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Study of Failure of Concrete

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***Abstract*-A theoretical framework for the analysis of localized failure in concrete is presented. The theory is predicated upon the assumption that discrete failure planes arise as a result of a process of localization of damage. The onset of localized modes is characterized as a bifurcation phenomenon whereby local neighborhoods of the material depart from near-uniform straining in favor of highly localized deformation patterns. Simple bifurcation techniques are discussed which suffice to detect when localization initiates and to determine the geometry of the localized deformation modes. Localization techniques are seen to provide a simple yet effective means of extending the range of applicability of traditional distributed damage models to situations of localized failure. Numerical calculations for biaxial stress paths exhibit a good overall agreement with experimental observations.**

***Keywords:-* concrete, factors**

I. INTRODUCTION

The age-old axiom in concrete construction is that concrete cracks. While cracks may develop in concrete for a variety of causes, the underlying principle is the relatively low tensile strength of concrete. Visible cracking occurs when the tensile stresses exceed the tensile strength of the material. Visible cracking is frequently a concern since these cracks provide easy access for the infiltration of aggressive solutions into the concrete and reach the reinforcing steel or, other components of the structure leading to deterioration. This document reviews the causes of cracking, discusses various tests that can be performed to assess the susceptibility of a material to cracking, and provides several case studies.

It is important to understand why cracks develop in highway concrete structures and pavements.The impact of cracking on durability, especially corrosion, is detrimental to many transportation structures

Collapse of concrete structures during construction has been happening since concrete has been placed in formwork.Structural concrete plays the role of being the main contributing component to the strength of a structure, and it is widely perceived that sound concrete is synonymous to strong concrete. While this statement holds true in terms of the structural aspect of concrete, the performance of concrete, in the form of its durability, is also an indispensable factor to the maintenance of strength and serviceability of the structure.From a structural standpoint, buildings are designed to stay erect for scores of years without any notable failures, and concrete is known to maintain its strength over time. For this, the durability of concrete, which is independent from achieving strength in the batching plant, is an important factor in building for performance, and not just strength, and is therefore key to study and take into account in any design process.

In addition to the prevalent environmental conditions and exposure of the construction site, the factors affecting the durability of concrete are dependent on all the elements that constitute the final concrete mix, as well as the how the concrete is cast, finished, and cured on site. The aggregates used and their gradation, the gradation and fineness of sand used, the type of mixing water and the water cement ratio obtained, as well as all components of the casting, finishing, and the curing process, therefore all affect how durable the concrete will be.

II. CAUSES OF CRACKING

Concrete structures do not frequently fail due to lack of strength, rather due to inadequate durability or due to improper maintenance techniques. The most common cause of premature deterioration is attributed to the development of cracks (Mehta, 1992; Hobbs, 1999). Cracking can occur in concrete pavements and structures for several reasons that can primarily be grouped into either mechanical loading or environmental effects. It should also be noted that for most practical structures, reinforcement is used to bridge and hold cracks together when they develop, thereby assuring load transfer while adding ductility to a relatively brittle material. Therefore not all cracking causes concern. Reinforced concrete elements are frequently designed on the assumption that cracking should take place under standard loading conditions. For example continuously reinforced concrete pavements (CRCP) are designed with longitudinal steel in an amount adequate to hold shrinkage cracks tight, while joints exist only at locations of construction transitions and on-grade structures. In this pavement type wherein shrinkage cracks develop over time and stabilize over the first 3 to 4 years, cracking in the transverse direction in specific patterns is not detrimental to the structure as long as the cracks remain tight and retain good load transfer. Therefore, cause of cracking should be carefully identified to determine which cracks are common and acceptable and which cracks merit repair or further investigation.

III. MECHANICAL LOADING

A. STATIC LOADING:

Concrete is a composite material that is made by binding aggregates together with a cementitious paste. While the independent response of a cement paste and aggregate to an applied load is linear as shown in Figure 2, it can be seen that response of the composite concrete is highly nonlinear. This non-linearity can be attributed to the development of small cracks (micro cracks) throughout the concrete matrix as load is applied. Others have suggested that this may be attributed to existence of a weak bond or interfacial transition zone between the aggregate and the paste matrix. While these cracks occur over a wide range of load levels they can be attributed to the development of high local stresses that occur at the interface of the aggregates and paste.The cracks in a structure typically develop at the location that has the highest stress and the weakest bond. This can occur at a reduced section, a preexisting flaw, or an area of stress concentration. The study of how cracks develop and propagate in a structure is commonly referred to as fracture mechanics. Over the last four decades significant research has been performed to better understand the fracture processes in concrete. Fracture mechanics differs from continuum mechanics approaches in that it relates local stress levels (stress intensity) with the existence of a crack.

B. CYCLIC LOADING

Failure under repeated mechanical loading is referred to as fatigue or cyclic loading. Note that the load levels in the case of fatigue failures are not sufficient to result in failures under static conditions. While the mechanisms of fatigue failure are not completely understood there are two hypotheses concerning crack initiation and its evolution in plain concrete. The first hypothesis attributes the fatigue failure to the progressive deterioration of the bond between the coarse aggregate and the matrix. The second hypothesis attributes the fatigue failure in concrete to the coalescence of pre-existing micro-cracks in the matrix, resulting in a single localized macro-crack. Fatigue causes a crack to propagate through the matrix (typically starting along the interfacial zone between an aggregate and the paste). As cyclic loading proceeds, stresses are redistributed and the macro-crack width decreases but never closes completely.

IV. VOLUMETRIC STABILITY

A. SETTELEMENT

Settlement cracking occurs in freshly mixed concrete as the concrete settles over time and encounters some restraint. The heavier particles 'sink' due to gravity until the concrete sets. Plastic settlement cracking has been frequently observed to occur at changes in cross section (i.e., over reinforcing bars or at change in section height). The practical significance of settlement cracking is in the construction of reinforced slabs, and bridge decks. The magnitude of tensile stress generated as a result of plastic settlement, along with the capillary stress and the autogenous effect, may be sufficient to initiate plastic cracking.

TABLE I. CLASSIFICATION OF CRACKS

Type of cracking	***Form of crack***	***Primary cause***	***Time of appearance***
Plastic settlement	Over and aligned with reinforcement	Poor mixture design leading to excessive bleeding, excessive vibrations	10 min to 3 hr
Plastic shrinkage	Diagonal or random	Excessive early evaporation	30 min to 6 h
Drying shrinkage	Transverse, pattern or map cracking	Excessive mixture water, inefficient joints, large joint spacing	Weeks to months
Freezing and thawing	Parallel to the surface of concrete	Lack of proper air void system, nondurable coarse aggregate	After one or more winters
Sulfate attack	Pattern	Internal or external sulfates promoting the formation of ettringite	1 to 5 years

The role of settlement in plastic cracking has been studied for several decades. Powers (1968) measured the settlement of cement paste by manually monitoring the displacement of a steel pin resting on the surface of fresh concrete. The amount of settlement observed was related to specimen height, water-to-cement ratio (w/c) and concrete consistency (Powers, 1968). A uniform settlement (i.e., homogenous volume contraction) in a fresh concrete mixture does not lead to plastic cracking.

B. SULFATE ATTACK

Concrete may crack due to internal expansion resulting from sulfate attack. This type of deterioration is the result of two chemical reactions: the combination of sulfates with lime to form gypsum, and the combination of sulfates with hydrated calcium aluminates to form ettringite. The final reaction product occupies a larger volume than the original constituents. It is also postulated that crystallization of sulfate salts generates stresses that can cause disruption (ACI 201). Some sulfate salts, such as magnesium sulfate, contain cations that lead to further expansions thereby exacerbating the effects of sulfate attack. To protect against sulfate attack, cements with low tricalcium aluminate (C3A) content, pozzolanic materials that react with lime and low-permeability concretes can be used.

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REFERENCES

[1] ACI Committee 318, (2008). ACI 318-08 “Building Code Requirements for Structural Concrete and Commentary” pp. 81-82

[2] ACI Committee 318, (1963). ACI 318-63 “Building Code Requirements for Structural Concrete and Commentary” pp..

[3] Arthur H. Nilsen, David Darwin and Charles W. Dolan, (2004). “Design of Concrete Structures” pp. 12-17

[4] Charles D. Reese and James Vernon Eidson, (2006). “Handbook of OSHA Construction Safety and Health” pp. 181-183

[5] Norbert J. Delatte Jr., Ph.D., P.E. (2009). “Beyond Failure” *Forensic Case Studies For Civil Engineers* pp. 129-155.

[6]Yingzi Yang, Michael D. Lepech, En-Hua Yang and Victor C. Li., (2009) "Autogenous healing of engineered cementitious composites under wet–dry cycles". *Cement and Concrete Research*

[7] Altoubat, S., and D. A. Lange. Tensile Basic Creep: Measurements and Behavior at Early Age. ACI Materials Journal, Vol. 98, No. 5, 2001, pp. 386–993.

[8] Aktan, H. M., T. M. Ahlborn, and Y. Koyuncu. Prestressed Concrete Bridge Beam Health Monitoring In Michigan. Presented at Concrete Structures in the 21st Century, FIBS Congress 2002, October 13–19, 2002, Osaka, Japan.

[9] Petroski, H. “Failure as a Source of Engineering Judgement: Case of John Roebling”, Journal of Performance of Constructed Facilities, ASCE, vol 7, n2, Feb. 1993, 46-58.

[10] Kagan, H. A., “ Common Causes of Collapse of Metal-Plate-Connected Wood Roof Trusses”, Journal of Performance of Constructed Facilities, vol. 7, n4, Nov, 1993, pp. 225-233.