

## **RECENT DAMAGING EARTHQUAKES OF INDIA AND RELATED SOCIETAL ISSUES**

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### **SUMMARY**

The social aspects related with destructive earthquakes of Killari-1993 and Uttarkashi-1991, which occurred in the fairly populated regions of the Indian subcontinent, have been reviewed. The sufferings and psyche of the affected people have been portrayed on the basis of actual observations made at hundreds of earthquake ravaged localities. Stunning of emotions in the high intensity meizoseismal zones and aggressive and possessive attitudes in lower damage areas have been found to be common characteristics of human behaviour. In the Himalayan region, the secondary effects like coseismic landslides assume equally menacing status and their fear lingers for long times to come. Proper understanding of this nature's most abrupt and unpredictable phenomenon is crucial in the preparation for living with the hazard.

### **INTRODUCTION**

The entire Himalayan mobile belt and several tracts of Peninsular India are prone to earthquake hazard. In case of the former, accounting for almost five percent of the world's total seismicity, the recurrence rate of even damaging events is quite high. In the last one hundred years or so, macroseismic surveys of many earthquakes of the sub-continent have been carried out. The author was intimately associated with the investigations of some of the major seismic events of the nineties. In this paper an attempt has been made to bring out the social aspects of the calamity. Recent earthquakes of Killari in the Peninsular region and Uttarkashi in the Himalaya, which were responsible for heavy casualties and destruction, have been taken up for discussion and analysis as test cases.

### **KILLARI EARTHQUAKE OF 30 SEPTEMBER 1993**

Darkness had already set in and the distant horizons were smeared with an orange glow. Tired and pensive, we walked in utter silence along the swampy banks of Tirna river, a small tributary of Godavari basin in the Indian Peninsula. After crossing the shallow waters of the stream we climbed the muddy path to Sastur village, a cotton and sun-flower growing locality, where a few dozens of hours ago, some one thousand people had perished in one of the most, devastating earthquakes of Central India, named "Killari earthquake" of magnitude 6.3. Rows of fresh graves and remains of pyres at the village outskirts bore enough testimony to what had happened in this locality of so far, tranquil seismicity. As the village dwellings came nearer, stench of rotting carcasses and corpses, still entrapped under tons of debris, became more and more pervading and unbearable. The strong ground tremors lasting for half a minute had raised the dwellings into grey and brown heaps of mud and masonry. Not a soul was to be seen anywhere and even the birds, which nested in the trees after sunset, seemed to have migrated elsewhere. A frail looking dog came from somewhere and as if searching for something, climbed atop the ruins of a mud house - perhaps its abode. The poor creature appeared to be waiting in despair for its masters to return, and at the same time, a sense of duty towards its home prevented it from abandoning the ghost locality. Finding none there, it raised its head towards the sky in prayer like fashion and started howling. The haunting wail, laden with deep anguish and helplessness, pierced the deathly silence at regular intervals, petrifying the grim atmosphere still further.

Seventeen such villages, located in and around the banks of Tirna, were swallowed in the fury of the earthquake which occurred at dead of night when the inmates, engaged in day long festivities, were fast asleep. Thousands

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were killed instantly. Scores of others who were seriously injured and got trapped inside, died a slow death as it took hours or even days for the rescue parties to search for the survivors and the dead and extricate them through the mangled mass. The final surveys revealed that in the epicentral tract occupying an area of 110 sq km, the number of dead was 6154, that is 13.3% of the total population and an equal number receiving various degrees of injuries. A staggering 92% of the houses were completely destroyed in this isoseist of Intensity IX on MSK scale. In the surrounding isoseist including 43 villages, 1182 people got killed and 4903 were injured due to the collapse of 71% of the dwellings (Narula et al.1996).

The misery and sufferings were overwhelming during the initial stages of the survey. When we reached the affected areas, the Army and the State Administration had already moved in to carry out the rescue and rehabilitation operations of stupendous scale. Voluntary organisations from different parts of the country and even from abroad were coming in large numbers to provide the much needed relief to the displaced and dispossessed, who had by now abandoned their devastated villages and were staying in make-shift hutments under sub-human conditions. During the day-time it was a common site to see the survivors rummaging forlornly through the ruins of what was once their homes. This unfortunate lot, which had lost most of their near and dear ones in the tragedy and almost all their worldly belongings except their cultivated fields, appeared blank when asked about that fateful night. The impact of the calamity was so profound on them that they had almost forgotten to react and their faces had turned stony.

As we moved away from the epicenter, the damage and sufferings decreased almost proportionately. There were deaths in the house collapses but here the number of injured and survivors were many more. People of these localities were found to be vociferous, argumentative and much more demanding, a glaring contrast in the human psyche when compared with that of the epicentral zone. At times, we had to face the wrath of the infuriated inhabitants who mistook us as officials engaged in relief distribution work.

The Killari earthquake assumes great social and seismological significance in the Indian context since it was the deadliest among the Peninsular events, apart from being centered at a place where it should not have occurred, that is the seismically stable craton of Deccan Plateau (Pande et al.1993). The historical and archaeological records of Marathwada region (Central India), spanning for over several hundred or even thousand years, do not tell of the occurrence of any major earthquake. This fact is also reflected in the design of old as well as new civil structures. In the meizoseismal area of Killari earthquake the extreme damage to majority of the civil structures was not only on account of very high intensity of ground shaking but also because of the type of civil constructions which had almost no regard to seismic forces. The houses of the area, whether old or new, were constructed of very thick outer walls of mud-masonry with an equally thick flat mud roof supported over timber beams and rafters. The stones used as rubble in most of the constructions were locally and cheaply available basalt spheroids set in mud mortar. Such heavy walls of poor material had very low shear strength and when acted upon by strong ground motions, fell like a house of cards producing enormous amount of dust and debris that trapped and choked the inmates inside. The basic objective of having such thick and heavy structures was to guard against the most probable and frequently occurring hazards of theft (robberies and invasions in older times) and intense summer heat. The very low probability seismic hazard, how so ever destructive, had therefore no recognition in the design of these civil structures. Some stray buildings adopting innovative designs of slender resistant brick walls, RCC columns and lintel beams and RCC roof, though badly shaken and cracked, escaped collapse, spared the inmates and stood awkwardly amidst the ruins of village dwellings. The fear of death and destruction due to the earthquake was so deep that the residents not only of the meizoseist but of far off places, slept in the open, in tents or even in their bullock carts for months together.

In our survey, we went to over two hundred earthquake affected villages. In some places the groundwater had gone down consequent to the earthquake and the dug wells had gone dry. At a few other places, the water table had come up. Cases of emanation of gas and smoke and rise in ground temperatures were also reported from some places away from the epicentral tract. An intriguing phenomenon of disappearance of water from a small water pool of a temple in Killari village ten days prior to the catastrophe was narrated to us by a native. This middle aged person with prominent cheek bones told us that an old man of Killari, who died a few days before the earthquake due to illness took it to be a bad omen and prophesied that some calamity might befall the village. And the deadly earthquake struck and raised almost the entire village to ground, killing 1166 people and countless livestock. A fortnight later, the pool started retaining water, regaining its original position. It appears that the stresses in the substrata were producing or opening up the microfractures much before they became critical. After the stresses were released, the strata gradually relaxed and sprang back to their original position. Could such events observed or reported by experienced and mature residents be used as precursors, in selective cases?

The earthquake displaced overnight, lakhs of persons from hundreds of villages. Their speedy rehabilitation in the area was a gigantic task. Initially, they were put up in all sorts of makeshift huts, Government buildings and tents. When the turmoil subsided to some extent, the Government agencies got busy in selecting proper sites for constructing housing colonies, keeping in view factors such as proximity to land holdings but away from the devastated zones, geotechnical feasibility and easy approach. Earthquake resistant houses were built in hundreds at these sites. These single storied structures were constructed of thin walls of hollow concrete bricks, framed at the corners with RCC columns and light roof of corrugated sheets. This design was quite in contrast with that of the original structures of the area, which over the years, had evolved to cater to the requirements, habits and natural conditions. Initially, many of the displaced persons were rather reluctant to move into these alien premises. But nowhere to go, these scientifically designed shelters became the abode for most of the displaced families. Many from the region migrated to the nearby and even distant urban centres or villages, either for seeking employment or out of fear of recurrence of the deadly phenomenon.

### **UTTARKASHI EARTHQUAKE OF 20 OCTOBER 1991**

In the Uttarkashi earthquake, occurring in the Garhwal Himalaya, 768 people were killed and about 5000 others were injured. Nearly one hundred thousand houses located within an area of 24000 sq km suffered various degrees of damage, ranging from minor cracks to complete collapse. The spectacle of a spark of nature's wrath was most evident in a 20 sq km area restricted on the banks of Bhagirathi river, that is 'Ganga' in its nascent stage. In one of the devastated villages, a survivor who was a mute witness to the nature's orgy narrated the incident this way.

“In the very early hours of the day we were awakened by some unknown force. The ground first heaved and then shook most violently causing collapse of our poorly constructed dwellings of thick mud-masonry walls and slate roof. Some got buried under the debris and those who escaped major injuries tried frantically to get out but the small wooden doors would not open as they got jammed by the pressure of the fallen mass. Somehow the doors were broken and we rushed out in the open. Outside, it was endless darkness and utter chaos and it was difficult to know where we were. The rumbling and roaring sound of destruction was punctuated by the wail of the injured and the lamentation of the bereaved ones. Thick dust, generated out of collapse of mud-masonry houses and from the surrounding failing hill slopes had engulfed the air and made even breathing difficult. When the initial shock and confusion subsided, the able bodied got together and launched the search and rescue work. As the day broke we were desperately looking for help from outside so that the injured could be provided medical relief and the dead bodies could be extricated from underneath the debris and disposed off.” Villages located within the epicentral tract presented a ghastly sight of destruction with practically most of the poor type houses, raised to the ground. Village after village were visited in our survey and it seemed that the loss of life and property was directly proportional to the level of poverty and ignorance.

The earthquake, which recorded a magnitude of 6.4, was also responsible for inducing innumerable landslides and fractures in a 2500 sq km area of this Himalayan terrain. As a result, almost all the roads in the meizoseismal and surrounding areas were blocked at several places by boulders, rock blocks and debris mass. These coseismic slides in their fearful descent through the steep slopes, snapped or uprooted countless trees, electric and telephone poles and wires, disrupting the power supply and telecommunication links for days together. A 53 m span girder bridge superstructure over a Bhagirathi river tributary got dislodged from its bearings and was thrown into the river bed, disallowing even the foot traffic to move ahead for some days.

The foremost need was to clear the roads so as to reach to the affected areas. This task was taken up on war footing and the vehicular traffic was restored to some extent in only a few days time. Then stepped in a number of Government agencies and voluntary organisations to redress the sufferings of people of earthquake affected areas. Relief started pouring in from near by and distant places, from religious groups and social organisations, from educational institutions and individuals. One could see convoys of trucks laden with articles like blankets, old clothes, food stuff, medicines, corrugated roof sheets, cement, etc. snailing their way through the partially cleared narrow hill roads.

A long, treacherous winter was round the corner and with practically every thing destroyed in the catastrophe, the inhabitants had to think and plan for their survival and for the survival of the ones who had survived. This brought in a complete metamorphosis in the human behaviour. The grief stricken people, so far driven into their shell and completely resigned to their fate suddenly became belligerent and possessive. A scamper for acquiring more and more began. The young and not so young could be seen lined up along the road side the whole day to corner whatever passed their way. Heated arguments with distributing agencies and occasional brawls and even fist-fights among the receivers became a common sight. The old and infirm, however, could not get out of their

villages and bore silently the enormous tragedy, in the hope that with passage of time the scars of agony would heal.

Many of the devastated villages were located at remote places, far away from the motor road. It took hours or even days of arduous determined walk through difficult mule tracks to reach there. Such localities were the most deprived of the relief supplies. The distributing agencies, coming from far off places, often dumped their load at the road-side shops without bothering how it would reach the needy, staying at distant places. The distribution of relief articles was therefore unbalanced and fraught with various problems. Those who remained deprived could be seen lamenting and cursing their fate and the Government. Those belonging to the road-side villages received articles much in excess of their requirements. Some of the relief material of superior quality therefore found its way to the nearby-town markets for sale.

The traumatic months of October and November 1991 passed over and a severe winter set in. There was rain and snow and the entire area shivered under exceedingly low temperatures. The ground fissures, opened up by the earthquake induced motions, got saturated and at times, the infilling waters froze causing failures of a number of precariously balanced slopes. A number of rockslides were thus generated which in certain areas marginally missed the village dwellings. In some cases, the reactivated debris slides annihilated part of the overlying villages but in the process made the inhabitants terribly scared, once again compelling them to move over to safer zones. The District Authorities were flooded with letters and complaints of unsafe living conditions due to the failing slopes. Some demanded immediate rehabilitation of the entire village to other areas whereas others asked for protection measures. The author was deputed to study the problem in detail and outline mitigation measures.

The high relief and deeply dissected topography of this Himalayan region, constituted of structurally and lithologically fragile rock formations and existing in an environment of accelerated rate of erosion, rendered the hill slopes highly susceptible to the processes of mass wasting. In the prevailing scenario, the strong shaking put to test the performance of various slope segments, many of which failed during the earthquake and a number of others were left in critical and vulnerable states (Pande et al.1996). In this rugged mountain terrain cultivable land is scarce to get and has developed only in the alluvial terrace remnants and old slide debris mass, confined mostly in the river valleys. The sparsely located pockets of human settlements are therefore restricted at such places. To save upon the limited cultivable land, the main source of livelihood of the villagers, the dwellings are constructed in non-productive zones, comprising rocky or colluvial patches at the foot of ridges and hill faces, where incidentally, the danger of rock/debris fall is maximum.

A village of hundred such dwellings, located at the base of a high quartzite ridge, was visited. The earthquake intensity here was VIII on MSK scale, activating a few rockslides. The villagers apprehended further activity during the impending monsoon months and took me all along the ridge for an expert's advice. The slopes were examined in detail and nothing wrong was found with them. On coming down I tried to impress upon the villagers that the worst was over and the ridge posed no more danger to the village. However, their silence convinced me that they were not very impressed by my observation. As I was explaining to them about landslides, thick black clouds floated through the valley and the sky was overcast. Soon, a severe thunderstorm set in lashing the area with almost torrential rain. I took shelter in one of the make-shift huts along with others since the dwellings were damaged by the earthquake. The rain did not show any sign of slowing down even after two hours. I could see the water run off, now flowing through the mud floor of the hut, turning from a trickle to a turbulent flow. The faces of other occupants were grim and anxious. Suddenly I was gripped with an intense fear, a fear of death, a fear of getting washed away by the mud flow down into the river, a fear of getting crushed under huge boulders hurtling down from the enormous ridge. As the time tickled away the fear transformed into a phobia and I found myself almost sick. By this time all my scientific theories and explanations had evaporated in thin air and, in my heart of hearts, I was frantically praying for the rain to stop so that I could get out of this situation. The rain stopped as suddenly as it started giving me the biggest relief of my life. On seeing the clear blue sky I came back to my normal self and started trekking the 8 km long mule track to reach my vehicle. During this walk I pondered over the experience and realised how genuine was the fear psychosis of the inhabitants of these places who had to live under such conditions day after day and year after year.

Many of the villagers could be seen repairing their damaged dwellings from the aid that they got from the Government and from their own meager savings. On understanding that I was an earthquake man, some of them approached me, and with all the sincerity, asked whether they should go ahead with the repair work or abandon this locality since an earthquake of 8.3 magnitude was round the corner in the area. It happened so that some self styled Seismologists had predicted that the Garhwal Himalaya would be struck with a Great earthquake within an year's time and such revelations received lot of publicity in the press and even posters were pasted on the

walls of Uttarkashi town. It was very difficult for me to make comments or contradict such statements. The district authorities were in a real fix on how or what to tell to the villagers whose passion and concern were quite understandable. In case of Killari earthquake, a contrary situation had developed. A moderate tremor of 4.5 magnitude unexpectedly occurred in Killari village almost a year before the main earthquake and caused some minor damage. At that time also a few scientists investigated the event, and on being asked about the seismic status of the area, categorically opined that whatever seismic strain had accumulated had been released and so the area held no seismic potential. And when the 1993 earthquake occurred, killing thousands, the highly inflamed people of the area were after the blood of these scientists. These incidences very clearly indicate that the science of earthquake prediction is still least understood and therefore one must refrain from making any sensational disclosures like astrologers.

## CONCLUSIONS

The earthquakes are large scale natural experiments, making available valuable data on features like earth's interior, characteristics of wave propagation, response of ground and structures to particle oscillations, slope behaviour, etc. A damaging earthquake also provides a platform for an insight into the social aspects of the tragedy which is unique because of the suddenness of the event, occurring without any recognisable warning and unpredictable nature, both in space and time. Investigations of several strong earthquakes have revealed remarkable similarities in the human behaviour of equal intensity zones. Whereas the human feelings in the high destruction areas, corresponding to intensities VIII and above get muted and disarrayed, the inhabitants of lower damage areas become much more apprehensive and cautious about their future, transforming them into a highly possessive and sensitive lot. In case of the former, particularly for those who have experienced death from close quarters, the trauma lasts for years.

The loss of life and damage to property due to an earthquake is basically on account of the faulty designs and poor type construction of the dwellings apart from their improper location. Hence, to a large extent, man is responsible for his own destruction - the earthquake being only a medium. It is like a detonator detonating a dynamite - the damage is caused by the latter only (Pande, 1998). At this stage we cannot predict an earthquake nor can we prevent it from occurring. The only thing that remains in our hand is to prepare for it. The foremost requirement is therefore construction of seismically safe structures at suitable sites in the earthquake prone regions, like the Himalaya. In India, there is unfortunately no legislation, which can enforce aseismic designing of civil structures even in the high hazard regions. Sometimes lack of knowledge and many a times poverty result in construction of dwellings most unsuitable for earthquake forces. There is hardly any organisation in the country involved in educating the masses regarding the scientific aspects of the phenomenon. Various seismic zoning maps do exist but are of a general nature and a very restricted community is aware of them - certainly not the ones living in the hazard zones. So, as far as earthquakes are concerned, whatever is done is when the calamity actually befalls and at that stage it is mostly in the form of reparation and rehabilitation.

Resettlement of the displaced persons, thousands or lakhs in case of a devastating earthquake, is always a very intricate issue involving huge expenditure and effort. The new structures, howsoever earthquake resistant, at times prove to be quite alien and unacceptable to the natives since they neither fulfil their basic requirements nor match with their age-old concept of living. It would therefore be prudent to assimilate factors such as habits and demands of the people of the area in the designs of the new dwelling.

A sizable population of the Indian Subcontinent inhabits the seismically sensitive regions. The art of living with the hazard should therefore be learnt by the inhabitants. The invaluable lessons taught by damaging earthquakes on various aspects of life and matter should be thoroughly imbibed and not forgotten with passage of time.

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