BEHAVIOUR OF INFILLED FRAMES UNDER CYCLIC LOADS

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CERTIFICATE

This is to certify that the thesis entitled **"Behaviour of Infilled Frames Under Cyclic Loads"** submitted by **UDAY BHANU CHOUBEY** 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 under our guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to the best of our knowledge has reached the requisite standard. The material presented in the thesis has not been submitted in the part or thereof to any other university or Institute for the award of any other degree or diploma.

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ABSTRACT

The present study aims at experimental investigation of behaviour of brick masonry (infills), reinforced concrete frames and brick infilled frames without and with central opening under repeated cyclic loading. It also includes the material nonlinear analysis of infilled frames using isoparametric finite element formulation.

The study begins with the experimental investigation conducted on brick masonry specimens under uniaxial cyclic compressive loading perpendicular and parallel to bed joint. For each case of loading three types of tests were conducted. In the first type of test the load was increased steadily upto failure. In the second type of test, the specimens were tested under cyclic loading in which the peak strains in each cycle of loading coincided approximately with envelope curve. In the ascending zone of stress-strain curve the load histories were controlled by monitoring the incremental strain in each cycle, so that the loading curve attains the envelope curve. In the descending zone of stress-strain curve, the load was released when reloading curve tended to descend. The stress-strain curve so obtained possessed a locus of common points which is a point of intersection of reloading curve with the previous unloading curve. In the third type of test, the cyclic load

was applied as in the case of second type of test except that in each cycle loading and unloading were repeated several times, each time unloading was done when reloading curve intersected with initial unloading curve. These points of intersection descended and stabilized at a lower bound and further cycling led to the formation of a closed hysteresis loop. Such lower bound points are termed as stability points.

One general analytical expression is proposed for the determination of stress-strain envelope curves, common point curves and stability point curves for both cases of loading, which provides a reasonable fit with experimental data. The stability point curve is used in defining the permissible stress level. The values of nondimensional plastic strain at the end of unloading are plotted against the values of nondimensional envelope strain, common point strain and stability point strain respectively. These are termed as plastic strain curves. The mathematical expressions are proposed for these curves by least squares fit method. It is found that these curves can be very well represented by second order parabolic expressions.

A mathematical model is proposed to obtain the stress-strain reloading and unloading curves of brick masonry at different values of plastic strain. The model predictions compare well with the experimentally obtained stress-strain reloading and unloading curves.

An experimental program was also carried out to investigate the behaviour of reinforced concrete frames and brick infilled frames without and with central opening under lateral cyclic loading. Tests were conducted on seven models of reinforced concrete frames and infilled frames without and with central opening to establish the load-deflection envelope curves, common point curves and stability point curves. The use of stability point curve is made in assessing the permissible load capacity of frames. The nondimensional plastic deformation at the end of unloading is plotted against envelope point deformation, common point deformation and stability point deformation respectively for reinforced concrete frames and infilled frames without and with central opening. These are termed as plastic deformation curves and suitably represented by mathematical expressions. Second order parabolic expressions are found suitable to represent them. The various parameters, such as, separation of infill with frame, load carrying capacity, stiffness, ductility and energy dissipation are studied. The comparison of behaviour of infilled frames and frames without infill is made.

The study further includes nonlinear analysis of infilled frames using isoparametric 8-noded panel elements, 6-noded modified interface elements and 3-noded beam elements taking into account the material nonlinearities of infill panel and surrounding frame. The stiffness matrix

(15 x 15) of 6-noded modified interface element is derived. A computer program INFILL is developed for nonlinear analysis of infilled frames. The results obtained from the analysis are compared with the experimental results and a good agreement is observed.

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