An Approach for Ranking of Triggering Parameters of Pipeline Failure

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Abstract
Pipe line failure is a significant apprehension of researchers and engineers. Loss of water due to the pipeline failure is a common problem and a demanding challenge. Deficit knowledge of structural mechanism of pipeline and finding appropriate triggering parameters of pipeline failure is a big challenge. There are various parameters are liable for pipeline failure. It is required to understand the most important causing parameter for the failure of pipeline. In this paper a method is established to rank various triggering parameters for pipeline failure using multicriteria decision making matrix. Four influence parameters viz. Pipe age, internal and external loads exerted by soil pressure and traffic load, seasonal climatic variation and corrosion are chosen. These parameters are ranked using three different criteria viz. wastage of energy, reduction in the pipe carrying capacity, increased potential for contamination. Analytic Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution method is used for the multicriteria decision making matrix. From the analysis it is found that the parameter, internal and external loads exerted by soil pressure and traffic load has got first rank among the other triggering parameters for pipeline failure.

Keywords: Analytic Hierarchy Process, Pipeline failure, Ranking, Technique for Order Preference by Similarity to Ideal Solution method

Introduction

Pipeline failure is an immense challenge for our civilization. Pipeline failure is not only the reason behind contamination but also caused environmental pollution and various chemical and biological hazards [7]. There are various parameters viz. pipe age, pressure, corrosion, reduces the working capability of pipe and causes pipe failure [16, 13]. It is essential to find out the significant reason behind the pipeline failure so the researchers can analyze the reason. Generally, pipe intrinsic, environmental, operational factors are impacting the failure of pipeline [3]. Traffic load is a significant parameter for the pipeline failure [17]. Due to higher traffic load, there is more protuberant of the vertical displacement of the pipe joint and increase the stress concentration on the corroded part of pipe. Various research shows the measurement of the traffic loads by field response. For maintenance and failure prediction of pipeline, load measurement plays a vital role [10]. Another study shows the impact of different loads on water pipeline and its calculations are used for life time prediction models [9].

Pipeline failure is also caused due to seasonal climatic variation [2,15]. For various pipe material viz. cast iron, steel are fully affected by weather condition. Generally, in high temperature, failure occur at steel pipes whereas at low temperature, cast iron pipes gets failure. Weather condition doesn't create any impact on PVC pipes. Pipe age is another important parameter and can be taken into consideration for pipe failure [6]. For steel pipes pipeage plays a vital role for the wall decay [1]. Though pipe age creates great impact on cast iron pipes, whereas steel pipes are less affected by the pipeage. Other study shows, assessment of corroded pipeline for the prediction of pipe failure is an important task [8, 14].

Method

This paper shows the ranking of triggering parameters of pipeline failure using multicriteria decision making matrix (MCDM). MCDM tools viz. Analytic Hierarchy Process [4] and Technique for Order Preference by Similarity to Ideal Solution are used for the criteria weightage calculation and ranking of various triggering parameter of pipeline failure. Initially weights are given for different criteria. After that, consistency index and consistency ratio are calculated and finally calculated eigen value are taken as weightage for Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) during ranking of various triggering parameters [5, 12]. The process flow chart for ranking of triggering parameters of pipeline failure is shown in Fig.1.

Following equation is suitable for the calculations of consistency ratio (CR).

$$CR = \left\{ \frac{(\gamma_{\max} - n)}{n-1} \right\} \Big/ 0.58$$

(1)

Where γ is eigen value and "n" is number of elements from pairwise comparison matrix. Here, value of n is considered as 0.58 (for n =3). $\frac{(\gamma_{\max} - n)}{n-1}$ is considered as consistency index. Consistency ratio should be less than 0.1 for reliable outcome [11] .

Technique for Order Preference by Similarity to Ideal Solution includes following equations.

- Calculation of weighted normalised matrix

$$W_{ij} = N * X_j$$

(2)

Where N is Normalised Matrix ($N = Y_{ij} \Big/ \sqrt{\sum Y_{ij}^2}$, Y_{ij} is score of alternative where i= 1……n and j= 1….n) and weights of various criteria from AHP is denoted by X_j.

- Performance Score(E) calculation

$$E = \beta_i^- / (\beta_i^+ + \beta_i^-)$$

(3)

Where Euclidean distance from the ideal best and ideal worst is denoted by β_i^+ and β_i^- and are calculated using weighted normalised matrix(eqn.2).

- Final ranking of triggering parameters of pipeline failure as per performance score.

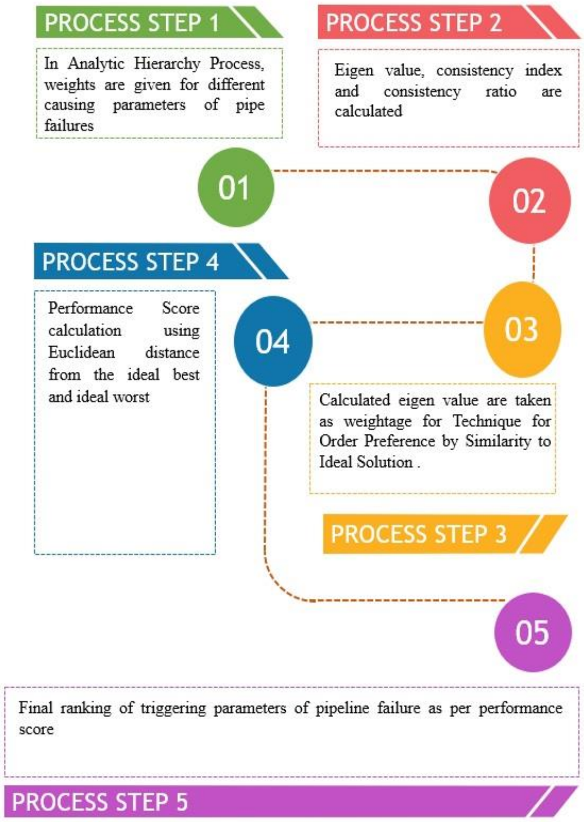

Fig.1 Process flow chart for ranking of triggering parameters of pipeline failure

Result and discussion

In this research four triggering parameters of pipeline failure viz. pipe age, internal and external loads exerted by soil pressure and traffic load, seasonal climatic variation, corrosion and three criteria for those parameters viz. wastage of energy, reduction in the pipe carrying capacity, increased potential for contamination are chosen. Initially, AHP is used for comparing three different criteria. It is found from the comparison analysis, out of three different criteria, the third criteria i.e. increased potential for contamination is most important as compared to other two criteria. The comparison matrix is shown in table.1. From the matrix, eigen values are considered as weights for the next comparison analysis i.e. Technique for Order Preference by Similarity to Ideal Solution method. In this method four triggering parameters are compared using the weights from AHP (Table.2). It is found that the performance score of the parameter i.e internal and external loads exerted by soil pressure and traffic load is maximum and is ranked as 1, whereas another parameter i.e., seasonal climatic variation has minimum performance score and is ranked as 4. According to the performance score, the other two parameters are also ranked and is shown in table.3. Figure 2 shows the complete view of criteria, parameters and their rank.

Table1 Comparison matrix of three criteria

Criteria		*c1*	*c2*	*c3*
Wastage of energy(*c1*)	*c1*	1.00	0.33	0.20
Reduction in the pipe carrying capacity(*c2*)	*c2*	3.00	1.00	0.33
Increased potential for contamination(*c3*)	*c3*	5.00	3.00	1.00

Table 2 Decision making matrix of four triggering parameters and three criteria

Triggering Parameters	*c1*	*c2*	*c3*	*Pi*	*Rank*
Pipe age (*a1*)	3	3	5	0.317459	3
Internal and external loads exerted by soil pressure and traffic load(*a2*)	5	3	7	0.820463	1

Seasonal climatic variation(*a*3)	3	4	4	0.179537	4
Corrosion(*a*4)	5	3	5	0.340442	2

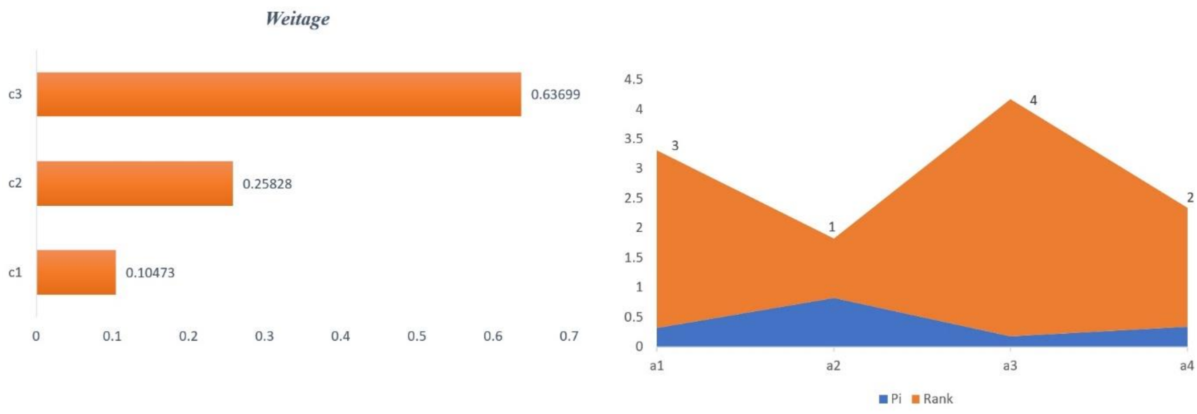

Fig.2 Complete view of criteria, parameters and rank

Table 3 Over view of criteria, triggering parameters of pipeline failure and their rank

Sl no.	Triggering parameters of pipeline failure	Criteria for various parameters	References (***Rank***)
1	Pipe age(*a*1)	i)Wastage of energy(*c*1) ii) Reduction in the pipe carrying capacity(*c*2) iii) Increased potential for contamination(*c*3)	[1, 6] (***3***)
2	Internal and external loads exerted by soil pressure and traffic load(*a*2)		[17, 9,10] (***1***)
3	Seasonal climatic variation(*a*3)		[2,15] (***4***)
4	Corrosion(*a*4)		[8,13,16]**(*2*)**

Conclusion

Finding the important triggering parameter of pipe failure eases work of pipeline and environment engineers. If the causing parameter is not found accurately then pipeline failure analysis and finding failure location is not possible. This research shows the approach to rank those parameters by Analytic Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution method using multicriteria decision making matrix (MCDM). From the analysis it is found that internal and external loads exerted by soil pressure and traffic load got ranked as 1, whereas another parameter i.e., seasonal climatic variation has got last rank i.e., 4. Though the above approach for ranking is efficient but using artificial intelligence (AI) based model [8] may give precise result.

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