A Review on the Study of Formation of Cracks in Structure and Different Techniques to Heal the Cracks

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ABSTRACT: Formation of cracks in concrete is major problems in damage of structure. Due to this transportation of moisture takes place which damage the structure permanently. A crack in a structure give rise to local flexibility that would affect the main vibration response of the structure. Detection of damage in structural engineering is one of the most important aspects for safety reasons. To collect various information from different research papers published by different researchers for crack/damage detection of beams through various techniques is the main aim of this survey paper. Modern intelligent techniques such as Artificial Neural Network(ANN), Fuzzy Logic Techniques are used for prediction of crack location and depth and size of the cracks by different authors. For prevention of this impact, self healing concrete properties developed. Bacterial, Capsule, Induction Heating are the three types of self healing properties discussed in this review article. It is found by many researchers that cracks will be healed initially and later on it increases the strength of structure.

KEYWORDS : Crack; Free Vibration; Natural frequency; Fuzzy logic; Finite Element Method; Beam; Natural frequency, Bacterial, Capsule, Induction Heating.

I. INTRODUCTION

The main in civil engineering is strength and durability of a structure but due the cracks in structure reduces the strength of structure. A crack is nothing but any deviation that is introduced to a structure maybe deliberately or unintentionally, which affects the current or future performance of that system. Among the most encountered damage types in the structures due to fatigue or manufacturing defects, cracks are the leading ones. When the stresses near the crack tip will exceed the permissible limit, cracks will initiate in a structure. Cracks found in structural elements may arise due to fatigue cracks, limited fatigue strength, mechanical defects or manufacturing defects. The issues that can lead to a crack in a mechanical structure are mechanical accidents, fatigue, erosion, corrosion as well as environmental attacks. In structure analysis and in the field on Engineering, damage analysis is one of the most important aspects. At the time of operation to avoid the unexpected or sudden failure, earlier crack detection is essential. Presentation of various cost effective reliable analytic numerical and experimental techniques developed by various researchers is the main intention of this survey paper.

Fig. Uncracked Cantilever Beam Model

Fig. Cracked Cantilever Beam Model
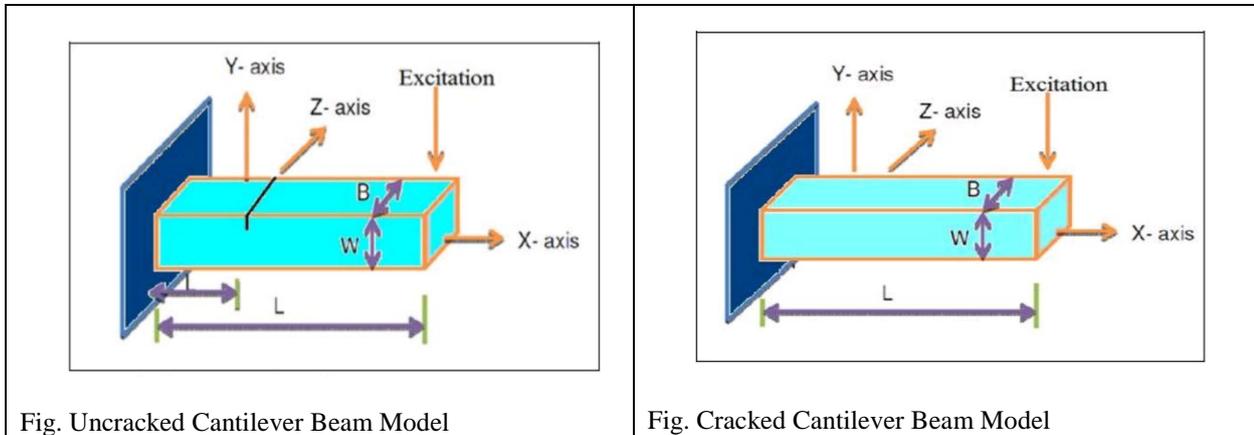
For the safety of the structure, crack/damage is such an important phenomenon to be studied. If a crack is present in a structure, it reduces the stiffness of the structure which in turn reduces the natural frequency of the structure. As a result the dynamic characteristics of the structures are changed. It is very much necessary to ensure that the structure is free from any defect or not; for this purpose we need to detect the crack in the structure. Hence for the detection of cracks various techniques are adapted by different authors. The FINITE ELEMENT METHOD is said to be a mathematical tool to analyze complex structures. Even the commercial software ANSYS is also frequently used for the prediction of the crack location and size, depth of the crack. To overcome the above problems the self healing concrete properties developed. Different mechanism of self healing concrete were tested but still optimize solutions is required. The efficiency of self healing concrete method is determined by regaining it's mechanical properties like regain it's strength, stiffness, etc after cracks were healed.
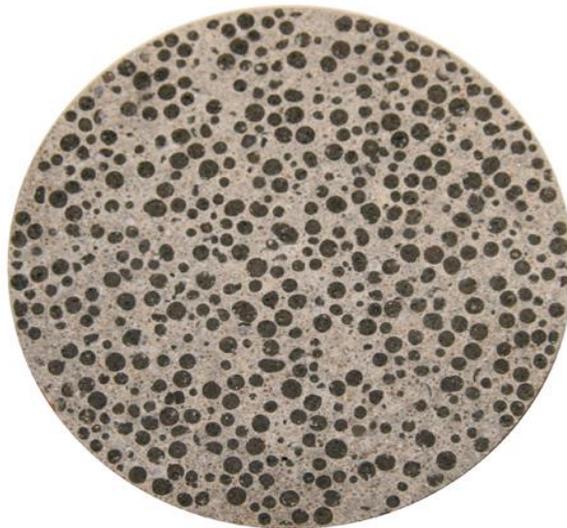

Fig. Cracks in structure

II. RESEARCH OF DIFFERENT RESEACHERS ON CRACK DETECTION ON STRUCTURAL BEAMS

Many attempts have been made to detect cracks using vibration monitoring technique as the presence of cracks changes the dynamic characteristics of the structures. A crack in aluminium cantilever beam was analyzed using such a vibration monitoring technique. The aluminium cantilever beam containing a crack was excited by accelerometer. Digital Storage Oscilloscope was used for finding the experimental result frequency. 3D graph of normalized frequency was plotted in terms of crack depth and location.

III. MATERIAL AND METHODOLOGY ASSUMPTIONS

Following assumptions were made for the purpose of identification of cracks :
1. The crack is open
2. The crack is regular over the surface of the specimen and it is simultaneously uniform in propagation.
3. The crack is a transvers crack.
4. The beam containing the crack is a long beam.
5. **The vibrations are not axial but flexural in nature.**

IV. MATERIAL SELECTION

There is a vast use of structural steels in various structures such as towers, water tanks, bunkers, beams, domes, folded plates, trusses, bridges, chimneys, space frames, silos, offshore platforms etc.
As a result structural steel have been used widely for making various specimens and structures.

V. SOFTWARES USED IN CRACK DETECTION

[1] Matlab : MATLAB is used to plot the 3D surfaces from the data generated from the theoretical data.
[2] Minitab : MINITAB is the software used to plat contour lines.
[3] Microsoft Excel : MICROSOFT EXCEL is used to plot three contour lines on the same axix to get their common intersection point.
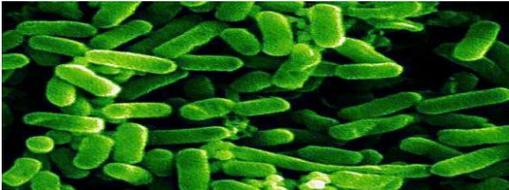
VI. METHOD OF SELF HEALING CONCRETE

A. BACTERIAL CONCRETE.

Sir H.M.Jonkers et al introduce the self healing concrete properties in 2010. It was found that the bacteria were used which is naturally available anywhere on earth surface as well as in rock at depth of 1km or more than that.
The various types of bacteria :-
- Bacillus pasteurized
- Bacillus pseudofirmus
- Bacillus cohnii
- Esherichia coli

1.	Bacillus pasteurized	
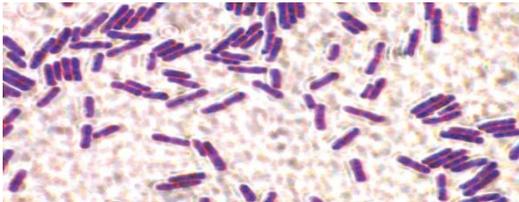
2.	Bacillus pseudofirmus	
3.	Bacillus cohnii	
4.	Esherichia coli	
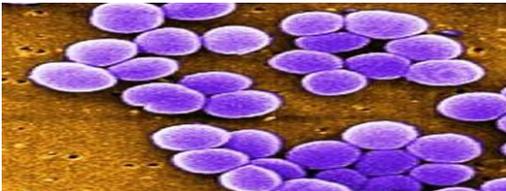
The bacteria are found in desert, rocky and ultra basic environment which is same in internal concrete environment. In this method, the bacteria is mixed with concrete at initial stage. Calcium hydroxide present in concrete structure reacts with atmosphere carbon dioxide and gives a calcium carbonate as a product.

$$CO_2 + Ca(OH)_2 \longrightarrow CACO_3 + H_2O$$

In bacterial concrete calcium lactate is more efficient due to its metabolic activity.

$$Ca(C_3H_5O_2)_2 + 7O_2 \longrightarrow CaCO_3 + 5CO_2 + 5H_2O$$

This method is not only use produce calcium carbonate but also carbon dioxide with Portland Ore which is present on surface of cracks. It was concluded that bacteria improves the calcite in cracks which increases the strength of structure later on.

B. CAPSULE METHOD.

Sir H. M. JONKERS et al selected healing porous asphalt concrete. In capsule method, Bitumen is used in two phase(states) one is liquid phase called as Maltenes and other is solid phase called as Asphaltenes. As soon as bitumen liquid dries it makes asphalt dry & brittle which only affects the few centimeters of the surface. To solve this problem capsules filled with Maltenes were mixed with concrete is used. Later on when cracks occur due to this moisture transportation takes place and capsule breaks and it heals the structure and later on it increases the strength of structure also.
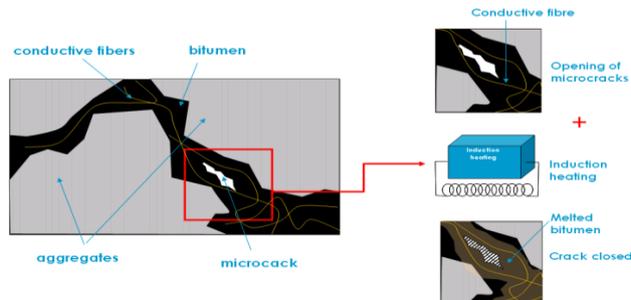
Fig. CAPSULE METHOD

C. SUPER ABSORBENT POLYMER METHOD.

N. Ganamanikarnika study the behavior of super absorbent polymer to heal the cracks. Internal curing is a process of crystallization using substance present in the substrate itself. It is also known as self healing. In this method concrete was mixed with different substance.

Table 1. MIXING PROPORTION OF COMPONENTS (in kg)

CEMENT	FINE AGGREGATES	COARSE AGGREGATES	S F	SUPER PLASTICIZER	WATER
620	520	902	25	5	215

The mixture of fine and coarse aggregates along with water and super plasticizer for a four minutes. It was concluded that there is decrease in amount of fresh concrete composition in addition of curing water.

VII. CONCLUSION

The changes in the natural frequencies are the important parameters that determine crack size and location and Researchers are presently focusing on using the fuzzy logic as an effective tool for crack detection.As far as safety is taken into consideration, the fault detection in structures is considered to be the most important engineering problem. In this paper a review is conducted on the detection of cracks in structures.

Bacteria are used to precipitate calcite in cracks. With the help of this method it was concluded that large cracks in reinforced cement can be filled. Bacterial concrete method is better than the other methods because it is eco-friendly than the other methods. According to research group the cost of bacterial concrete is increased by 30% to conventional concrete. It is easy and convenient but more work more work is required due to economical factors. Internal curing in which adding the different types of polymer along with curing water to increase the strength of concrete.

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