NONLINEAR ANALYSIS AND EXPERIMENTAL INVESTIGATION OF REINFORCED CONCRETE FRAMES

by

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C E R T I F I C A T E

This is to Certify that the thesis entitled "NONLINEAR ANALYSIS AND EXPERIMENTAL INVESTIGATION OF REINFORCED CONCRETE FRAMES", being submitted by Sh. Anil Kumar to the Indian Institute of Technology, Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY in Civil Engineering, is a bonafide research work carried out by him. Sh. Anil Kumar has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The material presented in this thesis has not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

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A C K N O W L E D G E M E N T

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S Y N O P S I S

Analytical and Experimental investigation has been carried out with the aim to study the nonlinear behaviour of reinforced concrete frames. Suitability of the proposed nonlinear analysis, extent of redistribution due to inelasticity, and rotation capacity of 'hinging' regions have been critically discussed.

The theoretical analysis of tall building frames, considering nonlinearities due to material inelasticity and large deformations is presented in Chapter II. The moment curvature relationships, used in the analysis, have been computed for a nonlinear stress-strain curve of concrete, elastic-plastic stress strain curve of steel for different values of axial forces acting on the section. The analysis is based on the assumption of bilinear moment curvature relationship. Making use of these inelasticity parameters describing member properties, overall inelastic behaviour and structural failure process has been analytically traced through different stages of loading.

The material nonlinearity is taken into account by integrating the inelastic part of the curvature distribution based on the bilinear idealisation. The resulting value obtained from the integration is shown as an angle discontinuity

discretised at the centroid of the inelastic part of the curvature diagram. A set of simultaneous nonlinear equations is formulated with these angle discontinuities as unknowns. The number of unknowns at a given load depends upon the number of maximum moment points referred as softening points at which the moment values are larger than the limiting elastic moment, M_e. An iterative scheme is developed for the evaluation of these unknowns. The iterative approach proposed for the nonlinear analysis takes into account the P-Δ effect also.

Computer programs are developed for the complete analysis using the Transfer matrix and Stiffness matrix methods. The Transfer matrix method is developed for the analysis of tall frames. A technique is also proposed to overcome numerical instability arising in the analysis of tall frames.

Chapter III presents the various aspects of the experimental investigation. A two storey reinforced concrete portal was tested to near collapse for checking the adequacy of bilinear idealisation of moment curvature relationship. An important feature of the casting is the erection of the shuttering in stages in vertical position at the site of testing, to avoid any stresses which might occur due to differential settlement and handling if erected after casting.

A transducer is devised to measure rotations at various points on the concrete frame (Art. 3.7.1). The underlying principle of the instrument is that the rotation is a function of the strains produced in the transducer. These strains are measured with resistance strain gauges. The performance of the instrument is found to be satisfactory.

The experimental results are discussed in Chapter IV. The theoretical results obtained for the test frame are found to have generally good agreement with the experimental observations. Large rotations at softening zones without any crushing of concrete ensured complete redistribution till collapse. The satisfactory convergence of the analytical results using transfer matrix method, and its comparison with the stiffness method and experimental values validates its usefulness in respect of theoretical accuracy and justification of the moment curvature idealisation respectively.

C O N T E N T S