NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 12, Dec.-2016

DISTENTION IN CONCRETE

SWARNIMA REWATKAR
Student, M.Tech Construction Management,
SVSU, Maharashtra, India

ABSTRACT

The paper discusses the distention in concrete .When a blemish is seen on the surface of a concrete slab it could likely be swelling. Blisters, cracking, curling, discoloration, dusting, efflorescence, low spots, Pop outs, scaling or spalling are different types of distention's. Which are caused when an extra amount of entrapped air withheld in the concrete by a high percentage of material passing through various size sieves it can also occur due to restraint to shortening, sub grade settlement, thermal contraction etc. Reduction in absolute volume of solids and liquids in hydrating paste results to chemical shrinkage. Main causes for this are an excess amount of entrapped air in concrete, insufficient vibrations during compaction and finishing when the concrete is still spongy. Crack which occurs before hardening which is usually the result of settlement caused by rapid loss of water. When concrete is at just beginning to get strength, the climatic condition like relative humidity during the drying period in a wetting and drying cycle also makes crazing. Distention also includes rising up of a slab's corners and edges. Some of the blisters results from bleed water and bleed air. Sometimes blisters are very difficult to identify during finishing. Some factors are found to influence blisters are calcium chloride admixtures, cement alkalis, hard toweled surfaces, wet substrate. Some of these results of a thin, weak layer called laitance, composed of water, cement and water uniformly distributed. Sometimes blister is a deposit usually white in color. It is the general loss of surface mortar exposed to freezing and thawing. Other names used to describe these types of soils include expansive, shrinking and swelling.

INTRODUCTION

Early-age cracking can be a costly problem in concrete. Volume changes in concrete will drive tensile stress development when they are restrained. Cracks can develop when the tensile stress over crosses the tensile strength, which is generally only 10 percent of the compressive strength. At early ages, this strength is still developing while stresses are generated by volume changes. Controlling the variables that affect volume change can minimize high stresses and cracking. "Swelling" soils contain clay minerals that attract and absorb water. As a result, these soils expand when they get wet and shrink when they dry.
Other names used to describe these types of soils include expansive, shrinking and swelling.
To sum up, the following precautions are required to be taken by the Architects, Structural Consultants and Specifies:

- Standardized specification for concrete materials and concrete.
- Proper specifications to take care of environmental as well as sub – soil conditions.
- Constructible and adequate structural design.
- Standardized quality and thickness of concrete cover around the reinforcement steel.
- Planning proper reinforcement layout and detailing the same in slender structures to facilitate proper placing of concrete without segregation.
- Selection of proper agency to construct

TYPES OF DISTENTION

2.1 BLISTERS

Blisters are the bumps, of varying size, appears when bubbles of trapped air or water rising through the plastic concrete get trapped under an already sealed, airtight surface.
Blisters arise due to:

NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 12, Dec.-2016

1. An extra amount of trapped air held in the concrete by a high percentage of material passing the 600 µm, 300 µm, and 150 µm (No. 30, 50, and 100) sieves,
2. Insufficient vibration during compaction that does not adequately release entrapped air; or extreme use of vibration that leaves the surface with excessive fines, inviting crusting and early finishing.
3. Any tool used to compact or finish the surface will tend to force the entrapped air toward the surface. Blisters may not appear after the first finishing pass.

The appearance of blisters on the surface of a concrete slab during finishing operations is irritating.

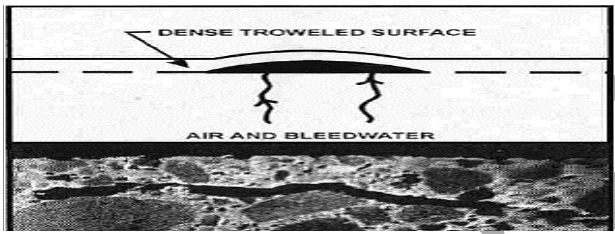

Fig -1: Cause of Blister

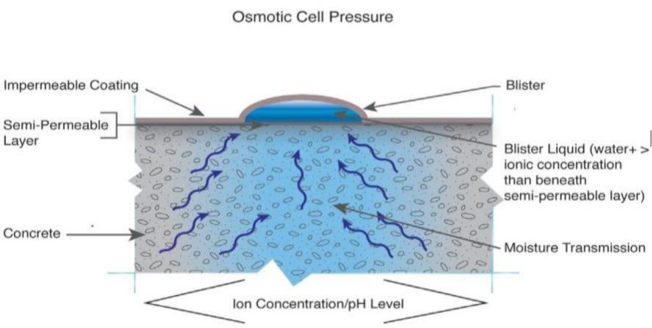

Fig -2: Cause of Blister

2.1.2 PREVENTION

The following should be considered:

1. Do not use concrete with a high slump, excessively high air content, or excess fines.
2. Use appropriate cement contents in the range of 305 to 335 kg/m3(515 to 565 lb/yd3). Blisters are surface bumps that may range in size from 5 mm to 100 mm (1/4 in. to 4 in.) in diameter with a depth of about 3 mm (1/8 in.).

2.1.3 CONCRETE SLAB SURFACE DEFECTS CAUSES, PREVENTION, REPAIR

1. Warm the sub grade before placing concrete on it during cold weather.
2. Avoid placing a slab directly on polyethylene film or other vapor barriers. Use a 100-mm (4-in.) layer of compactable, drainable fill (not sand). A “crusher run” material, usually graded between 38 mm to 50 mm (1-1/2 in. to 2 in.) down to rock dust, is suitable. Following compaction, the surface can be choked off with a fine-grade material to separate the vapor.

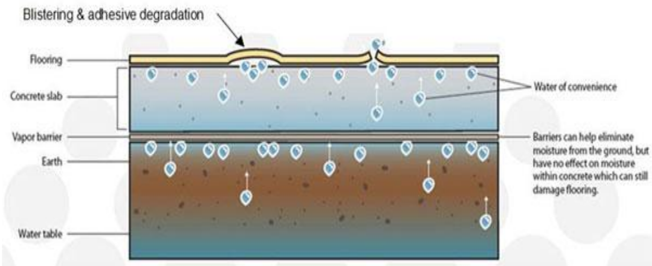

Fig -3: Cause of Blister

BARRIER FROM THE CONCRETE

1. Avoid overworking the concrete, especially with vibrating screeds, jitterbugs, or bull floats. Overworking causes aggregate to settle down, it bleeds water and excess fines to rise. Properly vibrate to release entrapped air.
2. Do not attempt to seal (finish) the surface too soon. Use a wood bull float on non-air-entrained concrete to avoid early sealing. Mg or Al tools should be used on air entrained concrete.
3. Use proper finishing techniques and proper timing during and between finishing operations. Flat floating and flat troweling are often suggested. Hand floating should be started when a person standing on a slab makes a 5-mm (1/4-in.) imprint or about a 3-mm (1/8-in.) imprint for machine floating. If moisture is deficient, a magnesium float should be used. Proper lighting is also very important during finishing.
4. Reduce evaporation over the slab by using a fog spray or slab cover.
5. Avoid using air contents over 3% for interior slabs.

2.1.4 REMEDIES TO FIX BLISTERS

- Blisters and other surface defects can usually be removed with a solvent bath
- This sometimes works with water-based sealers, but testing first is always recommended.
- Sometimes simple surface blisters in a solvent system can also be removed just by applying an additional coat of the same sealer.
- Surface sanding and re-application of the sealer has also worked in spot applications
- If bubbles run deep, then the sealer is usually on too thick, and a solvent bath along with back rolling may be needed.
- As a last resort, the surface can be stripped of all sealer, cleaned, and resealed.
- Xylene is commonly used to re-wet the sealer and lay the bubbles back down.
- The bubbles and blisters should be broke open for this to work best. In most cases xylene should fix the whitening also. If it doesn't these areas will have to be stripped of the sealer and re-sealed.
- The best time to seal new decorative stamped concrete is 28 days after it is poured. It can be wet cured or curing paper can be used to cure the concrete in the first week.
- The best time of day to seal new or old decorative concrete (or use xylene) is late afternoon or early evening when the concrete is cooling down and the sun is setting. By now most all the moisture has escaped the concrete from the day and night before.
- The temperature should be 50 - 70 degrees. This will give the sealer all night to harden and best resist any moisture escaping the next day. Once the sealer is fully cured, blisters and bubbles will not be a problem.
-

Fig -3: Xylene Sealantto Fix Blisters

2.2 CRACKING

Unexpected cracking of concrete is a frequent cause of complaints. Cracking can be the result of one or a combination of factors, such as drying shrinkage, thermal contraction, restraint(external or internal) to shortening, sub grade settlement, and applied loads.

Cracking can be significantly reduced when the causes are taken into account and preventative steps are utilized. For example, joints provided in the design and installed during construction force cracks to occur in places where they are inconspicuous**.**

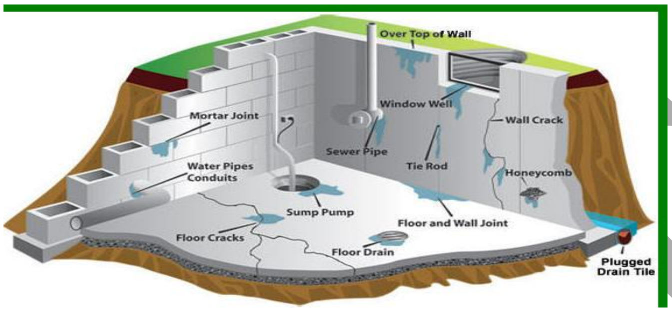

Fig -4: Types of Cracks

2.2.1 CAUSES

1. Cracks that occur before hardening usually are the result of settlement within the concrete mass, or shrinkage of the surface(plastic-shrinkage cracks) caused by rapid loss of water while the concrete is still plastic .

2. Settlement cracks may develop over embedded items, such as reinforcing steel, or adjacent to forms or hardened concrete as the concrete settles or subsides. Settlement cracking results from insufficient consolidation (vibration), high slumps (overly wet concrete), or a lack of adequate cover over embedded items

3. Plastic-shrinkage cracks are relatively short cracks that may occur before final finishing on days when wind, a low humidity, and a high temperature occur. Surface moisture evaporates faster than it can be replaced by rising bleed water, causing the surface to shrink more than the interior concrete. As the interior concrete restrains shrinkage of the surface concrete, stresses develop that exceed the concrete's tensile strength, resulting in surface cracks.

4. Cracks that occur after hardening usually are the result of drying Shrinkage, thermal contraction, or sub grade settlement.

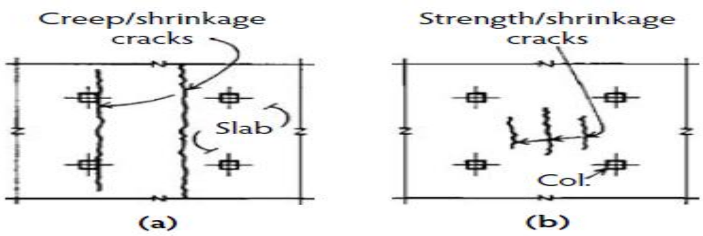

Fig -5: Shrinkage Cracks

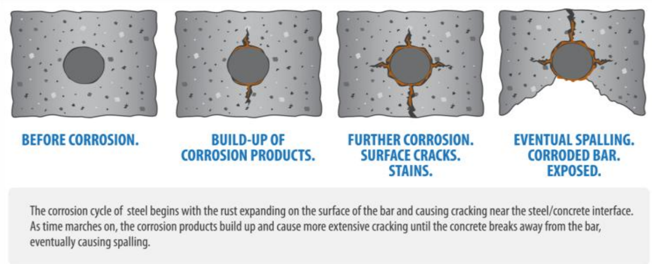

Fig -6: Corrosion Cracks

2.2.2 PREVENTION

1. Use proper sub grade preparation, including uniform support and proper sub base material at adequate moisture content.
2. Minimize the mix water content by maximizing the size and amount of coarse aggregate and use low-shrinkage aggregate.
3. Use the lowest amount of mix water required for workability; do not permit overly wet consistencies.
4. Avoid calcium chloride admixtures.
5. Prevent rapid loss of surface moisture while the concrete is still plastic through use of spray-applied finishing aids or plastic sheets to avoid plastic-shrinkage cracks.
6. Provide contraction joints at reasonable intervals, 30 times the slab thickness.
7. Provide isolation joints to prevent restraint from adjoining elements of a structure.
8. Prevent extreme changes in temperature.
9. To minimize cracking on top of vapor barriers, use a 100-mmthick (4-in.) layer of slightly damp, compactable, drainable fill choked off with fine-grade material. If concrete must be placed directly on polyethylene sheet or other vapor barriers, placed directly on polyethylene sheet or other vapor barriers, use a mix with low water content.
10. Properly place, consolidate, finish, and cure the concrete.
11. Avoid using excessive amounts of cementations materials.
12. Consider using a shrinkage-reducing admixture to reduce drying shrinkage, which may reduce shrinkage cracking.
13. Consider using synthetic fibers to help control plastic shrinkage cracks.

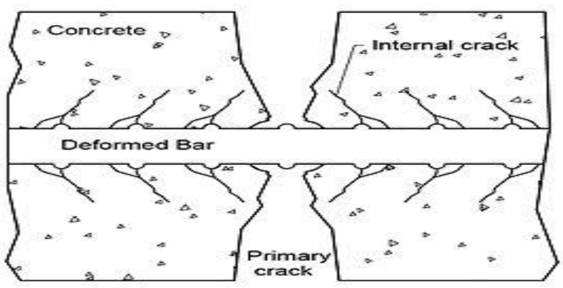

Fig -7: Internal and Primary Cracks

2.2.3 METHODS OF CONCRETE CRACK REPAIRS

EPOXY INJECTION: Cracks as narrow as 0.002 in. (0.05 mm) can be bonded by the injection of epoxy. The technique generally consists of establishing entry and venting ports at close intervals along the cracks, sealing the crack on exposed surfaces, and injecting the epoxy under pressure. Epoxy injection has been successfully used in the repair of cracks in buildings, bridges, dams, and other types of concrete structures (ACI 503R). However, unless the cause of the cracking has been corrected, it will probably recur near the original crack. If the cause of the cracks cannot be removed, then two options are available.

ROUTING AND SEALING: Routing and sealing of cracks can be used in conditions requiring remedial repair and where structural repair is not necessary. This method involves enlarging the crack along its exposed face and filling and sealing it with a suitable joint sealant. This is a common technique for crack treatment and is relatively simple in comparison to the procedures and the training required for epoxy injection. The procedure is most applicable to approximately flat horizontal surfaces such as floors and pavements. However, routing and sealing can be accomplished on vertical surfaces (with a non-sag sealant) as well as on curved surfaces (pipes, piles and pole).

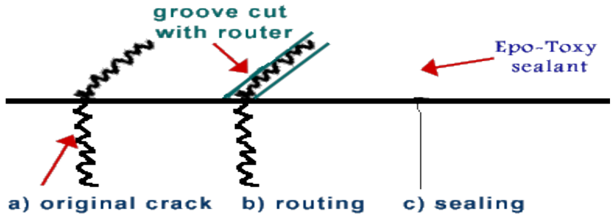

Fig -8: Crack Repair by Routing and Sealing

STITCHING: Stitching involves drilling holes on both sides of the crack and grouting in U-shaped metal units with short legs (staples or stitching dogs) that span the crack. Stitching may be used when tensile strength must be reestablished across major cracks. The stitching procedure consists of drilling holes on both sides of the crack, cleaning the holes, and anchoring the legs of the staples in the holes, with either a no shrink grout or an epoxy resin-based bonding system.

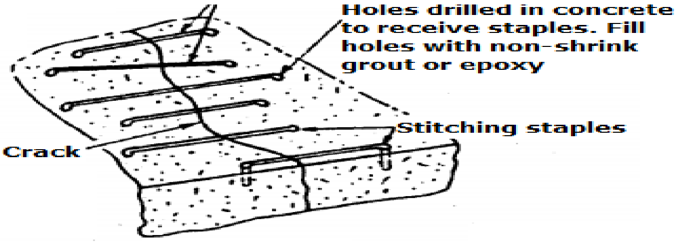

Fig -9: Crack Repair by Stitching

DRILLING AND PLUGGING: Drilling and plugging a crack consists of drilling down the length of the crack and grouting it to form a key. This technique is only applicable when cracks run in reasonable straight lines and are accessible at one end. This method is most often used to repair vertical cracks in retaining walls. A hole [typically 2 to 3 in. (50 to 75 mm) in diameter] should be drilled, centered on and following the crack.

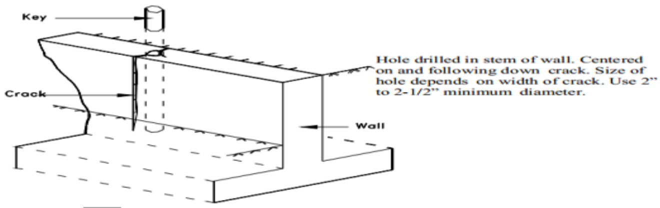

Fig -10: Crack Repair by Drilling and Plugging

GRAVITY FILLING: Low viscosity monomers and resins can be used to seal cracks with surface widths of 0.001 to 0.08 in. (0.03 to 2 mm) by gravity filling. High-molecular weight methacrylate, urethanes, and some low viscosity epoxies have been used successfully. The lower the viscosity, the finer the cracks that can be filled. The typical procedure is to clean the surface by air blasting and/or water blasting. Wet surfaces should be permitted to dry several days to obtain the best crack filling.

Fig -11: Crack Repair by Gravity Filling

OVERLAY AND SURFACE TREATMENTS: Fine surface cracks in structural slabs and pavements may be repaired using either a bonded overlay or surface treatment if there will not be further significant movement across the cracks. Unbounded overlays may be used to cover, but not necessarily repair a slab. Overlays and surface treatments can be appropriate for cracks caused by one-time occurrences and which do not completely penetrate the slab.

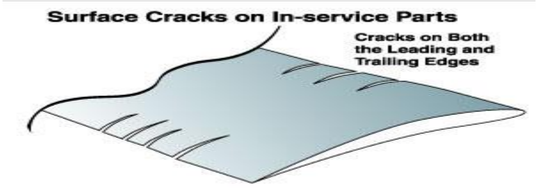

Fig -10: **Crack Repair by Overlay and Surface Treatments**

2.3 CRAZING

Crazing is a network of fine surface cracks. Crazing cracks are very fine and barely visible except when the concrete is drying after the surface has been wet. The cracks encompass small concrete areas less than 50 mm (2 in.) in dimension, forming a chicken-wire pattern. The term “map cracking” is often used to refer to cracks that are similar to crazing cracks only more visible and surrounding larger areas of concrete. Although crazing cracks may be unsightly and can collect dirt, crazing is not structurally serious and does not ordinarily indicate the start of future deterioration. When concrete is just beginning to gain strength, the climatic conditions, particularly the relative humidity during the drying period in a wetting and drying cycle, are an important cause of crazing. Low humidity, high air temperature, hot sun, or drying wind, either separately or in any combination, can cause rapid surface drying that encourages crazing. A surface into which dry cement has been cast to hasten drying and finishing will be more subject to crazing. The conditions that contribute to dusting, as described below, also will increase the tendency to craze.

2.3.1 PREVENTION

Curing procedures should begin early, within minutes after final finishing when weather conditions warrant. When the temperature is high and the sun is out, some method of curing with water should be used, since this will stop rapid drying and lower the surface temperature. The concrete should be protected against rapid changes in temperature and moisture wherever feasible.

2.3.2 REMEDIES

Crazing is rarely anything other than a cosmetic problem. Craze cracking is not repaired because it does not deteriorate over time and will not lead to further slab cracking, and the crazing cracks will not spread or become larger. : **Sealers and surface hardeners** actually can make crazing more obvious. If the owner really wants to fix crazing, a thin overlay is about the only choice.

2.4 CURLING

Curling is the distortion (rising up) of a slab’s corners and edges due to differences in moisture content or temperature between the top and bottom of a slab. The top dries out or cools and shrinks more than the wetter or warmer bottom. If the curled section of a slab is loaded beyond the flexural strength of the concrete, cracks may develop to relieve the stress.

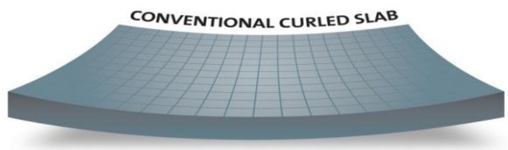

Fig -12: Curled Slab

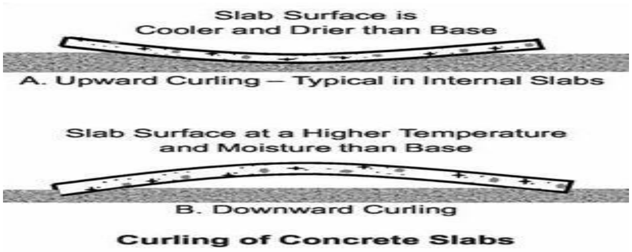

Fig -13: **Types and Cause of Curling of Concrete Slabs**

2.4.1 PREVENTION

1. Using a low-shrinkage concrete mix.
2. Using proper control-joint spacing (see Cracking).
3. Creating uniform moisture content and temperature of the slabfrom top to bottom.
4. Using large amounts of reinforcing steel 50 mm (2 in.) down from the surface.
5. Using thickened slab edges.
6. Using vacuum dewatering, shrinkage-compensating concrete or post-tensioning.

2.4.2 REMEDIES TO FIX CURLING

1. WET THE TOP OF THE SLAB

- Build a dam, seal joints and cracks, and pond water on the slab surface. Since curling is caused by the top of the slab being drier than the bottom, wetting the top of the slab should reverse the curling process. If ponding is feasible, this technique can temporarily reduce the amount of curl. Surface water at room temperature reduced the curling about 40%. Heat lamps produced a further 20% reduction before heat induced drying caused the slab to start curling again. Ponding with hot water then brought the corners down to their initial elevation
- But when the water was removed and the slab dried, the slab returned to its original curled condition. One suggested curling remedy is ponding the slab until its level again and cutting additional control joints where the slab has curled (Ref. 2). The success of this method varies, depending on the extent and cause of the curling.

2. CUT MORE JOINTS

- Cut slab corners on a diagonal, or cut at the centrelines of the slab panels. Holland says diagonal cuts are much more effective than centreline cuts, but even diagonal cuts reduce curl no more than 50%, and the reduction is usually much less
- For best results, cut the slab after most of the drying shrinkage has occurred, since further shrinkage can cause curling of corners and edges at the new cuts. Cutting additional joints is most likely to be a successful solution for curled floors that receive no forklift traffic and will be covered with carpet.
- On some projects, cutting to only one-third the slab depth reportedly reduced curled elevation 50%

3. GRIND

- Perform an elevation survey, choose an acceptable floor profile, and diamond grind the curled slab edges and corners to achieve the desired profile.
- Typically this involves grinding to a distance of 2 to 6 feet from the curled edges. Grind only those areas that need a new profile, such as traffic aisles or areas that will be tiled instead of carpeted.
- Grinding is a common curling repair option that doesn’t create any new joints and maintains existing aggregate interlock to provide load transfer.

- Grinding should be done after most of the drying shrinkage has occurred. If grinding is done too soon, continued curling may require regrinding.

4. REMOVE AND REPLACE PART OF THE CONCRETE

- Saw cut around the curled area, use a chipping hammer to remove concrete below the desired profile, and place and finish patch material to the desired elevation
- Be sure to maintain joint integrity by recutting a joint in the patching material. If only a few curled areas need repair, this partial-depth patch repair may cost less than hiring a grinding contractor.
- And if the joint edges show no deterioration, it may not be necessary to grout the under slab void created by curling

5. GROUT AND GRIND

- Drill or core a 1- to 2-inch-diameter hole at the elevated joint corners and at slab edges, where necessary
- Use a flow able, low-shrinkage grout to fill the under slab voids, or use a stiff, low-shrinkage grout to make columns that support the four corners and any curled edges
- Monitor and control the grout pressure (typically limited to 10 psi) to avoid or minimize slab uplift during grouting
- After the grout hardens, grind the slab surface at curled elevations, if needed, to produce the desired floor profile
- The grout-and-grind method is typically used on floors subjected to frequent forklift traffic or heavy forklifts.

6. ADD DOWEL BARS

- Steel dowels can be installed across a curled joint to improve load transfer and minimize differential movement under traffic.

1. Saw the floor at right angles to the joint, making each saw cut 1 ⁄4 inch wide, 4 inches deep, 36 inches long at the bottom, and 12 inches on centre.
2. Blow each saw cut clean with compressed air.
3. Place a 1 ⁄4x2x36-inch steel flat bar in each saw cut, making sure the bar rests firmly on the bottom of the cut. Grease each bar to inhibit bonding.
4. Fill each saw cut with high strength epoxy grout, leaving the surface slightly crowned. Do not let epoxy enter the joint.

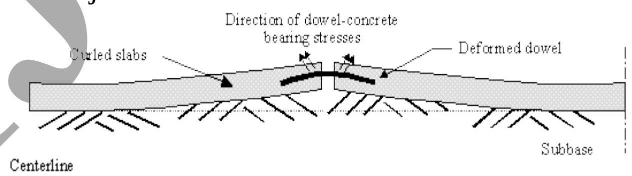

Fig -14*:* Installation of Dowel Bar Across a Curled Joint

5. Fill the joint with a semi-rigid epoxy—not with the high strength grout used in the saw cut.
6. After the high-strength grout and joint filler have hardened, grind them flush with the surrounding floor surface.

2.5 DELAMINATION

Delamination's are similar to blisters in that delaminated areas of surface mortar result from bleed water and bleed air being trapped below the prematurely closed (densified) mortar surface. Delaminations are very difficult to detect during finishing and become apparent after the concrete surface has dried and the delaminated area is crushed under traffic. The delaminated mortar thickness ranges from about 3 mm to 5 mm (1/8 in. to 1/4 in.). To avoid conditions that lead to delaminations, see the recommendations under the section on blisters.

2.5.1 CAUSES

The primary cause is finishing the surface before bleeding has occurred. Delaminations are also more likely to occur when factors that extend the bleeding time of concrete (e.g. cold substrate) are combined with factors that accelerate surface setting (e.g. High ambient air temperature).It is necessary to wait for a period of time after placing the concrete to allow air and water to escape from the concrete. The waiting period varies with the concrete mixture, mixing and placing procedures, and weather conditions.

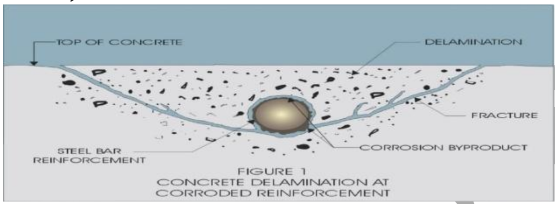

Fig -15: **Cause of Delamination**

Delaminations also may be the result of disruptive stresses from chloride-induced corrosion of steel reinforcement or of poorly bonded areas in two-course construction. The resulting delaminations are deeper than those caused by trapped air or bleed water and are often called spalls (see Spalls). A delaminated area that has separated from the underlying concrete can leave a hole in the surface and resembles spalling. A delamination survey can be conducted by sounding dragging a chain across the surface or tapping with a hammer and listening for hollow sounds. A hollow sound indicates delaminated areas, and a ringing sound indicates intact areas. This test is described in ASTM D 4580, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding. Nonstandard methods for detecting delaminated areas are acoustic impact, infrared thermography, and ground-penetrating radar. Delaminations can be repaired by patching or, if widespread, by grinding and overlaying with a new surface. Epoxy injection may also be beneficial in some applications

2.5.2 PREVENTION

Greater care in lift placement and consolidation, allowing more time for bleed water to dissipate before closing the surface, proper curing and sealing measures to prevent moisture ingress, and checks to insure minimum concrete cover over steel is provided.

2.5.3 REMEDIESTO FIX DELAMINATION

If delamination occurs, take following steps to restore the coating:

- Work in small, manageable areas.
- Saturate them with xylene and allow dwelling for several minutes. These will re-solvate the disbanded sealer.
- Dampen a roller cover in xylene and gently back-roll the area. This will redeposit the sealer directly to the concrete surface
- Allow to dry
- Repeat if necessary on localized areas

In most cases this will solve your problem. If needed, scrap excess sealer off the roller cover during back-rolling operation

Fig -16: **Delamination Before and After Applying Remedies**

2.6 DISCOLORATION

Surface discoloration of concrete flatwork can appear as gross color changes in large areas of concrete, spotted or mottled light or dark blotches on the surface, or early light patches of efflorescence (see section below).Laboratory studies to determine the effects of various concreting procedures and concrete materials show that no single factor is responsible for all discoloration. Factors found to influence discoloration are calcium chloride admixtures, cement alkalis, hard-toweled surfaces, inadequate or inappropriate curing, a wet substrate, variation of the water-cement ratio at the surface, and changes in the concrete mix. Discoloration from these causes appears very soon after placing the concrete.

Discoloration at later ages may be the result of atmospheric or organic staining—simply stated, the concrete is dirty. This type of discoloration is usually removed by power washing with pressurized water and, possibly, chemical cleaners. The use of calcium chloride in concrete may discolor the surface. Calcium chloride accelerates the hydration process but has a retarding effect on the hydration of the ferrite compound in Portland cement. The ferrite phase normally becomes lighter with hydration; however, in the presence of calcium chloride the retarded, unhydrated ferrite phase remains dark.

Extreme discoloration can result from attempts to hard-trowel the surface after it has become too stiff to trowel properly. Vigorously troweling a surface to progressively compact it can reach the point where the water-cement ratio is drastically decreased in localized areas. This dense, low-water-cement-ratio concrete in the hard troweled area is almost always darker than the adjacent concrete. Waterproof paper and plastic sheets used to moist-cure concrete containing calcium chloride have been known to give a mottled appearance to flat surfaces due to the difficulty in placing and keeping a cover in complete contact with the surface over the entire area. The places that are in contact will be lighter in color than those that are not. Concrete materials and proportions affect concrete color. Individual cements may differ in color. Thus, substituting one cement for this delamination is the result of sealing the surface before bleeding has occurred.

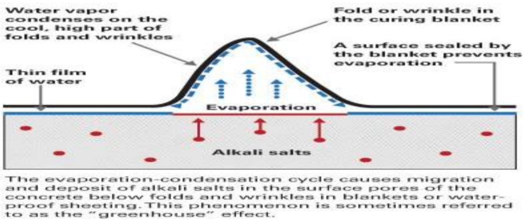

Fig -17: Cause of Discoloration

2.6.1 CONCRETE SLAB SURFACE DEFECTS

Driveway discoloration due to the use of a calcium chloride admixture in the concrete at the bottom but not the top of the photo. This illustrates just one of several types of discoloration. Another may change the color of concrete. Concretes containing significant amounts of mineral admixtures—fly ash, silica fume, met kaolin, or slag, for example—may differ in color from those containing no mineral admixture. The color of the sand has an effect on the color of the concrete. High-strength concrete with a low water-cement ratio is darker in color than low-strength concrete with a high water-cement ratio.

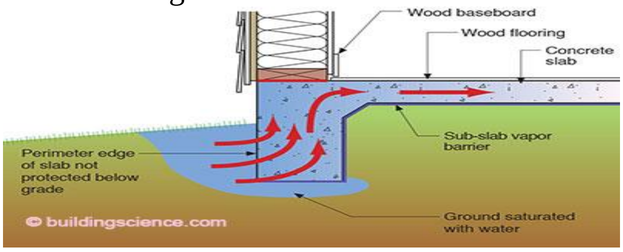

Fig -18: Cause of Discoloration on Concrete Slab

NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 12, Dec.-2016

2.6.2 PREVENTION

(1) Avoiding the use of calcium chloride admixtures.
(2)Using consistent concrete ingredients uniformly proportioned from batch to batch.
(3) Using proper and timely placing, finishing, and curing practices. Concreting practices should not be allowed to vary, as any disruption or change in the concrete mixture, formwork, finishing, or curing can result in significant and sometimes permanent discoloration.

To eradicate discoloration, the first (and usually effective) remedy is an immediate, thorough flushing with water. Permit the slab to dry, and then repeat the flushing and drying until the discoloration disappears. If possible, use hot water. Acid washing using concentrations of weaker acids such as 3% acetic acid (vinegar) or 3% phosphoric acid will lessen carbonation and mottling discoloration. Treating a dry slab with 10% solution of caustic soda (sodium hydroxide) gives some success in blending light spots into a darker background. Harsh acids should not be used, as they can expose the aggregate. One of the best methods to remove most discoloration, when other remedies have failed, is to treat a surface with a 20% to 30% water solution of diammonium citrate. This chemical is expensive to buy in small quantities, so consider it as a last resort. These and other treatments and recommendations to prevent and eradicate discoloration are contained in surface.

2.6.3 REMEDIES TO FIX DISCOLORATION

FLUSH AND SCRUB

Flushing is when you flood the surface of concrete slab with hot water and then scrub vigorously with a hand brush. For Mild discolorations, you can repeat this process several times and eventually it will even out as the concrete breathes in and evaporates the water. This natural breathing process helps to evenly distribute any sort of moisture and mineral build up within the concrete's surface that could be causing discoloration

ACID WASH

Severe discolorations that do not disappear without flushing require the next step up, which is a light solution of muriatic acid.You must always start with less than a 1% solution of acid to water and increase if you do not see significant enough results. To make sure that the acid does not penetrate farther than the surface layer, flood the concrete beforehand. From there, apply the acid solution directly and scrub it with a scrub brush. After each scrub down, rinse the surface down with clean water no later than 15 minutes.

CONCRETE STAIN

If acid does not work, then the only means available are chemical top coats. A paintbrush or a paint roller is the option for application. You should always test a small out-of-the-way area in advance, and always start with a shade of stain that is two or three shades lighter than what you actually want the results to be. This is because you can never lighten a stain, you can only add additional layers to make darker coats, so you should start light and build way to perfect results.

TINTED SEALER

Another option to hide imperfections is a tinted sealer. Just as you can use topcoat sealers on natural stone installations to protect the stone as well as give it a slightly different colour, the same option exists for concrete. They are only useful for wide open areas where the discoloration is slight, because these are translucent top coats which will still show blotchiness. For best results, apply a sealer after you have finished putting on a coat of concrete stain which will help blend the two layers together.

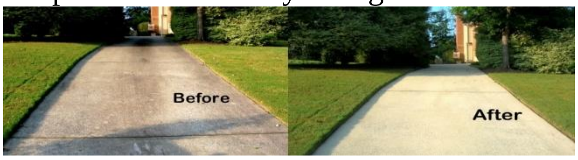

Fig -19: **Discoloration Before and After Applying Remedies**

2.7 DUSTING

Dusting—the development of a fine, powdery material that easily rubs off the surface of hardened concrete—can occur either indoors or outdoors, but is more likely to be a problem when it occurs indoors (Fig. 7). Dusting is the result of a thin, weak layer, called laitance, composed of water, cement, and fine particles. Fresh concrete is a fairly cohesive mass, with the aggregates, cement, and water uniformly distributed throughout. A certain amount of time must elapse before the cement and water react sufficiently to develop hardened concrete. During this period, the cement and aggregate particles are partly suspended in the water. Because the cement and aggregates are heavier than water, they tend to sink. As they move downward, the displaced water moves upward and appears at the surface as bleed water, resulting in more water near and at the surface than in the lower portion of the concrete. Thus, the laitance—the weakest, most permeable, and least wear-resistant concrete—is at the top surface, exactly where the strongest, most impermeable, and most wear-resistant concrete is needed. Floating and troweling concrete with bleed water on it mixes the excess water back into the surface, further weakening the concrete's strength and wear resistance and giving rise to dusting.

Fig -20: Cause of Concrete Dusting

2.7.1 CAUSES

(1) Water applied during finishing,
(2) Exposure to rainfall during finishing,
(3) Spreading dry cement over the surface to accelerate finishing,
(4) A low cement content,

Fly ash aggravates the staining by intensifying the color. This staining is probably caused by differences in curing and degree of hydration of the surface cementations materials under high humidity and high ambient temperature conditions. In particular, additional hydration of the ferrite compounds in cementations materials leads to more reduced iron being available to oxidize and discolor the concrete. Research has found that the staining occurs under a certain set of conditions, which includes the availability of water and oxygen.

Rapid drying of the concrete results in insufficient moisture to produce staining, while continuous immersion does not allow access of air. In both cases, discoloration does not occur. Therefore, it is recommended that the concrete be kept fully wet for the required curing period, then allowed to dry as rapidly as possible thereafter. For instance, wet burlap with a plastic sheet covering should be removed in the morning of a hot day rather than in the evening or before rain is expected. This type of staining is difficult to remove. Commercial sodium bisulfate cleaners are somewhat successful in removing the stain; however, the difference between cleaned and stained areas decreases over several weeks. The following chemicals are largely ineffective at removing these buffs to red/orange stains: hydrochloric acid (2%), hydrogen peroxide (3%), bleach, phosphoric acid (10%), diammonium citrate (0.2M), and oxalic acid (3%).

2.7.2 REMEDIESTO FIX DUSTING

To minimize or eliminate dusting, apply a chemical floor hardener. If dusting is reduced but still noticeable, retreat with hardener. Other solution is to grind off or shot blast off this thin

ISSN: 2394-3696
VOLUME 3, ISSUE 12, Dec.-2016

layer to expose the solid concrete underneath and potentially a new surface with good wear resistance**.** Another solution is extending the life of the concrete slab by using surface treatments containing certain chemicals, including sodium silicate and magnesium flu silicate.Sealing products can upgrade a dusty floor and improve its wear resistance**.**

2.8 EFFLORESCENCE

Efflorescence can be considered a type of discoloration. It is a deposit, usually white in color that occasionally develops on the surface of concrete, often just after a structure is completed. Although unattractive, efflorescence is usually harmless. In rare cases, excessive efflorescence deposits can occur within the surface pores of the material, causing expansion that may disrupt the surface.

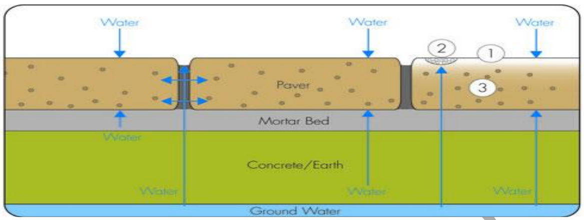

Fig -21: Cause of Efflorescence

2.8.1 CAUSES

A combination of circumstances: soluble salts in the material, moisture to dissolve these salts, and evaporation or hydrostatic pressure that moves the solution toward the surface. Water in moist, hardened concrete dissolves soluble salts. This salt-water solution migrates to the surface by evaporation or hydraulic pressure where the water evaporates, leaving a salt deposit at the surface. Efflorescence is particularly affected by temperature, humidity, and wind. In the summer, even after long rainy periods, moisture evaporates so quickly that comparatively small amounts of salt are brought to the surface.

Usually efflorescence is more common in the winter when a slower rate of evaporation allows migration of salts to the surface. If any of the conditions that cause efflorescence—water, evaporation, or salts—are not present, efflorescence will not occur.

Fig -22: Efflorescence on Brick, Concrete, Stucco, Pavers

2.8.2 PREVENTION

Accelerators or heated concrete often prevents delamination in cool weather. Emphasis in finishing should be on screening, straight edging, floating the concrete without working up an excessive layer of mortar and without sealing the surface layer. Do not place concrete directly on retarder. Do not use air entrained concrete for interior floor slabs.

2.8.3 REMEDIESTO FIX EFFLORESCENCE

Efflorescence will stop forming when the movement of moisture through the concrete stops. Try to wash and scrub off the white deposits using clean water as soon as they appear. You will need a mild or diluted acidic solution that is stronger than vinegar water. For grey concrete following solutions are recommended. One part HCL in 10-20 parts of water. One part Phosphoric acid in 10 parts of water. One part Phosphoric acid, plus one part Acetic acid in 20 parts water.Pre-packaged efflorescence removers.Start with one part HCL in 50 or 100

ISSN: 2394-3696
VOLUME 3, ISSUE 12, Dec.-2016

parts of water (2% to 1% concentration) and increase the concentration as needed. Flood the surface with clean water (to prevent acid being absorbed into the concrete).Allow the acidic solution to set on the surface for 3-5mins.Scour off the efflorescence with a stiff brush. Immediately and thoroughly flush the surface with clean water to remove all acid and then apply the acidic solution uniformly in terms of concentration, amount and duration. Perform a trial treatment on an inconspicuous area to check for adverse effects and to perfect the technique. After removing efflorescence, consider sealing with an exterior concrete sealer.

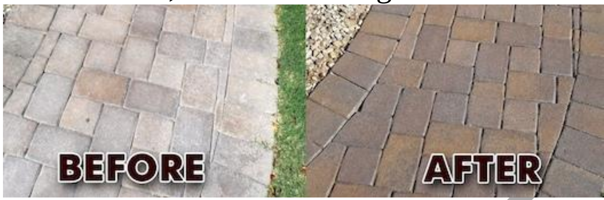

Fig -23: Efflorescence Before and After Applying Remedies

2.9 LOW SPOTS

Low spots can affect slab drainage or serviceability if items placed on the slab need to be level. Low spots are often caused by poor lighting during placement and finishing, improperly set forms and screeds, damage to form and screed grade settings during construction, use of overly wet or variably wet concrete, and poor placement and finishing techniques

2.9.1 PREVENTION

(1) Using a low-slump, low-water-content concrete mix.
(2) Providing adequate light.
(3) Frequently checking grades and levels, and filling the low areas.
(4) Using a vibrating screed for strike off.
(5) Using a "highway" straightedge in lieu of a bull float to smooth and straighten and surface.

2.9.2 REMEDIES

Low spots in the concrete surface that can trap water. Areas of extreme low spots may be corrected somewhat by grinding adjacent high spots or, depending on the floor use, by installing a leveling course or topping. Hwever, as discussed, low spots should be expected because perfect flatness is unlikely, and achieving greater flatness increases the cost.

2.9 POPOUTS

A pop outs is a conical fragment that breaks out of the surface of the concrete leaving a hole that may vary in size generally from 5 mm to 50 mm (1/4 in. to 2 in.) but up to as much as 300 mm (1 ft.) in diameter (Fig. 8). Usually a fractured aggregate particle will be found at the bottom of the hole, with part of the aggregate still adhering to the point of the popouts cone.

Fig -24: Cause of Pop outs

2.10.1 CAUSES

Pop outs usually is a piece of porous rock having a high rate of absorption and relatively low specific gravity. As the offending aggregate absorbs moisture or freezing occurs under moist conditions, its swelling creates internal pressures sufficient to rupture the concrete surface. Pyrite, hard-burned dolomite, coal, shale, soft fine-grained limestone, or chart commonly causes popouts. Popouts may also occur to relieve pressure created by water uptake of expansive gel formed during the chemical reaction between the alkali hydroxides in the concrete and reactive siliceous aggregates. Scaling is a scabrous condition where the surface mortar has peeled away, usually exposing the coarse aggregate. Most popouts appear within the first year after placement. Popouts caused by alkali-silica reactivity (ASR) may occur as early as a few hours to a few weeks, or even a year, after the concrete is placed. Popouts caused by moisture-induced swelling may occur shortly after placement due to the absorption of water from the plastic concrete, or they may not appear until after a season or year of high humidity or rainfall or after the concrete has been exposed to freezing temperatures. Popouts are considered a cosmetic detraction and generally do not affect the service life of the concrete.

2.10.2 PREVENTION

1. Use concrete with the lowest water content and slump possible for the application.
2. Use a durable crushed-stone or beneficiated aggregate concrete.
3. During hot, dry, and windy weather, cover the surface with plastic sheets after screeding and bull floating to reduce evaporation before final finishing. This reduces the migration of alkalis to the surface due to drying and therefore helps reduce popouts caused by alkali-silica reactivity (ASR).
4. Do not finish concrete with bleed water on the surface.
5. Avoid hard-steel troweling where not needed, such as most exterior slabs.
6. Avoid use of vapor barriers. If required, cover the vapor barrier with 100 mm (4 in.) of compactable granular fill, slightly dampened, and choked off appoints is a small fragment of concrete surface that has broken away due to internal pressure, leaving a shallow, typically conical, depression
7. Use wet-curing methods such as continuous sprinkling with water, fogging, ponding, or covering with wet burlap soon after final finishing. Wet-cure for a minimum of 7 days, as wet cures can greatly reduce or eliminate popouts caused by ASR. Avoid plastic film, curing paper, and especially curing compounds as they allow an accumulation of alkalis at the surface. Flush curing water from the surface before final drying. Impervious floor coverings or membranes should be avoided as they can aggravate popouts development.
8. Use a blended cement or a supplementary cementations material such as fly ash (proven to control ASR) where popouts are caused by alkali-silica reactivity. Use of low-alkali cement is also beneficial.
9. Use two-course construction with clean, sound rock in the topping, and the offending aggregates in the base slab, thus limiting the susceptible aggregate’s exposure to excess moisture.
10. Slope the slab surface to drain water properly.
11. Use air-entrained concrete.
12. Reduce concrete temperature to 10°C to 20°C (50°F to 70°F). Surfaces with popouts can be repaired. A small patch can be made by drilling out the spelled particle and filling the void with a dry-pack mortar or other appropriate patch material. If the popouts in a surface are too numerous to patch individually, a thin-bonded concrete overlay may be used to restore serviceability.

Fig -25: **Popouts on Concrete Surface**

2.10.3 REMEDIES

For small popouts, use a rotary-hammer drill and drill out the remaining deleterious substance and unsound concrete to create a hole with a minimum depth of ½ inch. For medium and large popouts, use a hammer and chisel, small chipping hammer, or core drill to remove all remnants of deleterious substances and unsound concrete. Create a hole with square edges (perpendicular to the surface) and a minimum depth of ½ inch. Do not feather edges. Remove all unsound concrete, dirt, and debris. For site-mixed, dry-pack repair mortar, mix one-part Portland cement to two-and-a-half parts sand. Use only enough water to produce a stiff mortar that will pack into a ball when molded by hand. If possible, use the same type of cement and sand used in the original concrete. To improve the color match of the repair mortar, substitute white cement for the gray cement. Determine the amount of white cement by trial mixes. Before placing the dry-pack repair mortar, scrub the repair area with a thick and creamy bonding grout consisting of one part cement and one part fine sand. Immediately, tamp the repair mortar into place and finish or texture to match the surrounding surface. Do not place or smear the repair mortar over a larger area than necessary. Cure repaired areas using wet burlap and plastic sheeting or a spray-on curing compound. Prepackaged concrete repair materials can be used but it will probably not match the color of the existing concrete. If there are too many popouts for individual repairs, consider using a thin-bonded concrete overlay.

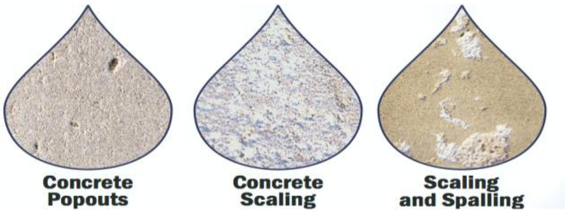

Fig -26: **Popouts, Scaling and Spalling.**

2.11 SCALING

Scaling is the general loss of surface mortar exposed to freezing and thawing. The aggregate is usually clearly exposed and often stands out from the concrete.

2.11.1 CAUSES

1.Scaling is primarily a physical action caused by hydraulic pressure from water freezing within the concrete and not usually caused by chemical corrosive action.

2. When pressure exceeds the tensile strength of concrete, scaling can result if entrained-air voids are not present to act as internal pressure relief valves.

3. Scaling is also caused due to the use of deicing solutions.

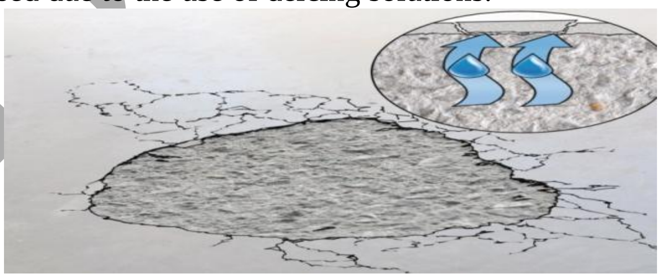

Fig -27: Scaling of Concrete Surface

2.11.2 REMEDIES

Begin by thoroughly removing any loose material to create a relatively smooth surface. Contact the repair material manufacturer for guidance. Most manufacturers suggest surface preparation should include repairing shallow delaminations, surface, scaling, and aggregate popouts. This may require grinding the resulting rough surface. The committee recommends trying to achieve a concrete surface profile in the range of 3 to 5 as described in the International Concrete Repairs Institute's Document 03732.

This is often the best range for applying most liquid-applied membranes and most thin coatings. Most liquid-applied products are not intended to level off or hide imperfections, although trowel-grade materials can sometimes be used for this purpose. Remember that the temperature of the repair material should be as close to the floor slab as possible.

Fig -28: Scaling Before and After Applying Remedies

2.12 MOTOR FLAKING

It over coarse aggregate particles sometimes called pop offs, is another form of scaling that somewhat resembles a surface with popouts.Poor finishing practices can also aggravate mortar flaking

2.12.1 CAUSES

1. Mortar flaking over coarse aggregate particles is caused essentially by the same actions that cause regular scaling.
2. However, the moisture loss is accentuated over aggregate particles near the surface.
3. The lack of moisture necessary for cement hydration results in a mortar layer of lower strength and durability, higher shrinkage, and poorer bond with the aggregate.

2.12.2 PREVENTION

1. Concrete exposed to freezing and thawing cycles must be air-entrained.
2. DO NOT use deicing salts, such as calcium or sodium chloride, in the first year after placing the concrete. Use clean sand for traction.
3. DO NOT perform any finishing operations with water present on the surface.
4. Protect concrete from the harsh winter environment. It is important to prevent the newly-placed concrete from becoming saturated with water prior to freeze and thaw cycles during winter months.

2.12.3 REMEDIES

1. Use properly air entrained concrete (6.5 + 1.5%).
2. Concrete should have a water/cement ratio of < 0.45.
3. Do not over finish or finish with bleed-water present.
4. Provide sufficient and timely curing.
5. Avoid late season placement – Concrete needs a minimum of 30 days before being subjected to deicing salts.
6. Use a penetrating sealer

Fig -29: Flaking, Cracking, And Spalling

2.13 SPALLING

Spalling is a deeper surface defect than scaling, often appearing as circular or oval depressions on surfaces or as elongated cavities along joints. Spalls may be 25 mm (1 in.) or more in depth and 150 mm (6 in.) or more in diameter, although smaller spalls also occur.

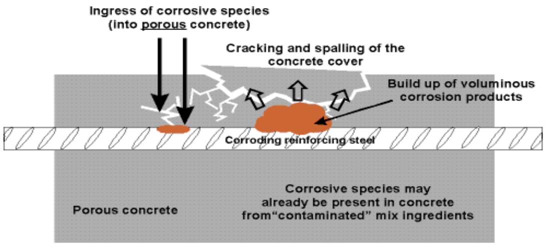

Fig -30: Cause of Spalling

2.13.1 CAUSES

1. Spalls are caused by pressure or expansion within the concrete, bond failure in two-course construction, impact loads, fire, or weathering. Improperly constructed joints and corroded reinforcing steel are two common causes of spalls.
2.If left unrepaired, spalls can accelerate pavement deterioration.

Fig -31: Spalling

2.13.2 PREVENTION

1. Properly designing the concrete element including joints for the environment and anticipated service.
2. Using proper concrete mixes and concreting practices.
3. Taking special precautions where necessary

2.13.3 REMEDIES

1. Remove loose or delaminated concrete above corroded reinforcing steel.
2. Once initial removals are made, proceed with the undercutting of all exposed corroded bars. Undercutting will provide clearance for under bar cleaning and full bar circumference bonding to surrounding concrete, and will secure the repair structurally. Provide minimum ¾ inch clearance between exposed rebar and surrounding concrete or ¼ inch larger than the largest aggregate in repair material, whichever one is greater.
3. Concrete removal shall extend along the bars to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.
4. If non-corroded reinforcing steel is exposed during the undercutting process, care shall be taken not to damage the bar's bond to surrounding concrete. If bond between bar and concrete is broken, undercutting of the bar shall be required.
5. Any reinforcement which is loose shall be secured in place by tying to other secured bars or by other approved methods.
6. All heavy corrosion and scale shall be removed from the bar as necessary to promote maximum bond of replacement material. Oil free abrasive blast is the preferred method. A tightly bonded light rust build-up on the surface is usually not detrimental to bond unless a protective coating is being applied to the bar surface, in which case the coating manufacturer's recommendations for surface preparation should be followed.

If reinforcing steel has lost significant cross section, a structural engineer should be consulted. If repairs are required to the reinforcing steel, which is obviously the case in Shilshole condominium building, one of the following repair methods should be used:

1. Complete bar replacement.
2. Addition of supplemental bar over affected section.

CONCLUSIONS

Concrete repair projects are very challenging, as is true with most repair and renovation projects. It is imperative that the engineer understands the reasons which led to the damage and/or deterioration prior to developing a repair program. The underlying causes should be corrected, although this is not always possible. As a minimum, all unsafe conditions must be corrected, and if necessary, temporary shoring or bracing provided, as soon as they are identified. The owner must be included when formulating a repair program, especially determining the project objectives. Because budget constraints often control the approach to a repair program, it is important that the owner has a clear understanding of what is being done. Furthermore, the owner should be apprised of the anticipated life of the repairs and the long-term costs to maintain that structure, after the repairs are implemented.

REFERENCES

1) Shetty M. S., "*Concrete Technology-Theory And Practice." Chand& company, New Delhi, (1982)*

2) Gambhir M. L., "*Concrete Technology." Tata McGraw-Hill Company, New Delhi (1986)*

3) Krishna Raju N., "*Design of Concrete Mixes." Faridabad (1975)0*

4) Remedios A. p., "*Concrete Mix Design-Handbook*", *Himalaya Publishing House, New Delhi (2008), pp.137-199*

BIOGRAPHIES

	Name: Swarnima S. Rewatkar B.Tech (Civil), M.Tech (CM) Pune