Reliability Analysis of Time-Dependent System when the Number of Cycles Follow Geometric Distribution and Stress-Strength Follow Exponential Distribution

N. Swathi¹,*

¹ Department of Mathematics, Kakatiya University, Warangal, Telangana, India.

Abstract: Failure of a system may occur due to certain type of stresses acting on them. If these stresses do not exceed a certain threshold value the system may work for a long period. On the other hand, if the stresses exceed the threshold they may fail within no time. There is uncertainty about stress and strength random variables at any instant of time and also about the behavior of the variables with respect to time and cycles. Time dependent stress-strength models are considered with repeated application of stress and also the change of the strength with time. Reliability of time dependent stress-strength system is carried out by considering each of stress and strength variables are random-fixed. In this paper to find the reliability, components are assumed to be identical and the number of cycles for any time period t is assumed to be random. Expression for system reliability have been attained when number of cycles can be follow Geometric distribution and stress and strength both follow exponential distribution & computations were also done.

Keywords: Stress-strength system, reliability, Geometric distribution, Exponential distribution, Time dependent.

1. Introduction

Time dependent stress strength system is defined by [1]. A component fails if the stress on it is exceeding than its strength. In the present paper, the uncertainty about the stress and strength variables is classified into three categories:

(1). Deterministic: the variable assumes values that are exactly known a priory.

(2). Random fixed: the variable is random at any particular instant of time; the word fixed in this classification refers to the behaviour of the random variable with respect to time and/or cycles; it means that the random variable changes or varies with time in a known manner.

(3). Random independent: the variable is not only random but unlike the random fixed case, the successive values assumed by the variables are statistically independent, in accordance with Kapur and Lamberson and Schatz, et al. Here, in this paper, the components are assumed to be identical and the number of cycles for any time period t is assumed to be random. Expression for system reliability have been attained when number of cycles can be follow geometric distribution and stress and strength both follow different distribution.

* E-mail: swathinalabolu11@gmail.com
1.1. Notations

- $R_n$: Reliability after $n$ cycles
- $R(t)$: Reliability at time $t$
- $R$: Reliability, independent of the cycle number (fixed)
- $X$: Stress variable
- $Y$: Strength variable
- $x_0$: Deterministic stress
- $y_0$: Deterministic Strength
- $X_i$: Stress on the $i^{th}$ cycle
- $Y_i$: Strength on the $i^{th}$ cycle
- $f(x)$: Probability density function of a random variable $X$
- $g(y)$: Probability density function of a random variable $Y$
- $E_i$: Event no failure occurs on the $i^{th}$ cycle
- $f_0(x_0)$: Probability density function of a random variable $x_0$
- $g_0(y_0)$: Probability density function of a random variable $y_0$
- $p_i(t)$: Probability of $i$ cycles occurring in the time interval $[0, t]$
- $p$: Probability of success in any trial
- $q = 1 - p$: Probability of failure

2. Reliability Evaluation

If the cycles occur at random times, then

$$R(t) = \sum_{i=0}^{\infty} p_i(t) R_i$$

Where $p_i(t)$ is the probability of $i$ cycles occurring in the time interval $[0, t]$ and $R_i$ is, as before, the probability of all $i$ success. Clearly the case of deterministic cycle times becomes a special case above equation. In some cases it is appropriate to assume that the number of cycles occurring in a given time interval are Geometric distributed. Hence

$$P(X = x) = q^x p, \ x = 0, 1, 2, \ldots$$

Case 1: Deterministic Stress and random-fixed Strength

Let the stress be $x_0$, a constant, and the strength on the $i^{th}$ cycle be $Y_i$ given by

$$Y_i = Y_0 - a_i, \ i = 1, 2, \ldots$$

Where $a_i \geq 0$ are known constants. Further, the $a_i$’s are assumed nondecreasing in time. The probability density function of $Y_0$, $g_0(y_0)$ is assumed known. Then

$$P[E_n] = P(x_n \leq Y_n)$$
$$= P(x_0 \leq y_0 - a_n)$$
$$= \int_{x_0 + a_n}^{\infty} g_0(y_0) dy_0$$
Hence

\[ R_n = P[E_n] = \int_{x_0 + a_n}^{\infty} g_0(y_0) dy_0 \]

Let \( Y_i = Y_0, i = 1, 2, \ldots \) be the strength random variable with a known probability density function \( f_0(y_0) \). Then

\[ R_i = P[E_i] = \int_{x_0}^{\infty} f_0(y_0) dy_0 = R \]

The expression for \( R_i \) is independent of the cycle number \( i \). Hence

\[ R(t) = \sum_{i=0}^{\infty} p_i(t) R_i = p_0(t) R_0 + \sum_{i=1}^{\infty} p_i(t) R_i = p + R(1 - p_0) \]

\[ R(t) = p + R(1 - p) = p + qR \]

Case 2: Deterministic Stress and Random independent Strength

Let the stress be constant at \( x_0 \). Let \( g_i(y) \) be the probability density function of the random variable strength \( Y_i \) during the cycle \( i \). Since successive values of \( Y_i \) are independent, we get

\[ R_n = P[E_1, E_2, \ldots, E_n] = P[E_1] \cdot P[E_2] \cdot \cdots \cdot P[E_n] \]

Where

\[ P[E_i] = P(x_0 \leq y_i) = \int_{x_0}^{\infty} g_i(y) dy \]

In particular, if the probability density function remains unchanged over time, that is, if

\[ g_1(y) = g_2(y) = \cdots = g_n(y) = g(y) \]

Then

\[ R_n = (P[E_i])^n = \left( \int_{x_0}^{\infty} g(y) dy \right)^n \]

Let \( R_i = R^i, i = 0, 1, 2, \ldots, n \), where \( R = \int_{x_0}^{\infty} g(y) dy \)

\[ R(t) = \sum_{i=0}^{\infty} p_i(t) R_i = \sum_{i=0}^{\infty} q^i p R^i = p \sum_{i=0}^{\infty} (qR)^i = p \left[ 1 + qR + qR^2 + \cdots \right] = \frac{p}{1 - qR} \]

Case 3: Random-fixed Stress and deterministic Strength
Let the strength be \( y_0 \), a constant, and the stress on the \( i^{th} \) cycle be \( x_i \) given by

\[
X_i = X_0 + b_i, \quad i = 1, 2, \ldots
\]

Where \( b_i \geq 0 \) are known constants. Further, the \( b_i \)'s are assumed nondecreasing in time. The probability density function of \( X_0 \), \( f_0(x_0) \) is assumed known. Then

\[
R_n = P[E_n] = P(X_n \leq y_n) = P(x_0 + b_n \leq y_0)
\]

\[
R_n = \int_{y_0 - b_n}^{y_0} f_0(x_0) dx_0
\]

Then

\[
R_i = P[E_i] = \int_{y_0 - a_n}^{y_0} f_0(x_0) dx_0 \equiv R
\]

The expression for \( R_i \) is independent of the cycle number \( i \). Hence by reciprocity of Case 2, we get

\[
R(t) = p + qR, \quad \text{where} \quad R = \int_{y_0}^{y_0} f_0(x_0) dx_0
\]

**Case 4: Random-fixed Stress and random-fixed Strength**

Let the stress be given by

\[
X_i = X_0 + b_i, \quad i = 1, 2, \ldots
\]

Where \( b_i \geq 0 \) are known constants. Further, the \( b_i \)'s are assumed nondecreasing in time. Let the strength be given by

\[
Y_i = Y_0 - a_i, \quad i = 1, 2, \ldots
\]

Where \( a_i \geq 0 \) are known constants. Further, the \( a_i \)'s are assumed nondecreasing in time. The probability density functions \( f_0(x_0) \) and \( g_0(y_0) \) are assumed known. We have to required the stress to be nondecreasing and strength to be nonincreasing. Hence

\[
R_n = P[E_n] = P(X_n \leq Y_n) = P(x_0 + b_n \leq y_0 - a_n)
\]

\[
= \int_{y_0 - a_n}^{y_0} \left( \int_{y_0 - b_n}^{y_0} f_0(x_0) dx_0 \right) dy_0
\]

Let \( X_0 \) and \( Y_0 \) be the random fixed stress and strength with known probability density functions \( f_0(x_0) \) and \( g_0(y_0) \) respectively. \( X_0 \) and \( Y_0 \) will be assumed not vary with time that is \( a_i = b_i = 0, \ i = 1, 2, \ldots \). Hence

\[
R_i = \int_{y_0}^{y_0} g_0(y_0) \int_{y_0}^{y_0} f_0(x_0) dx_0 dy_0 = R, \quad i = 1, 2, \ldots
\]

\[
R(t) = \sum_{i=0}^{\infty} p_i(t) R_i = p_0(t) R_0 + \sum_{i=1}^{\infty} p_i(t) R_i
\]
\[= p(1) + R(1 - p_0)
= p + R(1 - p) = p + qR\]

**Case 5: Random-independent Stress and deterministic Strength**
Let the strength be constant at \(y_0\). Let \(f_i(x)\) be the probability density function of the random variable stress \(X_i\) during the cycle \(i\). Since successive values of \(X_i\) are independent, we get
\[
R_n = P[E_1, E_2, \ldots, E_n] = P[E_1] \ast P[E_2] \ast \cdots \ast P[E_n]
\]
Where
\[
P[E_i] = P(X_i \leq y_0) = \int_0^{y_0} f_i(x) \, dx
\]
In particular, if the probability density function remains unchanged over time, that is, if
\[
f_1(x) = f_2(x) = \cdots = f_n(x) = f(x)
\]
Then
\[
R_n = (P[E_i])^n = \left\{ \int_0^{y_0} f(x) \, dx \right\}^n
\]
Let \(R_i = R^i\), we get
\[
R(t) = \sum_{i=0}^{\infty} p_i(t) R_i
\]
\[
R(t) = \frac{P}{(1 - qR)} \quad \text{where} \quad R = \int_0^{y_0} f(x) \, dx
\]

**Case 6: Random-independent Stress and random-independent Strength**
Let \(f_i(x)\) and \(g_i(y)\) be the probability density functions of stress \(X_i\) and strength \(Y_i\) respectively in cycle \(i = 1, 2, \ldots\). Then, since \(X_i\)’s and \(Y_i\)’s are independent,
\[
R_n = P[E_1, E_2, \ldots, E_n]
= P[E_1] \ast P[E_2] \cdots \ast P[E_n]
= \prod_{i=1}^{n} P(E_i)
\]
Where
\[
P = P(X_i < Y_i)
= \int_0^{\infty} f_i(x) \int_x^{\infty} g_i(y) \, dy \, dx
\]
Let \(f(x)\) and \(g(y)\) represent the probability density functions for stress \(X\) and strength \(Y\) respectively. Further the random variables be independent on each cycle. Then
\[
R_i = R^i, \quad i = 0, 1, 2, \ldots, n
\]
\[
R(t) = \sum_{i=0}^{\infty} p_i(t) R_i
\]
Reliability Analysis of Time-Dependent System when the Number of Cycles Follow Geometric Distribution and Stress-Strength Follow Exponential Distribution

\[
= \sum_{i=0}^{\infty} q^i p R^i
\]
\[
= p \sum_{i=0}^{\infty} (q R)^i
\]
\[
R(t) = p \left[ 1 + q R + q R^2 + \ldots \right]
\]
\[
= \frac{p}{(1 - q R)}
\]

where, \( R = \int_{0}^{\infty} f(x) \int_{x}^{\infty} g(y) dydx. \)

3. In Geometric Distribution, the Stress and Strength Follow Exponential Distribution

Case 1: Deterministic Stress and random-fixed Strength

\[
R(t) = p + q R
\]

where

\[
R = \int_{y_0}^{\infty} f_0(y_0) dy_0
\]
\[
= \int_{y_0}^{\infty} \mu e^{-\mu y_0} dy_0 = e^{-\mu y_0}
\]
\[
R(t) = p + q e^{-\mu y_0}
\]

Case 2: Deterministic Stress and random-independent Strength

\[
R(t) = \frac{p}{(1 - q R)}
\]

where

\[
R = \int_{y_0}^{\infty} g(y) dy
\]
\[
= \int_{y_0}^{\infty} \mu e^{-\mu y} dy = e^{-\mu y_0}
\]
\[
R(t) = \frac{p}{(1 - q e^{-\mu y_0})}
\]

Case 3: Random-fixed stress and deterministic Strength

\[
R(t) = p + q R, \text{ where } R = \int_{0}^{y_0} f_0(x_0) dx_0
\]
\[
R = \int_{0}^{y_0} \lambda e^{-\lambda x_0} dx_0 = \left( 1 - e^{-\lambda y_0} \right)
\]
\[
R(t) = p + q \left( 1 - e^{-\lambda y_0} \right) = 1 - q e^{-\lambda y_0}
\]

Case 4: Random-fixed Stress and random-fixed Strength

\[
R(t) = p + q R
\]
where

\[ R = \int_0^\infty g_0(y_0) \int_0^{y_0} f_0(x_0) \, dx_0 \, dy_0 \]

\[ = \int_0^\infty \mu e^{-\nu y_0} \int_0^{y_0} \lambda e^{-\lambda x_0} \, dx_0 \, dy_0 \]

\[ R = \frac{\lambda}{(\lambda + \mu)} \]

\[ R(t) = p + \frac{q\lambda}{(\lambda + \mu)} \]

\[ = \frac{[\lambda + p\mu]}{(\lambda + \mu)} \]

**Case 5: Random-independent Stress and deterministic Strength**

\[ R(t) = \frac{p}{1 - qR} \text{ where } R = \int_0^{y_0} f(x) \, dx \]

\[ R = \int_0^{y_0} \lambda e^{-\lambda x} \, dx \]

\[ = \left(1 - e^{-\lambda y_0}\right) \]

\[ R(t) = \frac{p}{1 - q\left(1 - e^{-\lambda y_0}\right)} \]

\[ = \frac{p}{(p + qe^{-\lambda y_0})} \]

**Case 6: Random-independent Stress and random-independent Strength**

\[ R(t) = \frac{p}{(1 - qR)} \]

where

\[ R = \int_0^\infty f(x) \int_0^\infty g(y) \, dy \, dx \]

\[ R = \int_0^\infty \lambda e^{-\lambda x} \int_x^\infty \mu e^{-\mu y} \, dy \, dx \]

\[ = \frac{\lambda}{(\lambda + \mu)} \]

\[ R(t) = \frac{p}{\left(1 - q\frac{\lambda}{(\lambda + \mu)}\right)} \]

\[ = \frac{p(\lambda + \mu)}{(p\lambda + \mu)} \]

### 4. Numerical Results

**Case 1: Deterministic Stress and random-fixed Strength**

<table>
<thead>
<tr>
<th>p</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>R</td>
<td>0.9144</td>
<td>0.9239</td>
<td>0.9333</td>
<td>0.9429</td>
<td>0.9524</td>
<td>0.9619</td>
<td>0.9715</td>
<td>0.9809</td>
<td>0.9905</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. (\(\mu = 0.2, x_0 = 0.5\))
Reliability Analysis of Time-Dependent System when the Number of Cycles Follow Geometric Distribution and Stress-Strength Follow Exponential Distribution

<table>
<thead>
<tr>
<th>p</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>µ</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>R</td>
<td>0.9561</td>
<td>0.9239</td>
<td>0.9025</td>
<td>0.8912</td>
<td>0.8894</td>
<td>0.8963</td>
<td>0.9114</td>
<td>0.9341</td>
<td>0.9638</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 2. \((x_0 = 0.5)\)

<table>
<thead>
<tr>
<th>p</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>µ</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>R</td>
<td>0.5387</td>
<td>0.7243</td>
<td>0.8183</td>
<td>0.8751</td>
<td>0.9131</td>
<td>0.9403</td>
<td>0.9608</td>
<td>0.9768</td>
<td>0.9895</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 3. \((µ = 0.2, x_0 = 0.5)\)

<table>
<thead>
<tr>
<th>p</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>µ</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>R</td>
<td>0.6949</td>
<td>0.7243</td>
<td>0.7547</td>
<td>0.7862</td>
<td>0.8189</td>
<td>0.8527</td>
<td>0.8876</td>
<td>0.9238</td>
<td>0.9613</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 4. \((x_0 = 0.5)\)

<table>
<thead>
<tr>
<th>µ</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0.9534</td>
<td>0.9131</td>
<td>0.8777</td>
<td>0.8465</td>
<td>0.8188</td>
<td>0.7942</td>
<td>0.7720</td>
<td>0.7520</td>
<td>0.7340</td>
<td>0.7176</td>
</tr>
</tbody>
</table>

Table 5. \((p = 0.5, q = 0.5, x_0 = 0.5)\)

<table>
<thead>
<tr>
<th>q</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0.9095</td>
<td>0.8190</td>
<td>0.7285</td>
<td>0.6380</td>
<td>0.5475</td>
<td>0.4571</td>
<td>0.3666</td>
<td>0.2761</td>
<td>0.1856</td>
<td>0.0951</td>
</tr>
</tbody>
</table>

Table 6. \((λ = 0.2, y_0 = 0.5)\)

Case 2: Deterministic Stress and random-independent Strength

Case 3: Random-fixed stress and deterministic Strength

Table 6. \((λ = 0.2, y_0 = 0.5)\)
Table 7. \((q = 0.5, y_0 = 0.5)\)

<table>
<thead>
<tr>
<th>(\lambda)</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R)</td>
<td>0.6106</td>
<td>0.6967</td>
<td>0.7638</td>
<td>0.8161</td>
<td>0.8567</td>
<td>0.8884</td>
<td>0.9131</td>
<td>0.9325</td>
<td>0.9473</td>
<td>0.9589</td>
</tr>
</tbody>
</table>

Case 4: Random-fixed Stress and random-fixed Strength

Table 8. \((\lambda = 0.2, \mu = 0.5)\)

<table>
<thead>
<tr>
<th>(p)</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R)</td>
<td>0.3571</td>
<td>0.4286</td>
<td>0.5</td>
<td>0.5714</td>
<td>0.6428</td>
<td>0.7143</td>
<td>0.7857</td>
<td>0.8571</td>
<td>0.9286</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 9. \((p = 0.5, \mu = 0.5)\)

<table>
<thead>
<tr>
<th>(\lambda)</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R)</td>
<td>0.5833</td>
<td>0.6429</td>
<td>0.6875</td>
<td>0.7222</td>
<td>0.75</td>
<td>0.7727</td>
<td>0.7917</td>
<td>0.8077</td>
<td>0.8214</td>
<td>0.8333</td>
</tr>
</tbody>
</table>

Table 10. \((\lambda = 0.5, \mu = 0.5)\)
Reliability Analysis of Time-Dependent System when the Number of Cycles Follow Geometric Distribution and Stress-Strength Follow Exponential Distribution

<table>
<thead>
<tr>
<th>$\mu$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.8333</td>
<td>0.75</td>
<td>0.6667</td>
<td>0.6428</td>
<td>0.625</td>
<td>0.6111</td>
<td>0.6</td>
<td>0.5909</td>
<td>0.5833</td>
<td></td>
</tr>
</tbody>
</table>

Table 10. ($p = 0.5, \lambda = 0.2$)

![Graph](image1)

Case 5: Random-independent Stress and deterministic Strength

<table>
<thead>
<tr>
<th>$p$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$q$</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>$R$</td>
<td>0.1094</td>
<td>0.2165</td>
<td>0.3214</td>
<td>0.4242</td>
<td>0.5249</td>
<td>0.6237</td>
<td>0.7206</td>
<td>0.8155</td>
<td>0.9086</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 11. ($\lambda = 0.5, y_0 = 0.2$)

<table>
<thead>
<tr>
<th>$\lambda$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.5498</td>
<td>0.5986</td>
<td>0.6456</td>
<td>0.68099</td>
<td>0.7310</td>
<td>0.7685</td>
<td>0.8021</td>
<td>0.8320</td>
<td>0.8581</td>
<td>0.8807</td>
</tr>
</tbody>
</table>

Table 12. ($p = q = 0.5, y_0 = 0.2$)

![Graph](image2)

<table>
<thead>
<tr>
<th>$y_0$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.5498</td>
<td>0.5986</td>
<td>0.6456</td>
<td>0.68099</td>
<td>0.7310</td>
<td>0.7685</td>
<td>0.8021</td>
<td>0.8320</td>
<td>0.8581</td>
<td>0.8807</td>
</tr>
</tbody>
</table>

Table 13. ($p = q = 0.5, \lambda = 0.2$)

<table>
<thead>
<tr>
<th>$p$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$q$</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>$R$</td>
<td>0.1194</td>
<td>0.2716</td>
<td>0.4384</td>
<td>0.5973</td>
<td>0.7310</td>
<td>0.8327</td>
<td>0.9044</td>
<td>0.9519</td>
<td>0.9819</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 14. ($y_0 = 0.2$)

Case 6: Random-independent Stress and random-independent Strength
<table>
<thead>
<tr>
<th>$p$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.28</td>
<td>0.4667</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7778</td>
<td>0.84</td>
<td>0.8909</td>
<td>0.9333</td>
<td>0.9692</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 15.** ($\lambda = 0.5, \mu = 0.2$)

<table>
<thead>
<tr>
<th>$\lambda$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R$</td>
<td>0.6</td>
<td>0.6667</td>
<td>0.7142</td>
<td>0.75</td>
<td>0.7778</td>
<td>0.8</td>
<td>0.8182</td>
<td>0.8333</td>
<td>0.8461</td>
<td>0.8571</td>
</tr>
</tbody>
</table>

**Table 16.** ($p = 0.5, \mu = 0.2$)

5. **Conclusion**

In this, Reliability of stress-strength system has been done when the number of cycles follows Geometric distribution. Numerical calculations for reliability have been carried for six models, where stress and strength follow Exponential distribution. Reliability computations have been done for dependent and independent of time. It is observed by the computations, the reliability increases when stress parameter ($\lambda$), strength parameter ($y_0$) increase and reliability decreases when mean no. of cycles ($a$), strength parameter ($\mu$) and stress parameter ($x_0$) increase.

**References**


