P.D. SHARMA
S.E./ PROFESSOR

IRRIGATION DEPARTMENT

UTTAR PRADESH

INSTRUCTIONS ON REPAIR AND OTHER ITEMS FOR THE USE OF CANAL OFFICIALS

STATE ENGINEERS ACADEMY

KALAGARH

APRIL 1989

सहायक ... तृतीय
पूर्वी गंगा नं० नि० खण्ड I

P. D. Sharma
AE

सिंचाई भवन
सं० इशितयाक अहमद
प्रमुख अभियन्ता
S. I. AHMAD
ENGINEER-IN-CHIEF

तार : सेनेरिग Phone 46804 45811 (का०)
TEL. : CENIRRIG फोन 34610 (नि०)
सिंचाई विभाग उ० प्र०, सिंचाई भवन
कैनाल कालोनी, लखनऊ-226001

IRRIGATION DEPARTMENT (U.P.)
SINCHAI BHAVAN
CANAL COLONY, LUCKNOW-226001

सिंचाई भवन
III तल • नं० नि० खण्ड
पूर्वी गंगा नहर
सहायक अभियन्ता पूर्वी

PREFACE

The last two decades have been fairly traumatic in as much as the application of Northern India Canal & Drainage Act 1873, the ethics of maintenance of IRRIGATION WORKS ; the constant touring of canals by officials right from the Superintending Engineer to the grass-root level PATROL, the personal contact with the cultivators , disbursement of pay of staff and bills of the petty contractors at the Inspection H–ouses–located on focal points of the works–all has atrophied and the disciplined flow of irrigation water through well defined channels now looks like a distant dream.

Obviously, the expertise on maintenance, the indepth insight of water management and concern for Government Revenue has suffered badly and it causes a heartache to those who had cared and nurtured the canal system and Tubewell Units with exemplary devotion.

Perhaps a concerted effort is called for again to inculcate the lost zeal and to re-enthuse our staff with such TIPS as would help deliver the end product 'water' to our cultivators with efficiency and concern. To achieve this Shri R. P. GOEL, Chief Engineer (Canal west) has updated the available literature and edited "INRSTRUCTIONS ON REPAIRS & OTHER ITEMS" for use of the Canal and Tubewell Officials, Interestingly enough, this booklet was first brought out in the year 1900 AD and got brushing times and again when its Sixth edition was printed in 1962 AD.

I h–ope, armed with the valuable, enriched and time tested experience contained in this booklet–our staff will ensure Maintenance in true sense and serve the Cultivators with better water management and better upkeep of Works.

(S. I. AHMAD)
ENGINEER-IN-CHIEF, ID

March 31, 1989.

Instructions On Repairs And Other Items For The Use Of Canal Officials

A–Limes and Mortars

1. Kankar for lime should always be burnt with coal dust or wood and never with cow-dung (upla). It should be ground without delay, as it deteriorates rapidly, if left unground, especially during the rains.

2. White lime and kankar lime (after being ground dry) should be carried to the site of work in gunny bags. It should be placed on the dry brick floor and never dumped or stacked on the ground.

3. Before use white lime must be thoroughly slaked, screened of all lumps, and kept under water in soak pits for two days.

4. When ever practicable, both kankar and white lime mortars should be mixed wet in a mortar mill, and for an important work this should be done as near the site as possible. For petty works sifted lime may be mixed with the proper proportion of sand or surkhi wetted and thoroughly turned over before use.

5. Mortar of the proper consistency only should be delivered on the work any subsequent thinning being strictly prohibited. Mortar that is too thick or too thin should be sent back to the mixing floor. For brick work the mortar should be a thick paste, i. e. as stiff as is consistent with a proper filling of the joints.

Water for slaking and mixing must be clean.

6. Only as much mortar should be mixed with water in one day as can be used that day. This applies more specially to kankar than to white lime, Cement mortar should be prepared only in such quantity as can be used within half an hour of its mixing with water.

7. For cement mortar the cement and sand should be carefully measured out on a dry fioor and thoroughly mixed dry, after which watar should be added sparingly and the whole turned over with phaoras or shovels until the required consistency is obtained. Too much stress cannot be laid on the necessity for thorough mixing especially when the proportion of sand to cement is high. Too much water must not be used as it spoils the mortar.

8. The proportions of the various ingredients to be used will vary in different districts, according to the class of work and the quantities of the material available. If there are no existing orders on the subject, the Sub-Divisional Officer should be referred to.

B–Brick Work

1. Bricks for the next day's work should be set to soak in water the previous night, and new work kept thoroughly wet during construction and for at least ten days after completion. This requires special attention in May and June and in a dry September or October.

2. Every brick should be drawn up in the mortar and firmly bedded, no joint should exceed 10 mm (3/8th of an inch) or be less than 5 mm (3/16th of an inch) in thickness. To ensure that the frog of the brick is filled with mortar, bricks shouid always be laid in the work with the frog up wards, but in brick-on-edge flooring, the course below the brick-on-edge should be laid frog down wards, care being taken that the frog is filled with mortar before the brick is laid.

In floors of canal works the top brick-on-edge should be laid diagonally to the centre line of the channel or in herring-bone pattern.

The top layer of all walls, crests, floors, etc. should be a course of brick-on-edge, unless otherwise ordered.

3. Face bricks must not be cut, chipped nor rubbed on the outer surface, except where necessary, as on the face of a skew arch, the best bricks should be selected for face work.

4. When a work is to be built on soil that contains the slightest trace of "reh", selected well-burnt bricks only should be used for a height of at least 60 cm (2 feet) above ground level, as bricks that are not thoroughly burnt rapidly corrode away in such a situation.

5. The widths of brickwork should be so designed that it may not be necessary either to cut the bricks or to fill in pieces less than half a brick in size. Where the masonry will be covered up, as the backs of retaining walls, it is better to leave brick projections than to cut the bricks.

6. Where possible, the entire work should be carried up regularly throughout, and, except where required by the plans. No part should be more than 90 Cm (3 feet) higher than the rest. When the entire work can not be carried up in even courses, the break should be left in regular steps each of a length of at least one and a half times the height.

7. The surface of each course should be thoroughly cleaned of all dirt before another course is laid on top.

Should the mortar in any course have begun to set, the joints must be raked out to a depth of 12 mm (half inch), before another course is laid.

When a top course has been exposed to the weather for any length of time, it should be removed, and the surface of the second course thoroughly cleaned before any more courses are added.

8. If a work is to be pointed or plastered, joints must be raked out to a depth of 12mm (half inch) with a special tool while the mortar is still fresh, and in any case, within forty-eight hours of the time of laying, In no case, should a "basuli" be used. If pointing or plaster is not provided as a separate item in the estimate, the joint should be struck and finished at the time of laying, the face of the brickwork being kept clean of all mortar.

Brick work should be kept covered with water when work is not actually in progress and for ten days after completion. For this purpose the top of the masonry should be provided with a mortar daula all round the edge, with cross-daulas so as to form 'Kiaris' or compartments.

9. When repairing brickwork all damaged bricks that have been exposed should be removed, and sufficient of the old work dismantled as to give stepped joints. The old masonry at the junction with the new work should be thoroughly cleaned and wetted, and the joints raked out to a depth of 12mm (half inch). The Junior Engineer in charge should inspect the work and see that this has been properly done before he allows the new work to start.

Petty repairs to parapets should, as far as possible, be done in cement mortar during the monsoon or the winter rains, care being taken that wheel guards are provided where necessary and that approaches to the bridge are straight as far as possible.

C–Concrete

1. Concrete made with brick ballast should ordinarily consist of 0.37 cubic meter of wet mortar to 1 cubic meter of well burnt ballast broken to 38 mm (1½ inches) gauge. when stone ballast is used, the usual proportion is one part wet mortar to two parts ballast. The ballast should be perfectly clean, and brick ballast must also be well soaked with water before mixing. For foundation of buildings concrete made up of 1 part cement : 4 parts sand : 8 parts 38 mm (1½ inch) brick ballast can be used.

For cement concrete, the usual proportion of cement, sand and ballast is 1:2:4 for important works and 1 : 2½ : 5 or 1 : 3 : 6 for ordinary work. Stone or shingle ballast is preferable but if this is not obtainable, overburnt bricks or "Jhama" broken to a graded size of 20 mm to 32 mm (3/4 inch to 1¼ inch) may be used.

2. For lime concrete the ballast should be spread evenly on a floor of bricks laid flat with their frogs downwards, and the correct proportion of well-mixed wet mortar spread over it. The materials should then be turned over with phaoras and thoroughly mixed at least twice from end to end.

For cemcnt concrete, the mortar should first be mixed dry, after which it is mixe still dry, with the ballast, the whole being then wetted and mixed at least twice from e to end.

3. After mixing, the concrete should be laid immediately. It must not be thrown from height, but laid gently in position in layers not exceeding 20 cm (8 inches) in thickne and rammed with iron rammers until the lime flushes up to the surface, when the rammi should be stopped. The layer of finished concrete will then be about 15 cm (6 inche thick.

The surface of the concrete while being rammed should be lightly sprinkled with wa to compensate for loss by evaporation, but care must be taken that too much water is r used.

4. The surface of each layer of concrete should be thoroughly cleaned from dirt a roughened with picks before placing the next layer.

5. The surface of the concrete should be kept wet under sand and gunny bags when t work is not in progress and for ten days after completion. It is advisable that some tir should elapse before any masonry is started on the concrete.

6. Should there be spring water in the foundations of a work, the Sub-Divisional Offic should be asked for detailed instructions before any concrete is laid.

7. The following instructions should be carefully followed when laying lime concrete jack-arched roofs or in floors :

Concrete for floors and roofs should consist of ballast of 20 mm (3/4 inch) gauge wi 50 per cent of mortar.

When thoroughly mixed floor concrete should be laid in two layers and roof concrete in on It is tnen beaten with light rammers till it has partially set After which it is beaten wi blunt wooden Knives (Thapis) until the latter rebound from the surface without leavir any impression thereon.

While the beating is going on, the surface of the lime concrte on roof should be frce sprinkled with a mixture of 2.5 Kg (7Lb) coarse sugar (gur) and 1.4 Kg. (4Lb) bael fruit 1 85 litse (3 cubic feet) water.

As soon as the beating is completed the surface should be softened by sprinkling with pure water, and the mortar that has been brought to the surface rendered with trowel, the surface being worked to a fine polish.

During rendering, the surface should be sprinkled with the gur and bael fruit mixture and a very small quantity of lime putty may be added, though great care must be taken that too much is not used.

Concrete in roofs and floors must on no account be plastered, and after completion it must be kept wet for at least fifteen days.

8. If cement concrete is used, the floor will generally consist of 32 mm (1¼ inch) cement concrete laid over 75 mm (3 inches) of ordinary lime concrete of 38 mm (1½ inch) gauge. After laying the lime concrete the floor should be divided into panels about 60 centimeter (2 feet) square by strips of iron/glass/aluminium 25 x 3 mm (1" x 1/8",). The cement concrete should be made from graded ballast of from 6 mm to 20 mm (1/4 inch to 3/4 inch) gauge, and should be in the proportions of 1:2:4. It must be laid before the lime concrete has set about seven days after laying and the whole batch for one panel must be mixed in one lotand laid at the same time, alternate panels being left over for the next day. The surface should be beaten with wooden thapls for fifteen minutes only, after which it is finished off with a trowel. The minimum quantity of water should be used for mixing, and if any panel is sloppy when finished off, it should be condemned and the concrete removed at once. Joints between panels should be filled with cemen mortar after the concrete has set and finished off smoothly with a trowel.

For polished cement floors, plain or coloured with or without marble chips, 75 mm (3") lime concrete is first laid correctiy and truely level with the lines marked for this purpose on the walls around the room.

(a) The panels are then filled 20 mm (3/4 th of an inch) thick with cement concrete made up of 1 cement: sand : 4 ballast of 6 to 10 mm (1/4" to 3/8") gauge stone or khanjar bricks and levelled up with the trowel.

(b) The top 6 mm (1/4") is plastered over the same day with mortar consisting of neat cement paste to which the necessary amount of colouring matter such as lamp black, or red oxide of iron or well slaked white lime has been added, neat white or coloured cements are also used. For marble chips or mosaic flooring the necessary quantity of marble chips white red or black are added to the top coating of neat cement.

When a coloured marble chip floor is desired, the chips are added to neat cement of the desired colour.

(c) The floor is kept under water and after it has hardened, it is rubbed with carborandum blocks to a smooth polish.

9. In reinforced concrete work, care should be taken that all spaces in between the shuttering are completely filled with concrete. Vibrators or Iron bars may be used for pushing the concrete into inaccessible places.

The spacing of bars and their distance from the top and bottom of the slabs and beams should be strictly according to the plans.

D – Pointing

1. In new, brickwork, the joints should be raked out as brick laying proceeds. Before pointing old work, the joints should be similarly raked out, and the face of the masonry thoroughly cleaned and kept wet for two days. The raking out should be done with a hooked tool made especially for the purpose, all mortar being removed so that the lower face of the upper brick and the upper face of the lower brick are exposed for a depth of 12 mm (half inch). Joints should never be hacked out with a basuli or similar tool. as the edges of the bricks get chipped.

In the case of a new work, the joints should be raked out well in advance and inspected by a responsible officer before pointing is done·

2. Pointing will be in lime or cement mortar, as may be ordered by the Sub-Divisional Officer.

3. The joints should be filled flush with the mortar, which, however, must only fill the joints, and not extend over the faces of tne bricks on either side.

After flushing the joints, the horizontal lines are marked by a string, which is stretched tight and beaten into the mortar with a trowel, the line so obtained being deepened by running a tooi called a "jointer" (similar to a bent nail), guided by a straight-edge along it. The vertical lines are then struck with the jointer and straight-edge.

Pointing must follow the actual joints and must not represent false joints. All lines must be perfectly straight truly horizontal or vertical, and the mortar used so stiff that the pointing tool leaves a clean cut line with no appearance of ragged edges.

4. For floors flush pointing only should be used. Pointing must be done from the top of the work downwards. After completion,the work should be kept well watered for ten days.

E – Plaster

1. Plaster, except when otherwies ordered, should be of cement mortar.

2. Before plastering the joints in the brickwork must be rakad out, and the surface thoroughly cleaned and wetted, as for pointing,

3. The use of plaster in petty repairs should be limited to works already plastered, as it is often resorted to hide bad work.

4. Cement plaster should be 12 mm (halfinch) thick laid in one layer. The proportion of cement to sand will be from 1 : 3 to 1 : 6 according to the nature of the work and the quality of the sand.

F–Pitching

1. When laying brick or block kankar pitching, the following points must be carefully attended to :

(i) That pitching on the side slopes has a foundation at least 30 cm (1 foot) below bed or ground level;

(ii) That the bricks or block kankar are laid at right angles to the slope of the pitching and are tightly packed;

(iii) That the outer face of the pitching is smooth, so as not to set up eddies that may cause scour lower down;

(iv) That the top course in side pitching is brick-on-edge in lime, and that it is rounded off at the corners.

2. Block kankar or stone pitching should be composed of the largest blocks procurable, limited by ease of handling with the appliances provided. No block should be less than 1/35 cubic metre (one cubic foot) in size when roughly dressed.

It is advisable to lay such pitching on a 75 mm (3 inch) layer of ballast, rora, or smal kankar to prevent earth from being sucked out from between the stones by wave action.

3. When pitchihg side slopes care should be taken to give the pitching a good toe, and a steeper slope than 1 to 1 should not be attempted. A slope of $1\frac{1}{4}$: 1 should be usually adopted.

Pitching should, if possible, not be carried up to a greater height than 3 meter (10 feet) without giving a berm somewhere.

4. In R. B. pitching, care should be taken to leave expansion joints vertically at suitable intervals. The mortar joints should be thick enough to avoid the reinforcement touching the bricks. The bricks should be laid frog downwards.

G–Earthwork

1. Before starting any new embankment or excavation, "Namunas" must be made at intervals of every 100 meter. These "Namunas" should be approved by the Sub-Divisional Officer before the work is put in hand.

2. Before earthwork for new banks is commenced, grass, jungle, etc., on the ground to be covered by the banks must be scrapped off with phaoras or khurpas, and no earthwork should be allowed to start in any part of a reach between two "Namunas" until the whole reach has been properly cleared. Ground in which borrow pits will be dug should be similarly cleared, otherwise grass and roots will be carried along with the earth into the banks and form hallows therein.

3. The side slopes of an excavated channel should usually be cut at 1 to 1. In sandy ground they may be made $1\frac{1}{2}$: 1, or even 2 to 1 with advantage, under the sanction of the Executive Engineer. This allows room for the formation of natural silt berms.

4. Banks should be made in layers not more than 30 cm (one foot) thick. Each layers is being levelled off and rammed before the next is begun. All clods should be broken up in the borrow pits and only powdered earth should be carried on to the banks.

5. The width of each layer should be a little in excess of the width required by the cross-section of the bank, the slopes being dressed by cutting off the excess width, as shown in the sketch.

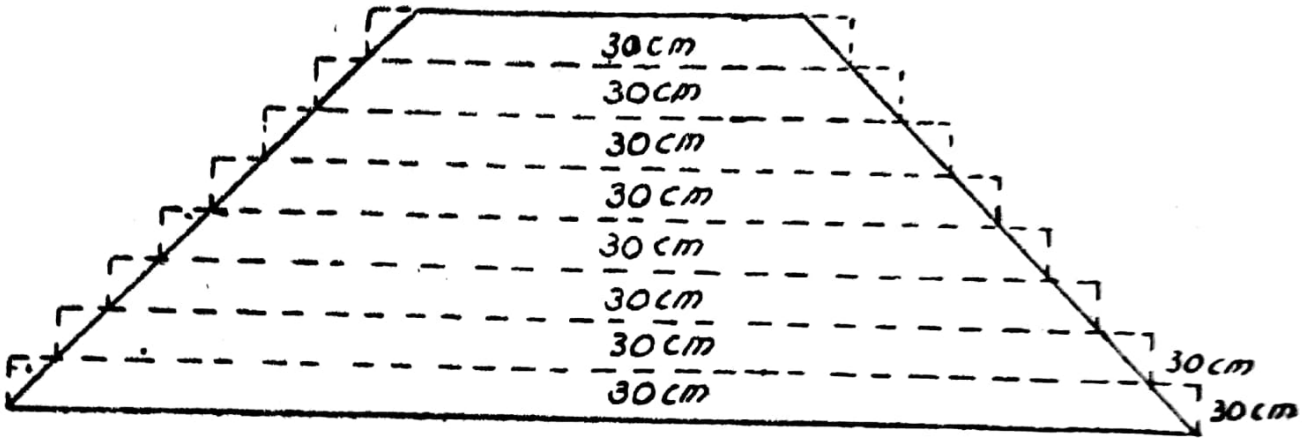


FIG. NO 1

The earth is laid in layers as shown by the dotted lines, and the slopes are then dressed off to the final section according to the full lines.

6, In new work the middle of the bank should be kept 50 mm to 75 mm (two to three inches) lower than the edges. This allows for some rain-water to be held up. and thus helps the bank to settle down quicker, and to a certain extent, it prevents the side slopes from being washed down. A settlement allowance should always be given, depending on the nature of the soil. For black cotton soil it should be 75 mm (3 inches) for stiff clay, where it is hard to break the clods 63 mm ($2\frac{1}{2}$ inches) for loams 50 mm (2 inches) and for sandy soils, 38 mm ($1\frac{1}{2}$ inehes) per 30 cm (1 foot) height of bank.

7. when adding new earthwork to old, the old bank must first be cut down to a stepped slope of atleast 1 : 1 to form a proper joint.

8. All earthwork repairs should be done, as far as possible during or immediately after the rains.

9. Earth required for repairs should not be taken from hollows near bridges, or from old borrow pits in plantations, if it is obtainable elsewhere, but from where it can best be spared, and ordinarily from the following sources in the order given.

(i) Berm-cutting during channel closures.

(ii) Borrow pits in the bed of the channel. These pits should, if possible, be the multiples of 3 meters(10 feet)in length, a tatti equal to half the length of the pit always being left, the wdith not to exceed half the bed width of the channel unless ordered by the Sub-Divisional Officer, and the depth according to the quantity of earth required, generally from 30 cm to 60 cm (1 foot to 2 feet) below the bed. These pits get silted up in three or four weeks running and they form a partly watertight bed. No pits should be dug in the bed in reaches where no silt is ordinarily deposited, as they encourage the growth of grass owing to their remaining full of water during channel closures. These should not be dug too near any masonry work.

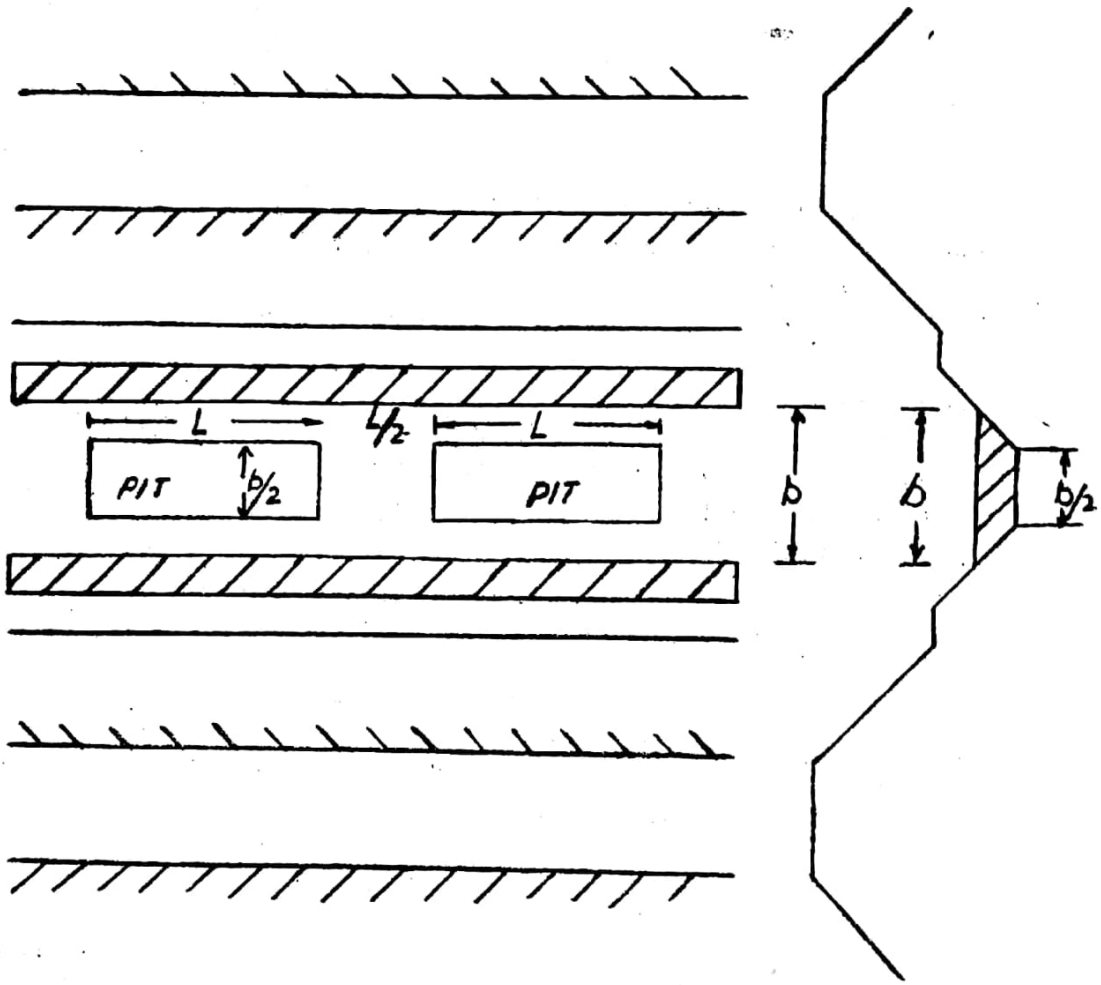


FIG. NO 2

(iii) The boundary ditch along distributaries and minors. This ditch should be 30 cm (one foot) wide and not more than 45 cm (18 inches) deep, care being taken that it is actually on the boundary.

(iv) Old spoil banks or the cross-drains through them.

(v) High mounds near athand, or the banks of water courses that have become abnormally high, owing to heavy silt clearnace, thus getting double advantage of earthwork done.

(vi) Borrow pits dug in the berm where it is too wnde and likely to silt up rapidly, the Sub-Divisional Officer's permission being first obtained. The earth should ordinarily be obtained by cutting vertical pockets in the berm, long lengths of which should never be dug down to below water level, as such stretches of low berm greatly increase percolation, and are slow to recover their height. As a rough rule, the length of pocket should not exceed the bed width of the channel or 3 M. (10 feet) whichever is less. Tattis should not be less than 1.5 Meter (5 feet) thick and where earth is being borrowed from pockets in both berms, the tattis should be made exactly opposite each other. These should not be too near any masonry work or dug on the outer side of a curve.

(vii) When not obtainable elsewhere, earth may be taken from neatly laid out borrow pits parallel to the bank, and as far away from it as practicable. For petty repairs these borrow pits, when in culturable land, should not exceed 15 cm (6 inches) in depth, where old borrow pits exist diagonal tattis (from corner to corner) should be insisted on in new pits. If this is not done the contractor may try to exaggerate the measurements of the work done by enlarging the old pits.

10. Borrow pits must nowhere exceed 30 cm (one foot) in depth nor be within 10 meter (30 feet) of the toe of the bank in the case of large channels or 5 meters (15 feet) in the case of small channels without the Sub-Divisional Officer's written sanction.

11. All tattis and matams must be removed as soon as the work has been measured up and passed, and the earth used up in the work. Water must never be admitted into a channel until all tattis have been removed.

H – Canal Roadway

1. The canal roadway should be maintained with an outward cross–slope of approximately 1 in 30.

2. Where there are spoil banks outside of and higher than the roadway, there should always be a continuous drain along the outer edge of the road, as well as cross drains through the spoil banks, the latter being at right angles to the the former, and leading with a gentle slope to the boundary ditch. Cross drain should not be allowed to get higher than side drains. Where there are no spoil banks outside the roadway, no drain is required.

The outer edge of the roadway should never be dagbelled.

3. The canal roadawy must never be allowed to remain blocked by fallen trees, or in a dangerous condition from holes, ghattas, etc. It is the subordinate's duty to start removing the obstruction or carrying out the necessary repairs at once reporting his action at the same time to the Sub-Divisional Officer for approval.

4. Trees should not ordinarily be allowed to grow on canal berms, or within 3 Meters (10 feet) of the inner edge of the right bank. If they are permitted in certain reaches, the fact should be recorded in the Divisional Standing Order Book.

5. The canaleroad daula should be kept up to the following sections, after settlement, with side slopes of 1½ to 1:

Channel	Height	Top width
For main canals and branches	30 Cm. (1.00 ft)	60 cm (1.75 ft,]
For distributaries	30 Cm. [1·00 ft]	45 cm [1.5 ft.]

The bottom edge of the daula should not be cut for repairing ruts in the banks.

6. If a portion of daula falls into the canal, another daula should be made a short distance behind and parallel to the old line, the old and new daulas being joined up with "S" curves. This should be considered only as a temporary measure, pending further appropriate action for protecting the edge of the road or cutting back the bank slopes, as ordered by the Executive or Superintending Engineer.

7. Junior Engineer should inspect the canal roadways after heavy rain, and arrange to fill up at once any holes they see. Holes must invariably be opened out and dug down to the bottom with stepped slopes; wet earth should then be rammed. in layer 30 cm [one foot] thick, allowance being made for settlement. Silt from the canal berm may be used for closing these holes where there are no outside spoil banks. Holes generally result from defective drainage, and this should be looked to and remedied, otherwise the holes quickly reopen.

8. Deep ruts in the approaches to bridges on main canals and branches and to district road bridges on distributarie should be filled in immediately they form as these give a bad bump to the cars. This is specially necessary where the canal and district roads cross, and these portions should gradually be metalled or provided with brick-on-edge protection as funds permit Ramps leading to bridges should have easy slopes and should always be kept in repairs.

9. Ordinary repairs to canal roadways should invariably be taken in hand just after the first heavy rain falls, and must never be postponed till the end of the monsoon.

10. Roadways on right banks where they exist should always be kept free from holes rain cuts.

11. Locks of canal gates should be periodically oiled.

12. In reaches where the canal road is lower than the F.S.L and there are "ghattas", breache may occur. The roadway at all "ghattas" should be raised to a level at least 15 cm [6' above the F.S.L. in a horizontal stretch of atleast 15 Meter [50 feet] with ramps of 1:3 on either side.

No attempt should be made to close "ghattas" by filling earth on the inside. Th width of the roadway at "ghattas" should be made up by widening on the outside.

13. If the top of the road over an outlet is higher than elsewhere, a horizontal stretch o 15 Metre [50 feet] should be provided over the outlet with ramps 1 in 30 at either end.

I-Canal Bridges

1- The roadway over a bridge should be carried straight and level from the ends of the parapets to at least on a line with the outer toe of the bank. Curves and ramps should commence beyond these points. The ramps of village road bridges should not have a slope steeper than 1 in 25. For Kachcha district roads the grade should not be steeper than 1 in 30, for metalled district roads 1 in 40, and for provincial roads 1 in 50.

2. On ridges stone or Kanker wheel-guards only should be used, as wooden posts are liable to be stolen. They should be fixed 15 cm (6 inches) away from the mansonry so as not to communicate the shocks received from carts, and in such a position as will not decrease the effective width of the roadway. Having a straight approach to the bridge is very effective in preventing damage to ends of parapets.

3. Over arches the earth filling should not generally exceed 30 cm (12 inches) and metalling should be 23 cm (9 inches) thick. Should it be less than 15 cm (6inches) the Junior Engineer should promptly report the matter and ask for section to the metalling being made up to the proper section.

J- Channels

1. Whenever a channel is closed, it should be inspected by the Junior Engineer-in charge at once. All pipes in the crest walls of falls must be opened cut, so as to run off the water above and dry the channel quickly. An intelligent beldar should be sent down the channel with one or two men to clean it up before it is run again. This frequent cleaning up of channel is most important and keeps them in good order. All "theks" and rubbish should be cleared from the bed each time a channel is closed. All masonry work should be

periodically cleared of rubbish, stones, brickbats etc., as opportunity offers. especially siphons and the cisterns of falls, and all brickbats buried.

2. Weeds and grass in the bed should be cleared with phaoras, except where the bed is lower than the theoretical bed, when darantis should be used, but on the inner slopes of a channel phaoras should not be used unless the section is contracted. If the section is normal the weeds and grass on the side slopes should be cleared with darantis, but if it is too large any clearance done should be very light, as the presence of weeds, and grass helps berms to form. Rugged berms, should be made smooth so as to prevent eddies and induce formation of berm.

3. Channels should always be cleared from below upwards, starting either from the tail or a fall. The clearance of isolated lengths should never be allowed.

4. While a channel is running, the brushwood, etc., that collect at bridges, siphons and falls must be removed at once a little distance away from the banks, dried and burnt.
5. When trees fall into a channel, the Junior Engineer should have them removed at once, at the same time reporting to the Sub-Divisional Officer and asking for orders regading their disposal.

t6. Excessive scouring or silting at any point should promptly be brought to the notice of he sub-Divisinal Officer, should the inner slope be scouring out driving in stakes to stop the action should neither be resorted to except under the special orders of the Sub-Divisional Officer nor is it suitable where the erosion is permanent on account of the velocity of the water being greater than the earth can resists; instead the side slopes should be pitched.

7. Stakes or branches should not be used to support the earth filled into "ghattas" or used in petty repairs to the banks.

8. Where banks have fallen in, ajudicious use of treespurs will often cause silt berms to form.

9. On hearing of a breach the Junior Engineer in charge must arrange immediately for its closure, at the same time reporting the matter to the Sub-Divisional Officer by wire or by special messenger.

Irrigation Channels :

The Chief requirements for a uniform channel are :—

(1) A clean regular bed (see sketch below), (2) straight clean berm slopes (3) Uniform berm widths (4) Uniform regular top width, and outer and inner faces to both banks. For uniformity, not only must the surfaces be smooth but the alignment of the following 12 lines must be correct :—

Two bed lines, two top lines of berms, two inner toes of banks, two inner edges of banks, two outer top edges of banks and two outer toes of banks.

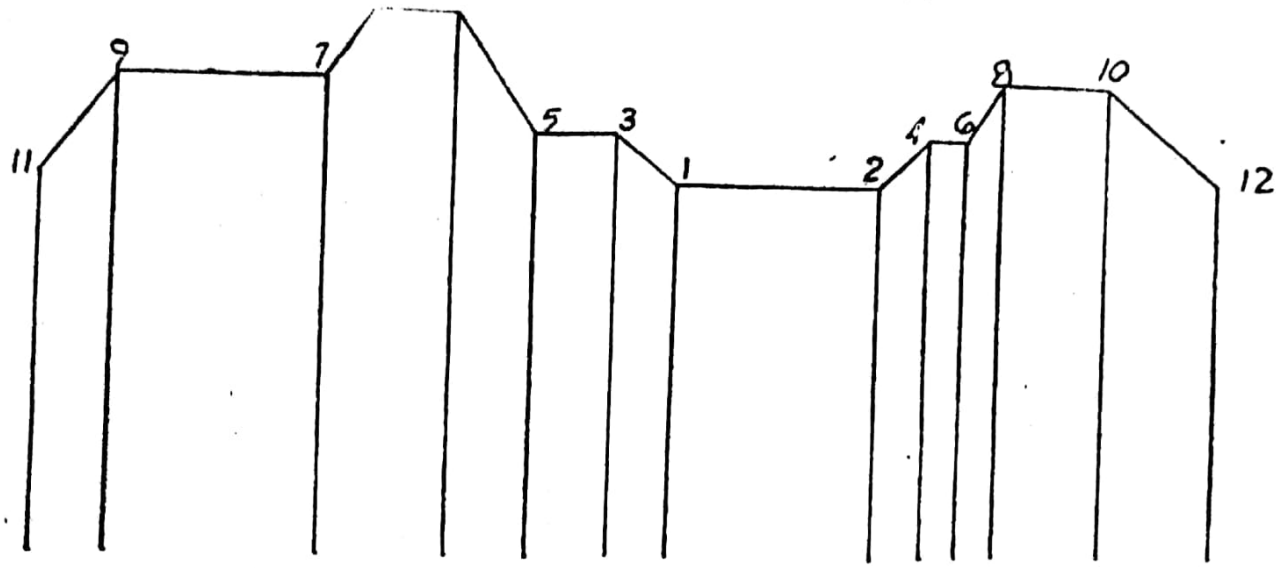


FIG. NO 3

Channel Section :

A clear regular bed and straight clean berms are the first requirements in Canal Maintenance. The following sketch depicts a "typical channel in proper condition", and the usual defects and irregularities found them :—

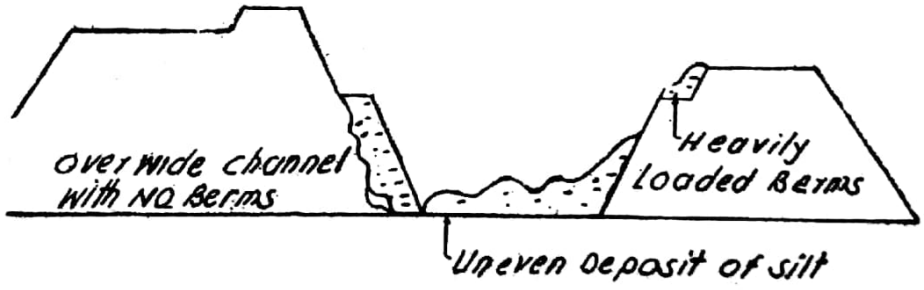


FIG. NO 4

(i) The following are the three items of wotk required to be done on the bed and the corresponding three on the berms to obtain and maintain a uniform and correct internal section.

Bed (i)bed scraping :

(i) All grass must be scraped and weeds removed from the bed where-ever they are found to exist. The presence of these induces the deposit of silt.

(ii) Thek clearance : All local accumulations or mounds of silt above authorised bed level must be removed down to correct bed level.

(iii) Silt clearance : Continuous deposits of silt must be reduced down to authorised bed level.

Berms : (i) Berm scraping : Where-ever berms are fully formed up, all grass and weed must be scraped from them. The presence of these induces abnormal and irregular growth of berms, resulting in contraction of the channel section.

(ii) Berm trimming : Irregular, protruding and over hanging berms must be cut back to proper alignment and slope. If this is neglected, berms fall in or protrude abnormally and the canal tends to adopt an irregular section and winding course.

(III) Berm cutting : Where-ever berms have grown excessively, thereby tightening the water-way they must be cut back to the authorised section.

(2) Berms and bed should be scraped where necessary and especially in tail reaches, but berms must not be scraped if they have not silted fully. Berm and bed lines must be correctly aligned before scraping.

(3) Beds should be levelled and their gradients regularised to the fixed slope by removal of silt theks and mounds of all irregularities higher than the authorised bed level

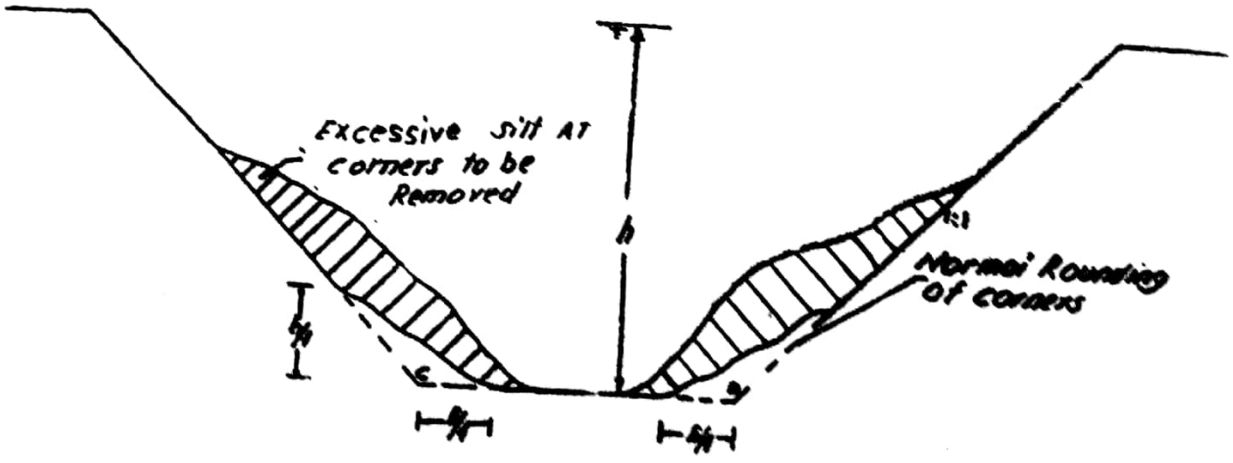


FIG NO 5

Bed levels should be fixed correctly at close intervals by means of boning rods. Silt at the junction of the bed and berm should be removed only when it becomes serious i. e where the silt theks become more than 1/4 water depth in height and 1/4 bed width in length. for in a true regime section corners C and D are rounded off as shown inred in the sketch.

Small minors and all tail reaches should, however, be cleared absolutely to the trapezoidal section.

The practice of cutting out the theks in the corners and throwing them into the centre of the bed to level it up must on no account be premitted.

(4) Berms should be kept straight by trimming projections after aligning them correctly. Heavy berms cutting can be avoided by regular trimming and scraping as the situation calls for every year.

(5) Sufficient material obtained from (2), (3) and (4) should first be placed along the inner edge of the banks and then dressed to a "straight edge" with a slight outer slope along the top of banks. Any balanced left should be used in filling hollows in the inner and outer slopes, or in other bank repairs.

Method Of Aligning Bed And Berms :

Case (I) A straight reach between two masonary works within clear range of vision :—

If B. theoretical bed width.

d. depth of silt deposited on bed.

D. depth of water (actual) on silting when running full. The, theoretical surface width should be B+2d+20 Examine the actual surface width within the reach and let this be called as "b,'

Then working surface width to be adopted will be greater of these two' Call it w.

Now fix flagged poles A^1, A^2, B^1, B^2, in to the berms adjoining the masonary work

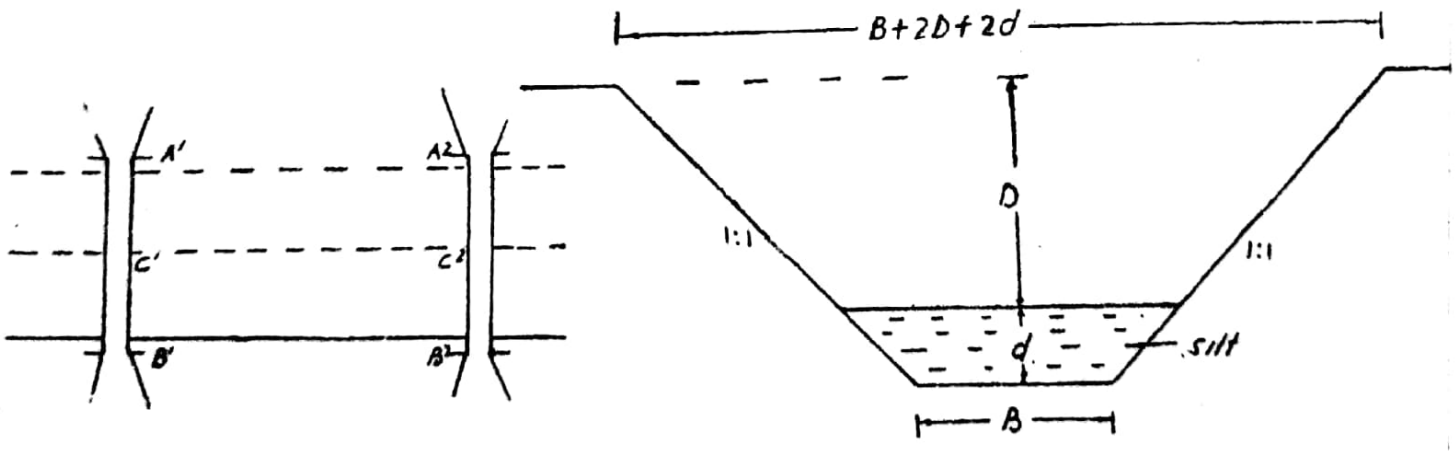


FIG. NO 6

at distance w/2 from the centre C^1, C^2 of the "masonary work" which are easily located and lay the dagbel in the line of the two corresponding flags. These then will be the berm lines. Similarly the bed width is located by making two lines at distance B/2 from the centre line, Any portion of the berm coming within this is to be cut at 1 to 1 slope.

Case (ii) A straight reach of channel where masonry works are not within the range of clear view.

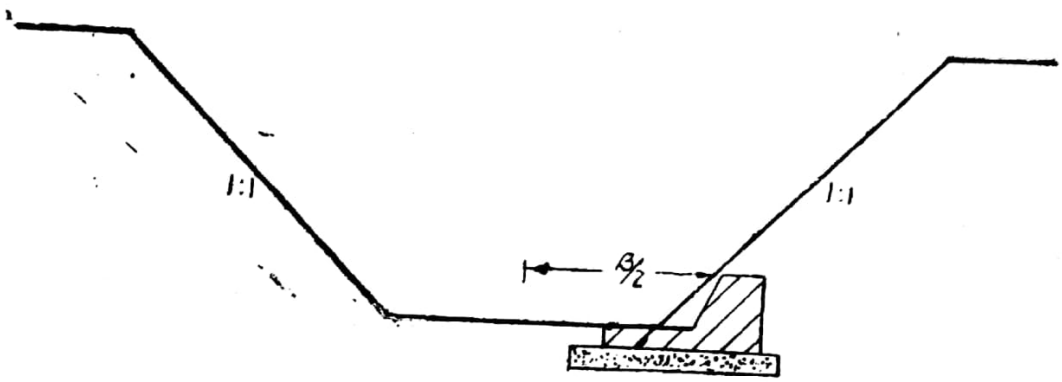


FIG. NO 7.

In this, centre line is to be located at two bed bars as far apart as possible by fixing two flags at a distance of B/2 from the corner of the bed bar.

The rest of the procedure is the same as in case (i)

Case (iii) A curved reach :—

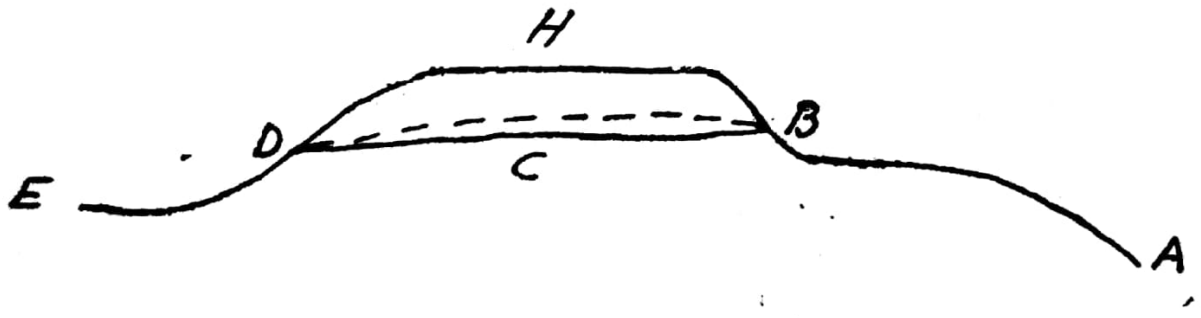


FIG. NO 8

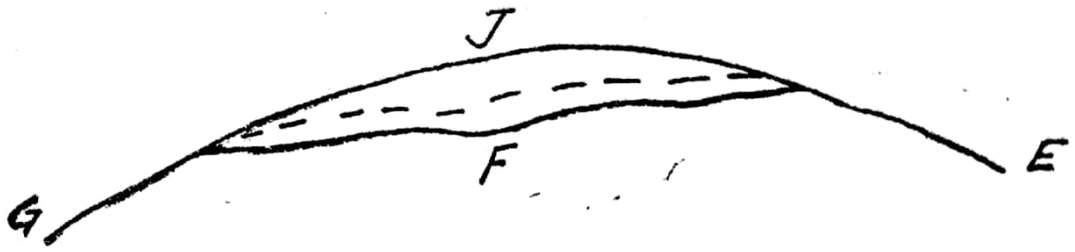


FIG. NO 9

Let ABCDE and EFG be the outer and inner berm lines (Theoretical) After running, the outer side is scoured in to shape BHD while growth of berms invariably takes place on inner edge along EJG, smooth curves with dagbels along dotted lines should be laid, cutting berm slope on the inner curve into 1 in 3 instead of 1 to 1 (though some advocate laying the dagbels along EFG).

Banks : (i) Banks should be brought up and maintained to full section. This is particularly important in the head reaches of larger channels as "breaches" here will throw the whole system out of action. The minimum width of banks, should be 1.2 Meter (4 ft.) and the free board 45 cm.(1½ ft.) above actual F.S.L.

(ii) Before continuous bank repairs are started, the sectional officer must get small profiles or namunas made at 100 Meter apart. These must be at the correct height and width of the bank repaired and must be checked and passed by the Junior Engineer before work is started.

(iii) All holes and rain cuts must be fully opened out and inspected by the Junior Engineer first. They should then be filled with wet earth and properly rammed.

(iv) Top of bank must be smooth and free from clods, theks and leaks while transversely they should be given a slight outward slope of say 25mm to 40 mm (1" to 1½") to take the rain water away from the channel there by preventing formation of ghattas and washings of bank earth into channel.

(v) Both edges of banks especially the inner ones should be neatly aligned parallel to the channel. They should be absolutely straight in straight raeches and regular in curves.

(vi) Both inner and outer slopes and toes of banks should not be neglected. They should be regular and free from irregularities. Any projecting irregularities should be cut down and earth thus obtained should be utilised in filling holes.

(vii) The bank slopes must on no account be scraped or cut back through out as a general rule. Only where the whole bank slope is so irregular that nothing less than redressing it from top & bottom will do, cutting the slope shall be done but only after obtaining prior approval of the sub-divisional office.

(viii) Loose earth must on no account be left lying on top. Whereever filling is necessary it must be well rammed.

(ix) Clods of earth must not be allowed to get dry hard before breaking and dressing of the earth work. Rammed and consolidate it while slightly wet, for then it adheres to the banks and soon gets a growth of grass and lasts much longer.

(x) Grass or turfing should on no account be scraped. It should only be cut as far as necessary to show the surface of the bank and to avoid the holes being hidden under long grass.

(xi) The practice of scraping the top edges of banks for appearance is forbidden.

(xii) Earth from any source for bank repairs must be placed where and in such quantities only as required. If this is not attended to very carefully, banks will become irregular by developing unwanted bulges and hollows.

(xiii) The left or the right bank as the case may be is to be maintained as a riding bank. The top should always be kept sound and free from holes.

Sources Of Earth For Repairs :

Earth for repairs can be obtained :—

(i) From internal clearances. Material obtained from them should be utilized as given in para 5 of channel section.

(2) By removal of irregularities existing in banks in excess of required section. High banks can be lowered and bumps or projection on top or sides cut down to fill in the hollows.

(3) From prominent mounds in the fields near the site

(4) From beds of drains near the site.

(5) From beds ef guls.

(6) From borrow pits in the bed of distributaries and minors. These borrow pits should be in the centre leaving at least 30 cm(1 ft.) on either side in the bed and its length

should not exceed 6 Meter (20ft.) or 2 B where B=Bed width and depth not more then 30 cm (1 ft.). A width of 1.5 Meter (5 ft.) strip should be left between two successive borrow pits.

From outside borrow pits as a last resort, the following rules should be observed in taking earth from this source.

(1) No borrow pits must be dug within 6 Meter (20 ft.), from the toe of banks or driving road or ramps of bridges.

(ii) No borrow pits must be dug within old borrow pits.

(iii) Where old borrow pits exist, earth must be taken from the outer edge and not the inner edge.

(iv) No borrow pits must be more than 30 cm (1 foot) deep at the utmost and in cultivated fields, they should be kept 15 cm (6 inches) as for as possible.

(v) No borrow pits should be put in 'Usar' or sandy land as Usar earth and sand areon no account to be used in repairs. Good earth must be taken from tanks or cultivated fields regardless of extra lead.

(vi) Earth should never be taken from the toe of banks, as the natural rounding off of the corner should not be disturbed.

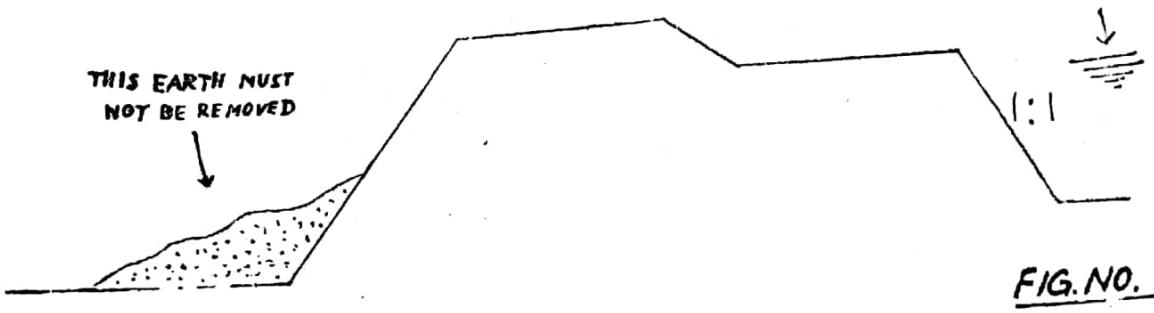


FIG. NO. 10

Driving Road :

This is an item requiring careful attention and which has often been spoiled by too enthusiastic and over zealous persons. All that is required in its upkeep is a well levelled surface free from hoof marks and undulations. Wholesale scraping of the grass

from the surface of roads after rains is shear waste of money and quite useless as it instead of levelling and smoothening the surface which it is supposed and intended to do roughens surface and renders it bumpy and uncomfortable. It is, therefore, desirable only to remove the thick, long and coarse grass such as patel, kans, etc. and leave intact the truf which is a protection to the surface.

A good road should be particularly level transversely and have a regular even longitudinal grade. It is in maintaining these two qualities that the chief object of repairs lies. During rains all roads to a greater or less degree develop the following three defects chiefly and to attain the above object these must be removed.

(i) **Rain cuts and holes :**

These must be carefully opened up and filled with well rammed earth. Deep holes should be puddled with a long 'balli'

(2) Accumulation of earth along the toe of canal bank due to erosion of the banks.

This takes place during rains and results in the rounding off of the road as shown exaggerated in the sketch below :—

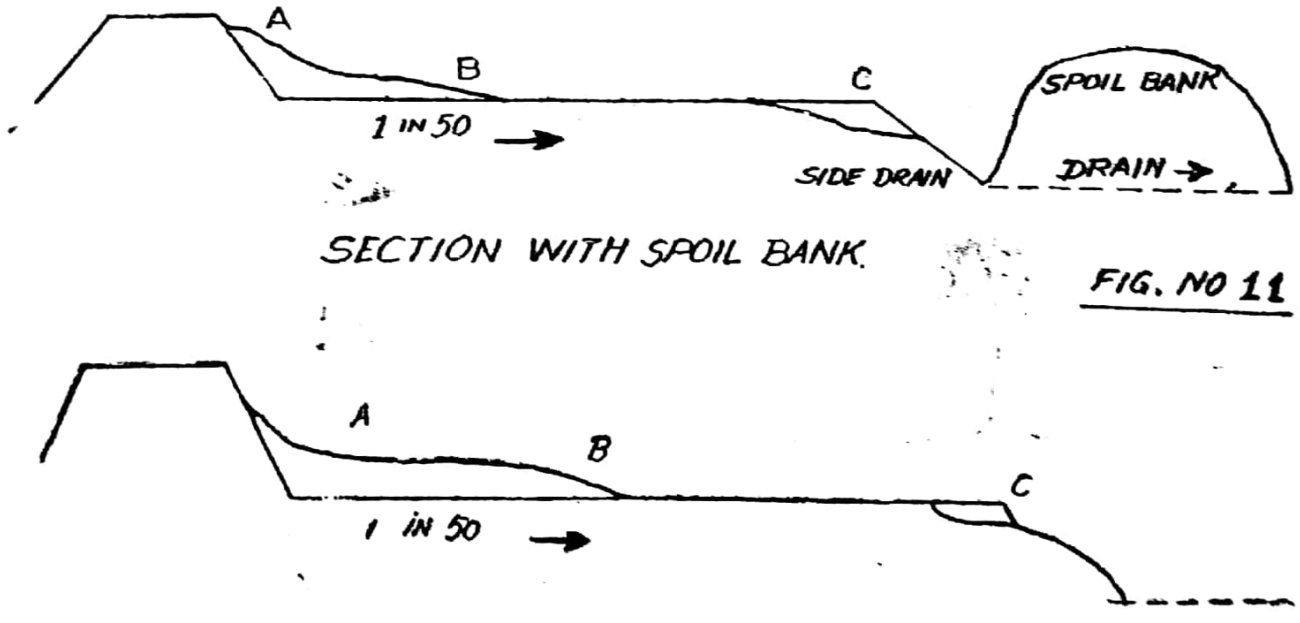


Figure 11 Typical cross Section :

To level off the road again, the accumulation between A and B must be cut away and spread between B and C. This width A B will generally be found to vary between 60 cm to 120 cm (2 to 4 ft.) only. A slight outward slope of 1 in 50 should be given from A to C for surface drainage.

(3) Waviness in the road surface in the longitudinal direction of the road :—

The sketch below represents a longitudinal section of the road, showing the top surface. It must be remedied by appropriate cutting and filling i.e. cutting down the crests of bumps and filling the hollows of depressions, or by spreading a thin layer of earth.

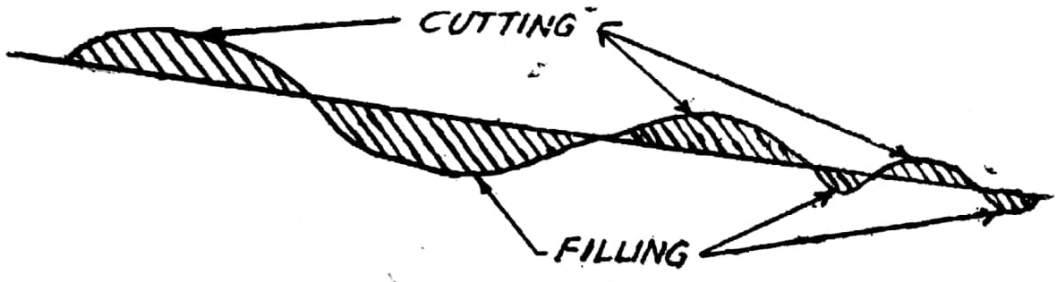


FIG.NO. 13

Figure 12 Longitudinal Section :

The practical way of dealing with these repairs, is first to filling the cuts and holes and dig out clumps of grass where necessary. Then a 60 Meters (200 ft.) long string is stretched along the toe of the banks, i.e. at the point A in Figure 11, and a dagbel cut along it to the required depth according to the depth of earth accumulated. Next the roadway is levelled of by cutting out the portion A–B and spreading this evenly by stretching a string tightly from A to C or by a wooden straight edge 3.5 Meters (12 feet) long. For drainage, 50 mm to 75 mm (2" to 3") outer slope is generally given which can be judged by the eye. To check the longitudinal surface, the string is tightly stretched along the edges line than in the centre of the road, the bumps and hollows being thus located and dealt with.

The dagbel along the toe of the bank is not to be done for apperance only. It is meant to, and should be made to, serve its definite and useful purpose, that is, the effective removal of the earth deposited along the bank.

At outlet and bridge crossings the road should be especially attended to for it is here

that one generally gets very bad jolts while motoring due to the bumps and hollows existing there as shown in the sketches below :—

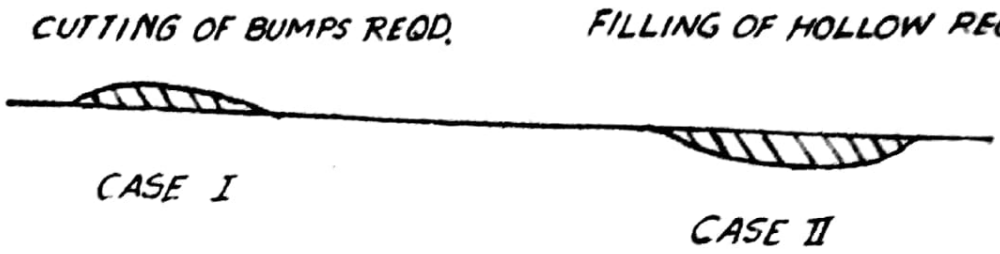
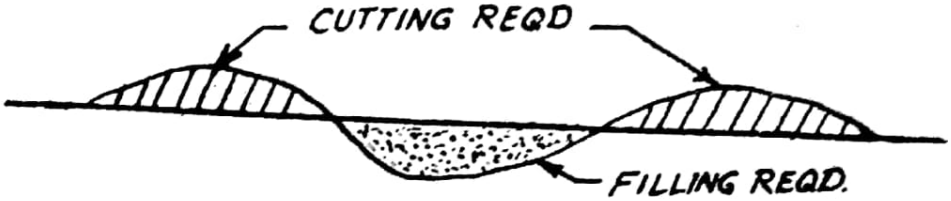


FIG. NO. 14



CASE III

FIG. NO. 15

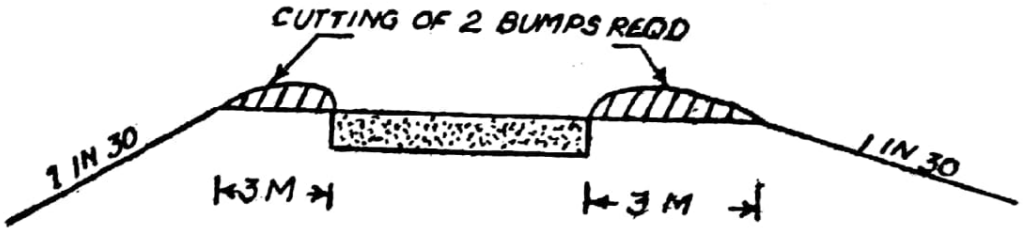


FIG. NO. 16.

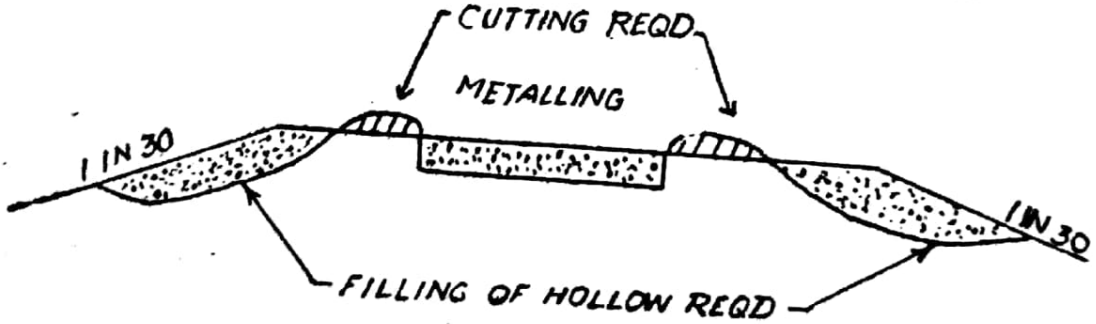


FIG. NO. 17

The above defects are removed by stretching a string across the top and shaving off the bumps and filling in the hollows till the string touches the surface all through.

Ramps at bridges should be gentle having a gradient of 1 to 30. The correct L.S. of bridges ramps is shown above. They should be flat for 3 Meters (10 ft.) on each side of the metalling or paving before the slope starts.

K–Distributary Banks

1. The minimum top width of banks should be as follows :

(i) Channels carrying over 30 cumecs (1000 cusecs) 3 Meter (10 ft)

(ii) Ditto 6.0 cumecs (200 cusecs) 2Meter (7ft)

(iii) Other channels ... ... 1.5 Meter (5ft)

The tops of banks should have a cross-slope of 1 in 30 out-wards to prevent rain-water from running into the channel.

2. Banks that are too low should, as a rule, be raised before/during the rains, or at the time of closure of channels. Silt can be dug from the bed for this purpose. If silt is used, however, it should be covered with 15 cm. (6 inches) of good earth, obtained either from berm cutting or from deep borrow pits in the bed of the channel. Large ghattas may be similarly treated. Where a channel is in deep digging it is not necessary to close ghattas on inside slopes.

The height of banks, above full supply level should, as a general rule, be as under :

(i) Channels carrying over 75 cumecs (2500 cusecs) 1 meter (3 ft)

(ii) Ditto 30 cumecs (1000 cusecs) 0.8 meter (2.5 ft)

(iii) Ditto 6.0 cumecs (200 cusecs) 0.5 Meter (1.5 ft)

(iv) Smaller channels 0.45 Meter (1.5 ft)

Banks should generally be atleast 30 cm (one foot) above country level to prevent drainage getting in.

3. The outer slopes of banks should not be less than 1½ to 1 and generally it is better to make them 2 to 1.

4. One bank should always be kept up as a riding bank, but the other should be in such a condition as to admit an inspecting officer riding slowly along it, if necessary.

5. Hollows at briges and elsewhere should be filled up with silt as opportunity offers

6. Deep footpaths in the banks should be filled up with earth taken from outside, or with berm silt. Turf should not be scraped off the banks durings repairs but encouraged to grow as being a valuable protection to the surface.

7. In reaches where a distributary runs through usar, earth should never be taken from outside borrow pit, but pits as deep as may be necessary should be dug in the bed, tattis being left at short intervals to facilitate silting. No attempt should be made to make up the inner slopes of the banks, all earth being thrown on the outer slopes.

The best way to obtain suitable earth for repairs in **such usar reaches** is to force berms to grow by setting back the banks as shown in the sketch , when pockets can be dug in the berms and the earth there from utilized. This should, however, not be done without the permission of the Sub-Divisional Officer, from whom detailed instructions should be obtained.

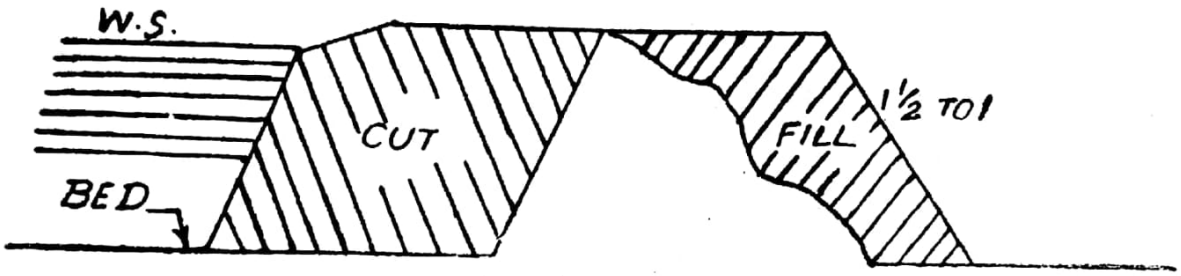


FIG. NO. 18.

8. When dressing the riding bank its inner edges should not be dagbelled, unless specially ordered by the Sub-Divisional Officer. Dagbelling should not be done merely by way of putting a "finish" to the bank.

9. Barrow pits should not be allowed in the bed within 6 Meter (20 feet) of where footpaths or cattle tracks cross a channel as they tend to cause the inner slopes of the channel to slip down.

L–Silt Clearance and Berm Cutting

1. Bed silt may be thrown on the outer slopes and in hollows, but never wehre it would be higher than the level of the bank, if it can be avoided.

2. Bed silt should generally be thrown on the outer slopes of the weaker bank to strengthen it; if both banks are equally strong; it would be thrown on each side alternately. Where there are high silt banks it should be thrown on the east side for preference, as the strong

west winds from February to June would blow the silt back into the channel. It should never be thrown on the **inner slopes of banks** or where it is likely to be washed back in to the bed. Advantage should however be taken of clearance to utilize all good excavated silt in repairing and improving the banks.

3. When general clearance are in hand, the Junior Engineer should particularly see that silt and rubbish are cleared from under the bridges.

4. As soon as a channel is closed for the rains or for any other long period, the bed bar should be uncovered and the depths of silt thereon reported to the Sub-Divisional Officer. I view of the latest theories of flow in alluvial channels, general silt clearance should only b done after preparing a long section of the silted bed and marking a proper bed slope.

5. If a channel is in good regime, is taking its full supply and is irrigating its allotted area it is not necessary to clear silt to the theoretical bed level and cross-section. If the channe is not doing its work properly, it may be sufficient merely to clear a portion of the silt t get it in to efficient working order, or it may be necessary to clear to the full theoretica cross-section. The Junior Engineer Incharge should ask the Sub-Divisional Officer in goo time to what section he conteplates clearing the channel, and should submit an estimate fo the work accordingly. Silt should not be cleared below falls but if outlets in such place are drawing more water due to a rise in water surface, they should be raised.

6. Tattis should be left at 30 Meter (100 feet) intervals for measurment, but they must b removed before the channel is opened. Boning rods should be used to see whether the si has been properly cleared.

Contractors are in the habit of leaving additional tattis at all intermediate theks other high places in the bed. When measuring up clearances Junior Engineer should tak care not to be deceived by such false tattis. A glance at the excavated silt will often sav Junior Engineers from overmeasuring.

7. Berm cutting should not be started until namunas have been cut, quantities estimate by Kilometers & Hectometers and the lines carefully lock-spitted. Berm silt is excelle material for banks repairs of all kinds, and the utmost advantage should be taken of it affact improvements.

8. Overhanging berms must be cut off at a slope of 1/2 to 1, else they will fall in when th channel is running. If lowered continuously 75 mm (3") below F.S.L. they will becan uniform next year. Such earth will be useful for repairing banks which are low or narrow.

9. Before starting work on either the bed or the berms of channel, they must be lined o with flags and string. The former are necessary for the alignment in general, and the latt to correct small irregularities, therein. Every opportunity should be taken to straighten o

the channel and to get rid of links and irregularities in the alignment also to ease off all curves where scouring or silting takes place.

10. Berms must not be dug into for earth with which to close watercourse,

M–Outlets

1. When two or more pipes have to be joined end to end to form an outlet, care must be taken that they meet accurately. To prevent their being lowered by cultivators outlets should rest on a concrete or masonry pillar at each end.

2. Great care must be taken that new outlets are fixed exactly at right angles to the line of the channel and at the correct level. The axis of the pipe should be truly hori zontal and 45 cm (1.5 feet) below the designed full supply level, unles otherwise ordered by the Sub–Divisional Officer. When the full supply depth is less than 50 cm (1.75 feet) the lower lip of the pipe should be fixed at bed level.

The site for the outlet should be chosen that the gul will run out straight and at right angles to the distributary or minor for at least 10 meter (30 feet) and then continue along the selected field mend.

When the mend runs skew to the distributary this will some times necessitate cutting off the acute angles of a field, but cultivators will not usually object to this. The gul should always be dug departmentally for the first 15 meter [50 feet] from the outlet.

3. When an outlet is abolished the gul should be levelled off for the first 15 meter [50 feet] of its length.

4. Guls should not be allowed to run along side of the bank of a Government channel and inside Government land.

5. Junior Engineer must inspect all outlet during the specified closure period and submit a certificate to the Sub–Divisional Officer as per Standing Order.

6. The size or depth of an existing outlet must never be altered without previous sanction. If the bank at an outlet is narrow because the outlet is too short, an extra length of pipel should be fixed with the approval of the Sub–Divisional Officer.

7. Outlet pipes must be fixed correctly as regards depth below actul F.S.L. straightness of pipe, horizontality and at right angles to the canal.

8. All outlets should be checked as regards position, size and correctness of fixing, as per roster fixed by Executive Engineer, and the monthly certificate of check submitted to the

Sub-Divisional officer regularly. Any outlet found fixed wrong should be corrected at once ane a report made to the Sub-Divisional Officer.

9. Outlet pipes should not be left lying about on the channels but should be carted to the nearest Inspection House as soon as a change in an outlet has taken place and pipes are found surplus there. They should be stacked nearly.

N–Jungle Clearance :

1. Jhunds must always be uprooted and not merely cut. The earth should be dustec from the roots to prevent them from taking root again when thrown outside, which they easily do, thus increasing the work of jungle clearance from year to year.

2. Jungle on canal banks should be cleared from 3 Meter [10 feet] beyond the shad line on the left bank to 1.5 Meter [5 feet] beyond the cart road on the right bank.

3. Jungle on distributaries and minors should, as a rule be cleared from toe to toe of th outer slopes of the banks. Kans grass, gundar, jhunds and small trees, especially dha should be dug out by the roots. Stumps of trees that have been sold standing should l cut down, to at least 3o cm (one foot) below the ground. Ant hills should be dug o and levelled off.

4. Jungle on escapes and drains should be cleared from the outer edge of the riding ba to the inner edge of the opposite bank.

5. Jungle and accumulations of silt should always be cleared from around Kilometer a Hectometer Stone to enable them to be seen from a short distance.

6. Grass growing against masonry works should not be scraped off as the masonry wc get damaged in the process, 75 mm (3 inches) of the bajri or fine brick ballast spread ro the masonry will prevent grass from growing up. Neither trees & tall grass, nor jungle of kind should be allowed within 7.5 meter (25 feet) of a masonry work. No pipal, g pilkhan or bargad tree should be allowed to grow within 25 meter (80 feet) of an impor masonry work, as the foots of these trees grow into the joints and damage the maso

7. Grass and jungle must never be allowed to grow on mansonry work. It should be out by the roots, and the masonry then pointed or plastered.

8. Slime and moss, which often coat masonry, should be carefully scraped off, care b taken not to injure the mortar or plaster in doing so.

9. Dried jungle and kabar should be burnt or used for compost, as it is liable to ge the channel and obstruct it.

O–Drains

1. Along drains the riding path is generally at the edge of the channel, and is 1.5 meter wide and approximately at country level, but sometimes it is on the top of the spoil bank.

2. Silt cleared from the bed should be used to fill up holes and ruts on the riding bank or spread out with an outer slope and in no case it should be thrown up in heaps such as to interfere with the tngress of drainage.

3. Drainage siphons must always be unwatered and examined in the hot weather b efore the rains begin, and a report on the condition of each submitted to the Sub-Divisional Officer for orders.

4. Percolation drains should also be cleared between October and December to allow of rabi sowings and to keep down the spring level.

5. Bed bars should always be uncovered by January 1, if possible, and estimates for bed clearances submitted without delay. Clearacnes should, as far as possible, be finished by the time the rabi harvesting starts, as it is very difficult to obtain labour once it has begun. Boning rods should be used to check bed clearances of drains.

6. Trees should not be allowed to grow on the inner slopes of drains.

7. All falls must be inspected during and after each monsoon, and any tendency for drainage to cut into a drain within 30 Meters of a fall must be immediately reported.

8. Just before the monsoon breaks, beldars should be sent along every drain to remove dead branches and rubbish that may have blown in during the hot weather.

9. No one should be allowed to put bunds in drains.

P–Inspection Houses

1. Inspection houses must be opened daily for at least an hour to air them thoroughly.

2. The roofs of all inspection houses and outhouses must be carefully examined before and after the rains. All rubbish is cleared off, and any cracks found therein are reported to the Sub-Divisional Officer and repaiared.

3. Furniture should always be kept clean and in good repair, punkha frills and durries neatly folded and put away when not in use, and the building generally kept clean, tidy and free from dust white-ants and cobwebs.

4. Before white washing is started in any room or verandah all furniture should be removed and the floor covered with sand, straw or old gunny bags. Stone mantel pieces, shelves, etc. should never be white washed.

5. Chick exposed to the weather should be removable and on the inspection house being vacated should be taken down, rolled up and stored away in the durrie box to be put up again when required.

6. A good furniture polish can be made up of equal parts of vinegar and linseed oil, or better still of vinegar and olive oil in the same proportions, as this mixture is less sticky than the former. A mixture of oil and water should never be used.

7. On the departure of visitors, Junior Engineer Incharge should see that the compound and inspection house, as also the stables, and out houses are at once cleaned, if necessary. All gharas, jugs, or other vessels should be emptied and kept mouth down wards until required again.

8. Wells should be cleared out as a rule about four times a year, and disinfected in July and October with permanganate of potash which the Sub–Divisional Officer will supply on indent. 25 GRAM [one ounce] should be mixed in a bucket with water and lowerd frequently in to the well till all the powder dissolves. The well should not be used for forty–eight hours after wards.

9. Thatched lean–tos must not be added to permanent buildings. Ventilator holes in outhourses should not be allowed to be closed up.

10. All jungle in the compound should be uprooted during the rains while the soil is soft. Grass should be allowed to grow, and indiscriminate grazing by animals belonging to officers' camp establishments or to other should not be permitted. The grass, when ready, should be carefully cut by beldars and stacked in the compound for use in cases of emergency.

11. All top and bottom bolts of doors and windows should be kept in order. Chair seats should be kept caned, Skylights should have a clean string and peg for tying, and purdhas should be clean and hung up properly with rings, Brass fittings should be kept shining.

12. Country beds should always be kept in repairs.

13. Door blinds, durries and niwar of beds should be washed once a year.

14. Inspection house rules, furniture list, and rules for canal roadways should be neatly framed and hung up in the main room of the inspection house.

15. Inspection house chimney should be tested against smoking by an actual fire in it on 15th of October each year and its flue cleaned if necessary.

16. Bathroom water should be carried by an open saucer shaped drain in to a soak–pit or a hedge and should not collect into a pool.

17. Apart from these items of annual attention, the following petty matters should receive regular weekly attention as on these depend largely the attractiveness of the place :—

[i] Regular cleanilines of the compound and precnicts of the house.

[ii] Regular sweeping inside.

[iii] Regular wiping [not dusting] of doors, windows and furniture.

[iv] Cleaning of window panes.

[v] Polishing all exposed brass work.

[vi] Regular dusting of durries, niwar beds, purdah and blinds.

[vii] Chicks or wire netting doors to be kept in order.

[viii] A few pictures to be neatly hung.

[ix] Copies of rules, lists of furniture etc. to be kept in frames and hung.

[x] Bath rooms, pantry and kitchen to be washed before and after occupation.

Junior Engineer should personally see that every Chowkidar or Patrol incharge of the Inspection House is at all times provided with [1] Dusters [2] Phenyle for item [x] [3] A bottle of "Brasso" [4] Soap for washing basins and cleaning panes of glass and [5] a pair ot sweepers baskets for taking Chamber pots etc. for cleaning.

Q–Ironwork And Woodwork

1. All exposed ironwork must be kept properly painted to prevent rusting. Ironwork that is liable to be submarged for any length of time, such as sluice gates and shutters, should be painted with anti–corrosive black enamel paint. For their ironwork, such as bridges, railings, and machinery, and for woodwork in buildings, such as the doors of out–houses and godowns, silicate paint of a selected colour should be used.

2. Rust must be carefully removed from the ironwork and the surface rubbed clean before painting.

3. All ironwork, if not to be erected at once, should be given a coat of paint when received and before being stored.

4. Coaltar should never be used on ironwork, as it does not prevent rusting. All paints should be supplied from Govt. stock, contractor being paid labour charges only.

5. The projecting screw threads of the lifting gears of sluices and gates should always be kept covered with hollow bamboo caps to keep them clean. Castor oil is a good lubricant for such screws.

6. Regulating planks should be made of sal wood for all important works, and of the best seasoned canal shisham or kikar for less important ones.

7. Planks must always be kept near the works for which they are needed, stacked on edge on masonry walls, built in the shade, if possible, and be occasionally turned to prevent their getting warped or destroyed by white ants.

8. Planks and exposed woodwork should be tarred with hot wood tar when thoroughly dry. The proper time to do the tarring is between 10 a.m. and 4 p.m. on a bright dry day and out in the sun. All regulator planks should be tarred at least once a year to keep them in good condition.

9. Where planks are apt to be stolen they may be marked with the initials of the division in 10 cm [4 inch] letters, careved about 12mm [half inch] deep into the sides of the plank.

10. Planks at head of off taking channels and regulators should be checked to see that they are complete in order. These should be painted with coaltar as and when necessary and properly stacked in row over walls at base. No plank should be left lying about carelessly.

11. Mechanical gates should be oiled, greased and put in to perfect working order. Expposed surfaces which have been recently painted should be occasionally examined and any patches of rust found should be repainted after removal of rust.

12. Junior Engineer in his section must maintain the Register of Trees [Plantation Register], where he shall have the record of name of tree with its chainage; its girth at 1.2 m height above the ground level. He must verify them physically every six months i.e. September and March of every year. Copy of this must be sent to Sub–Divisional & Division Office. Sub Divisional Officer must also verify the trees at site physically at least once a year.

Junior Engineer must maintain the register of trees in his section, where he shall have the records of name of tree with its chainage its girth at 1.2 m ht from ground dry or green we must check it every six month i.e. September & March of the year, copy of the yearlly record must be sent to Sub–Division & Division Office. S.D.O. must have the varification of trees, at site & counter sign in taken of cheeking once a year.

Sapling for fuel=1/16 C^2L Cubic feet

Add. for fuel =3/16 C^2L Maunds.

Sapling for fuel=3/2×1/16 C^2L Maunds

R — Plantations

1. When a reach of plantation is to be sold standing, some idea of the quantity of timber and fuel can be obtained by measuring the circumference [c] in 'M' at a height 1.2 meter [4 feet] from the ground and the lenght of hold [L] in 'M' of each tree, and apply the following formulae :—

Saplings for fuel $= C^2 \times L/23.77$ Cubic Meter

Ditto add for fuel $= 247.14 \times C^2 \times L$ kgm.

Saplings for fuel $= 61.785 \times C^2 \times L$ kgm.

2. When a tree is to be felled, a hollow should be dug round the base, and the trunk cut through as low down as possible, the hollow then being filled to cover the root.

3. Shade line trees must not be felled without special sanction.

4. All fallen or dead trees should be immediately reported to the sub Divisional Officer and his orders taken whether they should be stored for use at the nearest workshop or inspection house or sold by auction.

5. Pruning, if done at all, should not be carried out with axes. The branch should first be sawn about half through on the under side and then completely through from the top, so that the bark may not be torn off. It should be done in February just before the sap begins to rise.

6. No trees, not even kikar, should be sown nearer than 4.5 Meter apart. But if any have been sown more thickly they should be thinned out to in-terval of about 4.5 Meter when 3 Meter high or so. If timber trees have grown up close together they should be thinned out to intervals of from 10 Meters to 15 Meters according to the size of which the trees grow.

7. Trees that grow to a large size, such as mango, mahwa, jamun, teak, etc., should be put down at from 12 Meter to 15 Meter in-tervals from the start. Fuel trees can be grown in between to make full use of the land and thinned out later.

8. Sowing should commence on June 1 and be finished by the middle of the month, so as to get the full benefit of the rains, but if irrigation is available the best time for sowing is early in March, before the new leaves appear.

9. In low ground liable to flooding, seeds should be sown on ridges.

10. The roots of seedings should not be cut nor broken when transplanting. They should be dug out with a good ball of earth adhering, and so carried to the new site. If grown in

pots, like eucalyptus, etc., the roots are sure to be pot–bound. In such cases the pot should be carried to the new site and the seeding roots bared of earth and straightened down into the holes dug for them. This greatly facilitates their subsequent growth.

If the new "root and shoot" method of transplanting is adopted, when the seedlings are 75 cm to 90 cm (2½ or 3 feet) high, their roots are cut off one foot below and their stems 6 cm (2 inches) above ground, and they are planted out direct in to the shade line or plantation in February. If kept watered in summer these would be estabilished during the rains.

11. The parastie plants amarbel and banda should be removed at sight, carried to an open space and there burnt. If the tree is completely covered by the parasite, it is better to cut it down at once and burn the parasite on the trees.

12. Branches and twigs overhanging a bank or roadway should be sawn or lopped off sufficiently to give a clear headway of 3 Meters above the road or bank.

13. Young plants should not be cut in the shade line until they have attained a height of atleast 1.2 Meter. It is better to loose a few plants by their being rather too large for transplanting than to undertake the nursing of small seedlings in the shade line.

14. All large roots found in the plantation should be taken out during the rains and burnt into charcoal when dry.

15. Internal diameter of all earthen thamlas should be six feet to give sufficient light space and air to the young Plant for its growth. Thamlas round nature trees should be levelled and converted into earthen platforms round them.

16. Inspection houses should have good quality of ornamental, fruit and shade trees according to a plan approved by the Executive Engineer, as also boundary and roadside bedges.
17. Seeds should be collected or obtained before June and nurseries restocked at the break of rains for next years use.

18. Detailed inspection of shade, lines must in future be considered as a weekly duty of Junior Engineers. Beldars should have clear instructions explained to them and written in their Task book on what is to be done and Junior Engineers should see that these are complied with closely. A few of the important points to be done in mind are given below : –

(i) All newly planted trees and also those which are less than 2 meter in height should

be properly protected by new guards 1.0 meter in diameter and 1 meter high made from the earth taken from the trench (as shown in sketch).

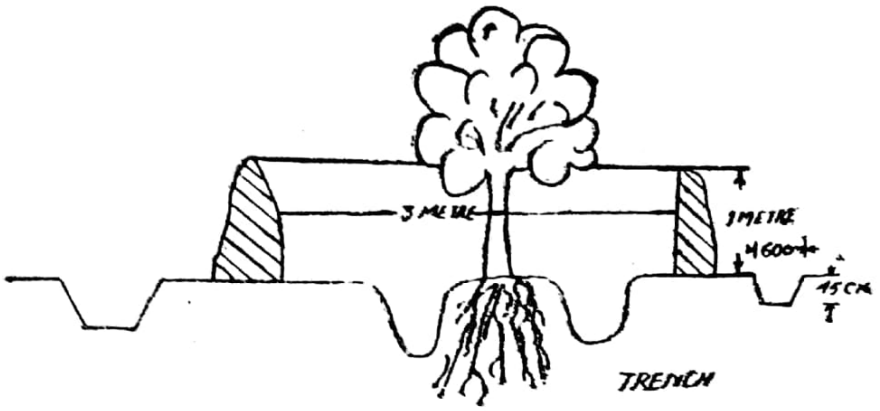


FIG.NO. 19

(ii) The old mud guards must be repaired properly where necessary and all grass, jungle and 'Kans' weeded out from the bed and surface of the thamlas.

(iii) There should be a hole at the bottom, enough to allow rain water to be drained off.

(iv) The small trees should be all erect and not leaning side-ways. Where necessary, a prop should be used for the purpose.

(v) There should be no double trees in any thamlas and branches taking off near the roots or lower down should be lopped off carefully to enable the plant to rise to its full stature.

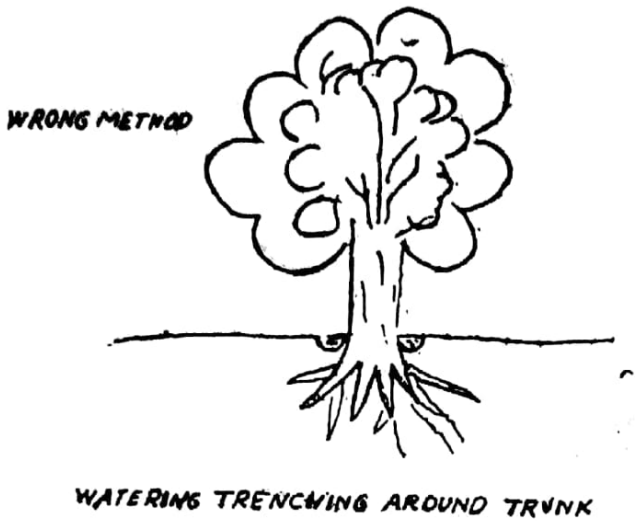
(vi) Newly planted trees must be watered regularly but not to excess and the top soil loosened soon after watering.

(vii) Established plants which have only been less than two years on the shade line require to be given similar treatment though not so often.

(viii) Large trees should not be given useless attention. They are well able to look after their own nourishment and giving them a bucketful of water is shear waste. A good heavy watering of 5 or 6 bucketfuls about once a month only in the very hot weather is about all that is necessary for trees of medium growth; and even so, the very big and established trees don't even need this attention.

(xi) Watering of trees should be give in ring treuches made away from the trunk. As

the tree grows the trench should be taken further away from the trees so as to lie over the root development where the water is required.



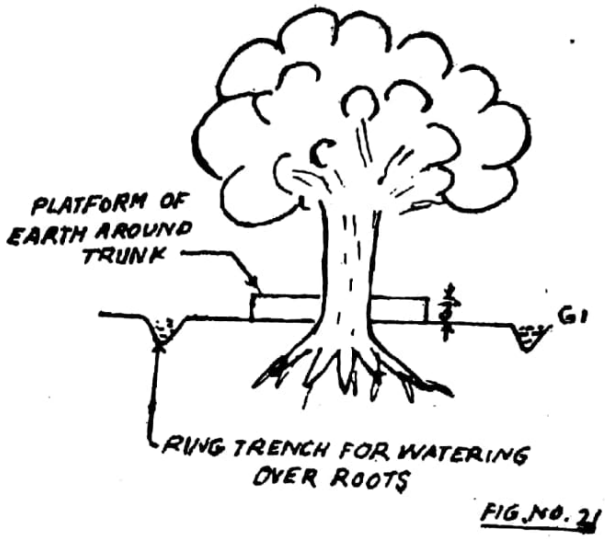


FIG.NO 20

[x] All trees should, however, be carefully watched and any bad effects noticed should be immediately attended to.

S–Regulations

1. No leakage should be permitted throught the heads of channels that have been closed' as a little water dribbling down a channel promotes the growth of grass and weeds in the bed. It is not always necessary to use erath for closing heads; grass, bhusa or weeds packed between the planks and in to the grooves will often be enough practically to stop the leakage.

When earth is used it must not be dug from the berms or banks but from outside.

2. When a channel is first opened after clearances, a low supply should be run, for a few hours at least, and the gauge then gradually raised according to requirements.

3. For regulating supplies to them' distributary heads should be planked up from the bottom so as to keep out silt. If the head has two or more bays, an equal number of planks should be kept in each.

4. On demand suddenly ceasing, channels must not be closed without orders. Their supplies may be lowered to three fourths and the remainder got rid of opening escapes and qulabas and running it off into tanks or banjar land.

5. No regulator should be planked up higher than is necessary for regulation, or kept planked up after the necessity no longer exists.

6. The staff in charge of a canal regulator or distributary head should always have written instructions about the gauges to be run, the maximum and minimum permissible being clearly stated therein. Gauges must not be altered without written orders.

7. A line marking the full supply level should be painted on the upstream face of every masonry work, if this is not already clearly indicated by the design of the work

T–Masonry Works

1. All masonry works must be maintained in proper repeair and in sound condition. Any damage noticed in these works must be speedily rectified. Special care must be taken to see that the repair work is kept wet for 10 days. Hence such repairs should be done in rainy season.

2. There should be no grass growing near the parapets or wings of bridges and falls which should be kept scruplously neat and tidy.

3. Metalling over bridges and earthwork in both cart road and driving road ramps should be complete and well consolidated every where.

4. Wheel guards should be fixed in the line with the straight protion of the parapets.

5. Cart ramps over bridges should be at right angles to the canal till they are 1.5 meter (5 feet) from the edge of the banks on driving road. Most of the damage to bridge parapets, canal banks and driving road is the direct result of wrongly aligned ramps. Any deviation necessary to pick up the cart track, should be made from beyond this point.

6. Side and bed erosion below falls caused by wave action should not be neglected. Pitching should be laid after filiing the earthwork to the proper section giving the proper berm. The pitching should be 30 cm(1 ft.) above the F. S. L. in 1½ to 1 slope.

Tail falls of all channels should be of the same crest type with 45 cm (1.5′) height above bed level and the allotted ventage holes kept at bed level. The guage should be fixed on upstream side of the tail wall with zero at bed level.

U–Establishment

1. Subordinates should attend the camps of officers inspecting in their sections, and should not leave without first obtaining permission from either the Executive Engineer or Sub-Divisional Officer.

2. The daily reports of Junior Engineers should mention the state of the demand of water in their sections, the readings of all gauges passed in the course of their inspections, with a note whether they proceeded along the right or left banks of the channels. It should also give the distance travelled, condition of supplies at tails, number of labourers on works, and results of discharges, if any, were observed.

3. Junior Engineer must observe discharges of all channels in their charge once a month, and should take discharges of "nadis" and drains during high floods.

4. Junior Engineers must always have their note-books and tapes with them on inspections, and when attending an officer in office.

5. Junior Engineer's note-books should contain the foilowing particulars relating to their sections :

(i) Depth of water, bed and berm width, land width and bed slope of every mile of their channels, together with the mileage, waterway, and important reduced levels of all masonry works.

(ii) Maximum gauges and head discharges.

(iii) Abstracts of local rules regarding regulation and escaping.

(iv) A list of "qulabas" showing their diameter.

In addition they should have a "qulabas" note-book showing irrigation done by each outlet during the last five year.

6. Patrols must always wear the prescribed coat and badge and carry about with them their "ghattas", "roznamchs", "khasras" and "qulaba bahis", and the "shajras" of villages where irrigation is to be written up.

7. Patrols must inspect the channels in their sections every morning.

Each patrol must be provided with a "panch foota", fitted with a double iron hook for removing "kabar" or rubbish from the channels. He should always carry this with him on his daily rounds.

8. Every patrol should be supplied with some sort of a note-book containing orders about gauges, regulation, closures, etc. The book should also contain a list of the planks and tools and plant for which he is responsible.

9. On the occurrence of a breach, the canal official who first sees it or hears of it must at once take measures to close it. If the breach is likely to get beyond his ability to close, he must send off a report immediately to the Ziledar and the Junior Engineer and also one direct to the sub-Divisional Offecer asking for help.

V - General

1. When a Junior Engineer is transferred, all the measurement books, note-books, standing orders and regulations, "mauqawar" stock and tools and plant registers, stock and tools and plant receipts, longitudinal sections of channels, plans of works in hand, copy of "Instructions on repairs", etc. in his charge must be handed over to his successor, a receipt for the same being submitted to the Sub-Divisional Officer

2. All local rules about regulation, action to be taken at any masonry work during floods etc , should be printed in English or Hindi, neatly framed and glazed, and hung up in the nearest inspection house, a copy being kept by the Junior Engineer and another (in Hindi) by the man in immediate charge.

3. A contractor is entitled to receive from the Sub-Divisional Officer a signed work order for every contract entered into with him; should this not be received within a week of the contract being given out, the Junior Engineer should obtain it from the Sub-Divisional Officer and hand it over to the contractor.

Sub Divisional Officers should give out contracts themselves and not leave this work to the Junior Engineers otherwise there will be confusion and it may cause disputes.

4. Junior Engineers are responsible that the terms of a contract are strictly enforced, and that nothing is done tending to nullify or vitiate it. All correspondence between subordinates and contractors should be headed 'Without prejudice' and copies sent promptly to the Sub-Divisional Officer.

5. The Junior Engineer is responsible that all works in his charge are carried out in workman-like manner and according to instructions. He should have, any defects noticed, removed by the contractor at once, and if the latter is not carrying out instructions or the progress is slow, he should report the matter promptly to the Sub-Divisional Officer.

6. Final measurements of works should be recorded within a week of their completion. If a work is not finished by the date given in the work-order, the Sub-Divisional Officer should be informed and an explanation for the delay submitted.

7. Verbal orders should be entered at once in a note-book, which should be initialed by the Sub-Divisional Officer. If this cannot be done, a report should be submitted to the Sub-Divisional Officer, for confirmation in writing.

8. Longitudinal sections must always show the R.L 's of the bench marks from which the levelling was started and on which it finished. The leveller's name and the date should be entered in the left lower corner.

W - Miscellaneous

1. To synchronize with the observations of the Meteorological Department, the rain-gauge of each day should be recorded at 8 a.m. on that day, and the gauge tube then emptied. If unusually heavy rain is falling a second reading should be taken later on in the day or else the gauge tube may fill up and overflow. This second reading must be added to the next morning's reading included in the rainfall for that day.

2. Rain-gauges and gauge tubes should be tested with water in May and December, and if found to be leaking they must then be repaired or renewed. All gauges should be repainted annually.

3. Enamelled iron gauges should be fixed to their wooden supports with brass screws, as iron nails and screws get rusted.

4. Levels and theodolites when not in use must be kept in their boxes, and carefully cleaned and dusted. The boxes should have quilted covers and newar straps for easy carriage They must not be carried on carts in any circumstances

Any damage to an instrument or any defects noticed in its adjustment should be reported immediately to the Sub-Divisional Officer. Junior Engineers are responsible for the condition of the instruments in their charge.

A detailed list of the contents of each box should be pasted on the inner side of the lid. A level should never be separated from its stand. If the instrument is broken or out of order it should be scnt with its stand to the Svb-Divisional Officer.

5. The Junior Engineer is entirely responsible for all stock and tools and plant in his charge and that his "mauqawar" registers are at all times correct and up to date.

Stock must be kept neatly stacked and clear of jungle. The stocks should be large and of uniform dimensions to admit of easy checking.

Spare bricks, pipes, stones or other building materials must not be left lying about on channels.

No stores nor tools and plant should be issued to contractors without written orders from the Sub-Divisional Officer and without obtaining unstamped receipts for them from the contractors.

6. In the execution of works, every care should be taken that the safety convenience of the public are duly attended to, and that all operations are carried out in such a

manner as to interfere as little as possible with everyday traffic. Wnere a public road has to be closed and a diversion made the contractor should be made responsible that a redlamp is kept burning all night on the barriers closing the road on either side of the work.

7. The Junior Engineer in charge of work must report immediately to the nearest police station, as well as to the Sub-Divsional Officer and Executive Engineer, in the occurrence of serious accident, and in the case of a deatn on the spot, the body should not be removed without the premission of the police.

8. No work should be commenced on land that has not been duly made over to this department by the responsible authorities.

9. All Kilometers, Hectometer and boundary-pillars should be kept in proper order. Displaced boundry-pillars should be re-fixed only after reference to the land plan, with which also land width should occasionally be checked at site.

Letters and numbers on Kilometer, Hectometer and boundary-stones, names or year-plates of bridges, falls and inspection houses, etc. and roadway notice boards should be painted witn Enamel paint. The use of tar for such purpose is strictly forbidden.

All Kilometers, Hectometers and Boundary stones must be clean. Jungle must be removed from front sides of the stones so that they are clearly visible. Damaged stones should be replaced immediately.

10. The following instructions should be followed for the prevention of malaria near cantonments and military areas :

(1) Sluice gates and planks at heads of channels should be kept water–tight when channels are kept closed.

(ii) Seepage from canal should be drained off,

(iii) The instructions laid down under G-Earthwork should be carefully followed. Borrow pits in bed in the rainy season during the long clousers and borrow pits in parti land near habitations should be prohibited with in a kilometer, in cantonments and other military areas.

(iv) Wastage of water into depressions and hollows within a kilometer of cantonments and military areas should be prevented and measures indicated in paragraph 152 (32) (a) (3) and sub-paragraphs (9) ,(27) , (30) and (31) of paragraphs 153 of the Irrigation Manual of Orders should be strictly enforced to stop such wastage and

(v) Areas within a Kilometer of all cantonments and other military areas should not be supplied with canal water for rice-irrigation.

11. **Bed Bars :**

(i) Bed bars should be examined to see that they are intact and clearly visible. The' serve no useful purpose if they are allowed to be buried and hidden in silt.

(ii) They should be repaired where needed in cement mortar and no loose brick: should be left lying in the bed, on bank or on service road.

12. **Chaining and Levelling :**

(i) All Junior Engineers should measure length only by use of metallic or steel tap and lengths in levelling work by use of 30 meter long Guntur chains.

(ii) Junior Engineers while doing level work should use levelling instruments properl and record the readings for fore sight, back sight and intermediate sight taken on levellin staff properly on level book in ink. All levelling must be started from a bench mark and clos ed on same bench mark. The check for levelling work on each page of the level book i.e "difference in fore and back sights equal to difference in levels" may be got done by junic engineer himself and subseqently by another junior engineer. This is a must for corre chaining and levelling work.

2. **Laying of the well curb :**

The well curb is laid in 1 : 2 : 4 reinforced C. C. at 15 cm (6") above the spring lev as per type design of the pump house. A form is made in mud masonry, inner sides whicn are plastered with cement mortar 1 : 10.

3. **Sinking of the well :**

Sinking of the well should be done after allowing setting time of at least 14 days the well masonry built above the curb. Care should be taken to take out the earth or from the centre of the well to avoid unequal sinking. Verticality during sinking should ensured by means of four plumbs to be hung on the outside of the steining diametrica opposite one another.

4. **Plugging of the well :**

After sinking of a well has been completed plugging of its bottom should be done two layers with still water standing in the sump. Before laying concrete the bottom sho be well levelled.

The ingredients should first be mixed dry and just sufficient quantity of water adc so as to enable the mixture to be made into a ball without giving out water on squeezi

The concrete should then be laid by filling it in gunny bags which should then be lowered, one by one, in water and opened at the bottom without disturbing the water. The laying should be started from one side and proceeded till all the surface is uniformly covered. This should be ensured by taking soundings while the laying is in progress and on completion by sending a diver down to feel with his feet, whether the top of the concrete is even and in full contact with the steining and the bore pipe. Any gap left over should be filled.

The concrete should be allowed ten days to set without disturbing the water inside the sump. This is important. After ten days water should be bailed out and the top surface cleaned with wire brushes and water allowed to rise to its full-level. Second layer of richer mix should then be laid uniformly as before.

To ensure proper bond of the concrete with the steining, inside of the steining should not be plastered up to the height to which the plugging is to be done.

5. Repairs to leaking plugs.

Old concrete may first be removed to a depth of 15cm (6") provided it does not result in a very excessive leakage in which case new concrete will have to be laid on top of the old one, after cleaning its surface and allowing the water to rise to its highest level. Thickness of new concrete should not be less than 15cm (6") and its mix not leaner than 1:1½:3.

6. Borehole wells.

The boring pits should be completely filled in with earth in layers of not more than 15cm (6") each layer being well rammed and watered before the next is begun. This is important in order to prevent any settlement of the earth after the foundation of the pump-house have been laid on the made earth.

7. Repairs to the lined gul.

Lined guls are generally of two types : (i) brick lining 75 mm (3") thick and (ii) through lining of 40 mm (1½") thick cement concrete 1 : 2 : 4. The former type is to be preferred.

The Junior Engineer should attend to the repairs of guls promptly otherwise the damage will extend further.

The earthen sides of the breach should first be cut in steps 15 cm (6") high and the breach closed with earth rammed in layers of 15 cm (6") thick and well soaked with water. The brick lining should then be repaired. Care should be taken to clean the existing masonry to ensure proper jointing between the old and new work.

All outlets taking off from the lined guls should be made according to the type design. Crest of the cistern should be kept at the same level as the bed of the gul.

8. Repairs to un-reinforced cement concrete pipe lines of 30 cm (one foot) inside diameter.

The pipe lines leak from defective joints or cracks in the pipes or some times bursts occur due to water hammer when the length of the pipe line is excessive. To repair the leakages from the joints the earth at points where the leakages have been noticed is dug out. The collars at the joints are broken and the joints of the pipes are cleaned with iron brushes. Forms are then made under the joints and mix of 1 : 2 : 4 cement concrete is filled in them from one side until it comes out from the other side. Concrete is then laid over the joints so as to make a complete collar. The thickness of the collar should be at least 50 mm (2") to ensure water tightness.

Cracked and burst pipes should be replaced by new ones. In such cases hemp soaked in cement mortar 1:2 should be wrapped all round before a cement concrete collar is made all around the joints.

After repairs, the pipe line should be given seven days to set. It should be tested by the Junior Engineer before covering it with earth.

9. Gul culverts.

These are built of 30 cm (one foot) diameter un-reinforced cement concrete pipes with proper cisterns at both ends The pipe should always have at least 30 cm (one foot) earth over them to provide good cushion against damage by a truck.

The village road culverts should be as wide as the road itself with a minimum width of 3.6 meters (12 feet) between the cisterns.

On both sides of the gul culverts 4.5 Meters (15 feet) length of gul should be lined.

10. Survey

Whenever survey of the command for a State tube-well is ordered the Junior Engineer should take the levels at every Hectometer along the main water sheds and then take cross section levels at every two Hectometer intervals, so as to be able to contour the area. When survey is done for aligning a gul the levelling should be done along the watershed right up to the end of the command taking cross levels up to one furlong on either sides. All levelling must be connected to a reduced level.

11. Land plans

For acquiring land for service roads, lined channels and tube-well compounds the Junior Engineer should prepare plans after careful alignment and accurate measurements at site. Land to be acquired for service road should be 3.6 meters (12 feet) in width and

in special cases it may be 4.5 Meters (15 feet). For lined channel average width of land should be 3.6 Meters (12 feet). For the tube-well compound, a square plot 25 Meter x 25 Meter (80' x 80') should be acquired.

12. Fitting insida the pump house.

All electrical fittings inside the pump house and installations of the pumping set are to be done by the supervisor. The cubical or M.E.M. switch and the meter inside the pump house are the property of the electricity department and will be installed By them.

As soon as the pump house is ready, the Junior Engineer will get the supervisor concerned to mark the height of the foundation for the pumping set and will take immediate action to construct the foundation.

13. Tube-well service roads.

They should be aligned along watersheds as far as possible so that they may be possable during the rains as well. Sandy or bhur reaches and waterlogged places should be avoided.
All earthwork on roads must be done during the rains.

No borrow pit shall be made within 5 feet from the edge of the road. In case of light and usar soils. the service road may run at the ground level. In sandy reaches the road level should be kept somewhat lower than the country level in order to catch moisture and enable grass to grow.

At village road crossings, the service road should be brought down the level of the village road with an easy gradient.

At gul crossings the level of the service road should not be raised but if this is necessary, proper ramps shou d be made on both sides.

Tube well subordinates shou'd see that no encroachment is made by cultivator on land taken up for service roads or pucca guls.

Cutting of service roads by cultivators for taking water across is not to be allowed.
Barhas along the service roads should not be permitted.

To prevent unauthorised traffic over the service road and for the care of pucca guls and the tube-well in general it is necessary that the tube-well operator should live all the year round in a village near the well, the Junior Engineer should see that he does'

Measurement and Calculation of Discharges

Section I – General instructions

1. The discharge of a channel at any point is given by the cross-sectional area multiplied by the mean velocity. The first factor can be obtained by direct measurement, and the mean velocity is usually arrived at by observations in one of the following ways :—

(1) with velocity rods;

(2) of the slope of the water velocity;

(3) of the maximum surface velocities;

(4) of a series of surface velocities;

(5) with the current meter or pitot tube;

(6) of sub-surface velocities;

(7) of the depth of water passing over a broad crested weir.

(8) of the depth of water over the throat of a standing waive frame;

2. Captain Cujningham at Roorkee arrived experimentally at the following conclusions :—

"The actual velocity of a floating thin vertical rod reaching from the surface nearly to the bed, is very nearly equal to the mean velocity of the vertical plane in which it moves."

3. Discharges of canals and distributaries should be taken by the velocity rod method wherever practicable. In rivers, however, it is nearly always impossible to adopt this method on account of the difficulty of mooring boats in position of the depth of water necessitating unmanageably long rods, and of small irregularities in the bed making it impossible to run rods of the proper length Other methods of arriving at the mean velocity, there fore, have to be employed and the two most satisfactory have been shown by experience to be by calculation from the water surface slope and by observation of a series of surface velocities.

4. The measurement of the surface slope is a delicate operation, It should therefore only be used as a check, as the direct observation of a series of surface velocities is comparatively simple. High flood discharges, however, can often best be measured by the surface slope method.

5. Discharges of rivers and main canals and large branches should, whenever practicable, be taken jointly by two officers.

6. Discharges should only be taken in calm weather. If a slight breeze is blowing, its direction relative to the stream should be noted.

7. The gauge should be read immediately before and after the observations are made, as any appreciable fluctuation during the taking of the discharge will vitiate the results. The mean of the two gauges should then be taken.

8. In the case of distributaries and minors the actual depth of water on the silt should be measured and recorded, so that the depth of the deposit may be known.

9. The fall in the water surface between points 300 M. (1,000 feet) above and below the discharge site in the case of rivers and main canals should be observed with a level. The sine of the surface slope thus ascertained should be recorded.

10. For each velocity taken with rods five observations should be made, and for each surface velocity taken with floats eight or ten observations are required.

11. The floats or rods should be dropped in to the stream at such a distance above the discharge site that when they reach the beginning of the run they are moving at the average velocity of the surrounding water.

12. Only rods or floats which run free and parallel to the main direction of the stream should be recorded. Differences in the timings are, however, to be expected, and do not necessarily indicate that the observations are incorrect.

13. Wooden discs about 10 cm (four inches) in diameter and 12.5mm (half an inch) thick are sometimes used for floats They can also have a small hole in the centre through which a piece of white tape is passed, which renders the float easily visible.

14. The standard pattern of velocity rod consists of a hollow cylindrical tube of sheet tin, about 25 mm (one inch) in diameter, the lower portion being loaded with a short lenght of rod iron, fitting tight into the tube and of such a length that its weight submerges the rod to the desired depth A length of 50 or 75 mm (two or three inches) is left projecting out of the water, and the opening at the top is sealed with a disc of sheet tin to which is attached a small graphel of iron wire for picking up the rod out of the water. The rod is painted black, a ring of red paint marking the depth of submersion. A later type now much into use is the telescopic type. This is more convenient than the standard one as fewer rods are required.

15. Standard rods are made up in sets of from 4 to 8 of each lenght required from 3o cm

(one foot) upwards, increasing by 7.5 cm (three inches) at a time for short ones and by 15 cm (6 inches) for long ones. When not in use. care should be taken to prevent them from getting bnet.

16. In taking croes-section the soundings should be taken at the following intervals :—

Surface width	Intervals of soundinge
Under 3 Meter (10 Feet)	30 Cm. (1 Foot)
From 3 to 15 Meter (10 to 50 Feet)	60 Cm. (2 Feet)
From 15 to 30 Meter (50 to 100 Feet)	1.5 Meter (5 Feet)
From 30 to 45 Meter (100 to 150 Feet)	3.0 Meter (10 Feet)
Over 45 Meter (150 Feet)	6.0 Meter (20 Feet)

A sounding should also be taken at the foot of the side slope of the channel.

Soundings should be taken, whenever possible with a rod divided into Meters and Centimeters (feet and tenths of a foot). The rod is provided with a disc at the foot to prevent its sinking into the silt.

17. The best form of rod is a steel bar about 12 mm diameter, as it obviates a reading higher than the actual owing to the heading up of the water on a layer section in wood.

Where water depth is too deep for rods, soundings are taken with a sounding line.

18. Timings should be taken with a stop watch reading to fifths of a second, but if this is not available, an ordinary watch with a seconds' hand may be used.

19. All river discharges should be promptly reported to the Superintending Engineer, a copy of the detailed calculations with explanatory diagrams accompanying the report.

Section II-Discharge of Rivers

It is not possible to lay down precise instructions as to how the discharges of rivers should be measured owing to the varying circumstances of each, and so much has to be left to the discretion of the observer. The following instructions are intended as a general guide.

1. There are three general cases, of which only the first and the last are dealt with here :—

   a) When the river-bed is stable and surface velocities can be taken by actual observation.

b) When the bed is stable, but in one or more sections the current is too strong to permit surface velocities being taken by actual observation.

c) Large rivers in which the bed is of shifting sand.

In all cases a reach of nearly uniform section and as straight as possible should be selected.

2. Case (a) - When the river bed is stable and the velocity not too high :—

1) Before the flood comes down, mark by posts or mounds of earth three parallel lines 30 Meter (100 feet) apart at right angles to the stream at the selected site.

2) Level along the centre line so as to obtain an accurate cross-section of the bed, extending well beyond the highest known flood, and connect the level readings with a permanent bench mark.

3) Construct and keep ready a raft sufficiently buyoant to support two or three men. The raft should be supplied with a cheap form of anchor, a couple of towing lines, and a bamboo pole.

4) Note beforehand the lines of probable maximum velocity down which the floats will have to pass.

5) When the flood comes down, the water surface should be connected by levelling with the permanent bench mark, and drawn on a diagram previously plotted from the levelled cross-section. The section of the stream thus obtained should then be divided into suitable sections, according to the variations of the depth. The depths themselves may later on be worked out from the previously levelled profile.

6) The surface slope should be observed at the same time.

7) The raft should be launched well above the point of observation, and be paddled out into the stream until it comes on to the first line down which the floats have to pass. It should then be allowed to drop down until within a convenient distance of the first rope, when the anchor is let go. Then by a few trial floats thrown out on either side the line of maximum velocity will be found, down which the requisite number of floats should be passed and accurately timed. This operation having been repeated for each section into which the stream has been divided, the maximum surface velocity for each section can be obtained.

8. The mean velocity of each section will be found by multiplying the observed surface velocity by the co-efficient given in Table A in next page corresponding to the hydraulic mean depth of that section.

The wetted perimeter in each case is the length along which the water is in contact with the bed and sides.

9) The partial discharge is found by multiplying the area of each section, as obtained from the plotted cross–section, by mean velocity of that section. The sum of these products is the total discharge.

10) It will be found advisable to practice the men who are to work the raft prior to making observations.

Table – A

Value of Ct for Earthen Channels for different value of R (from 0.15 Meter to 3 Meter) - value of Ct.

Value of R in metres	Value C (for earthen channels)		
	N=0.020	N=0.0225	N=0.0250
0.15	0.695	0.670	0.646
0.175	0.703	0.677	0.654
0.20	0.711	0.686	0.663
0.225	0.719	0.694	0.671
0.25	0.724	0.699	0.677
0.275	0.729	0.705	0.683
0.30	0.734	0.710	0.688
0.35	0.741	0.717	0.695
0.40	0.746	0.726	0.705
0.45	0.752	0.729	0.708
0.50	0.756	0.733	0.712
0 60	0.763	0.741	0.720
0 70	0.768	0.747	0.727
0.80	0.772	0.752	0.732
0.90	0.776	0.755	0.735
1.00	0.780	0.759	0.739
1.25	0.787	0.767	0.747
1 50	0.791	0.771	0.752
1.75	0.795	0.776	0.757
2.00	0.798	0.779	0.760
2.50	0.804	0.786	0.765
3.00	0.806	0.787	0.769

Note : The table to be employed should be as follows :—
N = 0.020 for very smooth earthen channels in very good regime.
N = 0.0225 for average Canal Channels.
N = 0.0250 for rivers and channels in bad regime.
An example of a discharge worked out on the above system is shown in Page 51.

Sample Discharge Calculation For An Irregular Shaped Channel

Sl. N.	CHANNEL "A"			CHANNEL "B"			CHANNEL "C"			REMARK
	Time in Sec. by Float			Time in Sec by Float			Time in Sec by Float			
	Arrival	Dep.	Sec.	Arr.	Dep.	Sec.	Arr.	Dep.	Sec.	
1	0	78	78	04	103	99	0	85	85	Note:– (i) Time observed is for a Run of 60 m. Length. (ii) The value of "N" Rugosity co-efficient is assumed to be 0.0225
2	10	87	77	13	108	95	10	94	84	
3	20	100	80	23	119	96	20	107	87	
4	30	109	79	34	132	98	30	116	86	
5	39	117	78	45	144	99	39	123	84	
6	05	82	77	06	103	97	51	136	85	
7	15	93	78	15	111	96	05	92	87	
8	24	101	77	26	125	99	16	102	86	
9	35	113	78	37	132	95	25	109	84	
10	47	127	80	47	144	97	36	121	85	
Total			782			971			853	
Av, Surface Velocity.			78.2			97.1			85.3	
Area of channel Section in Sq.m "A"			41.806			14.029			21.879	Cross-Sectional area may be calculated by soundings.
Wetted Perimeter "P" in m.			31.212			24.536			26.329	
Value of "R" $= \frac{A}{P}$ in m			1.339			0.5717			0.8309	Coeff "Ct" is calculated from Table "A" for the value of R in m. calculated
In m Coeff. "Ct"			0.7814			0.7387			0.7532	
Discharge Qin cumecs = V × A × Ct			25 065 cumecs.			6.403 cumecs.			14.591 cumecs.	

3. Case (c) Large rivers with beds of shifting sand :-

(1) Mark out the intended iine of the section by flags on opposite bank, and measure a convenient base line exactly at right angles to it on one bank. Place a theodolite at each end of the base line, the telescepe of the one placed at the intersection of the base and section being directed along the section line. The boat from which soundings are to be taken is pulled out and dropped gently down across the section line. When the e sounding rod crosses the hairs of the telescope directed along the section line the observer at the telescope gives a signal, and the sounding is taken. At the same moment the observer at the other theodolite, who has been following the movements of the boat with the telescope cross hairs directed on the sounding rod, read the angle, which thus fixes the position of the soundings.
This process is repeated until a sufficient number of soundings is obtained for and accurate plot of the section.

(2) For taking velocities, anchor the boat near the shore some distance above the cross section line. Floats started from it are followed by the cross hairs of the theodolite below the section. When the floats cross the telescope fixed along the section line, a signal is given, and the angle fixing the position is read on the lower theodolite At the same time an observer at the centre of the run notes the time of crossing the section line.
Similarly, when the vernier reading shows that the floats are crossing the line parallel to the section line at the other extremity of the base a frther signal is given, and the time of crossing the lower and of the run is noted by the observer in the centre.

(3) In order to obtain the sounding and velocity measurements at approximately equal distance across the section, it may be advisable to place a few buoys at nearly equal distances apart across the stream and some 15 Meters (50 feet) above the section. These can be dropped from a boat directed by signals from the shore.

(4) From the date obtained as described above the section is plotted and a velocity curve constructed, from which the areas and surface velocities in 6 Meters (20 feet) sections across the stream can be computed. Ths remaining calculations for the hydraulic mean depth, mean velocity, etc. are then worked out as dscribed under case (a).

(5) This method of measuring a discharge requires two observers at the lower theodolite, one at the upper, a time-keeper in the center of the run, and an intelligent boatman As the observer and other engaged in such measurements require some training before reliable results are obtained, a few practice discharges should first be taken. The table "B" will be found useful in working out the area of cross section and wetted perimeters of the channel.