A REVIEW OF MODIFIED DIMENSIONAL ANALYSIS

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Abstract - This paper presents a review of modified Dimensional analysis. This method subsumed the modified Buckingham-Pi theorem to formulate a general equation using only experimental results. Dimensional analysis does not base any assumptions and hypothesis. The systematic groups of pertinent variables involved in the physical phenomenon to form dimensionless group. A unique trial and error procedure is substantiating that generates the universal dimensional analysis formulation. The results of dimensional analysis compared with the available experimental results. Dimensional analysis predict the results rationally well and shows to be an easy and sufficiently accurate method of analysis.

Keywords - Buckingham's- Pi theorem, Modified Dimensional Analysis, Trial and error method.

I. INTRODUCTION

Every engineer seeks to have an easy, fast and reliable solution to his problems. For this, he took help of various analysis tools. There are various methods such as Limit Equilibrium Analysis, Finite Element Analysis etc. involves simple rule and assumptions to more complex techniques.
The aim of dimensional analysis is reduce to minimum the dimension space in which the behavior of a specific system studied by combining and arranging systematically governing variables.
Dimensional analysis is a mathematical technique, which is a primary tool for engineers and scientists. Buckingham's-Pi method has certain demerits due to that the method provides unrealistic and vague results. Prof. R. Butterfield paper [1] has suggested a modified version of the Buckingham's-Pi method. Modified Buckingham's-Pi method is quite realistic and full proof.

Dimensional analysis is the analysis of the relationship between physical quantities identifies their base quantity. Dimensional analysis does not base any assumptions and hypothesis.

The various physical quantities used by the engineers and scientists, to describe a phenomenon by given a set of quantities that are independent with each other. These quantities are known as fundamental or primary quantities. The primary quantities are mass, length, time and temperature, designated by the letter M, L, T and φ respectively. All other quantities such as area, volume, velocity, force, etc. are termed as derived quantities or secondary quantities.

II. DIMENSONAL ANALYSIS TECHNIQUES

A. Rayleigh Method

Lord Rayleigh proposed this method in 1889. In this method a functional relationship of some variables are forms of exponential equation, which must be dimensionally homogenous.
Thus if X is some functional variables X_1, X_2, X_3….X_n, the functional equation can be written in following general form;
$X=f(X_1, X_2, X_3 \ldots X_n)$
In this equation, X is dependent variables, while X_1, X_2, X_3….$X_n$are independent variables. A dependent variables is the one about which information is required while independent variables are those which governs the variation of dependent variable.
When the number of variables is considerably increased, the Rayleigh method becomes tedious.

B. Buckingham's-Pi method

Buckingham's-Pi method has certain demerits due to that the method provides unrealistic and vague results. Prof. R. Butterfield paper [1] has suggested a modified version of the Buckingham's-Pi method. Modified Buckingham's-Pi method is quite realistic.
Buckingham's-Pi theorem states that if there are 'n' dimensional variables involved in a phenomenon, which described by 'm' fundamental quantities such as mass, length, time etc. and related by a dimensionally homogeneous equation.
Wherein each dimensionless π- term is formed by combining 'm' variable's out of the total 'n' variables with one of remaining (n-m) variables. These 'm' variables appear repeatedly in each of π- term, thus called repeating variables and chosen from among the variables and they themselves do not from form dimensionless parameters.

III. LITERATURE RIVEW

1) R. Butterefield recommend dimensional analysis for geotechnical engineers. In that paper researcher, recommended dimensional analysis is an important tool for engineers, aiding the design of experiments and concise expression of the results generated by them. This paper suggested a general dimensional analysis algorithm imposes both necessary and

sufficient condition. The development of the dimensionless groups, which are the output of such analyses from a global set of dependent and independent variables are consider.

Buckingham's- Pi theorem defined as the tools to use well-established and general method. In this paper researcher, used modified Buckingham's-Pi theorem this method is realistic and gives incorporates solutions. Most authors have realized that conventional way in which Buckingham's theorem provides an incomplete algorithm comes. Buckingham's theorem usually stated that the number of variables to be considered in dimensional analysis problems. Dimensional analysis is required to reduce to a minimum dimension in which assumed governing variables. Variables should be enclosed in 'square brackets' only. In that paper, some assumptions are separated for modified Buckingham's- Pi method.

2) D. R. Phatak and H. B. Dhonde proposed dimensional analysis of reinforced concrete beams subjected to pure torsion. The writes formulated a general equation to determine ultimate torsional strength of reinforced concrete beam using dimensional analysis

The results predicted by dimensional analysis and compared with experimental results. The aim of dimensional analysis is try to reduce to minimum the dimension combining and arranging the assumed variables V= (V1, V2, V3… Vn). Where m is independent primary dimension (D) = (D1, D2, D3… Dm) into N= (n-m) dimensionless groups, that are (π1, π2, π3….. πN).

After finding out all parameter researcher do the grouping of dimensionless variables. After getting all-dimensionless group used multiple regression analysis. The writer was test total 39 results from empirical study. In that, paper the results compared with limit state and dimensional analysis. The writer proved that predictive performance of dimensional analysis method is remarkably good.

Significantly observe that only two experimental data sets are required for the formulation; one is for control point for initial formulation and other is for checkpoint for validating derived formula.

3) Siddhesh P. Narvekar, Akshay R. Thorvat and Manoj M. Mujumdar has proposed use of dimensional analysis in cement industry. Compressive strength of cement is one of the main property. This can be find out as per test procedure but results obtained after 7 or 28 days. To overcome this difficulty various approaches has been adopted, in that paper the researcher has tried to formulate the same with the help of modified dimensional analysis method by which results obtained in one day.

IV. METHODOLOGY

The basic formulation of any problem done by using following procedure of modified dimensional analysis:-

1. List all the physical quantities (n) or variables involved in the phenomenon and the number 'm' of the fundamental dimension comprised in them.
2. Select 'm' variables out of these, which are to serve as repeating variables. The repeating variables should not have same dimensions and each variables are different from each other. They do not from a dimensionless parameter.
3. The dependent variables should not be takenas repeating variablesotherwise; it will not be possible to obtain a clear relationship.
4. Write general equations for different π-terms. These may be expressed as the product of their repeating variables each raised to an unknown exponent and one of the remaining variables.
5. Compute the values of the unknown exponents by equating the exponents of respective fundamental dimensions on both the sides of each of the dimensional equation and obtain the different dimensionless groups or π-terms.
6. Write final general equation for the phenomenon in terms of π.

CONCLUSION

The outcomes of this work indicates that the DA is easy, rapid, and sufficiently accurate method, where conventional analysis would prove to be tedious and complex. The scrutiny clearly indicates that the predictive performance of modified dimensional analysis is remarkably good. This process requires only two experimental data sets to formulate an equation; one data set to "train" the equation, and another one to "validate" the established equation.

The main advantage of modified dimensional analysis is that it is not based on any assumptions and hypothesis.

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