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Prediction and probabilistic analysis of accidents in elevator installation -Nigerian Experience

Adekomaya, S.O.and Akinyemi, O.O

Department of Mechanical Engineering, Olabisi Onabanjo University, Nigeria
*Corresponding Author: oludaisiyetunde@gmail.com

Abstract.
Elevator sector is one of the safety methods of travel, and sadly hundreds of people suffer extreme injury or death due to elevator accident. Most elevator accidents occur during installation of the elevator itself. This paper takes a closer look at elevators industry in Nigeria focusing on the occurence of installation of elevators accident in 2009 and come up with the statistical distribution of each of the risk involved in the stages of installation of elevator.
The methodology involves statistical modelling of the occurrence of installation accident. A Poisson sequence or Poisson process is used to develop a model that will predict the probability of accident in installation of elevator.This research concludes that the point statistic estimator for the probability distribution for installation elevators accident for the year 2009 is 0.88.
Keywords: elevators, installation, risk, shaft, probability..

Introduction:
Incidents involving elevators kill about 30 and seriously injure about 1,700 people each year in the Nigeria [2]. Elevators cause almost 90% of the deaths and 60% of serious injuries. Injuries to people working on or near elevators (installation of elevator while working) including those installing, repairing, and maintaining elevators, and working in or near elevator shafts – account for 14 (almost half) of the annual deaths. Half of the deaths of workers working in or near elevator shafts were due to falls into the shaft. Incidents where workers were caught in/between moving parts of elevators, are in or on elevators or platforms that collapse, or are struck by elevators or counterweights are also numerous[6].
Elevators are potential sources of serious injuries and deaths to the general public and to workers installing, repairing, and maintaining them. Workers are at risk also, for instance, when cleaning elevator shafts, conducting emergency evacuations of stalled elevators, or doing construction near open shafts. State and local authorities recognize such hazards and require periodic inspections of elevators and escalators[7]. Organizations such as the Nigeria Society of Mechanical Engineers (NSME) have set standards for the construction and maintenance of elevators and escalators and for their safe operation[3].

METHODOLOGY
The approach involves statistical modelling of the occurrence of intallation accident for the year 2009. A Poisson sequence is used to analyse the data and the process is based on the following assumption [4].

- An event can occur at random and at any time or any point in space. Past installation Accident possessed this characteristic-they occurred in a random manner in different installation in Nigeria.
- The occurrence of an event in a given time or space interval is independent on what happened in any other non-overlapping interval. Accident do occurr as the series of independent events in time and space
- The probability of an event occurring in small interval Δt is proportional to Δt and can be estimated by $\lambda\Delta t$ where λ is the mean rate of occurrence of the event.

$$\lambda = \frac{1}{T_a} \qquad \text{.............................. (1)}$$

Where T_a is the average time interval between consecutive events.
Fig.1 below, illustrates a scheme of a Poisson process that commences at time t = 0 and at random times t_1, t_2, t_3, t_4, ..., t_i , t_N, the Poisson-type events occur. Where t = 0, is the first event that occur in a given period.

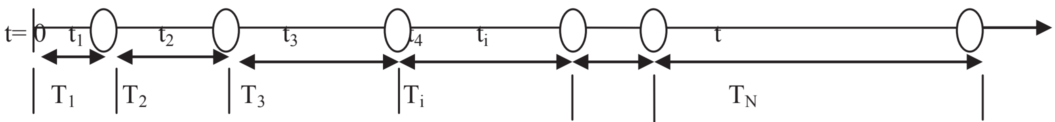

Figure.1 A scheme of poisson process.

Data Analysis
Data were collected for installation Accident for monthly occurence for the year 2009 and were used to analyse the frequency of installation accident. The data were grouped into two namely; pre-safety period and Safety

period. From fig. 1 above which illustrate Poisson events, we determine time interval between two consecutive events that occur per month.

Therefore, let

t_o = 1st day in a year

t_1 = 1st installation accident recorded.

t_2 = 2nd installation accident recorded.

t_3 = 3rd installation accident.

⁞ = ⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞

t_i = i accident occur at i

Where i = 1, 2, 3,..., i

Let $T = \Delta t = t_1 - t_0$

Where T is the time interval between two consecutives installation Accidents that occur per day and the interval was group in a class width range and was used to drawn bar charts which represent a probability distribution.

Result and Discussion

Data for pre-safety period stated in the 2009 was used, the time interval of consecutive installation accidents were fined and grouped in an interval class width range, which was used to drawn a smooth and likely probability distribution.

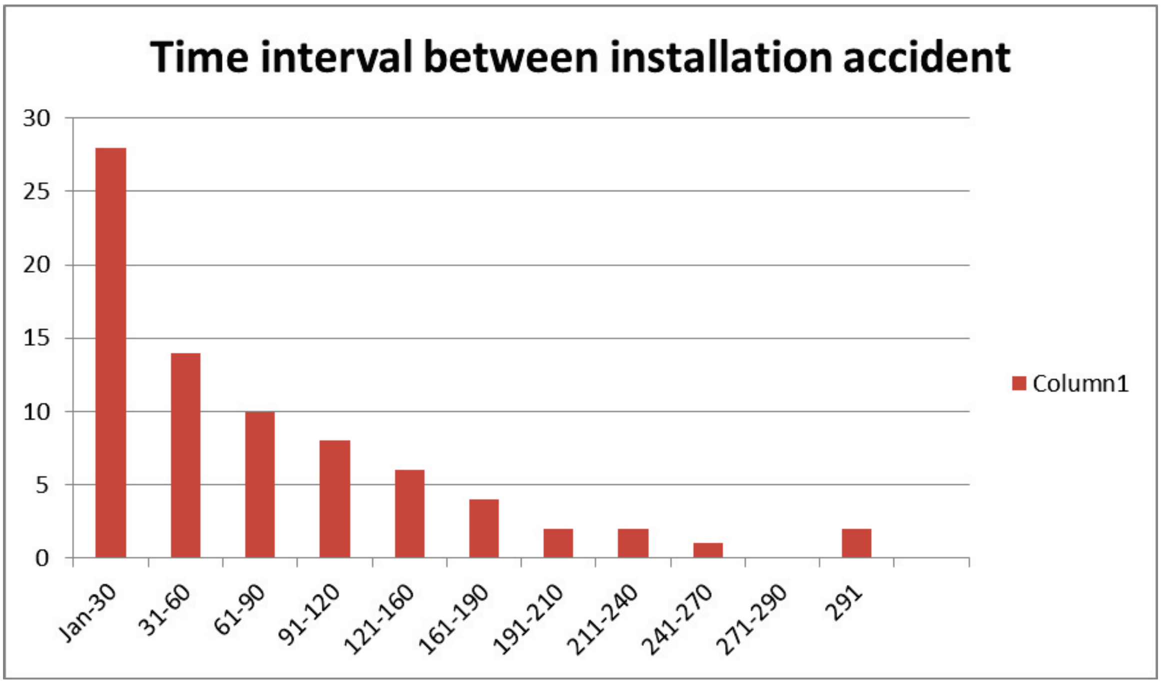

Figure.2: Bar Chart showing Distribution of time intervals between consecutive installation Accidents.

According to these bar charts, range 35 appears to be the smoothest and shape resembles that of a Poisson mass function. This graph is a discrete distribution graph where $\sigma = \frac{\sqrt{vari(x)}}{\bar{x}}$ is a point statistic estimator to affirm the likely probability distribution of data collected.

The point statistics is calculated using this formula

$$\sigma = \frac{\sqrt{vari(x)}}{\bar{x}} \quad \text{...} \quad (5)$$

The result $\frac{\sqrt{vari(x)}}{\bar{x}} < 1$ might suggest a binomial distribution; near 1 suggest a Poisson distribution while $\frac{\sqrt{vari(x)}}{\bar{x}} > 1$ would be characteristic of negative binomial or geometric. From the data obtained, the probability distribution is calculated using the formula above

Table 1: Installation accident during Pre-Safety Period in the year 2009

Range	X	No of installation Accident occur (f)	Fx	$(x - \bar{x})$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
1 – 30	15.5	28	434	-45.03	2027.70	56775.6
31 – 60	45.5	14	637	-27.53	730.62	10228.68
61 – 90	75.5	10	755	-2.47	6.10	61.0
91 – 120	105.5	8	844	32.47	1025.92	3207.36
121 - 160	140.5	6	843	67.47	4552.20	27313.2
161– 190	175.5	4	702	102.47	10500.10	42000.4
191 – 210	200.5	2	401	127.47	16248.60	32497.2
211 – 240	225.5	2	451	152.47	23247.10	46494.2
241 – 270	255.5	1	255.5	182.47	33295.30	33295.30
271 – 290	280.5	0	0	207.47	43043.80	0
291 – 310	300.5	2	301	227.47	51742.60	103485.2
		∑ = 77	∑ =5623.4			∑ =355358.14

$$\text{MEAN} = \frac{\sum f(x)}{\sum f}$$
$$= \frac{5623.4}{77}$$
$$= 73.03$$

$$\text{Standard deviation} = \sqrt{\frac{\sum f(x-\bar{x})^2}{\sum f}}$$
$$= \frac{355358.14}{77}$$
$$= 67.93$$

Therefore, point statistic estimator for this probability distribution

$$= \frac{\sqrt{\text{vari}(x)}}{\bar{\bar{x}}}$$
$$= \quad 67.93/77$$
$$= 0.88$$

This value is near 1 which suggests that the probability distribution for installation Accidents occurrences is a Poisson distribution.

Conclusion

As the installation of elevators continue, the probability of accident will occur will also increase. This fact was established by using poisson distribution. There are two types of period of accident and they are pre safety period and safety period. From the range of days accident may occur, we find the average mean of installation and then determine the standard deviation of the pre safety period of installation accident. The standard deviation enables us to find the point statistic estimator for this probability distribution. This point static elevator will enable us to take preliminary caution to avoid accident.

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