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A Case Study of Cracks in Building: Causes and Repair

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***Abstract*— In today's time there is shown presence of defects in building because of poor quality control during the construction, lack of maintenance and unfavorable or abrupt change in the weather condition. It is essential to maintain quality in terms of material quality, mixture with their desire specification, workmanship etc. During the construction stage and after the construction suitable maintenance system should be there to reduce tendency of occurring defects in the building for durable and reliable future usage of the building. Cracks are common and major defects are shown in the building occurring mainly because of uneven distribution of shear stresses at poor structural sections so that an engineer should have sufficient knowledge about suitable repairing techniques for particular type of damage in the structure like, which type of defects is there, its reason, its adverse effects and other characteristics of constitution material by that there will be suitable final decision of evaluate the repairing technique to get desired reliable output. It is very tropical process to estimation of materials because of so many irregularities in distress. There is no accurate measurement for depth and width which is same throughout the length of cracks and dimensions of efflorescence. This report includes a case study having estimation and costing as reference to other case studies with their remedial measures and some repair.**

Index Terms— cracks, methods to repair cracks, stresses causing cracks

I. Introduction

Sustainable development has become the challenge for humanity particularly with rapid growth of urbanization. Critical issue is to provide food, shelter and other basic needs to rapidly growing world population and save natural resources on which the very existence of population depends. We have got wide variation in the Perception of responsibility to future generations and ethical issue. There is an urgent need of us the professional to understand and implement cleaner production and sustainable development and maintenance objectives at all level of responsibility. The buildings in which we live, work, and play protect us from Nature's extremes. Yet they also affect our health and environment in countless ways. As the environmental impact of buildings becomes more apparent, a concept called green building is gaining momentum. The maintenance of building is a lifelong continuous process. It has been observed that the minimum maintenance of concrete structures require an integral approach which need the introduction of as much preventive measures as possible in accordance with the basic established concept –"Prevention is always better than cure". Repair/rehabilitation/retrofitting is the fastest growing segment of the concrete industry. Across the globe, billions of dollars are spent annually in repair and restoration of distressed concrete structures. Thus selection and evaluation of repair materials and protective coatings is receiving more and more attention among Civil Engineers in the recent past. The new technologies and new repair materials, which have been extensively being used by the advanced countries, are also being tried in developed country like India.

II. Literature Review

A) Cracks in building:

Cracks are of common occurrence. A building component develops cracks whenever stress in the component exceeds its strength. Stress in a building component could be caused by externally applied forces, such as dead, live, wind or seismic loads, or foundation settlement or it could be induced internally due to thermal variations, moisture changes, chemical action, etc.

Cracks could be broadly classified as structural or non-structural.

1) Structural cracks: Structural cracks are those which are due to incorrect design, faulty construction or overloading and these may endanger the safety of a building. Extensive cracking of an RCC beam is an instance of structural cracking. Principal causes of occurrence of structural cracks in buildings are as follows: a) Faulty design b) Faulty construction c) Overloading

2) Non-structural cracks:

Non-structural cracks are mostly due to internally induced stresses in building materials and these generally do not directly result in structural weakening. In course of time, however, sometime non-structural cracks may, because of penetration of moisture through cracks or weathering action, result in corrosion of reinforcement and thus may render the structure unsafe. Vertical cracks in a long compound wall due to shrinkage or thermal variation is an instance of non-structural cracking.

Principal causes of occurrence of non-structural cracks in buildings are as follows: a) Moisture changes, b) Thermal movement, c) Elastic deformation, d) Creep, e) Chemical reaction, f) Foundation movement and settlement of soil, g) Vegetation.

a) Moisture changes: As a general rule, most of the building materials having pores in their mortar, burnt clay bricks, some stones, timber, etc. Expand on absorbing moisture and shrink on drying. These movements are reversible, that is Study on control of cracks in a structure through Visual Identification & Inspection Cyclic in nature and is caused by increase or decrease in the inter-pore pressure with moisture changes, extent of movement depending on molecular structure and porosity of a material. The various effects of moisture changes: Reversible Movement, Initial Shrinkage.

b) Thermal movement: Thermal movement is one of the most potent causes of cracking in buildings. All materials more or less expand on heating and contract on cooling. The thermal movement in a component depends on a number of factors such as temperature variations, dimensions, coefficient of thermal expansion and some other physical properties of materials. The coefficient of thermal expansion of brickwork in the vertical direction is fifty percent greater than that in the horizontal direction, because there is no restraint to movement in the vertical direction. Thermal variations in the internal walls and intermediate floors are not much and thus do not cause cracking. It is mainly the external walls especially thin walls exposed to direct solar radiation and the roof which are subject to substantial thermal variation that are liable to cracking.

Prevention: Thermal joints can be avoided by introducing expansion joints, control joints and slip joints. In structures having rigid frames or shell roofs where provision of movement joints is not structurally feasible, thermal stresses have to be taken into account in the structural design itself to enable the structure to withstand thermal stresses without developing any undesirable cracks.

c) Elastic deformation: When the walls are unevenly loaded, due to variation in stresses in different parts of wall the cracks are formed in walls. When two materials having wide different elastic properties are built together under the effect of load, different shear stresses in these materials create cracks at the junction. Dead and live loads cause elastic deformation in structural components of a building.

Prevention: Create slip joints under the support of RCC slab on walls. Masonry work on RCC slabs and beams should not be started before drying RCC slab and beam. Provide horizontal movement joints between the top of brick panel and RCC beam/slab.

d) Creep: Concrete when subjected to sustained loading exhibits a gradual and slow time dependant deformation known as creep. Creep increases with increase in water and cement content, water cement ratio and temperature. It decreases with increase in humidity of surrounding atmosphere and age of material at the time of loading. Use of admixtures and pozzolana in concrete increases creep. Amount of creep in steel increases with rise in temperature.

e) Chemical reaction: Chemical reactions in building materials increase their volume and internal stress causes cracks. The components of structure also weaken due to chemical reactions. Some common instances of chemical reactions are following.

Prevention: Use dense and good quality concrete i.e. richer mix of cement concrete 1:1.5:3 (M20) to prevent cracks. Repair corrosive cement concrete surface by 'gaiting'/ injecting technique after removing all loose and damaged concrete and cleaning reinforcement from all rust also.

f) Foundation movement and settlement of soil: Shear cracks occur in buildings when there is large differential settlement of foundation due to any of following causes.

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

Prevention: The design of foundation must be based on sound engineering principles and good practice.

g) Vegetation: The roots of trees located in the vicinity of a wall can create cracks in walls due to growth of roots under foundation. The cracks occur in clay soil due to moisture contained by roots.

Prevention: Do not let trees grow too close to the buildings, compound walls etc. Remove any saplings of trees as soon as possible if they start growing in or near of walls etc. The trees are kept 'K' times its length where K varies from 0.5 to 2 as per the type of trees.

B) General causes of cracks:

- Poor quality of bricks.
- For masonry work, use the porous stones.
- Absence of grading in before the use of fine aggregate fine mortar.
- If percentage of clay and slit in fine aggregate exceed 3 percent.
- Due to the excessive amount of soluble sulphate.
- Plumb alignment.
- Differential loading.
- Weak mortar.
- Improper curing.
- High daily temperature variations.
- Atmospheric pollutions.
- Improper binding of thick walls.

C) Causes of cracks in concrete structure:

a) Plastic shrinkage cracking
b) Plastic settlement cracking
c) Drying shrinkage crack
d) Concrete crazing
e) Steel corrosion induced cracking

a) Plastic shrinkage cracking: It occurs within 1 to 8 hours after placing, 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. These factors can combine to cause high rates of surface evaporation in either hot or cold weather.

Fig. 1. Plastic shrinkage crack

b) Plastic settlement cracking: After initial placement, vibration and finishing concrete has tendency to continue to consolidate. During this period, the plastic concrete may be locally restrained by reinforcing steel, earlier placed hardened concrete or formwork. This local surface. Fig. 2, settlement causing crack & void.

Fig. 2. Plastic settlement cracking

c) Drying shrinkage crack: When associated with reinforcing steel, settlement cracking increases with increasing bar size, increasing slump and decreasing cover. The degree of settlement may increase with insufficient vibration, lack of compaction at top layers of concrete, or by the use of leaking or highly flexible forms. This is more of a problem with high bleed concrete particularly in winter when the cooler temperatures provide longer time to initial set and therefore a higher amount of bleed (Fig. 3).

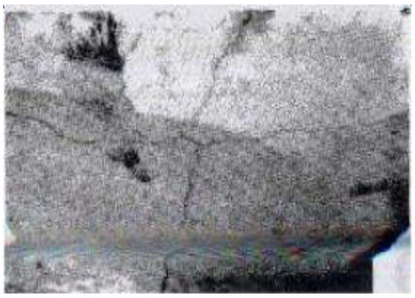

Fig. 3. Drying shrinkage crack

d) Concrete crazing: Crazing is the development of a network of fine random cracks or fissures on the surface of concrete caused by shrinkage of the surface layer. These cracks are rarely more than mm deep, and are more noticeable on over floated or steel-trowel surfaces. The irregular hexagonal areas enclosed by the cracks are typically no more than 40 mm wide and may be as small as 10mm in unusual instances (Fig. 4).

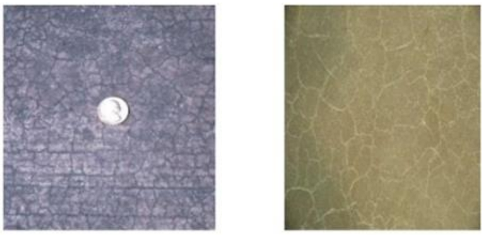

Fig. 4. Concrete crazing

e) Steel corrosion induced cracking: Corrosion of the steel produces iron oxides and hydroxides, which have a volume much greater than the volume of the original metallic iron. This increase in volume causes high radial bursting stresses around reinforcing bars and results in local radial cracks.

Fig. 5. Steel corrosion induced cracking

D) What is repair?

It is defined as the process of restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition or state.

Fig. 6. Repair

E) Crack repair method:

a) Epoxy injection
b) Crack stitching
c) Sealing of cracks
d) Dry packing
e) Polymer impregnation
f) Underpinning

III. Methodology

A) Location of sight:

Location of sight: Meera shree apartment, Annapurna (Indore).

B) Place of work

Site 1: Outlet window in drawing hall, first floor (horizontal crack).
Site 2: Stair, near drawing hall first floor (vertical crack).
Site 3: Living room, first floor (diagonal crack).
Site 4: Porch near flat no.110 (expansion joint).

TABLE I
Description about Crack

S. No.	Location	Description
1.	Outlet window, Drawing hall first floor	Non-structural
2.	Porch near room no.110	Expansion joint problem
3.	Living room, first floor	corner crack and non-structural
4.	Stair, near drawing hall first floor	Cracked plaster, efflorescence

C) Crack testing instrument:

1) Dial Caliper:

1) Identify four types of measurements that dial calipers can perform.
2) Identify the different parts of a dial caliper.
3) Accurately read an inch dial caliper.
4) Dial Calipers are arguably the most common and versatile of all the precision measuring tools.

Dial Calipers are used to perform four common measurements on parts.

1. Outside Diameter/Object Thickness
2. Inside Diameter/Space Width
3. Step Distance
4. Hole Depth.

Fig. 7. Dial Caliper

2) Rebound hammer test or Schmidt hammer:

A Schmidt hammer, also known as Swiss hammer or a rebound hammer, is a device to measure the elastic properties or strength of concrete or rock, mainly surface hardness and penetration resistance.

The test hammer will hit the concrete at a defined energy. Its rebound is dependent on the hardness of the concrete and is measured by the test equipment. By reference to the conversion chart, the rebound value can be used to determine the compressive strength.

TABLE II
CONCRETE TEST

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
<20	Poor Concrete
0	Delaminated

Fig. 8. Rebound hammer test

D) Crack testing: By using Rebound Hammer Test to find out strength and quality of concrete before crack repairing.

Fig. 9. Damaged expansion joint

Fig. 10. Vertical crack

TABLE II
QUALITY OF CONCRETE BEFORE REPAIRING CRACK

Damaged Expansion Joint	
Average rebound hammer	30.73
Quality of concrete	Good layer
Vertical crack	
Average rebound hammer	35.05
Quality of concrete	Good layer
Horizontal crack	
Average rebound hammer	28.08
Quality of concrete	Fair
Diagonal crack	
Average rebound hammer	26.33
Quality of concrete	Fair
Damaged Expansion Joint	
Average rebound hammer	41.75
Quality of concrete	Very good hard layer
Vertical crack	
Average rebound hammer	46.08
Quality of concrete	Very good hard layer
Horizontal crack	
Average rebound hammer	38.75
Quality of concrete	Good layer
Diagonal crack	
Average rebound hammer	34.53
Quality of concrete	Good layer

Fig. 11. Horizontal crack

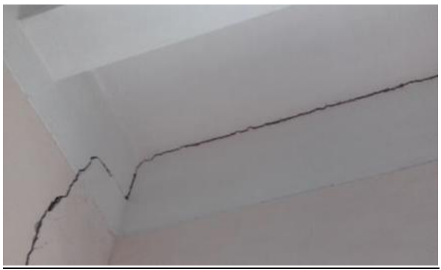

Fig. 12. Diagonal crack

Result: By using Rebound Hammer Test to find out quality of concrete before crack repairing.

IV. Conclusion

After completing this case study we found that all cracks were distresses-cracks. Cracks formed because of shrinkage and overload of the structure. They are not affecting the structural stability of the structure. Distress present in the buildings can be easily repaired. All type of crack requires same level of attention. Distress present in the buildings can be easily repaired.

References

[1] IS 456:2000 "Plain and reinforced concrete " "Fourth Revision".
[2] Text book of "Concrete Technology " Nirali Prakashan, First Edition 2014.
[3] Peter H Emmons "Concrete Repair and Maintance.
[4] www.concretenetwork.com.
[5] www.civildigital.com.
[6] Institution, I. s. (1968),"Design and installation of joints in buildings", IS codes.
[7] Santhakumar, A.R (2007), "concrete technology" Oxford university press.
[8] Institution, I. s. (1991),"Brick works – code of practice", IS 2212.