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TO STUDY THE CAUSES, MOVEMENT MEASUREMENT, INVESTIGATING PRINCIPLES AND REMEDIES OF CRACKS IN BUILDINGS: A REVIEW

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Abstract: *Appearance of Cracks in buildings is one of most critical issue throughout the world. So therefore it is much more important to provide proper attention in order to prevent these cracks to reduce the strength of the Structure. Thus cracks appear in concrete with Passage of Time that cannot be entirely prevented. For prevention of these cracks different types of adequate materials, techniques of construction and design criteria is also considered for cracks prevention. It is dream of every human that his house/home is aesthetically and structurally safe and sound. But during construction work different types of errors occurred due to unavoidable reasons at sites which lead towards the crack appearance in structure and non-structure parts of buildings with time to time. It is not important to give attention to all type of cracks but There are different types of cracks appeared in which some are active cracks. So for active cracks proper prevention measurements must be taken in order to prevent structure failure of Building. The paper mainly focused and describes different type of methods (Direct or indirect) used for prevention of cracks. For this purpose simple as well as instrumental methods use to deal with such type of issues. This Paper also reflect information of how ultimate failure cause due to these cracks, its reasons and preventive measurements. In this paper it was found that cracks having direct and indirect impacts on the structure or building. Moreover it was also found that cracks in building cause the problem indirectly due to facilitating the activities which finally cause the structure problems instead of direct way to cause. So this paper concluded that different types of techniques were used for different type of appeared cracks in buildings which depending upon intensity and reason of problem. That's why the main question was raised that why they are produced and how they are examined and controlled?*

Key Words: *Cracks, Buildings, techniques, Concrete, Structure failure*

Introduction:

In civil engineering the live cycle of infrastructure having large scale is the actual tendency. We trust on existing structures instead of new constructions because of limited or less resources available in many countries. Two consequences produced due to this tendency (a) Required regular monitoring, (b) To improve existing buildings new Concepts and strategies required. During monitoring cracks in concrete structures is one of the main information which showed weak zones. Till now for measuring the cracks accurately, repeatedly and objectively, no system is available to allow (Stratmann et.al. 2008). The appeared cracks may show some movements in direction of width or depth with passage of time if they are active. The Cracks remain unchanged if they are dormant. Dormant or inactive cracks were no danger to structure but if they were not repaired they provide channels for penetration of water inside the structure. The Cracks produced in concrete structure is very common throughout world but it was complicated to understand the crack. When Client/owner saw a crack in structure or non-structure components in newly constructed building/house, he felt fear that there was something wrong in it. Some Cracks are unavoidable so it is keen responsibility of contractor to control it. In order to do proper job the contractor must maintained water cement ratio, provide proper reinforcement, placing and compacting of concrete. According to **ACI 302.1-04** "It is unrealistic to expect crack free and curl free floors even using best design and construct properly".

The width of Cracks were different and varied in concrete structure. The cracks were also classified as per their width and Mentioned in Table 01.

Table 01: Types of Cracks as per width

S.No	Type of Crack	Width of Crack
1	Thin Crack	Less than 1mm
2	Medium Crack	1mm to 2mm Crack
3	Wide Crack	More Than 2mm

Fig No. 1 Crack width Images

Cracks Understanding:

Commonly the Cracks may be divided into two Main groups

Non-Structure Cracks

These types of Cracks were produced in Building Materials due to internally induced stress. These cracks are not dangers to safety but if they are not repaired, causes impression of faulty or instable work. The example of non-structure cracks are wall cracks, Parapet wall and drive way etc.

- **Structure Cracks**

The Cracks produced due to overloading or improper design or faulty construction at site. These types of cracks are very dangerous to the building safety. These Cracks are wider more than 3mm in length. These Cracks were appeared in Buildings Beam, Columns, slab and Foundations. The shape of these cracks were vertical, Horizontal, diagonal or just like staircase.

The cracks are also divided according to time of occurrence, Activeness, their width and Building components. There are two types of cracks according to activeness such as active and dormant cracks.

Plastic concrete Crack: Plastic Concrete crack when subjected to very loss rapid of moisture caused by high temperature or low humidity and wind or both. These cracks appeared on surface of concrete placed freshly or larger surface areas of slab or floors. This type of cracking also known as plastic Concrete crack.

Shrinkage Cracks: When the moisture losses from the cement paste constituent due to which volume decreases and Shrinkage cracks were produced. Several types of factors effecting this type of Concrete cracks such as ambient temperature, relative air humidity, wind and sun, water cement ratio and mixing of concrete. In last two decades reinforced concrete structures are effected by environments because of its corrosive effect. Such type of effects caused cracks in concrete cove and reduce its bond strength.

Reasons/Causes of Cracks:

a) Corrosion of reinforcements:

As environment consisting of chloride iron which causes electrochemical Corrosion and due to this process steel oxidized. When Corrosion continuous the accumulated products formed from various materials such as ferrous and ferric oxidization of steel it causes pressure on surrounding concrete reinforcement. Due to extent in pressure the internal cracking in concrete caused and even it damaged the coating of concrete.

b) **Creep Movement:**

Creep is define as the property of Martials (concrete) to deform with time under sustainable loading. So when concrete is subjected to sustainable loading and causing deformation with passage of time know as creep. It is difficult to understand the mechanism of creep because at low stress it was thought due to low seepage and viscus flow while at high stress it may be due to micro cracking. Creep I directly proportional to water and cement content increase, W/C ratio, and while inversely proportional to increase in humidity and materiel age at loading time. When temperature rises creep in steel also increases. The Structure Cracks formed in Beam, Columns and slab are given Below in Table 02.

Table 02: Beams, columns and Slab Structure Cracks

Columns Cracks	Beam Cracks	Slabs Cracks
Horizontal	Flexure	Flexure
Diagonal	Shear	Shrinkage
Corrosion	Corrosion	Corrosion
Splitting	Torsional	

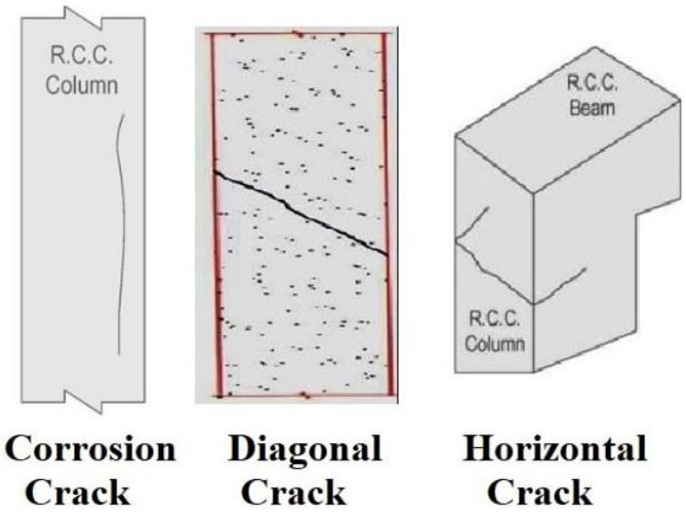

Fig No.02 Types of Cracks in columns

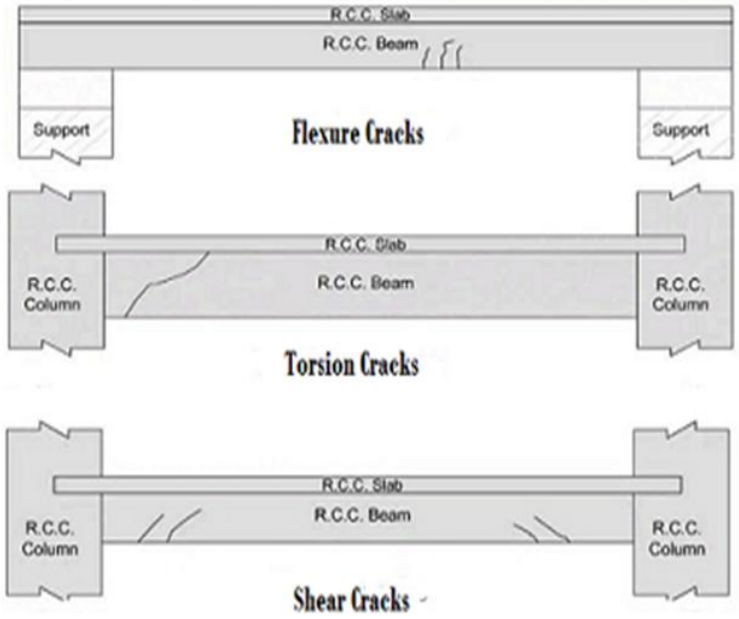

Fig No. 03 Types of Cracks in Beams

c) Thermal Movement/Changes:

This is most important reason of Cracking in buildings because in winter materials contract and in summer expanding of materials occurs. The thermal expansion of Brick work is 50% lesser in horizontal directions as compared to vertical directions. Cracking was not caused in internal walls and intermediate floors because of not much thermal variation occurs. The Cracking may cause in external thin walls due to expose to solar radiation and Slabs due to expose to Substantial thermal variation.

d) Poor Practices in construction:

When the Construction industry hire non-technical persons in which most having less or no knowledge of construction and this cause cracks in the buildings. For a healthy building good quality materials and construction practices was important. Some of the main causes of poor Construction Practices are as followed

- Selection of Materials were not as per specification
- Bad Quality Materials
- Bad mixing of Concrete
- Construction and Expansion joints provided at improper location
- Addition of water in mix
- Improper Monitoring of Concrete cause honey combing, leakage and cracking of Structure.

e) Movement due to chemical Reactions:

Certain chemical reactions in building materials result in appreciable increase in volume, developing internal stresses which result in outward thrust and formation of cracks. The materials involved in reaction also become weaker in strength. Sulphate attack on cement products, carbonation in cement based materials, corrosion of reinforcement in concrete and brickwork, and alkali aggregate reaction are the common chemical actions on building materials.

f) Foundation Movement and Soil Settlement:

Shear cracks occur due to large differential settlement in foundation. Building constructed on expansive soils which are susceptible to swelling on absorbing moisture and shrink on drying due to change in moisture content of the soil. These are extremely susceptible to cracking. Special measures are needed to prevent the cracks. Cracks occur due to foundation movement of a corner on an end of building they are usually diagonal in shape. These cracks are wide at top and decrease in width downward. These cracks can be easily distinguished from those due to thermal or moisture movement. Settlement of building built on made-up soil may occur when water due to heavy rains or floods gets into the foundation and causes settlement in the soil under load of the structure. Such settlements are generally not uniform in different parts and cause cracking.

g) Elastic Deformation:

Structural components of a building e.g., walls, columns, beams, slabs generally built of materials like masonry, concrete, steel, etc. undergo elastic deformation due to load, in accordance with Hook's law. The amount of deformation depends upon elastic modulus of the material, magnitude of loading and dimension of the components.

h) Poor Specifications and Structure design:

Before Construction of building/Structure the designer and owner must consider the existing environmental conditions of site because at preparation time of drawings and Specification building loses its durability. For proper structure design it is most important to investigate the soil condition for constructing of foundation and selecting type of concrete Materials and grade. Beside this deterioration of Buildings also cause due to unexperienced and insufficient skills contractor.

Cracks Movement Measurements and Monitoring

It was very essential to measure and monitor the width of Crack at any stage with respect to time. While Some times it was also necessary to know the crack was alive or dead.

The Cracks observed by Engineers in Buildings requested to measure the cracks. By doing this it was important to know that whether the size of crack increased or not. There are different Methods in order to measure the cracks but the best method was crack Monitor or "tell-Tale"

In this method a tell-Tale was fixed (consisting a strip having width and Length of 2 to 3 cm and 10 to 12cm respectively) with quick setting adhesives or mortar across a crack. During this method two types of conditions occurs. First the Tell Tale will crack if the width of Crack increase. Secondly buckling will cause in tell-tale if the crack closes.

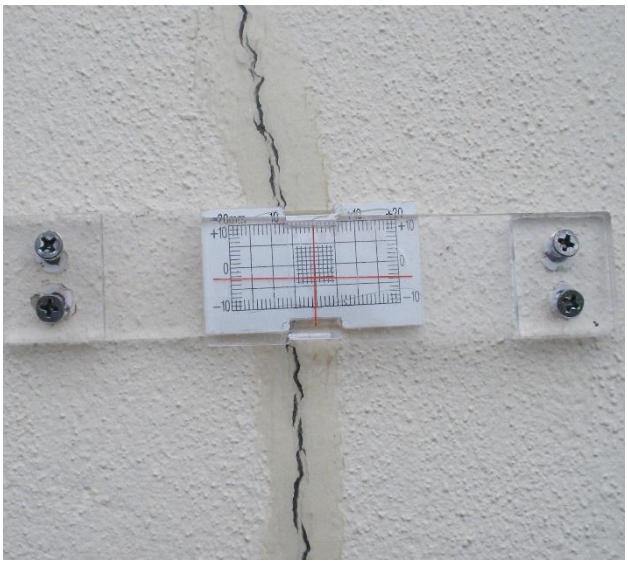

Fig No. 4 Measurements of Crack with Tell-Tale

Hinge Type of Gauge was used to measure the cracks as cracks occurs at junction of the walls or at corners. This Gauge is mainly used for corners because most of wall junctions were not accurately at an angle of 90 degree and this gauge may be used also for a bay window corner of 45 degree of angle.

Fig No. 05 Corner Cracks Measuring

Cracks investigation Principals

The Cracks may be investigated using following steps

1. Discussion with the owner or client of the buildings to collect information about when building constructed, about drawings and design and finally but not least about first time developments of cracks and how long it was seen in the buildings.
2. Site visit where the building was constructed and took drawings and design on the based of which this Building was constructed. Took Photograph and report than according to their width. Also Collect Samples from site.
3. To know the type of Crack whether it was live or dead. Also find the causes of cracks such as due to corrosion, vegetation, creep, chemical reaction and foundation settlements etc.
4. Measured and monitored the movement of Cracks by using Tell-Tale or crack width Gauge.
5. In order to repair the cracks different techniques were used such as given below

a) Stitching
b) Sealing and routing

c) Gravity Filling
d) Injection with epoxy
e) Overlay and surface Treatment
f) Drilling and Plugging
g) Drying Packing

6. Finally a report was Prepared

Remedies or Technique's to Repair the Cracks:

There are two types of cracks while dealing with cracks remedial measures. First to prevent the cracks and secondly to cure crack. As per saying "Prevention is better than cure" therefore we used proper specifications, materials, techniques and supervision to avoid such type of problems. To avoid the cracks in Buildings following things should be taken in to account which were as given below

a) Proper Mix design review for water cement ratio as per specifications
b) Review the mix design to check the Course aggregates as per specified size
c) Review the mix design in order to supervise the familiarity of contractor with Mix design.
d) To reduce the drying shrinkage chemical admixtures were used
e) Proper Planning of Curing the concrete as specified.
f) Provision of construction and expansion joints as per specified location shown on drawings to so to neutralize temperature effect.

The different techniques used for repairing of Construction Crack are as followed.

a. Epoxy Injection:

This method of repairing was used when crack were observed in walls, slabs and columns etc. but having of non-moving nature. Epoxy injection was used when width of crack was 5mm. along the cracks closely entering and venting ports were established, sealing crack on exposed surfaces and with pressure epoxy was injected. To repair the Building cracks this method was used successfully (ACI 503R).

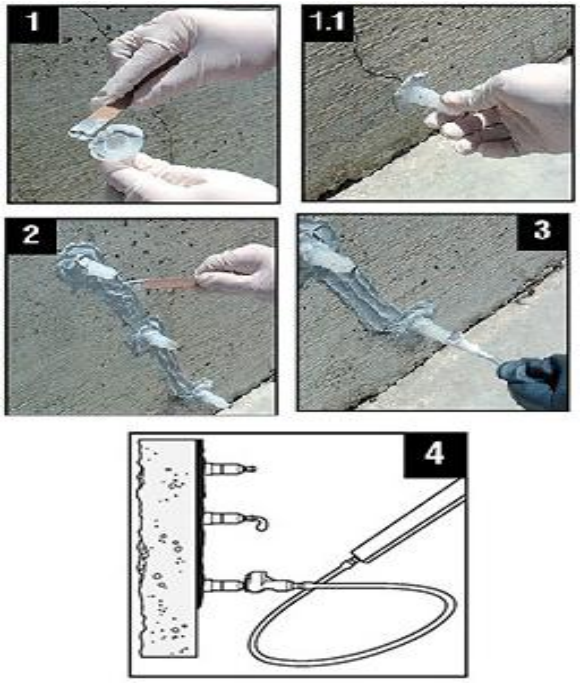

Fig No. 06 Epoxy Injection Procedure

b. Gravity Filling

In this type of technique the cracks were sealed having width of 0.03 mm to 02mm with low viscosity resins and monomers. The examples of gravity fillings which used successfully for sealing the cracks were High molecular weight methacrylate, urethanes and some low viscosity epoxies. If the viscosity of filling materials was low than filling done finely. In this Method the air blasting or water blasting was used to clean the surface and best crack filling was achieved when wet surfaces were permitted to dry several days.

c. Stitching

For masonry repairs and crack wall reinforcement this method provide permanent solutions. In this method holes were done on both sides of crack with drilling machine, clean the holes and anchoring the staple legs with non-shrink grout.

Fig No.07 Wall Cracks Stitching

d. Dry Packing

In this method cement sand mortar was used having low water content in it. The mortar was placed on crack and compacted to achieve the intimate contact between existing concrete and mortar.

e. Overlay and Surface Treatments

This Type of repair technique was used when there was no further crack movements occurred. In addition, this method was used in structure slabs and pavements having fine surface cracks. This Type of treatment was appropriate for crack with one time occurrence.

f. Sealing and Routing

This type of Technique was used where structure repair was not important. In this method the crack along with its exposed surface was enlarged, filled and sealed with suitable joint sealant. This is very common technique's to repair the crack as compared to epoxy injection. This Method of repair was mostly used for floors and pavements but also used for vertical surfaces as well as curved surfaces.

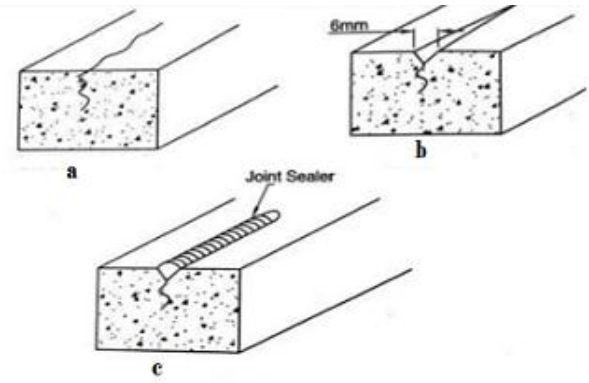

Fig No. 08 (a) Original Crack (b) Routing (c) Sealing

Conclusion:

This review paper concluded that it is impossible to avoid all cracks in the buildings but can be reduced up to maximum extent. It was also observed that different types of crack required different types of attention to care. The reasons/causes due to which crack developed in Buildings was controlled if proper attentions were given during implementation of Concrete structure to utilized proper mix design, Specified drawing and design, specified materials and techniques. Monitoring of cracks were done at early starts. More time were to study and collect the data about crack and sort out the solution for its repair. Most efficient and effective method was used after detail study and analysis of crack parameters in case of existing cracks in the buildings.

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