



East Central Railway

Office of the
General Manager (Engg)/Hajipur

PCE's CIRCULAR No- 20/2007/WORKS

Sub: -GUIDELINES FOR LEAK PROOF FLAT ROOF

1. Water proofing system on the roofs get deteriorated due to weathering effect and may become ineffective due to development of cracks/debonding/ disintegration of water proofing material etc. Stagnation of water due to undulation in roof surface, provision of less no. of drainage pipes or choking of the same and improper detailing at junction of parapet and roof etc., are other major contributors in making the roof leaky.

2. BASIC REQUIREMENT OF ARRESTING LEAKAGE OF ROOFS:

2.1 Provision of adequate slope:

It is absolutely essential that roofs are provided with adequate slope to ensure effective drainage. The slope of roof should be such that the water gets drained off quickly by achieving adequate velocity under influence of gravity. For efficient drainage of rain water from the roof the slope should not be less than 1 in 100 and preferably it should be 1 in 60

2.2 Provision of adequate openings:

The size and spacing of the rain water pipes require careful consideration for efficient drainage of the roof. In general, one 100mm diameter pipe is considered suitable for every 40 Sq.M of the roof area to be drained. The diameter of rain water pipe shall not be less than 100mm.

2.3 Proper detailing at junction of roof with parapet wall:

Junction of roof with parapet wall is a vulnerable location for leakage. It is necessary that detailing at the junction of roof and vertical face of parapet wall is done very carefully. Following should be ensured:

- (i) The fillet (angular or concave, not convex) of 75mm should be provided all along the junction of parapet wall with roof.
- (ii) Coping on top of the parapet wall should also be provided with adequate slope along with the provision of drip course on either side.
- (iii) Water proofing system should be extended from roof to parapet wall for a minimum height of 150 mm with a chase. General arrangements at junction of roof with parapet are given in Figure-1 below.
- (iv) Typical details of junction arrangement of rain water pipe with roof are indicated in Figure-1.1. Invert level of rain water pipe should be approx. 25 mm below the level of top of adjacent tiles. Grating should be fixed at the mouth of rain water pipe to prevent entry of leaves/other waste material from roof. Unless, specified otherwise, rain water pipe and fittings should be properly

secured to the walls.

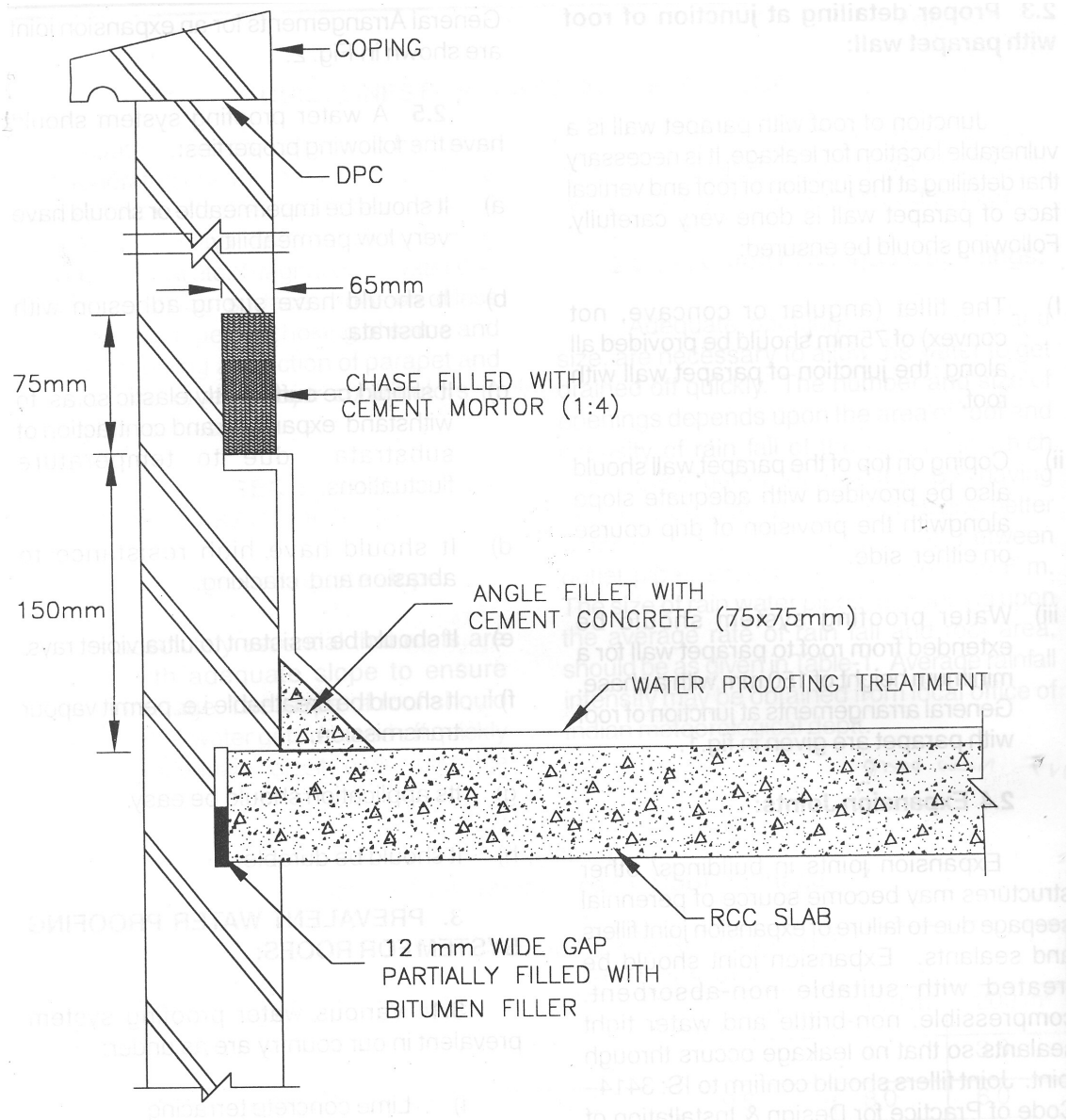
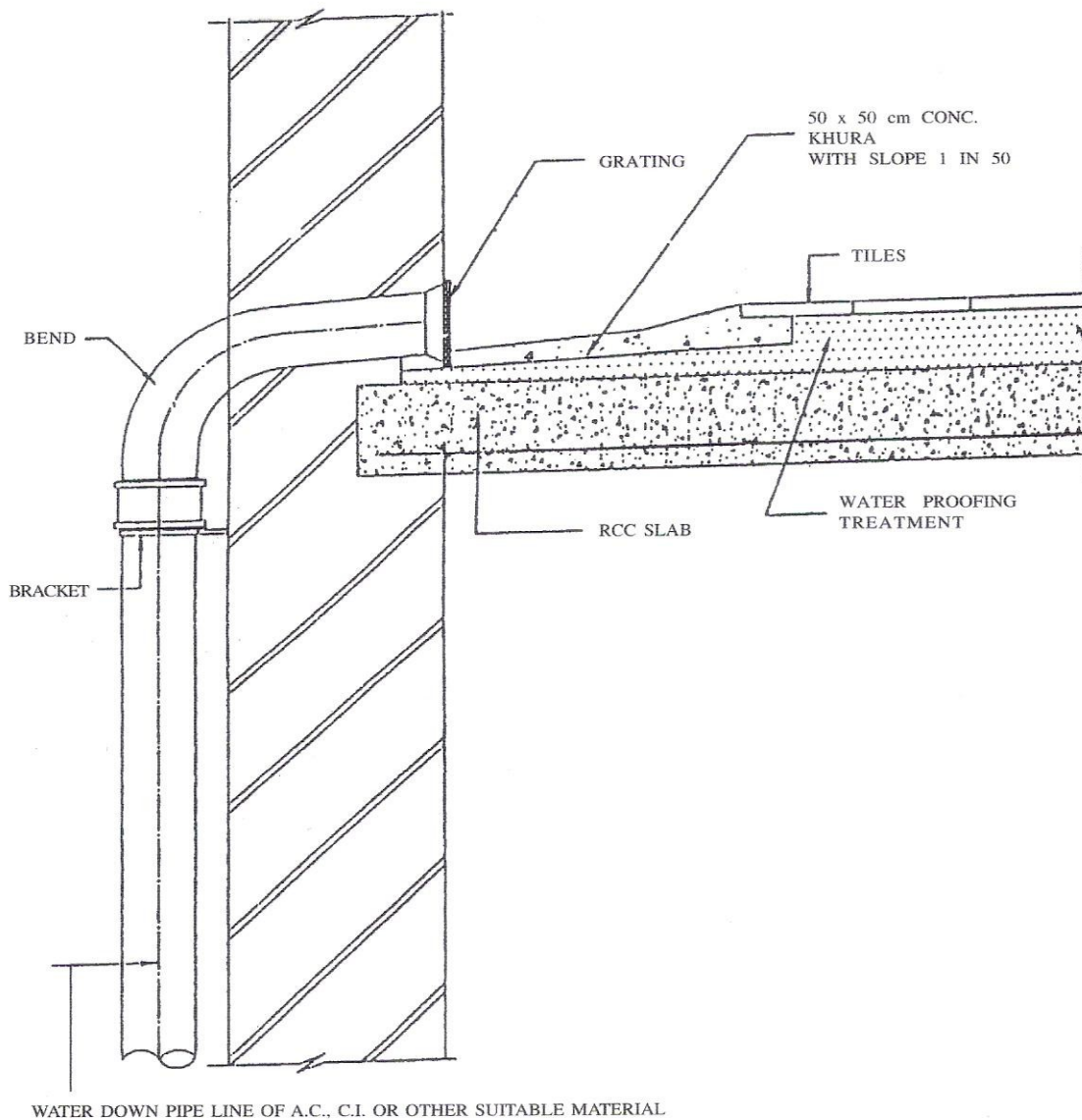


Fig.1

GENERAL ARRANGEMENT AT JUNCTION OF ROOF AND PARAPET WALL



TYPICAL DETAILS OF JUNCTION ARRANGEMENT
FOR RAIN WATER PIPE WITH ROOF

Figure-1.1

2.4 **Expansion Joints:**

Expansion joints in buildings/ other structures may become source of perennial seepage due to failure of expansion joint fillers and sealants. Expansion joint should be treated with suitable non-absorbent, compressible, non-brittle and water tight sealants so that no leakage occurs through joint. Joint fillers should confirm to IS: 3414 - Code of Practice for Design & Installation of Joints in Buildings or IS: 1838 (Pt.I or Pt.II) - Specification for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures. Sealing compound should confirm to

IS: 1834 - Specification for Hot Applied Sealing Compounds for Joints in Concrete. General Arrangements for an expansion joint are shown in Figure-2

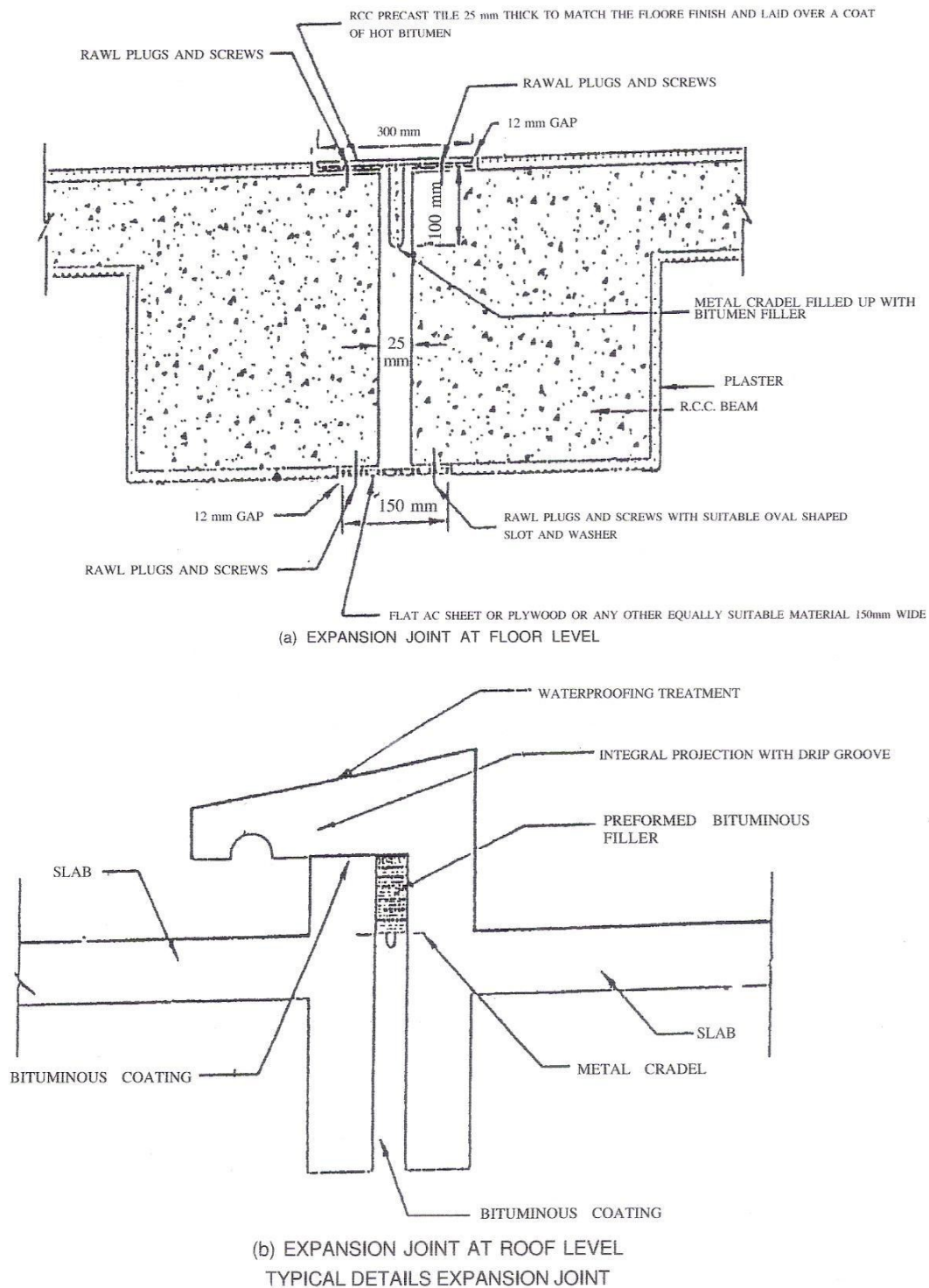


Figure-2

3. **PREVALENT WATER PROOFING SYSTEM FOR ROOFS:**

3.1 Various water proofing system prevalent in our country and as detailed in IRWM is as under:

- (i) Lime concrete terracing
- (ii) Mud-Phuska treatment.
- (iii) Water proofing using polyethylene films.
- (iv) Water proofing using polymer cementitious slurry coatings.
- (v) Water proofing using polymer modified bitumen membranes.
- (vi) Water proofing using bitumen felts.

Based upon the climatic conditions, rainfall, availability of standard code of practice for execution and past experience of the field, out of total six recommended methods as mentioned above S.No (i), (iii) and (vi) may be adopted for East Central Railway.

Lime Concrete Terracing (IS: 3036-1992)

This method of waterproofing is suitable for hot and humid regions. Therefore may be adopted as one of the method of leaky roof treatment in E.C.Railway.This system consist of laying, ramming & compaction of lime concrete to a desired slope. Lime concrete used in this system is a mixture of hydrated fat lime (conforming to IS 712) pozzolanic material (calcinated clay pozzolana conforming to IS 1344) and concrete aggregate (broken burnt clay bricks conforming to IS: 3068 or natural stone aggregate conforming to IS 383) having maximum size 25mm. This system is suitable for new as well as old roofs. It is important to ensure high quality of workmanship during execution.

3.2.1 Application Procedure:

Various steps involved in this system are as under:

1. Preparation of Roof Surface-

- a) Top surface of the roof to be given proper slope for effective draiange.If the slope of the existing roof surface is not adequate then a finishing course must be provided with cement concrecte/mortar depending upon the requirement to achieve desired slop on the roof surface. On flat roof, slope of 1 in 60 shall be given. However, in heavy rainfall area, slope of 1 in 40 is recommended.
- b) The roof surface to be cleaned with wire brushes and gunny cloth. All loose materials and scales should be removed and surface may be cleaned with a piece of cloth lightly soaked in Kerosene oil to improve adhesion of bitumen with the surface.
- c) The roof surface is painted with hot bitumen only when it is throughly dry.Bituman of grade 80/100 should be heated to about 180 degree C.The Bitumen shall be applied at the rate of 1.7 Kg per Sq.M of the roof surface. The coat of bitumen should be applied in a uniform manner ensuring that no blank patches are left. The coat of bitumen should be continued 150mm along the vertical surface of the parapet, pipe, inverted beams etc.

- 2. **Preparation of Lime Concrete:-** One part of slaked lime and two parts of burnt brick pozzolana, by volume , shall be mixed on a water tight platform. This shall then be sprinkled with required quantity of

water and well ground in a mill or using mechanical grinder to obtain lime pozzolana mortar. Coarse aggregate and lime pozzolana mortar, in proportion of $2\frac{1}{2}$:1 parts by volume, shall be used for preparation of lime concrete. In case of hand mixing, coarse aggregate shall be staked to an even surface on the platform and lime pozzolana mortar shall then be evenly spread over the aggregate and the whole thoroughly mixed in just sufficient quantity of water to obtain concrete of uniform consistency. The mixing shall be done by turning it over and over several times - until all the aggregate are covered with mortar and a concrete of uniform consistency is obtained. In case of machine mixing, two and a half parts by volume of clean saturated surface dry coarse aggregate shall first be fed into the mixer and then one part, by volume, of lime. Pozzolana mortar shall then be added to the mixer and the content mixed well. Mixing shall be continued until there is a uniform distribution of the material. Final adjustment of water, to obtain concrete of required consistency may be made by adding clear water, if necessary, and turning the ingredients in the mixer.

3. **Laying, ramming & compaction of lime concrete:-** Laying of lime concrete shall be started from a corner of a roof and proceed diagonally towards centre and other sides considering the slopes required for draining the rain water smoothly. The average thickness of lime concrete shall not be less than 100mm. After laying it shall be initially rammed with a rammer weighing not more than 2 kg and the finished to the required evenness and slopes. Further consolidation shall be done using wooden '*thapies*' with rounded edges. The workmen will sit close together and beat the surface lightly. The beating will normally have to be carried on for at least seven days until the '*thapi*' makes no impression on the surface and rebounds readily from it when struck. In order to achieve more progress, ramming and compaction of lime concrete can be done mechanically with the help of a tamping machine developed by C.B.R.I., Roorkee. During compaction the surface shall be sprinkled liberally with lime mortar and small proportion of sugar solution (i.e. solution prepared by mixing, 3 kg of jaggery, $1\frac{1}{2}$ kg of Bael fruit to 100 litre of water by boiling) or a solution prepared by soaking drynuts of terminalia chebula in water, for obtaining improved water proofing of concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float.
4. **Curing:-** The lime concrete after compaction shall be cured for a minimum of 10 days or until it hardens by covering with a thin layer of grass or straw which shall be kept wet continuously.
5. **Treatment at junction of roof and parapet:-** All along the junction of roof surface with parapet wall, a strip of lime concrete fillet shall be laid and finished smooth. Typical detail of treatment at junction between lime concrete water proofed roof finish and masonry walls are illustrated in the Figure-3

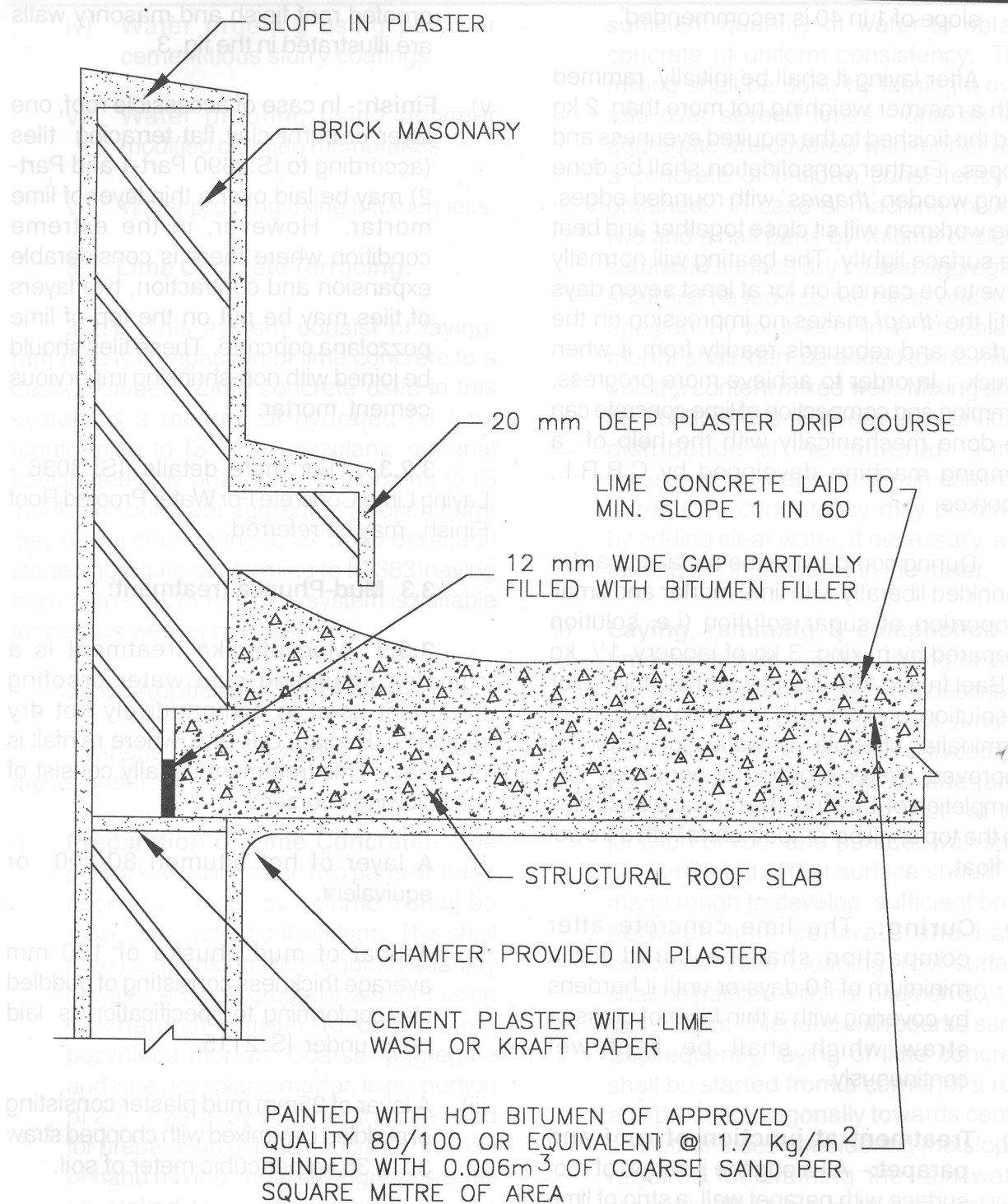


Fig. 3

DETAIL AT JUNCTION BETWEEN LIME CONCRETE WATERPROOFED ROOF FINISH AND PARAPET WALL

6. Finish: - In case of accessible roof, one layer of burnt clay flat terracing tiles (according to IS: 2690 Part-1 and Part-2) may be laid over a thin layer of lime mortar. However, in the extreme condition where there is considerable expansion and contraction, two layers of tiles may be put on the top of lime

pozzolana concrete. These tiles should be joined with non-shrinking impervious cement mortar.

7. For more details, IS: 3036 - Laying Lime Concrete For Water Proofed Roof Finish, may be referred.

3.3 **Water proofing using polyethelene film:**

3.3.1 It consists of laying of polyethylene film on slopped roof surface. This system is suitable for new as well as old roofs. This treatment generally consists of application of following courses:

- i) A coat of bitumen primer conforming to IS: 3384 applied to the prepared surface at the rate of 0.3 to 0.5 kg/m².
- ii) Application of hot applied bitumen (straight run bitumen conforming to IS: 73) at the rate of 0.70 kg/m² minimum.
- iii) Laying of polyethylene film conforming to IS: 2508 with cold cutback adhesive in overlaps.
- iv) Laying of 100 gm brown Kraft paper laminated insitu over the film with semi hot layer of straight run bitumen.
- v) Application of semi hot applied bitumen at the rate of 0.7 kg/m² dusted with fine sand.
- vi) **Laying of finishing layer of factory made plain CC tiles confirming to IS 1237-1980.**

3.3.2 Application procedure:

Various steps involved in this system are as under:

- i) **Provision of slope and completion of preparatory works:** - Prior to application of water proofing treatment roof surface shall be provided with a minimum slope of 1 in 60 with cement concrete or cement sand mortar or lime surkhy mortar. After provision of slope all preparatory works like filling up of cracks in roof structures by cement sand slurry, provision of adequate number of drain outlets, provision of 75mm fillet at junction of roof slab with parapet wall., provision of a groove/ chase in parapet wall etc. as described in IS:3067-1988 "shall be completed.
- ii) **Method of laying:** - After completion of preparatory works, a coat of primer shall be applied on the prepared roof surface by brushing and allow it to dry for 6 to 12 hours. Then a coat of hot bitumen shall be spread on the roof surface and allowed to cool to a temperature so that the film may be laid without any damage to it.

The polyethylene film shall be carefully laid and pressed on the bituminous layer. The film shall be pressed down with the help of a gunny cloth so as to prevent any damage to the film. The next length of the polyethylene film shall be similarly laid down with proper longitudinal and end overlaps firmly pressed on the bituminous layer. The joints and overlaps shall be carefully sealed with the help of cutback bitumen applied over the upper surface of lower layer of polyethylene film. Minimum width of lap shall be 10 cm between adjacent films and at the ends. As far as possible for flat roof the film shall be laid at right angles to the direction of flow of water with overlap facing downwards. Width of film should be selected in such a way so that no. of laps are minimum.

On polyethylene film 100 gm brown Kraft paper shall be fixed with semi hot layer of straight run

bitumen. The technique of fixing kraft paper to polyethylene film is to paint semi hot bitumen on the paper, reverse it and laminate over the film.

Kraft paper shall be coated with semi hot applied bitumen at the rate of 0.7 kg/m² dusted with fine sand. After finishing roof surface, treatment shall be applied to parapet, gutters and drain mouth.

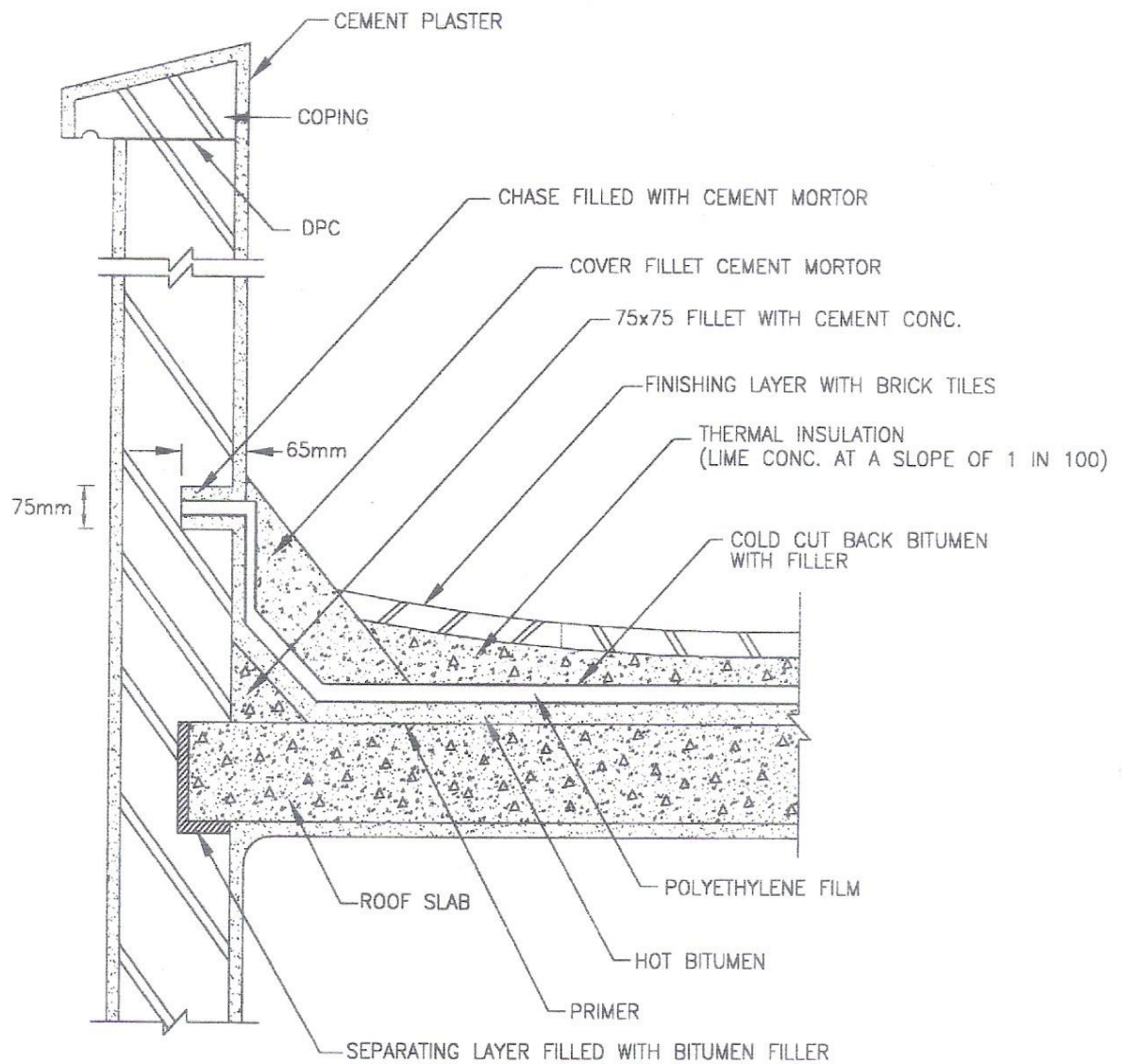
- iii) **Treatment at the junction of roof with parapet wall:** - Typical details of treatment at junction of roof with parapet wall are shown in Fig 4&5. Where down water pipes are provided to drain off the rain water, extra piece of polyethylene film shall be provided in the opening covering the edge of the water pipe and covered with cement plaster 1:6.
- iv) Surface Finish: - After completion of treatment, roof shall be provided with any one of the following:
 - a) Cement concrete flooring tiles of 20 mm thick conforming to IS: 1237;
 - b) Burnt clay flat terracing tiles conforming to IS: 2690 (Part-1) or IS: 2690 (Part-2);
 - c) Indian Patent Stone i.e. 1:2:4 concrete 40mm thick with 10 mm down aggregate.

Typical details for complete treatment for new roofs are shown in Figure-4 and For old roofs; details are shown in Figure-5

3.3.3 Precautions in laying polyethylene film:

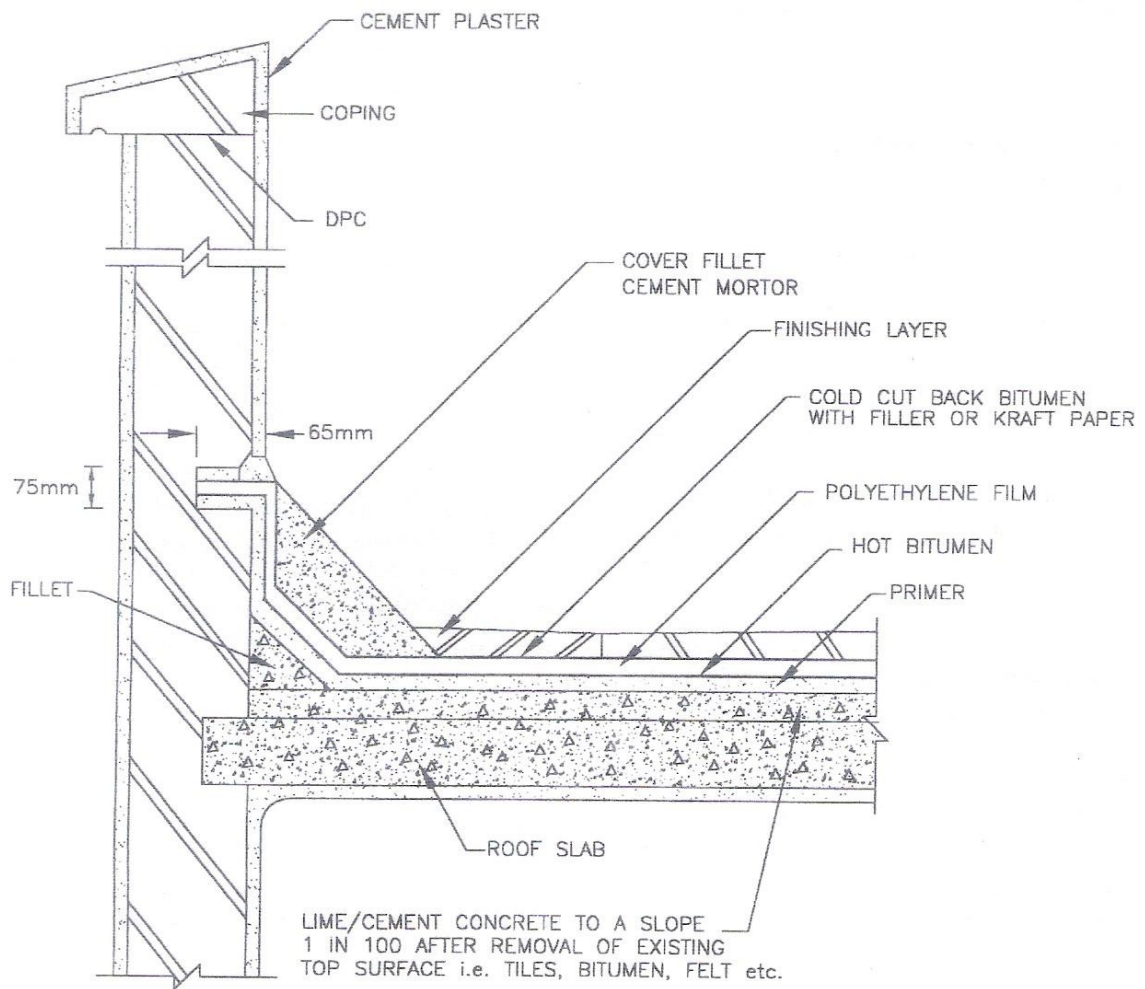
- i) The roof surface should be reasonably smooth so as to avoid puncturing of film. Primer should not be applied on wet surface.
- ii) Excessive bitumen should not be used for bonding the film to the prepared surface, which may otherwise result in the film sliding and wrinkling.
- iii) Over stretching of the film shall be avoided at the time of laying, which otherwise leads to wrinkles when the film retracts.
- iv) The laying of the film should be immediately followed by subsequent operations of covering with bituminous compositions. It is found that if the film is left, exposed, it can lead to softening of bitumen layer underneath causing wrinkles, which may possibly lead to damage. The work should not be carried out at high temperature.
- v) The workman should preferably walk barefooted or with canvas shoes to prevent damage to the film.

3.3.4 For more details IS: 7290 - Recommendations for Use of Polyethylene Film For Water Proofing of Roofs, may be referred.



TYPICAL DETAIL OF WATER PROOFING TREATMENT
USING POLYETHYLENE FILM (FOR NEW ROOF)

Figure-4



TYPICAL DETAIL OF WATER PROOFING TREATMENT
USING POLYETHYLENE FILM (FOR OLD ROOFS)

Figure-5

3.4 Water proofing using bitumen felts:

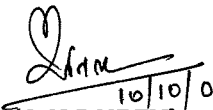
This system consists of laying of bitumen felts over sloped roof surface. Life of this treatment is limited to 4-6 years only. Water proofing treatment with bitumen felt consists of four or six courses. The choice of four or six course treatment depends upon the climatic conditions and extent of rainfall.

3.4.1 Four Course Treatment

- a) First Course: Initial layer of bonding material i.e. blown bitumen 85/25 or 90/15 conforming to IS : 702-1988 applied hot @ 1.45 Kg per square meter of area
- b) Second course: Laying of Bitumen felt/Membrane Type 3 grade-I (Hessian based self finished bitumen felt) conforming to IS-1322 manufactured by Bengal Bitumen, STP Ltd, Arcus Ltd etc.
- c) Third Course:-Another layer of bonding material (bitumen) applied hot as in first course @1.20 Kg per Sq.M of roof Area.
- d) Fourth and final course:-Final layer of pea size gravel or stone grit 6mm and down size or spread at 6 cubic meter per square meter in case of non accessible roofs. Where the roof is to be used for sleeping or other purposes, brick or precast concrete tiles (or any other suitable cladding) are laid in cement mortar to the required slope over the waterproofing treatment. In such cases, the final course of grit or pea size gravel is not necessary.

3.4.2 Six Course Treatment

- a) First Course: Initial layer of bonding material i.e. blown bitumen 85/25 or 90/15 conforming to IS : 702-1988 applied hot @ 1.45 Kg per square meter of area
- b) Second course: Laying of Bitumen felt/Membrane Type 3 grade-I (Hessian based self finished bitumen felt) conforming to IS-1322 manufactured by Bengal Bitumen, STP Ltd, Arcus Ltd etc.
- c) Third Course:-Another layer of bonding material (bitumen) applied hot as in first course @ 1.20 Kg per Sq.M of roof area.
- d) Fourth Case- The fourth layer consists of bitumen felt; care should be taken that laps in the felt are staggered from those in the previous layer.
- e) Fifth Course: Another layer of bonding material (bitumen) applied hot as in first course @ 1.45 Kg per Sq.M of roof area.
- f) Sixth & Final Course: Final layer of pea size gravel or stone grit 6mm and down size or spread at 6 cubic meter per square meter in case of non accessible roofs. Where the roof is to be used for sleeping or other purposes, brick or precast concrete tiles (or any other suitable cladding) are laid in cement mortar to the required slope over the waterproofing treatment. In such cases, the final course of grit or pea size gravel is not necessary.


10/10/07
(A.K.DUBEY)

Chief Engineer/Works

Docket No- W-2/118/09/Works Policy /412

Date-10.10.07

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1. CAO/Con/N, CAO/Con/S/MHX for information Pl.
2. Sr.DEN/ (Co-ord)/DNR, DHN, MGS, SPJ & SEE for information and necessary action.
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10/10/07
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For General Manager (Engg)