Quality control of concrete overlays

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Abstract:

In civil infrastructure,the united states has a significant investment which is degenerate under heavy use, age, and environmental attack. A heavy portion of this infrastructure conposed of plain and reinforced concrete pavements and bridge decks. For pavement and bridge deck rehabilitation concrete overlays have been used for many years. Concrete overlays on pavements or bridge decks can attain three design functions – they can build up the structure against more distant decline due to fatigue cracking (or rutting, with whitetopping overlays), they can upgrade smoothness and reinstate ride standard, and they can add drop resistance.

This research expand and experiment a range of plain and fiber reinforced concrete laminate mixes that allow authentic, economic, and durable laminate establishment as well as early opening to traffic. This report documents the advantage of using nondestructive testing technologies, including spectral examine of surface waves, in laminate inspection, planning, construction, and quality control . In this report recommendation are made for materials choice, design, and construction controls for overlay construction.

Index Term: Quality control, concrete, overlays.

Introduction:

Selection, design, and quality control of suitable materials are censorious for inexpensive and long-lasting repairs. To evaluate repair materials and strategies appropriate models are also mandatory. Safety of concrete bridge decks and pavements can be greatly enhanse by giving increased decline resistance through thin concrete overlays. Upgrade economy and Authenicity of overlays will make easier administration of transportation networks. In some cases, poorly organised or established repairs, unsuitable materials collection, or a combination of factors resulted in early non-sucess. This has developed in assorted cases for concrete pavement and bridge deck overlays. Such cases lead to even more very bad infrastructure problems, with continued impaired use of the facility in addition to a need to separate the original repair before a new repair can be build. In addition, other elements of infrastructure may be overburden during inlarge repairs of one portion. Convalescence of a vital bridge may path heavy trucks onto nearby bridges that were not planned for that level of fatigue loading. A thorough laboratory-testing program of overlay and repair materials and methods, coupled with finite element simulation for verification, will lead to important advances in concrete overlay technology.

Concrete overlays have been used for pedestrian and bridge deck convalescene for many years. For pedestrian, both unbonded and bonded overlays have been used. Unbonded overlays use the existing pavement as high quality sub-base support. In contrast, use of bonded overlays is less common, although they offer remarkable advantages. This report respectively addresses the automation of bonded overlays. To overlay the concrete pavements, concrete bridge decks, and bitumen pavements plain and fiber reinforced concrete have been used.. Currently concrete overlays are distinguish to be costly and difficult to build. However, properly build up concrete overlays are long lasting and can greatly inlarge the service lives of existing facilities. Concrete overlays on pavements or bridge decks can fulfill three design functions – they can nourish the structure opposed further decline due to fatigue cracking (or rutting, with whitetopping overlays), they can enhabce smoothness and replace ride quality, and also add skid resistance. The latter two functions are normally met with asphalt overlays in current practice. However, this could be changed with faster and more dependable bonded concrete overlay technology, since with actual design all three functions could be perform simultaneously. This investigation will have petition to all repairs using adhesive materials by helping further define the materials choice, coherence, and quality control delibration that upgrade the etiquette and presentation of renovate and overlays.

The main impartial of this research was to expend and test a extent of plain and fiber reinforced concrete overlay mixes that would permit authentic, economic, and longlasting overlay manufacture as well as early opening to traffic. Other impartial were to explore a number of nondestructive testing technologies related to overlay planning and construction, and to investigate the consequence of design, materials, environment, and construction mutable on overlay presentation through systematic modeling. Proper control of these mutable is important for overall overlay quality control and quality guarantee.

Material Used:

Materials selection should address cement and other cementitious materials, aggregates, admixtures, and fibers.

1. Cement: Use of lower heat cements, such as Type II/V, as well as renewal with fly ash or slag, can lessen heat development in the overlay, and thus decrease thermal stresses. They may also give additional resistance against environmental attack, and the higher ultimate strength may guide to longer fatigue life of the overlay. In this paper is ultra tech 43 grade cement is used. For concrete Use of fly ash, slag and silica fume should be examine for bonded overlays. In addition to better production, these materials can decrease the cost of the overlay concrete.

2. Aggregates: Aggregates should be choosed for the lowest feasible coefficient of thermal expansion in order to reduce thermal stresses. A heavy aggregate range can decrease paste necessity and diminish, as can use of the big possible maximum size aggregate. Maximum size of coarse aggregate should not be more than a third of the overlay thickness, and ideally a fourth. However, the overlay concrete must be workable sufficient for advance placement methods.

3. Admixtures: Typical admixtures include air entrainment, high range water reducers, and decelerator. Sufficient air must be entrained for long lasting. High range water reducers (HRWR) can make concrete with a low water-cementitious ratio workable sufficient for deployment. Decelerator detain set in hot weather, and may be with HRWR in a single admixture.

Concrete overlays bonded to existing concrete pavements are called Bonded Concrete Overlays (BCO) or Thin Bonded Concrete Overlays (TBCO). Concrete overlays bonded to existing bitumen pavements are called Ultrathin Whitetopping (UTW). Typical blend proportions for Bond Concrete Overlays (BCO) and Ultrathin Whitetopping (UTW) have had preferably high pacify of cementitious materials, as shown in Table 1. Although research may visible that cement pacify may be lowered unaccompanied harming long-term performance, it is supreme at early ages to have sufficient paste at the alliance for bond. When the overlay is placed, the surface of the existing pavement is soaked surface dry it will draw wetness from the overlay, perhapse constrain with hydration. The low water-cement ratio of the BCO concrete, coupled with a very dry surface, is thought to have contributed to overlay debonding. Therefore, a higher water-cementitious materials ratio (w/cm) of 0.38 to 0.42 is probably appropriate.

Table 1. Typical BCO and UTW Mixture Proportion

Mixture proportion(per cubic yard)	BCO	UTW
Cement(lbs)	580	820
Fly ash(lbs)	310	-
Water	260	300
Coarse aggregate(lbs)	1800	1720
Fine aggregate(lbs)	1100	1250
Air content(%)	5	-
Water/cementitious materials ratio	0.30	0.38
Synthetic fibers(lbs)	3.5	3.5

Using the volumetric mix design method of American Concrete Institute (ACI) committee 211 (ACI, 1991) coarse and fine aggregate proportion should be grow. Proper air particles should be 5 to 6 %. Admixture measurement should be regulate through trial batches, and the interachange between admixtures should be examine. Typical amounts of synthetic fibers used are 3.5 pounds per cubic yard .

Results and Discussion:

Structural Behavior and Performance: The long-term showing of bonded overlays is mostly contingent on early age behavior , if debonding or imprudent cracking happen at early ages and leads to non-success, long-term showing will clearly be poor. Within the first 48 hours following placement mostly debonding happen at a very early age . The overlays were detach or repaired by connect them to the original pavement with epoxy, so how they would have execute if left unbonded is not known. In other overlays, Small debonded areas have been found . These overlays mostly have not failed. Early age debonding of UTW in service has not been describe.

High Performance Concrete (HPC): For BCO and UTW overlays, early opening to traffic is often important, and early age behavior decide whether bond is achieved. Therefore, for this applications the use of high performance concrete (HPC) should be examine :

a) Ease of arrangement

b) Compaction without segregation

c) Early age strength

d) Long-lasting mechanical properties

e)Permeability

f) Density

g) Heat of hydration

h) Toughness

Early Age Behavior: At early ages, it is supreme to decrease stresses within the overlay and at the interface to smaller than the tensile and bond strength of the concrete. Due to concrete shrinkage and thermal contraction the overlay contracts. This escort to tensile stresses within the overlay, which can lead to rupture, as well as shear and tensile stresses between the overlay and existing pavement, which can lead to debonding. Debonding may lead to fine concrete slabs that will fail rapidly in fatigue, with failure exhibit as corner cracks.

Therefore, advisable features at early ages for BCO and UTW concrete involve:

a) High bond strength

b) Low shrinkage

c) Low thermal contraction

d) Low modulus of elasticity

e) High creep (stress relaxation)

Early age conduct also pivot on component other than the concrete properties. The developed existing pavement surface must be bumpy and clean sufficient to smooth bond .At the alliance actual surface composition enhance the shear and tensile bond strength . Adequate concrete curing enhance concrete strength gain, while reduce the shrinkage and thermal shrinkage of the concrete. Deficiency in surface preparation, materials, or curing can lead to overlay failure. For actual showing of BCO or UTW Properly engineered overlay concrete is a compulsory but not a sufficient condition.

Long term performance: For long-lasting showing, the overlay must pursue to give smoothness and skid resistance with minimum stagnation. Advantageous characteristics for long-term overlay concrete include:

a) High durability, including resistance to freeze-thaw, alkali-aggregate, and sulfate attack

b) Fatigue strength and High flexural

c) High abrasion resistance

As noted earlier, if early age properties are not acceptable the long-lasting properties do not matter . However, once early age failure is intercept, environmental assault, enervation, and tire erosion are the most dominant factors influence long-term performance. Therefore, in drawing of overlay HPC long-term performance as well as early-age behavior should be examine .

Testing:

Six different concrete overlay mix designs were examined. These are condanse in table 2. Three of these were high early strength (designated with H), with 800 pounds per cubic yard of adhesive material, and a water/cementitious materials ratio of 0.36. Four of these were normal strength (designated with N) with 625 pounds per cubic yard of cementitious material, and a water/cementitious materials ratio of 0.45. Although the normal strength (N) variety were more standard concrete, they can still be confidential as HPC. Of each type, one was plain (HP or NP) and two were reinforced with synthetic polypropylene fibers. The fiber reinforced overlay designs have an F as the second letter of the stipulation. Half of the mixes used a 30 % substitution of cement with fly ash (HFFA and NFFA).

Table 2: Overlay Mix Designs Investigated

Mix	Cement	Fly ash	Water	Coarse aggregate	Fine aggregate	Fibers	Air(%)	Slump (inches)	W/cm Ratio
HP	815		300	1740	1250		5.5	2-3.5	0.36
HF	815		300	1740	1250	3.5	5.5	2-3.5	0.36
HFFA	580	250	300	1740	1250	3.5	5.5	2-3.5	0.36
NP	635		300	1740	1400		5.5	2-3.5	0.45
NF	635		300	1740	1400	3.5	5.5	2-3.5	0.45
NFFA	440	190	300	1740	1390	3.5	5.5	2-3.5	0.45

*Above values are in pounds per cubic yard.

Strength Testing Results: Compacting and splitting tensile strength tests were execute at 1, 3, 7, and 14 days. Two variety of each kind were tested at each time. The documentation of strength growth with time as well as the real mix proportions and properties six overlay drawing in table given below. Concrete strength test outcome are in pounds per square inch. Most of the high strength overlay variety (except HFFA) attain a 14-day compressive strength of around 8,000 psi, and a one-day strength of around 4,000 psi. In disparity, the usual strength variety attain one-day strength of around 2,000 to 3,000 psi, and 14-day strength of 4,000 to 5,500 (except NFFA). In both occurrence, the 14day strength grow by the specimens with fly ash was significantly under Only the normal strength overlay designs with fly ash substitution would have failed to meet that basis.

The splitting tensile strengths accompany same shift, but there was more disperse. With the departure of the normal strength overlay designs with fly ash renewal, all had chop tensile strengths between 300 and 600 psi at one day, and between 450 and 850 psi at 14 days.

Table 3: Actual Proportions and Concrete Strength Test Results of Mix HP

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	4850	600
3	6600	680
7	7400	790
14	8150	725

Table 4: Actual Proportions and Concrete Strength Test Results of Mix HF

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	4200	450
3	7205	740
7	7795	690
14	8610	825

Table 5: Actual Proportions and Concrete Strength Test Results of Mix HFFA

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	2945	410
3	3870	485
7	5350	615
14	5705	595

Table 6: Actual Proportions and Concrete Strength Test Results of Mix NP

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	3950	485
3	6550	652
7	7315	645
14	7850	655

Table 7: Actual Proportions and Concrete Strength Test Results of Mix NF

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	2248	327
3	3675	432
7	4205	527
14	3724	455

Table 8: Actual Proportions and Concrete Strength Test Results of Mix NFFA

Concrete age (days)	Compressive strength(psi)	Splitting tensile strength(psi)
1	1424	-
3	2800	365
7	3032	415
14	-	-

Durability testing: The resistance of concrete to frosty and defrost cycles is an main crucial of longevity (Polivka et al., 1975, Powers, 1975, Toutanji et al., 2001). To regulate the durability of the concrete blend used in this test plan Freeze-thaw test were execute. The concrete specimens were unprotected to swiftly replicate cycles of freezing and thawing in following with ASTM C666 (1997). Procedure A,To carry out the tests quick freezing and thawing in water, was followed in the laboratory . This stratagem does not give any numeric crucial of the service life that can be anticipate of a specific mix type, but can be used to specify the disparity in both possession and determine of concrete samples. The freeze–thaw tests were convey out on beam samples made from the similar concrete mixed for the overlay variety. Convey to a freezer, After curing these samples for 14 days in a water tank. The beams were remain in the freezer upto enough samples of each mix type were accessible to run the freeze-thaw machine. This was done to continue the stability of the test. The beam prism samples used in this test were 3 by 4 by 16 inches long. To lowering the temperature of the frosty plate to zero degrees Fahrenheit and then enlarge the temperature to 40 degrees Fahrenheit the cycle will be start alternately. The cycle length was kept at 4 hours in conformity with ASTM C666 (1997). As per the standards given in ASTM C215(1997) Initial calculation of length, cross section, weight and elemental transverse recurrence were made for each specimen.

During the test, beam specimens were separate from the freeze-thaw machine at mean time not considerable 36 cycles of submission. The machine was cease while it was in the thawing cycle at the end of each mean time. They were remain in the freeze-thaw equipment for a day to assure that the specimens were entirely defrost and preserve at the described temperature. The beam specimens were then move out and water was used to wash them free of scale, then they were place into a water tank for 4 to 5 hours. calculation of length change, cross sectional dimensions, weight decrease and elemental transverse frequency were made after rubb the specimen surface free of surplus water. The stainless steel vessel were also cleaned free of the scale with water, and come to the freeze-thaw machine along with the specimens.

The specimens were come back to the vessel based on a prearranged revolving and inclination scheme so that each specimen was subjected to same state on all sides and in all parts of the machine. The vessels were then filled with fresh water and the test was restart. This complete method was carry on for 300 cycles after which the test was cease and final calculation were taken to calculate the percentage mass decrease and longevity factor to specify the comparative durability.

Conclusions:

1) Concrete used for pedestrian overlays (BCO and UTW) is a specific classification of High Presentation or say perfomance Concrete (HPC). Therefore, this concrete should take supremacy of the fresh HPC research and technology. As with any HPC, materials choice and combine proportions are very supreme for performance.

2)On surface composition and rehabilitate Performance of overlays also depends . The best-designed materials may fail even if these are abandon. Authority of overlay temperatures at early ages is dominant. Thus, knowledge of forecast habitat conditions during build up can help keep away early-age etiquette problems.

3) All of the overlay concrete designs examine have sufficient mechanical properties, compressive and splitting tensile strength, and durability. The normal strength concrete is more inexpensive than the high strength concrete, but expand these properties more steadily.

4) Early age behavior must be think about as well as long-lasting performance, component such as depletion and thermal contraction must be think about, and in many cases will control design. These factors are as supreme as strength, if not more so. Fibers seem to give satisfaction, but they have not yet been calibrate for this specific application.

5) The investigation so far has concentrate on pavement overlays. However, the same concepts appeal to bridge deck overlays and concrete renovate, since indistinguishable material and design variables govern behavior and presentation.

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