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# Analysis of Down Time and Reliability Estimation in Hostel Building Maintenance- a Case Study

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**Abstract:** The growths of present Hostel Building Maintenance (HBM) are forced towards the use of more complex systems. In consequences, with the increase in automation and usage of complex systems, evaluation of reliability has recently been recognized for effective maintenance. Reliability has been evaluated mostly for civil, electrical and chemical components and presently we are going to calculate reliability for components in a Hostel Building. For this purpose, the breakdown time is calculated from the Hostel Building of Higher Education Institution in Malacca, Malaysia. The data is analyzed and the reliability is calculated for each component by exponent distribution in probability. Reliability is analyzed and criticality of each component is found by using FMEA (Failure Mode and Effect Analysis) to suggest an appropriate preventive maintenance schedules. The study was carried in the Hostel Building at Kolej Universiti Islam Melaka (KUIM) with the capacity of 5300 students per semester. The preliminary discussions with the officer's in charged reveals that the hostel buildings are often create problems due to breakdown of various components. Hence, it is decided to carry out failure analysis and to suggest measures to improve the availability of the components. The objective of this study is to estimate availability, reliability of the component system and also to perform the FMEA analysis to identify the critical components to “prepare Preventive Maintenance (PM) schedules”. The methodology that has been followed to achieve this study is starting with the collection of the historical failure data of the hostel building. Then, the down time and the availability of the equipment is calculated based from the past data. Once finished the failure history is modeled using exponent distribution. After that, the reliability of the components is estimated using exponent parameters and finally calculating criticality index of all the components using FMEA software. It is possible to correlate the equipment reliability with maintenance requirements. In order to attain maximum productivity, it is necessary to optimize man inducement in minimizing failure. This can be achieved by applying a proper maintenance and timely replacement of some parts of components or at times the whole equipment’s. An attempt has been made in this work to study the failure pattern and down time of the components. The critical components are also identified by carrying FMEA Analysis.

**Key words:** Hostel Building Maintenance · Failure Mode Effect Analysis · Exponents distribution parameters · Criticality Index

## INTRODUCTION

Hostel is one of the important buildings in Higher Education Institution. In order to keep the hostel in good conditions, a proper maintenance schedule is essential for students to have a comfortable place to stay [1, 2, 3, 4]. The study was carried at Hostel Building in KUIM with the capacity of 5300 student per semester. The preliminary discussion with the officers reveals that the hostel building is often problematic due to breakdown of various components. It is decided to carry out failure analysis in this hostel building and to suggest measures to improve

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the availability of the components. The objective of the study is to estimate the availability, reliability of the components system and also to perform the FMEA analysis to identify the critical components to prepare Preventive Maintenance (PM) schedule by officials.

## MATERIALS AND METHODS

The methodology to achieve this study is:

- Collecting the historical failure data of the production system.
- Calculating the down time and the availability of the equipment from the past data.
- Modeling the failure history using exponent statistical distribution.
- Estimating the reliability using exponent Parameters.
- Finally, calculating the criticality index of all the components using FMEA software.

**Data Collection and Mean Time Between Failures (MTBF):** The failure data of equipment are collected based on the average time of breakdown until the beyond repair. Meanwhile the mean time between failures is also collected and it is one of the useful terms in maintenance and reliability analysis.

The formula:

MTBF = Operating Time/Number of failures

**Availability:** It is possible to define three types of availability depends on the time elements we take into consideration [5]. These are inherent availability, which means that the probability that a system or equipment shall operate satisfactorily when used under stated conditions in an ideal support environment without consideration for any scheduled or preventive maintenance at any given time. Achieve availability means, in the definition of inherent availability we considered MTBF which does not take into account the downtime caused by maintenance. If this is also taken into account, we get the achieved availability, which is defined as the probability that a system or equipment shall operate satisfactorily when used understated conditions in an ideal support environment at any given time. In any real time operation, we can't reduce administrative downtime and supply own time to zero. A certain amount of delay will always be caused by time elements if they are taken into account. Operational availability of the system is the probability that a system or equipment shall operate satisfactorily and in an actual supply environment at any given time.

The formula for availability, A is in (1).

$$A = MTBF/ (MTBF+MDT) \quad (1)$$

where MTBF is mean time between failures and MDT is mean downtime.

### Estimation of Operational Availability

**Downtime of Components:** Downtime is the non-productive time of the machine. Downtimes of the components are calculated and tabulated with the help of the data collected [6]. Table 1 shows the downtime of the various components from July 2012 to December 2012. For example, the downtime of the DOOR during June 2012 is observed to be 3144hours, which is the sum of the breakdown hours on various occasions during the month of July to Dec 2012. Similarly for all other components, for various periods, the time are calculated and tabulated. Table 2 presents the data with respect to number of failures for each component month wise.

### Reliability Estimation

**Definition of Reliability:** Reliability in simplest form, means the probability that a failure may not occur in a given time interval [7]. A more rigorous definition of reliability is as follows “reliability of a unit (or product) is the probability that the unit performs its intended operating conditions or environment”. Reliability characteristics, such as probability of survival, mean time to failure, availability, mean down time and frequency of failures are some of the measures of system effectiveness. Apart from the above factors, reliability does change due to other factors like quality, workmanship, hostel building process, material, storage, handling, engineering changes and deviations in production, inspection and test.

**Application of Exponent Distribution:** Exponential suggested a simple empirical expression, which represents a great varies of actual data. The exponent cumulative distribution function is given by:

Table 1: Downtime of Components (Past Data)

| | | Downtime Calculation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | July | August | Sept | Oct | Nov | Dec | Total Time | Percent |
| Total Fault | | 11,667 | 8,033 | 1,224 | 2,998 | 1,518 | 2,208 | 27,648 | 100% |
| Component Name/ Area of Fault | Sink | 168 | 264 | | 72 | 96 | 96 | 696 | 7.23 |
| | Door | 1035 | 881 | 504 | 382 | 222 | 120 | 3144 | 45 |
| | Bed | | 24 | | 24 | | | 48 | 0.1 |
| | Shower | 168 | 144 | | 168 | 240 | 96 | 816 | 5.37 |
| | Toilet | 144 | | | | 216 | 96 | 456 | 7.63 |
| | Pipe | | 168 | 240 | 168 | | 72 | 648 | 5.32 |
| | Window | 720 | 648 | | 360 | 288 | 432 | 2448 | 25.06 |
| Percent | | 42.19 | 29.05 | 4.42 | 10.84 | 5.49 | 7.98 | | 100% |

Table 2: No. of Failures of all component

| | | Causes of Faults of Civil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | July | August | Sept | Oct | Nov | Dec | Total Fault | Percent |
| Total Fault | | 93 | 88.7 | 31 | 56 | 44.5 | 45 | 358.2 | 100% |
| Component Name/ Area Of Fault | Sink | 7 | 11 | | 3 | 4 | 4 | 29 | 7.77 |
| | Door | 43 | 36.7 | 21 | 16 | 9.5 | 5 | 131 | 35.12 |
| | Bed | | 1 | | 1 | | | 2 | 0.54 |
| | Shower | 7 | 6 | | 7 | 10 | 4 | 34 | 9.12 |
| | Toilet | 6 | | | | 9 | 4 | 30 | 8.04 |
| | Pipe | | 7 | 10 | 7 | | 3 | 27 | 7.24 |
| | Window | 30 | 27 | | 15 | 12 | 18 | 102 | 27.35 |
| Percent | | 25.96 | 24.7 | 8.65 | 15.6 | 12.42 | 12.56 | | 100% |

Table 3: MTBF of various components considered

| No | Component | MTBF |
|---|---|---|
| 1 | Sink | 128.28 |
| 2 | Door | 9.71 |
| 3 | Bed | 2206.5 |
| 4 | Shower | 105.88 |
| 5 | Toilet | 123.2 |
| 6 | Pipe | 139.56 |
| 7 | Window | 18.90 |
| 8 | Corridor | 221.33 |
| 9 | Lamp | 3.74 |
| 10 | Fan | 66.122 |
| 11 | Plug | 235.76 |

$$f(t) = \lambda e^{-\lambda t} \qquad (2)$$

where,

$$R(t) = \int_t^{\infty} f(t)dt = e^{-\lambda t}$$

**MTBF of Components:** Mean time between failures is referred to as the average time to satisfactory operation of the system. This term is useful to carry out the maintenance and reliability analysis.

MTBF = (Total Available Time – Non-operating time) / No. of failures)

**For Example:**
Component name = Door

**Total Available Time** = 31(July) + 31(August) + 30 (September) + 31(October) + 30 (November) + 31(December) x 24 hours = 4 416 hours
Non-operating time = Total break down time of Door = 3144 hours
Number of failures = 131 (from Table 3)

MTBF= (4416 - 3144) / 131 =9.71 hours
Thus, Table 3 shows the MTBF of all the components

**Mean down Time:** The statistical mean of downtime d1, d2, d3….including supply time and administrative downtime is called mean downtime. This mean downtime is concentrated on breakdown time, maintenance time and non-availability of components. Table 4 shows the mean downtime of various components.

**For Example:**
**Month = July**
Component = Door
Downtime due to break down (BDT) = 1035 hours
**Month =August**
Component = Door

Table 4: Mean Down Time of Components

| | | Mean Down Time (hrs) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No | Component | July | August | Sept | Oct | Nov | Dec | Total MDT |
| 1 | Sink | 296 | 167 | 120 | 57 | 31 | 25 | 116 |
| 2 | Door | 1035 | 881 | 504 | 382 | 222 | 120 | 524 |
| 3 | Bed | 11 | 11 | 9 | 8 | 6 | 3 | 8 |
| 4 | Shower | 216 | 204 | 176 | 136 | 61 | 23 | 136 |
| 5 | Toilet | 220 | 150 | 119 | 102 | 71 | 58 | 120 |
| 6 | Pipe | 148 | 124 | 113 | 103 | 87 | 73 | 108 |
| 7 | Window | 1207 | 458 | 408 | 241 | 105 | 29 | 408 |
| 8 | Corridor | 134 | 97 | 72 | 61 | 42 | 26 | 72 |
| | Total | 3267 | 2092 | 1521 | 1090 | 625 | 357 | |
| | Mean | 1089 | 697.33 | 507 | 363.33 | 208.33 | 119 | |

Downtime due to break down (BDT) = 881 hours

**Month = Sept**
Component = Door
Downtime due to break down (BDT) = 504 hours

**Month = Oct**
Component = Door
Downtime due to break down (BDT) = 382 hours

**Month = Nov**
Component = Door
Downtime due to break down (BDT) = 222 hours

**Month = Dec**
Component = Door
Downtime due to break down (BDT) = 120hours

Mean down time (TDT July + TDT August + TDT Sept + TDT Oct + TDT Nov+ TDT Dec) / no. Month =
= (1035+881+504+382+222+120) / 6
= 3144 / 6
= 524
Mean Downtime of Door = 524 hours

**Availability of Components:** It is possible to define the availability of equipment hours in actual environments. Operational availability is defined as to be the probability that a system of equipment shall operate satisfactorily when used understated condition in an actual environment at any given time.

$$A = \{MTBF / (MTBF+MDT)\} \times 100 \quad (3)$$

For Example,

**Component name = Door**
MTBF = 9.71 hours
MDT = 524 hours
Availability = 9.71 / (9.71 + 524) = 0.018 x 100= 1.8 %.

1.8 %. Thus the availability of all the components were calculated and given in Table 5.

This analysis aims to assess the faults developed by the components in terms of their effects. It gives indication on which fault effects is the most recurrent one. By using availability date range from June 2012 and 30 December 2012, a data given in Table 5 will be produced. This result shows data the availability of component number of the heights value component is Bed and followed by Plug and Toilet. Most of these effects focused on Door availability is the lowest value followed by Window and Sink.

**Failure Time Distribution: Calculation Procedures:** The following procedure is adopted to calculate the required parameters.
Class Interval:

I = (T max –T min) / (1+3.3logN)
where, T max – Maximum time between failures and T min –Minimum time between failures
N–Total number of failures in the test time

**Percentageoffailure:**

% failed = (No. of failures in the time interval / Total no. of failures)

**Cummulative%of Failure:**

$$F(t) = \sum_{i=1}^{n} f_i$$

n – Corresponding time interval sequence number.

Table 5: Availability Of Components

| No | Component | MTBF | MDT | Availability (%) |
|---|---|---|---|---|
| 1 | Sink | 128.28 | 116 | 52.5 |
| 2 | Door | 9.71 | 524 | 1.8 |
| 3 | Bed | 2206.5 | 8 | 99.6 |
| 4 | Shower | 105.88 | 136 | 43.8 |
| 5 | Toilet | 123.2 | 120 | 50.7 |
| 6 | Pipe | 139.56 | 108 | 56.4 |
| 7 | Window | 18.90 | 408 | 4.4 |
| 8 | Corridor | 221.33 | 72 | 75.5 |
| 9 | Lamp | 3.74 | 872 | 0.427 |
| 10 | Fan | 66.122 | 196 | 25.2 |
| 11 | Plug | 235.76 | 68 | 77.6 |

Table 6: Reliability of components

| No. | Component | (t) | R |
|---|---|---|---|
| 1 | Sink | 0.0741 | 36.85 |
| 2 | Door | 0.1853 | 36.75 |
| 3 | Bed | 3.1141 | 36.83 |
| 4 | Shower | 4.1067 | 36.86 |
| 5 | Toilet | 4.4234 | 36.80 |
| 6 | Pipe | 5.168 | 36.88 |
| 7 | Window | 12.291 | 36.93 |

Table 7: T max and T min (From Past Data)

| No | Component | T max (hours) | T min (hours) |
|---|---|---|---|
| 1 | Sink | 264 | 72 |
| 2 | Door | 1035 | 120 |
| 3 | Bed | 24 | 24 |
| 4 | Shower | 240 | 96 |
| 5 | Toilet | 216 | 96 |
| 6 | Pipe | 168 | 72 |
| 7 | Window | 720 | 432 |

**Reliability:**

$R(t) = \exp(-\lambda t)$

**Reliability of Components**

**For example,**
Component Name: Door
From Exponent graph

$R(t) = \exp(-\lambda t)$
$\lambda=5.397$
$t=0.1853$
$R(t) = \exp[-(5.397)(0.1853)] \times 100$
$R(t) = 36.75\%$

Thus, the Reliability is calculated for all the components under consideration and tabulated in Table 6. From the calculation it is found that the Reliability of Door is very less.

This analysis aims to assess the faults developed by the components in terms of their effects. It gives indication on which fault effects is the most recurrent one. By using reliability date range from June 2012 and 30 December 2012, a data given in Table 6 are produced. This result shows that the reliability of listed components have a similar value. These can be concluded that the reliability result cannot be used to identify severe or reliable components. In order to identify specific components to be focused and prioritized, the need to use Failure Mode and Effect Analysis (FMEA) to make a decisions on performing a maintenance.

**Failure Mode and Effect Analysis**

**Introduction:** Failure Mode and Effect Analysis (FMEA) is a logical structured analysis of a system, subsystem, device or process. It is one of the most commonly used reliability and system safety analysis techniques. FMEA is used to identify possible failure modes, their causes and the effects of these failures.

Proper identification of failure may lead to solutions that increase the overall reliability and safety of a product FMEA analysis is a powerful design and reliability tool that examines the potential failure modes within a system in order to determine its effect on the system performance.

**FMEA Analysis And Process:** The following logical steps should be followed when an FMEA identify the product or system components.

- List all possible failure modes of each component.
- Set down the effects that each mode of failure would have on the overall function of product system.
- List all the possible causes of each failure mode.
- Assess numerically the failure modes on a scale from1 to10.
- Experience using expert choice and reliability data from historical data as an input to determine the values which a scale of 1-10 for severity (S), occurrence (O) and detection (D).

**Severity (S):** Severity is the assessment of the seriousness of the effect of potential failure of the system, subsystem or component severity is applicable only to effect of failure mode severity is rated by ranking by which 1 is for no effect and 10 for the most severe (serious) effect.

**Occurrence (O):** Occurrence is the probability that one of the specific cause / mechanism of failure will occur.

Table 8: Criticality Index

| No | Component | Mode of Failure | Failure effect | Causes | Severity | Occurrence | Detection | Criticality Index |
|---|---|---|---|---|---|---|---|---|
| 1 | Sink | Repair | Water leakage | Leak | 5 | 5 | 5 | 125 |
| 2 | Door | Need to replace | Damage door | Age | 7 | 7 | 7 | 343 |
| 3 | Bed | Repair | Broken | Poor design | 1 | 1 | 1 | 1 |
| 4 | Shower | Replace & repair | Jammed & leak | Leak | 4 | 4 | 4 | 64 |
| 5 | Toilet | Repair & change | Water leakage | Clogged | 3 | 3 | 3 | 27 |
| 6 | Pipe | Repair | Water leakage | Jammed | 2 | 2 | 2 | 8 |
| 7 | Window | Repair | Replace all window | Broken | 6 | 6 | 6 | 216 |

The likelihood of occurrence is assessed as 1 for least chance of occurrence and 10 for highest chance of occurrence.

**Detection (D):** It is the relative measure of difficulty of detecting the failure before the product or service is used by customer. If the design control certainly detects cause/mechanism of failure then it is ranked or it is difficult or detect then it is ranked. The details of T max and T min from past data are shown in Table 7. Thus when these inputs are given, the results generated from the software are tabulated in Table 8. The criticality index for each components is generated and ranked according to the critical failure modes. This indicates the relative priority of each failure mode and to concentrate on preventive activity of critical components.

## CONCLUSION

Thus, the criticality index of all the components were calculated and analysed. Then, the components can be effectively used after rectifying the failures according to the severity. Availability of data regarding the equipment reliability is of considerable benefit to HBM in many situations. Knowledge of wear out characteristics of the system components leads to the development of appropriate provision for spare parts and stand by equipment's. It is possible to correlate equipment maintenance requirements. To attain maximum productivity it is necessary that technician minimizes failure. This can be achieved by proper maintenance and timely replacements of some component of HBM. The timely replacement improves the HBM reliability as well as availability and made it useful for achieving high HBM. An attempt had been made in this research the failure pattern and downtime of the components used in a particular HBM under consideration. The combined all analysis aims to assess the criticality of the components to compare and decide which components are more critical. By combining the analysis, each component will be assessing based on three major consequences [11-13]. The ranks could be performed based on the number of availability, reliability and criticality Index. Table 5, Table 6 and Table 8 show the criticality ranking for each of the components. From the table, it s hows that Door is the highest value followed by Window and Sink. The critical components have also been identified by carrying out FMEA analysis. It will be economical if the severity and the availability of data regarding the equipment reliability is of considerable benefit to HBM in many situations when system failures by conducting a proper maintenance schedule.

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