CRACK INVESTIGATION AND PROPOSING REMEDIES : A CASE STUDY IN “JEEWAKA” HOSTEL, BORELLA

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***Abstract*—This paper discusses the crack investigation and the proposed corrective and preventive measures for the newly constructed 3-story building named“Jeewaka” hostel in Borella. The building was found to have many cracks, including thermal cracks in the joints between the masonry wall and the RCC (Reinforced Cement Concrete) columns and beams, and shrinkage cracks below the window openings. This paper outlines the type of crack and the cause and suggests preventive and corrective measures to improve building safety and usability. Causes, corrective measures, and preventive measures were taken from expert interviews and analysed using the Delphi technique. According to the findings, it is strongly recommended to provide a chicken wire mesh between the RCC and the masonry joint before starting plaster work. In addition, expansion and construction joints are recommended as good practises. Furthermore, the findings reveal that most cracks under the windows are shrinkage cracks, and it can be recommended to have preventive measures such as providing the sill beam, avoiding the use of rich cement mortar in masonry and by delaying plaster work until the masonry has dried after proper curing.**

***Index Terms*—Thermal cracks, Shrinkage cracks, Structural cracks, Non-structural cracks, Delphi technique, Epoxy grouting**

I. INTRODUCTION

Cracks are a common problem in buildings that can be caused by poor workmanship, faulty construction, age, and natural and environmental causes. They can take various forms, including uniform or varying widths, straight, toothed, stepped, map pattern, or random, and can be found in vertical, horizontal, or diagonal orientations [1]. Cracks may be only at the surface or may extend to multiple layers of materials. Although cracks are subjective, they can indicate a serious defect that could affect the stability and serviceability of the building [2]. Building serviceability is the ability of a building to meet the needs of its users in terms of safety, comfort, and functionality. Cracks in a building can impact its serviceability in a number of ways [3]. They can:

- Allow water to enter the building, which can cause damage to the structure and its contents.
- Allow pests and vermin to enter the building.
- Compromise the structural integrity of the building.
- Make the building unattractive and uncomfortable to live or work in.

For these reasons, it is important to repair cracks in a building as soon as possible. The type of repair that is needed will depend on the severity of the crack and the underlying cause of the crack. In some cases, a simple repair with joint compound may be sufficient. In other cases, more extensive repairs may be required, such as injecting the crack with a sealant or reinforcing the structure with steel rods.

The importance of crack repair in a building cannot be overstated. By promptly repairing cracks, building owners can help to ensure the safety, comfort, and functionality of their buildings for years to come.

“Jeewaka” hostel, a newly constructed three-storey building in Borella, provides hostel facilities for students of the Colombo medical college. However, cracks have been visually detected in several locations of the building, including walls, joints between walls and columns, and wall-beam joints, as well as near the corners of the door and window frames. After two years of service, the appearance of cracks seems to have worsened, potentially causing damage to the building. Nevertheless, the building is a valuable resource for the Colombo medical faculty students, and it is important to protect it to extend its usefulness. The study aims to provide technical solutions to protect the building before it deteriorates further. Cracks may vary from very thin hairline cracks with a width of about 0.01 mm to cracks with a width of more than 5mm. Depending on the width of the crack, the classification is as follows.

- Thin cracks – crack width is less than 1mm.
- Medium cracks – crack width is between 1mm and 2mm.
- Wide cracks – crack width is greater than 2mm [1]

The cracks can be classified according to the direction of propagation such as,

- Vertical
- Horizontal
- Diagonal [4]
- Straight

- Toothed
- Variable and Irregular [5]

Cracks are found to be divided into two main categories as structural cracks and nonstructural cracks [6]. Structural cracks occur due to reasons such as incorrect design, improper construction, or overload. Non-structural cracks do not have a direct influence on structural weakening of the structures. [7] Non- structural cracks occur because of excessive internal forces developed in the material due to the effects of gas, water content, temperature variation, moisture variation , chemical reactions, etc.

In addition to the above types, the main types of cracks in the building can be categorised depending on the causes of the crack [6]. They are,

- Thermal cracks
- Elastic Deformation
- Shrinkage
- Creep
- Chemical reaction
- Foundation movement and settlement of soil
- Cracks due to vegetation.

There are many methods and techniques that can be used to repair cracks as follows [8].

- Surface Filling Method
- Cementitious Grouting Method
- Epoxy Resin Grout
- Crack Stitching.

II. Objectives

The objectives of this study can be listed below.

- To identify the crack types in the "Jeewaka hostel".
- To identify the causes of the identified cracks.
- To propose the preventive measures and corrective measures for the cracks.

III. Methodology

Cracks in the buildings were identified by a reconnais- sance Survey. In the process, the building inspection was performed to diagnose the cracks in the building, by looking at the entire building from a distance, walking around the building, and inspecting each room to identify the type of crack, measuring each crack in detail and their position in the building. Photographed the cracks and identified the crack type based on shape, and cause through visual identification and knowledge gained by literature review. The fig.1 represent the clear methodology flow chart throughout the case study carried out.

The identified crack types were summarised and a questionnaire was prepared to interview experts in the relevant field of structural engineering to identify the causes, corrective measures and preventive measures of cracks in the identified places. Qualitative data collected by interviewing was analysed using the Delphi technique and Fig.2 shows the methodology of the Delphi technique carried out.

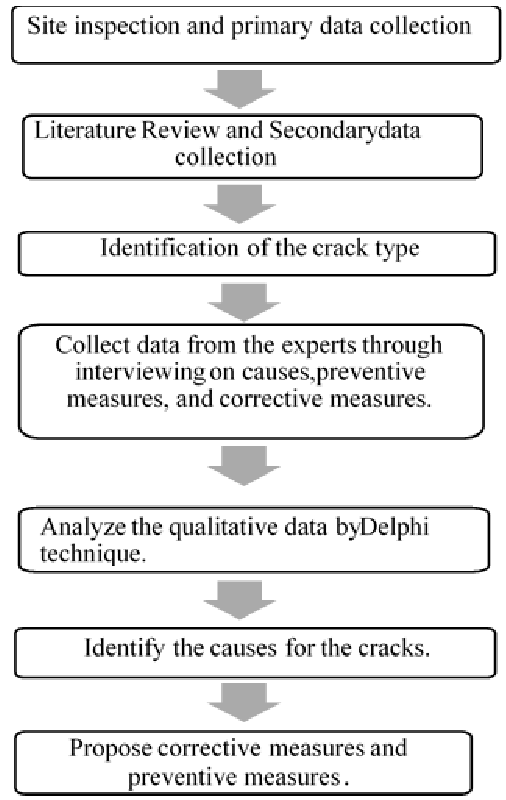

Fig. 1. Methodology flow chart

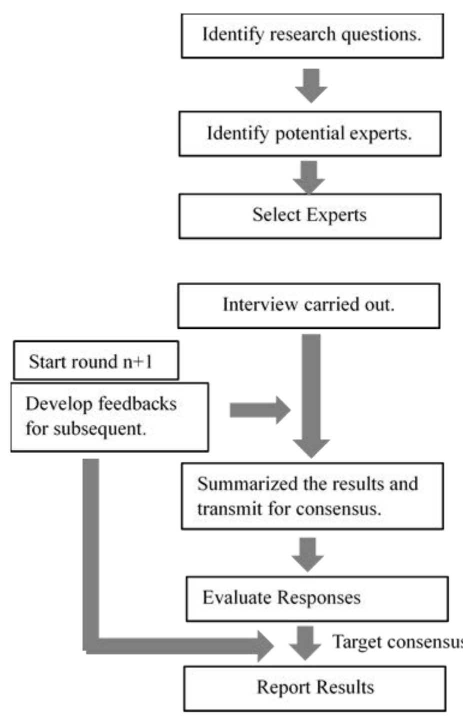

Fig. 2. Carried out Delphi technique

Fig. 3. Ground floor cracks

Fig. 4. First floor cracks

IV. Data Collection And Analysis

To achieve these objectives, it is very important to understand the appearance of the building and the locations in which the cracks appeared. Therefore, the cracks were photographed and the floor plans were drawn by numbering the cracks during site inspections. The collected photographs and summarised details are properly arranged and the ground floor crack data are represented by Fig.3 and TABLE I, the first flow crack data are represented by Fig.4 and TABLE II and Fig.5 and TABLE III represent the second floor crack data.

Identification of crack types

According to the above data, it is identified that mainly 3 types of cracks were found in the Jeewaka hostel. They are,

- Vertical cracks at the joint of masonry wall and RCC columns.
- Horizontal cracks in the joints of the masonry wall and RCC beams.
- Diagonal and vertical cracks below the window opening.

According to the literature, it can classified the crack types with relevance to their causes. Therefore, vertical cracks in

Fig. 5. Second floor cracks

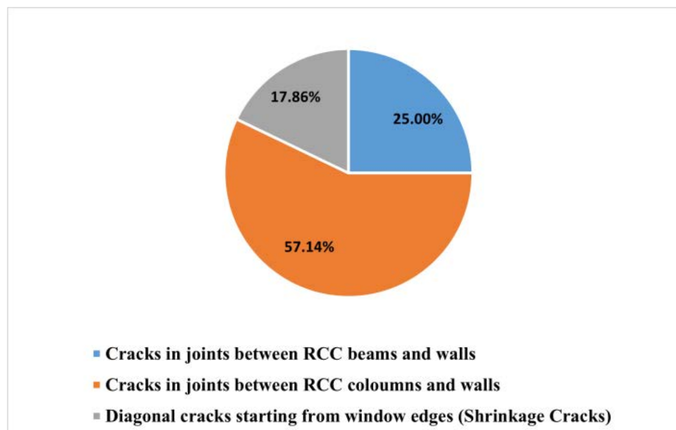

Fig. 6. Crack distribution within the building

the joints of the masonry wall and the RCC columns are thermal cracks. Horizontal cracks in the joints of the masonry wall and RCC beams are also thermal cracks. Diagonal and vertical cracks below window openings are shrinkage cracks.
[2] According to the crack classification based on the width of the cracks and based on the primary data collected, all cracks can be classified as 'thin cracks'.

The figure 6 illustrates the summary of crack types within the building and, accordingly, the majority is represented by the cracks between RCC columns and walls, it is 57.14% in percentage.

Identification of causes, preventive measures, and corrective measures for the cracks.

Causes, preventive measures, and corrective measures for the identified crack types were identified by interviewing five structural engineers who are experts in the relative fields. The interviewed questions are as follows in order to carry out the

TABLE I
GROUND FLOOR CRACK DATA

Crack No.	External/ Internal	Crack Type	Structural/Non structural	Width	Location/Description
C1	External	Vertical	Non-Structural	Less than 1mm	Crack in the wall starting from window sill level to down
C2	External	Diagonal	Non-Structural	-do-	-do-
C3	External	Vertical	Non-Structural	-do-	-do-
C4	External	Vertical	Non-Structural	-do-	-do-
C5	External	Vertical	Non-Structural	-do-	-do-
C6	Internal	Horizontal	Non-Structural	-do-	Crack in the wall at the joint of beam and wall
C7	Internal	Horizontal	Non-Structural	-do-	-do-
C8	Internal	Horizontal	Non-Structural	-do-	-do-
C9	Internal	Horizontal	Non-Structural	-do-	-do-
C10	Internal	Vertical	Non-Structural	-do-	Crack in the wall at the joint of the column and the wall
C11	Internal	Vertical	Non-Structural	-do-	-do-
C12	Internal	Vertical	Non-Structural	-do-	-do-
C13	Internal	Vertical	Non-Structural	-do-	-do-
C14	Internal	Vertical	Non-Structural	-do-	-do-
C15	Internal	Vertical	Non-Structural	-do-	-do-
C16	Internal	Vertical	Non-Structural	-do-	-do-
C17	Internal	Vertical	Non-Structural	-do-	-do-

TABLE II
FIRST FLOOR CRACK DATA

Crack No.	External/ Internal	Crack Type	Structural/Non structural	Width	Location/Description
C18	External	Diagonal	Non-Structural	Less than 1mm	Crack in the wall starting from window sill level to down
C19	External	Diagonal	Non-Structural	-do-	-do-
C20	External	Diagonal	Non-Structural	-do-	-do-
C21	External	Diagonal	Non-Structural	-do-	-do-
C22	External	Horizontal	Non-Structural	-do-	Crack in the wall at the joint of beam and wall
C23	Internal	Horizontal	Non-Structural	-do-	-do-
C24	Internal	Horizontal	Non-Structural	-do-	-do-
C25	Internal	Horizontal	Non-Structural	-do-	-do-
C26	Internal	Horizontal	Non-Structural	-do-	-do-
C27	Internal	Horizontal	Non-Structural	-do-	-do-
C28	Internal	Vertical	Non-Structural	-do-	Crack in the wall at the joint of Column and wall
C29	Internal	Vertical	Non-Structural	-do-	-do-
C30	Internal	Vertical	Non-Structural	-do-	-do-
C31	Internal	Vertical	Non-Structural	-do-	-do-
C32	Internal	Vertical	Non-Structural	-do-	-do-
C33	Internal	Vertical	Non-Structural	-do-	-do-
C34	Internal	Vertical	Non-Structural	-do-	-do-
C34	Internal	Vertical	Non-Structural	-do-	-do-
C34	Internal	Vertical	Non-Structural	-do-	-do-
C35	Internal	Vertical	Non-Structural	-do-	-do-

Delphi technique.

1) What is the cause of thermal cracking at the joint of column and wall?
2) What can do as preventive measures for such type of cracking in future works?
3) What can be done as corrective measures for thermal cracking at the joint of the column and the wall?
4) What is the cause of thermal cracking at the joint of beam and wall?
5) What can be done as preventive measures for such type cracks in future works?
6) What can be done as corrective measures for cracking at the joints of beams and walls?
7) What caused the cracking of the shrinkage in the walls below the window opening?
8) What can be done as preventive measures for such type of cracking in future works?
9) What can be done as corrective measures for shrinkage cracking in the walls below the window opening?

The Delphi technique was carried out in 3 rounds.

Round 1 The first questionnaire that was sent to the panel of experts asked for a list of opinions that included experiences and judgments, a list of predictions and a list of recommended activities.

Round 2 As per the above collected data causes, preven- tive measures and corrective measures were summarised and presented for the second round of interviewing to take their agreements and disagreements. Experts were free to provide their consensus or more views on the summary that was generated by the data taken from round one.

Round 3 The summary of round 2 was provided for experts to make their consensus as agree (1), nominal (0) and disagree (-1) by rated the decisions taken in round 2. Then analysed the final output using SPSS software descriptive analysis

TABLE III
SECOND FLOOR CRACK DATA

Crack No.	External/ Internal	Crack Type	Structural/Non structural	Width	Location/Description
C36	External	Vertical	Non-Structural	Less than 1mm	Crack in the wall at the joint of Column and wall
C37	External	Vertical	Non-Structural	-do-	-do-
C38	External	Vertical	Non-Structural	-do-	-do-
C39	External	Vertical	Non-Structural	-do-	-do-
C40	External	Vertical	Non-Structural	-do-	-do-
C41	External	Vertical	Non-Structural	-do-	-do-
C42	External	Vertical	Non-Structural	-do-	-do-
C43	External	Vertical	Non-Structural	-do-	-do-
C44	External	Vertical	Non-Structural	-do-	-do-
C45	External	Vertical	Non-Structural	-do-	-do-
C46	External	Vertical	Non-Structural	-do-	-do-
C47	External	Vertical	Non-Structural	-do-	-do-
C48	Internal	Vertical	Non-Structural	-do-	-do-
C49	Internal	Vertical	Non-Structural	-do-	-do-
C50	Internal	Vertical	Non-Structural	-do-	-do-
C51	Internal	Vertical	Non-Structural	-do-	-do-
C52	Internal	Horizontal	Non-Structural	-do-	Crack in the wall at the joint of beam and wall
C53	Internal	Horizontal	Non-Structural	-do-	-do-
C54	Internal	Horizontal	Non-Structural	-do-	-do-
C55	Internal	Horizontal	Non-Structural	-do-	-do-
C56	Internal	Diagonal	Non-Structural	-do-	Crack in the wall starting from windowsill level to down

frequency charts.

The causes for the identified Thermal cracks between RCC column and masonry wall was,

- Thermal variation causes the expansion and contraction between two different construction materials with two thermal coefficients and due to not providing adequate reinforcement for expansion between the joint, both had 80% consensus in frequency.

The causes for the identified Thermal cracks between RCC beam and masonry wall was,

- Thermal variation causes the expansion and contraction between two different construction materials with two thermal coefficients and due to not providing expansion joints, which both had 100% consensus in frequency.

The causes for the identified shrinkage cracks below the window openings was,

- Concrete shrinks begin to crack due to not providing a sill beam which had 100% consensus in frequency.

The preventive measures for the thermal cracks between RCC column and masonry wall was,

- Chicken wire mesh should be fixed between RCC and masonry joint before commencing plaster work (Chicken wire mesh of 300 mm width should be fixed along the full joint length with nails.) which had 80% consensus in frequency.

The preventive measures for the thermal cracks between RCC beam and masonry wall was,

- Introduced expansion joints and prior to the plastering and fixed a chicken wire mesh between RCC beam and masonry joint which had 80% and 100% consensus in frequency respectively.

The preventive measures for the identified shrinkage cracks below the window openings was,

- Provide a sill beam and application of sound construc- tion practices which had 80% and 100% consensus in frequency respectively.

The corrective measures for the thermal cracks between RCC column and masonry wall and RCC beam, and masonry wall was,

- Epoxy grouting which had 80% consensus in frequency.

The corrective measures for the shrinkage cracks below the window openings was,

- Use fiber mesh with a sealant and plaster on top of that and use of high-pressure flexible polyurethane which had 100% consensus in frequency.

V. CONCLUSION

The potential causes of crack can be controlled if proper consideration is given to the construction material and tech- niques used. Based on this study, using the Delphi technique, it is focused on the main causes of cracks in “Jeewaka” hostel and to propose preventive and corrective measures for the identified cracks. The Delphi technique was carried out in 3 expert rounds to take the final output, and analysis was done using SPSS software descriptive analysis frequency tables.

According to the findings, the cracks in the building could be classified into 3 types. They are thermal cracks at the joint of the RCC column and the masonry wall, thermal cracks between the RCC beam and the masonry wall, and shrinkage cracks below the window openings. Ground floor C1-C5, first floor C18-C21, and third floor C56 occurred due to shrinkage and improper construction practises. The corrective measure is to use fibre mesh with a sealant and plaster on top, and high-pressure flexible polyurethane can also be used. The preventive measure for the above-mentioned crack is providing a sill beam down to the windows and following

TABLE IV

CRACK DATA SUMMARY

Crack no	Description	Crack type	Cause	Corrective measure	Preventive measure
C1-C5, C18-C21, C56	Vertical and Diagonal cracks below the window openings	Shrinkage cracks	Concrete shrinks begin to crack due to not providing a sill beam and bad workmanship.	Use fiber mesh with a sealant and plaster on top of that and high-pressure flexible polyurethane also can be used.	providing a sill beam down to the windows and following, sound construction practices.
C10-C17, C28-C35, C36-C51	Cracks at the junction between RCC column and masonry wall	Thermal cracks	Thermal variation causes the expansion and contraction between two different construction materials with two thermal coefficients and due to not providing expansion joints and bad workmanship.	Epoxy grouting	Chicken wire mesh should be fixed between RCC and masonry joint before commencing plaster work (Chicken wire mesh of 300 mm width should be fixed along the full joint length with nails.)
C6-C9, C22-C27, C52-C55	Cracks at the junction between RCC beam and masonry wall	Thermal cracks	Thermal variation causes the expansion and contraction between two different construction materials with two thermal coefficients and due to not providing expansion joints,	Epoxy grouting	Introduced expansion joints prior to the plastering and fixed a chicken wire mesh between RCC beam and masonry joint

sound construction practises. The ground floor cracks C10-C17, the first floor cracks C28-C35, and the second floor cracks C36-C51 occurred due to thermal variation that causes expansion and contraction between two different construction materials with two thermal coefficients and due to the insufficient reinforcement for expansion in the joints. The preventive measure suggested was that chicken wire mesh should be fixed between RCC and the masonry joint before beginning plaster work (Chicken wire mesh of 300 mm width should be fixed along the full length of the joint with nainails). The corrective measure was epoxy grouting the cracks. The thermal variation of the ground floor cracks C6-C9, the first floor cracks C22-C27 and the second floor expansion and contraction between two different construction materials with two thermal coefficients and due to the inability to provide expansion joints, The suggested preventive measure was introduced expansion joints to plastering and fixed a chicken wire mesh between the RCC beam and the masonry joint. The corrective measure was epoxy grouting the cracks. If we were able to take their preventive measures at the start, we will minimise the cracking problem in the hostel. Therefore, the corrective measures for the cracks were proposed, grouting techniques were proposed to minimise them and propose preventive measures to prevent the crack not occurring again in future construction works. The summary of the final output is illustrated in the Table IV.

VI. Recommendation

There are many types of cracks that can be seen in buildings, and specified corrective and preventive measures are available for them. According to the findings of this project work, it is recommended to have preventive measures for thermal cracks in the joints between the RCC column and the ma- sonry wall, provided that chicken wire mesh should be fixed between the RCC and the masonry joint before beginning plaster work. Chicken wire mesh 300mm wide should be fixed along the full length of the joint with nails. And for the corrective measures, can recommended grouting methods and epoxy injection, stitching, gravity filling, routing and sealing. Preventive measures for thermal cracks at the joint between the RCC beam and the masonry wall can be recommended, such as introduced slip joints, expansion, and construction joints between them and the joints should be designed at the time of planning and should be constructed carefully. Prior to the plastering, a chicken wire mesh was fixed between the RCC beam and the masonry joint. According to the findings, corrective measures can be recommended as grouting methods, epoxy injection, stitching, gravity filling, routing and sealing. The findings reveal that most of the cracks under the windows are shrinkage cracks and it can recommend having preventive measures such as providing a sill beam, avoiding the use of rich cement mortar in masonry and by delaying plaster work until masonry has dried after proper curing. Masonry work carried out with composite cement-lime-sand mortars (1:1:6, 1:2:9, or 1:3:12), which are weak, will have a lesser tendency to develop cracks. It is due to the accommodation of shrinkage in weak mortar of the individual masonry unit. As corrective measures, it can recommended use fibre mesh with a sealant and plaster on top of that.

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