UNIT 6 ADMIXTURES AND WATER PROOFING MATERIALS

Structure

6.1 INTRODUCTION

In the previous unit, we discussed about wear resisting materials, their types, properties and application in the construction field. Now, in this unit we shall talk to you about admixtures and water-proofing materials.

Conventional cement concrete is manufactured from four ingredients namely cement, fine aggregates, coarse aggregates and water. The four ingredients sometimes are not able to have the required properties when used in different situations. There arises the need for a fifth ingredient to modify the property of concrete. Presently it has become a trend to use a fifth ingredient in concrete which is known as concrete admixture or concrete chemicals. These admixtures arc generally polymer/silicon based, produced from waste products and hence cheap. Their dosages arc very less generally not exceeding 1to2% weight of cement, end these come in a liquid form or powder form, which is easily soluble in mixing water. They surprisingly change many of the fresh and hardened concrete properties hence, no concrete in an advance country is produced without an admixture. In Indian market many admixtures have come up and as a concrete technologist one should strongly advocate their use.

Admixtures can be of different types, each one can be used to improve some desired properties of concrete. One of the most commonly used admixtures is superplasticizer. It not only improves many properties of concrete like improvement in strength and workability, less bleeding and segregation, but also leads to considerable saving in cement.

Structures are planned, designed, constructed with materials so choosen that they ultimately fulfill all the functional requirements. One of the most important functional requirements is water proofing and damp proofness. With the present trend for high rise buildings, this aspect has attained paramount importance, as these buildings will expose greater surface area to the sun and rain. This aspect is also important for under ground structures, water retaining structures, structures housing sensitive electronic equipments

etc. There are various types of conventional water/damp proofing materials of which some are very effective. Also a new class of water proofing materials, based on the present day research, have come up in the Indian market.

Objectives

After going through this unit, you should be able to

* explain admixtures, their types, advantages and application areas and some commonly available admixtures
* describe superplasticizers, their chemistry, types, functioning, advantages and applications,
* list various types of water proofing/damp proofing compounds, both conventional and modern and
* apply water proofing/damp proofing compounds, and precautions for the best effective usage.

6.2 ADMIXTURES

Admixtures are materials other than the basic ingredients of concrete-cement, water and aggregates-added to the concrete mix immediately before or during mixing to modify one or more properties of either fresh or hardened concrete. Admixtures should improve one or more properties of either fresh or hardened or both concretes which otherwise could not be achieved economically by adjusting the proportions of cement and aggregates. Admixtures at the same time should not adversly affect any property of concrete. Admixtures ranging from addition of chemicals to waste materials, have been used to modify certain properties of concrete. The properties commonly modified are the rate of hydration, setting time, workability, dispersion, air entrainment, strength, segregation and durability. The admixture is generally added in a relatively small quantity. A degree of control must be exercised to ensure proper quantity of the admixture, as an excess quantity may be detrimental to the properties of concrete.

6.2.1 Function of Admixtures

Following are the important purposes for which admixtures are used :

a) To accelerate the initial set of concrete,
b) To retard the initial set,
c) To increase the strength of concrete,
d) To improve workability,
e) To reduce heat evolution due to hydration of cement,
f) To increase durability of concrete i.e. its resistance to special conditions of exposure, like repeated freezing and thawing cycles, chloride, alkali silicate reactions, carbonation, etc.
g) To control alkali-aggregate expansion,
h) To decrease the capillary flow of water through concrete and to increase its impermeability to liquids,
i) To improve the penetration and pumpability of concrete,
j) To reduce segregation in grouting mixture,
k) To increase bond between old and new surface,
l) To increase the bond of concrete to the steel reinforcement,
m) To inhibit corrosion in concrete,
n) To increase resistance to chemical attack,
o) To produce celluar concrete,
p) To produce coloured concrete or mortar for coloured surfaces,
q) To produce concrete of fungicidal, germicidal and insecticidal properties,

r) To produce non-skid surfaces, and

s) To produce light weight concrete.

6.2.2 Types of Admixtures

In addition to admixtures, there are other construction chemicals to improve the quality of construction. Admixtures and construction chemicals can be broadly classified into the following four groups :

a) Group **1** - Concrete and mortar admixtures.

b) Group 2 - Mould release agents and surface retarders.

c) Group **3** - waterproofing liquid membrane, decorative waterproofing coatings and primers.

d) Group 4 - Surface hardeners, water rcpcllents, curing compounds, polymer mortar for concrete repairs and maintenance, leakage stoppers and waterproofing slurry, non-shrink grouts, injection grouts, waterproof tile adhesive and joint mortars.

Group - 1

Concrete and mortar admixtures arc further classified into the following types

a) Plasticizers and superplasticizers – their basic function is to

i) incrcasc workability, or

ii) water reduction against a constant workability requirement and thus improving strength, or

iii) saving cement against constant workability and strength requirement.

b) Retarding plasticizers; their basic function is to retard selling process with increased workability.

c) Accelerating and guniting aids; their Its basic function is to accelerate the setting and hardening process thus provide rapid strength development. In addition to this, guniting agcnts increase bond strength and workability of concrete so that less energy is spent in guniting and gunited concrctc does not rebound from surface where it is gunited.

d) Air entraining agcnts; their function is to improve :-

i) Improve workability,

ii) avoid segregation and bleeding in the resulting concrete,

iii) incrcasc resistance to dc-icing salts,

iv) to improve coverage of plasters, scrccds etc. by entraining air in the concrete during mixing operation.

e) Waterproofing compound it makes concrete waterproof, prevents moisture penetration, allows higher dispersion of cement and incrcasc workability also.

f) Grouting additive it is an expansion grouting admixture causing expansion in the grouting mortar concrete and thus making grout not only non-shrink but also expansive depending on the situation,

g) Polymer bonding agcnts these arc high quality, saponification resistant, liquid resin latex dispersion material for improving adhesion and strength of all types of commonly used mortars. It is suitable as an admixture for concrete, cement mortars, lime and gypsum mortars for obtaining waterproofing, efficient adhesion and bonding properties.

Group - 2

a) Mould rcleasc agcnts are highly concentrated, and when applied on shuttering surfaces, ensures fair faced concrete, protects formwork with no staining hence, lower maintenance and cost. A modified version of these can be used as machinery protcctor.

b) Surface retarders; Surface retarders when applied to form work surface it retards hydration of the surfacc concrete which is in contact with formwork. Hence, it can be used to achieve the exposed aggregate concrete finish. It avoids hacking for future plasters, and provides mechanical keys for plasters, mortars etc. for better bonding,

Group - 3

Various polymer based universal waterproofing liquid membranes, free from tar and' bitumen which can be applied on new as well as old roofs, terraces and balconies, etc. and various decorative waterproofing coatings and primers for decorative waterproofing treatment on walls, etc. fall under this category.

Group - 4

Following admixtures from this group:

a) Surface Hardeners— Admixtures to be applied sprinkled on green concrete surface after floatation. Makes concrete surface high abrasion and wear resistant, dust proof. Useful for industrial flooring, spillways, roads and airfield pavements etc.

b) Concrete curing compound—refer to Unit **4.**

c) Injection grout for cracks—premixed polymer based grout for injection into cracks.

d) Leakage stopper; polymer based quick sealer to stop water leakages.

e) Waterproof slurry; polymer modified hydralically setting slurry for waterproofing and damp proofing.

f) Polymer mortar for repairs and maintenance. These are polymer modified fine mortar, ready-to-use.

6.2.3 Some Commonly Available Admixtures

i) Plasticizers

a) Emceplast B V Liquid produced by M/s. MC-Bauchemic (India) Pvt. Ltd., 296, Perin Nariman Street, Bombay - 1.

b) Centriplast F F 90 produced by M/s. MC-Bauchernic (India) Pvt. Ltd., 296, Perin Nariman Street, Bombay - 1.

c) Chemicrete produced by M/s. Chemisol Agencies, 41 Princess Street, Bombay - 2.

d) Sikanol-M produced by M/s. Sika Qualerete Private Ltd., 24 B, Park street Calcutta - 16.

e) Sikament F F produced by M/s. Sika Qualerete Private Ltd., 24 B, Park street Calcutta - 16.

ii) Air Entraining Agents

a) MC - Mischoel L P Liquid produced by M/s. MC- Bauchemic (India) Pvt. Ltd.

b) MC - Mischoel AEA Liquid produced by M/s. MC- Bauchemic (India) Pvt. Ltd.

c) Chemicrete produced by M/s. Chemisol Agencies, 41 Princess Street, Bombay-2.

d) Fro - Be produced by Ms. Sika Qqualcrete Pvt. Ltd.

e) Frio plast A Flomo AEP produced by Ms. Sika Qual Crete Pvt. Ltd.

iii) Waterproofing Compound

a) MC - Special DM (powder) produced by M/s. MC - Bauchemic India Pvt. Ltd.

b) Dreiseal 330 (powder) produced by M/s. MC - Bauchemic India Pvt. Ltd.

c) Ditchament DM (liquid) produced by M/s. MC - Bauchemic India Pvt. Ltd.

d) Putz - Ditcharnent (liquid) produced by M/s. MC - Bauchemic India Pvt. Ltd.

e) Rubbersied Waterproofing Compound produced by M/s. Chemisol Agencies Pvt. Ltd.

f) Chemistic Clear Water Proofer produced by M/s. Chemisol Agencies Pvt. Ltd.

g) Epoxy Mortar produced by M/s. Chemisol Agencies Pvt. Ltd.

h) Chemisil Water Repellent produced by M/s. Chemisol Agencies Pvt. Ltd.

i) Plastocrete M produced by M/s. Sika Qual Crete Pvt. Ltd.

j) Noleek CP produced by M/s. Sika Qual Crete Pvt. Ltd.

k) Sika 1 produced by M/s. Sika Qual Crete Pvt. Ltd.

l) Sikalite for concrete produced by M/s. Sika Qual Crete Pvt. Ltd.

iv) AC celerating and Guniting Aids

a) MC - Schnell SOS produced by M/s. MC - Bauchemic India Pvt. Ltd.

b) MC - Schnell OE produced by M/s. MC - Bauchemic India Pvt. Ltd.

v) Retarding Agents

a) MC - Retard *060* produced by M/s. MC - Bauchemic India Pvt. Ltd.

(It may be noted that list of brand names & manufacturers are not exhaustive)

6.3 SUPER PLASTICIZERS

In concrete making water-cement ratio plays a major role. If water-cement ratio is less, a concrete with less capillary voids can be produced thus improving the improving strength of the concrete. However, with less water/cement ratio the workability of the mix is reduced and hence, compaction with available means becomes difficult. This introduces air voids known as entrapped air which in turn causes reduction in strengtli. There is a tendency on the part of the workers to increase quantity of water and thereby workability, resulting in highcr water/cement ratio. This is a dilemma for the site engineers. Here concrete chemicals like plasticizers and superplasticizers come to a big rescue, their addition improves workability, even for low water-cement ratios. Thus in the mix design of concrete, one more parameter is introduced, i.e, superplasticizers.

6.3.1 What is Superplasticizer

The superplasticizers are a new class of water reducing admixtures, chemically different from normal water reducers, capable of reducing waler content by as much as 25 to 30% against same workability requirement. They were first introduced in Japan, in 1964, and in Germany, in 1972. In recent years, construction agencies over the globe have shown keen interest in these admixtures.

The superplasticizers are organic chemical compounds. They are chemicals which when added to normal concrete, impart high workability without any undesirable side-effects such as excessive air entrainment or any appreciable retardation of setting action. Allows large reduction in unit water content against same workability, much beyond the range of normal plasticizers.

Generally, the dosage of the conventional plasticizer does not exceed 0.25% by weight in the case of lignosulphates or 0.1% by weight in the case of carboxylic acids. The superplasticizers, in general could be used in considerably higher dosage *(0.5* to 2%), since they do not entrain air. The LS variety of superplasticizers have an effective fluidizing action but at relatively high dosages. However, they can produce some undesirable effects, such as acceleration or delay in setting times. They may also slightly increase air entrainment in concrete.

6.3.2 Classification

The superplasticizers are broadly divided into four catagories, based on their chemical composition. These are :

a) Category A - Sulphonated Melamine Fornialdehydc (MSF) condensate or their sodium salt. In this, melamine reacts with sodium bisulphite, and then goes fur polymerization.

b) Category B - Sulphonated Napthelene Formaltlchyde (NSF) condensate or their sodium salt. The material is produced from napthelene by oleum or sulphar trioxide sulphonation. Subsequent reaction with formaldehyde leads to polymerization and the sulphonic acid is normally neutralized with sodium hydroxide.

c) Category C - Modified Lignosulphates (LS). During the process for the production of paper making pulp from wood, a waste liquor is formed as a by-product containing a complex mixture of substances, including decomposition products of lignin and cellulose, sulphoiiation products of lignin, various carbohydrates and free sulphurous acid or sulphates. Subsequent neutralization, precipitation and fermentation processes produce a range of lignosulphonates of varying purity and composition depending on a numher of factors, such as the neutralizing alkali, the pulping process used, the

degree of fermentation and even type and age of the wood used as pulp feedstock.

d) **Category** D - (a) Polyhydroxylated polymer, or (b) Mixture of acid-amids and poly saccharides.

6.3.3 How Superplasticizers Act

Cement particles, during grinding, acquire randomly positive or negative charges on their surface. When water is added, they form agglomeration imbibing water within agglomeration, which will not be available for workability.

The plasticizing action in superplasticizers is physical in nature and is explained by absorption of isotherms, i.e. sticking of admixtures particles on cement particles attributing like charge to all cement particles which increase Zeta potential and thus causing cement particles to mutually repel each other, releasing imbibed water within agglomeration. The absorption causes changes in the water cement system and therefore in its rheology. By dispersing the cement in aqueous solution of superplasicizers, the latter are absorbed on the surface of solid particles. If the dosage of superplasticizers is increased beyond limit the unabsorbed superplasticizers particles will hinder with normal hydration process. However superplasticizers can be safely used at much higher dosage than the ordinary plasticizers without the problems of excessive air entrainment, retardation or bleeding, which might otherwise be expected in case of the ordinary plasticizers.

Dispersion of cement particles releases the imbided water trapped within agglomerated cement particles and increases workability. Also as cement particles are well-dispersed more number of particles as also larger surface area are available for hydration. Uniform coating of hydrated cement products on sand and aggregate surface results in uniform binding capability of micro-structure and hence concrete higher strength.

Due to this action of superplasticizer there is considerable change in the morphology of resulting hydrated cement paste, forming smaller size crystals and smaller dimension capillaries. This improves both durability and strength of concrete.

6.3.4 Advantages of Superplasticizer

a) Makes flow concrete, i.e. self compacting concrete with slump more than 200 without segregation or bleeding.

b) Water-reduction against the same workability requirement. Unit water content can be reduced by 25 to 30%.

c) High strength concrete—By reducing water content against the same workability, strength can be increased by 50 to 80%, depending on cement/aggregate ratio.

d) Saving in cement—Against same workability and strength requirement, cement/aggregate ratio can be reduced to effect economy.

e) Retempering done with superplasticizer will not cause any reduction of strength.

6.3.5 Some Commonly Available Superplasticizers

a) Zentrament - Super (BV) —produced by M/s. MC-Bauchemic (India) Pvt. Ltd., Sangli Bank Bldg., 296 Perin Nariman Street, Fort, Bombay-1. Dosage 0.5 to 1.1% of cement weight, brown liquid miscible with water.

b) Conplast - 337—produced by M/s. Fosroc Chemicals (India) Ltd., Shankar House, 1 & 18 Rajmahal Vilas Extn., Mehkri Circle, Bangalore-80. Brown liquid, dosage 0.7 to 1% by weight of cement.

c) Chemisol—produced by M/s. Chemisol Agencies Pvt. Ltd., 41, Princess Street, Bombay-2. Brown liquid, dosage 1 to 2% of cement weight.

d) Sikament FF—produced by M/s. Sika Qual Crete Private Limited, 24 B, Park Street, Calcutta-16. Brown liquid, dosage 1 to 2% of cement weight.

(It may be noted that the list of brand names and manufacturers are not exhaustive)

SAQ 1 :

1. Explain in what way the superplasticizers arc different from plasticizers.

2. What are the different categories of the superplasticizers ? Which of them arc most commonly used and why ?

3. Explain the mechanism by which superplasticizers increases workability.

4. Discuss various factors on which superplasticizer action depends.

5. Name some of the commonly available superplasticizers in the Indian market.

6.4 WATER PROOFING MATERIAL

Generally materials used to contruct the structures are so cliosen or to exclude water from any source entering into a building in the form of leakage, seapage or dampness. This has become a formedable task for the architechts, engineers and builders inspite of the tremendous advancement made in the building technology and materials in the recent years. In spite of the fact that the engineers understand intimately the material they use the problem related to the structural behaviour, the effect of forces of nature on the structures leakage and seapage have not been solved. On the contrary, the dampness in modern buildings has assumed a greater dimension than ever before.

The dampness of building causes unhygienic condition, affects functional efficiency, causes deterioration, degradation, impairs structural integrity and, in fact, the root cause of many other serious defects which subsequently cause failure of the structures. The rough estimate of the loss of assets to the nation in terms of rupees on account of leakage and seapage which causes deterioration to structures would be the order of about 300 crores or even more per year.

Problems of water proofing and damp proofing have assumed serious dimension in modern time because :

i) the volume of construction has greately increased of late, disproportionate to the qualified trademen available.

ii) there is dilution in the quality of some of the building materials like bricks, sand, lime, etc.;

iii) presently as the structures are becoming taller for want of space, the building elements like wall, slabs etc. are made thinner to reduce load on foundation causing more susesptibility of leakage through these elements.

iv) high rise buildings expose a greater surface area to the sun and rain, which promotes greater seapage and leakage,

v) as the buildings are becoming taller there arises necessity to anchor tlie structure deep into the ground. As a logical step, provision of basement floors are common, which are usually subjected to water pressures and, hence, causes seapage problem,

vi) in modermodermodermodermodermodermodermodemtimes the construction of large number of underground structures such as swimming pools, static water tanks, liquid retaining structures, deep sewers, buried water mains, deep pump houses, underground storage, underground structures for housing sensitive electronic signal equipments etc. are of common requirements,

vii) necessity for construction of innumerable overhead water tanks, large span grains or fertilizers silos, leakage in which is difficult to eliminate,

viii) provision of roof garden, terrace lawns, the swimming pools on terraces of high rise buildings requires careful considerations for waterproofing.

ix) complicated consealed plumbing system, buried conduit drainage stacks and pipe joints which remains wet all throught their Life span, demand waterproofing and damp-proofing of the highest order.

Most of the building materials have in-built capillary pore system, which forms about 15 to 25%, depending on materials the type of. Owing to these capillary pore system, these materials are more or less pervious to water and allows the capillary rise of water through them causing dampens. This can be prevented by constructing an impervious layer which acts as a barrier to water ingress, or by mixing some compound during the manufacture of such building material which in turn, will block the capillary pores. In next few sections, we shall be discussing about some of the conventional as also unconventional types of waterproofieg systems, their method of application, advantages and disadvantages.

6.4.1 Mud Phuska

Preparation of Mud Phuska

The dry soil shall be stackecl in the required quantities in about **30** cm high stacks over a level ground, and the top surface divided will be into a suitable compartment by bunding. The estimated quantity of water, corresponding to the optimum moisture content shall be added about 12 hours before the use, and allowed to soak. The stacks of soil shall then be

worked up to ensure proper distribution of moisture at the time when the soil is to be used.

Preparation of Mud Plaster

The dry soil shall be reduced to fine powder, and mixed with water in the pit, adding 6% wheat straw and 12% cow dung by weight. The mixture is to be allowed to rest for a period not less than 7 days. During this pcriod, it shall be pugged manually, using spades if necessary, to get a homogeneous mass free from lumps and clods.

preparation of Mud Mortar

Mud mortar used as bedding under brick tile layer shall be prepared in the same manner as mud plaster but without any addition of fibrous reinforcement material and binding building material. The mud mortar may be used without any maturing period.

Leeping Plaster (Gobri Lipping)

This shall be prepared by mixing soil which is free from coarse sand with approximately equal volume of cow dung and adding the required quantity of water. The mixture shall be worked to a homogeneous mass.

Laying

The mud phuskn shall be laid in loose layers of thickness not more than 15 cm, to tlic proper slope and rammed manually with wooden rammers and thapis so as to obtain maximum density. The surfacc shall then bc allowed to dry for a period of not less than 24 hours. If any cracks appear, these shall be filled with a grout of cow dung used in the leeping plaster.

Over mud phuska, a mud plaster shall be laid to a total thickness of not lcss than 25 mm in a single coat or two coats of 15 mm and 10 mm, the latter being preferable. Each coat of plaster shall be allowed to dry; hair cracks, if any, shall bc filled with gobri leeping. The surfacc shall be checked for slope and evenness with a straight edge and spirit-level and made up where necessary by application of plaster.

When the surfacc of mud plaster has dried; a thin coat of leeping plaster shall bc applied to a thickness of not less than 3 mm and finished with trowel or float. Tlic surface shall bc allowed to dry. When hair cracks appear, they shall bc filled with gobri leeping.

Paving with Brick Tiles

Where tile paving finish is indicated, brick terracing tiles sliall he laid directly over tlic mud plaster and no leeping plaster sliall bc provided. Brick tiles sliall be laid flat on a thin layer of mud mortar to give a level surface. The tiles shall bc laid close to each other and the thickness of joints sliall not bc lcss than 6 mm and not morc than 15 mm. It shall be ensured while laying the tiles that the mud niortar rises vertically in the joints to a height of about 15 mm. The brick tile work shall hc allowed to dry for a period of 24 hours before grouting of joints. The joints shall bc grouted flush with cement and sand mortar (1:3) mixed with crude oil 5 percent by weight of cement. The surface of the finished roof sliall bc kept wet far a period of not lcss than 7 clays. The completed brick tile surface shall bc checked for evenness and slopc.

6.4.2 Lime Concrete Terracing

Preparation of Lime Concrete

One part of slaked lime and two parts of surkhi by volume, shall bc mixed on a water-tight platform. This shall then be sprinkled with the required quantity of water, and shall be well ground in a mortar mill or mechanical grinders. Hand pounding may bc done for small quantities. Burnt brick aggregate shall be soaked thoroughly in water for a period not lcss than six hours before use in the concrete mix. The lime concrctc shall be prepared by thoroughly mixing aggregate and lime-surkhi mortar in the proportion of 2.5 : 1 by volumc. 12 kg of washing soap and 4 kg of alum dissolved in water shall bc added to each cubic metre of lime concrete. Lime concrctc shall be used in the work within 36 hours of the preparation of lime mortar.

Laying

The roof surfacc shall be wire brushed and cleaned of all dust and foreign matter. Where indicated, a coat of blown grade bitumen conforming to IS:702-1961 sliall bc evenly applied at the rate of 1.2 kg per sq.m.

Laying of lime concrete shall be started from a corner of the roof and preceded diagonally towards centre and other sides considering the slopes required for draining

the rain water smoothly. Unless otherwise indicated, average thickness of lime concrete shall not be less than 10 cm and the minimum thickness not less than 7.5 cm. After lime concrete is laid, it shall be initially rammed with a rammer weighing not more than 2 kg and further consolidation shall be done using wooden thapies. The beating shall be carried out by mazdoors who will sit close together, and beat the surface lightly and in rhythm and move forward gradually. The beating shall be carried on for atleast seven days until the hand beater makes no impression on the surface and rebound readily from it when struck.

During compaction by hand beating, the surface shall be sprinkled liberally with lime water and small proportion of jaggery solution (prepared by mixing 3 kg of jaggery and 1/2 kg of bael fruit to 100 litres of water in the northern parts of country or a soultion prepared by soaking in water dry nuts of terminalia chebula). For preparation of the solution of Terminalia chebula (kadukkai), the dry nuts shall be broken to small pieces, and allowed to soak in water. A soultion shall be made of 600 gm. of kadukkai, 200 gm. of jaggery and 40 litres of water (sufficient for 10 sq. m. of roof), and brewed for 12 to 24 hours.

The resulting liquor shall be decanted and added to lime water. On completion of beating, the mortar coming out on the top shall be trowelled with the addition of jaggery solution, if necessary, and finished smooth. The finished surface shall be even, and slope as directed.

If the surface during the process of compaction becomes so uneven that the water stands in pools, the surface shall be pricked and fresh lime concerte spread and consolidated as necessary, so as to ensure proper slopes and Icvels, with adequate bonding between old and new concrete by sprinkling requisite quantity of lime water (1 part patty and 3 to 4 parts water) with sugar solution as specified above. Lime concrete, after compaction, shall be cured for 6 days or until it hardens by covering with a thin layer of grass or straw, which shall be kept wet continuously. The construction details are illustrated in Figure 6.1.

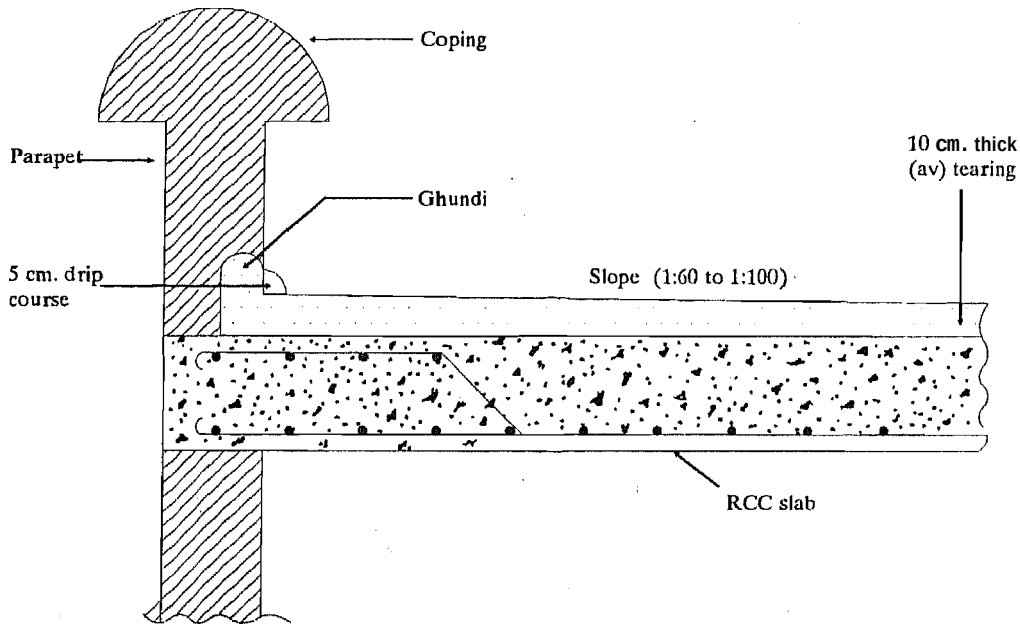


Fig. 6.1 : Lime Concrete Terracing

6.4.3 Bitumen Felt Treatment

Felt shall be cut to the lengths required lor the work, rolled on to cores and kept in position for laying. Felt shall be laid commencing at the lowest level and working towards the highest, thereby ensuring that overlaps of strip do not oppose free drainage of rain water.

Preparation of the Surface

Any cracks in the roof structures shall be cut into "V" shape, cleaned, and wetted its surface and filled up with cement and sand mortar (1:3) slurry. It shall be ensured that the top of the roof is at a uniform gradient of not less than 1:80.

The surface of roof and that part of parapet and gutters, drain mouths, etc, over which the waterproofing treatment is to be applied, shall be cleaned of all foreign matter, such

as, fungus, moss, dust, etc. by wire brushing and dusting. For cast-iron drain outlets, a groove shall be cut alround to tuck in the treatment. Concrete angle fillets shall be provided at junctions between roofs and vertical faces of walls (parapet and other walls), around obstacles such as pipes, chimney stacks, etc, and other similar situations to case up abrupt corners in the waterproofing treatment and the treatment taken over the fillets. At drain mouths, the fillet shall be suitablly cut back and rounded off for proper application of waterproofing treatment and easy flow of water.

A groove of 75 mm × 65 mm shall be formed (or left where possible) at a minimum height of 15 cm above roof level, for tucking in edges of waterproofing treatment in case of brickwalls, etc. The groove shall coincide with the horizontal joint of a brick course, and shall be shaped with cement and sand mortar (1:3) for properly accommodating the waterproofing treatment. In case of low parapets (not exceeding 45 cm in height), no groove shall be provitled and the waterproofing treatment shall be carried right over the top. In the case of concrete and stone walls, providing chase in the wall for tucking in the waterproofing treatment is not recommended. At the junction between the roof and verticle face of the wall, cement concrete angle fillet 75 mm in radius shall be constructed. A groove shall be made in this fillet on top where it meets the parapet and waterproofing trcatmcnt shall be tucked into this groove and filled solidly with bitumen.

Outlets at very low dividing wall less than 300 mm in height shall bc cut open to full depth and the bottom and sides shall be rendered smooth and corners rounded off for easy application of waterproofing treatment.

Primer

After all the cement and lime work has set and dried, and the surface has been cleaned, primer shall be brushed over the entire prepared surface at the rate specified above, but not less than 0.7 litre per sq m, and alluwed to dry. Primer shall conform to the requirement of IS-3384-65

Treatment

Waterproofing with bitumenous felt shall consist of any of the following treatments

Normal treatment, 4 courses, for moderate conditions using thc hessian basc felt over primer.

a) Applied hot bitumen (blown type bitumen conforming to IS -702-1961, penetration not exceeding 40 units) at the rate of 1.2 kg. (minimum) per sq. m. of roof surface,

b) Hessian-base self-finished felt, type 3, grade 1 conforming to IS-1322-82,

c) Applied hot bitumen at thc rate of 1.2 kg. (minimum) per sq, m. of roof surface, and

d) Pea sized gravel or grit at the rate of 0.006 m^3. per m^2. of surface.

Heavy treatment, 6 courses, for severe conditions using the hessian base felt over primer.

a) Applied hot bitumen at the rate of 1.2 kg.(minimum) per sq. m. of roof surface

b) Hessian basc self finished felt, type 3, grade 1,

c) Applied hot applied bitumen at the rate of 1.2 kg. (minimum) per sq. m. of surface

d) Hessian-base self-finished felt, type 3, grade 1,

e) Applied hot bitumen at thc rate of 1.2 kg. (minimum) per sq. m. of surface, and

f) Pea gravel or grit at thc rate of 0.006 m^3. per m^2. of surface

Flashing and Drain Mouth

The surface finish of pea gravel or grit shall be omitted on flushings, and at drain mouths, and a finish of two coats of hot bitumen at the rate 1.2 kg. (minimum) per sq. m. of surface provided instead.

Laying

Prior to laying, the preparatory works, as described earlier, shall be completed and the cement or lime work allowed to set and dry. The bituminous bonding material shall be prepared by heating to the correct working temperature, and conveyed to the point of work in a bucket or pouring cane.

The felt shall normally be laid in length at right angles to the direction of the run-off gradient, commencing at the lowest level, and working up to the crest. In this way thc

overlaps of the adjacent layers of felt offer the minimum obstruction to the flow of water. The felt shall be first cut to the required lengths, brushed, cleaned of dusting material and laid out at flat on the roof. Each length of felt prepared for laying shall be laid in position and rolled up for a distance of half of its length. The hot bonding material shall be poured on to the roof across the full width of the rolled felt, as the latter is steadily rolled out and pressed down. The excess bonding material squeezed out at the ends shall be removed as the laying proceeds.

When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and unrolled onto the hot bonding material in the same way. The minimum overlaps of 100 mm. and 75 mm. shall be allowed at the ends and sides of strip felts, respectively. All over laps should be firmly bonded with hot bitumen.

The process of applying the coat of bitumen shall be simultaneously carried out with gravelling. The pea sized gravel or grit shall be clean and shall be pushed on to the hot coat of bitumen and not spread by hand from containers. When gravelling is complete and the coat cold and firm, all surplus gravel or grit shall be removed by brushing. If pea sized gravel or grit is not available, locally available coarse sand may be used.

In case of pent roofs where the type of treatment consists of one layer of felt only, as in normal treatment, an additional layer of felt shall be provided at the ridge, which shall cover a minimum length of slope by 25 cm on both sides of the ridge. The laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

Felt shall be laid as flushings in width, wherever junctions of vertical and horizontal structures occur, with a minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flushing shall be tucked into the groove made in the wall in case of brick walls and in the concrete fillet angle in case of the RCC and stone masonry walls, on the vertical face of the wall. The edge of the groove coming directly under the felt shall be slightly rounded to avoid any damage to the felt. Each layer shall be so arranged that the joints are staggered with those of the layer beneath it.

After all the specified layers have been laid and the flashing properly bonded, the groove in brick wall shall be filled up with cement and sand mortar (1:3) or cement concrete (1:2:4) which, when set, will satisfactorily secure the treatment to the wall. The groove filling shall be cured by watering for at least 4 days after filling to ensure satisfactory strength and to avoid shrinkage cracks.

Drain mouths shall be widened. Felt shall be laid as on the other portion of the roof excepting that the treatment shall be carried inside the drain mouth overlapping at least 100 mm.

6.4.4 Polyethylene Film/Film-Paper Laminate

Unsupported polythcne film or laminate of film with paper constitutes an excellent and durable moisture barrier, since it is practically impervious to water-vapour.

The progressive architects, engineers and contractors in this country are already familiar with the unique properties which make polyethylene film ideally suitable for waterproofing. This highly durable moisture barrier is already being used in this country for such diverse usages as waterproofing of roofs, damp proofing of floors/basements, air-strip and road underlay, lining of canal/reservoirs and tanks, shuttering, etc.

Polyethylene film is wear resistant. If punctured or cut, it will not shatter, crack or run. While retaining flexibility even at subzero temperature, it will not become sticky in hot weather either. It is flexible its elongation is approximately 600% .On account of this, the film remains unaffected by the temperature fluctuations that cause expansion and contraction in roof slabs.

It is light weight, and has a specific gravity of 0.914 to 0.925. It gives larger coverage per unit weight, i.e. over 110 sq. m. of 100 μ film for less than 10 kgs. Because of its lightness, polyethylene film is easier to transport to up-countries and gives lasting performance. The film is available in various thickness ranging from 25μ to 250μ, and width 10 ft. and above are preferable for roof-lining and damp proofing applications. Black film is recommended specially for outdoor installations, since the carbon black added to the natural polyethylene resins renders the film resistant to ultra-violet rays.

Recommended thickness of the polyethylene film for different constructional applications.

Natural film thk-50 μ, 100 μ, 150 μ

* Air strip underlays
* Crawl space covers
* Slab underlays
* Shuttering
* Concrete covering

Black film thk-100 μ, 150 μ

* Roof lining
* Damp-proofing of floors/basements
* Railways embankments/canal lining etc.

Procedure for Roof Lining

Roof lining treatment can be

a) Normal treatment
b) Heavy treatment

Both normal as well as heavy treatment can be applied on top of thermal insulation layer which is normamally laid on the roof slabs. Heavy treatment become necessary only when the durnal range of temperature variation is high (usually about 15°C). Both the treatments can be finished either with tiles or with pea-sized gravel, as desired.

Normal Treatment

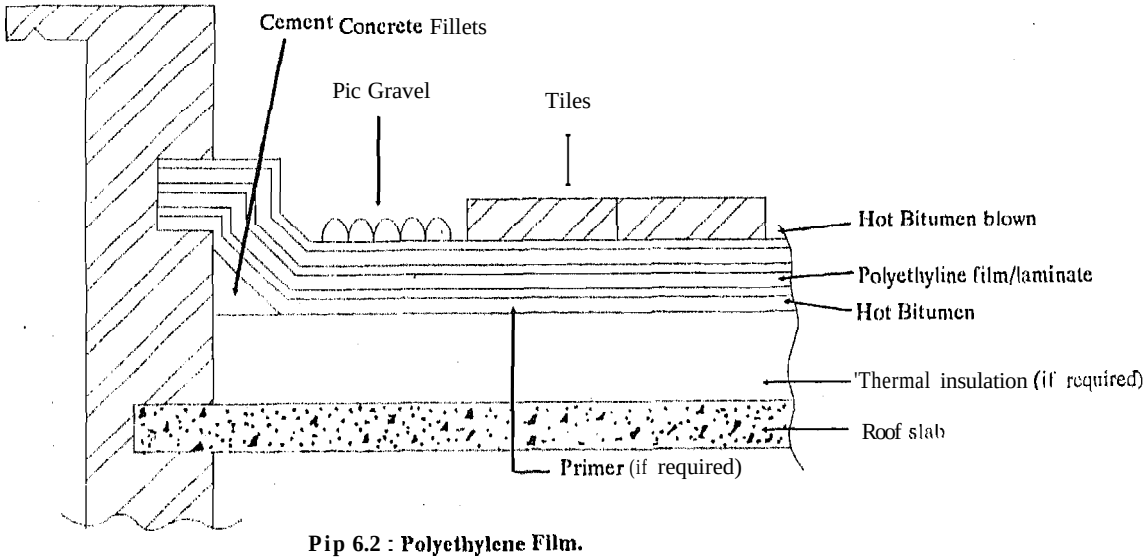
i) Cold bitumen emulsion applied at 0.8 kg per sq.m. minimum
ii) Wide width polyethylene film of 100μ thick.ess
iii) Bitumen emulsion @ 1.5 kg per sq.m. minimum
iv) Fine jute cuttings @ 1.2 kg per sq.m. minimum
v) Pca-sized gravel or grit @ 0.006 cu.m. per sq m.

OR

i) Hot applicd bitumen @ 1.2 kg per sq.m. minimum
ii) Polyethylene film-paper laminate (film surface in contact with bitumen)
iii) Hot applied bitumen, of melting point not exceeding 60 degree C.
iv) Hot applicd bitumen blown type at 1.5 kg per sq.m. minimum
v) Pea-sized gravel or grit @ 0.006 cu.m.per sq.m.

Heavy Treatment

i) Cold bitumen emulsion applicd @ 0.8 kg per sq.m. minimuin.
ii) Wide width polyethylne film 150 or 175 micron
iii) Bitumen plaster of 3/8" thickness minimum
iv) Hot applied bitumen @ 1.5kg per sq. m. minimum



Pip 6.2 : Polyethylene Film.

v) Pea-sized gravel or grit @ 0.006 cm.per sq.m. or tile finish

OR

i) Hot applied bitumen @ 1.2 kg per sq.m. minimum

ii) Polyethylene film-paper laminate

iii) Hot applied bitumen of melting point not exceeding 60 degrees C @ 1.2 kg per sq. m. minimum

iv) Polyethylene, film-paper laminate

v) Hot applied bitumen of melting point not exceeding 60 degrees C @ 1.2 kg per sq.m. minimum

vi) Hot applied bitumen, blown type @ 1.5 kg per sq. m. minimum

vii) Pea-sized gravel or grit @ 0.006 cm. per sq.m. or tile finish

A typical application of polyethylene film treatment is shown in Figure. 6.2

Suggestions for Proper Laying :

i) For flat roofs, the film or laminate should be laid at right angles to the direction of the run off gradient.

ii) Overlaps shduld be so arranged that they do not offer any hindrance to the drainage of water.

iii) Hot applied bitumen should be allowed to cool to about 60 degrees C prior to laying of film overlay.

iv) The film or laminate should be carefully unrolled on the bituminous coat and pressed down, preferably with the help of a roller in order to avoid formation of wrinkles or air pockets.

v) Excess of bitumen, if any, should be squeezed out from below the ends of the film or laminate.

vi) Anchoring of film or laminate in the parapet walls should be carried out as indicated in the figure.

6.4.5 Damp Proofing

Damp proofing application of Polyethylene film can be grouped into the following categories

A) Damp proofing treatment for floors above the ground level

i) Damp proofing coarsing should cover the entire area of the floor space including the thickness of the walls, but excluding rendering, in order to ensure adequate moisture protection. The treatment should not be set back from the wall face for pointing.

ii) The surface on which the film is to be laid should be smooth and free from sharp protrusions.

iii) The film paper laminate should be interlinked in order to constitute an uninterrupted barrier to the subsoil moisture.

B) Damp proofing treatment for the basement

i) Provision of a prepared base of cement concrete, .or any other suitable material, finished smooth and of a size covering the whole area of the basement, and extending upto at least 25 cm beyond the outer faces of the structural walls. Also protective vertical wall made of brick or other suitable material is constructed.

ii) Damp-proofing treatment laid over the entire area of the basement and taken up vertically as shown in Figure. 6.3.

iii) Prolective layer of bricks, laid flat, or any other suitable material laid soon after the laying of damp proofing treatment on the floor. Vertical inner protective wall made of bricks or other suitable material is also constructed simultaneously.

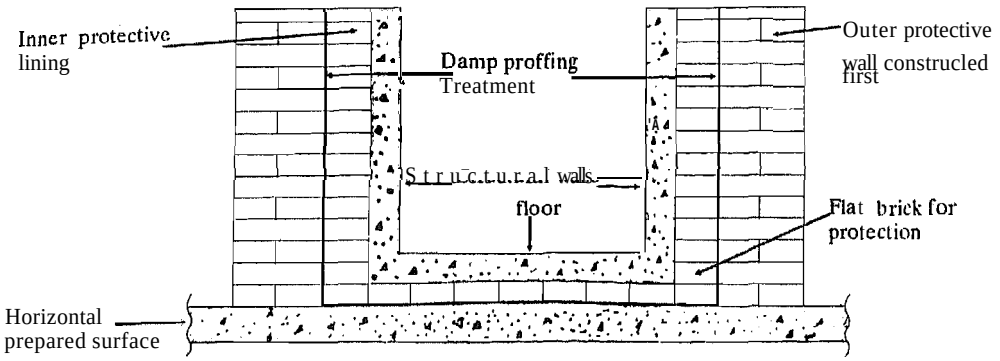


Fig. 6.3 : Damp Proofing Treatment for Basement

Detail of Damp-proofing

For case **A** above one of the following treatment is recommended :

Method 1

i) Fine sand layer of 5 cm thickness minimum for cushioning.
ii) Polyethylene film of 150 to 175 micron thickness
iii) Fine sand layer of 5 cm thickness minimum

Method 2

i) Hot applicd blown bitumen @ 1.5 kg per sq.m. minimum
ii) Polyethylene film or film paper laminate (film surface to he in contact with bitumcn)
iii) Hot applied blown bitumen @ 1.5 kg per sq.m. minimum

For case B one of the following methods can be adopted.

Method 1

i) Primer to be applicd if necessary
ii) Hot applied blown bitumen @ 1.5 kg per sq.m. minimum
iii) Polyethylene film-paper laminate
iv) Hut applied blown bitumen @ 1.5 kg per sq.m. minimum
v) Polyethylene film-papcr laminate
vi) Hot applicd blown bitumen @ 1.5 kg per sq.m. minimum

Method 2

For floor

i) Fine sand layer of 10 cm thickness minimum for cushioning
ii) Polyethylene film of 150 to 175 micron thickness
iii) Fine sand laycr of 5 cm thickness minimum

For walls

i) Hot applicd blown bitumcn @ 1.5 kg per sq.m. minimum
ii) Polyethylene film of 150 to 175 micron thickness
iii) Cold bitumen emulsion @ 0.8 kg per sq.m. minimum
iv) 10 oz. hessian cloth
v) Cold bitumen emulsion @ 1.0 kg per sq.m. minimum

Suggestions For Proper Execution of Damp–proofing Treatment

i) The damp proofing of basement etc, should be taken in hand only when the subsoil water level is at its lowest, preferably during the dry season. Till treatment is laid and is properly finished, the site has got to be kept dry by adequate arrangements. If necessary, water may have to be pumped out continuously the until damp-proofing lreatment is completed.

ii) The surface, over which the film-laminatc has to be laid, must be rendcrcd smooth and free of protrusion. If, in spite of the best arrangements, the surface to be treated remains slightly wet, even then, the damp-proofing may be laid on

hot damp bitumen primer. Although tlie surface is not sticky, tlie purpose may be served if the layer of film or laminate adheres to bitumen, sufficient care is taken to ensure proper overlapping, and the joints are well stuck.

iii) Suitable structural support has to be provided to the damp proofing treatment to ensure that it can withstand the water pressure from the basement.

iv) It is preferable, in fact easier, to apply the treatment in new buildings right at the time of construction. However, it is neither too late nor diffcult to provide such treatment to existing basenicnts.

v) In case vertical damp-proofing has to be laid continuous to the horizontal one, a fillet 7.5 cm, in radius must be provided, and tlie vertical wall face must be given an even coat of mortar, which will provide a sort of smooth cushioning for the treatment.

vi) The space between the inner protective wall and the treatment, has to be cement grouted. This will ensure that no air is trapped between the gaps. The structural walls are then to be constructed as dcsircd.

vii) The minimum overlaps of 7.5 to 10 cm should be allowed while laying the film. Film overlaps have to be firmly bonded with bitumen or emulsion and sealed with polyethylene adhesive tapes. In case of film-paper laminate, the overlaps can be joined with hot bitumen.

6.4.6 Fiberglass Tissue Sheet Treatment

Fiberglass tissue sheet is a thin resin bonded menibrani: of long stable fibres drawn from cliemically resistant molten glass. The thickness of the tissue sheet can be varied depending upon individual requirements. The tissue sheet is porous and permits rapid impregnation by resin, coal tar enamel, bitumen or film forming paint. It is chemically inert and rot-proof and is ideally suited as a reinforcing and carrier membrane for organic or inorganic coatings.

The fiberglass tissue sheet is used in two ways. In the first cnsc, the fiber glass tissue sheet is treated with a coatant consisting of hard gracle blown bitumen with mica or talc powder. The physical characteristics of fiberglass tissue sheets are given in IS7193-74.

Alternatively, the fiberglass tissue sheet is treated on-the-spot with hard grade blown bitumen. Bitumen is treated and poured over the primed roof surfaces and the tissue sheet is constantly laid on the sprayed hot bitumen layer. This forms a single layer of bitumen fiber glass system. This operation is repeated to build up a system consisting of multiple layers of bitumen/fiber glass tissue sheets. The final step consists of finishing the top layer with a medium such as sand, pea-gravel, slate pieces or any other available inert material. The code of practice for in-site waterproofing and damp proofing treatment with bitumen-impregnated fiber glass tissue sheet is given in IS 9918-1981.

6.4.7 Plastofelt Treatment

This is a hi-performance plastomeric waterproofing system. It consists of torchable water-proofing membrane made up of a non-woven polister reinforcement base, saturated and coated with plastomeric modified bitumen, finished on the upper side with fine sand and tlie under side covered with a thermofusible plastic film. Plastofells are laid on a bitumen primer with the help of a flaming torch. The felt comes in a roll. A typical laying process is shown in Figure 6.4.

6.4.8 Elastomeric Waterproofing System

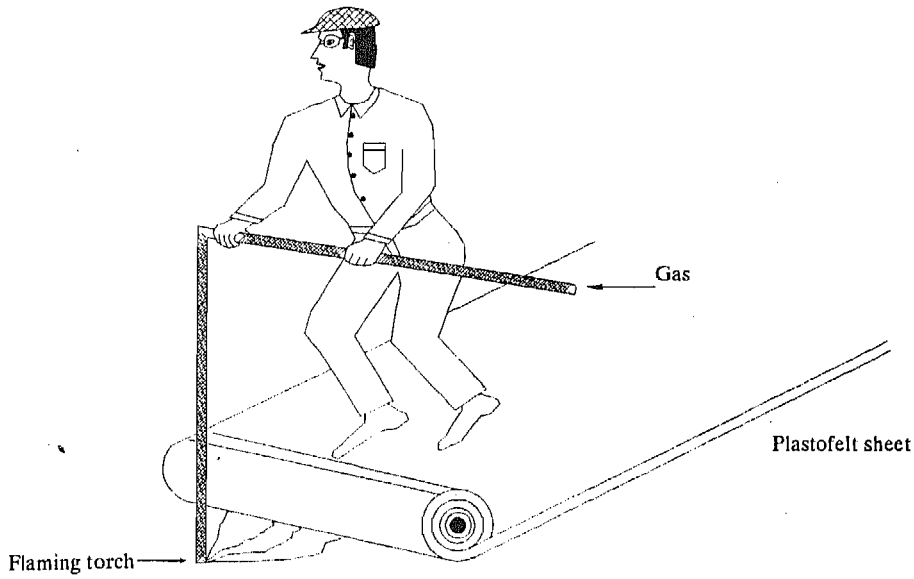
It consists of three compounds

a) Elastokote an elastomeric rubber based bitumen which gives a elastic coating.

b) Polyester mat or equivalent-felt made of polyester. which comes in rolls.

c) Elasto Aluminium-elastomeric Aluminium, i.e., rubber reinforced aluminium. It forms a coat of very high heat reflecting property.

The surface is first treated/brushed with elastokote on which immediately the polyester mat is laid on which a layer of elastokote is applied with the help of brush, and finally a coat of clastoalumin.



Pig. 6.4 : Plastofelt Treatment

Advantages

It is seemless, easy to apply, liquid part dries in 24 hours, very tough, flexible, elastic, rubber like base and lop film, excellent adhesion to moist surface, excellent weather resistent and has excellent reflectant qualities.

6.4.9 Integral Waterproofing Compounds

Even in the case of excellent composition and compactness, each type of concrete consists of small voids, the so-called "capillary pores" (on an average 13-16 per cent by volume) which arc due to a generous addition of mixing water used to obtain a sufficient compactness and workability, Owing to these capillary pores, concrete is always more or less pervious to water or hygroscopic. Integral waterproofing compound contains various chemicals, which, on one hand, cause a contraction of capillaries and on the other hand, convert the water-absorbing capillary forces into water-rcpcllcnt capillary forces due to the hydrophobic effect of the constituents.

Integral waterproofing compounds are formulated and designed to prevent the passage of water through pores and capillaries of the concrcte, thereby imparting to concrete an efficient, reliable and durable waterproofing protection against rains, ground water, moisture, clampncss, humidity, etc, It is a waterproofing compound for fabrication of permanently capillary proof, water tight and hydrophobic concrete.

It also improves the workability and considerably reduces the bleeding and segregation tenhencies of the mix. It lowers the surface tension of the mixing water by virtue of which the cement particles and aggregates are more effectively dispersed. These factors make concrcte strong, durable, dense and watertight.

Integral waterproofing compounds are available either in a powder or liquid form. It can be mixed with dry a ingredient if in the powder form or during the mixing process. However after adding, concrete should be mixed at least for one minute. The dose generally varies between 1 to 2% by weight of cement. It can be used with all standard cement, (Portland cement, ordinary and reinforced, portland blast furnace cement). A 10% cut in gauging water can be made by using integral waterproofing compound against constant workability, which, in turn, leads to a strength increase by 15 to 20%.

Advantages

a) Makes the concrete waterproofing.
b) Resists water penetration and absorption into concrete.
c) Makes the mix more workable.
d) Makes W/C ratio reduction possible,
e) Does not change the setting time nor adversely affects the reinforcement.
f) Disperses rapidly, and makes a homogeneous mix.
g) Surrounds, binds and seals the ingredients in concrete, thereby making concrete non-absorptive.

h) Makes concrete dense.

i) Provides an efficient and durable barrier against rain water, moisture and ground water.

j) Does not contain chlorides or any other harmful ingredients.

k) Reduces the efflorescence, segregation and bleeding tendencies.

Applications

1) Water reservoirs, tanks and swimming pools.

2) Foundations, basements and underground structures.

3) Roofs, balconies, terraces and sunshades.

4) Sanitary areas and bathrooms.

5) Dams, harbours, irrigation structures and water canals.

6) Subways and tunnels.

7) Cooling towers.

8) In all concrete where water penetration and absorption is to be prevented.

6.4.10 Waterproofing Liquid Membrane

These are thixotropic, cold applied, one component elastic material on a polymer basis for use on verticle as well as horizontal surfaces. Upon curing, they form a seamless and joint free, watertight, flexible and elastic membrane, thereby making the treated surface absolutely impervious to water. By virtue of its formation, the cured membrane is resistant to ultra-violet radiations, and exhibits excellent resistance to aggressive attacks from industrial pollution. They are non-flowing on vertical surfaces and becomes touch-dry in approximately 1 hour time and hardens in about 2 days. They are resistant to temperature range –20 degree C to + 100 degree C. They are generally applied in one or more coats by brushes over a manufacturer's recommended primer. They have however, low abrasion resistance, have to be sandwitched for accessible roof, and are to be over coated for under water application.

6.4.11 Epoxy Resins and Compound

Epoxy resins and epoxy resin based lormulations are not new for civil engineers. Over the past decade, epoxy resins as well as other polyineric resins have been experimeiited with and successfully used in India for many Civil Engg. applications. The need for such resins is felt for emergency repairs, maintenance, waterproofing and corrosion resistance. Epoxy resins can be further modified in formulating resin rich mortars, putties or coating compounds with the addition of coal tar and other additives.

Waterproofing by epoxy resins can be done in the following ways :

i) **Surface treatment–** By applying a brush coat of epoxy resins formulation which forms an impervious film on the surface, and thus, restricts the seepage of water.

ii) **Integral treatment –** In this case an epoxy resins based mortar is prepared and 3 to 5 mm thick layer of it is laid on concrete.

iii) **Injection grouting–** This method is used when fine cracks appear in the concrete/masonry structure. In this case a low viscosity resin is pressure injected into the fine cracks. The resin hardens even in wet condition, and gives a firm bond between separate layers.

Terrace Water Proofing

The waterproofing of the roof is done through the following stages :

i) Cleaning of application surface.

ii) **New concrete–** Remove laitance upto a depth of 6-10 mm and also curing compounds if they were applied. Allow sufficient time lor the concrete to set so that the initial water content is not too high.

iii) **Old concrete surface–** Remove all heavy deposits of dirts, asphalts, oils, or grease by using mechanical scraping and washing with detergents. The preferred mechanical methods are grinding, sand blasting and scarping. If mechanical cleaning is impracticable, use chemical etching treatment using

mild acid solution made with one part of commercial hydrochloric acid and two parts of water. After the acid etch, the floor should be washed with plenty of water and allowed to dry.

iv) **Application of epoxy system–** An epoxy system is made with an epoxy resinous compound, a hardener, and a flexibilizer when flexible epoxy resins arc used. Generally, resins and hardeners are mixed in 4:1 proportion. A coal of such a system is applied by brush, and when this coat becomes semidry, i.e., after **1-3** hours, a second coat is applied with brush.

v) **Curing–** The epoxy system is allowed to cure for **24-28** hours at room temperature.

6.6 SUMMARY

Conventional concrete is manufactured from a binder namely cement, fine and coarse aggregates and water. The conventional concrete many times do not acquire certain desired properties. Addition of a fourth ingredient which is called admixture or concrete chemicals can drastically improve certain selected properties of concrete, which are needed for a specific application. Depending on which properties of concrete are to be altered, the admixtures can be classified.

One of the most popularly used admixtures is superplasticizer. It can alter a wide range of properties of concrete. In fact in the advanced countries, no concrete is produced without super plasticizers. In this unit we have discussed about different admixtures, in general with a section devoted only to supel·plasticizers.

With the trend towards construction of high rise structures, which expose more surface to sun and rain, the construction of complicated structures and plumbing system, with more and more improvement in standard of living, it has become imperative to incorporate more and more effective damp-proofing and water-proofing systems. Presently very innovative and effective water-proofing/damp-proofing system has come up in the market. In this unit, you have been exposed to these new techniques and material, along with conventional systems of walcr-proofing and damp-proofing.

6.6 KEY WORDS

Admixtures	:	Additives used to modify the properties of concrete.
Workability		Measure of ease with which concrete can be compacted.
Plasticizers		Admixture which improves workability of concretc.
Superplasticizers	:	It is new class of water readucing admixtures.
Epoxy	:	Polymeric resins with bonding properties.
Lime terracing	:	Surface finish of lime mortar.
Felt treatment	:	It is a surface treatment by spreading mat lick material over surface and fixing in position.
Gunniting		Forcing cement slurry or fine mortar through nozzle.
Elastomeric compounds	:	Polymer based compound having elastic propertie's.
Run-off gradient		It is a slop given to surfaces to facilitate easy flow of rain water.

6.7 FURTHER READINGS

A. M. Neville, Properties of Concrete, The English Language Book Society & Pitman Publication.

M. R. Rixon & N. P. Mailvaganam, Chemical Admixtures for Concrete 1986.

M. S. Shetty, Concrete Technology, S. Chand Publications.

6.8 ANSWER TO SAQs

Check your Answers with Preceding text.