International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Assessment of CCS Building Structural Cracking

Alma P. Kuizon

Associate Professor, Eastern Samar State University-Salcedo

Abstract

Building cracking is a tough occurrence that affects all structures considering, any building will eventually crack. A building to be structurally sound is not always simple. Also, it is common to number of the building's structural and non-structural components start to reveal fractures as a result of construction errors and other inescapable factors. Thus, it is essential to identify these fissures early and take preventive actions. Diverse restoration techniques and materials are employed depending on the types of cracks and their occurrences within the structure. Some fracture types need to be treated with urgency because they endanger the structure. The study's main concerns are the apparent cracks in the CCS building and how to prevent new cracks from appearing after.

Keywords: *Structural Cracking, Masonry Walls, Beams, Columns , Slabs*

I. INTRODUCTION

The College of Computer Science building is a two-storey design reinforced concrete with a masonry wall. The structure has been completed and occupied in 2017. During the early age of its service, the structure has shown occurrences of concrete cracks which can be traced until now. Likewise, repairs have been done in 2020 on cracks occurrences in the concrete slabs. However, numerous occurrences of cracks can be readily detected and too visible on the masonry walls, columns, beams, and concrete slabs. Also, the appearance of cracks on masonry walls and concrete slabs changes in size, shape, and dimensions and increasing visible appearances can be traced when the structure shakes due to earthquake or from heavy vehicles disturbance which causes vibration and building shake.

Cracking on buildings is a perennial problem of most construction manufacturers. The challenge of every structure for a free crack building is somewhat impossible. As mentioned by Nama et.al, (2015), cracking is an unavoidable response of any structure and is more activated when poor constructions processes and practices were implemented. The American Concrete Institute emphasizes that concrete cracking is the complete or partial division of either concrete masonry into two or more portions caused by breaking or fracturing. Also, the presence of cracks may indicate that the damage has reached its full extent or that there are more serious issues. Likewise, according to the American Concrete Institute, cracking can be caused by external loads, poor construction practices, overloading during construction, chemical reactions, weathering, plastic shrinkage cracking, settlement cracking, drying shrinkage, thermal stresses, and chemical reactions.

Mendhi et. al., (2014), revealed that structural failure is often preceded by cracking, the more concrete shrinks when it is lighter and it is important to remember that cracking in concrete can occurs frequently such, an overly numerous cracks are abnormal. Furthermore, Rodriquez's (2015) study on assessment revealed that the primary challenge in damage detection is fracture width measurement. Visible fractures not only detract from appearance, but too wide fissures may also speed up reinforcing degradation. For the proper preventative maintenance of concrete buildings, early detection of these fissures before they become evident is of considerable interest.

Nonstructural cracks and structural cracks are the two different types of cracking. Non-structural cracks are less significant from a safety standpoint, but are more significant from an aesthetic standpoint.

Structural cracks are more significant and require more care because neglecting them results in an unsafe structure.

The study aims to provide an investigation in the field of the analysis in the concrete cracking occurrences of CCS building structure. The analysis of the cracking occurrences will utilized the Principle of Investigating Cracks (Rajbather, 2017), & (Kumar, 2021) and the American Concrete Institute Standards.

Research Objectives

This study aims to investigate all visible occurrences of cracks in the College of Computer Studies building structure.

1. What are the causes of the visible appearance of cracks ?
   i. Masonry wall
   ii. Beam
   iii. Column
   iv. Slab
2. What are the techniques in curing visible cracks ?
   i. Masonry wall
   ii. Beam
   iii. Column
   iv. Slab
3. How can concrete cracks be preventive?
   i. Masonry wall
   ii. Beam
   iii. Column
   iv. Slab
4. Identification and Treatment of Cracks occurrences at CCS
   i. Masonry wall
   ii. Beam
   iii. Column
   iv. Slab

II. REVIEW OF RELATED LITERATURE

Concrete is a strong solid substantial material that provides structures the desirable strength, rigidity, and resilience not to yield deformation (Giatic Scientific, Inc., 2019). However, cracking occurrences in concrete structures appear even in the early years of the structure service life. The lack of flexibility to adapt in response to environmental or dimension changes of concrete ingress cracking. Visible signs of cracking are developed and caused when concrete shows distress. Moreover, long-term shrinkage and loading gradually cause the expansion of cracks during the serviceability of the structure (Johnson, 2002). Also, a possible deterioration will exist before cracks appear. Consequently, cracking can occur in both hardened and fresh, or plastic, concrete as a result of volume changes and repeated loading (Giatec, Inc. 2019). Though, some field civil engineers, has limited awareness on causes of concrete cracking (Kashyzadeh & Kesheh, 2012). Such, structures should be constructed according to its design and quality specifications to avoid major occurrence of failure. Wherein, restorative work suggests serious damages that is sometimes too costly and unreliable restoration treatment challenges.

Carino, 1995, contributed to some factors affecting the formation of cracks in hardened concrete by providing a model and techniques in predicting behaviors of reinforced concrete members caused by shrinkage cracking. Similarly, a case study of (Matar & Morstead, 1987) implies that the behavior of concrete masonry walls shrinkage has limited consideration where implementation of the following; construction practices, material standards, manufacture, and design specification are contributory to shrinkage cracking. Furthermore, Sivakumar, 2012 found that the cement/total aggregate ratio has a

significant impact on plastic shrinkage cracking. The mean crack width does not increase when the water-to-cement ratio rises, but the overall crack length does. Furthermore, for any kind of concrete mix with various water/cement ratios put under real-world site conditions, the crack's maximum width is mild.

Numerous research writers have examined and assessed the cracking patterns of cement composites, and they emphasize the critical significance of the degree of pattern development for the practical qualities and durability of cement composites (Szelag, 2020). However, still very few publications that directly and numerically quantify the relationship between the cracking patterns and the material's mechanical and physical properties. This knowledge appears to be essential for building robust cement composites that would be resistant to cracking and the process of crack development in particular settings). Hence, the study of Mendhi & Ahmad, 2020, suggests that in India their research work focused on checking the causes and evaluation of cracks at every stage in reinforcing concrete structures evaluated that the cracks size and cause of cracks generally occur in plastic and elastic state of concrete.

The repair materials and repair techniques are different depending upon the forms of cracks according to their positions in the structure. Good crack repair methods depend on knowing the cause of cracks and selecting appropriate repair methods that take these causes into account otherwise the repair would not last long evaluation of concrete cracks.

In the Philippines at Villa Milagrosa Townhouses, cracks on masonry walls, concrete slabs, and generally the concrete houses were assessed, investigated, and evaluated and found out from their study that concrete masonry assessment, cracks must be controlled as recommended (Ganiron, Jr., 2016).

III. METHODOLOGY

Research Design

The study utilized a descriptive analysis design. The descriptive analysis technique is the foundation of every diagnostic process, and it seeks to answer the question, "What happened?". It accomplishes this by organizing, processing, and analyzing raw data from a variety of sources in order to transform it into useful applications (Anand, 2021).

Research Locale

The study was conducted at the ESSU-Salcedo Campus, particularly it investigated and examined the occurrence of cracks of the CCS Building Structure.

Respondents of the Study

There are no respondents of the study per say, but the researcher will be exclusively investigating cracks visible surface cracks of the CCS building.

Data Analysis

The study investigated and evaluated all visible existing cracks employing the Principle of Investigating Cracks (Rajbather, 2017), & (Kumar, 2021) and the American Concrete Institute Standards (ACI). The Principle of Investigating Cracks will utilize the following steps; Step 1: Discussion with Client/Owner of the Building , Step 2: Visit the Site, Step 3: Understand the Cracks and Its Causes, Step 4: Monitoring and Measuring the Movements of Cracks, Step 5: Finding the Suitable Techniques to Repair Crack , Step 6: Identification and Treatment of Cracks.

RESULTS AND DISCUSSION:

Table 1: Visible appearance of cracks in masonry walls, beams, columns and slabs.

Causes of Cracks	Masonry Walls	Beams	Columns	Slab
Settlement and movement	**P**			
Thermal expansion and contraction	**P**			
Moisture and water damage	**P**			**P**
Poor workmanship	**P**			
Structural Stress	**P**			
Age and deterioration	**P**			
Foundation Issues	**P**			
Overloading/Structural Overloading		**P**	**P**	**P**
Insufficient structural support		**P**	**P**	
Material defects		**P**	**P**	
Fatigue		**P**	**P**	
Temperature variations		**P**	**P**	
Corrosion		**P**	**P**	
Design and construction flaws		**P**	**P**	
Structural settlement and movement		**P**	**P**	
Earthquakes or seismic activity			**P**	
Plastic Shrinkage				**P**
Drying Shrinkage				**P**
Thermal expansion and contraction				**P**
Settlement or movement of the substrate				**P**
Structural Overloading				**P**
Lack of control joints				**P**
Insufficient reinforcement				**P**

Depending on the intensity and size of the cracks, the cracking of masonry walls, beams, columns, and slabs can be caused by a variety of things. The following conclusions about the above structural elements' cracking are:

1. Masonry Walls: Cracking can be caused by a variety of factors, such as structural overloading, differential settlement, thermal expansion and contraction, moisture-related problems, or insufficient reinforcement. Masonry wall cracks can jeopardize the walls' structural integrity, raise the danger of moisture intrusion, and affect the building's stability as a whole. To keep the wall stable and functioning, it is essential to properly examine and fix the cracks.
2. Beams and Columns: Inadequate reinforcing, excessive loads, poor building techniques, structural motions, and cracking in beams and columns are only a few causes for this problem. The entire stability of the structure may be jeopardized if certain structural components develop cracks that reduce their ability to support heavy loads. To choose the best methods for reinforcing or repair, it is crucial to assess the origin of the cracking and the severity of the cracks.
3. Slabs: Several reasons, such as drying shrinkage, temperature variations, insufficient reinforcing, excessive loads, or settling, can cause slabs to crack. Slabs' structural performance, aesthetics, and usability can all be impacted by cracks. To adopt effective repair methods and stop additional damage, a thorough study of the cracks and their underlying causes is required.

In conclusion, it is important to note that masonry cracking in walls, beams, columns, and slabs should not be disregarded because it may result in structural weaknesses and associated safety risks. To treat the cracks and guarantee the structural integrity and durability of the damaged elements, prompt assessment, cause identification, and proper repair procedures are crucial.

Table 2: Techniques in Curing Cracks on Masonry Walls, Beams, Columns and Slabs.

Techniques in curing visible cracks	Masonry walls	Beams	Columns	Slabs
Epoxy injection	**P**	**P**	**P**	
Grouting/structural grouting	**P**	**P**	**P**	**P**
Crack Stitching	**P**	**P**		**P**
Wall reinforcement		**P**		
Expansion joints		**P**		
Moisture management		**P**		**P**
Inspection and Assessment		**P**		
Carbon fiber reinforcement		**P**	**P**	
Steel Plate Bonding			**P**	
Post Tensioning		**P**	**P**	
Protective Coatings		**P**		
Structural Monitoring				
Steel Reinforcement			**P**	
Concrete Jacketing			**P**	
Steel Jacketing			**P**	
Joint repair				**P**
Slab Jacking				**P**
Overlay or Resurfacing				**P**
Reinforcement				**P**

The severity, source, and extent of the cracks determine the methods employed to repair them in masonry walls, beams, columns, and slabs. In general, the following can be said about how to repair cracks in various structural components: A comprehensive evaluation of the cracks should be done before using any repair methods. This entails identifying the origin, size, and severity of the fractures as well as assessing any potential structural problems. To conduct a thorough analysis and suggest appropriate repair methods, a structural engineer should be consulted.

1. Crack Injection: The method known as "crack injection" is frequently used to fix cracks in masonry columns, beams, and walls. Epoxy or polyurethane resins are injected into the cracks to fill and bind them. By using this technique, you can restore the structural integrity and stop cracks from spreading further.
2. Reinforcement: If fractures are a sign of structural problems, reinforcing methods can be needed. To strengthen the weakened components, this may entail inserting carbon fiber sheets or strips or adding more steel reinforcing bars. Increased load carrying capacity and more effective stress distribution are two benefits of reinforcement techniques, which lower the risk of crack initiation and growth.
3. Structural Stabilization: Structural stabilizing procedures could be necessary if masonry walls, beams, columns, or slabs suffer from severe cracks. Techniques like external post-tensioning, which employ compressive forces to offset tensile stresses and stop further cracking, can be used in this situation. Other techniques include adding external steel bracing or applying fiber-reinforced polymers (FRPs) to strengthen the structure.

4. Moisture and Waterproofing: Addressing waterproofing and moisture control is essential in situations when cracks are brought on by moisture-related problems, such as water infiltration or an excessive amount of moisture content. This can involve taking steps to stop further moisture infiltration and lessen the chance of further cracking, such as using waterproof coatings, enhancing drainage systems, or erecting moisture barriers.

Depending on the type and extent of the fractures, the underlying reasons, and the structural requirements, each instance may call for a unique strategy.

Table 3: Preventive measures of concrete cracks on masonry walls, beams, columns and slabs.

Prevention of cracks	Masonry Walls	beams	columns	slabs
Adequate design	**P**	**P**	**P**	**P**
Proper Material Selection	**P**	**P**	**P**	**P**
Control joint	**P**	**P**	**P**	**P**
Reinforcement		**P**	**P**	**P**
Proper construction practices	**P**	**P**	**P**	**P**
Expansion joints	**P**			
Quality Control		**P**		
Control of Shrinkage		**P**		**P**
Monitoring		**P**	**P**	
Moisture Management			**P**	**P**
Regular maintenance	**P**	**P**	**P**	**P**
Addressing Foundation and Settlement Issue	**P**			
Avoiding Overloading	**P**	**P**	**P**	**P**

The structural integrity and durability of masonry walls, beams, columns, and slabs must be preserved by preventing cracks in these components. A general conclusion with respect to guarding against cracks in various structural elements is as follows:

Proper Design and Construction:
Ensuring proper design and construction practices is essential in preventing cracks. This includes considering factors such as load-bearing capacity, material selection, appropriate reinforcement, and structural detailing. Employing experienced professionals and following established building codes and standards can significantly reduce the risk of cracks.

Adequate Reinforcement:
Proper reinforcement, such as steel bars or fibers, should be incorporated during construction to enhance the structural strength and prevent cracks. Reinforcement helps distribute loads more effectively and can mitigate the effects of shrinkage, temperature changes, and other potential causes of cracking.

Control of Moisture and Temperature:
Managing moisture levels and temperature differentials is vital in preventing cracks. Proper waterproofing measures, effective drainage systems, and insulation can help minimize the impact of moisture and temperature changes, reducing the risk of cracking due to swelling, shrinkage, or freeze-thaw cycles.

Structural Movement Considerations:
Accounting for potential structural movements, such as settlement or expansion/contraction, is crucial. Proper foundation design, adequate joint spacing, and appropriate expansion joints or movement joints can accommodate these movements and minimize stress concentrations that can lead to cracks.

Quality Control and Maintenance:
Regular quality control during construction, including proper curing of masonry, adequate compaction of concrete, and monitoring of material properties, can help prevent cracks. Additionally, routine inspections and maintenance of the structure throughout its lifespan can identify and address any potential issues before they develop into significant problems.

Proper Load Distribution:
Ensuring proper load distribution across the structural elements can help prevent overloading and subsequent cracking. This involves designing and constructing the structure to appropriately transfer loads from one component to another, avoiding localized stress concentrations.

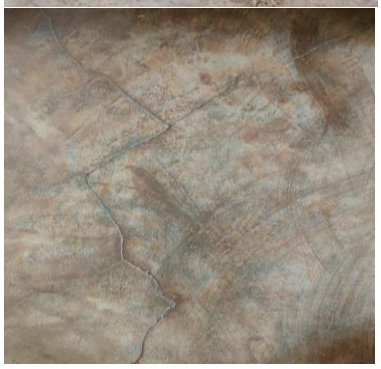
Education and Awareness:
Educating building occupants, homeowners, and construction professionals about the importance of crack prevention measures can help foster a proactive approach. This includes raising awareness about the causes of cracks, proper maintenance practices, and the need to address any signs of distress promptly.

It is important to note that while these preventive measures can significantly reduce the likelihood of cracks, it is not always possible to eliminate them entirely. However, by implementing these strategies, the risk of cracks and their potential negative impacts can be .

4. Identification and Treatment of Cracks occurrences at CCS
i. Masonry wall
ii. Beam
iii. Column
iv. Slab

Cracks	Identification/Causes	Treatment
Masonry Walls		
	**Horizontal Cracks** **Shrinkage cracks**	**Epoxy Injection**
	**Shrinkage cracks**	**Epoxy Injection**

	**Hairline cracks**	**Epoxy Mortar**
Beams		
	**Spalling**	**Epoxy Injection** **Epoxy Mortar**
	**Spalling**	**Epoxy Injection** **Epoxy Mortar**
Columns		
	**Hairline cracks**	**Epoxy Injection**
	**Corner cracks** **Shear Cracks**	**Epoxy Injection**
Slabs		

	**Settlement cracks** **Shrinkage cracks**	**Epoxy Injection** **Epoxy Mortar**
	**Hairline Cracks**	**Epoxy Mortar**

Identifying concrete cracks involves visually inspecting the concrete surface and looking for visible signs of cracking.

1. Visual Inspection: Carefully examine the concrete surface, both horizontally and vertically, to identify any visible cracks. Look for irregularities, lines, or discontinuities on the surface that indicate potential cracks. Pay attention to areas where cracks are more likely to occur, such as corners, joints, or areas of stress concentration.
2. Crack Patterns: Different types of cracks may have distinct patterns that can provide clues about their causes. Some common crack patterns include:

- Hairline Cracks: Very thin cracks that are barely visible to the naked eye. They may be tight and uniform in width.
- Shrinkage Cracks: Cracks that occur due to the drying and shrinkage of concrete. They are typically narrow and occur in a random pattern.
- Settlement Cracks: Cracks that form due to uneven settling of the concrete or the supporting ground. They may be wider at the top and taper down.
- Structural Cracks: Cracks that indicate structural issues, such as excessive loading, inadequate reinforcement, or design flaws. These cracks may be wider, longer, and may follow a particular pattern.

3. Crack Width and Depth: Evaluate the width and depth of the cracks. Measure the crack width using a crack gauge or a ruler. Note that some cracks may be too small to measure accurately, in which case you can categorize them as hairline cracks. Assess the depth of the crack by visually inspecting whether it is superficial or extends deeper into the concrete.
4. Location and Context: Consider the location of the cracks and their context within the structure. Cracks near joints, corners, or areas of stress concentration are common, but cracks appearing in unexpected locations might require further investigation. Assess whether the cracks are present in specific parts of the structure or distributed uniformly.
5. Other Indicators: Look for additional signs that may help identify the cause or severity of the cracks. These can include spalling (flaking or chipping of concrete), rust stains, efflorescence (white mineral deposits on the surface), or any visible signs of movement or displacement.

It's important to note that visual inspection is the initial step in identifying concrete cracks. If you suspect structural issues or the cracks are extensive, it is recommended to consult a qualified structural engineer or construction professional who can conduct a more detailed evaluation and provide appropriate recommendations for repair or further assessment.

Conclusion

Visible cracking occurrence at CCS building in masonry walls, beams, columns and slabs occurs due to variety of reasons, such as; structural overload, settlement, thermal expansion and contraction, moisture and water damage, poor construction practices, and earthquake and seismic activity. Typical crack patterns on masonry walls, beams, columns and slabs are common on shrinkage, settlement and spalling which is common to poor construction practices, materials defects, moisture, and thermal expansion and contraction. Hence, implementation of treatment such as epoxy mortar and epoxy injection are necessary and requires immediate action to prevent catastrophic cracking implications.

IV. REFERENCES

1. **Abhyankar, Snehal, (2019**). *Research on Different Types of Cracks in Plain and Reinforced Concrete.* International Journal of Recent Technology and Engineering (IJRTE). Vol. 8. Issue-2S11
2. **Safiuddin, et., al., (2018).** *Early-Age Cracking in Concrete*: Journals. Vol. 8., Issue 10
3. **Pan, H., & Pi, L., (2018).** *Study on Cracks in Concrete Structures and the Database*. International Conference on Civil and Hydraulic Engineering (IConCHE). IOP Publishing.
4. **Rajabather, A., (2016).** *Investigation of Cracks in Building.* Forensic Structural Engineering
5. **Nama, et. al.,(2015).** *Study on Causes of Cracks & its Preventive Measures in Concrete Structures*. International Journal of Recent Technology and Engineering (IJRTE). Vol. 5. Issue 5.
6. **Nama, P., Jain, A., Srivastava, R., & Bhatia, Y. (2020).** [PDF] Study on Causes of Cracks & its Preventive Measures in Concrete Structures |
7. **Das, D. B., Umnag, K., & Murthy, G. (2020).** Study on causes of cracks and its preventive measures in concrete structures of CCEM building, Raipur |
   In-Text Citation: (Das et al., 2020)
8. **Bano, S., Jaiswal, G., Kumar, R., Tiwari, A., & Karthikeyan, M. (2023**). Experimental Study on the Crack Repair Techniques of Concrete Structures: A Case Study - IOPscience. Experimental Study on the Crack Repair Techniques of Concrete Structures: A Case Study - IOPscience. https://doi.org/10.1088/1757-899X/1273/1/012006
   In-Text Citation: (Bano et al., 2023)
9. **Zanke, A. S. (2022).** [PDF] BUILDING CRACKS: CAUSES AND PREVENTIONS |. https://semanticscholar.org/paper/07fd034329e24f666df48ddaa8e6f50ed88b4527
10. **Jun-ba, C. (2015).** Causes and prevention of concrete cracks | Semantic Scholar. Causes and Prevention of Concrete Cracks |
11. **Mendhi, et. al., (2014).** *Causes and Evaluation of Cracks in Concrete Structures*. International Journal of Technical Research and Applications.
12. **As'ad. Et. al., (2013).** *Investigation on Wall Crack Damage and its Proposed Repair Method.* International Conference on Rehabilitation and Maintenance in Civil Engineering. Procedia Engineering
13. **Johnson, Roger. W., (2002).** *The Significance of Cracks in Low-rise Buildings*. Chartered Civil and Structural Engineer and Surveyor.
14. **Pise, N., Meshram, T., Doijad, Y., Gathe, R., Bobade, A., Kutemate, A., Patil, S., Raut, P. A., & Gudadhe, A. (2023).** A Brief Study on Causes of Cracks, Prevention and Pattern of Cracks on Concrete | https://semanticscholar.org/paper/8fd6b44129d99917576fc613130e254f604317b7
    In-Text Citation: (Pise et al., 2023)

15. **Zhong-rong, B. (n.d.).** Study on the causes of cracks in concrete structure and preventive measures | Semantic Scholar. Study on the Causes of Cracks in Concrete Structure and Preventive Measures | Semantic Scholar. https://semanticscholar.org/paper/276d63a5a36c1879bbda4196879c8d3d8ff73373
In-Text Citation: (Zhong-rong, n.d.)
16. **Rui-lian, L. (n.d.).** Causes and prevention measures of cracks in concrete structures | https://semanticscholar.org/paper/09d03089f5e48d767dd223acb8873964bfca1628
In-Text Citation: (Rui-lian, n.d.)
17. **Shu-lin, Z. (2022**). Study on Reasons and Prevention Measures of Cracking in Concrete Structure | https://semanticscholar.org/paper/8c698a8feff8f0efcd1f23b98a57f48efb39354b
In-Text Citation: (Shu-lin, 2022)
18. **Raajamurugan, S. (2007**). [PDF] EXPERIMENTAL INVESTIGATION ON CAUSES OF CRACKS IN CONCRETE STRUCTURES AND TECHNIQUES TO CONTROL THE CRACKS | https://semanticscholar.org/paper/2974b5bc1b24eed071f89e69cdec5065d04bec77
In-Text Citation: (Raajamurugan, 2007)
19. **Xiao-feng, L. (2022).** The Causes and Prevention Measures for Concrete Cracks | Semantic Scholar. The Causes and Prevention Measures for Concrete Cracks | Semantic Scholar. https://semanticscholar.org/paper/bf87771f1b4e6c14585ed669fbd7c30a1a5c724d
In-Text Citation: (Xiao-feng, 2022)