

## "Dense population and old construction in high seismic zones in India : A serious problem"

*In a tête-a-tête with Ms Alpa Sheth, Partner, Vakil Mehta Sheth Consultants, Mumbai, Prof Bruce Bolt talks about his association with seismology and current state-of-art and practices in earthquake engineering, etc. Before reproducing the excerpts, we are pleased to include introductory remarks by Ms Sheth.*

There are some inexplicable things that happen in life. For one, I had not been able to take a course under Prof Bruce Bolt whilst at Berkeley. For another, I had not had a chance to read his internationally acclaimed book titled 'Earthquakes' until very recently. I did however get an opportunity to meet him during his visit to India earlier this year.

As chance would have it, I was visiting my alma mater — University of California, Berkeley (UCB) — this summer and having just started reading Bruce Bolt's book I decided to call on him. In his typical style, Prof Bolt invited me over to lunch at the Faculty Club. Prof Bolt may have retired from classroom teaching but he is still just as active on the UCB campus. He continues to be President of the Faculty Club. (What Prof Bolt will not tell you is that he has designed the beautiful redwood cabinet in the club). Little wonder, then, that the Maybeck designed all-wood Faculty Club seemed the most appropriate place to meet with him and get his insight into the world of earthquake engineering. I have always loved the warm building (apparently of low seismic vulnerability) with its tall ceilings and airy verandahs.

During the course of an elaborate meal, punctuated by pauses to talk to Nobel Laureate Charles Townes as he passed our table or to wave to his old friends and colleagues including UC Executive Vice Chancellor Paul Gray, Prof Bolt spoke about impressions he had gathered about seismology, India and the earthquake engineering scene in

the country. He had visited India earlier this year for a five-week lecture and research trip to the country under the National Programme in Earthquake Engineering Education (NPEEE). During his stay, he visited the Indian Institute of Technology (IIT) Kanpur, Indian Institute of Science (IISc) Bangalore, IIT Madras, amongst other institutions.

### Prof Bruce Bolt



**Bruce Bolt**, Emeritus Professor of Seismology, was born "Down Under" in Australia in 1930. He obtained his honors degree in Applied Mathematics at the University of Sydney and then appointed to the faculty in the mathematics department. After completion of a Ph.D. in elastic wave theory, he won a Fulbright scholarship to Lamont Geological Observatory at Columbia University in 1960, and to Cambridge University (U.K.) in 1961. There, a chance meeting with the late Perry

Byerly, Prof of Seismology at U.C. Berkeley, led to an invitation to a chair in seismology at U.C. Berkeley in 1963.

At UCB, he was the Director of the University of California Seismographic Stations for 28 years; Chairman of the UCB Academic Senate in 1992-1993 and recipient of the University Citation in 1992. He has been Chairman of the California Seismic Safety Commission, President of the California Academy of Sciences (its Medallist in 1989) and President of the Seismological Society of America. He was elected to the National Academy of Engineering in 1978, Overseas Fellow of Churchill College, Cambridge University in 1980, and Associate of the Royal Astronomical Society, London in 1987.

Prof Bolt received the Alfred Alquist Medal of the California Earthquake Safety Foundation in 1995. He has made many post-earthquake investigations and has written six and edited eight textbooks on earthquakes, geology and computers, among other topics. After emeritus status in 1993 his time is now taken up with engineering consulting, writing, sailing and enjoying the trails near the family cabin at Bear Valley, California.

Source: <http://eps.berkeley.edu/www/index.html>

Prof Bolt was all praise for the activities being conducted under programmes such as NICEE, NPEEE and other capacity building programmes in earthquake engineering at the state and national level. He did however warn of the high seismic hazard in the North East and worried about the very difficult task of ensuring earthquake code compliance in a country with numerous other pressing priorities and limited resources.

Prof Bolt has quite literally traveled a long way. Born and educated in Australia, he joined faculty at Berkeley in 1963 and has been Professor Emeritus since 1993. Excerpts from the conversations over lunch and e-mails are given below.

— *Alpa Sheth*

**Alpa Sheth (AS): How did you get interested in seismology?**

*Bruce Bolt (BB):* I was trained as a mathematician at the University of Sydney, Australia, working under Prof K.E. Bullen, a leading theoretical seismologist. He proposed the study of the structure of the earth's core as a PhD topic. This led to an important change in knowledge of the earth's internal structure.

**AS: You have seen the science of seismology and engineering grow from infancy to its present stage. Tell us more about the trajectory of these fields.**

*BB:* In its beginning, before the twentieth century the early seismologists, like Mallet and Milne, were mainly engineers. R.D. Oldham who studied the great 1897 Assam earthquake was a geologist and head of the India Geological Survey, but he still discussed intensity and engineering damage. The two parts of earthquake studies then developed along different lines for 80 years. In the late twentieth century, the two aspects of earthquake studies came together again after the operation of both strong and weak motion digital seismographs. Engineers and seismologists began to talk to each other.

**AS: What has it been like to have spent more than 40 years on Berkeley campus — the environment, students, colleagues.**

*BB:* I was the Director of the Seismographic Stations for thirty years and taught seismology and earthquake engineering to hundreds of both undergraduate and graduate students. Having students from both science (mainly applied mathematics, geology) and engineering in my classes was a great advantage.

**AS: What were your most exciting projects or findings during your 40-plus years in the field? What do you feel is your single most important contribution to the field of seismology and earthquake engineering?**

*BB:* The successful development of the University of California, Berkeley seismograph network through widespread telephone links between broad-band digital seismographs. In seismology, the discovery of detail on the structure and properties of the earth's inner core. In engineering, the discovery of the effect of ground motion pulses ("fling").

**AS: What do you feel about the current level of knowledge in the field of earthquake engineering? Do you feel somewhat disappointed that after all these years we are still far from being able to predict the time, location and magnitude of an earthquake?**

*BB:* The advance in predicting confidently the future strong ground shaking in a seismic region gives me much satisfaction. Strict prediction in time and place is probably impossible, but we have greatly improved the location and moment estimates of earthquakes.

**AS: What is your perception of the earthquake problem in India? Which areas do you see as those with high seismic hazard and those with high seismic risk?**

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*BB:* The dense population and old construction in high seismic hazard zones in India produces a very serious national problem. Of course, the zone along the southern boundary of the Himalaya is the highest hazard and should be studied more intensely.

**AS: You visited India earlier this year under the NPEEE programme. What did you feel about the current state of art and practice in earthquake engineering in the country?**

*BB:* I feel that two tasks need critical attention: firstly, the strict application of building and retrofit codes and, secondly, an increase in college teaching of earthquake engineering and risk reduction, as envisaged in NPEEE. Appropriate modern geological and seismological textbooks at various levels are needed.

**AS: You have various interests in life — it is not just seismology. I hear you are very good at dramatic work and carpentry, for example. What do you do for instance when you are not trying to study faults or the behaviour of earthquakes?**

*BB:* My hobbies include sailing my yacht in San Francisco Bay, theatre (directing and acting), gardening and tennis.

**AS: You have made tremendous contributions in the field of seismology. One could say it was a life well lived. Is there anything you would have done differently in your professional life?**

*BB:* Not really. I enjoyed teaching (applied math, geophysics, statistics) and working with graduate students. The University life is a privileged one because of the freedom to choose problems and follow individual curiosity.

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