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Case Study on Cracks in Public Buildings and their Remedies

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Abstract: ***Cracks are inherent and detrimental elements of building detailed investigation should be carried out regularly to ensure the assessabillity and serviceability of the building. For rehabilitation of cracks it is important to understand the causes and the types of cracks appeared in the structure. This paper shortly describes the causes and types of cracks and their remedial measures. Non destructive testing methods are used to access the strength of the structure at a first instance to know the actual state of the structure whether it will be serviceable/workable or to be demolished. Few case studies were conducted at different public buildings at Gwalior M.P. Political science, economic and archaeological blocks of Jiwaji University. Moti Mahal building.NITM (Nagaji institute of Technology and Management building. Which were reported cracks and they were in suspension to whether it will work or should be demolished. The purpose of this study is to determine the position of structure whether it is further serviceable or not and secondly, if we use the same building how it will be repaired.***

Keywords: Cracks, Public Building, Remedies

1. Introduction

Now concrete is one of the composite materials which is normally used at every stage of construction and it may suffer damage or defects during its service life due to number of reasons i.e.

1) Poor workmanship
2) Faulty design.
3) Structural overloading.
4) Moisture.
5) Chemical reaction.
6) Creep.
7) Permeability of concrete.
8) Thermal movement.
9) Corrosion of reinforcement.
10) Foundation settlement.
11) Poor maintenance.

To understand cracks in wall due to above factors and their remedial measures thorough study was conducted at 3 public buildings.

1) Jiwaji University.
2) Moti mahal.
3) Nitm.

2. Literature Review

Poor and improper building maintenance will definitely will cause more damages and costly repair work if left unattended. Building defects are inevitable aspects of building construction. Defects occur in various forms and to different extent in all types of building irrespective of their age. Cracks can be structural or non structural depending upon the location of the crack in the building.

Non Structural cracks occur mostly due to internally induced stresses in building material and generally do not affect the safety of structure but develop an anaesthetic appearance and create an impression of faulty construction work. These defects can be seen on the walls of structure in various forms like dampness, paint peeling, cracks. plaster rendering etc. Whereas structural cracks are the result of incorrect structural designing or insufficient survey of site and statistics of the location or even both in the worse scenario and are seen on structural elements i.e. Beam, column, slab, footing and structural cracks are the one which may cause the failure of the structure during its life period. Causes of the cracks can be listed as:-

1) Poor workmanship Poor mixing of building materials, lack of curing, change in water-cement ratio, proper compaction will cause cracks in the walls, beams, slabs etc. Normally poor workmanship is as a result of ignorance, carelessness, negligence, lack of proper supervision or many others.
2) Faulty design. Poor structural design and specifications are another cause of the cracks in concrete works. It's important the most important factor in the failure of a building. Design should be in accordance of all the environmental surveys that include soil (Geotechnical) investigations. Buildings are designed for particular uses, and also to withstand a given load conditions for example a building designed as residence will have different structural specifications from the one designed to operate machinery.
3) Structural overloading
   - Overloading of the ground
   - Overloading due to its dead load
   - Overloading due to live loads present result in cracks
4) Due to moisture. Most of the building materials with pores in their structure in the form of intermolecular space expand on absorbing moisture and shrink on drying. These movements are cyclic in nature and are caused by increase or decrease in inter pore pressure with moisture changes. Initial shrinkage occurs in all building materials that are cement/lime based such as concrete, mortar, masonry and plasters. Generally heavy aggregate concrete shows less shrinkage than light weight aggregate concrete.

5) Chemical reaction cement is an alkaline material and will react with acidic compounds present in moisture and will result in the weakening of the internal bonds. Certain limestone aggregate forms alkali -silica product, this reaction is known as alkali carbonation reaction. These reactions of aggregate, cement paste with the surrounding often causes cracks in building.
6) Creep Concrete when subjected to sustain 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 pozzolonas in concrete increases creep. Amount of creep in steel increases with rise in temperature..
7) Permeability of concrete. As deterioration process in concrete begins with penetration of various aggressive agents, low permeability is the key to its durability. Concrete permeability is controlled by factors like water-cement ratio, degree of hydration/curing, air voids due to deficient compaction, micro-cracks due to loading and cyclic exposure to thermal variations. The first three are allied to the concrete strength as well. The permeability of cement paste is a function of water-cement ratio given good quality materials, satisfactory proportioning and good construction practice; the permeability of the concrete is a direct function of the porosity and interconnection of pores of the cement paste.
8) Thermal movement. Various building materials are used for the construction of a building and all the materials have different coefficient of expansion. Due to changes in the temperature, the expansion and contraction of the building components takes place which result in the changes in the size and shape of the components. Smaller buildings are less affected. In larger buildings, the change in size of one part causes cracks although not in expanded part.
9) For example; Crack below the slab/beam in RCC frame Brick pin buildings. These cracks can close up completely as a result of changes of temperature.
10) Corrosion of reinforcement. This primarily causes structural failure or structural crack in building. Oxidation of the steel due to the presence of oxidants like o2 in the atmosphere causes the change in volume of steel reinforcement which develops a radial bursting stress in the surrounding area and resulting in cracks. Corrosion of the reinforcement cannot be eliminated but can be reduced to lower extent by using various techniques during construction
11) Foundation settlement. Foundation may settle due to land slips, earthquakes, moisture changes due to clay shrinkable soils (for example, Black cotton soil). cracks occur because a part of the building is displaced from its position without any change in the size of material
12) Poor maintenance it's always important to take good care of your house, by doing maintenance works after a lapse of certain periods. This will keep the building intact and also extend their life span.

3. Types of Cracks

The magnitude of the risk caused due to a crack can be characterized in terms of its direction, and dimensions. Cracks can be horizontal, vertical, diagonal or random.

1) Horizontal crack horizontal crack or crack which runs zigzag 45-degree angle, reason for this zigzag form might be severe such as foundation shifting or water damage. Severe cracks usually require immediate attention and might include some reconstruction to prevent further damage.
2) Vertical crack whereas vertical crack starting near the junction where the wall and ceiling meet, it indicates that it developed when the foundation settled after construction. Vertical cracks run the same direction as drywall.
3) Stair-step crack A stair-step crack looks like a flight of stairs and runs in both vertical and horizontal directions across the wall. The continuous pattern usually follows the brick line or the stone block and can be seen in unfinished basements due to the result of soil settling beneath the centre of the wall. For the rehabilitation of such cracks the soil test and the core test is recommended to encounter the probable damage to the building.
4) Doors and window it is a way to test the severeness of a wall cracks in wall by checking the swing of the doors and windows while opening and closing the internal doors and evaluate whether the door is obstructed. If so, ensure that the obstruction is not due to the recent paint work, faulty material if you determine there's nothing obstructing the swinging motion of the door, it might be a sign of a moderate or severe foundation settlement, and may result in wall cracks. According to Real Estate, sticky doors could indicate that the frame has been twisted by a shifting house. If you notice a visible gap at the top of a sticky door where it meets the door frame and you see light shining through, that might also signal a serious settlement problem, often resulting in jagged, horizontal cracks on nearby walls.
5) Visible nails inspect the area surrounding the crack on wall and look for nail heads or screw heads that might be visible on the surface of the wall. The nail or screw might not have damaged the drywall, but it has likely pulled away from the wooden stud beneath. This phenomenon is often known as "nail pops" or "nail popping" and might be a sign of structural problems. Nail pops are frequently associated with more serious wall cracks and often signal significant drywall shear movement.

4. Methodology

In order to achieve the aim and objective, qualitative approach is used in this study because more unknown and unexpected extra information can be gained through conversation with experienced professional respondents.

All the defects were observed by visual observation. The defects were captured with the aid of digital camera and the data are recorded manually. An important and authorities method of collecting information in the field. The purpose of the interview is to gather information from a person with firsthand knowledge

5. Observation

Case Study 1: Political Science, Economical and Archaeological block of Jiwaji University.
In political science building the cracks were found in partition walls and a rear column of the block.

Figure 1: Short wall of classroom16 (political block)
Width- above 2mm
Type- Wide (Non- structure)
Shape- Diagonal, Horizontal crack
Cause- settlement of foundation

Figure 2: Long Wall of Sir Alexander Cunningham hall (political block)
Width- above 2mm
Type- Wide (Non-structural crack)
.Shape- Stair step crack
Cause- settlement of foundation.

Figure 3: Rear column
Type- Major Structural crack.
Cause- settlement of foundation.

Figure 4: Wall in archaeological block
Width- 1to 2 mm
Type- medium, non-structural crack
Shape- diagonal
Cause- settlement of foundation

Case Study 2: Moti Mahal Building.

Figure 1: Column at industrial court
Width- 2mm
Type- Major structure Crack
Shape- vertical crack
Cause-thermal variation, due to joint

Figure 2: Wall of labour court
Width- 1mm
Type- Medium (Non-structural crack)

Shape- Random pattern
cause- Temperature variation, Shrinkage.

Figure 1: Roof of commissionary hall

Failure of slab
Type- Major structure Crack
Cause- due to Fire

Figure 2: Transportation block

Width-varying from 1mm to 2mm.
Type- Medium (structural crack)
Cause- due to Fire

Case study 3: NITM (Nagaji institute of technology and management).

Figure 1: Exterior wall of hostel building

Width – 1 to 2mm
Type – medium, non-structure.
Cause – improper construction practice And maintenance

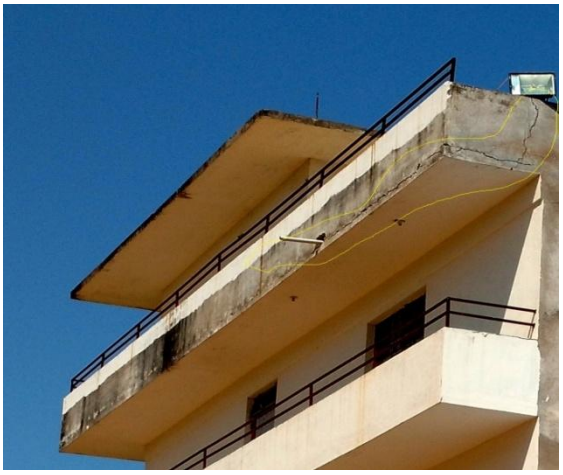

Figure 2: lintel of top floor of MBA block

Width -2mm
Type - major, Structural.
Cause-water logging due to incorrect slope of floor

6. Remedial Measures

1) Non structural or surface cracks they do not require elaborate measures as they prevail on the surface only after removal of the rendering, cracks observed in masonry are cut V shape upto a depth of 12-30 mm and filled with cement mortar 1:4 and then the surface is replastered.
2) Very heavy cracks if there are very heavy cracks all over the external load bearing wall along with sign of settlement, the wall is considered beyond repair and need to replacement the load carried by the wall is supported on props, the old wall is demolished part by part and then rebuilt either in brick wall or suitable RCC frame work.
3) RCC bend crack arrester:- The brick work has to be opened on either side of the crack upto a depth of 100 to 150 mm or one third of the thickness of wall. The exposed surface is roughened and cleaned the reinforcement mesh is placed and filled with good concrete. The procedure is repeated on both side of wall.
4) Cracks observed at junction of 2 different material i.e RCC column and masonry wall:- Cracks appear due to difference in the thermal coefficient of 2 materials and can be prevented by GI Butterfly ties between RCC column and brick work. The ties are provided at different layer of brick masonry.
5) Cracks in RCC column is strengthened by adding reinforcement steel with proper key and bonding with old member is done.

7. Conclusion

It can be observed that structure is subjected to various stresses and real time environmental conditions which lead to different types of cracks and demands specific rehabilitation for the serviceability of the building.

Case study 1(Jiwaji university) and case study 3 (NITM) requires following rehabilitation work:

1) Minor Cracks:

Minor cracks found in the building may be repaired using a Epoxy polymer with the cement mixes used to reduce the temperatures stresses as well as to avoid the present cracks of the building as well as to avoid further formation of cracks in future years to come.

Epoxies: Epoxies also come in the category of polymers but in the case of epoxies the polymerisation process takes place when two materials called the epoxy resin and hardener come in contact by thoroughly mixing in specified proportion. The epoxy resin materials have good mechanical strength, chemical resistance and ease of working these are being used in civil engineering for high performance coatings, adhesives, injection grouting, high performance systems, industrial flooring, or grouting etc.

2) Major Cracks

a) Major cracks found in the building shall be repaired by placing 2 Nos of 8 mm dia M.S bars at every third course of brick masonry followed by the epoxy resin cement mix. Along with the ties of 6mm dia bars to tie the two 8 mm bars.
b) Walls with the major cracks should be provided with 2 Nos 8 mm dia M.S bars at the joint of wall and the column to check the shear cracks.

3) Rehabilitation of columns:

Columns should be provided with 4 nos 16mm dia bars as vertical reinforcement along with the tie bars of 6mm dia bars at 300mm spacing.

With clear cover of 40mm of concrete and **Case study 2 (moti mahal)** have severe cracks and structural failure therefore it needs to be demolished and rebuilt to ensure the stability of the structure.

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