PP CM 0202

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MICROZONATION STUDIES IN TRANS-JAMUNA AREA OF DELHI CITY USING MICRO-TREMOR MEASUREMENTS – INDO FRENCH PROPOSAL

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Project Proposal CM 0202

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Bangalore 560 037, India

INDO-FRENCH INTER-GOVERNMENTAL
SCIENCE & TECHNOLOGY COOPERATION PROGRAMME
PROFORMA FOR APPLICATION OF JOINT RESEARCH PROJECT
(Application form for Joint Research Project)

A. PROJECT IDENTIFICATION

1.	**Title of the Project :**	Microzonation studies in Trans-Jamuna area of Delhi City using micro-tremor measurements.
2.	**Duration of the project :**	3 months
	Expected date of commencement	October 1, 2001
	Expected date of completion	December 31, 2001
3.	**Field of S & T covered by the proposal :**	Earth Sciences : Seismology
	Key words qualifying the scope of the proposal:	Seismic Hazard Assessment, Site response, Microtremors, Microzonation.

4. Project Investigator/Project coordinator (PI) & collaborating institution

INDIAN

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Name of Co-Principal Investigator	Dr. Imtiyaz Ahmed Parvez
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Project Advisor **Designation**	Prof. V.K. Gaur Honarary Emeritus Scientist, C-MMACS Distinguished Professor, IIA, Bangalore
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FRENCH

Name of Principal Investigator	Dr. Jean-Luc Chatelain
Designation	Chargé de Recherche 1ère classe
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Name of Co-Investigator	Bertrand Guillier
Designation	Chargé de Recherche 1ère classe IRD
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B. TECHNICAL INFORMATION

1. Objectives of the Project (in about 200 words, point-wise)

Delhi – the capital of India – is a fast growing megacity that influences the economic and industrial developments of much of the country. This region has experienced many earthquakes since ancient times and faces severe seismic threats from the Central Himalayan seismic gap just 250-300 km north of it. The Trans-Jamuna part of Delhi is situated on thick soft alluvium soil of Yamuna Sedimentary Basin and is subjected to relatively high site amplification by a future earthquake. The objective of this project is to prepare a first order microzonation map based on microtremor measurements in a 100 sq km area of Trans-Yamuna region of Delhi using Nogoshi-Nakamura technique (1989). This technique measures the three components of background noise at a site and, from these, computes the site-specific resonant frequency. This method involves computing the spectral ratio of each of the horizontal components (E-W and N-S) of ground motion relative to the vertical component. It gives the better results in estimating the dominant period of a site compared with results obtained from the analysis of actual earthquake data. The Nogoshi-Nakamura method yields the site frequency response estimate better available at the moment and also provides some indication of the amplification to be expected at a site.

2. Justification for collaboration & short information about national and international scenario in the proposed area of research (up to 200 words)

There are no detailed studies available in India on site specific ground motion modelling and microzonation studies in megacities. Yet, the need to prepare quantitative microzonation studies for several metropolitan cities of India exposed to major earthquake hazard has been tragically underlined by the five disastrous earthquakes of the past decade. The Co-Principal Investigator of this proposal has completed a first order microzonation study of a part of Delhi City (presented at the Indo-Italian workshop on Seismic Risk Evaluation at NGRI, March 3-9, 2001). Meanwhile, Nath et al., (2000) have proposed the study of site response estimation for the microzonation of Sikkim Himalaya using the local strong motion network. Iyengar (2000) also published a report regarding the seismic status of Delhi in terms of past seismicity, tectonic and geological setting, soil conditions and approximate bedrock depth. Such inputs are useful for site specific ground motion modelling.

On the international scenario, several developing countries like the United States, Japan, France and Italy have already demonstrated their expertise in this field. The researchers at Laboratoire de Geophysique Interne et de Tectonophysique, Grenoble, France have the expertise of working with microtremor measurements for the

estimation of site effects based on Nogoshi-Nakamura (1989) technique. This technique is very famous and used worldwide towards the microzonation studies based on the measurement of the three components of background noise at a given site. Some of recent examples are Teves-Costa et al (1995), Chavez-Garcia and Cuenca (1996), Bour et al (1998), Jensen (2000) and many others. As already emphasized, it would be a highly desirable exercise to prepare a first order site specific microzonation map of the Trans-Yamuna part of Delhi city under this project. This task can be completed with the complementary inputs available with Indian and French scientists under the Indo-French Inter-Governmental Science and Technology Cooperation programme.

3. Description of the project including methodology (up to 400 words):

Seismic microzonation is a procedure for estimating the total seismic hazard from ground shaking and related phenomena by taking into account the effects of local site conditions. The subsurface and topographic conditions can amplify or reduce the peak ground acceleration at a site with respect to what would be expected for firm ground at that location. These local effects would then be incorporated in a seismic microzonation map. Seismic microzonation parameters, when available, can be used jointly with other scientific data banks, integrated in an expert system, to prepare land use and urban planning maps fully accounting for the complete interaction between the solid earth system, the environmental system and the social, economic and political system, in addition to providing well estimated seismic inputs needed for seismically resilient building design. The construction of an integrated expert system will make it possible to tackle the problem at its widest level of generality and to maintain the dynamic updating of zoning models, warranted by new data and the development of new strategies for model building.

Considering the extant situation obtaining in the country, a drastic change is required in the basic approach to hazard mitigation that must no longer be considered a post disaster activity. To make this possible, it is imperative to invest our resources in developing insightful scientific knowledge products that could be usefully employed to mitigate the effects of the next earthquake, using all available technologies. As clearly underlined by the horrendous losses of lives and properties suffered in the wake of the moderate recent Indian events of Uttarkashi (1991), Latur (1993), Jabalpur (1997) and the most devastating Bhuj (2001), it is extremely important to anticipate as best as possible, the future probable earthquake threats in the country as well as areas of high vulnerability, so that effective scientific activities may be initiative now to mitigate their impacts whenever they happen to strike again. In particular, we propose to initiate such preventive steps for high risk areas in the country, by extending, in a scientifically acceptable way, reasonably well tested paradigms developed for similar areas elsewhere.

The Nogoshi-Nakamura (1989) technique will be used to obtain first-order microzonation map of the Trans-Yamuna part of Delhi City with the use of microtremor measurements for the estimation of site effects. This technique has been described in

several papers (Jensen, 2000; Bour et al., 1998; Teves-Costa et al., 1995; Chavez-Garcia and Cuenca, 1996; Nakamura, 1989 etc.) and is based on the following assumptions for the fundamental characteristics of microtremors.

1. Microtremors are essentially composed by Rayleigh waves L_R, propagating in soft surface layers overlying an half-space.
2. There are four Fourier Spectral amplitudes involved: horizontal and vertical components of the motion at the surface and at the bottom of the layers (V_S, H_S, V_B and H_B), see (Figure 3)
3. The microtremors are originated by local near surface sources (such as traffic and industrial noise) and they have no contribution from deep sources.
4. The amplification of the vertical component of motion is exclusively related with the depth dependence of surface (Rayleigh) waves motion.

Usually it is assumed that the transfer functions of surface layers can be given by the ratio

$$S_T = \frac{H_S}{H_B}$$

However, considering the great contribution of Rayleigh wave propagation for the ambient noise, it will be necessary to convert the ratio H_S/H_B, in order to estimate a transfer function for microtremor measurements. Assuming that the vertical tremor is not amplified by the surface layers, the ratio E_R defined below should represent the effect of the Rayleigh wave on the vertical motion.

$$E_R = \frac{V_S}{V_B}$$

Assuming that the effect of the Rayleigh wave is equal for vertical and horizontal components, it is possible to define a corrected modified spectral ratio,

$$S_M = \frac{S_T}{E_R} = \frac{H_S / H_B}{V_S / V_B}$$

As a final condition it is assumed that for all frequencies of interest

$$\frac{H_B}{V_B} = 1$$

Thus, an estimate of the transfer function is given by the spectral ratio between the horizontal and the vertical components of the motion at the surface

$$S_M = \frac{H_S}{V_S}$$

Some of the above conditions were already tested, experimentally and theoretically by different authors (Jensen, 2000; Bour et al., 1998; Teves-Costa et al., 1995; Chavez-Garcia and Cuenca, 1996; Nakamura, 1989 etc.)

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Nakamura, Y., 1989. A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface. *Quarterly Report of the Railway Technical Research Institute* 30(1), 25-33.

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4. Plan of Work

a. Two French and two Indian participants will take part in the field work for a month from October 1, 2001 in the Trans-Yamuna part of Delhi in about 100 sq. km

b. 440 points will be covered at an interval of 500 meters for micro-tremor measurements in the region and will be completed in this period.

c. One Scientist (Dr. I. A. Parvez) will visit Grenoble, France to process the data and

finalise the work. The final report will be prepared in December, 2001 and the results will be communicated for publication.

Time Schedule	**Indian Responsibilities**	**French Responsibilities**
October 1, 2001 To October 31, 2001	Field work	Bringing the equipments to India for Field work and taking part as well.
November 7, 2001 To December 7, 2001	Data Processing at Grenoble, France.	Providing the facilities for Data processing
December 15, 2001	Finalising the work and preparation Of report.	

5. Number of exchange visit required to achieve the Project Objective

India to France		**France to India**	
Number	**Duration**	**Number**	**Duration**
One	One month	Two	One month

6. Expected results of this cooperation (e.g. joint publications, patents etc). Are any of the expected results likely to have commercial value? How do you propose to share it? (up to 100 words):

The first goal of the experiment is to obtain a first-order microzonation map of the Trans-Yamuna part of Delhi City.

At least one joint research paper is expected.

7. Bio-data of Indian and French investigators (the description should highlight the expertise of the PI's) in the proposed field of work supported by citing relevant publications only. (To be appended in about 2 pages)

Biodata of French Principal Investigator

A. Name: Jean-Luc Chatelain

B. Date of Birth: 07/07/1951

C. Institution and address:

LGIT (IRD)
BP 53
38041 Grenoble Cedex 09
France

D. Whether belongs to SC/ST : No

E. Academic (M. Sc. onwards) and Professional Career

Degree/ Position held	Year	University/Institution
D.E.A.	1976	Université de Grenoble
Thèse 3ème cycle	1978	Université de Grenoble
H. D. R.	1998	Université de Grenoble
Élève	1978 - 1980	ORSTOM
Chargé de Recherche 2eme classe	1980 - 1985	ORSTOM
Chargé de Recherche 1ere classe	1985 - présent	ORSTOM (now IRD)

F. Award / Prize / Certificate won by the investigator

Nil

G. Publications (numbers only)

Books	Research Papers & reports	General Articles	Patents	Others
2	9	Nil	2	57

H. List of Publications

Books

FERNANDEZ J., J. VALVERDE, H. YEPES, G. BUSTAMANTE, **J.-L. CHATELAIN**, F. KANEKO, C. VILLACIS, T. YAMADA, B. TUCKER, (1994), The Quito, Ecuador, earthquake risk management project: An overview, *Geohazards International Publication, San Fransisco*, 40 pp., 1 planche hors texte.

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Patents

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Others

Expertises

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BUSTAMANTE G., **J.-L. CHATELAIN**, B. GUILLIER, J. FERNANDEZ, J. VALVERDE, H. YEPES, B. TUCKER, G. HOEFER, C. VILLACIS, T. YAMADA, F. KANEKO, (1995), An example in Quito, Ecuador, of the use of seismic microzoning for risk reduction in developing countries, *Fifth International Conference On Seismic Zonation*, 15-19 octobre 1995, Nice.

TUCKER B., G. HOEFER, J. FERNANDEZ, J. VALVERDE, H. YEPES, C. VILLACIS, T. YAMADA, F. KANEKO, **J.-L. CHATELAIN**, G. BUSTAMANTE, (1995), The Quito, Ecuador, earthquake risk management project: An evaluation, *Fifth International Conference On Seismic Zonation*, 15-19 octobre 1995, Nice.

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FERNANDEZ J., J. VALVERDE, H. YEPES, **J.-L. CHATELAIN**, G. BUSTAMANTE, F. KANEKO, C. VILLACIS, T. YAMADA, B. TUCKER, (1995), Aspectos metodologicos del proyecto de mitigacion del riesgo sismico en Quito, *Sexto Curso Internacional sobre Microzonification y Seguridad de Systemas Publicos de Lineas Vitales (JAIKA-CISMID)*, 6-8 mars 1995, Lima, Pérou.

GUILLIER B., **J.-L. CHATELAIN**, H. YEPES, J. FERNANDEZ, J. VALVERDE, E. DUPERIER, R. VALLEJO, J. VEGA, G. BUSTAMANTE, C. VILLACIS, T. YAMADA, F. KANEKO, B. TUCKER, G. HOEFER, (1995), El escenario sísmico de la ciudad de Quito, *Conferencia Internacional sobre Desatres Naturales*, 29 mai-1 juin 1995, Huaraz, Pérou.

GUILLIER B., **J.-L. CHATELAIN**, H. YEPES, J. FERNANDEZ, J. VALVERDE, E. DUPERIER, R. VALLEJO, J. VEGA, G. BUSTAMANTE, C. VILLACIS, T. YAMADA, F. KANEKO, B. TUCKER, G. HOEFER, (1995), Utilization de SIG para la evaluation de los riesgos sismicos, *Préparation à Habitat II*, 14-16 novembre 1995, Quito, Équateur.

FERNANDEZ J., G. HOEFER, B. TUCKER, C. VENTURA, **J.-L. CHATELAIN**, B. GUILLIER, (1996), Identifying and retrofitting high-risk schools in Quito, Ecuador, *Eleventh World Conference on Earthquake Engineering*, 23-28 juin 1996, Mexico.

GUÉGUEN Ph., J. VALVERDE, H. YEPES, **J.-L. CHATELAIN**, B. GUILLIER, (1996), Presentacíon y analisis de la distribucion de los daños en relacion con un estudio de microzonificacion realisada en Pujili despues del sismo de 28 de marzo 1996, *Implicationes Ingenieriles, Sociales y de Administracion del Desastre en Caso de Terremoto*, 4-5 juillet, Quito.

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YEPES H., **CHATELAIN J.-L.**, B. GUILLIER, J. FERNANDEZ, J. VALVERDE, B. TUCKER, M. SOURIS, E. DUPERIER, G. HOEFER, F. KANEKO, T. YAMADA, G. BUSTAMANTE, C. VILLACIS, (1996), Sismologia Social: Un proyecto para el manejo del riesgo sismico en Quito, Ecuador, *Segundo Seminario Latino-Americano Volcanes, Sismos y Prevencion*, 4-9 novembre 1996, Lima-Arequipa, Pérou.

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GUÉGUEN Ph., **J.L. CHATELAIN**, B. GUILLIER, H.YEPES, J. VALVERDE, (1996), Microzoning and seismic risk in Quito, Ecuador: preliminary results, *2nd Seminario Latino-Americano: "Volcanes, Sismos y Prevención"*, 4-9 novembre 1996, Lima-Arequipa, Pérou.

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CHATELAIN J.-L., B. GUILLIER, PH GUÉGUEN, AND F. BONDOUX, (1997), Resultados de estudios de sitios en Nasca Y Vista Alegre (Peru) despues el sismo de Nasca (Mw 7.7), *Taller Sobre el Sismo de Nasca*, 8-13 mars 1997, Lima. Pérou.

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Other Publications

FERNANDEZ J., J. VALVERDE, H. YEPES, G. BUSTAMANTE, **J.-L. CHATELAIN**, (1994), The Quito project: Technical aspects and lessons, *In: Issues in Urban Earthquake Risk*, Tucker et al. Eds, NATO ASI Series, Series E: Applied Sciences, vol. 271, 115-120.

YEPES H., J. FERNANDEZ, J. VALVERDE, **J.-L. CHATELAIN**, G. BUSTAMANTE, B. TUCKER, F. KANEKO, C. VILLACIS, T. YAMADA, (1994), Escenario sismico para Quito, *Defensa Civil*, 4, 9, 6-7.

YEPES H., **J.-L. CHATELAIN**, J. FERNANDEZ, J. VALVERDE, E. DUPERIER, R. VALLEJO, J. VEGA, G. BUSTAMANTE, C. VILLACIS, T. YAMADA, F. KANEKO, B. TUCKER, G. HOEFER, (1994), El proyecto de reducción del riesgo sísmico en la ciudad de Quito, *Estudios de Geografía: El contexto geológico del espacio físico ecuatoriano, Colegio de geógrafos del Ecuador, Quito*, 6, 101-113.

CHATELAIN J.-L., B. GUILLIER, H. YEPES, J. FERNANDEZ, J. VALVERDE, M. SOURIS, E. DUPERIER, B. TUCKER, G. HOEFER, F. KANEKO T. YAMADA, G. BUSTAMANTE, C. VILLACIS, (1995), Un scénario sismique pour la ville de Quito, *ORSTOM Actualités*, 47, 8-14.

Bustamante G., R. Vallejo, **Chatelain J.-L.**, B. Guillier, H. Yepes, J. Fernandez, J. Valverde, M. Souris, E. Duperier, B. Tucker, G. Hoefer, F. Kaneko T. Yamada, C. Villacis, (1995), Riesgo sismico en Quito, *Boletin del Distrito Metropolitano*, 6/

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D. Whether belongs to SC/ST : No

E. Academic (M. Sc. onwards) and Professional Career

Degree/ Position held	Year	University/Institution
B. E. (Civil Engineering)	1986	Osmania University,
M. E. (Civil Engineering)	1988	Indian Institute of Science Bangalore
Scientist	07/1988-03/1993	Central Building Research Institute, Roorkee,
Ph.D. (Engineering)	2000	Indian Institute of Science, Bangalore Hyderabad

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F. Award / Prize / Certificate won by the investigator

1988 Gold medal for securing First in B.E.(CIVIL) from College of Engineering, Osmania University.

1988 Gold medal in "Soil Mechanics and Foundation Eng." from College of Engineering, Osmania university.

1989 Distinction awarded in M.E. (GEO-TECH ENGG.) from Indian Institute of Science, Bangalore.

1990 Elected as Founder Life Member of Indian Society of Rock Mechanics and Tunneling Technology

G. Publications (numbers only)

Books	Research Papers & reports	General Articles	Patents	Others
Nil	14	Nil	Nil	13 (Conference presentation)

H. List of Publications

Sridevi Jade, T.G.Sitharam and N. Shimizu, 2001. Practical equivalent continuum characterization of jointed rock masses. International Journal of Rock Mechanics and Mining Sciences, 2001, p. 1-12.

Sridevi Jade and T.G.Sitharam, 2000. Analysis of Strength and moduli of jointed rocks', International Journal of Geotechnical and Geological Engineering , Vol. 18, p. 1-19.

Sridevi Jade, T. G. Sitharam and H.M. Chandrashekar 2000. Simulation of Jointed Rock Mass Behaviour Using Finite Element Method. Journal of Rock Mechanics and Tunneling Tech. Vol. 6, No. 2, p. 113-132.

Sridevi Jade, K.S.Yajnik, and P.K.Nanda 1998. Numerical Analysis of Multi-Layered Pavement Systems, Highway Research Bulletin, No. 59. p. 41-55.

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Sridevi Jade and K.G.Garg. 1997. Finite element analysis of a reinforced earth wall. Indian Geotechnical Journal (IGJ) v 27 (1), p. 59-73.

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J. Freymueller, R.Bilham, R.Burgmann, K.M.Larson, J Paul, S.Jade and V.K.Gaur. 1996. Global Positioning System Measurements of Indian plate motion and convergence across the Lesser Himalaya. Geophysical Research Letters, v. 23 (22), p. 3107-3110.

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Sridevi Jade and Sarkar.S. 1993. Statistical Models for slope instability Classification. Engineering Geology, No 36, p. 91-98.

Siva Reddy, A. and Sridevi, J. 1991 Active earth pressures on retaining walls With partially saturated back fills, Journal of Institution of Engineers, Vol. 71, part Cv5, p. 129-137.

Siva Reddy, A. and Sridevi, J. 1990 Stability analysis of axi symmetric Slopes using method of characteristics, Journal of Institution of Engineers, Vol. 71, Part Cv2, p. 43-49.

Conference Papers:

Sridevi Jade, T.G.Sitharam and N. Shimizu,'Equivalent continuum analysis of acavern for Shiobara power station – A case study', Proceedings of JSCE annual conference. Sendai, Japan, 2000.

Sridevi Jade, Bhat, B.C.*, Anand, M.B. and Gaur V.K.: 'GPS derived Slip rate along the Karakorum fault in the Indo-Eurasian Continental Collision Zone', IUGG 99, International

union of Geodesy and Geophysics, 18-24, July, 99, Birmingham, U.K.

Sridevi Jade and T.G.Sitharam , ‘Finite element modeling of jointed rock mass’, Proceedings of the International conference on rock engineering techniques for site characterization, Dec 6-8, 1999, pp. 375-380.

Sridevi Jade, R.P.Thangavelu, P.S.Swathi and V.Kumar: 'Establishment of C-MMACS GPS station at IISC', National Conference on Global Positioning System, Feb 1997.

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J.Paul, V.Kumar, Sridevi Jade , P.S.Swathi, V.K.Gaur, R.Bilham, 'Historic and current deformation in South Indian Peninsula using GPS measurements', GA11A19, 0830h, IUGG, XXI General assembly, 1995.

Sridevi Jade , V.K.Gaur, J.Paul, V.Kumar, R.Burgmann, 'Direct determination of the relative velocities of the Indian plate', GA11A12, 0830h, IUGG, XXI General assembly, 1995.

Burgmann, R., Freymueller J, Larson KM, Paul J, Jackson M, Bilham R, Gaur VK, Jade S , Kumar V, Reigber C. 'Convergence between India and Himalaya, 1991-1994'.'Eos Trans. Am. Geophys.(abstr.) 1994.PL62

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Sridevi, J. and Agrawal, S.K. 1991. 2-D Finite Element Model for planar failure along a joint, igc '91, Geotechnical Analysis and Practices and Performances, 273-275.

Sridevi Jade and Kusum Deep: 'Stability Assessment of Slopes' presented in First IISc National Seminar on Geotechical Engineering , 26-27 July 1993, pp 100-102.

Sridevi, J. and Kusum Deep., 1992 Application of Global optimization technique to slope stability analysis, International symposium on landslides, Newzealand .

Ravi, V. and Sridevi, J. 1991 Reliability model for rock slope with two conjugate sets of joints, First Romanian Symposium on landslides.

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F. Educational Qualifications:

Ph.D. Banaras Hindu University in Geophysics (Seismology), 1995
M.Sc.(Tech.): Banaras Hindu University in Exploration Geophysics, 1991 First Class
B.Sc.(Hons.): Banaras Hindu University in Physics, Maths, Statistics, 1988 First Class
Intermediate: Central Hindu School, Varanasi, 1985 First Class
High School: Central Hindu School, Varanasi, 1983 First Class

Title of Ph.D. Thesis *: "Earthquake Source Mapping and Hazards Assessment in the Indian Subcontinent"*

G. Research Interest:

Earthquake Hazard Assessment; Probabilistic and Deterministic Approach.
Microzonation in Megacities and Large Urban Areas.

Attenuation of Strong Motion Amplitudes (Peak ground Acceleration and Velocity). Earthquake Source Mechanism Study by Waveform Modeling.

H. Employment Status:

1991-1995: Research Scholar at the Department of Geophysics, BHU, Varanasi
1995-1997: Project Asst. in DST project at the Department of Geophysics, BHU, Varnasi.
1997-1998: Research Scientist, DST project, Kumaun University, Nainital.
1998-2000: Research Fellow, Department of Earth Sciences, University of Trieste, Italy
2000- till : SRA, CSIR Pool Scheme, C-MMACS, NAL Belur Campus, Bangalore.

I. Awards and Honor

Awarded by the Regular Associateship of the Abdus Salam International Centre for Theoretical Physics (AS-ICTP), Trieste, Italy, 1998-2003.

Awarded by the fellowship under Training and Research in Italian Laboratories (TRIL) Program of AS-ICTP, Trieste, Italy.

J. Participation in International Scientific Conferences, Worksops abroad:

2000 - Fifth workshop on *Three-Dimensional Modelling of Seismic Waves Generation, Propagation and Their Inversion* at ICTP, **Trieste, Italy**

1999 - Fifth workshop on *Nonlinear Dynamics And Earthquake Prediction* at ICTP, **Trieste, Italy.**

1999 - Attended the *International Union of Geodesy And Geophysics (IUGG99)* meeting held at the University of Birmingham, **Birmingham, UK**.

1999 - Workshop on *Broad-Band Array Seismology* at Seismological Central Observatory (SZGRF), Mozartstr.57, 91052 **Erlangen, Germany.**

1998 - Fourth workshop on *Three-Dimensional Modelling of Seismic Waves Generation, Propagation and Their Inversion* at ICTP, **Trieste, Italy**

1997 - Fourth workshop on *Nonlinear Dynamics And Earthquake Prediction* at ICTP, **Trieste, Italy.**

1996 -Training at Syscom Instruments Ag. and discussion with eminent scientists of Swiss Seismological Service, both at **Zurich, Switzerland.**

1996 - Third workshop on *Three-Dimensional Modelling of Seismic Waves Generation, Propagation and Their Inversion* at ICTP, **Trieste, Italy**.

1995 - Third workshop on *Nonlinear Dynamics And Earthquake Prediction* at ICTP, **Trieste, Italy**.

K. List of Papers Published/Communicated

1. **Imtiyaz A. Parvez**, F. Vaccari and G.F. Panza (2001) “Firsrt order microzonation of Delhi city by 2-D modelling of SH and P-SV waves”. (under preparation)

2. **Imtiyaz A. Parvez**, G.F. Panza, A.A. Gusev and F. Vaccari (2001) “Strong motion amplitudes in Himalaya and deterministic approach for microzonation” (under preparation)

3. **Imtiyaz A. Parvez**, F. Vaccari and G.F. Panza (2001) "Seismic hazard assessment in the Indian subcontinent: A deterministic approach". (submitted to Geophysical Jr. International)

4. Sridevi Jade, Malay Mukul, **Imtiyaz A. Parvez**, M.B. Ananda, P. Dileep Kumar and V.K. Gaur (2001). “Estimates of upper bonds of coseismic displacement during the Bhuj earthquake of January 26, 2001. (submitted to Current Science).

5. **Imtiyaz A. Parvez**, A.A. Gusev, G.F. Panza & A. G. Petukhin (2001) “Preliminary determination of interdependence among strong motion amplitude, magnitude and distance for the Himalayan region”. Geophys. Jr. Int. 144, 577-596.

6. **Imtiyaz A. Parvez**, A.A. Gusev, G.F. Panza & A. G. Petukhin (1999) “Preliminary determination of interdependence among strong motion amplitude, magnitude and distance for the Himalayan region”. The Abdus Salam International Centre for Theoretical Physics Pre-Print IC/99/192.

7. **Imtiyaz A. Parvez** and Avadh Ram (1999) "Probabilistic Assessment of earthquake hazards in the Indian Subcontinent". Pure & Appl. Geophy. 154(1), 23-40.

8. **Imtiyaz A. Parvez** and Avadh Ram (1997) "Probabilistic assessment of earthquake hazards in the North-East Indian Peninsula and Hindukush regions". Pure & Appl. Geophy. 149 (4), 731-746.

9. **Imtiyaz A. Parvez** and Avadh Ram (1996) "Mapping of seismic sources of a few earthquakes in Himalayan region using the body wave spectral estimates". Himalayan Geology. 17, 81-89.

10. **Imtiyaz A. Parvez** and Avadh Ram (1996) " Bodywave waveform modelling and source parameters for the Indo-China border earthquakes". Pure & Appl. Geophy. 147(4), 657-673 .

11. **Imtiyaz A. Parvez** and Avadh Ram (1996) "Probabilistic models for the assessment of earthquake hazard". Jr. Assoc. Expl. Geophys. XVII (2), 81-89.

L. List of abstracts Presented/Accepted in Seminars, Symposium and Scientific Meetings

1. **Imtiyaz A. Parvez**, A.A. Gusev, G.F. Panza & A. G. Petukhin (2000) "Preliminary determination of interdependence among strong motion amplitude, magnitude and distance for the Himalayan region". Accepted for presentation in XXVII General Assembly of the European Seismological Commission (ESC) at the Lisbon University, Portugal held during September 10-15, 2000.

2. **Imtiyaz A. Parvez**, A.A. Gusev, G.F. Panza & A. G. Petukhin (2000) "Attenuation of Strong Motion Amplitudes for the Himalayan region". Accepted for presentation in the third meeting of Asian Seismological Commission (ASC2000) and symposium on Seismology, Earthquake Hazard Assessment and Earth's Interior related topics at the Institute of Geophysics, University of Tehran, I.R. Iran held during Oct. 10-12, 2000.

3. **Imtiyaz A. Parvez** and Avadh Ram "Source parameters by spectral analysis of oceanic earthquakes recorded at Gauribidanur Seismic Array, India " presented in XXII General Assembly of the International Union of Geodesy and Geophysics (IUGG99) meeting held at the University of Birmingham, UK held during July 18-30, 1999.

4. **Imtiyaz A. Parvez** and Avadh Ram "Probabilistic assessment of earthquake hazards in the Indian Subcontinent" presented in XXII General Assembly of the International Union of Geodesy and Geophysics (IUGG99) meeting held at the University of Birmingham, UK held during July 18-30, 1999.

4. **Imtiyaz A. Parvez** and Avadh Ram "Source parameters by spectral analysis of oceanic earthquakes recorded at Gauribidanur Seismic Array, India " accepted for presentation in the 29th General Assembly of International Association of Seismology and Physics of the Earth's Interior (IASPEI) at Thessaloniki, Greece during August 18-28, 1997.

6. **Imtiyaz A. Parvez** and Avadh Ram "Probabilistic assessment of earthquake hazards in the Indian Subcontinent" accepted for presentation in the 29th General Assembly of

International Association of Seismology and Physics of the Earth's Interior (IASPEI) at Thessaloniki, Greece during August 18-28, 1997.

7. **Imtiyaz A. Parvez** and Avadh Ram "Probabilistic assessment of earthquake hazards in the North East Indian Peninsula and Hindukush regions" accepted for presentation in the 29th General Assembly of International Association of Seismology and Physics of the Earth's Interior (IASPEI) at Thessaloniki, Greece during August 18-28, 1997.

8. **Imtiyaz A. Parvez** and Avadh Ram "Seismicity and Hazard Assessment using probabilistic models in the Indian Subcontinent" accepted for presentation in the National Seminar on Neotectonic Movements and their Geo-Environmental Impacts (NETMOGEI) held during December 27-29, 1996 at the Department of Studies in Geology, University of Maysore, Maysore.

9. **Imtiyaz A. Parvez** and Avadh Ram "Probabilistic Assessment of Earthquake Hazards in the North-East Indian and Hindukush Regions" accepted for the presentation in World Conference on Natural Disaster and Mitigation held at Cairo University, Egypt during January 6-10, 1996.

10. **Imtiyaz A. Parvez** with Avadh Ram "Bodywave waveform modelling and source parameters for the Indo-China border earthquakes". Presented in the XXI IUGG General Assembly held in Boulder, Colorado, U.S.A. during July 2-14, 1995

11. **Imtiyaz A. Parvez** and Avadh Ram "Probabilistic models for the assessment of earthquake hazard". Accepted for presentation in the Twentieth Annual Convention and Seminar on Exploration Geophysics organised by Association of Exploration Geophysicists at Bangalore during February 6-8, 1995.

12. **Imtiyaz A. Parvez** with Avadh Ram "Source parameters of a few earthquakes from north-east Himalayan region as determined by Bodywave waveform modelling". Presented in the Group Discussion on Geological Hazards in the Himalayan Region: Assessment and Mitigation held at Wadia Institute of Himalayan Geology, Dehradun during 10-12 March, 1994.

13. **Imtiyaz A. Parvez** with Avadh Ram "Source parameters of a few earthquakes from north-east Himalayan region as determined by Bodywave waveform modelling". Accepted for presentation in the 27th General Assembly of the International Association of Seismology and Physics of the Earth's Interior held at Willington, New Zealand during January 9-23, 1994.

14. **Imtiyaz A. Parvez** with Avadh Ram "Evaluation of source parameters for Indo-China border earthquakes using Bodywave waveform modelling". Presented in the Workshop and first regional meeting of the ILP TASK group II-4 held in Chengdu, China during September 14-23,1993.

Biodata of Project Advisor

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Born: 11th July 1936, at Azamgarh, U.P

Education:

High School,1949, Wesley High school, Azamgarh.	First class
Intermediate,1951 , Agra College, Agra	First class
B.Sc, 1953, Lucknow University	First class
M.Sc,1955, Banaras hindu University	First class First (Gold Medallist)

D.I.C,1959 Imperial College, London
Ph.D,1959 London University
Post-Doctoral Fellow, 1959-60, at sorbonne University Paris

Professional Service:

1960-61; Scientific officer at National Physical Laboratory, U.K.
1962-66; Reader, University of Roorkee
1966-83; Professor University of Roorkee and Dean Research (1978-83
1983-89; Director, National Geophysical Research Institute, Hyderabad
1989-92; Secretary, Government of India, Dept. Ocean Development
1992-96; CSIR Distinguished Scientist, Centre for Mathematical

Modelling, National Aerospace Labs:, Bangalore
1996-- Distinguished Professor, Indian Institute of Astrophysics,
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Awards:
Fellow, Indian National Science Academy,
Fellow, Indian Academy of Sciences,
Fellow, National Academy of Sciences,
Fellow, Andhra Pradesh Science Academy,
Fellow, Indian Geophysical Union,
Shanti Swarup Bhatnagar Prize (1979),
Khosla Research Award (1971),
Krishnan Medal of the Indian Geophysical Union,
Honoris Causa Doctoral degrees from:
Jawaharlal Nehru Technical University
Andhra University
Award of Excellence,of the Ministry of Mines(1996)
Edward A. Flinn III award of the American Geophysical Union (2001)

Publications: Over 90 in National and International journals (15 in the last 5 years)

Books: edited: six

Landmark contributions to Science:

* Discovery of the host-rock effect, an unsuspected phenomenon which completely modifies the electromagnetic response of conducting bodiesburied in the earth, if surrounded by a partially conducting medium (1959).

* Confirmation of the hypothesis that the Indian plate underthrusts the Asian plate along the Main Boundary Fault through direct measurement of slow deformation ,across an underground tunnel in the Tons valley, Chakrata (1973)

* Discovery of a thick (400 km) high velocity root of the Indian lithosphere under the Deccan Volcanic Province, using seismic tomography experiments, initiated for the first time in India.

* Quantitative measurement of the velocity of the Indian plate with respect to the Eurasian plate (between Bangalore and Siberia) using Global positioning System, for the first time in India, as well as delineating the strain field in the Southern Indian Peninsula(1994)

* Shear wave velocity picture under the Deccan(Hyderabad) using broad band seismogram analysis, the first in India (1996)

Scientific Services to the nation:

* Design of Academic programmes in Geosciences(under the aegis of UGC)

* Restructuring research directions and approaches at the Nat. Geophys. Research Institute, by initiating digital data acquisition in Seismology, Magneto-tellurics and geomagnetism, and new research fields,notably: seismic tomography, Isotope geochemistry and Mineral Physics.

* Design of contemporary Information Systems aimed at operational Ocean forecast service:

  #Marine Satellite Information Service (1991)
  #Coastal Ocean Monitoring and Prediction Systems(1989)
  #nATIONAL 0cean Information Service(1990)

* Founding of a Science to people programme in Hyderabad, as Andhra Pradesh Vigyan parishath(1984), since grown into a state wide vibrant organization (1989) as Andhra Pradesh Vigyan Vedika with over 50 centres all over the state.

Current Occupation:

* Research programme to quantitatively define the strain field in the Indian territory, especially in and across the constantly deforming Himalaya (funded by the Dept. of Science and Technology and the National science Foundation, USA0 using millimeter accurace Global Positioning System receivers.

* Setting up a 2 meter diameter Optical and Infra-red telescope at the world's highest site (15,200 feet) in Ladakh Himalaya, as Chairman of the Commitee

* Formulation of a National multidisciplinary Science programme for implementation at the telescope site in hanle in Ladakh to take advantage of its unique location in the globe. these will include; Cosmic-ray research, Geomagnetism, Aeronomy, Boundary-layer meteorology,glaciology, broad band seismology,GPS geodesy,gamma-ray astronomy ,and Ionospheric research

* Design of a modern curriculum for Integrated School Science (As Chairman of the commitee constituted by Indian Nat. Sc. Academy in consultation with NCER

Vinod K. Gaur studied Geophysics at the Banaras Hindu University and Imperial College, London. Later, he taught at the University of Roorkee for 20 years before moving to Hyderabad as Director of the National Geophysical Research Institute.

Professor Gaur's landmark scientific contributions include: discovery of the hostrock effect (1959) in geoelectromagnetics; a direct test of the hypothesis that the Indian plate slips along the main boundary fault; discovery of a thick high velocity root of the Indian lithosphere beneath the Indian shield, and determination of the velocity of Indo-Eurasian Plate convergence using GPS geodesy.

His contributions to the advancement of Indian Scientific endeavours include: painstaking design of Academic programmes in Geophysics, major restructuring of the research programmes of NGRI and design and implementation of Marine Satellite Information Service and Antarctic Research (1989-92) as Secretary to the Government of India in the Department of Ocean Development.

Prof. Gaur is the recipient of S.S. Bhatnagar Prize and the Krishnan medal of the Indian Geophysical Union. He is Fellow of the Indian National Science Academy and the Indian Academy of Sciences and was awarded doctorate degrees (Honoris Causa) by the Jawaharlal Nehru Technical University and Andhra University.

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C. ADMINISTRATIVE & FINANCIAL INFORMATION

1. Project Cost

Available Equipment*	Consumable	Contingency	Exchange Visits**	Total
2-3 Seismometers will be available from French Collaborator. However, the cost to bring them in India will have to be paid.	Rs. 4.0 Lakhs (The expenditure towards field work)	Rs. 1.0 Lakh (The expenditure towards travel within India plus other expenses)		Rs. 5.0 Lakhs

***** The expenses towards bringing the equipments should be added.

****** Two Scientists (**Dr. Jean-Luc Chatelain and Bertrand Guillier**) will visit India for one month. Their living expenses in India must be included separately as per norms of DST. **Dr. I. A. Parvez**, Co-PI will also visit Grenoble, France for one month to finalise the project and the expenses in his visit must be added separately as per norms.

2.