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Life-Cycle Cost Analysis of Concrete Structures

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Abstract - *The initial cost of structural design and construction is usually prioritized in concrete structural design. The performance and durability of a building, however, gradually decrease over time due to the progressive loss of material traits and attributes. To maintain the performance of the buildings, maintenance of decaying concrete structures is necessary on a regular basis. But when it comes to upkeep, it's important to utilize your money as efficiently as you can. The predicted number of maintenance needs for both new and decaying structures must thus be estimated using techniques. This essay examines a number of approaches that academics have suggested for examining the life-cycle costs of buildings.*

Key Words: Life cycle cost, rehabilitate, deteriorating structures, Carbonation Chloride attack Alkali Silica Reactivity (ASR), one-dimensional environmental

1. INTRODUCTION

For many years, concrete has been a common building material. Research over the last several decades, however, has shown that concrete constructions deteriorate with time and need care. A building's life-cycle cost also includes maintenance and repair expenses in addition to construction expenditures. Traditionally, structural design has tended to place a lot of emphasis on the upfront costs associated with structural design and construction. The fact that this method does not carefully take into account the real future expenses that would accrue over the course of the structure's life is a significant disadvantage [1]. Therefore, it was necessary to determine when and how to repair, renovate, and replace the failing buildings. In order to analyse maintenance costs for deteriorating buildings throughout their service life, efficient approaches are thus required [2].

The lifespan of a concrete building is comparable to that of a person. As people age, their bodies may deteriorate and become obsolete [3]. In general, life cycle cost analyses take into account the costs of construction, inspection, maintenance, and failure. This article examined many studies done by academics to determine the life cycle costs of concrete buildings..

2. CONCRETE STRUCTURES' DETERIORATION MECHANISMS

Major processes of RC Structures' degradation have been recognised as:

- Corrosion induced cracking
- Carbonation
- Chloride attack
- Sulphate attack
- Freeze thaw attack
- Alkali Silica Reactivity (ASR)

- **Corrosion induced cracking**

Numerous researchers have identified corrosion-induced cracking as the primary factor contributing to the degeneration of concrete structures. The entry of chloride ions and carbonation are the main causes of corrosion.

- **Carbonation**

In the process of carbonation, atmospheric carbon dioxide seeps into the concrete and interacts with hydroxides to produce carbonates. This lowers the concrete's alkalinity (pH) and raises the possibility of corrosion.

- **Chloride concentration**

Concrete provides a passive layer on steel that shields it from corrosion thanks to its extremely alkaline composition. The protective coating may be destroyed by a high input of chloride ions from saltwater.

- **Sulphate Attack**

Sulphates attack concrete by cooperating with hydrated parts in the solidified concrete glue, outstandingly calcium aluminates hydrate, which is why excessive levels of sulphates in soil or water may attack and ruin concrete. Places where cement is presented to the wetting and it are more helpless against dry cycle to sulphate assault.

- **Freezing and thawing attack**

Alternating cycles of freezing and thawing have an impact on concrete's durability. Concrete expands as it freezes as a result of the displacement of water by ice formation, which damages the concrete. The aggregate particles, subsequent expansion of the cement paste, or both may lead to degradation.

- **Alkali Silica Reactivity (ASR)**

When the alkali hydroxides and reactive silica in the concrete react, the concrete deteriorates. Alkali silica gel has an expanding tendency, which results in severe cracking conditions.

3. CONCRETE STRUCTURE DESIGN BASED ON LIFE CYCLE COST

From the standpoint of structural design, the initial costs associated with design and construction as well as the ongoing expenses associated with maintenance and repair are the most significant expenditures. Although energy and running expenses, like warming and cooling, might be significant elements in the all out life cycle cost contemplations for a construction or building, they normally are free of the underlying model particulars for strength, trustworthiness, and workableness. Thus, the primary objective of a "underlying life cycle cost plan" technique is to work out some kind of harmony between the underlying expenses of foundational layout and development and the future/repeating expenses of support with respect to the different plan models. The size and timing of these future not entirely settled by the assistance life of the construction, which not set in stone by the openness climate and the extended level of underlying execution. Thus, this plan methodology integrates administration life and the subsequent solidness worries into the foundational layout process.

4. LITERATURE REVIEW

Narasimhan (2006) A design's life cycle cost is the complete of the multitude of expenses caused from the hour of development to the furthest limit of its helpful life. Studies were conducted by a number of academics to determine the life cycle cost of concrete buildings. We already spoke about how the minimum concrete cover, maximum water/cement ratio, minimum cement content, and other specifications determine how durable a concrete construction will be. A clear connection between performance and structure life cannot be established with such guidelines. Therefore, it is important to choose a design strategy that will allow you to evaluate the structure's performance throughout the course of its existence on a solid and consistent foundation. [1]

Kong and Frangopol (2003) proposed a technique to assess the estimated cost of life-cycle maintenance as well as the likelihood of maintenance at a certain age or period for a decaying building. The suggested strategy may be used to maintain both new and old civil infrastructures using a variety of maintenance techniques. In order to illustrate this suggested technique, an existing reinforced concrete bridge was also examined. [2]

Li and Guo (2012) provided a case study for the examination of life cycle cost analysis using four buildings from Taiwan University. To create a life cycle cost prediction model, historical maintenance and repair data from the previous 42 years were used. [3]

Kim and Frangopol (2011) proposed a method for predicting how well constructions would perform structurally using structural health monitoring (SHM). It has been determined that SHM's goals are to evaluate underlying execution, gauge remaining help life, and give an instrument to pursuing upkeep arranging choices. [4]

Passer et al. (2009) outlined the discoveries of a plausibility study to decide likely calls for activity for the development area towards supportability: Contrasting three places of business using steel, reinforced concrete, and wood load bearing systems. A life cycle assessment (LCA) was conducted for the evaluation. It is looked at how the advantages of sustainable building may already be evaluated in relation to various construction methods. The key finding is that the three building methods are quite similar to one another and that no method can be chosen as the best only based on life cycle analysis. To complete the three dimensions of sustainability, it is important to add the two additional pillars of sustainability to the one-dimensional environmental evaluation in order to align it with holistic concerns. As a result, in the framework of buildings, considerations like safety and usability must also be taken into account in another aspect known as primary supportability. [5]

Humphreys et al. offered an idea guide to assist chiefs with distinguishing the optimal course of action for bridge restoration in Australia caused by early degradation due to exposure to hostile conditions. By taking into account the necessary components of bridge restoration costs, the choice investigation is alluded to as a full life cycle cost examination. Additionally, the outcomes of Queensland's bridge inspections are reported. [6]

Bowyer (2013) presented a report to explain how Life Cycle Cost Investigation (LCCA) and Life Cycle Appraisal (LCA) vary, to sum up what is realized about the existence cycle expenses of non-private wood development, to look at the existence cycle expenses of wood designs to those of different materials, and to audit processes for directing life cycle cost examinations on underlying frameworks or entire structures. There are extra synopses of LCCA materials available. [7]

Wen and Kang (2000) We out a responsiveness examination to assess the best plan corresponding to vital however begging to be proven wrong factors such plan life, mortality and injury costs, primary limit vulnerability, and markdown rate. The methodology is utilized to make plans for Los Angeles, Seattle, and Charleston, South Carolina, affected by seismic tremors, winds, and the two dangers. Current plans are diverged from the outcomes. Seismic pressure in Seattle and wind load in Charleston "overwhelm" the best plan. These dangers don't, in any case, "control" or "oversee" the plan since the smaller risk nevertheless has a big impact. [8]

Lagaros and Magoula (2013) For the purpose of constructing steel and steel-reinforced concrete composite structures subject to interstate drift restrictions, a performance-based seismic design technique was put forward. This approach was organized as a foundational layout streamlining issue. Eight experiments are considered for this reason, with four steel and four steel-supported substantial composite designs being the most unmistakably planned with the least beginning expense. The life-cycle cost examination (LCCA) technique is viewed as a legitimate strategy for assessing the expense of harm from tremors that will happen in the future and occur within the design life of a building. In this research, the best designs for composite design techniques using steel and steel-reinforced concrete are evaluated using LCCA.[9]

Gencturketal. (2014) provided an analysis to first pinpoint the elements of an LCC assessment that have a direct impact on the results and then put forth solutions to increase the study's accuracy. There are several issues with the LCC optimization of structures studies that have already been done. These flaws include the use of generic definitions for structural limit states, inadequate handling of uncertainty, and simplified analytical methodologies to evaluate structural capacity and seismic demand. The issue plan and a fast outline of the writing on LCC streamlining of designs are given underneath. Techniques are suggested to address the limitations described above while an LCC model is offered. In order to demonstrate the technique, LCC analysis of an example reinforced concrete (RC) structure is used. [10]

5. Conclusions

1. The actual life of structural services was impacted by premature degradation, such as corrosion of reinforced concrete structures brought on by hostile environmental conditions.

2. Due to numerous variables, such as corrosion of the reinforcing steel, the state of the concrete, and the environment, the actual design life of reinforced concrete might be decreased from the specified life to extremely low.

3. The failure to perform maintenance on time was one of the serious problems that shortened the service life of the buildings. Additionally, postponing maintenance may result in higher costs for repairs and rehabilitation.

4. The most important decision-making steps are the time to repair and the choice of protective system, both of which often have a significant influence on the life cycle cost. Planning maintenance and analysing repair costs is thus required from the design stage.

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