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Research Article

Probabilistic Service Life Appraisal of Abandoned Building Projects in Nigeria

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Abstract: Nigeria is a developing country where abandoned building projects abound. Knowing the reliability status of such abandoned buildings now becomes a task of paramount importance to both civil and structural engineers to avoid loss of lives or damage of properties in the event of collapse. In this paper, the result of probabilistic service life appraisal of an abandoned building project is discussed. The service life appraisal parameters employed in the reliability prediction were obtained from the non-destructive test conducted on the Laboratory Block at College of Continuing Education, University of Port Harcourt, Rivers State Nigeria. The period that elapsed between the project commencement and abandonment is a time dependent process and Gamma distribution model was the method invoked in the service life appraisal. The obtained value of performance index (3.00) was compared with the code specified values for the various classes of structural members involved and was found to be less than 4.9 for beams in flexure, 4.5 for slabs, 3.6 for beams in shear and 3.9 for compression members subjected to a combination of both dead and imposed loads. The structure is therefore, not safe and may result in fatal accidents and damage of properties on collapse.
Keywords: Reliability status, probabilistic service life, reliability prediction, abandoned building projects, non-destructive test

INTRODUCTION

In Nigeria is a developing country were many abandoned building projects abound. A question now arises 'how safe are the abandoned structures?' Probabilistic concept becomes a useful tool for decisions about the acceptability of the abandoned structures [1]. According to Melchers [2], structural appraisal of partially completed or existing buildings may be needed when there is concern about some aspect of the design or construction as well as the quality of the construction materials used and the structures would have undergone some degree of structural deterioration. Evaluation of reliability status of abandoned building projects is a task of paramount importance to both civil and structural engineers to enable the clients or building owners make optimum decisions on whether to demolish the existing structures, make modifications, carry out minor or major repairs, continue with the existing structures or put the structures into use [3]. In the event of structures showing signs of failure, recognizing the nature of the risk determines the implementation of measures that will reduce the risk rather than sitting down and watch the buildings deteriorate and collapse eventually. Loss financing will be reduced in most instances and losses will be avoided or reduced to the bearest minimum [4-6].

The use of conventional factor of safety in the prediction of structural reliability status is not the best way to assess the safety of existing structures as the parameters used in the safety evaluation and design models are mere deterministic quantities [7]. The aim of structural design is to design a structure so that it fulfils its intended purpose during its intended lifetime with adequate safety, serviceability and economy. Structural safety implies that the likelihood of collapse of structure is acceptably low not only under normal expected loads, but under abnormal but probable overloads. Probabilistic concept is the basis for defining design criteria to guide concrete structures against collapse. As a result uncertainties inherent in structural loadings, evaluation of structural safety can only be achieved using probabilistic concept . The philosophy is based on the theory that the various uncertainties in structural design could be handled more rationally in the mathematical framework of probability theory [8]. Although, it may not have provided answers to all issues of loading uncertainties instructural loading, it has helped in no small measures in the evaluation of reliability status of most engineering structures [9].

In this paper, gamma distribution model is used to predict the reliability status of an abandoned building project. The safety status evaluation model is simple, straightforward and can be manually achieved.

MATERIALS AND METHOD

Gamma Distribution Model

Consider signs of structural deterioration in an abandoned to attract evaluation of safety status as kth occurrence of the event of structural deterioration. Also, let X_k represent the time the kth event. The structure deteriorates over time. Hence, the time until the kth occurrence of structural deterioration occurs is a gamma process. According to Ranganathan [1],

The probability density function of the gamma variable X_k having parameters K and λ is given by:

$$f_X(x) = \frac{\lambda(\lambda x)^{K-1} e^{-\lambda x}}{(k-1)!}, \; x \geq 0 \text{ --------------- (1)}$$

The parameters K and λ are related to the mean and variance by equations (2) and (3) respectively:

$$E(x) = \mu_x = \frac{k}{\lambda} \text{ ------------------------------------ (2)}$$

$$Var(x) = \sigma_x^2 = \frac{k}{\lambda^2} \text{ ------------------------------- --(3)}$$

Where: k and λ are shape and scale parameter respectively. Using equation (2) and (3), the coefficient of variation δ_x is given by:

$$\delta_x = \frac{1}{\sqrt{k}} \text{ ---(4)}$$

The distribution is generalized when K is a non-integer value.

Therefore, for non-integer value of K, equation (1) can be written as:

$$f_x(x) = \frac{\lambda(\lambda x)^{K-1} e^{-\lambda x}}{\Gamma(k)}, \; x \geq 0, \; \lambda \geq 0, \; k \geq 0 \text{ ----- (5)}$$

Where:

$$\Gamma(k) = \int_0^\infty e^{-t} t^{k-1} dt \text{ ------------------------------ (6)}$$

Equation (5) represents the gamma function of K.

The incomplete gamma function is given by:

$$\Gamma(k, X) = \int_0^X e^{-t} t^{k-1} dt \text{ ---------------------- (7)}$$

Using equation (7), the cumulative distribution function of X is given by:

$$Fx(x) = \int_0^x f_X(x)\, dt \text{ ---------------------------- -(8)}$$

The right-hand side of equation (8) equals:

$$\int_0^X f_X(x)\, dt = \frac{\lambda^k}{\Gamma(x)} \int_o^x e^{-\lambda x} X^{k-1} dx \text{ --------------- (9)}$$

Implying that:

$$F_X(x) = \frac{\lambda^k}{\Gamma(x)} \int_0^x e^{-\lambda x} x^{k-1} dx \text{ ------------------- (10)}$$

Let

$$y = \lambda x \text{ ---------------------------------- (11)}$$

Equation (10) now transforms to:

$$F_X(x) = \frac{1}{\Gamma(x)} \int_o^{\lambda x} e^{-y} y^{k-1} dy \text{ ------------------- (12)}$$

The right-hand side of equation (12) equals:

$$\frac{1}{\Gamma}(x) \int_0^{\lambda x} e^{-y} y^{k-1} dy = \frac{\Gamma(k, \lambda x}{\Gamma(k)} \text{ -------------- (13)}$$

Implying that:

$$F_X(x) = \frac{\Gamma(x, \lambda x)}{\Gamma(k)} \text{ --------------------------------- (14)}$$

The structure fails when the concrete strength in the structure $\leq 15/mm^2$. Hence the probability of failure, p_f of the structure is:

$$p_f = p(X \leq 15) \text{ ----------------------------------- (15)}$$

Equation (15) can be written as:

$$F_X(x) = 1 - \frac{\Gamma(k, \lambda x)}{\Gamma(k)} \text{ ----------------------------- (16)}$$

RESULTS

Table 1: Results of Schmidt hammar test on concrete [1].

S/No	Location	Rebound Hammer readings	Average Rebound	Concrete Strength from Rebound Test (x)
1	Middle panel	23,23	23	18
2	Edge panel	23,23	23	18
3.	Beam 2	20,20	20	14
4.	Slab 2	24,24	24	20
5.	Slab 1	18,19	19	8
6	Beam 1	12,12	12	5
7	Staircase	23.3,19	21.2	15
8	Middle column	35,27	31	29
9.	Corner column	27,27	27	25
10	Column footing	12.5, 6	9	4
				$\mu_x = \sum_{i=1}^{10} \frac{X_i}{10} = 15N/mm^2$

From Table 1, $E(X) = \mu_x = 15N/mm^2$

Using equations (2) and (3) we have:

$$E(x) = \frac{k}{\lambda}$$

Var $(x) = \frac{k}{\lambda^2}$

From statistics,

Var $(x) = E(x^2) - [E(x)]^2$

Implying that:

$$E(x^2) = \frac{k}{\lambda^2} + \frac{k^2}{\lambda^2} = \frac{k(k+1)}{\lambda^2}$$

From Table 1,

$$\frac{1}{10}\sum_{i=1}^{10} X_i = 15$$

and

$$\frac{1}{10}\sum_{i=1}^{10} X_i^2 = 304$$

Using equation (2), we have:

$$\frac{k}{\lambda} = 15$$

and

$$\frac{k(k+1)}{\lambda^2} = 304$$

Substituting $k = 15\lambda$ into the second equation gives:

$$\frac{15\lambda(15\lambda+1)}{\lambda^2} = 304$$

$$\lambda = 0.1899, k = 2.848$$

The mix proportion of 1:2:4 was specified in the design and this corresponds to a strength of 20N/mm^2 [1].

Therefore, probability of failure $P_f = 1 -$ probability of concrete strength less than 20N/mm^2

$$P_f = 1 - F_x(20) \quad = 1 - \frac{\Gamma(k, \lambda x)}{\Gamma(k)}$$

$$= 1 - \frac{\Gamma(3.798)}{\Gamma(3.79)}$$

$= 1-0.9986 = 1.4 \times 10^{-3}$

The corresponding reliability index is 3.00

DISCUSSION AND CONCLUSION

The result of structural service life of an abandoned building appraisal using a time-dependent gamma distribution probabilistic model has been presented. The performance index of 3.0 obtained from the reliability analysis when compared with the code specified values for the various classes of structural members involved was found to be less than 4.9 for beams in flexure, 4.5 for slabs, 3.6 for beams in shear and 3.9 for compression members subjected to both dead and imposed load combination. In conclusion, the structure may not perform satisfactorily in service and can lead to uncommon accidents and damage of properties on collapse due to compromised as-built concrete quality judging from the obtained value of safety index. The structure is therefore, recommended for careful demolition to build a new one while a more stringent supervision should be carried out.

REFERENCES

1. Ranganathan R; Structural Reliability, Analysis and Design Jaico Publishing House, Mumbai, 1999.
2. Melcher R; Structural Reliability Analysis and Prediction. Second Edition, John Wiley and Sons, 1999.
3. Mori Y, Ellingwood BR; Reliability-Based Service Life Assessment of Aging Concrete Structure. Journal of Structural Engineering, 1993;119(5):1600 -1621.
4. Afolayan JO; Probability based design of glued thin-webbed timber beams. Asian Journal of Civil Engineering (Building and Housing) , 2005; 6(1-2):75-84.
5. Wilkinson S; Physical Control of Risk, (Witherby), London, 1992.
6. Villemeur A; Reliability, Maintenance and Safety Assessment. Vol.2, 1992, (John Wiley), Chichester.
7. Freudenthal AM; Safety and Probability of Structural Failure. Transactions, ASCE, 1956; 121:1337 -1375.
8. Unnikrishna Pillai S, Devdas M; Reinforced Concrete Design: Second Edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2003.
9. Haugen EB; Probabilistic Approach to Design, John Wiley, New York, 1986.