Modeling of Transients in Water Distribution Networks for Greater Guwahati Due to Leakage in Pipes

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Abstract:
Leakage in distribution network accruing huge loss of coveted, depleting water resource has become a serious concern of water Engineers and planners. The National Rural Drinking Water Programme (NRDWP) guidelines of the Ministry of Drinking Water and Sanitation, Government of India, effective from April, 2009, stipulates 15% transmission loss, while the Ministry, by its communication No F-11014/1/2015-Water-II-Part(5) dated 1st April, 2016, quotes media reports that 50% potable drinking water gets wasted because of leakages before it reaches the consumer and asked for, all the States to adopt suitable measures to check leakage in the condition of growing drinking water shortage, because of erratic monsoon and contaminated water in many regions. Guwahati, the second largest Metropolitan region in eastern India, next to Kolkata, gets heavy spells of rain during rainy season and the city experiences series of flash flood, putting the civic life at standstill for days at a stress. This leads to vulnerability of contaminant intrusion in the distribution network in the least pressure head condition of no flow period through the pipe openings posing a serious threat to Public Health. As Assam tops the list of Indian States in the State-wise Infant Mortality Rate, leakage control in water distribution network plays a pivotal role to address the issue seriously. In this paper, based on specific field study of 29 Piped Water Supply Schemes, in and around Guwahati city, models have been developed with Statistical Regression Method for quantification of leakage discharge, discharge at successive leakage location, effect of age of pipe on leakage, pipe material etc so that remedial measures could well be taken up to minimize loss and also to combat contaminants intrusion.

Keywords: Clear Water Pumping Main, Contaminant Intrusion, Fault location, Hydraulic Gradient, Infant Mortality Rate, Leakage, Water-borne disease.

I. INTRODUCTION

Guwahati with Dispur in its circuit city region is the Capital city of Assam. It lies between the banks of the river, Brahmaputra and the foothills of the Shillong plateau. The Guwahati Municipal Corporation (GMC), the city's local government, administers an area of 216sq. km, while Guwahati Metropolitan Development Authority (GMDA) is the planning and development body of Greater Guwahati Metropolitan area. With an area of 1528sq. km Guwahati is the second largest metropolitan region in eastern India, after Kolkata. Altogether 18 hills exist in and around the city giving it an unique landscape. The famous seat of Mother Goddess Kamakhya lies in the city on the Nilachal hilltop. In the natural drainage system, Bharalu, Bahini, Mora Bharalu Rivers emanating from the Meghalaya hills serve the city, while in the south-west part of the city lays the Deepor Beel, the permanent fresh-water lake, the bird sanctuary and the only Ramsar site of the region. The city located at an elevation of 55.5m above MSL, has humid subtropical climate with average annual temperature of 24.2 degree Celsius. As per Central Ground Water Board (CGWB) revelation, the ground water table falls rapidly within a short span which may be attributed to rapid urbanization or so. The government has taken immense step to provide needful potable drinking water to the masses in the State as a basic need. Inspite of its efforts, out of the total of 7717 Pipe Water Supply Schemes (PWSS) Completed by Public Health Engineering Department, Government of Assam, 908 are dysfunctional now, may be due to outlived design period, deep tubewell failure etc. The wastage of precious water in the roadside distribution network due to leakage, which is a common sight, is not only a wastage of resources, but also a vulnerable health risk to the consumers as through these faults, contaminants can enter the distribution system. The Strategic Plan (2011-22) of the Ministry of Drinking Water and Sanitation to provide potable, protected drinking water at door step, for ensuring drinking water security to all rural household with 90% of households with Piped Water becomes a farce with leaked, splashed water in the roadside.

II. LITERATURE REVIEW


III. COLLECTION OF FIELD DATA

Public Health Engineering Department (PHED), Government of Assam, entrusted in public water supply activities in the State from 1956 has 9371 sanctioned Pipe Water Supply Schemes and 292783 installed Spot Water Sources today. As per the strategic plan (2011-22) of the Government of India, emphasis is laid on Piped water than spot sources. With the formation of Assam Urban Water Supply and Sewerage Board and very recently, the Guwahati Jal Board, lately the PHED activities are reduced to rural Assam. As already owned, PHED maintains a 11.35 MLD capacity water supply scheme at Pan Bazar, Guwahati drawing water from the river Brahmaputra, installed in 1973, just after the State capital shifted from Shillong to Guwahati, supplying water to Guwahati Medical College and Hospital campus, Assam Secretariat Campus, MLA Hostel, Assam Veterinary College Campus etc. A good numbers of water supply schemes in and around the city is serving the consumers from Deep Tube Well sources. Here within the scope of the present work, 29 Piped Water Supply Schemes in and around Guwahati city have been studied for modeling on leakage. The data collected are amount of Clear Water Pumping Main Discharge, Discharge at first fault location, Discharge at next fault location, size and material of pipe, age of pipe in use etc.

IV. MODELING OF LEAKAGE

Thorough and elaborate analysis have been made on the extensive field data obtained for 29 Pipe Water Supply Schemes(PWSS) within Greater Guwahati area covering discharge from Clear Water Pumping Main (CWPM), discharge at subsequent fault locations, distance of the first fault location from the CWPM based on size, age and material of pipe. Altogether two models for each of PVC as well as Flexible Quick Coupling GI Pipe network have been developed.

IV.I MODELLING OF LEAKAGE FOR PVC PIPE NETWORK

IV.I.I Discharge at the next fault location (LPM) with respect to Discharge at first Fault Location (LPM)

Considering Discharge at First Fault Location as independent variable to be denoted by “X” and Discharge at the next fault location from the 1st fault location as dependent variable to be denoted by “Y”.

\[ X = \text{Discharge at first Fault Location (LPM)} \]
\[ Y = \text{Discharge at the next fault location (LPM)} \]

Now by calculation from the above set of data for 90% confidence level by linear regression method we get the following observations.
Since we assumed 90% confidence level that means our significance level is 10%.

Critical value for this analysis is, α = 0.10

F-Test
F-critical value for this set of data calculation is = 2.9609
Calculated F value for this set of data calculation is = 94.76363

Since calculated F-value is greater than that of F-critical value so we can say that there is some degree of correlation between variable X and Y.

Correlation between X and Y is given as, $R = \sqrt{R^2} = \sqrt{0.818595} = 0.904762$ i.e. there is a strong correlation between X and Y.

R square value is 0.81859 that means we are able to explain 81.85% variability of Y with respect to X.

Now let us use t-test and p-value test for evaluation of Y-intercept and X variable coefficient.

Y-intercept:
Calculated Y-intercept = -9.50280

Let’s assume null hypothesis, $H_0$: Y-intercept = 0

And alternate hypothesis, $H_1$: Y-intercept ≠ 0

The T statistic value for Y-intercept is $t = -2.92456$ and p-value is 0.0008100

Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept alternate hypothesis $H_1$. Hence Y-intercept = -9.50280 is accepted.

X-variable coefficient:
Calculated X-variable coefficient = 0.722343
Let’s assume that the null hypothesis, $H_0$: X-variable coefficient = 0

And the alternate hypothesis, $H_1$: X-variable coefficient ≠ 0

The T statistic value for X-variable coefficient is $t = 9.73466$ and p-value is $3.096178 \times 10^{-9}$

Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept the alternate hypothesis $H_1$. Hence X-variable coefficient = 0.722343 is accepted.

Based on the above analysis we can form the equation for the linear regression between “X = Discharge at first Fault Location (LPM)”, “Y = Discharge at the next fault location (LPM)”, which is given below:

\[ Y = -9.50280 + 0.722343X \]

Since we have assumed 90% confidence level that means our significance level is 10%.

Therefore critical value for this analysis is, $\alpha = 0.10$

Correlation between X and Y is $R = \sqrt{R^2} = \sqrt{0.614428} = 0.78385494$

i.e. there exists a strong positive correlation between X and Y.

R Square value is 0.614428 which means we are able to explain 61.44% variability of Y with respect to X.

F-Test
Calculated F-critical value for this calculation is = 2.9609
Calculated F value for this calculation is = 33.4646

Since F-value is greater than that of F-critical value so we can say that there is some degree of correlation between variable X and Y.

Now let us use t-test and p-value test for evaluation of Y-intercept and X coefficients.

Y-intercept:
Calculated Y-intercept = 0.13030815
Let’s assume null hypothesis, $H_0$: Y-intercept = 0
And alternate hypothesis, $H_1$: Y-intercept ≠ 0
The t-statistic value for Y-intercept is $t = -0.394848$
And p-value is = 0.696936
Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is greater than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be accepted and we must reject alternate hypothesis $H_1$. Hence Y-intercept = -0.13030815 is rejected.

X-coefficient:
Calculated X-variable coefficient = 0.0027329
Let’s assume that the null hypothesis, $H_0$: X-variable coefficient = 0
And the alternate hypothesis, $H_1$: X-variable coefficient ≠ 0
The t-statistic value for X-variable coefficient is $t = 5.7848$
And p-value is = $9.64576 \times 10^{-6}$

Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept alternate hypothesis $H_1$. Hence X-variable coefficient = 0.0027329 is accepted.

Based on the above analysis we can form the straight line equation for the linear regression between “$X$ = Distance of first Fault Location form the CWPM (KM)”, “Distance of first Fault Location form the straight line from CWPM (KM)”, which is given as,

$$Y = 0.0027329X - 0.1303$$  \[2\]

Since we have assumed 90% confidence level that means our significance level is 10%
Therefore critical value for this analysis is, $\alpha = 0.10$
Correlation coefficient between X and Y is

$$R = \sqrt{R^2} = \sqrt{0.001417} = 0.037638$$
i.e. there exist a very low correlation between X and Y

Y-intercept;
Calculated Y-intercept = 44.56289
Let’s assume null hypothesis, $H_0$: Y-intercept = 0
And alternate hypothesis, $H_1$: Y-intercept ≠ 0
The t-statistic value for Y-intercept is $t = 5.266495$
And p-value is = 0.00003203
Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept alternate hypothesis $H_1$. Hence Y-intercept = 44.56289 is accepted

X-coefficient:
Calculated X-variable coefficient = -0.00209
Let’s assume that the null hypothesis, $H_0$: X-variable coefficient = 0
And the alternate hypothesis, $H_1$: X-variable coefficient ≠ 0
The t-statistic value for X-variable coefficient is $t = -0.1726$
And p-value is = 0.864617
Since we have assumed that the critical value to be $\alpha = 0.10$ and therefore we observe that p-value is greater than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be accepted and we must reject the alternate hypothesis $H_1$.

Hence X-variable coefficient = -0.00209 is rejected

Based on the above analysis we observe that no linear relationship could be established between X and Y. Hence Y can be represented as a constant line which is given below.

$$Y = -0.0021 x + 44.56289$$

### FIGURE 5. DISTANCE OF FIRST FAULT LOCATION FORM THE CWPM (KM) VS DISCHARGE FROM CWPM (LPM)

### IV.I.III. Discharge at first Fault Location (LPM) with respect to Discharge from CWPM (LPM)

Considering Discharge from CWPM as independent variable to be denoted by “$X$” and Discharge at first Fault Location as dependent variable to be denoted by “$Y$”.

X = Discharge from CWPM (LPM)
Y = Discharge at first Fault Location (LPM)

Now by calculation from the above set of data for 90% confidence level by linear regression analysis, we get the following observations.

### TABLE III. REGRESSION STATISTICS

<table>
<thead>
<tr>
<th>Regression Statistics</th>
<th></th>
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<tbody>
<tr>
<td>R</td>
<td>0.037638</td>
</tr>
<tr>
<td>R Square</td>
<td>0.001417</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>-0.04613</td>
</tr>
<tr>
<td>Standard Error</td>
<td>7.912448</td>
</tr>
<tr>
<td>Observations</td>
<td>23</td>
</tr>
</tbody>
</table>

### FIGURE 6. DISCHARGE AT FIRST FAULT LOCATION (LPM) VS DISCHARGE FROM CWPM (LPM)

### IV.I.IV. Discharge at first fault location (LPM) with respect to Distance of first fault location form the CWPM (KM).

Considering Distance of first fault location form the CWPM as independent variable to be denoted by “$X$” and Discharge at first fault location as dependent variable to be denoted by “$Y$”.

X = Distance of first fault location form the CWPM (KM)
Y = Discharge at first fault location (LPM)
Now by calculation from the above set of data for 90% confidence level by linear regression analysis, we get the following observations.

### TABLE. IV. REGRESSION STATISTICS

<table>
<thead>
<tr>
<th>Regression Statistics</th>
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<tbody>
<tr>
<td>R</td>
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<tr>
<td>R Square</td>
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<tr>
<td>Adjusted R Square</td>
</tr>
<tr>
<td>Standard Error</td>
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<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

Since we have assumed 90% confidence level that means our significance level is 10%
Therefore critical value for this analysis is, \( \alpha = 0.10 \)
Correlation coefficient between \( X \) and \( Y \) is
\[
R = \sqrt{R^2} = \sqrt{0.004408} = 0.066391
\]
i.e. there exist a very low correlation between \( X \) and \( Y \)
**Y-intercept:**
Calculated \( Y \)-intercept = 44.97321
Let’s assume null hypothesis, \( H_0: Y \)-intercept = 0
And alternate hypothesis, \( H_1: Y \)-intercept ≠ 0
The t-statistic value for \( Y \)-intercept is, \( t = 7.179553 \)
And \( p \)-value is \( 4.46 \times 10^{-7} \)
Since we have assumed that the critical value to be \( \alpha = 0.10 \)
and therefore we observe that \( p \)-value is less than \( \alpha \). This means that there is enough evidence that null hypothesis \( H_0 \) must be rejected and we must accept alternate hypothesis \( H_1 \).
Hence \( Y \)-intercept = 44.97321 is accepted
**X-coefficient:**
Calculated \( X \)-variable coefficient = -1.05775
Let’s assume that the null hypothesis, \( H_0: X \)-variable coefficient = 0
And the alternate hypothesis, \( H_1: X \)-variable coefficient ≠ 0
The t-statistic value for \( X \)-variable coefficient is \( t = -0.30492 \)
And \( p \)-value is \( 0.763432 \)
Since we have assumed that the critical value to be \( \alpha = 0.10 \)
and therefore we observe that \( p \)-value is greater than \( \alpha \). This means that there is enough evidence that null hypothesis \( H_0 \) must be accepted and we must reject the alternate hypothesis \( H_1 \).
Hence \( X \)-variable coefficient = -0.002091is rejected
Based on the above analysis we observe that relationship could be established between \( X \) and \( Y \). Hence \( Y \) can be represented as given below.
\[
Y = -1.0577 + 44.973
\]

### IV. II. MODELING OF LEAKAGE FOR FLEXIBLE QUICK COUPLING GI PIPE NETWORK.

**IV. II. I.** Discharge at first Fault Location from CWPM (LPM) with respect to Distance at first Fault Location form the CWPM (KM)
Considering Distance of first Fault Location form the CWPM as independent variable to be denoted by \“X\” and Discharge at first Fault Location from CWPM as dependent variable to be denoted by \“Y\”.
\[
X = \text{Distance at first Fault Location form CWPM (KM)}
\]
\[
Y = \text{Discharge at first Fault Location form CWPM (LPM)}
\]
Now by calculation from the above set of data for 90% confidence level by linear regression method we get the following observations.

### TABLE. V. REGRESSION STATISTICS - MODEL III

<table>
<thead>
<tr>
<th>Regression Statistics</th>
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</thead>
<tbody>
<tr>
<td>R</td>
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<tr>
<td>R Square</td>
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<tr>
<td>Adjusted R Square</td>
</tr>
<tr>
<td>Standard Error</td>
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<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

Since we assumed 90% confidence level that means our significance level is 10%
Critical value for this analysis is, \( \alpha = 0.1 \)
**F-Test**
Calculated F-critical value for this calculation is \( 4.5447 \)
Calculated F value for this calculation is \( 11.6616 \)
Since F-value is greater than that of F-critical value so we can say that there is some degree of correlation between variable \( X \) and \( Y \).
**Correlation between \( X \) and \( Y \)**
\[
R = \sqrt{R^2} = \sqrt{0.7446} = 0.8629
\]
There is a strong correlation between \( X \) and \( Y \)
\( R \) square value is 0.7446 that means we are able to explain 74.46% variability of \( Y \) with respect to \( X \).
Now let us use t-test and p-value test for evaluation of \( Y \)-intercept and \( X \)-variable coefficient.
**Y-intercept:**
Calculated \( Y \)-intercept = 54.7413
Let’s assume null hypothesis, \( H_0: Y \)-intercept = 0
And alternate hypothesis, \( H_1: Y \)-intercept ≠ 0
The T statistic value for \( Y \)-intercept is \( t = 9.7986 \) and \( p \)-value is \( 0.0006 \)
Since we have assumed that the critical value to be \( \alpha = 0.1 \)
and therefore we observe that \( p \)-value is less than \( \alpha \). This means that there is enough that null hypothesis \( H_0 \) must be rejected and we must adopt alternate hypothesis \( H_1 \).
Hence \( Y \)-intercept = 54.7413 is accepted.
**X-variable coefficient:**
Calculated \( X \)-variable coefficient = -3.9334
Let’s assume that the null hypothesis, H₀: X-variable coefficient = 0
And the alternate hypothesis, H₁: X-variable coefficient ≠ 0
The T statistic value for X-variable coefficient is t = -3.4149
And p-value is = 0.02690
Since we have assumed that the critical value to be α = 0.1 and therefore we observe that p-value is less than α. This means that there is enough evidence that null hypothesis H₀ must be rejected and we must adopt alternate hypothesis H₁.
Hence X-variable coefficient = -3.9334 is accepted.
Based on the above analysis we can form the straight line equation for the liner regression between X and Y
\[ y = -3.9334x + 54.7413 \]  

**TABLE  V:REGRESSION STATISTICS - MODEL IV**

<table>
<thead>
<tr>
<th>Regression Statistics</th>
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<tbody>
<tr>
<td>R</td>
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<td>R Square</td>
<td>0.8694</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.8368</td>
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<tr>
<td>Standard Error</td>
<td>3.7613</td>
</tr>
<tr>
<td>Observations</td>
<td>6</td>
</tr>
</tbody>
</table>

Since we assumed 90% confidence level that means our significance level is 10%
Critical value for this analysis is, \( \alpha = 0.1\)

F-Test
Calculated F-critical value for this calculation is = 26.6301
Calculated F value for this calculation is = 4.5448
Since F-value is greater than that of F-critical value so we can say that there is some degree of correlation between variable X and Y.
Correlation between X and Y is
\[ R = \sqrt{R^2} = \sqrt{0.8694} = 0.9324 \]
There is a strong correlation between X and Y
R square value is 0.8694 that means we are able to explain 86.94 % variability of Y with respect to X.
Now let us use t-test and p-value test for evaluation of Y-intercept and X variable coefficient.
Y-intercept:
Calculated Y-intercept = -14.7287
Let’s assume null hypothesis, H₀: Y-intercept = 0
And alternate hypothesis, H₁: Y-intercept ≠ 0
The T statistic value for Y-intercept is t = -2.3473 and p-value is = 0.0787
Since we have assumed that the critical value to be α = 0.1 and therefore we observe that p-value is less than α. This means that there is enough that null hypothesis H₀ must be rejected and we must adopt alternate hypothesis H₁.
Hence Y-intercept = -14.7287 is accepted.
X-variable coefficient:
Calculated X-variable coefficient = 0.8372
Let’s assume that the null hypothesis, H₀: X-variable coefficient = 0
And the alternate hypothesis, H₁: X-variable coefficient ≠ 0
The T statistic value for X-variable coefficient is t = 5.1604
And p-value is = 0.0067
Since we have assumed that the critical value to be α = 0.1 and therefore we observe that p-value is less than α. This means that there is enough that null hypothesis H₀ must be rejected and we must adopt alternate hypothesis H₁.
Hence X-variable coefficient = 0.8372 is accepted.

**FIGURE 8.DISCARAGE AT FIRST FAULT LOCATION FROM CWPM (LPM) V/S DISTANCE AT FIRST FAULT LOCATION FORM THE CWPM (KM)**

**FIGURE 9.DISCARAGE AT THE NEXT FAULT LOCATION (LPM) V/S DISCHARGE AT FIRST FAULT LOCATION FROM CWPM (LPM)**
IV.II.II. Discharge at first Fault Location from CWPM (LPM) with respect to Discharge from CWPM (LPM)

Considering Discharge from CWPM as independent variable to be denoted by “X” and Discharge at first Fault Location from CWPM as dependent variable to be denoted by “Y”.

X = Discharge from CWPM (LPM)

Y = Discharge at first Fault Location from CWPM (LPM)

Now by calculation from the above set of data for 90% confidence level by linear regression analysis, we get the following observations.

### TABLE VII. REGRESSION STATISTICS

<table>
<thead>
<tr>
<th>Regression Statistics</th>
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<tbody>
<tr>
<td>R</td>
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<td>R Square</td>
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<td>Adjusted R Square</td>
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<tr>
<td>Standard Error</td>
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<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

Since we have assumed 95% confidence level that means our significance level is 5%

Therefore critical value for this analysis is, $\alpha = 0.05$

Correlation coefficient between X and Y is $R = \sqrt{R^2} = \sqrt{0.040648} = 0.201614$

There exist a very low correlation between X and Y.

Y-intercept:

Calculated Y-intercept = 37.5

Let’s assume null hypothesis, $H_0$: Y-intercept = 0

And alternate hypothesis, $H_1$: Y-intercept ≠ 0

The t-statistic value for Y-intercept is $t = 8.09019$

And p-value is = 0.001269

Since we have assumed that the critical value to be $\alpha = 0.05$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept alternate hypothesis $H_1$.

Hence Y-intercept = 37.5 is accepted

X-coefficient:

Calculated X-variable coefficient = 0

Based on the above analysis we observe that no linear relationship could be established between X and Y. Hence Y can be represented as a constant line which is given below.

$$Y = 37.50$$

**FIGURE 10. DISCHARGE AT FIRST FAULT LOCATION FROM CWPM (LPM) V/S DISCHARGE FROM CWPM (LPM)**

IV.II.IV. Distance of first fault location form the CWPM (KM) and Discharge from CWPM (LPM)

Considering Discharge from CWPM as independent variable to be denoted by “X” and Distance of first fault location form the CWPM as dependent variable to be denoted by “Y”.

X = Discharge from CWPM (LPM)

Y = Distance of first fault location form the CWPM (KM)

Now by calculation from the above set of data for 90% confidence level by linear regression analysis, we get the following observations.

### TABLE VIII. REGRESSION STATISTICS

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>R</td>
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<td>R Square</td>
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<td>Adjusted R Square</td>
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<tr>
<td>Standard Error</td>
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<tr>
<td>Observations</td>
</tr>
</tbody>
</table>

Since we have assumed 95% confidence level that means our significance level is 5%

Therefore critical value for this analysis is, $\alpha = 0.05$

Correlation coefficient between X and Y is $R = \sqrt{R^2} = \sqrt{0.02228} = 0.149265$

There exist a very low correlation between X and Y.

Y-intercept:

Calculated Y-intercept = 4.38333

Let’s assume null hypothesis, $H_0$: Y-intercept = 0

And alternate hypothesis, $H_1$: Y-intercept ≠ 0

The t-statistic value for Y-intercept is $t = 4.269909$

And p-value is = 0.012951

Since we have assumed that the critical value to be $\alpha = 0.05$ and therefore we observe that p-value is less than $\alpha$. This means that there is enough evidence that null hypothesis $H_0$ must be rejected and we must accept alternate hypothesis $H_1$.

Hence Y-intercept = 37.5 is accepted

X-coefficient:

Calculated X-variable coefficient = 0

Based on the above analysis we observe that no linear relationship could be established between X and Y. Hence Y can be represented as a constant line which is given below.

$$Y = 4.38333$$

**FIGURE 11. DISTANCE AT FIRST FAULT LOCATION FROM THE CWPM (KM) V/S DISCHARGE FROM CWPM (LPM)**
V. CONCLUSION

In case of PVC Pipe distribution network, as evident from Fig 4 and Fig 5, with the increase in discharge at the first fault location, the discharge at next fault location increases linearly. Again, distance of the first fault location from CWPM increases linearly as discharge from CWPM increases. In case of Flexible Quick Coupling GI Pipe distribution network, as evident from Fig 8 and Fig 9, with the increase in discharge at the first fault location, the discharge at next fault location increases linearly. Again, distance of the first fault location from CWPM increases linearly as discharge from CWPM increases.

VII. REFERENCES


