch aluminum siphon tube varies from 60 to 70 cents, and the life is assumed to be a minimum of 10 years. Therefore, the irrigator has to pay 6 to 7 cents every year for one aluminum siphon tube, while the cost of a bamboo tube is 2 cents.[1]

DURABILITY AND STRENGTH

The durability of the wood in the bamboo pipe is dependent upon the resistance of the wood against humid weather or wet soil and decay. A brief consideration of the cause of wood decay and of the factors most favorable to it, is necessary to better understand the causes of failure. Wood decay will result from

[1] Calculated in the chapter on cost.

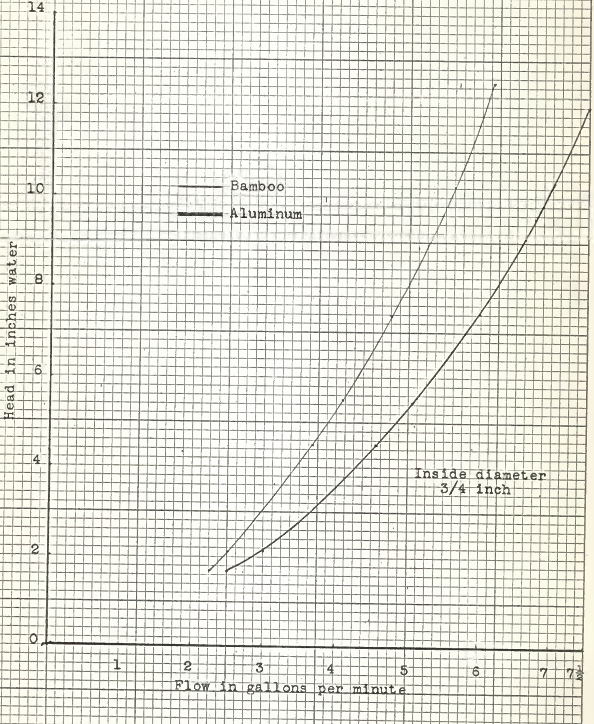


Fig. 2. Comparison of flow through bamboo and aluminum siphon tubes.

the growth of fungi, which is most rapid for a certain combination of moisture, air, and heat. At a temperature of 70 to 80° F., moist pipe and warm air are most favorable. Vegetative or organic matter in the soil containing the spores of fungus growth will also accelerate the decay (8).

The life of the bamboo pipe may be quite variable, depending on the type of bamboo species, weather conditions of a particular tract, the quality of the wood, the method of fabrication, type and strength of glue used, and the condition under which bamboo siphon or spile is used. The ultimate life of the bamboo pipe is not known, because the use of bamboo pipe or siphon is very limited in India.

Although the exact life of the bamboo pipe is not known, untreated bamboo kept in humid air or wet soil will last approximately one and one-half to two years. Bamboo pipe, if treated with a preservative like creosote oil which makes it impermeable to water, does not develop any cracks due to alternate drying and wetting. It does not deteriorate as quickly and can last a minimum of four years (26).

The life of the wood stave pipe has been studied in the United States. It's minimum life is four to six years under most unfavorable conditions, such as when the pipe is in sandy, dry soil, or in soil containing alkali or organic matter and allowed to dry out at times during the summer. Under favorable conditions, the life of the wood stave pipe is 40 to 50 years. In comparison with the wood stave pipe, the life and durability of the bamboo pipe is quite low.

The strength of the fiber of the bamboo pipe may be quite variable, depending on the type of bamboo genera and species. The tensile strength of the wood of the internodes of B. tuldoides, according to unpublished data from tests made by George Merritt (21), is about 40,000 pounds to the square inch, whereas, according to tests carried out at the College of Agriculture of the University of Puerto Rico, the tensile strength of B. tulda is 60,000 pounds to the square inch.

Coating of Bamboo Tube

The life of the bamboo tube will increase with a protective preservative or coating. A large number of different kinds of preservatives can be used. The type of preservatives most commonly and cheaply available are creosote oil, asphalt or tar mixture, asphalt varnish, turpentine, and other paints.

To obtain satisfactory results with different preservatives, certain precautions will have to be taken. The coating must be uniformly thick and must have absolute adhesion to the pipe. To prevent a layer of moisture beneath the coating, the mixture must be applied on a perfectly dry surface. The pipe may be cleaned of dust. To obtain a dense air and water-tight coating, the material must not contain impurities. Impure preservatives do not do a satisfactory job. Trinidad asphalts may contain impurities which are soluble in water or which may be attacked by alkali and leave a porous coating (8).

Choice of Preservatives

The choice of a preservative depends upon its availability, cost, toxicity, permanency, ease with which it enters bamboo, odor, and the effect on the strength of bamboo.

Importance of Siphon Tube in Irrigation

Siphon tubes convey the water over the ditch bank into the furrow. They are especially useful with ditch, furrow, basin, and border irrigation. They are available in plastic, aluminum, galvanized iron, and rubber.

The use of siphon tubes for siphoning water from irrigation ditches is favored by the American farmers or irrigators over other methods of water distribution into the individual furrows. This method facilitates uniform distribution of water, since all tubes of a given size will discharge the same quantity of water when operating under the same head. By having a knowledge of the capacities of siphons, it is possible for an irrigator to control the quantity of water which he applies within quite accurate limits (6).

Siphon tubes as irrigation equipment are not used in Indian irrigation, but Indian farmers feel that siphonic extraction of water should be introduced and popularized as soon as possible (24).

Methods of Irrigation

Siphon tubes for conveying water can be used in furrow, basin, and border irrigation methods.

<u>Furrow</u> <u>Irrigation</u>. Row crops such as potatoes, corn, fruit, and vegetables can be irrigated by the furrow irrigation method. Water is applied in the furrows which are generally made by cultivating between the plant rows. Furrows are most commonly run directly down the slope, but sometimes can be run on the contour to control erosion from rainfall or irrigation water. It may also run across the slope to keep the farm field rectangular, and to keep row lengths somewhat uniform. When this is done, care must be taken to prevent the water from over-topping the furrows and breaking them. The spacing of the furrows is ordinarily determined by the spacing of the crop row. Furrow irrigation is adaptable to a great variation in land slope and soil textures. Furrow irrigation can be used with either large or small streams of irrigation water because the farmer can divide the available water in any number of furrows. The soil in the furrows is generally loose from cultivation, so care should be exercised to limit the rate of flow of water in the furrow so that it will not cause erosion. Unnecessary water losses will occur from deep percolation if furrows are too long. With furrow irrigation, the initial stream should be large enough to get through the furrow rapidly without erosion. The stream should then be reduced so that excessive run-off will not occur during the remainder of the irrigation (7).

Length and Depth of Furrows. The length of the furrow varies from 100 feet or less for gardens, to as much as 1500 feet for field crops. Furrow lengths of 300 to 660 feet are commonly used in the United States.

Furrows from 8 to 12 inches deep facilitate control and penetration of water into soils of low permeability. They are well suited to orchards and to some furrow crops (15).

Amount of Water in Each Furrow. The size of stream a farmer can use in each furrow should be controlled to fit the slope of the furrow and the condition of the soil. The farmer should use the largest possible stream that will not cause serious erosion (maximum non-erosive stream). The soil then absorbs water evenly through the entire furrow length. After the water reaches the lower end of the furrow, the irrigator should reduce the stream (cut-back stream). By this procedure almost all the water will be taken into the soil along the length of the furrow and very little will be wasted as run-off at the lower end.

Control and Distribution of Water to Furrows. Water is distributed into the furrow with one of the following methods which are considered good (20).

1. Water is distributed to furrows with the use of small-diameter 48-inch-long siphon tubes made of light-weight plastic, aluminum, galvanized iron, or rubber which enables the irrigator to siphon water from the ditch to the furrows. The tubes are made in various sizes. Two or more small tubes are often used for each furrow until the water reaches the lower end. To cut back the stream, the farmer can remove one or more of the tubes, or use a smaller tube. This method permits easy and frequent change of water from furrow to furrow.

2. If the furrow slope is greater than 0.2 per cent, spiles can be used to control the water delivery from the equalizing

ditch to individual furrows. Spiles are straight tubes made of wood, metal, plastic, rubber, concrete, or possibly bamboo. Bamboos make good spiles. They should be large enough to deliver the maximum non-erosive stream when the ditch water surface is about 6 inches over the spile opening.

If the slope of the head ditch is nearly flat, an equalizing ditch is not necessary. The farmer can set spiles in the bank of the head ditch itself. Permanent spiles can be installed for each section of the level ditch.

The water surface in each ditch section can be controlled by a check gate. It should be held high enough above the center of the spile opening to deliver the maximum non-erosive stream until the water reaches the end of the run. Then the flow should be reduced to a point that will deliver the right cut-back stream through the spiles. Permanent spiles are not necessary unless farmers have plenty of hand labor to keep the ditches clean (20).

3. A gated surface pipe may be used to carry water to the furrows. The small gates (spaced to match furrow spacing) in this pipe can be adjusted to control the flow of water into the individual furrows. The advantage of gated surface pipe is that it is made in lightweight sections that are easily coupled together. Using gated surface pipe eliminates weed problems common to the open-field lateral. It also permits cultivation through several lengths of run since the pipe may be uncoupled and laid parallel to the furrows or removed from the field during cultivation. The disadvantage is that it is costly.

Basin Irrigation. The basin method of irrigation consists of running streams of water into level plots surrounded by dikes or levees. This method is especially adaptable to a land that is nearly level, and may be used on a wide variety of soil textures and crops. The farmer can use this method on fine-textured soils because of their low permeability rate. It is necessary, however, to hold the water on the surface to secure adequate penetration. Farmers often use this method to leach salts by deep percolation from areas being reclaimed.

The basin may be square, rectangular, or irregular in shape. Small basins are used for orchards, and large basins are used for grain crops (22).

The most satisfactory control and distribution of water to a basin is the use of siphon tubes. Siphon tubes increase the uniformity of the application of water to the basins by frequent regulation of the size of stream flowing into the basin (32).

Border Irrigation. Dividing the field into a number of strips, generally varying from 30 to 60 feet in width and 300 to 1,300 feet in length, and separating them by border ridges is known as the border method of irrigation. The bordered strips have a grade in the direction of irrigation and may be laid out on the contour or may run down the slope. The idea of border irrigation is to advance a sheet of water down the narrow strip of land, allowing the border to enter the soil as the sheet advances.

This method is suitable for a wide range of soil structures; however, it is not generally recommended for the finer-textured soils with low intake rates. It is generally used for grain crops on lands having a slope down the strip for an even application of water.

In this method, siphon tubes that lay over the ditch bank help the farmer to control the flow of water. With the more stable soil conditions, the farmer can use spiles through the ditch bank (32).

Use of the Siphon Tube

Siphon tubes are used to divert water from a supply ditch - over the ditch bank - into the furrows. They permit easy control of water, and eliminate cutting the ditch maintenance.

Methods of Priming. The methods commonly used to start small siphons are (31):

1. General. Grasp the tube in one hand about 4 inches from the end. Plunge the other end into the water until all of the tube below the hand is submerged. Place the other hand over the dry end and quickly pull the tube over the ditch bank.

2. Pumping. Grasp the tube in one hand about 2 to 3 inches from the end. Place the other end of the tube in water, leaving several inches above the water surface. Place the other hand over the dry end of the tube so that an air-tight seal is not obtained. Quickly push the tube into the water about 6 inches, then seal the end of the tube with the hand and quickly pull the tube upward about 6 inches. Release the air-tight seal with the hand and push back down. As this is repeated, water will rise in the tube. When the tube is completely filled with water, drop

quickly into position and the water will continue to flow.

3. Centrifugal method. The tube is taken into one hand at a point about one third the distance from one end. The other two thirds of the length should extend away from the operator. Place the tube in water and allow it to fill. By immersing it at an angle, the air will be expelled. With a quick motion of the wrist, swing the tube over the bank, at the same time holding the end nearest the operator under water. The centrifugal action of the water in the tube will cause it to start flowing immediately. This method permits tubes to be started with one hand (33).

Control of Flow in Tubes. The volume of water which will flow through a siphon tube depends upon many factors. The important factors are:

1. Diameter of the tube.
2. Head of water above the discharge end.
3. Smoothness of the interior.
4. Shape of the entrance.

Flow through siphon tubes is usually controlled by the size of the tube. Changing the head of water in the ditch will control the flow, but it is not used to any extent by practical irrigators.

Flow is sometimes controlled by a variety of gates placed at the discharge end of the tube. Rubber plugs with holes of various diameters are placed at the discharge end to get the desired stream.

Size of Tubes to Use. Two- and three-inch diameter tubes for furrow irrigation are common (33). Often the result was erosion in the furrow and waste of water at the lower end of the field. Under some soil and slope conditions, the large diameter tubes for furrow irrigation are warranted. Soils with high infiltration rates, and furrows with very little or no slope require large flows of water. Therefore, irrigation should be done by an experienced operator.

Field Trials are Needed to Determine Exact Size of Stream per Furrow. A field trial in which furrow streams are measured and erosion noted, is necessary if best results with furrow irrigation are to be obtained. By means of this trial, the length of run for a particular field can be accurately ascertained. If the operator has not had a field trial run made on his land, it would be better to borrow siphon tubes of various sizes and do some experimenting before making a large purchase. When in doubt, it is usually better to purchase more tubes of small diameter than a few tubes of large diameter when considering furrow irrigation. When the size of the tube has been decided, the number of tubes needed for various flows of water can be determined (33).

COST

Cost of Bamboo

In the Indian lumber market, the cost of bamboo varies according to species of bamboo, its length, and its diameter. Bamboos of 10 to 25 feet long and 1/4 to 4 inches in diameter are available in any lumber market in India. The cost of bamboo varies from \$4 to \$10 (Rs. 20 to 50) for 100 bamboos. The average cost of suitable bamboo for siphon tubes (bamboo for irrigation purposes) is \$7 (Rs. 35) for 100. Bamboos can be made available in every village (26).

Capital Required for 100 Siphon Tubes

A minimum of two siphon tubes can be made out of one bamboo. Hence, for 100 siphon tubes, 50 bamboos would be required.

1. Cost of material:

	Dollars	Rupees
a. Cost of 50 bamboos	3.50	17.50
b. Cost of waterproof glue	2.00	10.00
c. Cost of preservative	0.50	2.50
Total cost of material	\$ 6.00	Rs. 30.00

2. Cost of labor. One carpenter can make 100 siphon tubes with the help of one boy in one day.

a. Wages of one carpenter for one day	\$ 1.00	Rs. 5
b. Wages of one boy	0.40	2
Total wages required	\$ 1.40	Rs. 7

Total capital required = cost of materials + total wages required.

Total capital required = \$6.00 + \$1.40 = \$7.40 = Rs. 30 + 7 = Rs. 37.

3. Interest.

The interest rate in India is 6 per cent per annum (13).

For Rs. 37, the interest will be Rs. 2.22 or \$0.24.

Total cost of 100 siphon tubes = \$7.40 + \$0.24 = \$7.64 = Rs. 37 + 2.22 = Rs. 39.22.

4. Depreciation.

The life of bamboo treated with some preservative is assumed to be a minimum of 4 years.

Total cost	\$ 7.64	Rs. 39.22
For one year	1.91	9.85

If a farmer uses 100 siphon tubes for irrigation, it will cost him \$ 1.91 or Rs. 9.85 per year.

The cost of one bamboo siphon tube = \$ 0.02 or Rs. 0.1.

POSSIBILITY OF SIPHON TUBE AND SPILE FOR MEASURING IRRIGATION WATER

Efficient use of water for irrigation depends upon good management and knowing the water requirements for the crop being irrigated. Measurement of water is also important for efficient use of water. Increasing utilization and value of available water and the growing tendency among irrigation companies to base annual water charges on the volume of water used make it desirable to understand the principles and methods of water measurement necessary. Information concerning the relationships between water, soil, and plants can not be utilized in irrigation practice without measurement of water. Measurement of irrigation water is necessary to assure proper distribution of surface supplies according to rights, shares, or quantities ordered (15).

Application of the proper amount of water helps to produce maximum growth yields. It prevents poor growth because of insufficient water, and reduces drainage problems because of too much water (27).

Units of Water Measurement

Units of water measurement are considered in two classes: first, those expressing a specific volume of water at rest; and second, those expressing a time rate of flow. The commonly used units of volume of water at rest are the gallon, cubic foot, acre-inch, and acre-foot. An acre-inch is a volume of water sufficient to cover one acre one inch deep, and is 3630 cubic feet. An acre-foot of water will cover one acre one foot deep, and is equal to 43,560 cubic feet.

The commonly used units of rate of flow are gallons per minute, cubic feet per second, acre-inches per hour, and acre-feet per day. The miner's inch is defined as the quantity of water that will flow through an opening one inch square in a vertical wall under a given pressure head (15).

Use of Siphon Tubes and Spile for Measurement of Water

Although siphon tubes and spiles are used to deliver water from a ditch to a furrow or check, they can be used to measure the rate of flow being delivered (27).

SCOPE OF BAMBOO SIPHON TUBES IN INDIAN IRRIGATION

It is well known that for an increase in yields, irrigation should be given at the best time when it is needed by the plant. Timely irrigations will always give more yield than irregular ones. Moreover, such methods of irrigation should be adopted that every inch of water is utilized for the benefit of the crop.

Over-irrigation is more harmful than under-irrigation. It is not only the time of application and proper utilization of water applied to the field which increases the crop yields, but the proper amount of water applied is also equally responsible (4). This creates a necessity of equipment like the siphon tube which is used to control and distribute proper amounts of water (27).

The American farmer knows the importance of the siphon for irrigation. Hence, the siphon is common irrigation equipment on American farms. It has reduced labor and ditch maintenance cost. Therefore, the American irrigator can afford the cost of plastic and aluminum siphon tubes.

In certain states of India, bamboo pipes are used for irrigational purposes, but very few farmers use them. It shows that the Indian irrigator feels the need of such types of irrigation equipment for the distribution and control of water (2).

It was gathered from the farmers that considerable difficulty was experienced by them when extracting water from unbuilt channels, where properly built irrigation channels have not been provided. Loss of water occurs at such points if unbuilt channels are breached for letting in water in field ditches. It is therefore felt that siphonic extraction of water should be introduced and popularized as soon as possible (24). This involves the use of pipes in the shape of siphon tubes, which should be placed with one end in the water and the other into the furrow requiring water, thus enabling the field to become irrigated without making a cut in the water channel or ditch.

Although the Indian farmers feel the necessity of the siphon tube for irrigation, yet they cannot afford the cost of aluminum or plastic siphon tubes. It creates the need for use of cheap material to make siphon tubes or spiles.

Bamboo is a cheap, available material in the Indian villages. It all shows that bamboo siphon tubes or spiles have a vast scope in irrigation in India.

SUMMARY AND CONCLUSION

Water feeds crops. It carries soil chemicals into the roots, giving them the nourishment that builds abundant crops. Rain can furnish some of the necessary moisture, but the weather is not dependable. For centuries, farmers have sought to take the guess-work and gamble out of their water supply.

As early as 2000 B.C., irrigation ditches were dug in Babylon to take water to hungry crops. Farmers quickly learned that irrigation aids and increases the rate of germination. Irrigated crops have a head start and can be brought in earlier. They found that, in some localities, an additional crop is possible with irrigation, and that it extends the life and production of pasture land by several months. The progressive farmers continued to plan and develop better methods of field irrigation. Today, with modern equipment and advanced knowledge of agriculture, the American farmer can only make the soundest investment (25).

Basically, ditch irrigation is the same today as it was 4000 years ago. Today, machines make ditching easier and water supplies more readily available. However, the greatest single contribution to improved ditch irrigation was made by the siphon tube which controls water flow between the ditch and the field. Siphon tubes save water as well as labor, and check erosion. They eliminate the necessity of cutting away the ditch bank.

A variety of materials have been used in making many types of siphon tubes. Aluminum, because of its light weight and durability, has been most successful.

Although aluminum siphon tubes have proven their superiority in operation, durability, and handling ease, the Indian irrigator can not afford the cost of the aluminum siphon tube. Hence, material like bamboo must be developed to make a siphon tube or spile which will solve the problem of the Indian irrigator.

Irrigation is of great economic importance in a country like India which is predominantly agricultural. Hence, irrigation facilities and irrigation equipment must be developed.

The need of siphon tubes for diverting water from the water channel is felt by the Indian irrigator. Therefore, siphon tubes for diverting water to the field should be introduced and popularized as soon as possible.

Following are the ways in which farmers can use siphon tubes to control and distribute irrigation water:

1. For row crops: to deliver water from a ditch to each individual row.

2. For close-growing crops: to spread water in a thin sheet over the ground surface if the tubes are placed at close

intervals along ditch banks.

3. For borders: to bring irrigation water from ditches to border strips or areas between borders.

4. For ditches: to deliver the required amount of water from a main ditch to a small, field ditch.

Siphon tubes eliminate ditch breaks and secondary distribution ditches, thus reduce labor cost and save water and land.

Siphon tubes are made from many materials - metal, rubber, and plastic. But these materials are costly. Hence, cheap and readily available material like bamboo must be developed. Bamboo is readily available material in India. Therefore, it can be used for making siphon tubes and spiles for irrigation in India.

The following conclusions may be made on the tests conducted on the bamboo siphon tube.

1. Using bamboo siphon tubes for irrigation, the difficulty will have to be faced that the bamboo siphon tube may not be uniform in diameter. This type of difficulty is not found in the aluminum siphon tube which could be obtained with uniform diameter.

2. While conducting the test of the bamboo siphon tube for discharge in a laboratory, measurement of time should be very accurate otherwise a fraction of a second will change the data obtained.

3. The coefficient of discharge of the bamboo siphon tube is low, 0.545, while the coefficient of discharge of the aluminum siphon tube is in between 0.6 and 0.8 (15). This difference may be due to acute angles, roughness of the nodes, varying diameter

of the bamboo tube, and to some extent to the formation of small rings of glue at the joints in the side of the tube.

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APPENDICES

APPENDIX A

Discharge Data for a 3/4-inch, 52-inch-long Bamboo Siphon Tube

	Mano-meter reading M	Constant C	Depth of pan in inches	Head H = M + (c-dp)	Time in minutes	Dis-charge in pounds	Dis-charge Gallons per minute
1	12.00	15.50	15	12.5	1.95	100	6.153
	12.00	15.50	15	12.5	1.95	100	
	12.00	15.50	15	12.5	1.95	100	
2	9.50	15.75	15	10.25	2.14	100	5.58
	9.50	15.75	15	10.25	2.15	100	
	9.50	15.75	15	10.25	2.16	100	
	9.50	15.75	15	10.25	2.15	100	
3	13.90	8.5	15	7.4	2.53	100	4.74
	13.90	8.5	15	7.4	2.52	100	
	13.90	8.5	15	7.4	2.54	100	
	13.90	8.5	15	7.4	2.53	100	
4	12.00	8.5	15	5.5	2.92	100	4.109
	12.00	8.5	15	5.5	2.91	100	
	12.00	8.5	15	5.5	2.92	100	
	12.00	8.5	15	5.5	2.92	100	
5	11.00	8.5	15	4.5	3.23	100	3.71
	11.00	8.5	15	4.5	3.22	100	
	11.00	8.5	15	4.5	3.24	100	
	11.00	8.5	15	4.5	3.23	100	
6	8.6	8.5	15	2.1	4.80	100	2.50
	8.6	8.5	15	2.1	4.81	100	
	8.6	8.5	15	2.1	4.81	100	
	8.6	8.5	15	2.1	4.79	100	
7	8.2	8.5	15	1.7	5.31	100	2.26
	8.2	8.5	15	1.7	5.31	100	
	8.2	8.5	15	1.7	5.32	100	
	8.2	8.5	15	1.7	5.30	100	

APPENDIX B

Calculations

1 gal. = 8.338 lbs.

100 lbs. = 12 gal.

	min.		min.		gal.	
1	1.95	:	1	::	12	$\frac{1 \times 12}{1.95} = 6.15$ gal./min.
2	2.22	:	1	::	12	$\frac{1 \times 12}{2.15} = 5.58$ gal./min.
3	2.53	:	1	::	12	$\frac{1 \times 12}{2.53} = 4.74$ gal./min.
4	2.92	:	1	::	12	$\frac{1 \times 12}{2.92} = 4.11$ gal./min.
5	3.23	:	1	::	12	$\frac{1 \times 12}{3.23} = 3.71$ gal./min.
6	4.80	:	1	::	12	$\frac{1 \times 12}{4.80} = 2.50$ gal./min.
7	5.31	:	1	::	12	$\frac{1 \times 12}{5.31} = 2.26$ gal./min.

APPENDIX C

Calculations of a Coefficient of Discharge at Different Heads

$$Q = CA\sqrt{2gh}$$

$$C = \frac{Q}{A\sqrt{2gh}}$$

$$A = \frac{\pi \times 0.75^2}{4} \times \frac{1}{144} \text{ sq. ft.}$$

(1) $$C = \frac{2.26}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{1.7}{12}}} = 0.5415$$

(2) $$C = \frac{2.50}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{2.1}{12}}} = 0.541$$

(3) $$C = \frac{3.71}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{4.5}{12}}} = 0.547$$

(4) $$C = \frac{4.11}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{5.5}{12}}} = 0.548$$

(5) $$C = \frac{5.74}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{7.4}{12}}} = 0.545$$

(6) $$C = \frac{5.58}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{10.25}{12}}} = 0.545$$

(7) $$C = \frac{6.153}{450} \times \frac{4 \times 144 \times 7}{22 \times 0.75 \times 0.75} \times \frac{1}{\sqrt{2 \times 32.2 \times \frac{12.5}{12}}} = 0.5448$$

Average C = 0.545

FEASIBILITY OF USING BAMBOO AS AN IRRIGATION SIPHON TUBE OR SPILE IN INDIA

by

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AN ABSTRACT OF A MASTER'S REPORT

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requirements for the degree

MASTER OF SCIENCE

Farm Mechanics

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Manhattan, Kansas

1963

Increasing agricultural production is essential for feeding the increasing population of India. The success of Indian economic development depends upon the agricultural production, particularly food production. For the solution of this problem, increasing the practice of irrigation and improving equipment for irrigation are essential. Irrigation increases the welfare of a nation by increasing the yield of crops and the value of land.

Today, the progressive farmers of America, with the help of siphon tubes, modern irrigation equipment, and advanced knowledge of agriculture can make the soundest investment that has ever been put into soil.

American farmers use plastic, rubber, and metal siphon tubes for siphoning water from irrigation ditches into furrows. The use of siphone for irrigation in America is favored for the following reasons.

There is no heavy dirt work after the ditch is made, and no secondary ditch is needed. It doesn't require a lot of labor to make each set, as is the case with lath boxes. They are light to carry and handle, so a boy could easily change and set siphon tubes. This could mean a big saving in time and labor for an irrigator with children in the family.

It is possible to control the rate of flow in each row by moving the siphon tube so as to raise or lower the discharge end.

When the rate of flow changes in the irrigation lateral, it will raise or lower the water level, which in turn will increase or decrease the rate of flow in each siphon tube. This means siphons will automatically accommodate fluctuations in the rate of flow within certain limits.

Floating trash will not give as much trouble with siphon tubes as lath boxes since water enters below the surface.

It facilitates uniform distribution of water since all tubes of a given size will discharge the same quantity of water when operating under the same head.

The Indian irrigators also felt the necessity of equipment like the siphon tube for irrigation. Considerable difficulty was experienced by them when diverting water from unbuilt water channels. With their present method, they deliver water by breaking channels for diverting it into fields.

The farmers can not afford the cost of metal or plastic siphons. Hence, the object of this study was to try to utilize another material, and to investigate the possibility of using bamboo, which is inexpensive and a readily available material in India for carrying water.

For this study a 3/4-inch inner diameter and a 52-inch-long bamboo siphon tube was made, and the flow rates at different heads were determined. It was found that flow through the bamboo siphon tube increases uniformly at an increasing rate as the head of the water increases.

In this study it was found that the average coefficient of discharge for the bamboo siphon tube was 0.545. According to Israelson, the coefficient of discharge for the aluminum siphon tube ranges from 0.6 to 0.8 which is greater than that of the bamboo siphon tube.

The losses of head in a bamboo siphon tube can be minimized by careful fabrication, selection of material, drilling of smooth hole, increasing angle of joints, and by careful gluing.

It is estimated that one bamboo siphon tube would cost the Indian irrigator two cents per year as compared to seven cents for the American aluminum siphon tube.