

SPECIFICATION NO. 19.1—Canal Lining (General)

done or gharas are formed due to rainfall etc., these shall be treated in the following manner :—

If the depression is 2 inches (5 cm.) or less, it shall be filled with stabilized mud plaster with 5 per cent admixture of cement. If the cutting is more than 2 inches (5 cm.) it shall be filled with mud concrete and shall be properly tamped to give a uniform compact base. The earth-work dug from lip-cutting shall be used for the construction of the dowel, completion of unfinished banks and outer slopes. In cutting reaches, the earth work of lip-cutting shall be used for either widening or raising the spoils as may be directed by the Engineer-in-charge. The rate of lip-cutting shall include excavation of bed and side slopes, and rehandling of earth and its subsequent replacement on banks, side slopes or the spoils as the case may be.

Preparation of
sub-grade.

6. The sub-grade shall be perfectly true in profile as per cross section of the canal and according to correct levels longitudinally so as to form a firm compacted bed for the lining. To ensure correct formation of the sub-grade, 12 inches (30 cm.) wide profiles shall be dug true to the bed levels, and side slopes at 25 feet (7.5 metres) interval longitudinally.

Tiles shall be fixed in this profile at 10 to 15 ft. (3 to 4.5 metres) apart so that the top surface of the tiles is flush with the designed formation level of the sub-grade. The tile "nishans" will facilitate the laying and checking of final finish of the sub-grade and the lining. While dressing the sub-grade, no extra cutting shall be allowed or accepted. In case any extra cutting is done through the fault of the contractor or the labour, it shall not be allowed to be filled with earth. It shall be treated as specified in para 5 above at the cost of the contractor. The cutting and dressing of irregularities up to two inches (5 cm.) depth is included in the item of preparation of sub-grade. The excavation over and above this limit will be included in the lip-cutting and shall be paid for as such. Any earth which is removed during dressing will have to be laid on top of the bank or the spoil wherever required and properly dressed; the cost of removal and dressing being included in the rate for preparation of sub-grade. In case of tile lining, the Sub-Divisional Officer shall personally check the sub-grade before laying of bottom layer of tiles lining is started in any reach.

SPECIFICATION NO. 19.1.—Canal Lining (General)

7. Research staff shall take samples and carry out tests for salt contents in the soil along the length of channel. Areas where the total salt content is less than 0.5 per cent and sodium sulphate is less than 0.2 per cent do not require any special treatment. Where percentages of salts are more than this, the following treatment shall be carried out :—

Salt treatment.

- (a) In such reaches where salt contents range between 0.5 per cent and 1 per cent and sodium sulphate between 0.2 per cent and 0.36 per cent, the bottom layer of tiles shall be laid in 1 : 2 : 5 cement, surkhi, and mortar against 1 : 5 cement, sand mortar prescribed ordinarily.
- (b) In the reaches where total salt contents range between 1.0 per cent and 2.0 per cent and sodium sulphate between 0.37 per cent and 0.72 per cent the sub-grade shall be covered by 1/16 inch (1.5 mm) thick layer of 30/40 mexphalte bitumen.

In order to provide a bond between the sub-grade and the mexphalte, crude oil at the rate of one gallon per 100 sq. ft. (0.5 litre per sq. metre) shall be spread over the sub-grade before laying the mexphalte.

- (c) Reaches containing total salt more than 2 per cent and sodium sulphate more than 0.72 per cent shall be treated as in (b) above and in addition cement surkhi, sand mortar 1 : 2 : 5 shall be used for laying the first layer.

8. Templates for checking sub-grade in the curved portion and the side slopes etc., will be supplied by the department free of charge at site of work. In case, the same are supplied by the contractor extra allowance shall be paid to him. The contractor shall be responsible for movement, safe custody and repairs to all the templates supplied by the department. In case of mis-use of such templates, cost shall be made good from the contractor.

Templates.

9. In the reaches where the sub-soil water is high, pressure release valves should be installed at suitable intervals. Each pressure release pipe should be provided with a pocket of graded filter so as to prevent its clogging.

Pressure release valves.

**SPECIFICATION NO. 192—Double Layer Tile Lining
for Irrigation Channels**

General.

1. The lining shall consist of 2 layers of well-burnt tiles 12 in. \times 6 in. \times 2 in. (29 \times 14 \times 5 cm.) with 5/8 inch (15 mm.) thick 1 : 3 cement sand plaster sandwiched in between. Bottom layer of tiles rests on 3/8 inch (10 mm.) thick layer of 1 : 5 cement sand mortar. The top layer of tiles rests on 1/4 inch (6 mm.) thick layer 1 : 3 mortar laid over 5/8 inch. (15 mm.) thick sandwich plaster. The total thickness of the tile lining shall be 0.44 ft. (13 cm.).

Specifications of Tiles.

2. The tiles used shall comply with the specification No. 3.6. The tiles of the top layer may be machine moulded if so desired.

Preparation of Sub-grade.

3. Sub-grade shall be prepared as provided in Specification No. 19.1.

Soaking of Sub-grade.

4. The length to be lined shall be thoroughly soaked with water, without making it slushy to ensure that water penetrates to a depth of 12 inch (30 cm.) in sandy solid and inch (15 cm.) in other soils. Wetting of sub-grade shall also continue in advance of laying of tiles, so that it does not absorb moisture from 3/8 inch (10 mm.) thick mortar laid on the sub-grade for bottom layer of tiles.

To avoid absorption of water from mortar in reaches where sub-grade is purely sandy 5 per cent linseed oil emulsion in water shall be uniformly sprayed with the help of a knap sack or Hudson sprayer. Mortar shall be laid only after the lapse of 12 hours after spraying.

Portable Tanks for Soaking and Mortar.

5. Portable steel tanks shall be used for soaking of tiles and for mixing of mortars. These tanks may be supplied by the department on hire to the contractor at the site of work in which case the contractor shall be responsible for the day to day shifting of tanks with the advance of construction.

Soaking of Tiles.

6. Tiles shall be soaked in portable tanks for at least two hours before use so that they shall not absorb moisture from the mortar. All soaking tanks at each heading shall be numbered and tiles taken out of them in the order in which these have been filled.

Tiles shall be placed in the tank by hand, by one at a time, and not thrown, or tipped in. The soaked tiles shall be placed on wooden planks to avoid earth being smeared on them. These tiles shall be

SPECIFICATION NO. 19.2—Double Layer Tile Lining
for Irrigation Channels

kept moist by sprinkling water on them till they are actually consumed. All under burnt and rejected tiles shall be promptly removed from the site of work to prevent their mixing up with other tiles. The tiles shall be handled with care so as to reduce the breakage and wastage to the minimum. Tiles bats less than 5 inches (1.27 mm.) in length should not be used in lining of a channel. However, tile bats greater than 5 inches (1.27 mm.) may be used only very sparingly preferably in the lower layer of double tile lining. On the sides, however, in the case of double tile lining no bats should be used in the lower 1/3rd depth of the channel, the depth being taken upto the top of lining including the free board.

- (i) **Lining in Bed** :—Laying of tiles shall be started when the material has been carried to site and sub-grade prepared. No lining is to be done unless at least 50 ft. (15 metres) of sub-grade is ready ahead. Before starting the laying of tiles, profiles shall be laid at correct levels and alignment every 25 ft. (7.5 metres) interval. The profiles shall be laid very carefully and accurately with tiles selected for uniformity of size. The laying of tiles within gaps shall then proceed.

Laying of Tiles
operations for
1st day.

Wetting of sub-grade shall continue in advance of laying of tiles so that it does not absorb moisture from the 3/8 inch (10 mm.) thick mortar laid on the sub-grade for the bottom layer of tiles. 3/8 inch (10 mm.) thick 1 : 5 cement-sand mortar shall be spread on the formation and the lower layer of tiles laid at the same time using similar mortar of the joints. Masons shall work and spread out across the bed and retreat longitudinally. This means that in the bed the direction of the tiles shall be at right angle to the centre line, while on the sides the direction shall be parallel to the centre line.

To ensure straight joints and a level top of the lining, mason's lines shall be stretched longitudinally forward for 25 ft. (7.5 metres) from profile at 6 feet (2 metres) intervals, across the bed. The cord should be supported at intervals to prevent sag.

**SPECIFICATION NO. 19.2—Double Layer Tile Lining
for Irrigation Channels**

The mortar should not be kept in mortar pans for use by masons but laid directly over the sub-grade as soon as mortar pan arrives at sites. Masons should on no account be allowed to lay mortar with a trowel from the mortar pans. This can never lead to a satisfactory fill of joint and proper embedding of tiles and mortar. However, on the sandy bed the mortar should not be laid directly on the sub-grade but it should be kept in mortar pans and masons should be allowed to spread mortar only little excess of the tiles so that no bottom cavity may exist. The mortar shall be put on the sides of the tiles as usual before placing them in position. Each tile in the next row of tiles shall, however, be pressed on the mortar and pushed forward with the hand, so that the mortar squeezes out of the top of the joints, thus ensuring their complete filling. This simple method, if strictly followed will ensure hundred per cent full joints and be proof against cavities under the tiles.

During laying of the tiles, the top of the lined portion shall be checked by placing on it a wooden straight edge 5 ft to 6 ft. (1.5 metres to 2 metres) long or a template to see that the tile surface has been laid smoothly and no depressions have been formed. If any defects are noticed the same shall be removed straight-way while the work is still green. The contractor shall supply sufficient number of straight edges to his masons.

The thickness joints should normally be $\frac{1}{4}$ inch (6 mm.) and shall not exceed $\frac{3}{8}$ inch (10 mm.).

(ii) **Lining on side slopes** :—The laying of tiles on the side slopes is more difficult and requires great skill. Only selected masons shall be employed for this work and they shall not be changed ordinarily. Before starting the work profiles shall be laid accurately and truly in position from $11\frac{1}{2}$ ft. (3.5 mm.) centre to centre. These shall break joints with each other as well as with the profiles for the sub-grade. The curved portion between the bed and the side slopes shall be laid with the help of wooden templates made accurately to exact dimensions. The profiles should be laid with great care as these will serve as guides for masons laying tiles in the compartment.

Wooden step ladders shall be used for placing scaffolding planks $2\frac{1}{2}$ inches (62 mm.) thick to carry the masons as well as the tiles. Masons cord must invariably be stretched across the profiles at every course mark. The masons have a tendency to do this for every alternate course, which should not be permitted. Before placing the tiles in position the masons shall spread $\frac{3}{8}$ inch (10 mm.) thick 1 : 5 mortar on the moistened sub-grade which shall be little in excess of the area of the tiles. Each tile shall be pressed on the mortar and pushed forward with hand.

**SPECIFICATION No. 19.2—Double Layer Tile Lining
for Irrigation Channels**

ensuring complete filling of joints. The thickness of the joints should, normally be 1/4 inch (6 mm.) and shall not exceed 3/8 inch (10 mm.). Top surface of the layer must be checked frequently with straight edges to ensure smooth surface.

(iii) **Keeping the Lining Clear** :—Smearing of the tiles with mortar must be avoided as it fills the pores and reduces the bond with the sand-wich plaster. If any mortar comes on the surface of the tiles, it should be cleared straight away as the work proceeds. The joints should also be cleared as work proceeds. In case of lining of side slopes a man can follow sitting on a scaffolding plank a few steps below the working place and can clear the tiles and joints.

(iv) **Joining new work with old**.—When joining the work done previously with the one to be laid onward the joints shall be got thoroughly cleaned and washed with water.

On the second day, the lining laid on the previous day shall be sprinkled with water and kept wet with gunny mats to guard against the heat of the sun.

Operations for
second day.

(i) The joints of the work done on the first day shall be tested with a 5/8 inch (15 mm.) square or round M.S. bar having one of its ends made into a broad chisel point. All hollow joints be raked out and grouted with mortar by masons. The testing shall be hundred per cent. Also every tile laid must be examined by striking it with a stick. When struck with a stick, the sound of tiles with hollow underneath and empty joints will be different from those which are embedded firmly the mortar. Such tiles and those which get loose are to be taken out, joints cleaned, made wet, and relaid in fresh mortar. This shall of course be in addition to cent per cent testing of joints. The testing of hollowness of joints shall be done by the same personnel.

Operations for
third day.

(ii) After the joints have been repaired and loose tiles replaced, the surface of tiles shall be cleaned and scrubbed with water and wire brushed. When the tiles have been wetted thoroughly 5/8 inch (15 mm.) thick layer of 1 : 3 cement sand plaster shall be laid. Extreme care shall be taken in plastering as the imperviousness of tile lining depends on this sandwich plaster. For ensuring uniform depth of mortar, wooden L-shaped battens 5/8 inch (15 mm.) thick and 2 inches (50 mm.) wide shall be used by the masons. The plaster shall be spread with trowel and finished with a wooden batten.

On the fourth day, the plaster shall be lightly scraped with wide wire brushes and then covered with gunny mats and kept wet.

Operations for
fourth day.

**SPECIFICATION NO. 19.2—Double Layer Tile Lining
for Irrigation Channels**

Operation for
fifth day.

(i) On the fifth day, the plaster shall be cleaned and the top layer of the tiles shall be laid on 1/4 inch (6 mm.) thick 1 : 3 cement sand mortar. The vertical joint should normally be 1/4 inch (6 mm.) wide but shall not exceed 3/8 inch (10 mm.).

(ii) The laying of the top course of tiles shall be done by making profiles and using mason's cord and straight edges in the same way as the bottom layer. Due care shall be taken to see that the joints are straight and the top which is to be final designed section, is at the correct level.

(iii) To prevent damage to the plaster and the bottom course of tile in the bed by the labourers carrying the tiles and mortar, 1 1/2 inch (30 mm.) thick wooden planks shall be provided.

(iv) Some sort of obstacles shall also be put in to prevent the workmen going over green spots of masonry or plaster.

(v) Cleaning and scrubbing of the masonry in the top layer shall also be done in the same manner as for the bottom layer.

Operations for
sixth day.

On the sixth day, the top layer shall be covered with wet gunny mats and cured.

Operation for
seventh day.

On the seventh day, the joints shall be tested and repaired properly and neatly, as done in case of first layer.

In addition, all the tiles of the top layer of tile lining in the side curved portions shall be tested by the Sub-Divisional Officer himself by means of a stick in order to see whether every tile is properly laid. The result of tests by the Sub-Divisional Officer shall be entered in a log book separately maintained by the Sub-Divisional Officer. The log book shall show, the name of heading, date of test, reach for test and number of tiles taken out and relaid.

Operation for
eighth day.

On the eighth day 6 inches X 2 inches (15 cm. X 5 cm.) masonry dowels shall be made 50 ft. (15 metres) apart in bed on the completed lining at either end and water made to stand on the area. These dowels shall be extended as fresh area of lining is completed. About three inches deep water shall remain on the finished lining for not less than 28 days. For curing on side slopes, these shall be covered with gunny mats and cured for 28 days.

Watering of side slopes is better done by a pacca perforated water drain, constructed on the coping of cement concrete 1 : 3 : 6 at the top of the lining. The coping shall be laid as soon as lining is completed. The perforations in the drain should be about three inches (75 mm.)

above the bottom to provide for storage of water which can be utilised for sprinkling by hand in case of breakdown of pumps.

After curing period, earthen dowel of designed width and height shall be made immediately, on top of bank at the completed length of lining to protect the lining against penetration of rain water.

**SPECIFICATION NO. 19.3—Single Layer Tile Lining
in Bed for Irrigation Channels**

General.

1. The lining shall consist of a layer of well-burnt tiles 12 inch \times 6 inch \times 2 inch (29 \times 14 \times 5 cm.) resting on 3/8 inch (10 mm.) thick bed of 1 : 5 cement sand mortar. On the well cleaned exposed surface of tiles, 1/2 inch (20 mm.) thick 1 : 3 cement sand plaster shall be done and finished with a steel float.

Tiles.

2. The tiles used shall comply with the specification No. 3.6 only full and unbroken tiles shall be used in the lining except where half tiles are required to break the bond.

Cement Mortar.

3. The cement mortar shall conform to the specification no. 2.2 Proportions shall be as specified in paragraph 1.

Preparation of sub-grade.

4. Sub-grade shall be prepared as provided in specification no. 19.1.

Operations for first, second and third days.

5. Laying of layer of tiles and testing of joints shall conform to the specification no. 19.2 for first three days of operations for first layer of tiles of double tile lining with the following difference.

After repairing the hollow joints and replacing loose tiles but before washing and brushing the lining, all joints in the lining shall be raked out to a depth of 1/2 inch (13 mm.) with a hooked tool made for the purpose. Joints shall not be raked out with a trowel or a hammer as it damages the edges of the bricks. No loose material in the raked joints shall be left, otherwise it will be a hindrance in providing proper key to the exposed plaster.

Operations for fourth day.

6. **Plastering:**—After the joints have been raked, bottom layer cleaned and scrubbed, laying of 1 : 3 cement sand plaster 3/4 in. (20 mm.) thick shall start. Great care shall be taken to control the consistency of mortar through slump tests because the imperviousness of the tile lining depends on this plaster. For ensuring uniform and required thickness of plaster wooden L-shaped battens 5/8 inch (15 mm.) thick and 2 inch (5 cm.), wide shall be used. The plaster shall be spread with a trowel and then made smooth with a wooden float (gurmala). Finishing with steel float shall only be started when the moisture film has disappeared so that excess of fine material and water may be prevented from being worked to the surface. Hair cracks are usually the result of concentration of water and fines at the surface, caused by the immediate use of steel float or by over-manipulation during the finishing operation. Finishing with steel float must be done with a good pressure so as to produce a dense, uniform surface free from blemishes, ripples and float marks.

**SPECIFICATION NO. 19.3—Single Layer Tile Lining
in Bed for Irrigation Channels**

7. The curing of the bed shall be started next day after the finishing of the plaster according to weather conditions, when final setting of the plaster has taken place as otherwise it will pit the surface and make it rough. For curing, small 6 inch \times 2 inch (15 cm. \times 5 cm.) masonry dowels shall be made in bed on the completed lining at either end and water made to stand on the finished plaster up to a depth of at least 3 inches (75 mm.) for not less than 28 days. In fact single tile lining should remain covered with water throughout its life.

Curing.

$\frac{3}{4}$ inch (20 mm.) thick 1 : 3 cement plaster in bed shall be joined with top of double layer tile lining of side slopes with 1 : 2 : 4 cement concrete in smooth curve as per drawings.

**Joining bed and
side slopes.**

**SPECIFICATION NO. 19.4—Cement Concrete Lining
for Irrigation Channels**

General.

1. The lining shall consist of 1 : 3 : 6 cement concrete slabs. Ordinarily, thickness of the slabs in the bed will be 5 inches (12.5 cm.) and that on the sides 6 inches (15 cm.). The cement concrete slabs in the bed shall rest on cement concrete bed sleepers (mix 1 : 4 : 8) 9 inches (22.5 cm.) wide and 4 ½ inches (11 cm.) thick laid on situ and those on the sides shall rest on precast cement concrete blocks 9 inches (22.5 cm.) wide and 4 ½ inches (11 cm.) thick (mix 1 : 3 : 6) cast in 2 ft. (60 cm.) lengths. The lining shall have longitudinal and transverse joints at convenient and regular intervals to avoid cracks due to volume changes in concrete.

Specifications of cement concrete.

2. Cement concrete used shall comply with the specification no. 10.4.

Preparation of sub-grade.

3. Sub grade shall be prepared as provided in specification no. 19.1.

Laying of sleepers.

4. Laying truly of sleepers in the bed and the side slopes below the joints in slabs, will greatly help in having the sub-grade dressed perfectly. Trenches of the required sizes both in the bed and the sides shall be dug to receive the sleepers. Care shall be taken that cavities left on either side of the sleepers laid in the trenches dug on the side slopes are properly filled in and compacted before laying of the concrete slabs.

Before laying cement concrete slabs, to ensure water tight joints, the top of sleepers both in bed and side slopes shall be treated with bitumen bonding material and then covered with bitumen felt, having its ends raised by 2 inch (5 cm.) vertically as shown in fig. 19.4 (a). Felt shall be coated again with bitumen bonding material.

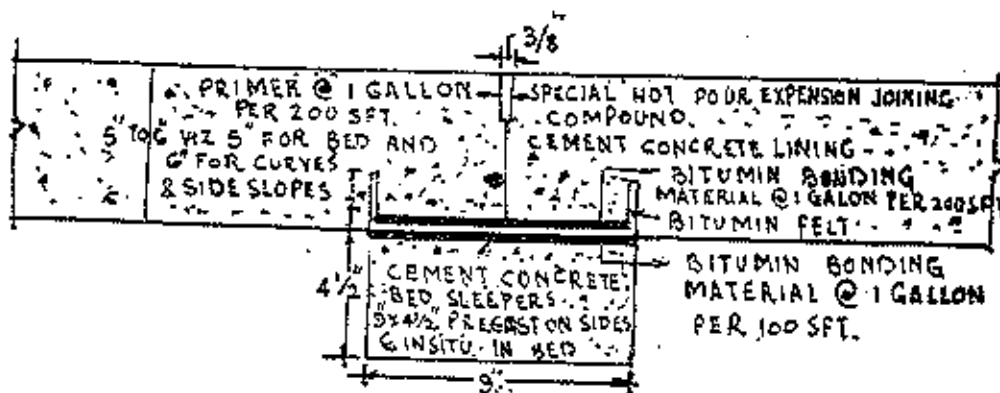


FIG. 19.4 (a)

**SPECIFICATION NO. 19.4—Cement Concrete Lining for
Irrigation Channels**

5. The sub-grade shall be moistened thoroughly before laying of the concrete slabs to avoid absorption of moisture from the concrete and making it spongy and permeable; 1 : 3 cement sand slurry $\frac{1}{4}$ inch (6 mm.) thick shall be spread over the sub-grade after it is moistened. The slurry shall be poured directly from the cans.

Soaking of sub-grade and putting 1:3 cement sand slurry

6. (a) **Aggregates.**—Maximum size of coarse aggregate shall be $1\frac{1}{2}$ inch (38 mm.) in 5 inch or 6 inch (12.5 cm. or 15 cm.) thick concrete. The coarse aggregate shall be batched properly to get good finish and shall conform to the specification no. 3.29. Fine aggregate shall also conform to the specification no. 3.30.

Laying concrete slabs.

(b) **Air-Entraining Admixture** :—Air entraining agent may be used, if specified, to increase workability, to make concrete impervious and more durable and free from honey-combs and bleeding. Air entraining admixture shall conform to the specification no. 3.52.

Mix of concrete will normally be 1 : 3 : 6 with a water cement ratio of 0.74 when an air entraining agent is used.

(c) **Surkhi.**—If specified, surkhi will be used as pozzolana up to a limit of 20 per cent by weight of cement in concrete mix and rate shall be amended accordingly. Surkhi shall conform to the specification no. 3.7. If full control on the manufacture of surkhi is not possible, no attempt shall be made to use surkhi as pozzolana.

(d) **Slump.**—A slump of $1\frac{1}{2}$ (38 mm.) is considered suitable for concrete to be placed on slopes of canal lining and 2 inches (50 mm.) to a $2\frac{1}{2}$ inches (62 mm.) for concrete slabs in bed.

A close control of slump is necessary as even relatively small variations in slump will leave honey combs on the under surface. The consistency of concrete used in lining is a very important factor. For side slopes, concrete must be fluid enough to stay and compact well.

The concrete for the slabs when laid in compartments shall be perfectly compacted by means of flat wooden hammers. To have the slab surface perfectly even a plain wooden template shall be moved over the slab and unevenness removed.

(e) **Operations of laying** :—Slabs shall be laid in alternate compartments with an interval of at least one day for setting and contraction. Slabs shall be so laid that these abut against each

**SPECIFICATION NO. 19-4—Cement Concrete Lining
for Irrigation Channels**

other at the centre of the respective bet sleepers both cross-wise and longitudinally. The expansion joint shall be made by inserting a flat iron of the required size of joint at each junction of the slab. The dimensions of slab panels, and whether the bed slab is to be poured first, shall be specified in the design drawings. Where lining placing operations are to be carried out by slip-form machines, the design of each machine and the operation shall be subject to the approval of the Chief Engineer.

Expansion Joint.

7. The joint shall be made 'V' type, 1.5 inches (4 cm.) deep, $\frac{3}{8}$ inch (10 mm.) wide at top and $\frac{1}{4}$ inch (6 mm.) wide at bottom filled with special pour expansion jointing compound, as shown in fig. 19.4 (b).

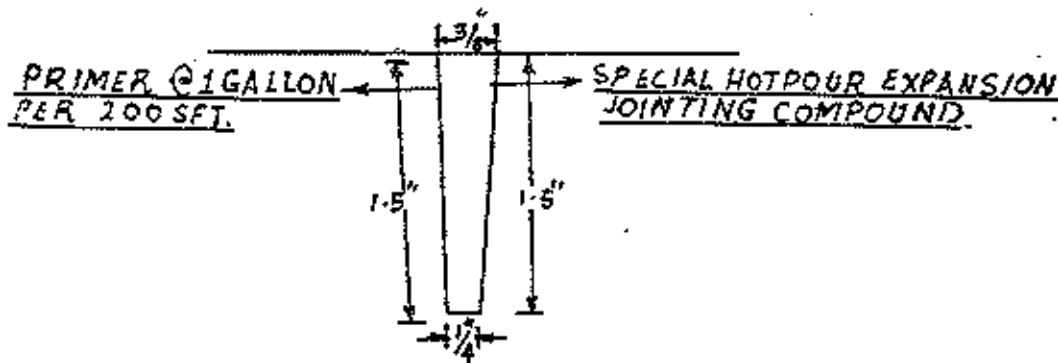


FIG. 19.4(b)

Filling of the joint with hot pour should be taken up after the curing period is over. In the mean time, the joints are liable to be filled with earth, which will be difficult to clean especially of the earth which will stick to the sides of the joints. It is, therefore, advisable to fill these joints with sand during the curing period. The sand can be easily blown out from the joints when these are required to be filled with hot pour.

Curing.

8. Masonry dowels of size of 6 inches x 2 inches (15 cm. x 5 cm.) shall be made in bed on the completed lining at either end and water made to stand on the area. These dowels shall be extended as fresh area of lining is completed. About three inches (7.5 cm.) deep water shall remain on the finished lining for not less 28 days. For curing on side slopes, these shall be covered with gunny mats and cured for 28 days.

**SPECIFICATION NO. 19-4—Cement Concrete Lining for
Irrigation Chamels**

Watering of side slopes is better done by a *pacca* perforated water drain, constructed on two feet level portion at the top of the lining. These perforations should be about three inches above the bottom to provide for storage of water which can be utilised for sprinkling by hand in case of breakdown of pumps.

9. Ordinarily, reinforcement of concrete shall not be resorted to but where serious cracking in concrete is feared, or where bank stabilities are questionable, adjacent sections of lining may be tied together with steel bars. This may be done only at certain specified places. The installation of reinforcement may be about 0.10% of the area, both in longitudinal and transverse directions. The extent and amount of reinforcement shall, however, be dictated by the Engineer-in-charge.

**Reinforcement of
concrete.**

10. For effective drainage, weep holes in the concrete lining shall be kept at adequate distances or drains shall be installed with outlets in the canal sections.

Weep holes.