A Test Bed for Indigenous Water Lifting Devices

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Introduction

Research on indigenous water lifting devices initiated in the Agricultural College & Research Institute was aimed at primarily to evaluate the performance of the existing types available in Kerala. This was consequent to the scant available information and the wide variation found among the published data (1,2). In this connection it was felt necessary to evolve and adopt a uniform procedure in regard to the manner and method of testing these devices. The design of a lest bed was therefore evolved to serve as a comprehensive testing unit with which the performance of all or any of these water lifting devices could be determined.

Design of the Test Bed

In designing such a test bed the types of water lifting devices considered were (i) Water Wheel (ii) Counterpoise Lift (iii) Picottah (iv) Thoni (v) Swing Basket; the equipment being those generally used under very different conditions of source of supply ranging from an open well to that of an open channel. To simulate such conditions it was considered that the test bed should at least consist of components amounting to: (i) an open well, (ii) a section of a field channel (iii) a measuring tank and (iv) a device to provide constant head conditions. These components were then connected together by means of open drains in a closed circuit towards the final design of the Test Bed the details of which are shown in Figure 1.

Compartment A

This is a simulated open well and measures 5′ × 4′–3″ with a depth of 15 ft from the ground level. The equipment that can be tested in this section are: (i) Counter poise Lift (ii) Picottah.

Compartment B

This is a simulated field channel. The partition wall forming one side of the compartment with openings at regular intervals which could be plugged, if so desired, provides both variable and constant head conditions for testing of water wheels. The opposite side of the same compartment was left as earth cutting to accommodate different sizes of "Petti" with corresponding water wheels.

Compartment C

This forms the measuring tank which collects water through drains from various

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compartments. It was graduated on one side to indicate the quantity of water collected.

Brick masonry was used in the construction of the test bed and earth pressure was not taken into account as the site at which the test bed was constructed consisted of stiff clay for the first five feet and hard laterite zone below.

Studies on Counterpoise **Lift**

The test bed designed was first used to study the performance of "Counterpoise Lift", an indigenous water lifting device widely used in Kerala State. In the northern parts of the Country the device is known as Dekli or Latha.

Description and working

The principle employed in this device is that of a lever of the first order. A long bamboo pole, which acts as a lever, suspended on an upright pillar or trunk of a small tree forms the essential component of this device. The pole is hinged on the pillar with two unequal arms, the effort arm being longer than the load arm. The lever carries a heavy weight at one end and a rope and bucket at the other end. The arrangements are so made that when the bucket is filled, it will partially counterbalance the weight on the other side. Normally only one man is required to operate this water lifting device. He stands on a log of wood fixed across the well or tank and pulls on the rope for filling the bucket. The bucket when lifted is emptied into a pan from which the water is conveyed to the fields.

Investigation

Tests were conducted with a view to studying the effects of various arrangements in the construction of the device. In Figure 2 is shown the device installed beside the Test Bed. The conditions tried were those to determine the variation in output when using (i) rope and tin bucket as working components (ii) a bamboo pole and wooden trapezoidal bucket in place of rope and tin bucket (iii) a pin joint to connect bucket and the bamboo pole and (iv) the employment of skilled and unskilled labour. In all cases except when otherwise mentioned, skilled labour was employed to carry out the tests.

In a single trial the person operated the device for half an hour at a stretch and took 10 minutes' rests before operating the equipment for another half an hour.

The tests were carried out under the following conditions :

Load arm = 6 ft., effort arm = 9 ft., Post height 11 ft 8 in, distance of post from well = 5 ft. 6 in., swing of rope or bamboo pole = 3 ft., depth of water level : 13 ft., and capacity of bucket and wooden trough 0.63 cuft each. The results of the experiments conducted are given in Table 1, and are shown graphically in Figure 3.

Table I illustrates that all the four conditions tried had a definite influence on the output obtained. The most satisfactory arrangement seemed to be the one to use a bamboo pole pin jointed with the wooden bucket. The variation is of the order of about 20% from the most crude arrangement that was used. However, it is to be noted that an even greater variation was obtained when unskilled labour was employed.

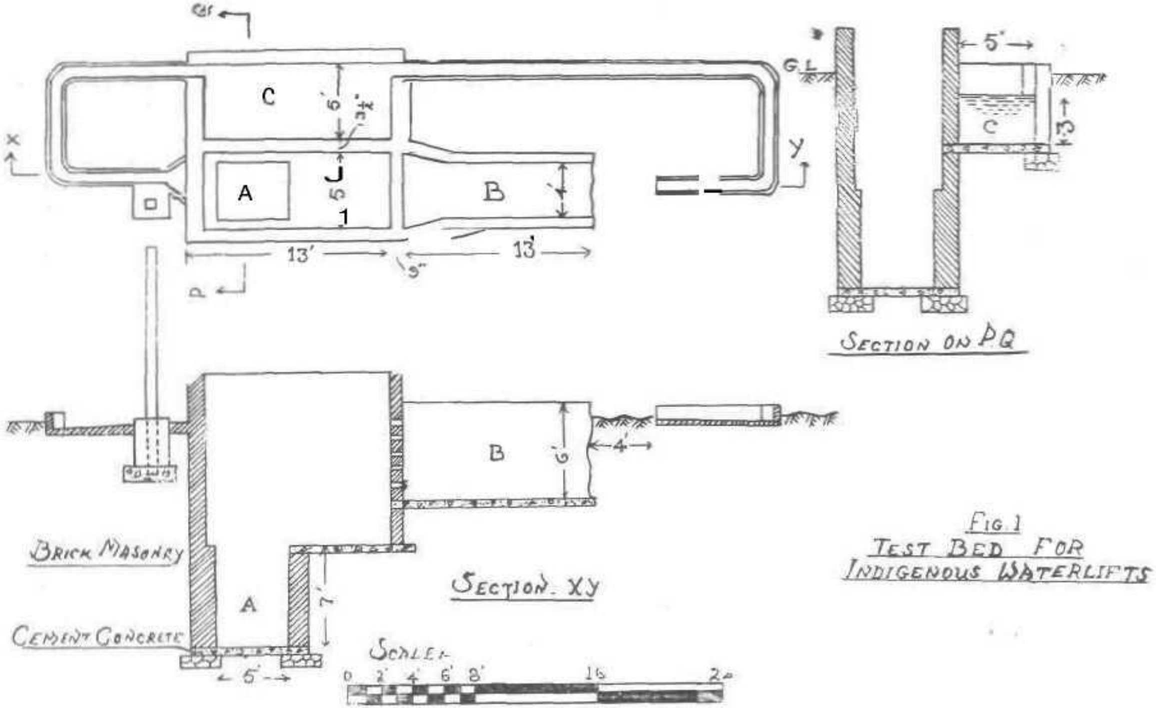


Fig. 1 Test bed for indigenous water-lifting devices.

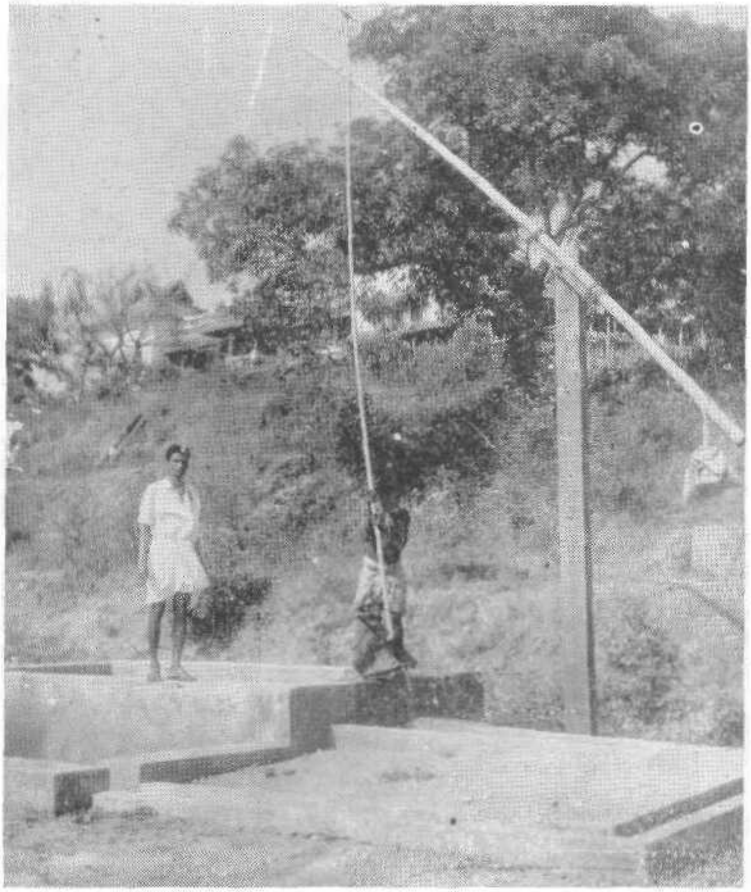
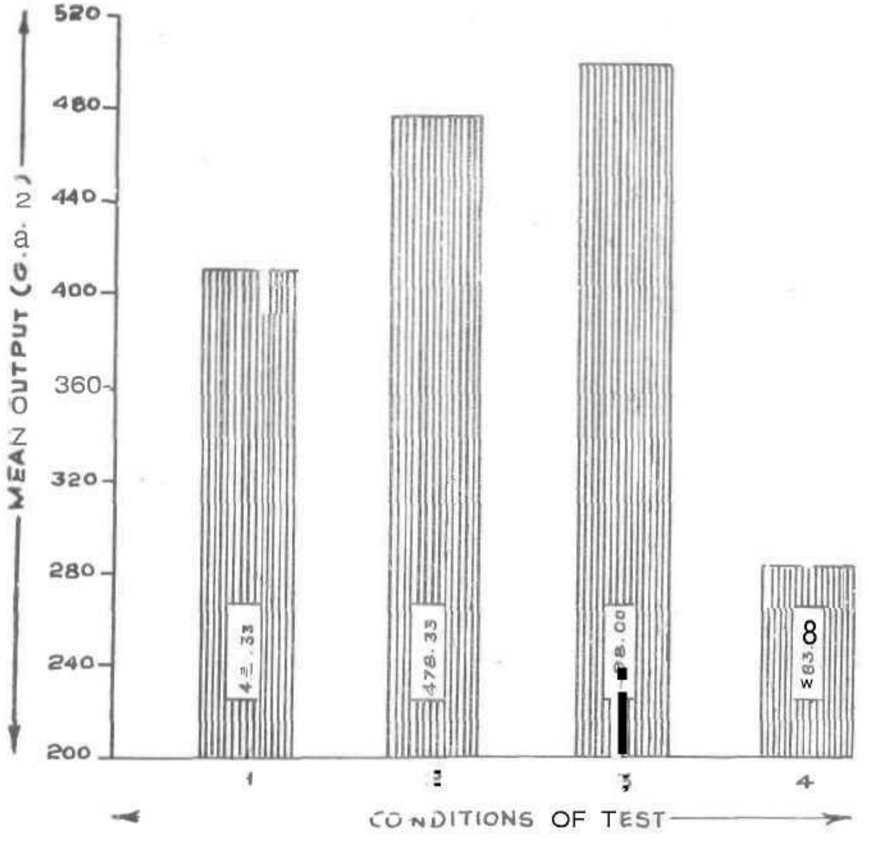


Fig. 2. Counterpoise lift beside the test bed.



1. ROPE AND TIN BUCKET.

2. BAMBOO POLE AND WOODEN TROUGH.

3. SAME AS WITH PIN JOINT CONNECTION.

4 UNSKILLED LABOUR.

Fig. 3. Effect of conditions of operation on the discharge capacity of a counterpoise lift.

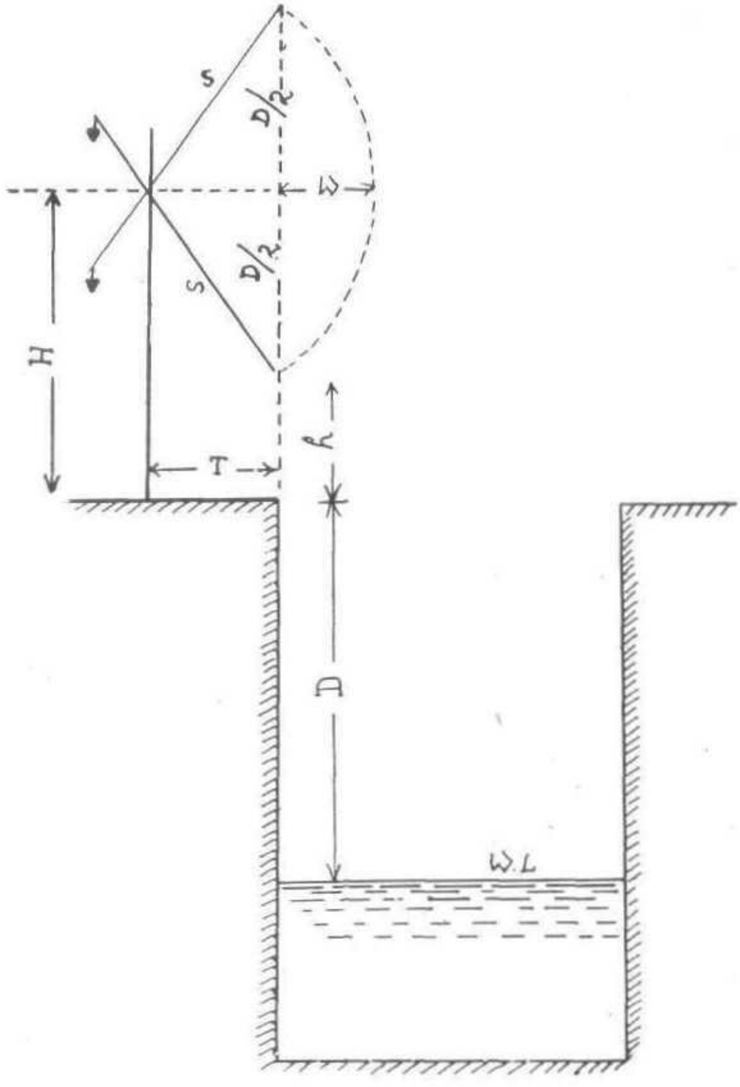


Fig. 4. Elements of a counterpoise lift installation.

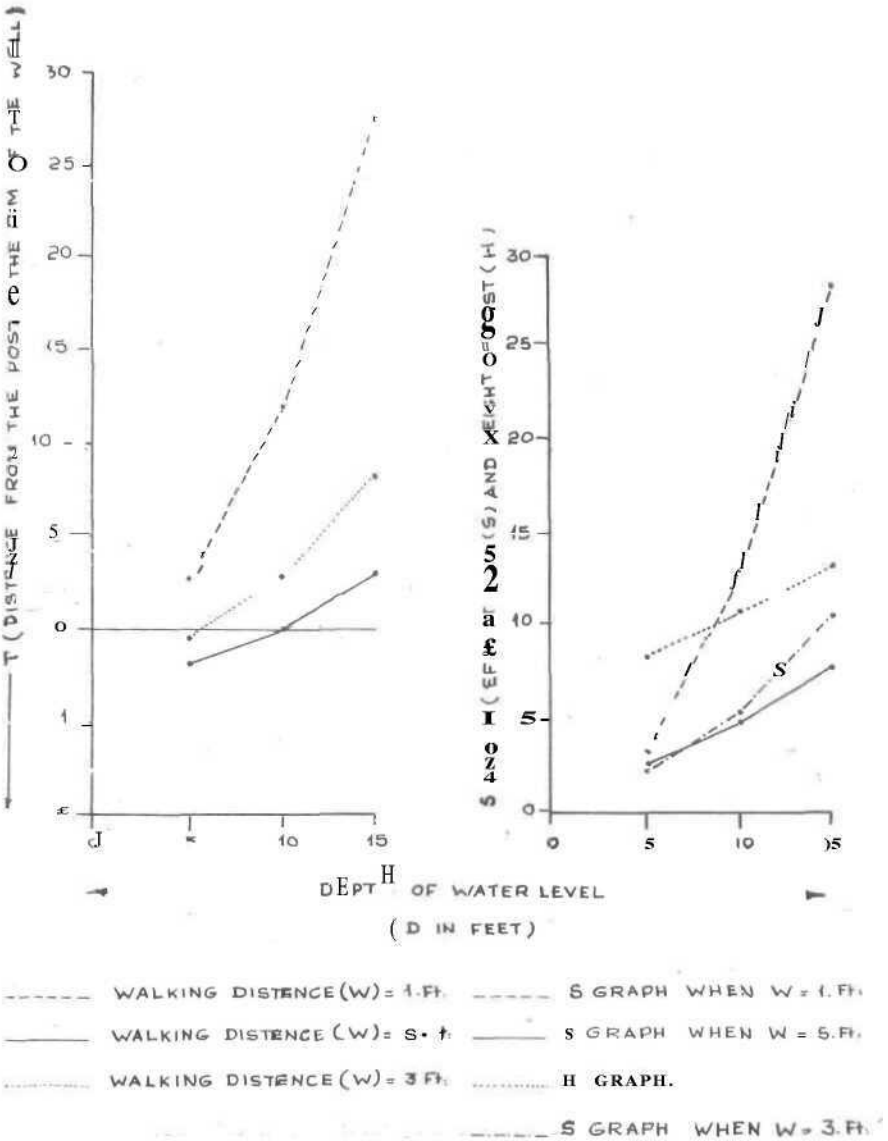


Fig. 5. Effect of depth of water level on installation values of a counterpoise lift.

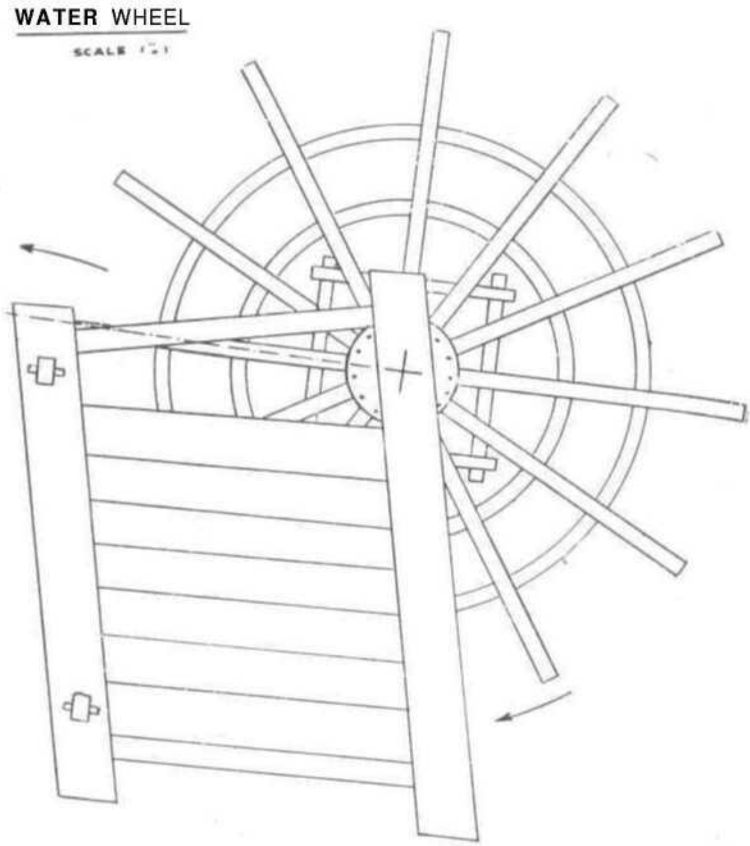


Fig. 6. Schematic diagram of the water wheel.

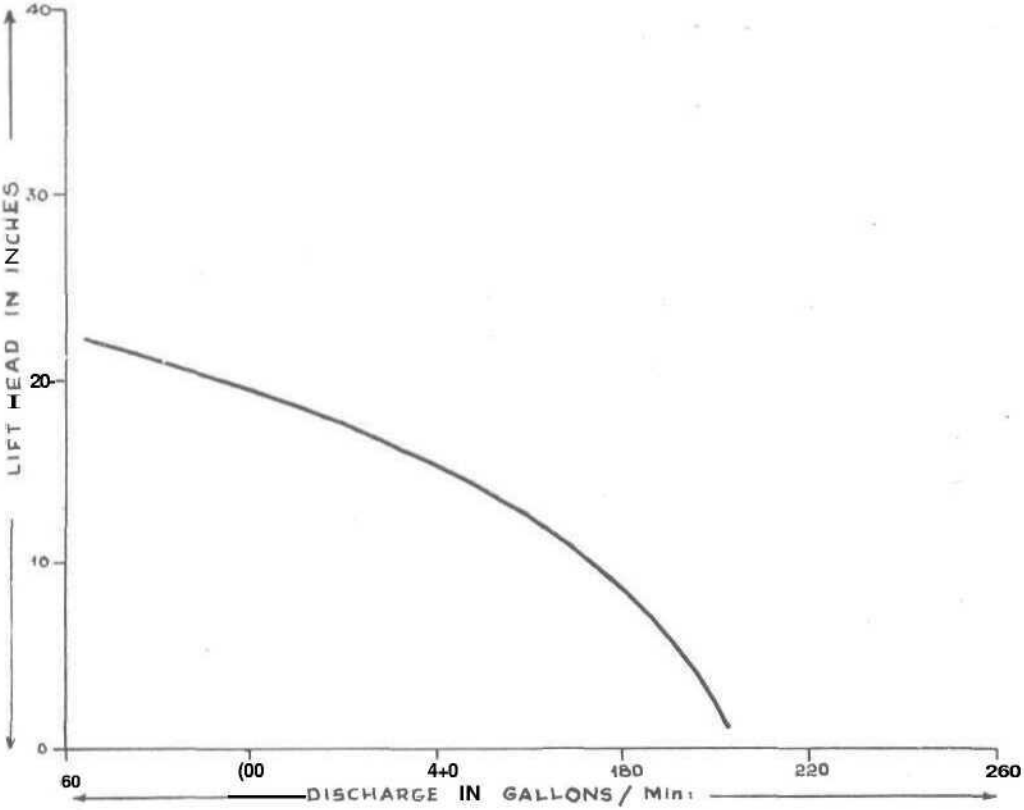


Fig. 7. Effect of lift head on discharge capacity of a water wheel,

TABLE I

Performance of Counterpoise Lift

Sl. No.	Conditions of test.	Replication number	Output in cuft/hour	Mean output G. P. H.
!	Rope and tin bucket	!	64	400
		2	64	400
		3	70	437
2	Bamboo pole & wooden trough	1	74	462
		2	76	474
		3	80	499
3	Same as above with pinjoint connection	1	80	499
		2	86	537
		3	7S	458
4	Unskilled labour	1	40	250
		2	46	288
	•	3	50	312

Farther considerations

For the present study only one man worked with the equipment and the output can be expected to be higher proportionately if relief labour could be provided and with greater size of bucket. In evolving a test procedure for the counterpoise lift installation, the variables to be considered need not be limited to only those that have been investigated in the present study. Variables such as (i) capacity and shape of bucket (ii) nature of fulcrum (iii) variation in load and load arm (iv) number of men employed at one time etc. may also be subjected to investigation.

A theoretical consideration in the installation of such a device, would be to predetermine the required height of post, position of post from the well and the length of effort arm for a given depth of water level. The assumptions made in this connection are (i) when the bucket dips in water the tip of the effort arm is at arm's reach of the operator and is directly above the rim of the tank and (ii) the tip of the effort arm is again directly above the rim of the tank at the time of emtying bucket.

Refering to Figure 4, let H=the height of post, h = the height at arms reach of the operator, W=walking distance during the operations, T = the distance from the post to the rim of the well, D=the depth of water level and S=the effort arm.

Knowing D and assuming suitable values for W and h, various other values can be determined as follows:

$$S = T + W \quad .... \quad (1)$$

Solving the two equations,

$$— 4 W \over 8 W \quad (2)$$

$$H : \frac{D}{2} + H. \quad (3)$$

In ordinary cases W may be assumed as half the diameter of the well, and has 6 feet. Table 2 gives installation values of T, S, and for various depths of water level. They are shown graphically in Figure 5.

TABLE 2

Installation details for various depths of water level

Quantities to be determined	W	D (ft.) 5	10	15
$T = \frac{D2 — 4 W^2}{8 W}$	i	2.62	12.00	27.60
	3	-0.46	2.66	7.88
	5	-1.87	0.00	3.12
S=T + W	i	3.65	13.00	28.66
	5	2.54	5.66	10.88
	5	3.13	5.00	8 12
$\frac{D + 2h}{2}$		8.50	11.00	13.50

Inspection of values in the table shows that the deeper the well, the farther should be the position of the post from the well and greater should be the effort arm and the post height. These values also show that depending upon the depth of water in the well some adjustment in the walking distance will have to be made if we are to arrive at reasonable values for the location of the post with respect to the well. A tabie or figure such as shown above can serve as basic design data. However, in most practical situations more appropriate values can be arrived at by trial and error since there are limitations due to assumptions made in arriving at the equations presented.

Studies **on Water Wheel**

The test bed was also used to study the performance of water wheel, another indigenous water lifting device extensively used in Kerala Slate. The device is also called paddle wheel and is locally known as Chakram.

Description and working

The water wheel is a low lift device used to both for watering and dewatering of paddy fields In this device usually 8 to 16 leaves or paddles made of wood emanate from the centre hub, also made of wood. The hub has an iron shaft which rests on two supports and the lower part of the wheel enclosed in a close fitting box. Struts are used to keep the paddles in position and the diameter of the wheel varies according to the lift requirements. The operator sits on an improvised scaffolding and turns the paddles with his feet.

Investigation

Initial trials with the water wheel were wholly unsuccessful on account of excessive absorption of water through the earth cutting. An attempt was made to plug the exposed surfaces adopting the procedure recommended in (3) with slight modification. This was also not satisfactory as the mud tend to peel off while in contact with stagnant water.

A lined canel was therefore made at the earth cutting between compartment B and the open drain. A 7 feet diameter water wheel together with its box (Figure 6) was thus installed and trials on the discharge apacity were carried out. However it was not possible, in these tests, to operate the water wheel with the shutter on the box removed and to obtain various head conditions simulating field operations. The limitation was that the open drain with its side walls only 9" high had too small a cross section to maintain a definite head of water in it and at the same time conduct the pumped water to the measuring tank without any overflow. As such the water wheel was operated with the shutter in position making use of the varying water level in compartment B to produce various lift conditions. Readings of variation in water level on the upstream side in compartment B and in the measuring tank were taken at intervals of one minute. The results obtained are shown in Figure 7 with the discharge plotted against the average variation in head. As could be expected the values which are the average of three replications indicate that the discharge capacity decreases with increasing head against which water is pumped.

However unlike in actual field, in these tests, the wetted area of the paddles had varied with increasing head conditions on the up-stream side of the wheel. This may have affected the values obtained and as such they could only be accepted with reservation as those representative of field operation, The restriction on the condition of test thus imposed provides room for improving the facilities at the test bed to simulate field operation of water wheels. A suggested alteration in the design of the test bed is to construct another compartment on the down stream side which amounts to widening of the open drain connection to the measuring tank with provision to control the level of water in the new compartment. This will enable the conduct of a new series of tests with different sizes of water wheels more accurately reproducing conditions of field operations.

Summary

A report is made on the design and construction of a test bed for evaluating the performance of indigeneous water lifting devices. Results of studies made on the output of counterpoise lift, a widely used water lifting device, on the test bed have been presented This has indicated various suggestions for improving the performence of the device and the possibilities of standardisation of a test procedure for indigeneous water lifting devices. Analytical considerations have shown that the required diamensions of members can be pre-determined if suitable assumptions are made. These equations can be improved if size of bucket, diameter of bucket and the exact position at which the bucket is tilted at the time of emptying are also taken into consideration.

A few trials with a 7 feet diameter water wheel were also made on the test bed, the results of which, however were not conclusive. The te bed needs further improvement such as a lined canal of large cross section on the down stream side for reproducing field conditions of operation more accurately.

References

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