EFFECT OF DRYING SHRINKAGE CRACKS AND FLEXURAL CRACKS ON CONCRETE BULK PERMEABILITY pdf

1: Effect of Shrinkage and Load-Induced Cracking on Water Permeability of Concrete

The prediction of shrinkage and flexural crack width and crack spacing will allow the user to consider the effects of various concretemixture designs. The mean values reported will assist the user in determining which factors have the greatest effect on the expected crack width and crack spacing.

Page 30 Share Suggested Citation: Control of Concrete Cracking in Bridges. The National Academies Press. Cracks caused by external loads are generally flexural and shear cracks and occur after the con- crete has hardened. Cracks independent of the loading condition include plastic shrinkage cracks, settlement cracks, drying shrinkage cracks, thermal cracks, and map or pattern cracks. Cracks may also be described by their orientation, such as longitudinal, transverse, diagonal, or random Patnaik and Baah In the survey for this synthesis, agencies were asked what lessons they have learned about con- trolling concrete cracking. Several agencies mentioned the necessity of timely and proper water or moist curing. Several agencies also mentioned that drying shrinkage was a major source of cracking, and that modifications to the concrete constituent materials to reduce shrinkage are beneficial. Modi- fications that were mentioned included the use of a shrinkage-reducing admixture SRA , includ- ing fibers in the concrete mix, limiting cement or paste content, and internal curing. Plastic shrinkage cracking is more likely to occur under conditions that produce high evaporation rates, such as high air and concrete temperatures, low humidity, and high wind velocity over the concrete surface. In addition, concrete mixes with lower amounts of bleed water, such as those containing supplementary cementitious materials SCMs , have a greater tendency to exhibit plastic shrinkage cracks ACI Committee In bridges, plastic shrinkage cracks are most likely to occur in the decks because of the relatively large surface area compared with the thickness. Plastic shrinkage cracks can be unsightly but do not normally affect the structural performance of the concrete member. In most cases, the cracks do not penetrate the full depth of the member but may act as initiators for full-depth cracks TRB Plastic shrinkage can be minimized through the use of fibers Kosmatka and Wilson The most effective solution is to prevent such cracks from occurring by providing a saturated atmosphere over all exposed surfaces during the curing process. Thus, it is important to cover the top surface of the concrete with a moisture-proof cover as soon as concrete placement and finishing are complete. Plastic settlement cracks Plastic settlement cracks occur when concrete continues to consolidate under its own weight after initial placement, vibration, and finishing. The cracks are most likely to occur when the vertical settlement is restrained by horizontal reinforcing bars. Settlement cracking increases with larger bar sizes, higher concrete slump, and smaller concrete cover Dakhil et al. Plastic settlement cracks can be reduced through the use of fibers Kosmatka and Wilson As with plastic shrinkage cracks, it is best to prevent plastic settlement cracks by using proper construction procedures. Consequently, high-strength concretes may have large amounts of autogenous shrinkage. Autog- enous shrinkage can contribute to plastic shrinkage cracking TRB Concretes susceptible to large amounts of autogenous shrinkage should be cured with external water for at least 7 days to minimize crack development Kosmatka and Wilson When the drying shrinkage is restrained by other components, tensile stresses develop in the shrinking concrete and can lead to cracking. Such is the case for concrete decks cast on steel or concrete beams. The mag- nitude of the tensile stress is influenced by many factors, including the amount and rate of shrinkage, the degree of restraint, the modulus of elasticity, and the amount of creep ACI Committee The amount of shrinkage is influenced by the concrete constituent materials and the member size. Thin- ner members have more shrinkage and shrink at a faster rate than do thicker members. For example, a bridge deck will heat more quickly from sunshine than will the girders supporting the deck. When these temperature differences occur, tensile stresses result, which can lead to thermal cracks. Ther- mal cracks can also occur when the two components have the same temperature change but have different coefficients of thermal expansion. This rest of this chapter addresses the causes and types of cracking in hardened concrete for each of the major components of a bridge. The major types are transverse, longitu- dinal, diagonal, and random. Transverse cracks are illustrated in Figure 1. In addition, there is map cracking, which is also called pattern cracking or crazing. In hardened concrete, cracks form where the tensile stress in the concrete exceeds the tensile strength of the concrete. Tensile stresses are caused by applied loads such as vehicles or restraint to the length changes caused by shrinkage or temperature changes. The tensile strength of the concrete depends on the concrete constituent materials, curing environment, and concrete age. Some cracking in nonprestressed concrete bridge decks is inevitable because the cross section is expected to crack before the reinforcement becomes effective. Such cracks include the following: Because some cracks are inevitable, their width and spacing need to be controlled through the use of reinforcement. This is discussed in chapter five. The incidence of cracking increases with span length [Larson et al. Michigan Department of Transportation. The study concluded that transverse cracking was the dominant type of cracking. These cracks typically were located above transverse reinforcing bars. Several other studies have identified that longitudinal and transverse cracks tend to fall directly above reinforcing bars in the top layer of reinforcement because the pres- ence of the reinforcement acts as a stress raiser, but this is not always the case Cheng and Johnston ; Perfetti et al. The formation of these cracks can be initiated by the presence of plastic shrinkage cracks. A survey indicated that more than , bridge decks in the United States have experienced early-age transverse cracking Brown et al. In the survey for this synthesis, agencies were asked which types of concrete cracking their bridges had experienced in the past 5 years in cast-in-place CIP concrete decks with removable formwork or stay-in-place steel forms on both steel and concrete beams. The results are summarized in Figure 3. On the positive side, nearly one quarter of the agencies reported that cracks occurred infrequently. On the negative side, more than one-half of the agencies reported that cracks occurred frequently. Fewer agencies reported frequent cracking when stay-in-place metal formwork was used compared with removable formwork. This could be the result of fewer states using stay-in-place formwork. The agencies were asked to identify the strategies they are using to minimize cracking in CIP con- crete bridge decks. Their responses are provided in Table 1 along with the results of surveys in Russell and Russell These strategies are the same as those that were rated highly in a survey Russell , as shown in Table 1. One difference between the and surveys is that more agencies now specify a maximum concrete temperature during curing. Agencies were asked to identify the strategies that were most or least effective in minimizing cracking in full-depth, CIP concrete decks. Although 23 strategies were listed as most effective, the strategy cited most often was to apply wet curing early and provide a minimum wet curing period for the deck, followed by the application of a curing compound. The strategy cited second most often was the use of fogging to reduce evaporation rates during concrete placement. The full list of strategies is provided in the answer to Question 7 in Appendix B. Fifteen strategies were identified as least effective in minimizing cracking in full-depth CIP concrete bridge decks. The strategy listed most often as least effective related to not requiring or enforcing the use of wet curing per the specifications. The strategies cited next most often were the use of fogging and the use of fibers. The full list of strategies is provided in the answer to Question 8 in Appendix B. High Performance Concrete Specifications and Prac- tices for Bridges Russell , state highway agencies identified that drying shrinkage cracking was a dominant issue in using high-performance concrete HPC in CIP bridge decks. It appeared that the use of HPC had not eliminated the concerns about deck cracking, although the use of HPC resulted in better performance overall. Individual agencies also reported that use of the following contributed to increased deck cracking: One agency reported in that the use of an SRA had helped reduce cracking but not to a satis- factory degree. The responses did not show any consensus. The one practice that was not successful in three states was the use of silica fume. As a means of limiting the free shrinkage of concrete, the criteria listed in Table 2 have been used. Based on the numbers in Table 2, a reasonable criterion would be less than to millionths after 28 days of drying. A low shrinkage alone does not guarantee that cracking will not occur. However, it does reduce the likelihood of cracking. In Kansas, 59 bridge decks were investigated to identify factors that contribute to cracking Schmitt and Darwin , ; Miller and Darwin ; Lindquist et al. The investigations concluded that concrete shrinkage or restraint of concrete shrinkage was a major contributor to bridge deck cracking. Additional details of the Kansas activities are provided in chapter seven. One of the goals of Class HP was to reduce cracking. Streeter reported that cracking in the HPC bridge decks resulted for a variety of reasons. If there was not sufficient retardation during placement, cracks developed, primarily on multispan continuous structures. Shrinkage cracks occurred when curing was delayed or fresh concrete was placed on existing concrete that was not in a saturated, surface dry condition. This latter problem was prevented by placing soaker hoses or sprinklers on the existing concrete for 12 or more hours below concrete placement. To quantify the effects of the use of Class HP concrete, 84 bridge decks, built from to , were inspected Owens and Alampalli Deck ages ranged from 1 to 4 years. Forty percent of the bridge decks exhibited both transverse and longitudinal cracking. It was observed that most cracks occurred within 2 weeks of the deck placement. After 48 hours, the temperature rise had dissipated. The authors concluded that the differential temperature alone was not sufficient to cause deck cracking. However, significant cracking occurred after 18 to 41 days of air drying. A survey of 72 bridges for transverse deck cracking in the Minneapolis-St. Paul metropolitan area was reported by French et al. The survey included 34 simply supported, prestressed concrete girder bridges; 34 continuous, steel girder bridges; and four continuous, rolled steel wide-flange girder bridges. Overall, the decks of bridges with simply supported prestressed concrete girders were observed to be in better condition than decks on continuous steel girder bridges.

2: Fiber-reinforced concrete - Wikipedia

Add tags for "Effect of drying shrinkage cracks and flexural cracks on concrete bulk permeability". Be the first.

Volume change is one of the most detrimental properties of concrete, which affects the long-term strength and durability. To the practical engineer, the aspect of volume change in concrete is important from the point of view that it causes unsightly cracks in concrete and called concrete shrinkage. One of the most objectionable defects in concrete is the presence of cracks, particularly in floors and pavements. One of the important factors that contribute to the cracks in floors and pavements is that due to shrinkage. It is difficult to make concrete which does not shrink and crack. It is only a question of magnitude. Now the question is how to reduce the shrinkage and shrinkage cracks in concrete structures. The term shrinkage is loosely used to describe the various aspects of volume changes in concrete due to loss of moisture at different stages due to different reasons. Types of Shrinkage in Concrete To understand this aspect more closely, shrinkage can be classified in the following way: Plastic Shrinkage Shrinkage of this type manifests itself soon after the concrete is placed in the forms while the concrete is still in the plastic state. Loss of water by evaporation from the surface of concrete or by the absorption by aggregate or subgrade, is believed to be the reasons of plastic shrinkage. The loss of water results in the reduction of volume. The aggregate particles or the reinforcement comes in the way of subsidence due to which cracks may appear at the surface or internally around the aggregate or reinforcement. In case of floors and pavements where the surface area exposed to drying is large as compared to depth, when this large surface is exposed to hot sun and drying wind, the surface of concrete dries very fast which results in plastic shrinkage. When this water at the surface dries out, the surface concrete collapses causing cracks. Plastic concrete is sometimes subjected to unintended vibration or yielding of formwork support which again causes plastic shrinkage cracks as the concrete at this stage has not developed enough strength. It can also be further added that richer concrete undergoes greater plastic shrinkage. Plastic shrinkage can be reduced mainly by preventing the rapid loss of water from surface. This can be done by covering the surface with polyethylene sheeting immediately on finishing operation; by fog spray that keeps the surface moist; or by working at night. Use of small quantity of aluminium powder is also suggested to offset the effect of plastic shrinkage. Similarly, expansive cement or shrinkage compensating cement also can be used for controlling the shrinkage during the setting of concrete. Drying Shrinkage Just as the hydration of cement is an ever lasting process, the drying shrinkage is also an ever lasting process when concrete is subjected to drying conditions. The drying shrinkage of concrete is analogous to the mechanism of drying of timber specimen. The loss of free water contained in hardened concrete, does not result in any appreciable dimension change. It is the loss of water held in gel pores that causes the change in the volume. Under drying conditions, the gel water is lost progressively over a long time, as long as the concrete is kept in drying conditions. Cement paste shrinks more than mortar and mortar shrinks more than concrete. Concrete made with smaller size aggregate shrinks more than concrete made with bigger size aggregate. The magnitude of drying shrinkage is also a function of the fineness of gel. The finer the gel the more is the shrinkage. Autogeneous Shrinkage In a conservative system i. The shrinkage of such a conservative system is known as autogeneous shrinkage. Autogeneous shrinkage is of minor importance and is not applicable in practice to many situations except that of mass of concrete in the interior of a concrete dam. Carbonation Shrinkage Carbon dioxide present in the atmosphere reacts in the presence of water with hydrated cement. Calcium hydroxide [Ca OH 2] gets converted to calcium carbonate and also some other cement compounds are decomposed. Such a complete decomposition of calcium compound in hydrated cement is chemically possible even at the low pressure of carbon dioxide in normal atmosphere. Carbonation penetrates beyond the exposed surface of concrete very slowly. The rate of penetration of carbon dioxide depends also on the moisture content of the concrete and the relative humidity of the ambient medium. Carbonation is accompanied by an increase in weight of the concrete and by shrinkage. Carbonation shrinkage is probably caused by the dissolution of crystals of calcium hydroxide and deposition of calcium carbonate in its place. As the new product is less in volume than the product replaced, shrinkage takes place. Carbonation of concrete also results in increased strength and reduced permeability, possibly because water released by carbonation promotes the process of hydration and also calcium carbonate reduces the voids within the cement paste. As the magnitude of carbonation shrinkage is very small when compared to long term drying shrinkage, this aspect is not of much significance Factors Affecting Shrinkage of Concrete One of the most important factors that affects shrinkage is the drying condition or in other words, the relative humidity of the atmosphere at which the concrete specimen is kept. If the concrete is placed in per cent relative humidity for any length of time, there will not be any shrinkage; instead there will be a slight swelling. The typical relationship between shrinkage and time for which concrete is stored at different relative humidities is shown in Figure. The graph shows that the magnitude of shrinkage increases with time and also with the reduction of relative humidity. The rate of shrinkage decreases rapidly with time. It is observed that 14 to 34 per cent of the 20 year shrinkage occurs in 2 weeks, 40 to 80 per cent of the 20 year shrinkage occurs in 3 months and 66 to 85 per cent of the 20 year shrinkage occurs in one year. The richness of the concrete also has a significant influence on shrinkage. Aggregate plays an important role in the shrinkage properties of concrete. The quantum of an aggregate, its size, and its modulus of elasticity influence the magnitude of drying shrinkage. Harder aggregate with higher modulus of elasticity like quartz shrinks much less than softer aggregates such as sandstone. Moisture Movement Concrete shrinks when allowed to dry in air at a lower relative humidity and it swells when kept at per cent relative humidity or when placed in water. Just as drying shrinkage is an ever continuing process, swelling, when continuously placed in water is also an ever continuing process. If a concrete sample subjected to drying condition, at some stage, is subjected to wetting condition, it starts swelling. It is interesting to note that all the initial drying shrinkage is not recovered even after prolonged storage in water which shows that the phenomenon of drying shrinkage is not a fully reversible one. Just as the drying shrinkage is due to loss of adsorbed water around gel particles, swelling is due to the adsorption of water by the cement gel. The water molecules act against the cohesive force and tend to force the gel particles further apart as a result of which swelling takes place. In addition, the ingress of water decreases the surface tension of the gel. The property of swelling when placed in wet condition, and shrinking when placed in drying condition is referred as moisture movement in concrete. Stay informed - subscribe to our newsletter.

3: Dry Shrinkage, Frost Resistance and Permeability of Rubber Included Concrete

To the practical engineer, the aspect of volume change in concrete is important from the point of view that it causes unsightly cracks in concrete and called concrete shrinkage.

4: Effect of cracks on the transport characteristics of cracked concrete

Research laboratories have mostly used permeability tests on intact concrete for assessment and effectively ignored in-service cracking such as shrinkage and load- induced cracks. This study is an attempt to isolate the effect of shrinkage and load-induced cracks on the apparent water permeability.

5: Shrinkage in Concrete, Definition, Types, and Factors Affecting Concrete Shrinkage

Types of Cracks in Fresh and Hardened Concrete Cracking of in Fresh or Plastic Concrete 1. Plastic shrinkage Cracks. Plastic shrinkage cracking (Fig.1) occurs when subjected to a very rapid loss of moisture caused by a combination of factors which include air and concrete temperatures, relative humidity, and wind velocity at the surface of the concrete.

EFFECT OF DRYING SHRINKAGE CRACKS AND FLEXURAL CRACKS ON CONCRETE BULK PERMEABILITY pdf

2 The phantom falcon Anne Schraff The Psalms are one book Tlc Talking and Listening With Care The Zen Gardening Kit/Book and Japanese Rock Garden Career guidance after 10th The making of an Englishcountry garden The Bishops address at the opening of the general conference in adjourned session at Napanee, January 9th Exchange of notes concerning a loan by the Government of the United Kingdom of Great Britain and Northern Emdex 2014 On war indexed edition The time of assassins Tales of Woodsman Pete Msha 8 hour refresher lesson plan Picture of Dorian Gray, The (Classic Collection (Brilliance Audio)) Tourette Syndrome A Medical Dictionary, Bibliography, and Annotated Research Guide to Internet References Seapower at the millennium The Love Affairs of Great Musicians, V2 Philip kotler marketing management ebook Handbook of Metaheuristics (International Series in Operations Research Management Science) Silas Cullys Tavern Tales Adobe Illustrator CS2 Gone Wild The fish shellfish cuisine I love Sleep With This Book Find of transformed random variable Silver Age Sentinels Roll Call Volume 3 Stedman, E. C. The faculty divine. Subject Directory of Special Libraries and Information Centers Sagas Of The Seas By American Writers The will kristen ashley tuebl Basics of currency trading Tsuki ga michibiku isekai douchuu novel The typicality of Oliver Wendell Holmes, by E. Carter. Bensonhurst and a murder attempt Two horseman of the Apocalypse. Interactive Neuroanatomy Aqueous Polymeric Coatings for Pharmaceutical Dosage Forms, Third Edition (Drugs and the Pharmaceutical S Consumer electronics components handbook Adobe opener The best ticket in town 3. Globalisation, International Capital Flows and