DAMAGE DURING KINNAUR EARTHQUAKE OF JANUARY 19,1975 IN HIMACHAL PRADESH, INDIA

S.Singh[I], A.K. Jain[II], V.N.Singh[I] and L.S. Srivastava[I]

SYNOPSIS

On January 19,1975 a strong earthquake of magnitude 6.8 occurred in the border districts of Himachal Pradesh which lies in the main Himalayan belt. The earthquake caused considerable loss of life and different degrees of damage to various constructions in the area. The more common constructions in stone masonry suffered extensive damage. Corrugated iron sheets nailed on timber arches and frames forming cylindrical shell and barrack type structures suffered little damage. Large sized boulders rolling down the hill slopes resulted in severe damage to some of the buildings and highways. The paper describes in brief the damage to various structures in the area. The isoseismal map of the earthquake has been presented.

INTRODUCTION

Kinnaur and Lahaul-Spiti districts of Himachal Pradesh near India-Tibet border were affected by a severe earthquake in the early afternoon hours of January 19, 1975. The main shock was preceded by a foreshock of magnitude 5.3 few minutes before and felt locally. The parameters of the main shock as reported by National Earthquake Information Service of U.S.A. are, origin time: 08h 02m 02.5s (UTC), epicenter: 32.45°N, 78.43°E, focal depth: normal, magnitude:6.8. The main earthquake was felt with severe intensity in Himachal Pradesh, Ladakh and hill districts of Uttar Pradesh and was felt at other places as far off as New Delhi. Loud rumbling noises accompanying the earthquake, which were also heard during major earthquakes, were reported in Parachu and Spiti river valleys.

During the earthquake 60 persons lost their lives, a few hundred were severely injured and more than 2500 became homeless. Nearly 2000 houses suffered heavy damage or were rendered dangerous for living in Kinnaur district. Landslides, rock falls, snow avalanches, falling boulders and stones damaged or blocked the highways and broke telegraph lines, thus completely disrupting the means of transport and communications. Most of the affected area lies at an altitude of more than 3000 metres above mean sea level.

The area affected by January 19,1975 earthquake lies in the highly seismic belt of the Himalaya. A very severe earthquake devastated area around Kangra in 1905. The southern edge of the Himalaya is laced by numerous thrusts that follow a general NW-SE trend. Further towards north the well known Main Central thrust is exposed. In between the above mentioned thrusts a series of north-south trending faults have been mapped (Gansser, 1964). In the epicentral tract of the Kinnaur earthquake, in the Spiti and Parachu valleys, a major fault with a general N-S alignment is noted. This fault is hereby named as Kaurik-

[I] School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, INDIA

[II] Department of Geology & Geophysics, University of Roorkee, INDIA

Chango fault (Fig. 1). The N-S trending fault in the meizoseismal area is characterised by the occurrence of thermal springs and gypsum deposits. These evidences show that the area along the Kaurik-Chango fault is active.

DAMAGE TO BUILDINGS

During the earthquake considerable damage to buildings occurred in Kinnaur and Lahaul-Spiti districts of Himachal Pradesh. Maximum damage was observed (Singh et.al., 1975) at Kaurik village, where not even a single structure was noted to have withstood the shock. Some of the most badly affected villages were: Leo, Chango, Shalkar, Sumdoh, Giu, Thabo, Sumera, Hurling and others (Fig.1) covering an area of approximately 10,000 sq. km in the Parachu and Spiti river valleys. Village houses located on hill slopes and valley base were hit by falling boulders from upper reaches which resulted in collapse of many dwellings.

Most of the buildings are residential type, single or double storeyed. These can be classified under the following four major types of construction: (i) mud houses (ii) stone masonry houses (iii) houses made of hallow concrete blocks and (iv) cylindrical shell and barrack type houses.

Mud Houses: In areas where glacial tillite and clay deposits are available mud houses are more common. Two types of mud houses exist in the area - those constructed in cast insitu mud walls and other with sundried mud brick masonry. These mud houses are in general provided with timber runners (trunks, branches of trees etc.) embedded or resting at the roof level. Most of these houses have a flat roof supported on timber beams. At some places the mud walls rest on 1 to 1.5m high plinth of random rubble stone masonry (RRSM) without mortar. Many houses had a ground floor in RRSM and the second storey in sundried mud bricks.

These type of mud houses in most of the villages upto a distance of 100km from epicenter developed wide cracks in the walls and got tilted. These houses from Indo-Tibet border upto Leo village were badly affected, often resulting in collapse of the structure. Extensive diagonal cracks occurred along mortar joints in mud brick walls. Fig. 2 shows complete collapse of E-W cast insitu mud wall of a double storey house at Shalkar. The ground floor is in RRSM in mud mortar.

Stone Masonry House: Stone masonry houses are quite common in the earthquake affected area. The older constructions are mostly in RRSM in mud mortar. New construction is in RRSM as well as dressed stone masonry (DSM) in mud mortar. In the newer construction pointing in cement along mortar joints has been adopted on the outer surfaces whereas interior walls has plaster in cement or mud. These houses have sloping roofs covered with corrugated iron sheets or phyllitic slates supported on timber beams.

Fig. 3 shows the collapse of gable end wall of a residential house. The wall is constructed in RRSM in mud mortar. The heavy roof is precariously hanging on the partially collapsed wall and the timber posts. Fig. 4 shows a badly damaged double storey house constructed in RRSM in mud mortar. The large boulder rolling down from left and seen below the collapsed roof caused severe damage to the building. Fig. 5 shows heavy damage to the stair case well of a double storeyed building in DSM in mud mortar. Several cracks developed in this building. Fig. 6 shows the collapse of gable end wall in a house made of RRSM in mud mortar. Movement of the roof resulted in tilting and dislocation of sewage ventilation pipes. However, an interior wall reinforced by timber having X-bracking did not collapse. Several buildings with heavy roof and timber trusses resting on walls in RRSM in mud mortar collapsed completely. Complete collapse of such a building is shown in Fig. 7.

Other damages to these types of houses were in the form of vertical cracks from roof to floor level, bulding of side walls, failure in roof trusses, fall of plaster and development of heavy cracks in the walls. Only one building in DSM with cement mortar and cement plaster was seen in the meizoseismal area. This suffered no damage except for minor development of cracks.

Monastries and Temples: In the earthquake affected area a large number of monastries and temples, generally located on the hill tops, exist. These consist of a comparatively large rectangular central sanctum with a timber frame structure which serves as the main hall for worship. Thick RRSM walls or mud brick masonry walls, with heavy flat roofs are common in such structure. These also serve as school buildings for children of the villages.

Almost all of the temples and monastries in the earthquake affected area were badly damaged, often resulting in complete collapse of the structure. At many places Budha idols were badly damaged.

Hollow Concrete Block Masonry Houses: Houses made of hollow concrete blocks are not very common in the area. They have sloping roofs made of corrugated iron sheets resting on trusses made of steel pipes. The mortar used is either cement or mud with cement pointing on the outer surface of the walls.

Fig. 8 shows the collapse of the gable end wall made in hollow concrete block whereas the columns and corrugated iron sheet roof resting on steel trusses did not suffer much damage.

Cylindrical Shells and Barrack Type Houses: Corrugated iron sheets nailed on timber arches and frame structure, forming cylindrical shell and barrack type houses exist in the area. In cylindrical shell type houses, the end walls are made in timber frame with hollow concrete blocks as filler walls. The barrack type houses have sloping roof of corrugated iron sheets.

These constructions, even when very close to the epicentral region did not suffer much damage and withstood the shock very well. Fig. 9 shows cylindrical sheds of corrugated iron sheets which suffered no damage except for developnent of cracks on the side walls near Sumdoh. Fig. 10 shows barrack type houses which suffered no damage.

BEHAVIOUR OF OTHER STRUCTURES

No major reinforced cement concrete (RCC) or steel structures were seen in the badly affected area. Steel water tanks resting on 20 to 30cm high concrete pedestals did not show any damage. A number of causeways with RCC slabs were burried in the landslides and avalanches. Steel frame Bailey bridges did not show any damage or loosening of bolts. No damage was reported in any of the Steel Rope Suspension bridges in the region.

Stone masonry retaining walls were washed down at many places with the land slides. Falling of huge boulders and landslides caused considerable damage to the Hindustan-Tibet highway. A portion of the damaged highway is seen in Fig.11. The earthquake produced very strong ground motion resulting in fissures in the ground,landslides, rock falls and avalanches. Thick succession of glacial moraine at Kaurik developed wide and extensive fractures from a few centimeters to 100m and a downthrow of ground towards west was noted upto 100m. Landslides in the area continued for several days along steep hill slopes. Dislodging and shifting of boulders at the crest of hill slopes were quite common. A major landslide filled the right bank of Parachu valley with debris upto a height of 60m and blocked the flow of water creating a reservoir behind it. After six days the water impounded in the reservoir started flowing from the left bank. Loosening of rocks along joints and other pre-existing discontinuity surface and movement along them have resulted in changing the seepage outlet in some of the surface springs in the area. One such natural spring in limestones near shalkar ceased to flow due to readjustments in limestone along joints.

INTENSITY AND ISOSEISMALS

The intensity of the earthquake on Modified Mercalli (MM)Intensity scale exceeded VIII and reached IX close to the epicentre. An estimate of magnitude and depth of focus were made from macroseismic data using empirical relationships of Gutenberg and Richter (1954). Based on this the magnitude is estimated to be 6.7 and depth of focus 25 km.

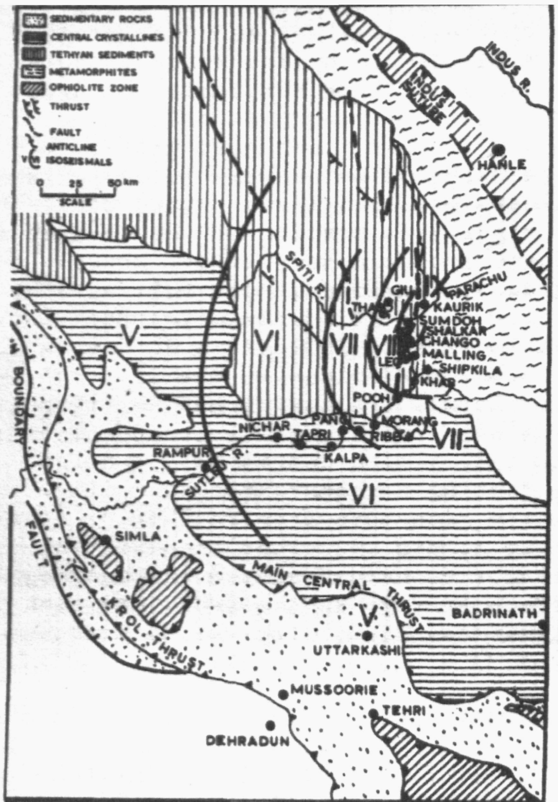
A questionnaire for collecting the details of damage was sent to the Post Masters of all the Post Offices in Himachal Pradesh, Jammu and Kashmir and hill districts of Uttar Pradesh. Fig. 1 shows the isoseismal map based on the field observations of the behaviour of buildings and ground, and data collected through the questionnaire. The isoseismal map shows intensities from IX to V. The isoseismals show a general N-S orientation parallel to Kaurik-Chango fault.

REFERENCES

1. Gutenberg, B. and C.F. Richter, "Seismicity of the Earth and Associated Phenomena", Princeton University Press, 1954.

2. Gansser, A., "Geology of the Himalaya", Inter-science, New York, 1964.

3. Singh, S., Sinha, P., Jain,A.K., Singh, V.N. and Srivastava, L.S., "Preliminary Report on the January 19, 1975 Kinnaur Earthquake in Himachal Pradesh, Bulletin of Indian Society of Earthquake Technology, Vol. 12, No. 1, 1975, pp. 1-57.



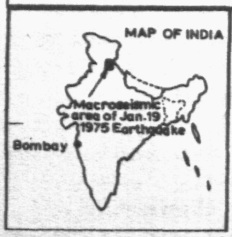


FIG. 1 _ ISOSEISMAL MAP OF KINNAUR EARTHQUAKE. GEOLOGICAL SET UP IS AFTER GANSSER (1964)

FIG. 2 _ COMPLETE COLLAPSE OF SUNDRIED MUD BRICK WALL OF A DOUBLE STOREYED HOUSE AT SHALKAR. THE GROUND FLOOR IS IN RRSM IN MUD MORTAR

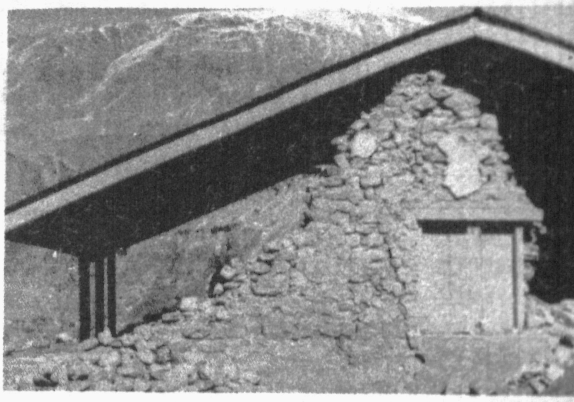


FIG. 3 _ DAMAGE TO GABLE END WALL OF A RRSM HOUSE IN MUD MORTAR. ROOF IS SEEN HANGING ON PARTIALLY COLLAPSED WALL AND TIMBER POSTS

FIG.4 _ DAMAGE TO A DOUBLE STOREY ROADSIDE HOUSE NEAR SHALKAR. IMPACT OF LARGE BOULDER ALSO CAUSED SEVERE DAMAGE.

FIG. 5 _ COLLAPSE OF STAIRCASE WELL IN A DOUBLE STOREYED HOUSE OF DSM IN MUD MORTAR AT LEO

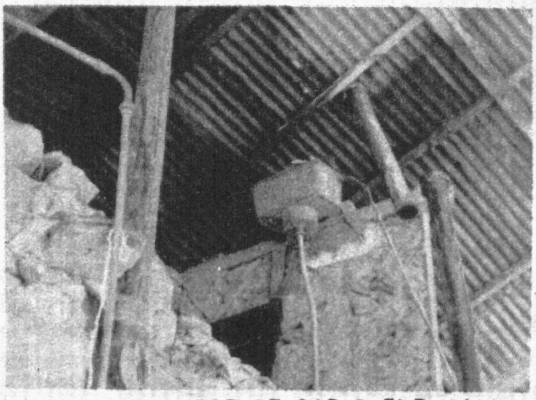


FIG 6 – COLLAPSE OF GABLE END WALL IN A HOUSE AT LEO AN INTERIOR WALL REINFORCED BY TIMBER HAVING X – BRACING DID NOT COLLAPSE

FIG.7 – COMPLETE COLLAPSE OF A BUILDING IN RRSM IN MUD MORTAR AT LEO

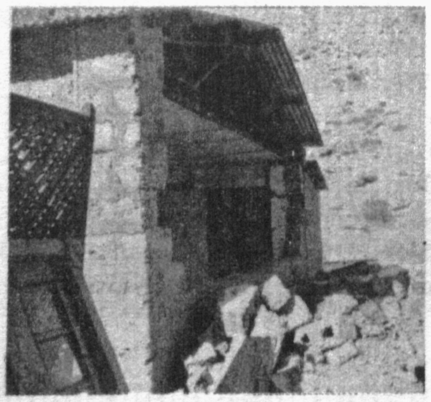


FIG.8 – COLLAPSE OF GABLE END WALL MADE OF HOLLOW CONCRETE BLOCKS NEAR SUMDOH

FIG.9 – CYLINDRICAL SHEDS OF CORRUGATED IRON SHEETS WHICH SUFFERED NO DAMAGE EXCEPT DEVELOPMENT OF MINOR CRACKS ALONG SIDE WALLS

FIG.10 – UNDAMAGED HOUSE MADE OF CORRUGATED IRON SHEETS NAILED ON TIMBER FRAME WITH SLOPING ROOF

FIG.11 – LARGE BOULDERS FALLEN ON ROAD PAVEMENT. PART OF THE ROAD DAMAGED DUE TO LANDSLIDE IS SEEN IN THE BACKGROUND

DISCUSSION

A.K. Srivastava (India)

Occurrence of thermal springs and gypsum deposits in the meizoseismal area has been taken as an evidence by the authors to show that the area along Kausik-Chango fault is active (Page 1-02 of preprint). Could the authors kindly elaborate their statement and explain as to how the above mentioned evidences can indicate activity along the fault.

Author's Closure

The existance of thermal springs in an active seismic belt gives an indication of the nature of the geotectonic processes operative in the region. The higher geothermal gradient responsible for heating the water could be due to nearness of an igneous plutonic mass or stress concentration resulting in rise of temperature. The later could lead to strain building resulting in sudden fractures responsible fo: the earthquake occurrence in the region. Thus a genetic interrelationship with existance of thermal springs with activ status of the fault can be assumed.