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Study on Causes of Cracks & its Preventive Measures in Concrete Structures

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Abstract
The problem of cracking in building is becoming a difficult puzzle for engineers nowadays. Cracking is an unavoidable response of any structure while designers are trying to eliminate many of the causes of cracking and design tolerance for other factors. We all want our building structurally safe but it is not so easy. Some faulty steps during construction and some unavoidable reasons different type of cracks starts to appear on various structural and non- structural parts of the building. So, timely identification of such cracks and adopting preventive measure are essential. The repair materials and repair technique are different depending upon forms of cracks according to their positions in structure. Some types of cracks seriously need attention as they are structurally hazardous. In this paper, we will discuss about the problem engineers are facing i.e. of cracking after construction and what preventive measures should be taken along with the techniques to cure cracks.
Keywords- Cracks, Causes of cracking, Preventive Measures, Techniques.

I. INTRODUCTION

A crack is a complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing. Concrete structure has been started applying since the mid-19th century, because of the low quality of cement and at that time the development of concrete structure was slow. Until the end of the 19th century, concrete structure was getting faster development with the development of production, experimental work, computational theory and improvement of construction technique and now it has became one of the most widely used building materials in the modern construction. Cracks are one kind of universal problem of concrete construction as it affects the building artistic and it also destroys the wall's integrity, affects the structure safety even reduce the durability of structure. Cracks develop due to deterioration of concrete or corrosion or reinforcement bars due to poor construction or inappropriate selection of constituent material and by temperature and shrinkage effects.

Cracks can be divided into two types:

A) *Structural Cracks:* These cracks occur due to incorrect design, faulty construction or overloading and these may endanger the safety of a building.

Structural cracks that are formed in Beam, Column and slabs are:

Beam	**Columns**	**Slabs**
Flexural Cracks	Horizontal Cracks	Flexural Cracks
Shear Flexure Cracks	Diagonal Cracks	Top Flexure Cracks
Torsional Crack	Corrosion/Bond Cracks	Shrinkage Cracks
Bond Slip Crack		
Disturbance Cracks		
Tension Cracks		

B) *Non-Structural Cracks:* They are due to internal forces developed in materials due to moisture variations, temperature variation, crazing, effects of gases, liquids etc.

Non-Structural Cracks are:

- Plastic Settlement
- Plastic Shrinkage
- Early Thermal Expansion and Contraction
- Long Term Drying Shrinkage
- Crazing
- Due to corrosion of concrete
- Due to Alkali-Aggregate Reaction
- Sulphate Attack
- Due to corrosion of Steel

A commonly known classification of cracks on the basis of their width is:

a) Thin - less than 1mm in width
b) Medium - 1 to 2mm in width
c) Wide - more than 2mm in width

II. LITREATURE SURVEY

Some researchers already worked on related topics of causes and remedies of cracks such as Study type of cracks in construction and its controlling done by [Kazem Reza Kashyzadeh and Neda Aghili Kesheh 2012], it shortly describes about what every civil engineer should know about face of the building i.e. cracking. Causes and evaluation of cracks done in concrete structure by [Sayed Mohd Mehndi et al. 2014], they explained about the evaluation of cracks that can be done by different technique like Crack Compactor and by ultrasonic Testing. Building cracks-causes and remedies by [Grishma Thagunna 2014], from this research it is found that building cracks has direct and indirect impacts and building cracks do not cause structural problem in direct way but it facilitates the activities which ultimately cause the problem. Prevention & repair of cracks in concrete structures by [B.B.Gamit et al. 2014], they broadly classified about the structural and non structural cracks that occurs in building along with their causes and remedy. Study on control of cracks in a structure through Visual Identification & Inspection [Kishor Kunal and Namesh Killemsetty 2014], they talk about how visual inspection of cracks can be helpful in order to identify and categorize them with respect to various parameters by taking case study of an institutional building.

III. CASE STUDY

For a better understanding, some cases are taken at Career Point University, Kota. CPU is new institute which is started in 2012 and it has world class Infrastructure. Some parts of the structure in this building have started showing cracks at various locations all across the campus which leads to the decrease in the durability as well as strength of the structure. Cracks generated in the academic building, hostel and mess has many different reasons which are responsible for the structural and non structural cracks. In the month of April 2015, the academic building along with hostel and mess of the University were inspected carefully and each type of cracks were photographed and recorded for further reasoning. These cracks are categorized on the basis of –

a) Thin - less than 1mm in width
b) Medium - 1 to 2mm in width
c) Wide - more than 2mm in width

A) Visual Identifications:

Fig 1. Crack on the wall
Width: Above 5mm
Type: Wide Crack
Probable Cause: Thermal Variation

Fig. 2. Crack at the corner
Width: Above 2mm
Type: Wide Crack
Probable Causes: Temperature Variation or Shrinkage

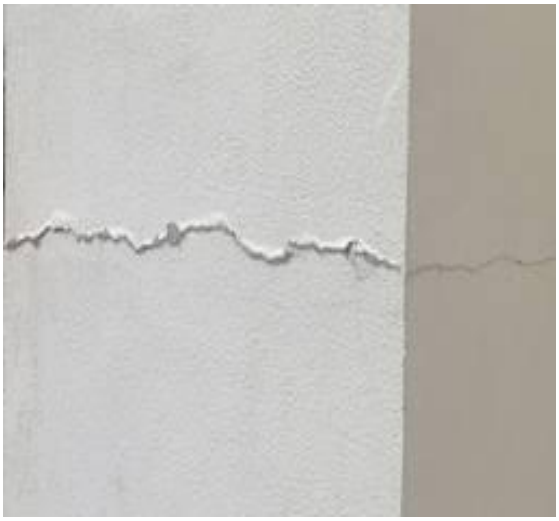

Fig. 3. Horizontal Crack
Width: Between 1 to 2mm
Type: Medium Crack
Probable Cause: Thermal Movement

Fig. 4. Crack above window
Width: Between 1 to 2mm
Type: Medium Crack
Probable Cause: Shrinkage

IV. CAUSES & ITS PREVENTIVE MEASURES

A. Elastic Deformation

It occurs when a material strains under stress. When two materials (having different elastic properties) built together under the effect of load then different shear stresses in these materials create cracks at the junction. Dead and live loads are the main cause of elastic deformation in any structural components of a building.

Preventive Measures: Create slip joints under the support of concrete slab on walls. Provide horizontal movement joints between the top of brick panel and reinforced cement concrete beam/slab.

B. Thermal Movement

Most materials expand when they are heated, and contract when they are cooled. The expansion and contraction with changes in temperature occur regardless of the structure's cross-sectional area. It is one of the most potent causes of cracking in buildings which need attention.

Preventive Measures: Joints should be constructed like construction joints, expansion joints, control joints and slip joints. The joints should be planned at the time of design and be constructed carefully.

C. Chemical Reaction

Chemical reactions may occur due to the materials used to make the concrete or materials that come into contact with the concrete after it has hardened. Concrete may crack with time as the result of slowly developing expansive reactions between aggregate containing active silica and alkalis derived from cement hydration, admixtures or external sources.

Preventive Measures: If sulphate content in soil exceeds 0.2 percent or in ground water exceed 300 ppm, use very dense concrete and either increase richness of mix to 1:1/5:3 and to prevent cracking due to corrosion in reinforcement it is desirable to specify concrete of richer mix for thin sections in exposed locations.

D. Shrinkage

Most of the building materials expand when they absorb moisture from atmosphere and shrink when they are dry. Shrinkage can be of plastic or dry. The factors causing shrinkage in cement concrete and cement mortar and their preventions are as following.

1) *Excessive Water:* The quantity of water used in the mortar mix can cause shrinkage. Vibrated concrete has less quantity of water and lesser shrinkage than manually compacted concrete.

Preventive Measures: Use minimum quantity of water required for mixing cement concrete or cements mortar according to water cement ratio. Cement concrete is never allowed to work without mechanical mix and vibrator.

2) *Quantity of Cement:* As a general rule, the richer the mix is, the greater the shrinkage/drying will be.

Preventive Measures: Do not use excessive cement in the mortar mix.

E. Foundation Movement and Settlement of Soil

Shear cracks in buildings occur when there is large differential settlement of foundation and it may be either due to the following reasons:

- Unequal bearing pressure under different parts of the structure

- Bearing pressure on soil being in excess of safe bearing strength of the soil
- Low factor of safety in the design of foundation
- Local variation in the nature of supporting soil

Preventative Measure: The design of foundation should be based on sound engineering principles and good practice.

F. Earthquake

Crack may occur due to sudden shift in lower layer of the earth. The voids in the earth might have suddenly collapsed and be filled with soil from the above. Many geological events can trigger earth movements but is continuous movement.

Preventive Measures: Construct the foundation of buildings on firm ground while doing construction. Tie up the building with connecting beams at foundation level, door level and roof level.

G. Vegetation

Fast growing trees in the area around the walls can sometimes cause cracks in walls due to expansive action of roots growing under the foundation. The cracks occur in clay soil due to moisture contained by roots.

Preventive Measure: Do not grow trees too close to the building. Remove any saplings of trees as soon as possible if they start growing in or near of walls.

H. Poor Construction practices

There is a general lack of good construction practices either due to ignorance, carelessness, greed or negligence. For a healthy building it is absolutely necessary for the construction agency and the owner to ensure good quality materials selection and good construction practices.

Preventive Measure: Proper monitoring and use of good quality of materials is required at the time of construction

V. TECHNIQUES TO CURE CRACK

A. *Epoxy injection*

Epoxy injection is an economical method of repairing non-moving cracks in concrete walls, slabs, columns and piers as it is capable of restoring the concrete to its pre-cracked strength. The technique generally consists of establishing entry and venting ports at close intervals along the cracks, sealing the crack on exposed surfaces, and injecting the epoxy under pressure.

B. *Routing and sealing*

In this method, the crack is made wider at the surface with a saw or grinder, and then the groove is filled with a flexible sealant. This is a common technique for crack treatment and it is relatively simple in comparison to the procedures and the training required for epoxy injection. It can be done on vertical surfaces and curved surface

C. *Stitching*

This method is done to provide a permanent structural repairs solution for masonry repairs and cracked wall reinforcement. It is done by drilling holes on both sides of the crack, cleaning the holes and anchoring the legs of the staples in the holes with a non-shrink grout.

D. *Drilling and plugging*

This technique is only applicable when cracks run in reasonable straight lines and are accessible at one end. This method is mostly used to repair vertical cracks in retaining walls.

E. *Gravity Filling*

Low viscosity monomers and resins can be used to seal cracks with surface widths of 0.001 to 0.08 in. by gravity filling. High molecular weight methacrylates, urethanes, and some low viscosity epoxies have been used successfully.

F. *Dry packing*

It is the hand placement of a low water content mortar followed by tamping or ramming of the mortar into place and also helps in producing intimate contact between the mortar and the existing concrete.

G. *Polymer impregnation*

Monomer systems can be used for effective repair of some cracks. A monomer system is a liquid consisting of monomers which will polymerize into a solid. The most common monomer used for this purpose is methyl methacrylate.

VI. CONCLUSIONS

This paper is divided into four parts. First part comprises of basic introduction about cracks and about the previous attempts which are made by the research scholars, second part contains the case study, visual identification of cracks and causes with preventive measures and third part contains techniques to cure crack. The potential causes of crack can be controlled if proper consideration is given to construction material and technique to be used. If we focus on the major causes to cracks in our building and take their preventive measures initially, we will able to minimise the problem of cracking in our structure.

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