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Research Article

Remedial Measure in Overlays and Mass Concretecracking

A.K.L.Srivastava

Department of Civil Engineering N.I.T. Jamshedpur, Bihar, India

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Abstract: An overlay can be constructed by placing mortar or concrete over a concrete surface. The use of overlays has rapidly increased since the early 1970s. Overlays can be divided into three groups. If the base slab is relatively crack free, or if the overlay is sufficiently thick and strong to resist the extension of cracks in the original slab, a well-bonded layer with matched joints is generally the best approach. There are many causes for developing cracks in overlays. Long-term observations of many overlays have shown that cracking due to differential shrinkage is the most common problem. Structural cracking can result from individual loads or load combinations, such as gravity, liquid pressure, and severe impact. Structural cracks are of any width but generally align in a structurally possible direction. The formation of hairline or wide crack usually indicates the existence, before the crack's formation; of principal tensile stress perpendicular to the crack. There are two measures that can minimize cracking. To ensure both the owner's and the engineer's satisfaction with the results, it should have the arrangement for inspection either by the owner's personnel, the engineer, or a reliable professional inspection service that will ensure that the construction is performed on the same basis, as it was bid.

Keywords: Unbonded, rehabilitation, delaminations, scabbling.

INTRODUCTION

An overlay can be constructed by placing mortar or concrete over a concrete surface. The use of overlays has rapidly increased since the early 1970s. They are now commonly used for rehabilitation of deteriorated bridge decks, strengthening or renovating pavements, warehouse floors, walkways and other concrete flatwork; and in new two-course construction.

Overlays can be divided into three groups: The first group is when Portland cement is used. These overlays can be low-slump dense concrete (LSDC). These overlays may also contain silica fume, fly ash, or granulated blast-furnace slag. The second group includes polymer and epoxy mortars or concretes. The third group includes polymer-impregnated concrete (PIC), which has not become generally effective, economical, or practical.

If the base slab is relatively crack free, or if the overlay is sufficiently thick and strong to resist the extension of cracks in the original slab, a well-bonded layer with matched joints is generally the best approach. If the overlay has sufficient thickness, a totally unbonded overlay is generally best where severe cracking is present or where it can later develop in the base slab. Systems that are essentially unbonded have been constructed satisfactorily where the overlay is placed over an asphalt layer. The asphalt itself acts as a debonding layer if it has a reasonably smooth surface. Another best approach to laid the material to be overlaid is reasonably smooth consists of placing the overlay over a polyethylene sheet. On irregular, spalled or potholed surfaces, a thin leveling and debonding layer of asphalt is desirable under the polyethylene sheet.

Mass concrete is defined as "any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking." Mass concrete structures are mainly concrete dams, power plants, bridge piers, and other large structural elements. They should resist the loads through shape, size and strength

CAUSES OF CRACKING IN OVERLAYS

There are many causes for developing cracks in overlays. Some important causes are:

- Plastic shrinkage caused by excessive evaporation due to environmental conditions while the concrete is in its fresh or plastic state.
- Differential drying shrinkage between material in the layer and the substrate concrete.
- Differential thermal stresses between the overlay and the substrate concrete. This can be caused by a different temperature in the layer as compared to the substrate and can also be caused or aggravated by different coefficients of thermal expansion and elastic properties.
- Reflective cracking from cracks in the substrate;
- Edge and corner curling stresses that can lead to delaminations and other cracking; and Poor construction practices.

Control of cracking in Overlays: Long-term observations of many overlays have shown that cracking due to differential shrinkage is the most common problem. To reduce the incidence of cracking in rigid concrete overlays, the following procedures are recommended:

The surface of the underlying concrete should be thoroughly prepared to ensure adequate bonding of the overlay. This can be accomplished by mechanical methods, such as shot blasting, scabbling, hand chipping, or sand-blasting, and hydraulically by high-pressure water-blasting (hydrodemolition). Procedures for each project should be selected considering the condition of the concrete, the availability of equipment, and the environmental conditions. The end result should be a clean, sound concrete surface;

All equipments used for mixing, placing, and finishing should be designed for the type of overlay being used and should be accurately calibrated and in good working order. Both the contractor and inspecting personnel should be trained in the proper construction techniques of the particular overlay system;

Material quantities, including total water content, w/c ratio, and amount of polymer, if use, should be closely monitored and recorded;

Contraction joints in the deck should not be overlaid unless a joint or saw cut is immediately provided. The preferred method is to form the joint with a compressible material and place the overlay against it. After curing, the compressible material can be removed and replaced with the final joint material;

Overlays should be placed only when the ambient weather conditions are favorable, or when appropriate actions are taken for hot-weather or cold-weather concreting; and

Mechanical shear reinforcement is effective in reducing cracking in overlays placed during periods of high evaporation rates.

TYPES OF CRACKS IN MASS CONCRETE

Cracking in mass concrete structures may result from material, structural causes, or both. Material-induced cracks result from drying shrinkage, a severe nonlinear thermal gradient initiated by heat of hydration and alkali-aggregate reaction. Surface cracking can appear as pattern cracking and result from a decrease in volume of the material near the surface or increase in volume below the surface. Random cracking from material-related causes is through a massive concrete element. Structural cracking can result from individual loads or load combinations, such as gravity, liquid pressure, and severe impact. Structural cracks are of any width but generally align in a structurally possible direction. The formation of hairline or wide crack usually indicates the existence, before the crack's formation, of principal tensile stress perpendicular to the crack.

Methods of Crack Control: Given the probable temperatures and strains, the designer should determine what measures are most practical to prevent cracking. Some of the conditions that facilitate crack prevention are:

Concrete with large tensile-strain capacity;

Low cement content;

Cement of low heat generation or use of pozzolans;

Casting small concrete segments or blocks;

Low placement temperature;

Slow rate of construction when no artificial cooling is used;

Artificial cooling by an internal network of cold water pipes;

Insulate concrete surfaces;

Low degree of restraint, as with yielding foundation, or in portions of the structure well removed from restraining foundation; and

Absence of stress raisers, such as galleries.

There are two measures that can minimize cracking. The first is to modify the materials and mixture proportions to produce concrete with the best cracking resistance or the greatest tensile-strain capacity. This requires careful aggregate selection, using minimum cement content for interior concrete, restricting the maximum aggregate size. The attempt made to produce a concrete with a large tensile- strain capacity can limit the maximum aggregate size to a value somewhat below that which might be the most economical. Where several sources of aggregate are economical, preference should be given to that which provides the best resistance to cracking. Usually, this will be a crushed material of low thermal expansion and low modulus of elasticity. The second measure to prevent cracking is to control the factors that produce tensile strain. This may mean precooling, postcooling, insulating, or possibly heating the exposed surfaces of the concrete and designing to minimize strains around galleries and other openings. In similar way, if we can control boundary strain; it will be sufficient to control cracking in mass concrete of many cases.

CONCLUSION

To ensure both the owner's and the engineer's satisfaction with the results, it should have the arrangement for inspection either by the owner's personnel, the engineer, or a reliable professional inspection service that will ensure that the construction is performed on the same basis, as it was bid.

Without the full and firm intent to confirm the specified character and degree of performance, there is likelihood that undesirable results will be obtained. Without firm inspection, a quality-control-assurance program, and a clear understanding of the project requirements by the contractor, it is likely that concrete will contain more water than it should. With less water content in the concrete, the finishing operations can be expedited and the curing process can start earlier. It is not enough to select suitable materials for concreting; it is also necessary to ensure a proper execution of all the operations involved in concreting. Such execution requires skill backed by appropriate knowledge at the execution level. If properly applied, the procedures discussed in this seminar can have an effective influence on producing high quality concrete with minimal cracking.

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***Correspondence Author: A.K.L.Srivastava;** Department of Civil Engineering N.I.T.Jamshedpur