AN INVESTIGATION INTO THE CAUSES AND EFFECTS OF CRACKS ON GOVERNMENT DAY SECONDRY SCHOOL KALGO

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ABSTRACT
Buildings after completion at times develop cracks which serve as a sign of failure of the building structure. The objectives were to identify and rank the various types of cracks in buildings and their related causes to know the various effects of cracks in building structures. The study adopted a quantitative structured questionnaire survey. Respondents were selected using purposive and random sampling technique. The same size for the study was 103 respondents made up of 5 professionals in building construction. Relative Importance Index (RII) was used to analyze both causes and effects. The study revealed that the ten (10) major causes of cracks are: permeability of concrete, freeze/thaw, natural forces, moisture movements, elastic deformations, temperature variations, among others. It was identified that: Some penetrate cracks on the wall can reduce performance, especially affect the building's usage and seismic performance. The study recommends that the structural engineers must ensure good structural design and specifications by considering all the environmental aspects that include soil (Geotechnical) investigations that will enable the designer to come up with a proper design of the foundation. Since, buildings are designed for particular uses, and to withstand a given measure of weight (loading) for example a building designed as a residence will have different structural specifications from the one designed to operate machinery. Proper consideration and supervision must be put in place to ensure good mixing of building materials such as cement, sand, and aggregate. It is always important to take good care of the buildings by doing maintenance works after a lapse of certain periods. This will keep the building intact and also extend their life span.

Keyword: Investigation, Causes, Effects, Cracks, Building, Structures

INTRODUCTION

The actual tendency in civil engineering is to extend the live-cycle of large scale structures. Due to limited or even reduced resources for new constructions, it is necessary to use and rely on existing structures, which in many countries are coming to age. According to Charles (2004,) one of the main sources of information in monitoring concrete structures is crack, indicating weak zones and acting forces. But up to now, there is no system available which allows to measured and analyzed cracks objectively, precise and repeatable**.** Cracks in buildings 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 load, foundation settlement or it could be induced internally due to thermal movements, moisture changes, chemical action, etc. (Kashyzadeh, & Kesheh, 2012).

Cracks could be broadly classified as structural or non-structural. Structural cracks are those which are due to incorrect design. Faulty construction or overloading and, these may endanger the safety of a building, (Charles, 2004). Extensive cracking of a beam is an instance of structural cracking. Nonstructural cracks are mostly due to internally induced stresses in building materials, and, these generally do not directly result in structural weakening. However, sometimes non-structural cracks may result in corrosion of reinforcement and thus render the structure unsafe due to the penetration of moisture through cracks or weathering action, (Kashyzadeh, & Kesheh, 2012).

Vertical cracks in a long compound wall due to shrinkage or thermal movement is an instance of nonstructural cracking. Non-structural cracks normally do not endanger the safety of a building, but may look unsightly, or may create an impression of faulty work or may give a feeling of instability. In some situations, cracks may due to the penetration of moisture through them, spoil the internal finish, thus adding to cost of maintenance. It is, therefore, necessary to adopt measures for prevention or minimization of these cracks (Howson, &George 2003).

Grishma, (2014) on his opinion explained that the crack is an inevitable response to the inability of a structure to accommodate the movement to which it is subjected. There are two issues to be considered when assessing the causes for cracking: the first is the nature and significance of the cause of movement; the second is the ability of the structure to accommodate movement.

REVIEW OF LITERATURE

Crack

Charles (2004) defined crack as an inevitable response to the inability of a structure to accommodate the movements or loads to which it is subjected. He further stressed that a building component develops cracks whenever the stresses in the component exceed its strength and that buildings can be designed and constructed to eliminate many of the causes of cracking and design tolerance for those factors that remained either by introducing joints or by choosing movement-tolerant materials. When a structure is overloaded to the extent not covered in safety factors, concrete may be damaged or fail. Overloading may be in shear, flexure, or tension, or may be a result of fatigue or cyclic loading. Each of these has a different cracking pattern to look for (Khan, 2006).

Types of Cracks in Building

According to Howson, & George, (2003), the severity of a crack can be characterized in terms of its direction, width, and depth; cracks may be longitudinal, transverse, vertical, diagonal or random. Different risks cracking exist for cured versus uncured concrete, and for reinforced concrete. Breakages occur through thermal, chemical, or mechanical processes causing shrinkage, expansion, or flexural stress. Below are the various types of cracks and some of their possible causes according to them:-

Non-Structural Cracks: Non-structural cracks appear in the building foundation but do not *at present* threaten the structural integrity of the building. Over time, weather conditions, changes in temperature, and moisture content**s** will naturally cause the foundation to experience these types of cracks. It can be caused by several factors. Creep damage, settlement, shifting of foundations, hydrostatic pressure, and vegetation or trees**.** These cracks are often very thin hairline cracks that are usually less than three millimeters in width.

Structural Cracks: Structural cracks are caused by a variety of issues, like poor soil bearing, overloading, swollen soil, and poor construction sites. Generally, structural cracks are accompanied by interior problems, like sloping floors, doors, and windows that stick when closed. Structural cracks usually have some tell-tale signs. These cracks can be horizontal, vertical, diagonal, or appear like a staircase. There can be cracks in the foundation wall, in beams, or foundation slabs. Structural cracks often extend to the upper floors of the building but generally wider than three millimeters in width. Below are some of the types of structural cracks in buildings:

a) **Shrink Cracking:** This type of horizontal cracks due to evaporation of moisture from the concrete surface in ambient air is created, and when the evaporation rate of the concrete surface is very high, high evaporation rate within the concrete as well as plastic shrinkage cracking of type is created. This type of concrete cracks depends on several factors including temperature, ambient temperature, the relative humidity of the air, sun and wind, steam velocity inside the concrete mix and water-cement ratio.
b) **Cracking due to Reinforcement Corrosion:** Environments are the very corrosive effect on reinforced concrete structures in the past two decades has been considered highly such effects on the environment of reinforced concrete structures, creating cracks in the concrete cover and bond strength is reduced. In corrosive environments, the influence of chloride irons causes electrochemical corrosion is that this process will be subsequently oxidized steel. Various materials such as ferrous, and ferric oxidation of steel that is formed these products occupy a greater volume of steel consumed and when the corrosion continues, These products accumulated in the reinforcement and expansion causes pressure on surrounding concrete reinforcement is. Corrosion progresses, the pressure builds to such an extent that it caused internal cracks in concrete and can even cause cracking of the coating.

Cracking due to drying during the curing: These cracks are caused due to the impact on load-carrying capacity. These cracks may lead to failure of the structure become possible. Factors in creating this type of cracks are failure design, change service, increase the time to design, use of poor quality materials, and make mistakes in construction.

Causes of Cracks in Buildings

Fowler, (2008) described cracks in the building as a common occurrence, and that building components developed cracks whenever stress in the component exceeds its strength. According to him also, cracks are classified into structural and nonstructural categories. The structural ones

are due to faulty design, faulty construction or, overloading, which may endanger the safety of buildings. The nonstructural cracks are due to internally induced stresses, depending on the width of the crack, and the width is classified in to thin (1mm), medium (1mm to 2mm) and wide (2mm wide). Internally induced stresses in building components lead to dimensional changes and whenever there is a restraint to movement as is generally the case cracking occurs. There are numerous causes of cracking in the building, but most instances are related more to concrete specification and construction practices than by stresses due to induced forces. Fowler further highlighted some of the causes of cracks in the building as follows:

- Permeability of Concrete
- Moisture Movement
- Thermal Movement
- Elastic Deformations
- Poor Maintenance
- Movements due to Creep

Effects of Cracks on a building Structure

Some of the effects of cracks on a building structure include the followings:

Crack as warning sign

Cracks in your walls aren't just ugly; they can be warning signs for very serious problems in your home. Some cracks are normal and come from the natural aging process of a home. When it comes to cracks, horizontal cracks are more indicative of trouble than vertical cracks. Turning a blind eye to cracks in walls may mean you're missing the warning signs for serious and ongoing structural damage caused by subsidence. Cracks in walls are common in buildings; though some are nothing to worry about, others can indicate a sinking or damaged foundation (subsidence). If you don't address problematic cracks in walls, the damage to the foundations can quickly devalue the property, (Suresh, 2012).

Deping, (2007). There are micro or macro cracks, and harmful or harmless cracks. The crack width of the building is less than 0.05 mm is micro-cracks, bigger than 0.05 mm are macro-cracks. The differences between harmful and harmless cracks are depends on the uses, properties, environment of building and crack position, width. Normally the cracks bring following consequences called harmful cracks, such as: damage to the building function, reduce the structural stiffness, affect to the integrity of the building damage to the surface function of the structure and so on. If the cracks need to be fixed or not, should be based on cracks' properties, width, environment, structure category and so on. The temperature shrinkage deformation cracks in normal indoor environment have the lower control requirements.

Longhu, (2012). The cracks in the concrete wall would cause the leakage of the building; it reduces the stiffness, durability and seismic performance of buildings, if the cracks in the wall expend, it might be a big threat to human life and property safety. For example: Some penetrate cracks on the wall can reduce performance, especially affect to the building's usage and seismic

performance, cracks on the external wall cause leakage reduce external wall moisture-proof function, cracks are too dense, every temperature change accelerates the expansion of the crack, will cause bigger cracks and cracks on the wall surface damage to the later rendering, will affect to the appearance. May cause rendering layer crack off.

However, Friedman (2007) opined that the modality for preventing cracks on building structures which includes; select materials having small moisture movement e.g. bricks, lime stones, marble, plan for less richer cement content, larger size of aggregates and less water content, porus aggregates (from sand stone, clinker etc) prone for high shrinkage, plan for offsets in walls for length o f more than 600 mm among others.

Research Objectives

i. To identify the various causes of cracks on the study area?
ii. To identify the various effects of cracks on the study area?
iii. To find out the remedial measures for the effects of cracks on the study area?

Research Questions

iv. What are the various causes of cracks on the study area?
v. What are the various effects of cracks on the study area?
vi. What are the remedial measures to the effects of cracks on the study area?

METHODOLOGY

The study adopted both quantitative and qualitative framework The target populations in this research paper consists of various professionals who are the stake holders of building project in the study area, the sources of data that were relied upon for this research paper was derived from primary and secondary data. The primary data were collected from the respondents based on the research objectives and care was taken to ensure the schedule of questions was sufficient to provide the required data. The administration of the questionnaire facilitated the collection of primary data, and the secondary sources were collected from literature and were accordingly cited and referenced. The data collection methods that were adopted included only self-administered questionnaires and observation. During the survey process, a total of One hundred and three 103 structured questionnaires were randomly distributed to the respondent, but eighty-five (85) questionnaires were returned, the 5 -point scale of 1- strongly Agree 2- Agree, 1- Disagree, 4- Strongly Disagree 3- Undecided were adopted and all data were analyzed by using Descriptive statistical analysis of tables, and ranking.

RESULTS

Table 1: The various causes of cracks on the study area.

CAUSES OF CRACKS IN BUILDING	1	2	3	4	5	RII	RANK
Natural Forces	0	5	0	30	50	0.894	1st
Poor Construction Practices	0	6	8	11	60	0.894	1st
Poor Maintenance	2	3	5	25	50	0.877	3rd
Poor Workmanship	2	1	2	45	35	0.858	4th
Temperature Variations	3	6	6	20	50	0.854	5th
Permeability of Concrete	5	3	2	35	40	0.840	6th
Thermal Movement	4	4	12	17	48	0.837	7th
Moisture Movement	5	7	0	40	33	0.809	8th
Foundation Movement & Settlement of Soil	12	5	8	31	29	0.741	9th
Elastic Deformations	8	12	12	20	33	0.736	10th
Movement due to Chemical Reaction	11	7	6	39	22	0.727	11th
Structural Design	8	17	10	20	30	0.710	12th
Corrosion of Reinforcement	10	12	3	45	15	0.701	13th
Overloading	5	25	5	25	25	0.694	14th
Indiscriminate Addition and Alterations	14	21	0	35	15	0.637	15th
Movements due to Creep	7	14	4	28	22	0.632	16th
Alkali-Aggregate Reaction (AAG)	23	9	3	32	18	0.630	17th
Shrinkage	6	54	0	15	10	0.527	18th
Freeze/Thaw	30	50	0	0	5	0.381	19th

Source: Field Survey, 2019

Based on Table 1, natural forces and poor construction practice are ranked first cause of crack on the building with RII of (0.894). Poor maintenance and workmanship were ranked third and forth with relative importance indexes of (0.877) and (0.858) respectively. The fifth-ranked cause of cracks in building construction from the respondents' point of view is Temperature variation.

Furthermore, the permeability of concrete was also ranked the sixth factor that causes cracks in building with a relative importance index of (0.840). The seventh-ranked cause is thermal movement with relative importance index of (0.837). The eighth and ninth ranked cause moisture movement and foundation movement/settlement of soil with Relative Importance Indexes of (0.809) and (0.741) respectively elastic Deformation was ranked tenth causes of a crack in building constructions followed by Movement due to a chemical reaction, structural design, corrosion of reinforcement, overloading, Indiscriminate Addition and Alterations, Movements due to Creep, Alkali-Aggregate Reaction (AAG), Shrinkage and freeze/thaw among others

Table 2: The various effects of cracks on the study area

EFFECTS OF CRACKS IN BUILDING	1	2	3	4	5	RII	RANK
Some penetrate cracks reduces the performance of the wall; affect the building's usage and seismic performance.	0	0	0	50	35	0.882	1st
Cracks on the external wall cause leakage to reduce external wall moisture-proof function.	0	5	0	35	45	0.882	1st
If cracks are too dense, every temperature change accelerates the expansion of the crack, will cause bigger cracks.	2	8	5	20	50	0.854	3rd
Cracks on the wall surface damage to the later rendering, will affect the appearance. May cause rendering layer crack off.	5	3	12	35	30	0.792	4th

Source: Field Survey, 2019

The table 2 shows reducing the performance of the wall, leakage, external wall moisture-proof function, every temperature change accelerates the expansion of the crack, will cause bigger cracks. And the later rendering, will affect the appearance, of the building

Table 3 The remedial measures for the effects of cracks on the study area

REMEDIAL MEASURES TO THE EFFECTS OF CRACKS ON BUILDING	1	2	3	4	5	RII	RANK
Gravity Filling	0	4	0	62	19	0.825	1st
Epoxy Injection	0	12	0	40	33	0.821	2nd
Use of Steel Wire Mesh	5	16	3	40	21	0.731	3rd
Filling in Flexible Putty	6	12	9	40	18	0.722	4th
Drilling and Plugging	5	25	0	35	20	0.694	5th
Stitching	14	17	2	40	12	0.644	6th
Routing and Sealing	15	22	5	25	18	0.621	7th
Repairing of Surface Cracked Wall	21	27	2	20	20	0.614	8th
Overlay and Surface Treatments	14	17	15	25	14	0.618	9th

Source: Field Survey, 2019

The table 3 shows that remedial measures were analyzed based on their Relative Importance Indices (RII). Gravity filling is identified to be the highest measure according to the result with relative importance index of (0.825). The typical procedure is to clean the surface by air blasting and water blasting. Wet surface should be permitted to dry several days to obtain the best crack filling. The lowest rank, according to the respondents, was seen to be the overly and surface treatments with a relative importance index of (0.618).

SUMMARY OF MAJOR FINDINGS

1 The respondents generally agreed that out of the total of nineteen (19) causes of cracks in the building, the top ten causes are arranged in descending order of importance as: natural forces, poor construction practice, poor maintenance, poor workmanship, temperature variations, permeability of concrete, thermal movements, moisture movements, foundation movement and settlement of soil, and elastic deformations.

2 The respondent identify that reducing the performance of the wall, leakage, external wall moisture-proof function, every temperature change accelerates the expansion of the crack, ill cause bigger cracks. And the later rendering, will affect the appearance, of the building

3 The analysis of data in the effects of cracks in building revealed that: Some penetrated cracks on the wall can reduce performance, especially affect the building's usage and seismic performance. Cracks on the external wall cause leakage reduce external wall moisture-proof function. If cracks are too dense, every temperature change accelerates the expansion of the crack, will cause bigger cracks. Cracks on the wall surface damages the later rendering, affects the appearance or may cause rendering layer crack, as some of the effects of cracks in building.

CONCLUSION

Based on the findings from the study, the following conclusions were drowned: natural forces and poor construction practice were found to be the major causes of cracks in building a structure in the study area. Poor maintenance was found to be the second major causes of cracks in buildings. Penetrate cracks are identified to be of the highest effect of a crack in building structures. Gravity filling is found to be the best remedial measure to the effects of cracks on building structures.

RECOMMENDATION

Consultants should always be involved in the execution of a building project; Periodic maintenance culture should be embraced by both the client and the users of the building accordingly. Public enlightenment campaigns should be organized to enlighten the people on the various causes and effects of cracks on buildings to facilitate for a better solution to the problem of cracks in buildings, among other things.

The project managers should ensure a proper choice of site for a given project; there must be effective supervision throughout the construction processes, adequate site investigation and analysis should be carried out before the commencement of construction process so as reduce the possible effect of cracks in future.

Remedial measures suggested in this study should be adopted to tackle the menace of cracks in the buildings. It is recommended that the execution of the remedial measures should be supervised by professionals in building industry.

REFERENCES

Charles C. R. (2004).*Evaluating Cracks in Building*. Retrieved from www.http//:crobberts. com.

Deping L. (2007). *The causes of cracks and prevention measures*. Retrieved from www.buildingresearch.com.np/services/srr/srr2.php 20121025.

Fowler, D. (2008). *Cause and Cures of Cracking in Concrete:* Paper presented at the Foundation Performance Association. Retrieved from www.buildingresearch.com.np

Friedman, D. (2007). *How to identify, evaluate and repair shrinkage cracks in poured concrete:* A paper presentation retrieved from www.concretenetwork.com

Grishma T. (2014). *Building Cracks – Causes and Remedies*: A paper presented at the 3rd World Conference on Applied Sciences, Engineering & Technology. Kathmandu, Nepal.

Howson, L. & George (2003). *Building Maintenance and Repairs*: (2nd Edition) London Group Limited Publication.

Kashyzadeh, K. & Kesheh, N. (2012). *Study type of Cracks in construction and its controlling:* Retrieved fromwww.ijetae.com.

Khan, M. S. (2006). *Control of Cracking in Concrete transportation Research Circular:* Transportation Research Board, Washington, D.C. P. 1-16. Retrieved from http://onlinepubs.trb.org/onlinepubs/circulars/ec107.pdf

Longhu L. (2012). *Cracks in Different Types of Concrete Construction and Renovation*: A Dissertation for Bachelor of Architectural Technology and Construction Management at VIA University College, Horsens, Denmark.

Suresh, C. (2012). *Cracks in Buildings and their Remedial Measures*: Indian Concrete Journal.