NONLINEAR FINITE ELEMENT ANALYSIS OF SLAB

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ABSTRACT

This paper deals with the linear and non-linear finite element analysis of reinforced concrete slab for various types of panels of slab given in IS 456:2000. Slab has been modeled for various thicknesses as 75mm, 100mm and 125mm. Eight nodded solid element and 3-D spar element is used for modeling of concrete block and reinforcement respectively. The comparison is carried out between linear and non-linear analysis of concrete slab with respect to the B.M. coefficients and deflection for various panels of slab. A three dimensional finite element modeling of the reinforced concrete slab yield satisfactory result for the nonlinear analysis. Nonlinear finite element analysis proves that it is very powerful tool for the nonlinear problem solution. For modeling and analysis of slab NISA software is used to get more accurate and practical results.

Keywords: Comparison between Linear and non-linear analysis, Eight nodded solid element & 3-D spar element, Finite Element Analysis, Geometric nonlinearity, NISA software.

I INTRODUCTION

Finite element analysis is a powerful numerical technique for the analysis of structure. Finite element analysis is used in various fields like aircraft, fluid flow, electric & magnetic field, solid mechanics etc. In civil engineering, finite element analysis is used for the analysis of plates, shells, beams, foundations, space frames etc. The method is extremely powerful as it helps to accurately analyse structures with complex geometrical properties and loading condition. All physical structures exhibit nonlinear behaviour up to some extent. They may be made of rubber or plastic materials that do not have a constant elasticity modulus. However, the general nature of its theory makes it applicable to various fields of civil engineering as follows:

1.1 Geomechanics

In the field of geomechanics, finite element method is used for the analysis of excavation, retaining wall, underground openings, soil-structure interaction problems, stress analysis in soils, dams, layered piles and machine foundations etc.

1.2 Structure

In the structural analysis, FEM is used in the static analysis of trusses, folded plates, shell roofs, shear walls, bridges, and prestressed concrete structure. Natural frequencies and modes of the structure and their stability can be find out with the help this method.

II DIFFERENCE BETWEEN LINEAR AND NON – LINEAR ANALYSIS

2.1 On The Basis Of Hooke's Law

In case of linear finite element analysis the structure is assumed to be behave linearly i.e. stress is linearly proportional to strain and it will regain its original configuration after the removal of load. Whereas in case of non-linear finite element analysis the stress is not linearly proportional to strain and it will not regain its original configuration. In case of a non-linear analysis structure is loaded beyond the elastic lim

2.2 On The Basis Of Geometry of the Structure

In case of linear analysis the geometry of the structure is assumed to be unchanged while loading process. Whereas in case of non- linear analysis the geometry of the structure is changes continuously during loading process.

2.3 On The Basis Of Load Carrying Capacity

In the linear analysis, the load carrying capacity of the structure cannot be predicted correctly. Therefore, it is necessary to use the non-linear equilibrium equations to describe the structural behaviour.

III TYPES OF NON-LINEARITY

Various non-linear problems in the finite element analysis may be grouped into the following three categories.

3.1 Material Non- Linearity Problem

Material Non- Linearity arises in problems where the stress is not linearly proportional to strain but in which small displacement and small strains are considered. The word "small" usually implies infinitesimal changes in the geometry of the structure. When we consider the displacement it will refer to the changes in the overall geometry of the structure whereas when we considered the strains, it is related to the internal deformation. This type of non-linearity might be due to the presence of creep, plasticity or any other complex relation

3.2 Geometric Non- Linearity Problem

Geometric non-linearity arises in the problem when strain-displacement relationships are non-linear and finite changes in the geometry of the structure. This category considered large strains and large displacement. In many problems strains - displacement relations are not linear. They need consideration of actual strain displacement relations rather than the linear strain displacement. Large deflection problems like the analysis of tension structures & post buckling studies of beams, plates and shells also fall under this category.

3.3 Both Material and Geometric Non – Linearity

This is the third and most general category of non-linear problem which is the combination of material and geometric non-linearity. As it is the combination of two, it involves non-linear constitutive behavior as well as non-linear strain-displacement relationship i.e. large strains and finite displacement. Deformation of a rubber like material is an example of this category.

IV MODELING OF SLAB IN NISA

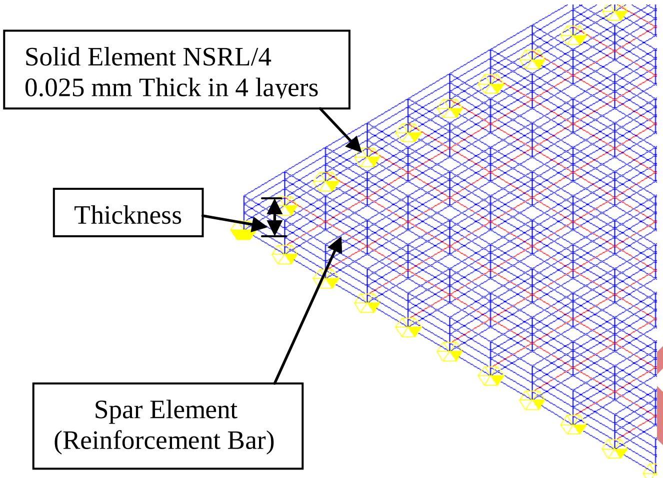

Fig1: 3-D View of the Finite Element Model of the Slab.

V FORMULATION AND ANALYTICAL RESULTS OF PROBLEM

Typical plan of Interior Panel for Ly/Lx ratio 1, 1.5 & 2 is as follow for which modelling and analysis is carried out in NISA for both linear & Non- linear analysis.

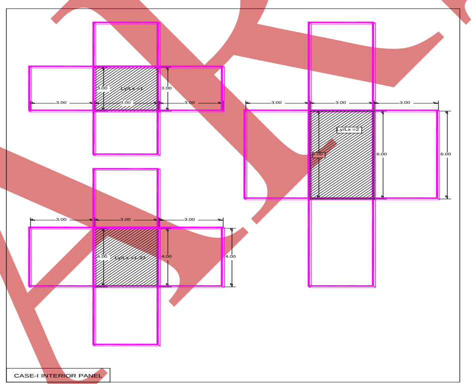

Fig. 2 - Interior Panel

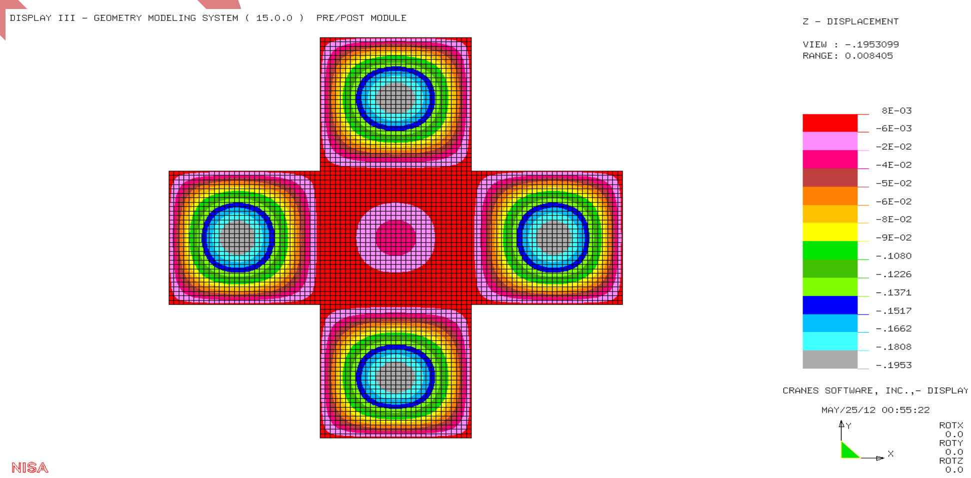

Fig. : 3x3x0.075 m Slab Panel (Nonlinear analysis)

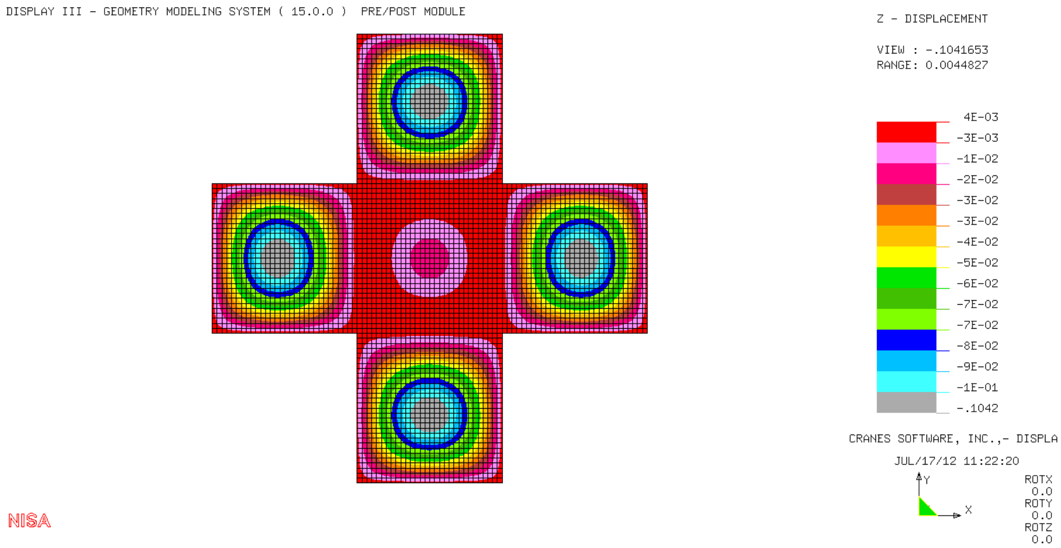

Fig.4: 3x3x0.075 m Slab Panel (linear analysis).

The above figure 3 and 4 represents the counter pattern of deflection for the Interior panel of slab 3x3x0.075 m of size at various location. Accordingly the slab is modelled and analysed for Ly/Lx ratio 1.5 &.2. Eight nodded solid element with 3 degrees of freedom at each node is used for modeling of concrete block and 3-D spar element is used as a reinforcement in the slab.0.12 % reinforcement is used in slab for the analysis.

Table 1: Comparison of Linear & Non-Linear Deflection for Interior Panel.

Ly/Lx	Plate Size (m)	Meshing Size (m)	Thk. Of Element (m)	Loading on Plate (KN)	Deflection (m)		Difference in %
					Linear	Non-Linear	
1	3x3x0.075	15x15	0.2X0.2X0.025	320	0.022	0.0188	11.86
	3x3x0.1	15x15	0.2X0.2X0.025	320	0.011	0.0060	46.43
	3x3x0.125	15x15	0.2X0.2X0.025	320	0.004	0.0028	32.50
1.5	3x4.5x0.075	15X22	0.2X0.2X0.025	320	0.032	0.0305	4.62
	3x4.5x0.1	15X22	0.2X0.2X0.025	320	0.016	0.0103	35.41
	3x4.5x0.125	15X22	0.2X0.2X0.025	320	0.008	0.0044	40.18
2	3x6x0.075	15X30	0.2X0.2X0.025	320	0.042	0.0358	14.61
	3x6x0.1	15X30	0.2X0.2X0.025	320	0.016	0.0116	27.5
	3x6x0.125	15X30	0.2X0.2X0.025	320	0.005	0.0053	0.34

From the analysis it is observed that linear analysis estimates the more deflection for the reinforced concrete slab than Non- Linear analysis for the same pressure intensity. It is because of the assumption for the linear load deflection behaviour of the material. Nonlinear deflection is about 10% to 40% less than the values obtained from the linear analysis.

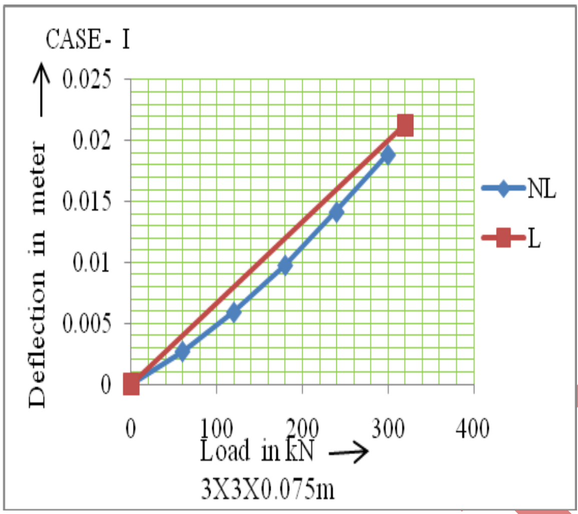

Fig.5-Linear And Nonlinear Deflection at The Centre Of Slab For Interior Panel

Moment value for the given load increment shows the nonlinear behaviour with respect to the applied loads. The moment values obtained from the nonlinear analysis are about 10% to 35 % less to that of the values obtained from the linear analysis. Therefore it also satisfies the moment strength criterion as per various codes and standards which will not satisfies by the linear analysis for the same load.

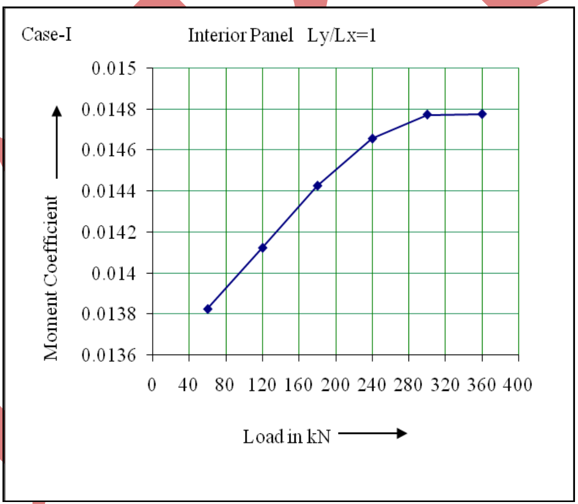

Fig.6- Moment Coefficient-Load graph

VI CONCLUSION

Finite Element Method is the most powerful technique used in the various field. From the present work we can conclude that the nonlinear deflection is about 10% to 40% less than the values obtained from the linear analysis for the same pressure intensity. The present work can be extended by considering torsion at the corner of slab. Behaviour of slab under dynamic and impact loading can also be analysed. As in the market many commercial software are available for nonlinear analysis of plates and shell structure. They can be utilized for realistic modeling of material behaviour under different loading and optimum design can be delivered using the nonlinear analysis.

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