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Delamination of Concrete Industrial Floors

INTRODUCTION

This data sheet highlights the potential causes of surface delamination of concrete industrial floors and pavements and makes recommendations to reduce the risk of occurrence.

Delamination is the detachment of a thin (typically from 3mm to 6 mm in thickness) surface layer from the rest of the slab. It is initially manifested by a 'drummy' sound when the pavement is tapped or trafficked.

The cause of delamination is predominantly related to the timing of the final trowel finishing operations. This should ideally start only after initial setting of the concrete.

If troweling (that compacts and thereby reduces the permeability of the surface layer of the concrete) is undertaken prematurely, bleed water or air can be trapped underneath the densified surface layer forming blisters that may delaminate under subsequent surface loading.

Delamination can occur during final troweling if surface mortar is moved by finishing equipment to fill 'low spots'. High angle trowel blades can cause shearing of the surface mortar in these low spots from the concrete layer beneath. The repositioned mortar simply sits on the underlying concrete rather than bonding to it and forming a monolithic slab. This mortar will eventually delaminate from the underlying concrete layer.

Most causes of delamination relate to the finishing technique and its timing not being appropriate for the behavior of the concrete being used in the particular environment, not to the properties of concrete as delivered.

It is essential that the concrete supplier be advised of the standard and quality of surface finish specified (e.g. burnished, super flat, 'F_F' and 'F_L' numbers [3]) at the tendering stage.

Such communication may identify the need for special concrete mix designs and different finishing techniques, either of which may incur higher construction costs. All parties should arrive at a clear understanding of each other's responsibilities and guarantees before the project starts.

The main items which should be controlled in order to minimize the risk of delamination are:

- Uniformity of placement, bleed rate and setting time over the surface.
- Surface evaporation rate.
- Finishing Processes.

UNIFORMITY OF PLACEMENT, BLEED RATE AND SETTING TIME OVER THE SURFACE

For large areas of pavement, numerous truckloads of concrete are required. Consistent bleed rate and setting time between the loads are important to avoid varying finishing times over the area placed. Placing concrete progressively from one side to the other, while maintaining a workable concrete face on which fresh concrete is placed, also allows finishing proceeding uniformly in the direction of placement.

The use of admixtures that impede the migration of bleed water to the surface, or extend setting times of the concrete, may result in drying of the surface prior to setting. This causes the concrete to appear to be ready to finish prematurely and increased the risk of delamination.

Any use of special admixtures must consider the impact on the bleeding and setting properties of concrete. This also can affect the time period during which bleeding occurs and on the time when final finishing can commence.

Recommendations

1. Uniform mix design, controlled within-tolerance slump and consistent delivery are essential. Supply from a single concrete batch plant for each pour (or plants using the same materials, mix design and delivery times) is essential to ensure the consistency of the properties of the pre‑hardened concrete and its finishing properties.
2. Air-entraining admixtures should be avoided where high values of Flatness and Levelness of the pavement are required. Set-retarding admixtures should be avoided, unless required to prolong the setting time in hot weather conditions or when long travel-time to deliver concrete to the project is expected.
3. Avoid specifying, ordering, requesting or allowing the use of additional admixtures that delay final finishing, as these will increase the exposure of the concrete surface to drying from the prevailing weather conditions before it is ready for finishing.
4. Ensure that the sub-base is dense and saturated and that plastic membranes (if used) have no cuts or tears. Also ensure that plastic membranes are correctly lapped and sealed to prevent the uneven escape of moisture from the concrete. If moisture is drawn unevenly from the concrete slab, this will result in uneven bleed or setting. This in turn, can affect the uniformity of surface finishing timing.
5. Avoid using plastic membranes under pavements where possible, as this increases the risk of delamination by driving all bleed water upwards to the surface.
6. Aim to achieve optimum flatness during initial placement and screeding. This avoids reliance on the final floating and troweling passes to achieve the required flatness and levelness (i.e. avoid having to move mortar from the concrete over the surface).
7. Ensure uniform compaction as bleeding and settlement may increase in less compacted areas. Use vibrating screeds for vibration up to 150mm depths, and/or poker vibrators for edges and greater depths. Poker vibrators should be inserted vertically in a regular pattern (of about 6 times the poker diameter) for a minimum of about 10 seconds.
8. Reinforcement should be located at the correct height and supported on chairs at the recommended spacing. Top concrete cover is recommended to be in the range of 50–65mm. If the cover to reinforcement is less than 50mm, then vibration of individual bars or strands may compact the concrete immediately above the bar more than elsewhere. This results in low spots along these lines. These low spots will require filling by an early float pass, thereby risking premature finishing. Establish a uniform placement pattern so that concrete is always placed against a workable face and that there are no significant setting‑time differences between adjoining loads. This, along with concrete supply rate limitations, may limit the width of a working face during a single concrete placement.
9. Ensure that the finishing operation also follows this same pattern.

EVAPORATION RATE

An indicator that the concrete is nearly ready for final finishing is the absence of either water or water sheen (from bleeding) on the surface. This can be misleading if the rate of evaporation of water from the surface is greater than the rate at which the bleed water is rising to the surface. The surface will appear dry and firm enough to give the impression that the concrete is ready for finishing. This may lead to premature finishing and the risk of delamination.

Recommendations

- Ensure that climatic factors such as wind, sunlight, ambient temperature and humidity that affect the evaporation rate and finishing times are uniform over the entire concrete surface. Variation in sunlight and localized “wind tunnels” will increase the rate of evaporation and may cause uneven drying of the concrete surface and localized premature crusting of the surface. This will make uniform finishing operations difficult. Once the surface shows signs of drying and/or crusting, the time at which bleeding ceases is difficult to determine.
- In order to reduce the evaporation rate of bleed water from the surface, fog misting or an evaporation retarder such as aliphatic alcohol should be used. Ensure that the product is applied as a fine mist after bull floating and thereafter as necessary up until final finishing.

FINISHING PROCESS

The finishing process should match the path of concrete placement. This should be undertaken at an appropriate time and rate so that concrete is finished at a consistent time after concrete placement and not prematurely. The finishing process should be planned and controlled by a documented work procedure. Objective evidence of compliance with the work procedure is recommended to ensure the stated pathway and timing of finishing matches that of placement (e.g. a plan with the location, placing time and finishing time of each load of concrete).

Recommendations

- Ensure that all finishing processes are performed by competent personnel, experienced in operating the equipment and achieving the finish required. The finishing contractor should be able to provide examples of previous work.
- **Initial floating** – Bull-floating removes ridges of mortar formed by the screeding operation and improves the finish by closing minor holes in the surface. It should be completed prior to any significant bleed water appears on the concrete surface. Excessive bull-floating will increase the risk of delamination.
- **Final floating** – Final floating should not commence whilst bleed water is present. The first pass of final floating is to flatten the surface. This should be done as late as practical and in a manner that ensures the surface is not closed, trapping rising bleed water or pockets of air.
- Plan, test and float areas as they become ready. Usually a maximum 3mm deep boot imprint in the concrete surface indicates the correct time to commence floating. If the equipment is *'throwing paste*', floating should be delayed until further stiffening of the concrete occurs.
- It is a good practice to use a walk-behind power floating machine for the initial pass. This will aid surface levelling before commencing with ride-on pan floats. Ride‑on equipment when fitted with pan floats can exert less pressure on the slab surface allowing early access. This may increase the risk of starting the final finishing process prematurely.
- **Troweling** – The first pass should be with blades as flat as possible to avoid moving the surface mortar around. Finishing blades are tilted at greater angles for successive passes (as the concrete stiffens) to gradually increase the compaction of the surface layer. Rapidly increasing the blade angle can cause tears or blisters on the surface. Sufficient time should be allowed between passes for the water that has been squeezed to the surface to evaporate. If blisters or tears form while troweling, the tilt-angle of blades is too great and a magnesium float or a flat trowel should be used to immediately push down and rebond the mortar to the concrete.
- Water should not be applied to the surface to aid the movement of finishing equipment, or to achieve the filling of minor holes in the surface.
- Equipment should not be ‘parked’ on the surface.

REFERENCES

1. ACI 302. 1R-15 “Guide to Concrete Floor and Slab Construction”, ACI Committee 302, American Concrete Institute.
2. ACI 117 – 10 “Specification for Tolerances for Concrete Construction and Materials”, American Concrete Institute.
3. ASTM E1155M – 2010, “Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers (Metric)”.

This data sheet replaces:

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