Central Water Commission
Ministry of Water Resources
Government of India

GUIDELINES FOR PLANNING OF PARALLEL CANALS

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FOREWORD

Canals have played an important role in creating assured irrigation supplies to agricultural fields and contributed substantially to the green revolution in the country. With the increase in demand of food and fodder, demand of water for irrigation is also rising. To meet the increasing requirement of water, need for constructing new canals has become obvious. For cost effectiveness, a parallel canal to the existing canal is a judicious choice by utilising one of the banks of the existing canal.

While on one side we economise, on the other side, we have to face the problem of increased pore pressure development in the common bank of the parallel canals. This may create stability problem of the common bank and thereby causes instability to both canals.

This publication deals with various aspects which may be considered while planning and construction of parallel canals particularly of large capacities. These guidelines are based on the experiences of functioning of existing parallel canals constructed in the states of Punjab, Rajasthan and Uttar Pradesh.

I hope this Publication will be useful during planning and construction as well as maintenance of the canals in particular with the parallel canals having common banks. Comments/suggestions, if any, are welcome.

New Delhi
March, 2000

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GUIDELINES FOR PLANNING OF PARALLEL CANALS

1. Introduction

With a view to modernise the existing canal or to increase the availability of water for irrigation or other purposes, the practice to construct a new canal generally parallel to the existing canal is often resorted to. The justification advocated is normally one of the following two reasons:

- Increasing the capacity of water transport system as per increase in demand duly justified.
- Risk aversion work.

Since the existing cross drainage or regulating structures on existing canal also need re-furbishing due to an obsolete design or deterioration of the structure making their continuous use an unsafe proposition., Thus the remodelling of the entire system is forced upon the Agencies that are responsible to own, operate and maintain these systems.

Most of the parallel Canal construction thus come under the category of 'Modernisation of Irrigation system'.

2. Socioeconomic consideration in regard to parallel canal proposition

The construction of parallel canal under modernisation programme has the following advantages:

- No closure of canal is required when the works on modernisation of canal is undertaken by constructing a new parallel canal; in this way, the agricultural production of the command area of the canal does not suffer due to lack of irrigation water.
- Even if the existing canal is remodelled for increasing its discharge capacity or improving its conveyance efficiency by closing it intermittently or otherwise for different construction activities, the proposal becomes time-consuming and uneconomical comparative to the construction of a new parallel canal.
- It is normally seen that the problems associated with land acquisition and relocation of displaced population is least in comparison to a new alignment as land adjoining existing canal alignment are seen to be Govt. Poromboke lands at the disposal of Irrigation Departments in most cases.

3. Technical problems associated with parallel canals & planning & design aspects

Though the aspects indicated as above demonstrate the desirability and to some extent the economics of the parallel canal, certain inherent technical problems are to be carefully looked into in all such proposals. These are:

- Problem of increased pore pressure development in the common bank of the twin canals surfaces as a technical off shoot. This increase is for all conditions of the running of the canals/canal.
- Stability problem of the common bank due to increased pore pressure, is not accounted for in the original design, resulting in the instability of both the banks of the separating bund of the parallel canals.
- In some cases, the old canal is found to be unlined, in general or even if lined, proper provision for releasing hydrostatic pressures behind lining are not made at the time of its initial design. This causes problems of lining failure due to an increase in the pressure behind the lining.

For uninterrupted and efficient operation of parallel canal the following aspects need to be carefully addressed in the different phases of the Project:

1. Investigation and Feasibility Report / Detailed Project Report (DPR)
2. Planning an appropriate alignment and design of the canal in due consideration to the type of soils encountered along the alignment / terrain keeping in view as to whether the existing canal runs in
    a) cutting
    b) in filling or
    c) partly in cutting and partly in filling.

These and other relevant aspects are dealt with in these Guidelines for parallel Canals.

3.1 Investigations

Before planning any parallel canal, a programme for detailed soil investigations along canal alignment at suitable intervals should be launched to assess the classification, strata and engineering properties of sub-strata, Ground water table etc.

Properties of sub grade

The soil investigations should include determination of type of soil by taking bore hole logs 10-20 metres deep (or up to impervious layer if encountered earlier), spaced at about a kilometre for larger canals. Where soil strata are variable, intermediate bore holes may be located to define the soil profile, as best as possible. If the soil stratum continues to be pervious for large depth as indicated by a few deep borings, the stratum may be assumed as extending to infinity for seepage computations. Soil tests to be carried out on bore hole samples should, in addition to usual classifications tests, include tests for expansive nature of sub-grade material and chemical tests to guard against presence of any possible deleterious substances which may adversely affect the lining materials. Sulphates of sodium and magnesium are known to be the worst enemies of concrete and brick. Suitable remedial measure should therefore be adopted in the reaches where total dissolved solids are more than 0.25 percent by weight. Where soils are susceptible to be dispersive, tests shall be undertaken sufficient to assess the situation for evolving remedial measures.

CH Soils

Generally, the types of soil that are likely to have the heaviest losses are relatively clean sands and gravel. Uniform gravel have the highest permeability followed by well-graded gravel, uniform and well-graded sand follow. Another type of material that is usually questionable is a highly plastic clay (Casagrande CH type) because of its tendency to develop large shrinkage cracks upon drying. This type of soil should have small seepage losses when continually wet.

Silt/Fine sand

Other soils that will have moderately heavy seepage losses are very find sands. Silt is inherently unstable, particularly when moisture is increased, with a tendency to become quick when saturated. It is relatively impervious, difficult to compact, highly susceptible to frost heave, easily erodible and subject to piping and boiling. Bulky grains reduce compressibility; flaky grains, i.e., mica, diatoms, increase compressibility and produce an "elastic" silt.

The classification of soils and their properties in the context canal construction are indicated in annex-1.

Ground Water Table

Data of water table in monsoon and spring for a few years shall be collected. Large number canal failure has been on account of high water table and therefore, the design of canal section should be such that in most of the reaches, the bed level of canal is fixed above highest ground water table, to the maximum extent possible. Where this is not feasible, extensive drainage arrangement is called for.

Drainage for Banks

The parameters that are needed to be investigated for planning of a parallel canal in a certain area, include type and permeability of the sub-grade in different reaches, water table conditions, quantitative assessment of seepage losses and area likely to be waterlogged.

In such cases the operational conditions and engineering properties of the sub grade material of the two canals may be studied in detail; model studies by electrical analogy method may also be done. Suitable treatment for the common bank and drainage behind lining of new canal may be designed accordingly. Also, for such cases, for reducing the extra pore pressures due to operation of either or both the canals, following methods may be tried.

3.2. Planning and Design aspects of parallel canals

Bank Width

The top width of common bank may be kept as twice the width of inspection path for the corresponding range of discharges given in IS 10430-1982. For large canals the top width is generally kept between 15m to 25m. However, this may be increased suitably in order to ensure that the phreatic line (Hydraulic gradient line) is below the beds of existing as well as new canal. The Hydraulic Gradient (H.G.) line through bank, though actually curved is assumed to be straight and sloping at 1:4 to 1:6 gradient, depending upon type of sub-grade. The slope of H.G. Line is taken as 1:6 for loamy soils, 1:5 for average clayey soil and 1:4 for highly clayey soil.

Side slopes

For general guidance the recommended side slopes of the bank of the canal in different sub-grade are indicated in Annexure-2. However, where height of banks is above 6m or where chance of sudden draw down is considerable, proper slip circle analysis should be made for stable slope.

Canal in filling

When the canal is in filling, the following options can be studied to ensure proper drainage & avoid back pressures which can cause failures of slopes/canal lining in the other parallel canal. The strategy for planning will differ for various reaches of canals depending on the canal reaches in filling or cutting below the new canal.

Method –1. Provision of suitable filter layer below the new canal-This filter shall not allow to develop unnecessary high pore pressures in the common bank. It will reduce the pore pressures which would have developed in the far end bank of the new canal, as the filter will work as a source of pressure release path for both the affected banks in all cases of operation of the twin canals. Fig. 1(a) show the details.

Method –2. Impervious Barrier & drains between parallel canals:The provision of a trench filled-up with filter material having an open jointed AC or PVC pipe in the centre can operate as impervious barrier/drain. This open jointed pipe shall work as pore pressure reducer and seepage collector. The size and location of the trench, which depends on the permeability of the sub grade, may best be decided by electrical analogy model studies. The seepage may be discharged into the side drains at suitable locations of the canal with the help of cross drains or the outlet may be provided in some local drain, crossing the canal system. The arrangement is shown in Fig.1 (b).

Method –3 Provision of horizontal filter layers in fill for new canal;If the new canal is in embankment then for the release of pore pressures number of filters as shown in Fig. –1© can be provided. Depending on the height of fill, these filters may be provided at different locations on the common bank and at the far end bank of the new canal.

Method-4: Lined Canals: When lining is provided, depending upon sub grade, drainage arrangements as shown in fig.2 shall be provided.

Canal in cutting

When the new canal is in excavation & the spring levels are low, the methods suggested above may not be practically possible to construct. In such cases, for a general guidance the recommended side slopes in different type of subgrades both for unlined and lined canals are shown in annexure 2. For the lined canals extra provisions of filter behind the lining, extensive network of drains with pressure release valves (non-return) or provision of dwarf regulators are suggested. Fig -3 indicates drainage arrangements for pervious and semipervious type of sub grade.

Pressure release valves

Pressure release valves (which open into the canal) are provided to relieve excessive hydrostatic pressure behind lining. The valves should be provided in pockets filled with graded filter underneath the lining. The pockets may be cylindrical with depth and diameter as 85 cm or cubical with sides as 85 cm. Horizontal and vertical pressure release valves are installed. 50 mm to 75 mm diameter valves are normally used on the side slopes and 100 mm to 150 mm diameter valves are used in the bed. The number of rows of pressure release valves in the slopes of canal should be such that for each 4m width along the slope, a row is provided .The first row should be provided at the junction of the curve and the sides. The number of rows on the bed of the canals shall be such that for every 10m bed width a row is provided. The spacing of the pressure release valves in a row should be decided on the basis of experiments carried out on models simulating site conditions. Valves in adjacent rows should be staggered. The longitudinal drains consisting of open jointed pipes encased in graded filter should have outlets in a trench of width 45 cm and depth 50 cm. The trench should be filled with graded filter and have outlet into the canal through pressure release valves. The outlet may be provided through precast concrete boxes collecting water from drains with pressure release valves on the tope of boxes.

Pressure release valves may, however, be useful in case of slow operational variations, as also serve to release excessive pressure built up through seams of previous material present in the sub-grade bank material. Further more, the moving part of pressure release valves may get damaged or get rusted in course of time so each one of them must be inspected and repaired at least once a year. Presently, pressure release valves made from PVC are available which should be given preference over steel.

Where the lining is subjected differential pressure due to very high spring level or large operational require variation as may be case in power channels, the most effective measure to release excess pressure on the lining is to provide continuous filter with adequate outlets to release seepage water.

Boulder set pocket

Where the sub-grade material is not free draining, 1mx1m filter pockets with open jointed boulder set encased in G.I.wire shall be provided at 5 m c/c in longitudinal drains and on side slopes to replace conventional pressure release valves. Fig. 4 shows the typical details of such an arrangement.

Dwarf regulators

Dwarf regulators are regulators of part height constructed across lined canals at suitable interval for ponding up water to counteract excess uplift pressure below the lining. These are provided in areas where the water table remains continuously high and the conventional pressure release arrangements are not likely to prove effective. The height and spacing of the dwarf regulators will depend upon the minimum depth of water required to be maintained inside the canal for counter balancing residual pressures for safety of the canal. The regulators also help in maintaining minimum water depth inside the canal even when the canal is operated at part capacity with lower normal depths. Their disadvantage is that the canal made stable with dwarf regulator cannot be emptied for repairs (till the water table goes down to bed level) and these may cause additional head loss in the canal. Under drainage arrangement shall be as per the recommendations of IS 4558-1968.

Rate of draw down

For long term stability of lined/unlined canals, the rate of draw down of water level in the canals has to be judiciously decided based on the experience and data of canals in similar formations. The canal lining is not designed for very fast rate of lowering which may result in greater differential head due to difference between rate of lowering of water in the canal and the rate of reduction in the pore pressure behind the lining due to time lag in the drainage of sub grade. Thus the first 30cm from FSL may be lowered in one hour but thereafter this rate may be as low as 3cm/hour.

Data of ground water table particularly in monsoon and type sub grade (in cutting and filling), drainage arrangements, if any, shall be kept in view while fixing the rate of draw down.

Saturation of common bank

The common bank of the parallel canals is likely to be saturated due to standing water in the canals and / or rainfall. This ultimately lead to sloughing of banks and further leading to collapse of lining. Silty soils are prone to such a phenomenon. To prevent saturation of the common bank, top of the bank may be provided with a clayey gravel/ clayey sand or the same may be covered with a plastic film/membrane (with soil cover) to make it impermeable. Catch water drains may be provided parallel to the canal bank and suitably drained into the canal at about 30 meter interval.

Compaction of Sub grade

Inadequate compaction of sub grade also results in failure of the banks as well as failure of lining. As such, the compaction of sub grade depending on the type of soil should be ensured during execution. For sub grade consisting of soil, compaction is to be done at OMC in layers not more than 15 cm thick where dry density of natural soil is not less than 1.8 tonnes / meter^3, the initial excavation is to be done up to about 30 cm above the final selection. Lip cutting of 50 cm to 100 cm in banks should be provided. The cutting to final shape should be done immediately before lining. The preparation and compaction of sub grade shall be done as per IS 3873-1993; Laying cement concrete/stone slab lining on canals – code of practice (second revision).

Provision of top coping

In case of lined canals, the top coping at the end of lining should be sufficient to cover the filter provided behind the lining, otherwise the soil particles along with rain water clog the filter. Also the rain water will not flow along the back side of the lining due to the adequate length of the coping. In case of parallel canals, the coping width could be kept as 35cm to 60 cm as shown in Fig-5.

Leakage through joints

In lined canals the velocity of flow is about 2 meter per second. Where the joints are weak, the soil particles of the embankment may be sucked and a cavity may form behind the lining, which ultimately may result in the collapse of lining over a period of time. As such suitable steps have to be taken to provide durable joints in the lining.

4. Conclusions

The provision of parallel canal is an involved subject and is case specific. No general guidelines could be sufficient, if issues of particular importance arises out considerations related to topographic situation, geo-technical/geological peculiarities (like kartzite formation etc.), permeability consideration, value of water and tolerance of losses, seepage etc.

Besides adequate importance should be assigned to environment & ecology, bio-drainage etc. while evolving an overall comprehensive plan.

REFERENCES

1. Manual on Canal lining (Revised – 1977) ,Uttar Pradesh Irrigation Research Institute (Roorkee).

2. Manual on Irrigation & Power Channels (1984) – CBIP Publication No. 171.

3. IS-10430-1982 – Criteria for design of lined canals and guidelines for selection of f lining .

4. Soil Mechanics – by T William Lambe & RV Whitman.

5. Bureau of Indian Standards : IS 4558-1995 ; Code of practice for under-drainage of lined canals (second revision).

6. Bureau of Indian Standards IS 3873-1993; Laying cement concrete/stone slab lining on canals – Code of practice (Second revision).

ANNEXURE –1

CLASSIFICATION OF SOILS AND THEIR SUITABILITY FOR CANAL LINING

Sl.No	Soil Classifi-cation & relative rating	Soil Description	Remarks
1	GP	Poorly graded gravel or gravel sand mixtures; little or no fines.	Extremely permeable needs lining.
2	G W	Well graded gravel, gravel	Extremely permeable need lining.
3	SP	Poorly graded sands or gravelly sands, little or no fines.	Moderate to highly permeable, usually requires lining.
4	SW	Well graded sands, gravelly sands, little or no fines.	Moderately permeable, usually requires lining.
5	C H	Inorganic clays of high plasticity, flat clays	Very impermeable when wet or extremely permeable after drying. Needs special consideration.
6	ML	Inorganic silts and very fine sand, silty or clayey fine sand with little /no plasticity	Fairly impervious, but bank section is difficult to hold in place. Need consideration.
7	MH	Inorganic silts of high compressibility micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Fairly impervious, but bank section difficult to hold. Needs special consideration.
8	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.	May range from moderate to very low permeability.

9	SC	Clayey sands, poorly graded sand Clay mixtures	Usually impermeable, good stability.
10	GM	Silty gravel, poorly graded gravel sand silt mixtures.	Usually fairly impermeable but hard to hold on bank.. Lining requirement is minimal.
11	CL	Inorganic clays, gravelly/ sandy silty clays, lean clays of low plasticity.	Usually very impermeable. Lining requirement is minimal.
12	OL	Organic silts & silts clay of low plasticity.	Permeability fairly low but stability is questionable. Provision of lining needs judicious consideration.
13	OH	Organic clays of, medium to high plasticity.	Low permeability if soil is kept wet but stability is questionable and shrinkage cracks are probable. Provision of lining needs judicious considerations.

Source : IS Code No. 1498-1970 (First Revision) and C.B.I.&P. Publication No. 82.

Annexure 2

RECOMMENDED SIDE SLOPES

Sl. No.	Type of soil	Side slopes (Hor Vert.)
1.	Very light loose sand to average sandy soil	2:1 to 3:1
2.	Sandy Soil/Loam	1:1 to 2:1 (in cutting) 1:5:1 to 2:1 (in embankment)
3.	Sandy soil or gravel	1:1 to 2:1
4.	Murram, gravel mixed soil	1:1 to 1:5:1 (in cutting) 1:5:1 to 2:1(in embankment)
5.	Black cotton	2:1 to 3:5:1 1.5:1 to 2:1 (in cutting)
6.	Clayey soils	2:1 to 2.5:1(in embankment)
7.	Rock	0.25:1 to 0.5:1

Source : IS : 10430 – 1982 (Criteria for design of lined canals.and guidelines for selection of type of Lining.)

Note : The above slopes are recommended for depth of cutting/height of embankment up to 6 metres. For depths/height in excess of the above special studies for the stability of slopes are recommended.

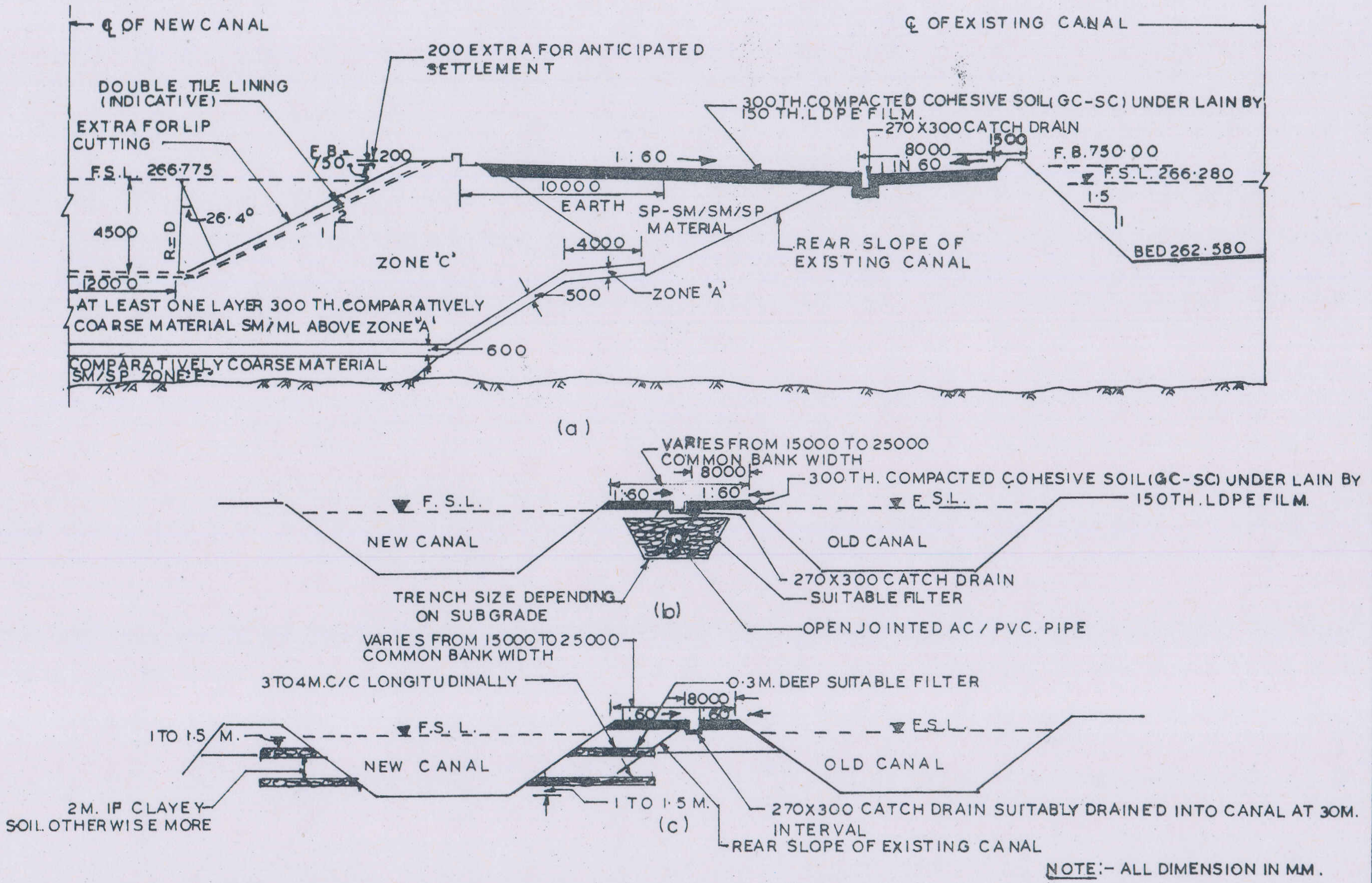
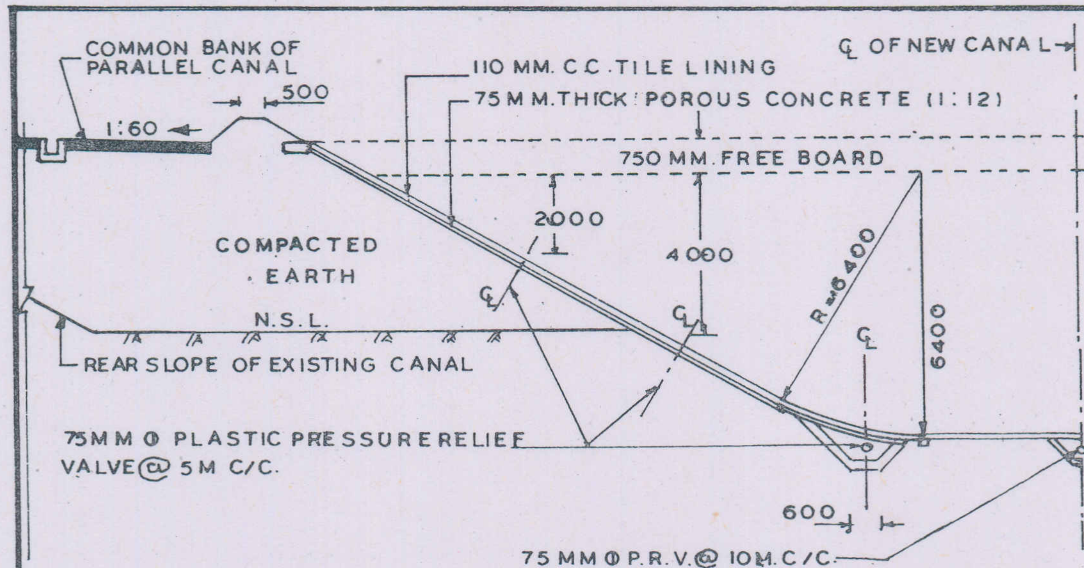
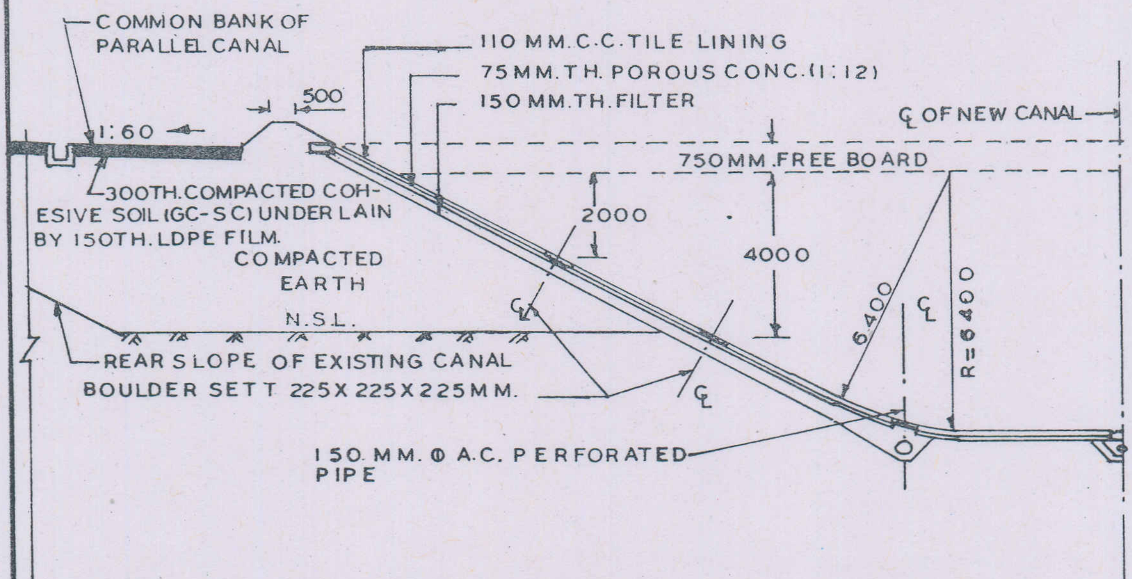


FIG-1 DRAINAGE ARRANGEMENT BELOW COMMON BANK OF PARALLEL CANALS



(A) FREE DRAINING SUBGRADE



(B) NON FREE DRAINING SUBGRADE

NOTE:- ALL DIMENSION IN MM.

FIG-2 DETAIL OF LINING AND DRAINAGE IN FILLING-SECTION

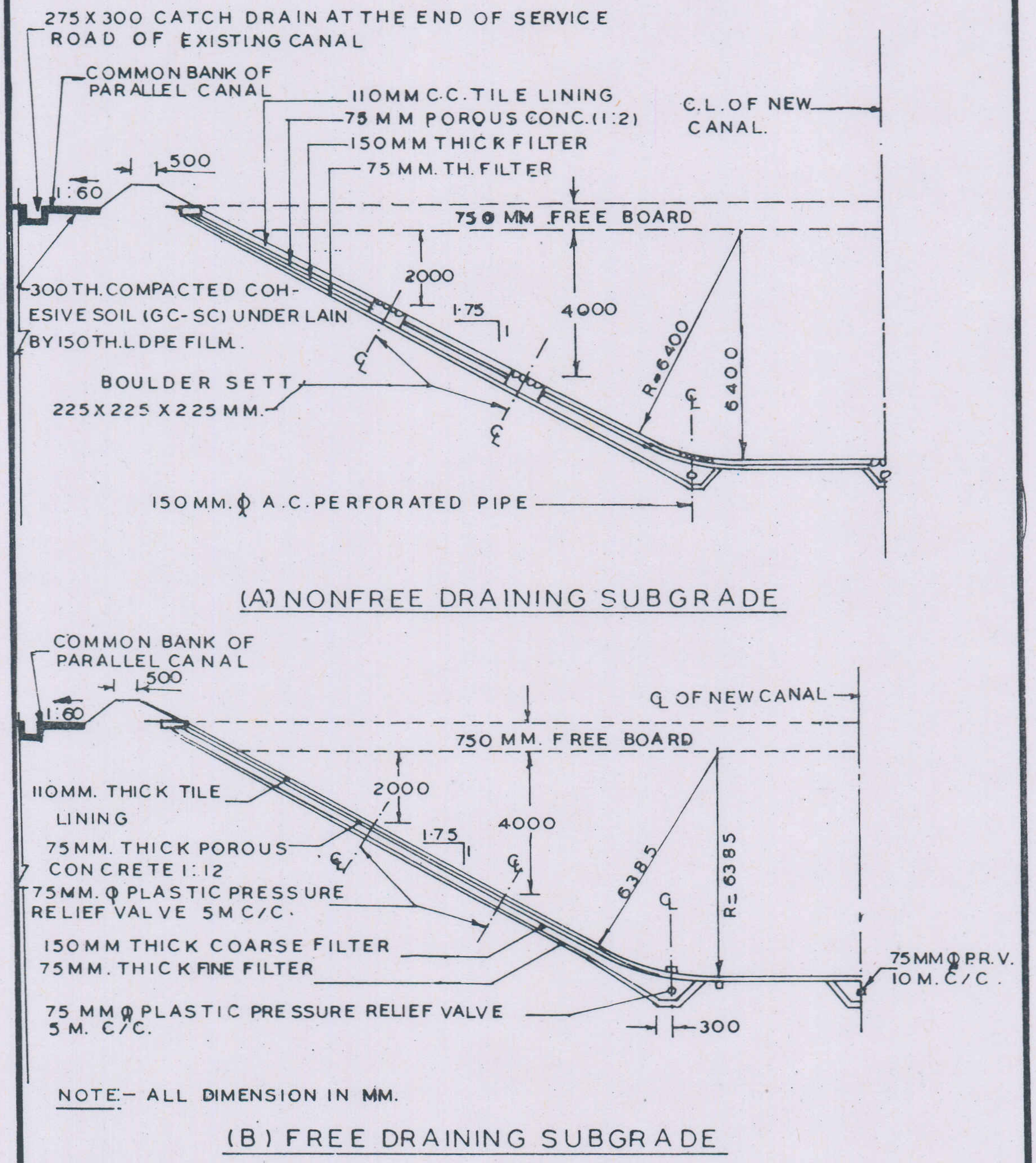
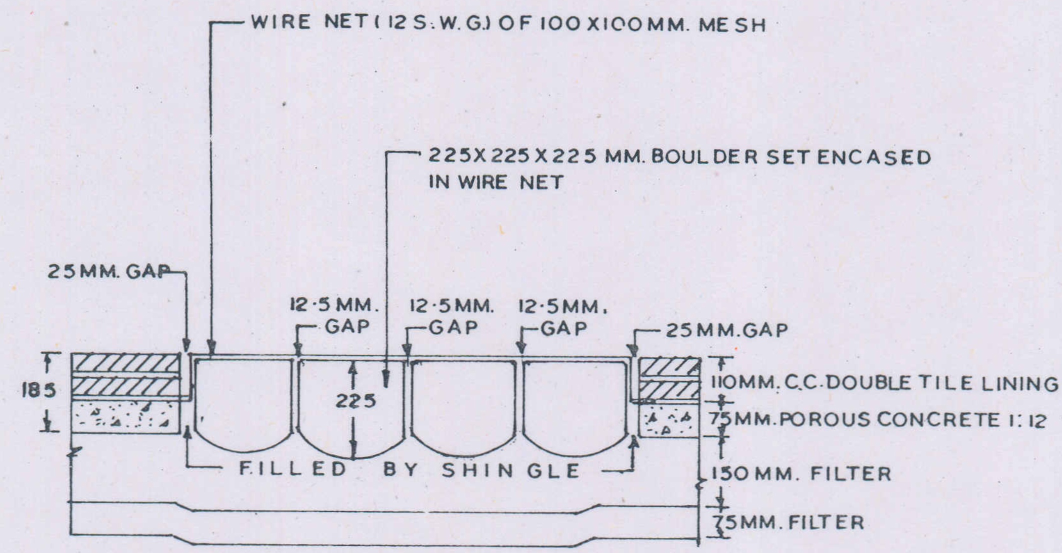


FIG.-3 DETAIL OF LINING AND DRAINAGE IN CUTTING-SECTION



(SUB GRADE COMPRISING OF VERY FINE SAND, MIXTURE OF SAND, SILT & CLAY AND CLAYS. PERMEABILITY LESS THAN 10^{-4} Cm./Sec. AND GREATER THAN 10^{-6} Cm./Sec.)

NOTE:- ALL DIMENSIONS IN MM.

FIG.4 :- DETAILS OF BOULDER SET POCKETS IN NON-FREE DRAINING SUBGRADE

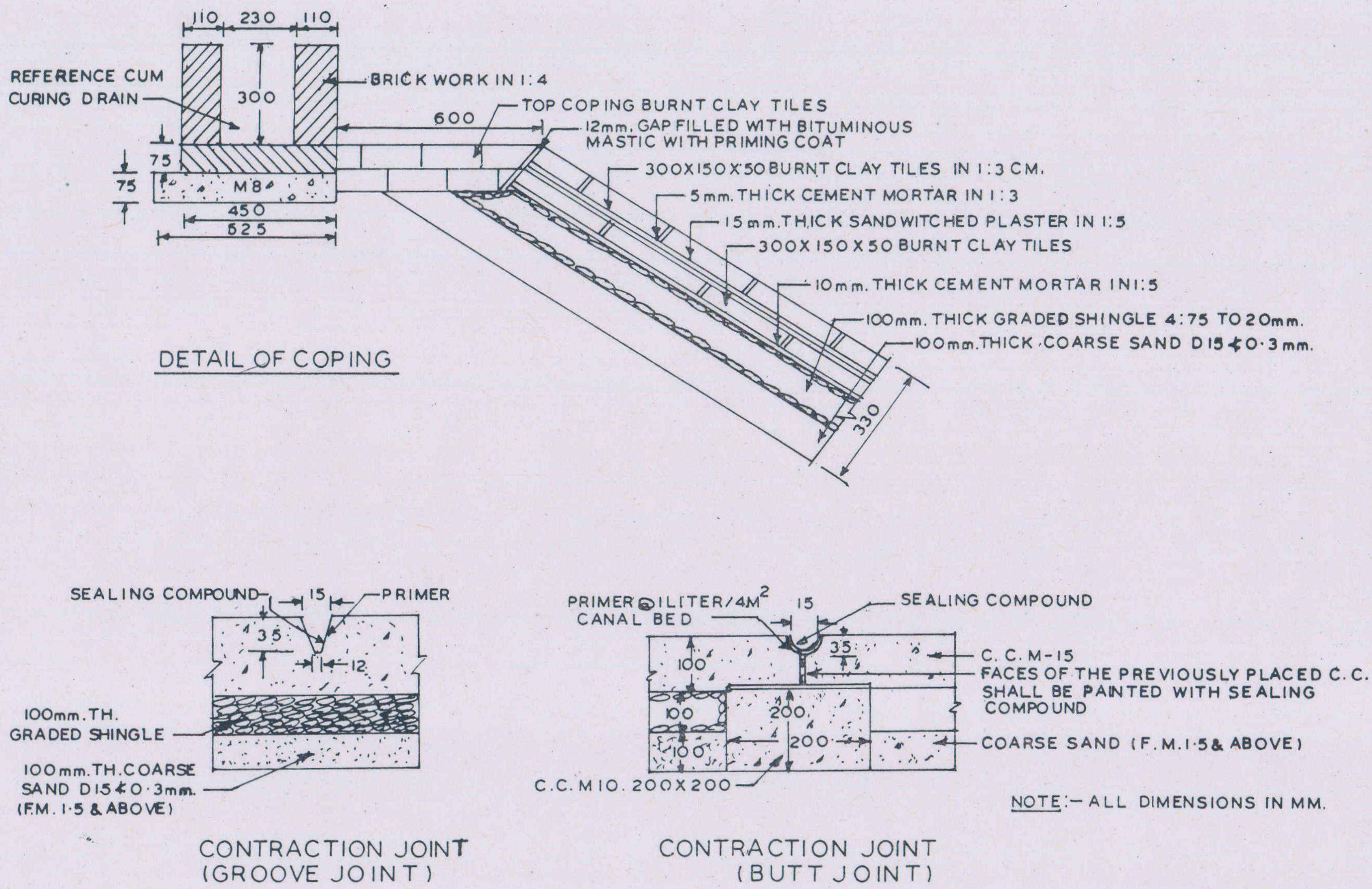


FIG.-5:- DETALS OF COPING AND JOINTS

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