Dr.Pankaj Agarwal
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Lecturer

Date of Birth : 30-11-1966

Qualification : Ph.D. (Specialization in Structural Dynamics)

Educational Qualifications :

- B. Tech., G. B. Pant Univ. of Agri. & Tech, Pantnagar, Dec. 1989, Civil Engineering, Ist with 77.655%.

- M.E. (GATE-90: 95.76), University of Roorkee, Roorkee, Feb. 1994, Earthquake Engg., Specialization in Structural Dynamics, Ist with 65.15% .Dissertation: "Assessment of Seismic Vulnerability of R. C. Buildings"

- Ph. D., University of Roorkee, Roorkee, Earthquake Engg. Specialization in Structural Dynamics, Submitted in June 1999. Topic: "Experimental Study of Seismic Strengthening and Retrofitting Measures in Masonry Buildings"

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Experience :

- Instrumentation of Multi-storeyed buildings in India for Seismic Performance (Department of Science and Technology Sponsored World Bank Aided Project)

- Installation of strong motion recording instruments in selected multi- storeyed buildings in India. The objective of study are evaluation of the reliability of system identification technique, validation of mathematical model for structural response, study of soil structure interaction effects, determination of dynamic characteristics such as natural frequencies, mode shapes and damping from the interpretation of the recorded response, study of torsional behaviour and upgrading of existing earthquake resistance design practices. The instrumentation may consist of two tri-axial force balance accelerometers fixed at the ground and roof of each building for measuring the output of the system. At intermediate floors of the building 3 to 4 uni-axial force balance accelerometers have been fixed in horizontal and transverse directions of the building for the study of response of the floor, story drift and torsion induced in the event of an earthquake.

These force balance accelerometers (transducers) have been connected to a central reordering system placed in control cabin generally at the ground floor. The central recording system is connected to a Global Positioning System (GPS) placed at the roof of the building open to sky. The function of the GPS is to measure the exact latitude and longitude of the building and time & date in the event of an earthquake. The central recorder receive a power supply from a battery chargeable to charger as well as a solar cell in the event of power failure. The solar cell has been placed at the roof of the building open to sun. The central recorder has a modem facility which is used for data retrieval and to change the parameters of the recorder through a telephone line. In this project four buildings have been instrumented so far which are Audit Bhawan (8 storeyed), C.G.O building (18 storeyed) and Telcom House (11 storeyed) in Mumbai and one building in Banglore i.e. Kendriya Sadan Building (8 storeyed).

- Model Testing of Masonry Houses on Shock Table to Study Adequacy of Earthquake Resistance and Retrofitting Measures (Sponsored by Department of Science & Technology, Govt. of India)

- This project involves the testing of six full scale models of one storeyed stone masonry houses with different strengthening measures under progressively increasing intensity of shock on shock table facility. This facility comprises of central model carrying platform on rails along with two loaded wagons on both the ends for striking and rebound. The duration of the main shock varies between 0.5 to 0.8 sec and peak acceleration of shock could be in the range of 0.45g to 2.28g. After the damage of models during shock table testing, these are retrofitted by existing techniques prescribed in the IS Code and tested again. The behaviour of each model including the pattern of cracking, identification of weak zones, damage with progressively increasing shocks have been studied. The natural frequency, equivalent viscous damping factor, acceleration at base of table and at roof of models measured from experiments. has been observed.

- Quasi-static Testing of Low Cost Non-engineered Construction (Sponsored by AICTE, New Delhi)

- Seismic behaviour of three brick masonry models, half-full scale size, with different strengthening measures has been studied under cyclic loading in quasi-static test facility with an aim to evaluate its effectiveness in enhancing the seismic performance. The models have been tested upto ultimate failure and their strength, deformabilty, energy dissipation capacity, hysteretic behaviour, damping, crack pattern has been studied. The models have been constructed and fixed on the strong floor. The hydraulic actuators attached to the reaction wall through a load cell are fixed on the top of the model. The model is subjected to alternate cyclic loading in the form of sine sweep waves. After substantial damage in cyclic testing the model 2 and 3 were retrofitted by two different techniques. The model 2 have been retrofitted by epoxy sand mortar while model 3 is retrofitted by grout injection and welded wire mesh. The retrofit models have

been tested up to ultimate failure and their strength, deformabilty, energy dissipation capacity, hysteretic behaviour, damping, crack patterns have been compared with the original models. Elastic and strength properties of masonry i.e. compressive strength, tensile and shear strength , modulus of elasticity, and damping, have been obtained by testing the specially prepared model specimens.

- Establishment of Quasi- Static Lab. in Department of Earthquake Engineering, University of Roorkee, Roorkee, which includes Planning, Design and Supervision of Reaction Wall, Strong Floor, Cooling Tower, Hydraulic Power Pack Cabin, Controller & Computer Room and testing of masonry houses models, RC frames, columns under static and dynamic loading through Computer Controlled Actuators.

- Ambient Vibration Survey is used to determine the natural frequencies, mode shapes and damping of a structure from the vibration measurements under ambient environmental and cultural forces. This data is used in variety of application such as (a) data base for dynamic characteristics (b) verification of analytical model © pre and post earthquake measurements to loss of stiffness (d) structural health monitoring etc. The ranger seismometer (SS-1) and solid state recorder (SSR-1) has been used for this study. The studies have been carried out so for on multi-storeyed buildings, tower, water tanks, bridges, aqueduct etc. for their validation of mathematical model.
- Seismic Analysis of Shapurkundi Dam, Greater Shillong Water Supply Scheme, Tala Dam, (Consultancy Projects)
- The static and dynamic analysis of different sections of dam are carried out by finite element analysis. The static analysis includes dead load, hydrostatic pressure, uplift pressure and concentrated loads on the section, if any. The dynamic analysis is carried out under combined actions of horizontal and vertical ground motion by response spectrum method. The stress contour for principal stress p1 and p3 are plotted under static loading as well as combined static and dynamic loading. The computer software COSMOS/M has been used for carrying out the analysis.

- Dynamic Analysis of Rocket Sled Foundation, (Consultancy Projects)

- The objective of analysis is to determine the dynamic forces developed in the concrete foundation due to the traversing of the vehicle over imperfections in the rail. The analysis is carried out by considering a lumped mass beam model of foundation resting on elastic soil springs. The dynamic response is found by integrating equations of motion of foundation under impulsive loading.

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Publications

Symposium/Conferences

- Agarwal, Pankaj., Thakkar, S.K., and Bose, P.R.,(1994) "Assessment of Seismic Vulnerability of Existing Reinforced Concrete Buildings" Proc. Tenth Symposium on Earthquake Engineering, UOR, Nov. 16-18, Roorkee.

- Thakkar, S.K., Dubey, R.N., and Agarwal, Pankaj (1996) "Damages and Lessons Learnt from Recent Indian Earthquakes", Symposium on Earthquake Effects on Structures, Plant and Machinery, Nov. 13 - 15 Ashoka Hotel, New Delhi.

- Agarwal, Pankaj., Thakkar, S.K., and Dubey, R.N., (1997) "Retrofitting of Stone Masonry Buildings" Proc. Workshop on Earthquake Disaster Preparedness, UOR, Oct. 13-14, Roorkee.

- Agarwal, Pankaj and Thakkar, S.K.,(1998) "Study of Adequacy of Earthquake Resistance and Retrofitting Measures of Stone Masonry Building" Department of Science and Tech. New Delhi, To be published.

- Agarwal, Pankaj and Thakkar, S.K., (1998) "Seismic Evaluation of Strengthening Measures in Stone Masonry Houses", Proc. Eleventh Symposium on Earthquake Engineering, UOR, Dec. 17-19, Roorkee.

- Thakkar, S.K. and Agarwal, Pankaj, (1999) "Seismic Evaluation of Earthquake Resistant and Retrofitting Measures in Stone Masonry Houses", 12th World Conference on Earthquake Enginnering, Auckland, New Zealand

- Agarwal, Pankaj and Thakkar, S.K.,(1999) "Quasi-Static Testing of Seismically Strengthened Brick Masonry Models", International Symposium on Theory and Application of Structueral Engineering Test Method, Dept. of Civil Engineering, Tsinghua Universiy, China.

- Agarwal, Pankaj and Thakkar, S.K.,(2000) "Quasi-static tests on Brick Masonry House Models for Evaluation of Retrofitted Measures" 6th International Seminar on Structural Masonry for Developing Countries, 11-13 Oct. 2000, Department of Civil Engineering, IISc Banglore, India.

Journals (Communicated)

- Agarwal, Pankaj and Thakkar, S.K.,(2000) "An Experimental Study of Effectiveness of Seismic Strengthening and Retrofitting Measures in Stone Masonry Buildings" Journal of European Earthquake Engineering.

- Agarwal, Pankaj and Thakkar, S.K.,(2000) "A Comparative Study of Behaviour of Brick Masonry House Model under Static and Dynamic Tests" ISET Journal of Earthquake Technology.

Salient findings

- The ATC-14 and screening methods are approximate methods for evaluating the seismic capacity of existing reinforced concrete buildings. These methods are generated a ranking system on the basis of possible damage in future earthquakes

- .The ATC-14 methodology is based on past performance of building during earthquakes while screening method is based on strength and ductility capacity of the building.

- Screening method results show that the building is unsafe for 0.3g and 0.45g earthquake. As per ATC-14 methodology, the same building is not ductile enough to resist future earthquake forces in Zone IV and V. The structural deficiencies in beam and column of the building are indicated.

- The strengthening measures in test structure constructed according to the recommendations of the codal provisions are effective in preventing the collapse and reduce the damage mainly above lintel band. The damage in piers of wall still occur. The insertion of sill band is effective in reducing the shear cracking of the pier of wall and deformation capacity of model. A rigid slab at roof level is absolutely necessary in order to, uniformly, transfer the force to shear walls and to utilise the full capacity of structure.

- On the basis of model tests, three criteria emerge for retrofitting of wall (i) increase the stiffness of wall, so that the storey drift is limited to 0.35% in order to avoid cracking, (ii) increase the ultimate strength of wall, (iii) increase the ductility of wall. Experimental tests suggested that retrofitting with welded wire mesh has increased the stiffness as well as ultimate load capacity.

- The shock table motion can be correlated with earthquake motion by considering the effect of peak base acceleration, duration and frequency content simultaneously. The shock table model responds with a significant higher initial strength and stiffness as compared to the quasi-static model subjected to equivalent lateral displacements.

- The 3-D elastic finite element analysis of masonry model can predict dynamic behaviour and the region of cracking in the structure. It accounts for both in-plane and out-of-plane action in the walls and can capture the key features of the response and provide a fairly close prediction of the distribution and severity of damage.

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