Comparative Study Of Different Structure Analysis Methods

[1]Kushal S. Shah, [2]Dr. Pankaj Singh
[1]M.Tech student, Civil Engineering Department SRK University, [2]HOD, Civil Engineering Department, SRK University

Abstract:- Conventional method of structural analysis adopted for practical design of most of the structures, ignores the effect of compressibility of soil and flexibility of foundation. Inclusion of soil and foundation in the analysis is likely to influence the computed values of stresses in the super structure members. The literature does not appear to provide much information regarding the magnitude of such influence and the effect of different parameters involved in the system. So, a comparative study of the stresses computed from such "integratedanalysis" with those obtained without including soil and foundation in the analysis, would be very useful. The analysis of complex structures like frames, trusses and beams is carried out using the Finite Element Method (FEM) in software products like ANSYS and STAAD. In this study, compare the deformation results of simple and complex structures obtained using these products. STAAD,RAM ,ETABS,SAP2000 are used by civil engineers to analyse structures like beams and columns.

***IndexTerms* – Structural loads, Structure analysis**

I. Introduction

A structural engineer have to determine such information like structural loads, support conditions, geometry and materials properties for performing an accurate analysis. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. There are many numbers of structural analysis methods are available, some are conventional methods and some are modern methods. Comparative study of four conventional methods like Slope deflection method, Moment distribution method, Kani's method, Moment area method has been discussed in this report for understanding about all methods properly. It also covers modern methods like Matrix method and finite element method to compare with conventional methods. Now a days different types of structural analytical software are also used to work more fast and efficient in manner so this study covers some of the structural software likes STAAD , ETABS and SAP2000 for comparative study of them.This research work gives more ideas and knowledge regarding advantages and disadvantages, limitations of manual working methods and computer programming methods.

II. Objective of the study

The purpose of this research work is to check out strength of structural analysis and compare four methods of structural analysis and find out limitations of these methods. The main objective of this research work was to understand analytical terms of structural methods in different members of structural part of any building.

1) To study different methods of structural analysis and compare them with software for better understanding about analysis of structure.
2) To acquire the knowledge to solve both statically determinate and indeterminate structures by different conventional methods like Slope deflection method,Moment distribution method (MDM), Kani's method and Moment area method.
3) To compare conventional methods with modern method like Finite element method and Matrix methods also used for study.
4) Nowadays structural analysis is easy by working on software, I had compare and study some of structural analysis software like STAAD, ETABS, SAP,RAM with manual methods to understand more about structural analysis.

III. Need of the study

Structural analysis is the determination of the effects of loads on physical structures and their components. Structural analysis is performed to checkphysical properties of different components of buildings. To compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability, the structural analysis is required and it is connected with the fields of applied mechanics, applied mathematics and materials science. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. So the Structural analysis is a key part of the Civil engineering.

IV. Literature Review

Sonali C. Javalge done comparative study of structures using softwares. Structural Analysis is a branch which involves in the determination of behaviour of structures in order to predict the responses of real structures such as buildings, bridges, trusses etc. Under the expected loading and external environment during the service life span of structure. In this paper, we are going to do a comparative study of softwares. We are going to analyse and design the structure on softwares. Then we will find the results based on Bending Moment, Shear force, Base Shear, Axial Force, Steel required for various sections.We will find out the software giving most economical sections. We will check which software is most easy to handle, gives safer and economical structure.

Based on the analysis and design of multi-storied building the following conclusions are made: Comparison of ETABS and SAP2000 is made on Analysis and Design basis. From the analysis results of columns and beams, she conclude that ETABS gave greater values of Shear Forces and Bending Moments as compared to SAP2000. From the design results columns and beams, steel provided in ETABS is greater than that provided in SAP2000. Therefore, she conclude that SAP2000 most economical and reliable design software as compared to ETABS.

Dinesh pagar performed comparative study of seismic responses of rcc, steel and mix construction. A Building of mixed Construction , in which the Structure is partly concrete and partly Structural Steel have been built for many years in many parts of the world. In general, this type of construction consists of either steel frames with concrete encasement or structure in which shear wall, tube frame, or other major components are concrete while the remainder of the framing is steel. A New form of mix construction in which five stories steel structure is stacked on top of a five story concrete structure. A RCC medium rise building of 10 stories with floor height 3.5m subjected to earthquake loading in V Zone has been considered. The variation of seismic response of mix construction building depending on various analysis methods namely Equivalent static method, Response spectra method and Time history method are evaluated and compared. This study examines G+10 stories buildings of R.C.C., Steel, & Mix Construction are analyzed and design under effect of wind and earthquake using ETABS. All three models are analyzed & designed by response spectra analysis & it proves that Mix Construction Frame building is satisfied the all result. Analytical results are compared to achieve the most suitable resisting system & economic structure against the lateral forces.

From his study he concluded that Mix construction can reduce residual lateral displacements as compare to RCC and Steel. For medium to high rise frames, RCC Structure can provide sufficient lateral strength and deformation capacity under strong shaking as Compare to Steel Structure. A very good control over displacement, drift, can be achieved by using mix construction in which five stories steel structure is stacked on top of a five story concrete structure. The large effect of earthquakes occurs in the lower stories as compare to above stories. Hence, a sudden decrease in lower story strengths should be carefully controlled by providing Mix construction. Mix Construction Frame building is satisfied the all result.

Inguva sai Surya prakash made a study on comparative analysis of rcc building resting on plain and hilly terrain. In a developing country like India there is a scarcity of land due to urbanization and industrialization, which led the way for construction of high rise multistorey buildings on hilly regions. The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. Therefore, there is popular and pressing demand for the construction of multistorey buildings on hill slope in and around the cities. Hill buildings are different from those in plains; they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Hence, they are susceptible to severe damage when affected by earthquake ground motion. Past earthquakes [e.g. Kangra (1905), Bihar- Nepal (1934 & 1980), Assam (1950), Tokachi-Oki-Japan (1968), Uttarkashi-India (1991)][1], have proved that buildings located near the edge of stretch of hills or sloping ground suffered severe damages. Such buildings have mass and stiffness varying along the vertical and horizontal planes, resulting the center of mass and center of rigidity do not coincide on various floors. This requires torsional analysis; in addition to lateral forces under the action of earthquakes. Little information is available in the literature about the analysis of buildings on sloping ground. The investigation presented in this paper aimed at predicting the seismic response of RC buildings with different configuration on sloping and plain ground.

The comparison of results of building shows that Although, the buildings on plain ground attract less action forces as compared to buildings on sloping ground, overall economic cost involved in levelling the sloping ground. In buildings on sloping ground, it is observed that extreme left column at ground level, which are short, are the worst affected. Special attention should be given to these columns in design and detailing. The graph shows that there is significant reduction in bending moments of columns in Z Direction from R.C.C Structure on Plain Ground and Sloping Terrain. The storey drift in R.C.C Structure on Plain Ground and Sloping Terrain is nearly equal. This is because; steel structure is more flexible as compared to RCC structure. From the study, it is observed that the building which are resting on sloping are subjected to short column effect , attract more forces and are worst affected during seismic excitation. Hence form design point of view, special attention should be given to the size, orientation, and ductility demand of short column. It is also found that the hill slope building are subjected to significant torsional effects due to uneven distribution of Axial force in the various frames of building suggest development of torsional movement which is found to be higher on a sloping ground building.

V. Methods of analysis:-

Slope deflection method:-

The slope deflection method use displacements asunknowns, hence thismethodisknown as a displacement method. In this method, if the slopes at the ends and the relative displacement of the ends are known, the end moment can be found in terms of slopes, deflection, stiffness and length of the members. The joints are treated as unknowns in the slope deflection method. For any one member which is bounded by two joints then end moments can be expressed in terms of rotations. All joints are considered as rigid in this method and the angle between members at the joints are considerednot-to change in value.

Assumptions in the Slope Deflection Method

(1) All the joints of the frame are rigid,when the members of frame are loaded, then the angle between themembersatthejointsdonotchange.

(2) Distortion due to axial and shear stresses are very small so these are neglected.

The degrees of freedom is known as thenumber of joints rotation and independent joint translation in a structure.There are two types for degrees of freedom.

In rotation: - For beam or frame is equal to D_r .

$$\boxed{D_r = J - f}$$

Where,

D_r = degree of freedom.

J = no. of joints including supports.

f = no. of fixed support.

Moment distribution method:-

In slope- deflection analysis, the unknown displacements (rotations and translations) are related to the applied loading on the structure. The slope-deflection method results in a set of simultaneous equations of unknown displacements. The number of simultaneous equations will be equal to the number of unknowns to be evaluated. Thus one needs to solve these simultaneous equations to obtain displacements and beam end moments. Today, simultaneous equations could be solved very easily using a computer. Before the advent of electronic computing, this really posed a problem as the number of equations in the case of multi-story building is quite large. The moment-distribution method proposed by Hardy Cross in 1932, actually solves these equations by the method of successive approximations. In this method, the results may be obtained to any desired degree of accuracy. Until recently, the moment-distribution method was very popular among engineers.

In moment-distribution method, counter clockwise beam end moments are taken as positive. The counter clockwise beam end moments produce clockwise moments on the joint Consider a continuous beam ABCD as shown in Fig 5.1a. In this beam, ends and Dare fixed and hence, $\theta_A = \theta_D = 0$. Thus, the deformation of this beam is completely defined by rotations θ_B and $\theta_C$at joints B and C respectively. The required equation to evaluate θ_B and θ_C is obtained by considering equilibrium of joints B and C. Hence,

$$\sum M_B = 0 \quad \Rightarrow \quad M_{BA} + M_{BC} = 0$$

$$\sum M_C = 0 \quad \Rightarrow \quad M_{CB} + M_{CD} = 0$$

According to slope-deflection equation, the beam end moments are written as

$$M_{BA} = M_{BA}^F + \frac{2EI_{AB}}{L_{AB}}(2\theta_B)$$

$\{4EI_{AB} / L_{AB}\}$is known as stiffness factor for the beam AB and it is denoted by K_{AB}.

Mf_{BA} is the fixed end moment at joint B of beam AB when joint B is fixed.

Thus,

$$M_{BA} = M_{BA}^F + K_{AB}\theta_B$$

$$M_{BC} = M_{BC}^F + K_{BC}\left(\theta_B \frac{\theta_C}{2}\right)$$

$$M_{CB} = M_{CB}^F + K_{CD}\left(\theta_C \frac{\theta_B}{2}\right)$$

$$M_{CD} = M_{CD}^F + K_{CD}\theta_C$$

Kani's method

This method was first developed by Prof. Gasper Kani of Germany in the year 1947. The method is named after him. This is an indirect extension of slope deflection method. This is an efficient method due to simplicity of moment distribution. The method offers an iterative scheme for applying slope deflection method of structural analysis. Whereas the moment distribution method reduces the number of linear simultaneous equations and such equations needed are equal to the number of translator displacements, the number of equations needed is zero in case of the Kani's method. This method may be considered as a further simplification of moment distribution method wherein the problems involving sway were attempted in a tabular form thrice (for double story frames) and two shear coefficients had to be determined which when inserted in end moments gave us the final end moments. All this effort can be cut short very considerably by using this method. Frame analysis is carried out by solving the slope−deflection equations by successive approximations. Useful in case of side sway as well. Preparation is simple, as it is carried out in a specific direction. If some error is committed, it will be eliminated in subsequent cycles if the restraining moments and distribution factors have been determined correctly.

Metrix method

As one of the methods of structural analysis, the direct stiffness method, also known as the matrix stiffness method, is particularly suited for computer-automated analysis of complex structures including the statically indeterminate type. It is a matrix method that makes use of the members' stiffness relations for computing member forces and displacements in structures. The direct stiffness method is the most common implementation of the finite element method (FEM). In applying the method, the system must be modelled as a set of simpler, idealized elements interconnected at the nodes. The material stiffness properties of these elements are then, through matrix mathematics, compiled into a single matrix equation which governs the behaviour of the entire idealized structure. Between 1934 and 1938 A. R. Collar and W. J. Duncan published the first papers with the representation and terminology for matrix systems that are used today. Aero elastic research continued through World War II but publication restrictions from 1938 to 1947 make this work difficult to trace. The second major breakthrough in matrix structural analysis occurred through 1954 and 1955 when professor John H. Argyrols systemized the concept of assembling elemental components of a structure into a system of equations. Finally, on Nov. 6 1959, M. J. Turner, head of Boeing's Structural Dynamics Unit, published a paper outlining the direct stiffness method as an efficient model for computer implementation (Felippa 2001). The direct stiffness method originated in the field of aerospace. Researchers looked at various approaches for analysis of complex airplane frames. These included elasticity theory, energy principles in structural mechanics, flexibility method and matrix stiffness method. It was through analysis of these methods that the direct stiffness method emerged as an efficient method ideally suited for computer implementation.

A typical member stiffness relation has the following general form:

$$\boldsymbol{Q^m = k^m q^m + q^{om}}$$

m = member number m.

$\boldsymbol{Q^m}$ =Vector of member's characteristic forces, which are unknown internal forces.

$\boldsymbol{k^m}$= member stiffness matrix which characterizes the member's resistance against deformations.

$\boldsymbol{q^m}$= vector of member's characteristic displacements or deformations.

$\boldsymbol{q^{om}}$ = vector of member's characteristic forces caused by external effects

If $\boldsymbol{q^m}$are member deformations rather than absolute displacements, then $\boldsymbol{Q^m}$ are independent member forces, and in such case (1) can be inverted to yield the so-called member flexibility matrix, which is used in the flexibility method.

VI. Conclusion:-

The following conclusions have been drawn from the study:-

- The kinematically indeterminate beams are analysed by slope-deflection equations.
- SDM method is advantageous only for the structures with small Kinematic indeterminacy.
- MDM is a repetitive method , and no. Of repetitions depend on the accuracy desired in the results.
- Moment distribution method, it the basic and by far the most accurate hand calculation.
- MDM there is an advantage of obtaining the member forces without actually calculating the value of displacements, so it is applied on questions , in which only member forces are needed.
- Before evolution of structural engineering software, the easiest method of analysis was and still is Kami's method.
- The method is self correcting, that is if any error, in a cycle is corrected automatically in the subsequent cycles.
- Metrix method is applicable for both statically determinated and Inditerminated problems.

VII. Acknowledgement:-

The author is thankful to Dr. Pankaj Singh, head of the department, civil engineering department for his continuing guidance since starting of the project. The author is also thankful to staff of NSIT, Jetalpur.

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