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PRELIMINARY REPORT ON JANUARY 19, 1975 KINNAUR EARTHQUAKE IN HIMACHAL PRADESH

S. SINGH[1], P. SINHA[2], A.K. JAIN[3], V.N. SINGH[1] AND L.S. SRIVASTAVA[4]

INTRODUCTION

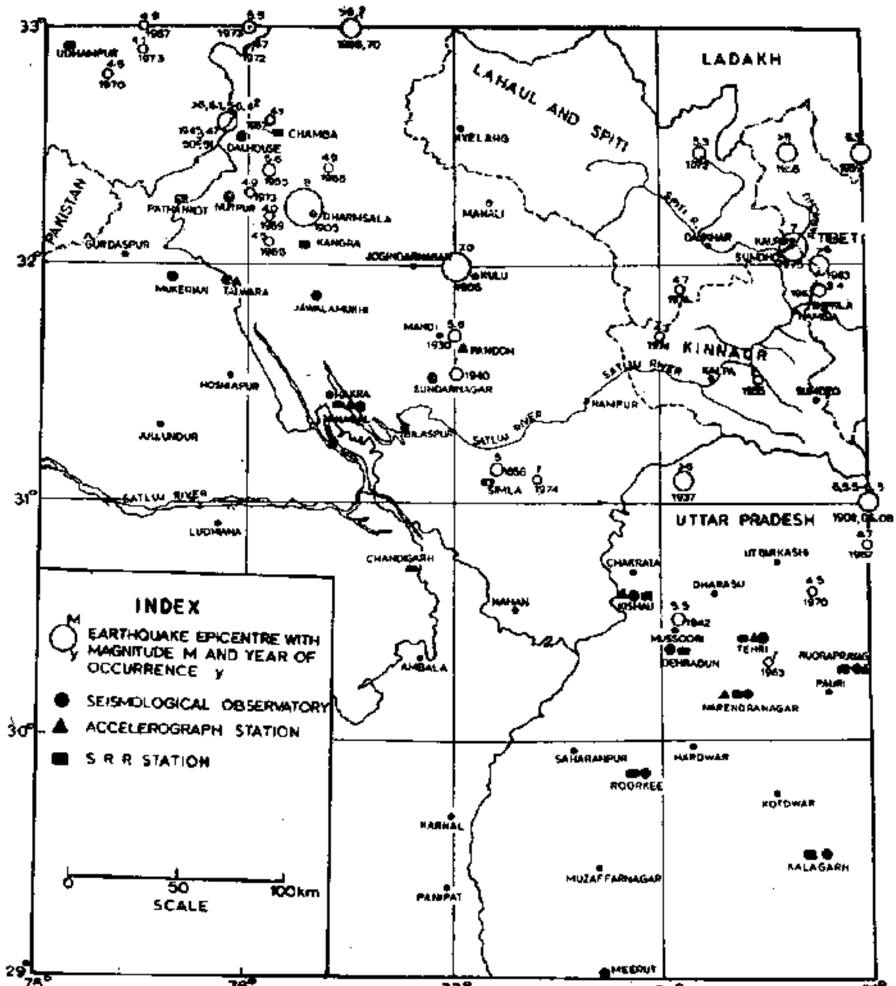
Kinnaur and Lahaul-Spiti districts of Himachal Pradesh were affected by a severe earthquake in the early afternoon hours of January 19, 1975. The main shock, which had been assigned a magnitude 7.0 on preliminary analysis of the earthquake records (India Meteorological Department, personal communication), is reported to have been preceded by a foreshock few minutes earlier and felt locally. The main event was felt with severe intensity in Himachal Pradesh, Ladakh region and hill districts of Uttar Pradesh, and was perceptible at other places as far off as New Delhi. Loud rumbling noises accompanying the earthquake were reported (which were also heard during major aftershocks) in Parachu and Spiti river valleys. Several hundred aftershocks, which are still (March 1975) continuing, have occurred in the region. It has been reported that 60 persons lost their life, few hundred were severely injured and more then 2500 became homeless. A considerable number of cattle, ponies and sheep were killed and injured. Landslides, rock falls, snow avalanches, falling boulders and stones damaged or blocked the roads and broke telegraph lines, completely disrupted means of transport and communications. Subsequent violent windstroms with dry driving snow and intense cold caused added misery to the people and hampered relief and rescue operations in the region. Fortunately, as the earthquake occured in the day time, the casualties were not very heavy.

Most of the affected areas which have suffered heavy damage are at an altitude above 3000 m. Nearly 2000 houses are reported to have suffered heavy damage or rendered dangerous for living in Kinnaur district, forcing the people to live in the open in freezing cold and under continuing snow fall. The earthquake is also reported to have caused disaster across the Indo-Tibetan border. Eye witnesses on the Indian side stated that they saw Tibetan hillocks crumbling with a deafening sound in heaps of debris.

Earthquakes occur very frequently in Himalaya, which is an active seismic belt. Figure 1 shows the epicentres of the prominent earthquakes in the region recorded by the seismological observatories in the country and the World wide network of seismological observatories upto Dec. 1973 as given in Appendix A. Figure 1 also shows the location of the epicentre of January 19, 1975 based on macroseismic data.

As the region forms a part of the global Alpine-Himalayan seismic belt, earthquake occurrence is a common phenomena. However due to lack of a closer and adequate network of seismological observatories, hundreds of events are not recorded and precise determination of epicentral locations and depth of focii cannot be made. Detailed geological mapping and seismotectonic investigations have not been carried out in the region. Thus it has not been possible to delineate active faults and other tectonic lineaments along which earthquakes have occured in the past or identify the potential seismotectonic alignments along which major earthquakes can occur in future.

1. Lecturer
2. Research Assistant
} School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee.
3. Lecturer, Department of Geology and Geophysics, University of Roorkee, Roorkee.
4. Associate Professor, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee.



EPICENTRES OF IMPORTANT EARTHQUAKES IN HIMACHAL PRADESH AND SURROUNDING REGION

FIG. 1

This report describes in brief the behaviour of the various types of structures and the ground, subjected to the January 19, 1975 earthquake and its aftershocks based on field survey carried out in the region from January 26, to February 2, 1975 and data on earthquake effects collected through a Questionnaire (Appendix C). An isoseismal map (Figure 2) delineating the intensity of these earthquakes on Modified Mercalli Intensity scale (Appendix B) in the region has been prepared, and the probable seismotectonic inter-relationships with earthquake effects have been outlined.

TYPES OF CONSTRUCTIONS

No major engineering structures exist in the area affected by the earthquake. Most of the buildings are of residential type single or double storeyed buildings. They are predominantly constructed in random rubble stone masonry (RRSM) in mud mortar.

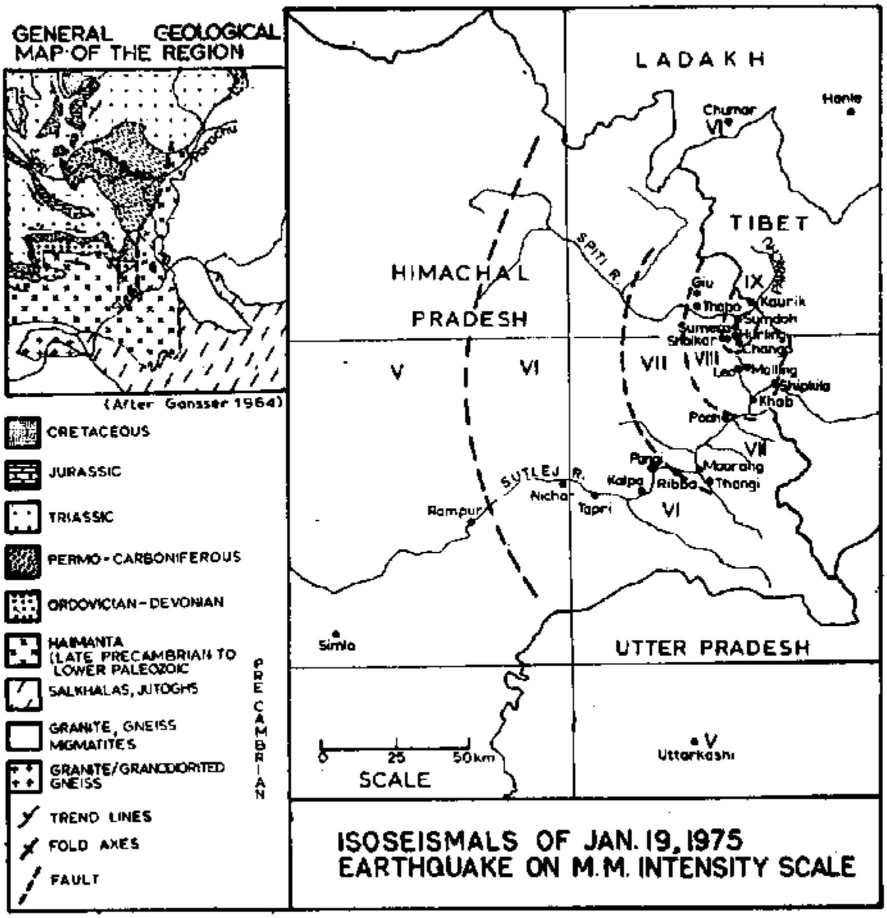


FIGURE. 2

In areas where glacial tillite and clay deposits are available mud houses are more common. These mud houses are in general provided with timber runners ('ballis' or thin branches of trees etc.) embeded or resting at the roof level. Most of the village houses in mud or stone masonry have a flat roof (Figure 3) supported on timber (balli) beams. Sloping roofs covered with phyllitic slates and corrugated iron sheets also exist in the area.

New construction in RRSM as well as dressed stone masonry (DSM) is mostly in mud mortar with sloping roof of corrugated iron sheets. Pointing in cement along mortar joints has been adopted on the outer surfaces whereas interior walls have plaster in cement or mud. Some structures in hollow concrete blocks have also been made.

Corrugated iron sheets nailed on timber arches and frame structure, forming cylindrical shell and barrack type of structures respectively, have also been constructed in the region.

Temples and monastries in the area which are generally located on hill tops have a 'basic' timber frame structure with filler walls of stone or mud brick masonry. These

Fig. 3. A general view of Leo village showing typical flat roof houses in the region.

in general have a flat roof. The temples as well as Buddha statues installed within them are generally massive in form. Monuments (locally known as 'Mane') of 150–200 cm in height on the outskirts of the village are very common. These consist of a rectangular turreted stone masonry block in mud mortar with a solid spherical dome at its top. These are often covered with a flat roof resting on timber posts or mud brick walls.

Due to high altitude and extreme climatic conditions timber is not readily available for construction. However few small timber frame structures with walls of timber planks exist in the area.

DAMAGE TO BUILDINGS

Considerable damage to buildings have occurred in Kinnaur and Lahaul and Spiti district of Himachal Pradesh. No damage has however been reported in adjacent Simla District. The maximum damage was observed 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 and Giu. The severely affected zone extends for a distance of 40 km from Kaurik towards south, covering an area of approximately 800 sq km in the Parachu and Spiti river valleys.

The mud houses in most of the villages upto a distance of 100 km from Kaurik developed cracks in the walls (Fig. 4) and got tilted. Most of the mud houses from Indo-Tibet border upto Leo have been badly affected often resulting in collapse of the structure. Stone masonry houses showed similar behaviour. However, dressed stone masonry construction in cement mortar with light sloping roofs suffered little damage. Light weight structures made of corrugated iron sheets nailed on timber frame-work did not suffer any damage. Damage to buildings in some of the severely affected villages is described below.

Damage at Kaurik: This village consisted of twelve houses. Figure 5 shows a general view of damaged Kaurik village. All the houses were constructed in cast-insitu mud walls (Fig. 6) and mud bricks with heavy flat roofs which collapsed during the earthquake. The village rests on the flat top of a glacial moraine. Extensive fractures and dislocations in the ground were observed. A timber frame house (Fig. 7) with walls of

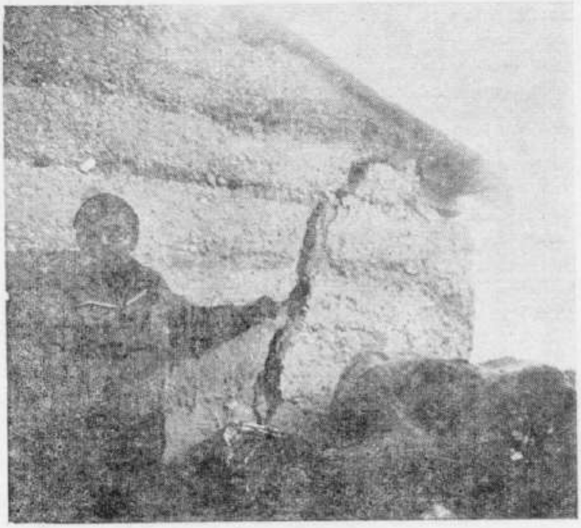


Fig. 4. Cracks in mud house at Pinauti village.

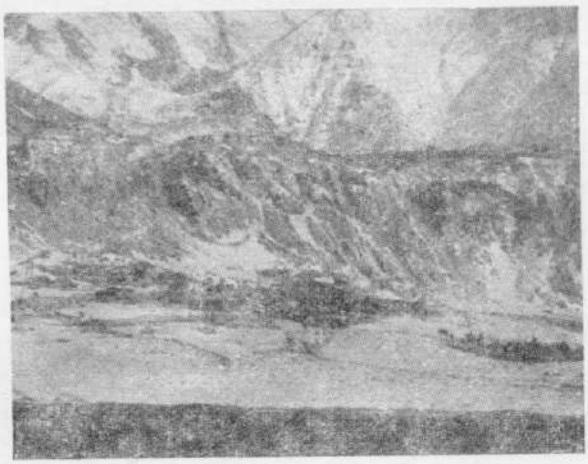


Fig. 5. A general view of the Kaurik village showing complete collapse of structures during the earthquake. Sliding of boulders and other materials at the crest of the terrace can be seen in the background.

Fig. 6. Collapse and fall of a house made of cast insitu mud walls at Kaurik village.

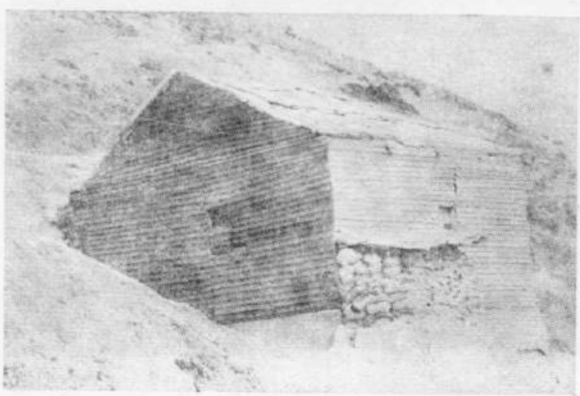


Fig. 7. A timber frame house over a concrete water tank which suffered very less damage. Fall of plaster and fine cracks were seen in the walls of the tank.

timber planks located on a hill slope 3 km south of Kaurik village, however, did not suffer any damage. This structure rested on a stone masonry water tank in cement mortar, the walls of which show fall of plaster and minor cracks. Small iron sheets covering the sloping roof were dislodged.

Damage at Sumdoh: Sumdoh village has about thirty houses in a row, in E-W direction, on a river terrace on the left bank of Spiti river. Each of these houses rests on about a meter high plinth of random rubble stone without any mortar. Houses with superstructure in RRSM without any mortar and heavy flat roofs have collapsed (Fig. 8). P.W.D. rest house constructed in RRSM in mud mortar was badly damaged. Figure 9 shows the collapse of the gable end wall of the rest house. The roof is precariously hanging on the partially collapsed wall and the timber posts (a number of which have fallen). Fig. 10 shows the collapse of RRSM residence of Asstt. Engineer (P.W.D.). However the semicircular shed (P.W.D. Store) made of corrugated iron sheets nailed on timber arches, adjacent to the Asst. Engineer's residence did not suffer any damage, except the collapse of the stone masonry walls at the ends. Some of the houses at the eastern end of the village were shattered by the impact of large size boulders rolling down the hill.

Some recent constructions near Sumdoh village on the terrace on right bank of Parachu river were constructed in hollow concrete blocks. Fig. 11 shows the collapse of the gable end wall of a hall whereas the columns and corrugated iron sheet roof resting on steel trusses did not suffer any damage. Fig. 12 shows tilting of the filler wall in such construction. Fig. 13 shows cylindrical shed made of corrugated iron sheets nailed on timber arches. The end wall made in timber frame with concrete blocks as filler walls did not suffer significant damage, except cracks along mortar joints. Some of the E-W walls collapsed completely.

Damage at Shalkar: Village Shalkar is situated on a fine grained glacial till. Most of the houses are made of mud as clay (Glacial till) is available locally. Fig. 14 shows cast-insitu mud walls (90 cm thick) which developed huge cracks and tilted. Such buildings rest on a 1 to 1.5 m high plinth of RRSM without mortar. Fig. 15 shows badly cracked damaged wall of a house in which all other walls have collapsed. Many houses had a ground floor in RRSM and the second storey in sundried mud bricks. Fig. 16 shows collapse of the east-west mud brick wall of a double storey house. The first storey of this house is in RRSM in mud mortar. Fig. 17 shows the collapse of Police check post on H.T. Road which was constructed in RRSM in mud mortar. The big boulder approximately 2.5 m long rolling down from left seen below the collapsed roof, caused severe damage to the building.

Priest's house (Fig. 18) suffered heavy damage. Fig. 19 and 20 show collapse of the temples housing the Buddha idols. Fig. 20 also shows damage to the Buddha idol. 'Manes' also suffered severe damage. Fig. 21 shows major cracks in the spherical dome whereas in the second (in the background), the solid spherical dome collapsed and the masonry rolled down.

Damage at Chango: Chango village is situated at two levels on a glacial moraine. Houses at the lower level are made of cast-insitu mud blocks or sundried brick masonry. Some of the houses have walls in RRSM in mud mortar. Fig. 22 shows extensive cracks along mortar joints in a mud brick single storey house. Fig. 23 shows cracks propagating from the window opening and bulging of the end wall. Fig. 24 shows failure of the RRSM wall in the Primary School. Some of the two storeyed houses have the ground floor roofs resting on timber post embedded 10–20 cm in the ground with timber beams resting on the top. The walls of the second storey resting on timber posts in such

Fig. 8. Collapsed RRSM houses at Sumdoh village.

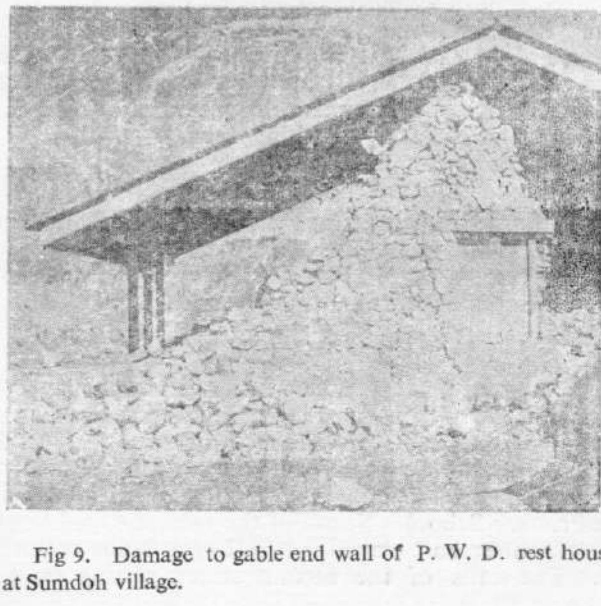


Fig 9. Damage to gable end wall of P. W. D. rest house at Sumdoh village.

Fig. 10. Collapse of RRSM of the Asstt. Engineer's residence, Semicircular shed (P.W.D. store) seen in the background did not suffer any damage except the collapse of the stone masonry side walls.

Fig. 11. Collapse of gable end wall, made of hollow concrete blocks near Sumdoh village.

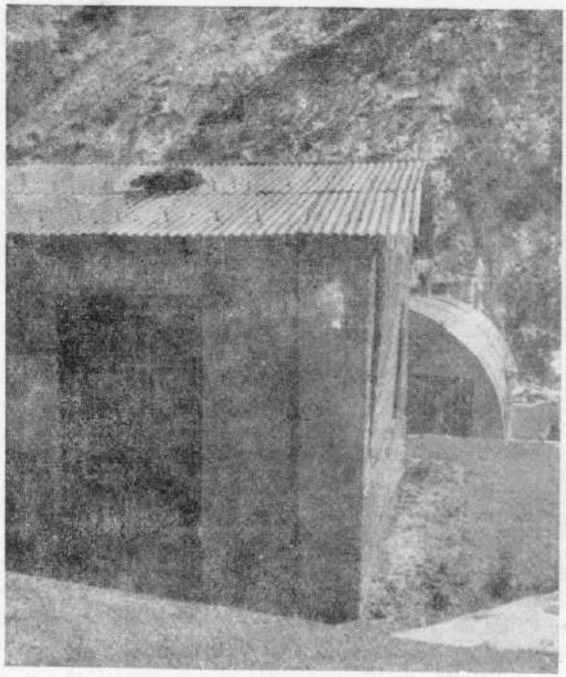


Fig. 12. Tilting of filler walls made of hollow concrete blocks near Sumdoh village.

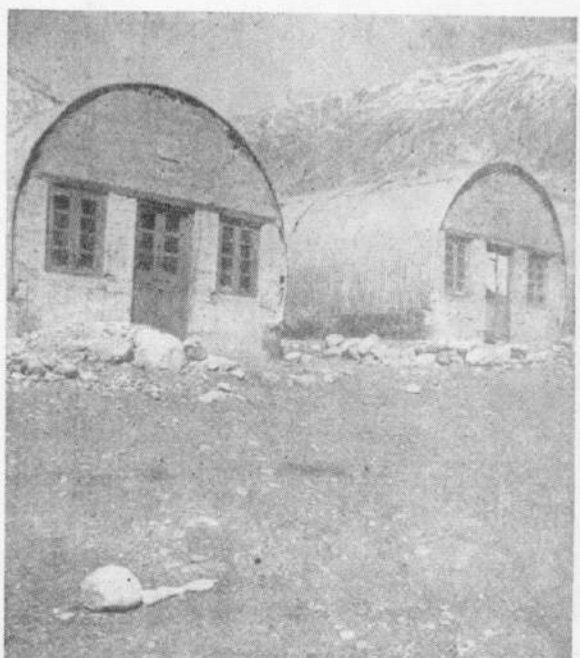


Fig. 13. Cylindrical sheds of corrugated iron sheets which suffered no damage except development of cracks on the side walls near Sumdoh village.

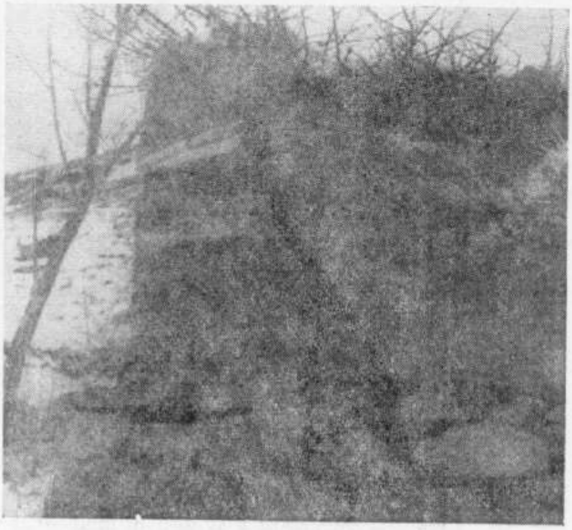


Fig. 14. Cast insitu mud walls showing tilting and development of cracks at Shalkar village.

Fig. 15. A badly damaged wall resting on plinth of RRSM without mortar. (All other walls of the house have collapsed) at Shalkar village.

Fig. 16. Complete collapse of E-W wall of mud brick of a double storey house at Shalkar village. The ground floor is in RRSM in mud mortar.

Fig. 17. Collapse of police check post at Hindustan Tibet road, Shalkar. A big boulder rolling down from left seen below the collapsed roof, caused severe damage to the building.

Fig. 18. Severe damage to the priest's house at Shalkar village.

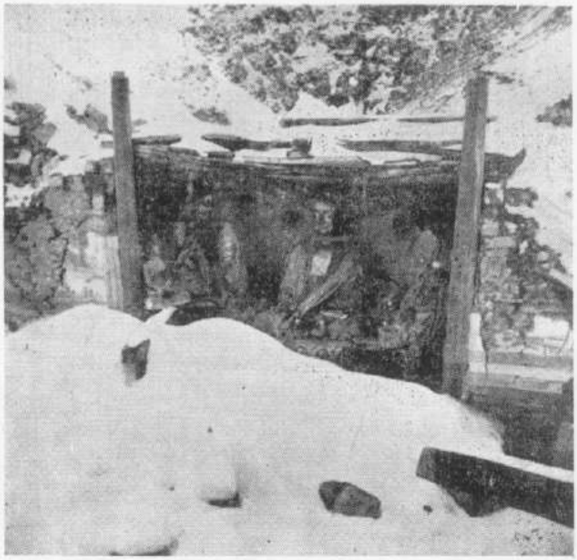


Fig. 19. Total collapse of temple housing Buddha idols at Shalkar village.

Fig. 20. Total collapse of timber frame work of a temple at Shalkar village. The Buddha idol is also damaged.

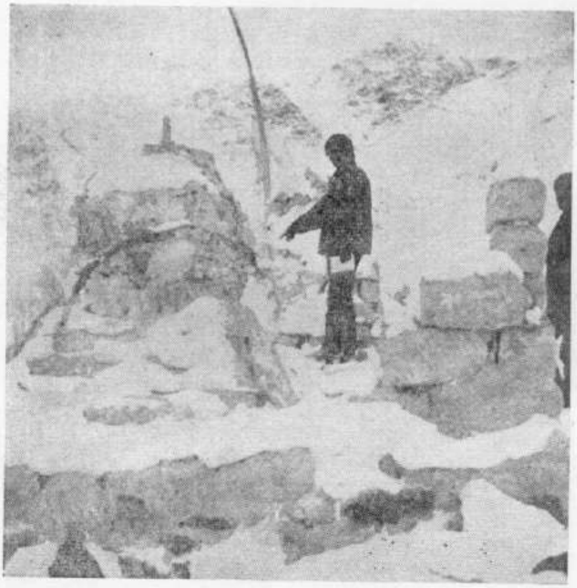


Fig. 21. Damages to 'mane' at Shalkar village; that in front shows cracks whereas the spherical dome of that in the background had collapsed and the masonry rolled down.

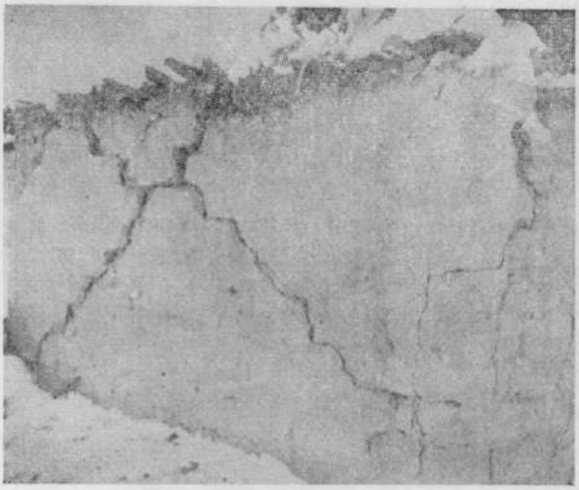


Fig. 22. Diagonal cracks along mortar joints in mud brick house at Chango village.

Fig. 23. Bulging of the end wall and cracks propagating from window openings of a mud brick house at Chango village.

Fig. 24. Failure of RRSM interior walls of the primary school building at Chango village.

houses, have suffered extensive damage. Fig. 25 shows extensive cracks in mud brick masonry on first floor with partial collapse in back walls.

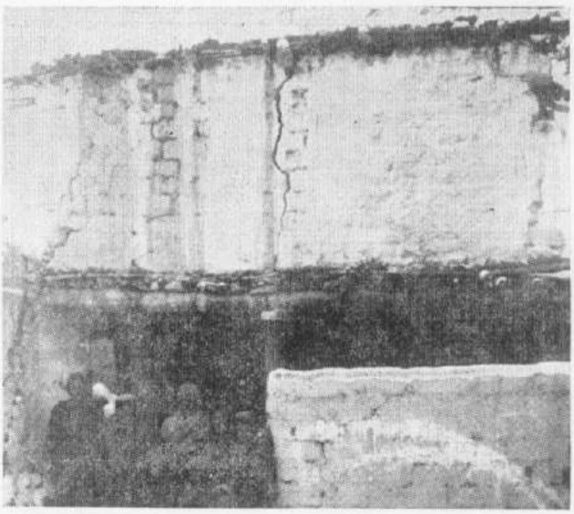


Fig. 25. Extensive cracks in mud brick masonry on second storey resting on timber posts, with partial collapse of back walls at Chango village.

New construction at Chango is at the higher level. This is in stone masonry with sloping roof made of corrugated iron sheets. Dressed stone was used in the outer facing of the walls, whereas, the inner facings had random rubble stone masonry with muck filled in between. Such masonry walls have been constructed in mud mortar with mud plaster in the interior surfaces and cement pointing along mortar joints on exterior surfaces. Extensive damage occurred in such masonry structures which often led to collapse of structures. Patwarikhana building (Fig. 26) and Dispensary building (Fig. 27) show collapse of end walls and damage to interior walls. Fall of plaster also occured in these buildings. Gramsevak building (Fig. 30) did not suffer damage except development of fine cracks in the plaster and along mortar joints. Chimneys made of thin iron pipes were tilted and bent above roof level (Fig. 29 and 30).

Damage at Leo: Leo village is situated on a terrace consisting of glacio-fluvial sediments on the right bank of Spiti river. Fig. 31 shows houses at five levels in the village. These have flat roofs and are constructed with RRSM in mud mortar. At the lowest level the central 'Mane' has collapsed. The houses show extensive cracks at all the levels from the central 'Mane' along N-S direction. This is probably related with a major ground fissure developed along this alignment during the earthquake. Some of the houses at Leo village on the hill side were hit and damaged by falling boulders of 1 to 1.5 m in diameter.

Recent construction on a level terrace approximately 100 m above the village was in RRSM. Fig. 32 shows collapse of gable end wall in RRSM exposing the interior. The sewage ventilation pipes were titled and detached due to movement of the sloping corrugated iron sheet roofs. The interior wall built in "Kashmir type Dhajji-Dewari construction" with stone masonry in timber frame developed extensive cracks, resulting in dislocation and fall of the masonry. However, the wall did not collapse. The two storeyed Police Station in dressed stone masonry building suffered extensive damage. The stair case well on the rear collapsed completely (Fig. 33). Extensive cracks developed along the junctions of the wall from the roof to floor level with bulging of the masonry (Fig. 34). Most of the fixtures on the walls were shaken and detached. Fig. 35 shows detachment and tilting of the fire extinguisher in one of the interior walls. Similar cracks were observed in the Ayurvedic hospital building (Fig. 36). Fig. 37 shows collapse of gable end wall of two storeyed Compounder's residence in RRSM in mud mortar. Fig. 38 shows the collapse of walls and partial collapse of the roof of the Patwari and Kanungo's house built in RRSM in mud mortar. Fig 39 shows collapse of the interior walls and consequent failure of the roof trusses in the office cum residence of Agricultural Authority. Fig. 40 shows complete collapse of Tehsil office building built with RRSM in mud mortar. Fig. 41 shows complete collapse of Post and Telegraph building which is of same type as Tehsil building.

Damage at Pooh: Pooh village is situated on a hill slope (Fig. 42) consisting of glacial moraine. Most of the houses were of stone masonry in mud mortar which developed cracks along mortar joints, which were often 1–2 cms in width. Fig. 43 shows cracks along mortar joints and window sill in SDM court building.

Recent construction on the river terrace 250 m. below the village made up of corrugated iron sheets nailed on timber frame work with sloping roofs did not suffer any damage (Fig. 44). However, cracks along mortar joints were developed in stone masonry buildings.

Damage at Tapri: Tapri village is situated on a river terrace of river Sutlej. Buildings in RRSM without mortar suffered damage (Fig. 45) resulting in fall of masonry. RRSM houses in mud mortar in the village also suffered extensive damage. Fig. 46 shows fall of DSM facings at the residence of S.D.O. Cracks also developed in the

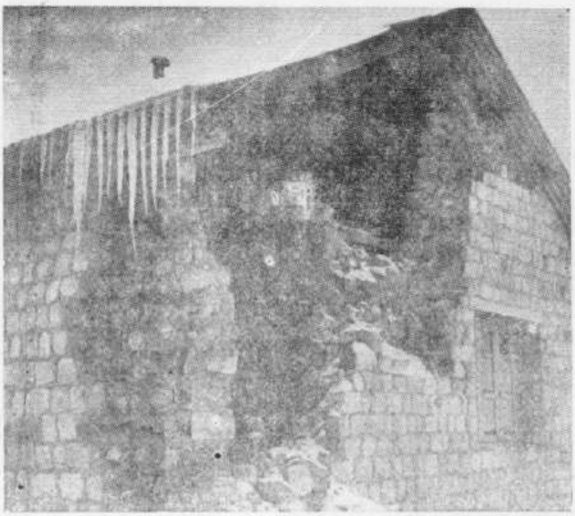


Fig. 26. Collapse of stone masonry gable end wall in Patwarikhana, at Chango village. Dressed stone was used in the outer facings whereas random rubble stone was used in the inner facings with muck filled in between,

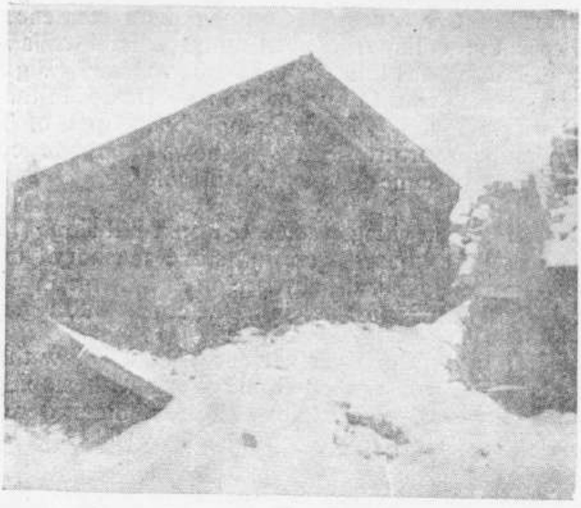


Fig. 27. Collapse of gable end wall in dispensary at Chango village. Collapse of interior walls and fall of plaster is also seen.

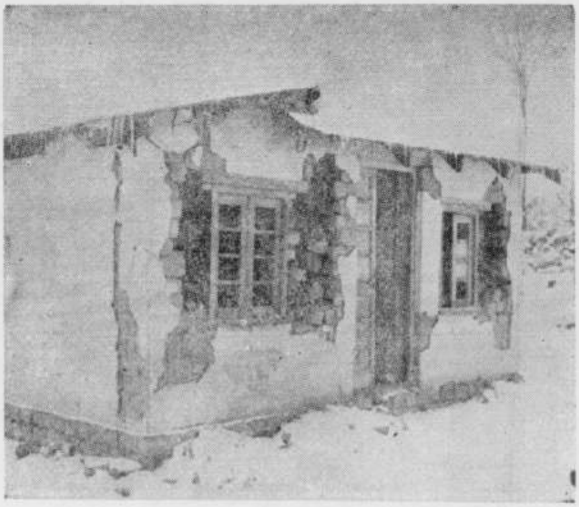


Fig. 28. Fall of plaster and development of cracks in the "gramsevak" building at Chango village.

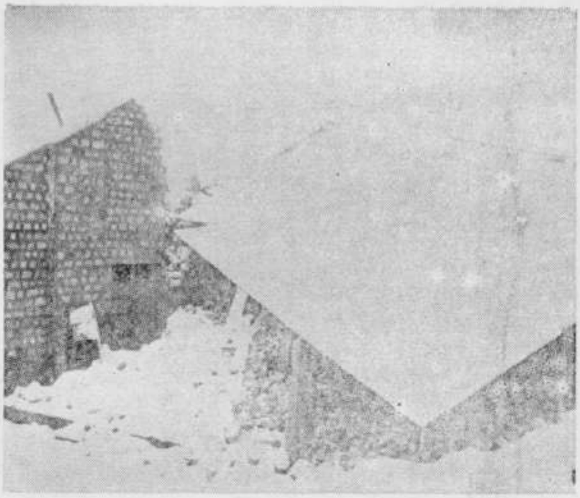


Fig. 29. Collapse of stone masonry wall and roof in peon's hut at Chango village.

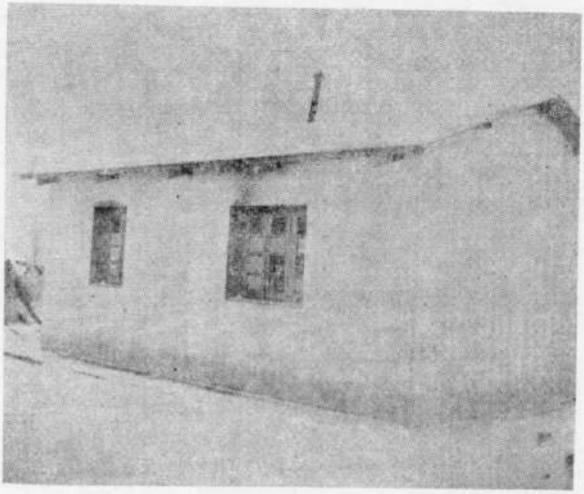


Fig. 30. Revenue building built in stone masonry in cement mortar suffered no damage except for minor development of cracks at Chango village.

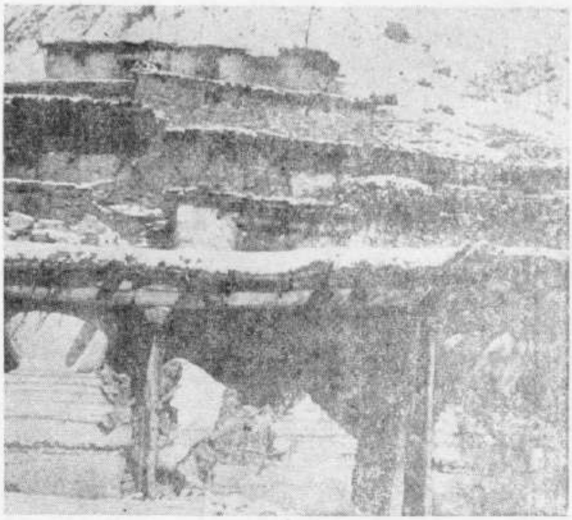


Fig. 31. Damage to 'Mane' and stone masonry houses at Leo village. The houses show cracks at all five levels from the central 'Mane' in N-S direction.

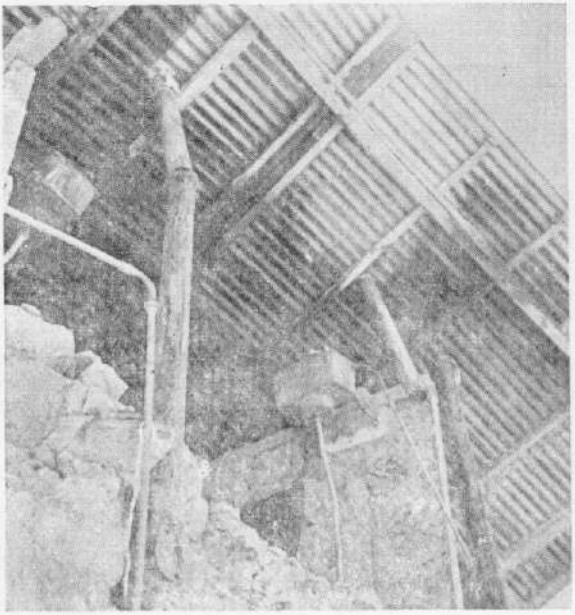


Fig. 32. Collapse of gable end wall in a house at Leo village. A timber frame interior wall with stone masonry filler built in Kashmir Dhaji-Dewari type construction did not collapse. Movement of the roof resulted in tilting and dislocation of sewage ventilation pipes.

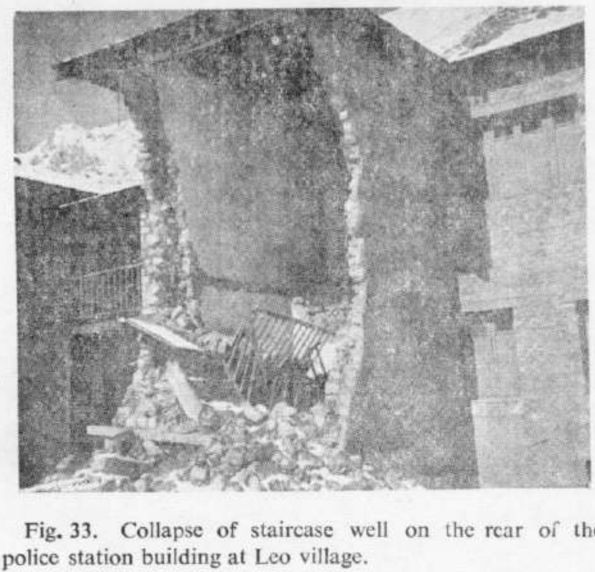


Fig. 33. Collapse of staircase well on the rear of the police station building at Leo village.

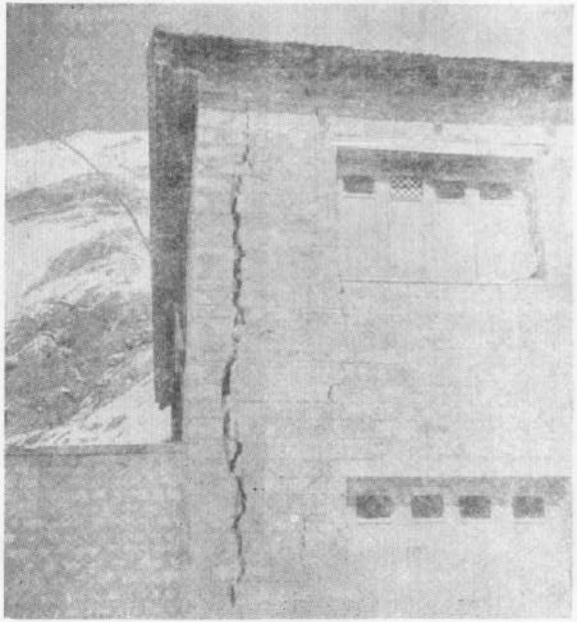


Fig. 34. Bulging of walls due to cracks from roof to floor level on the police station building at Leo village.

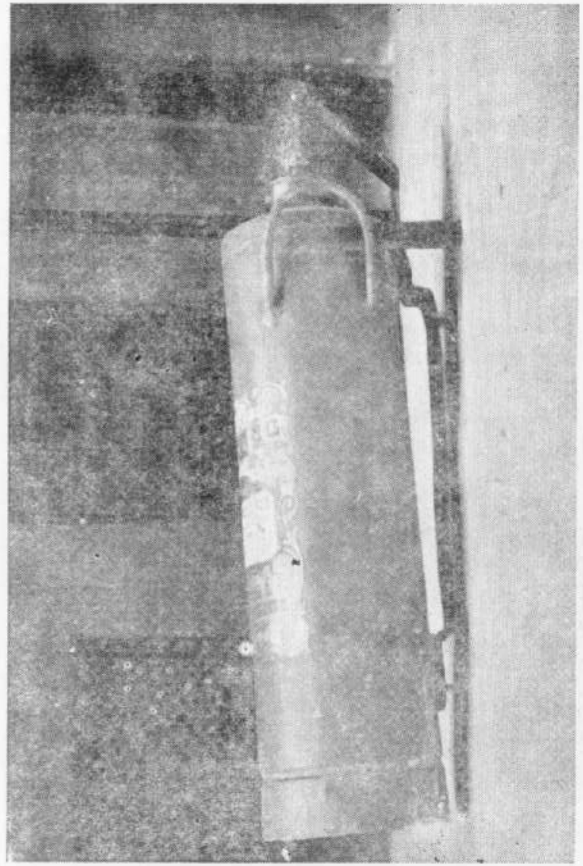


Fig. 35. Detachment of fire extinguisher from the wall inside police station Building at Leo village.

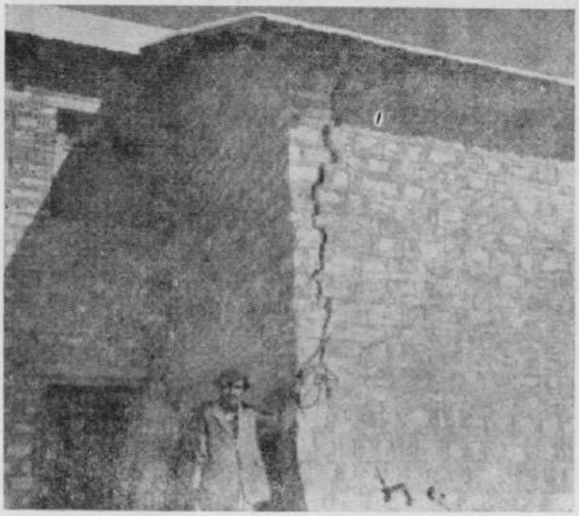


Fig. 36. Vertical cracks at the junction of walls in Ayurvedic hospital at Leo village.

Fig. 37. Collapse of gable end wall of two storeyed compounder's residence at Leo village. Fall of mud plaster can be seen on the walls.

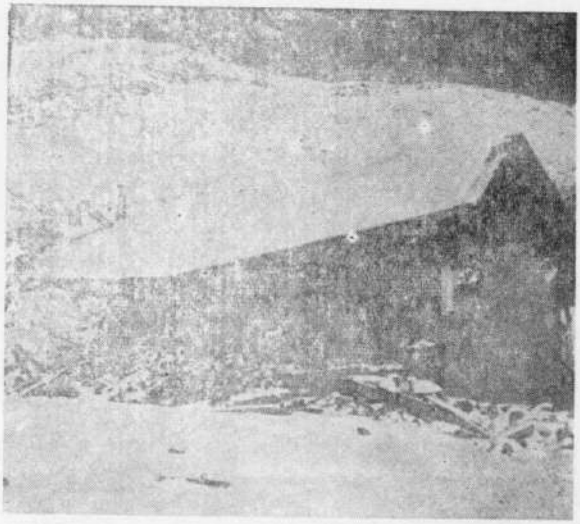


Fig. 38. Collapsed "patwari" and "kanungo" house at Leo village.

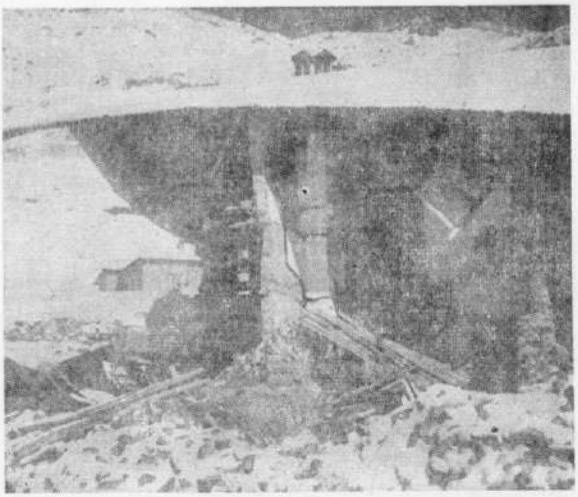


Fig. 39. Collapse of outer and inner walls and failure of roof trusses in the office-cum-residence of Agricultural Authority at Leo village. Single storeyed stone masonry house in cement mortar seen in the background developed only cracks along mortar joints and plaster fell down in the interior.

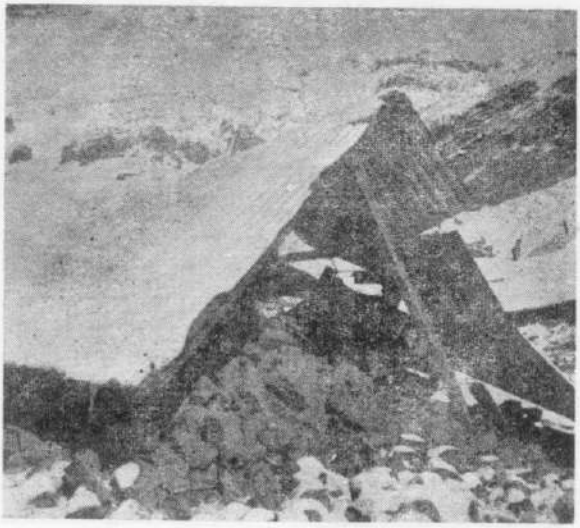


Fig. 40. Total collapse of Tehsil office building at Leo village.

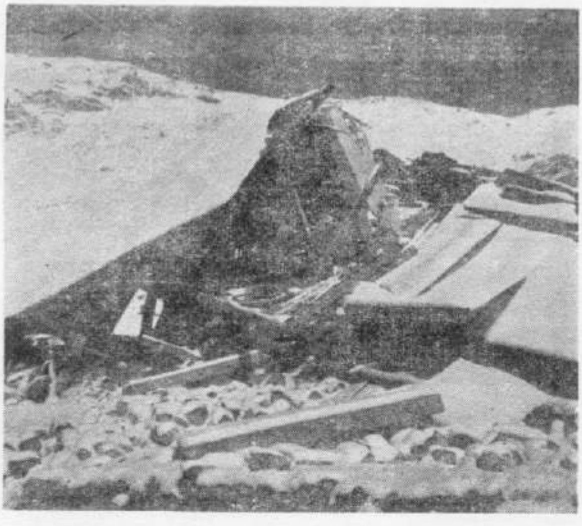


Fig. 41. Total collapse of Post and Telegraph building at Leo village.

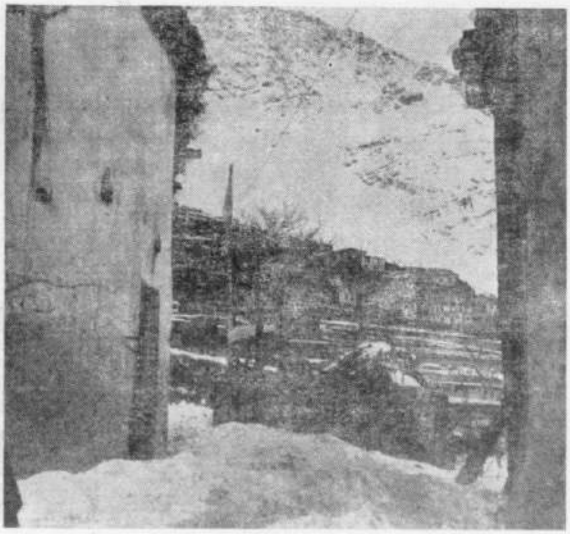


Fig. 42. General view of Pooh village situated on a hill slope, where the houses did not suffer any major damage.

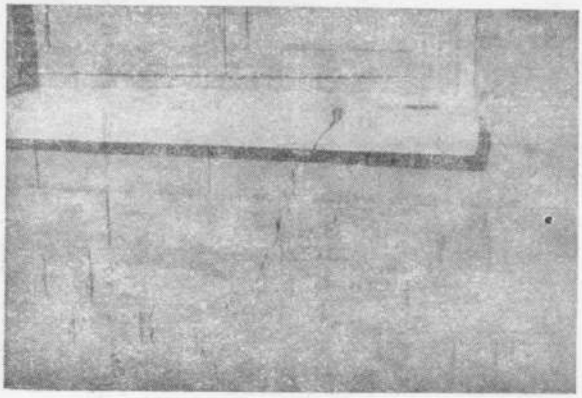


Fig. 43. Cracks along mortar joints and window sill in S.D.M's Court at Pooh village.

Fig. 44. Undamaged houses made up of corrugated iron sheets nailed on Timber frame work with sloping roof at Pooh village.

Fig. 45. A house with RRSM without mortar suffered heavy damage at Tapri village.

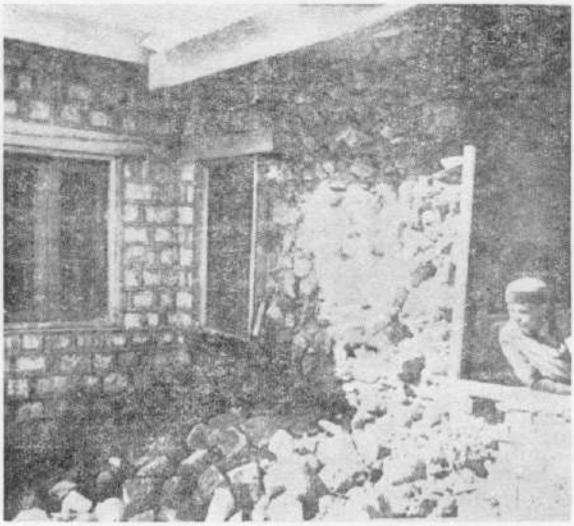


Fig. 46. Falling of DSM facings at the residence of S.D.O. at Tapri village.

interior of the house. Cracks in DSM were developed along mortar joints starting from window openings and at the junction of walls at the P.W.D. rest house. Fig. 47 shows reopening along pre-existing cracks, which probably had developed due to differential settlement of the foundation soil.

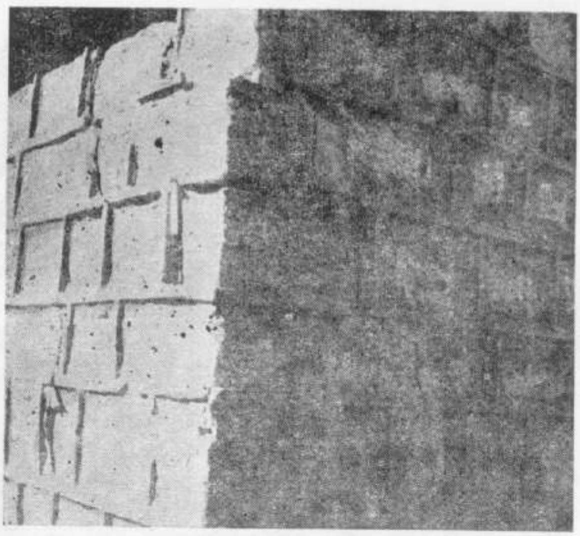


Fig. 47. Reopening of pre-existing cracks in P.W.D. rest house at Tapri village. Cement pointing along mortar joints had fallen.

DAMAGE IN OTHER AREAS

At Malling village, situated on glacial moraine, all mud houses developed extensive cracks in the walls. The Forest Rest House at Malling constructed in DSM in cement mortar developed cracks along mortar joints. Extensive fissures and collapse of stone masonry walls, often resulting in collapse of houses was reported from Thabo, Giu, Sumera, Hurling, Namgia, Khab and other villages in Spiti valley. Several houses developed wide cracks in walls at Shipkila, Ribba, Thangi and other villages. Minor cracks in stone masonry and mud walls were reported from Lari, Pangi, Moorang, Kalpa and other places. Village houses in Pin river valley, which were mostly in RRSM and mud were reported to have developed cracks in walls. Hanley Gompa (Monastry) about 200 km from Leh near the Himachal Pradesh—Ladakh border was reported to have developed cracks in walls.

BEHAVIOUR OF OTHER STRUCTURES

No major reinforced cement concrete (RCC) or steel structures was seen in the badly affected area. Steel water tanks of 120 cm × 120 cm × 120 cm resting on 20 to 30 cm high concrete pedestals on hill-slopes at Leo village did not show any damage, sliding or movement. The walls of RCC water tank resting on a hillslope near Kaurik village developed fine cracks with fall of plaster. A two metre high stone masonry wall of a surface water storage tank at Shalkar did not show any damage.

A number of causeways with RCC slabs resting on stone masonry piers exist over small streams along the roads. Some of these were buried in the landslide and avalanches. No damage to the RCC slabs or piers was observed in the region. Steel frame Bailey Bridges did not show any damage or loosening of bolts. However at Chango village one of the abutments made of stack of stone blocks without mortar had slumped. No damage was reported in Steel Rope Suspension bridges in the region.

Stone masonry retaining walls supporting road pavements on the valley sides suffered heavy damage. At many places these were rolled down with the landslide.

DAMAGE TO GROUND

The earthquake produced very strong ground motion in Parachu and Spiti valleys which were responsible for development of fissures in the ground, landslides, rock falls and avalanches. It was reported that the rocks, boulders and ice uprooted by the earthquake and sliding down the mountains covered the valley with dust reducing the visibility in the region for several hours. The falling of boulders blocked the Hindustan Tibet Road and other important roads at many places and knocked off and damaged may retaining walls, telegraph poles and the houses along the roads.

Fissures in the Ground: Extensive fissuros were developed in glacier moraines over the bed rock. These fissures at many situations were noted to extend along the valleys and hill slopes.

Thick succession of glacial moraine at Kaurik village developed wide and extensive fractures. Fig. 48 shows a fissure which passes through the village. Individual fissures extended to nearly 15–20 m trending N 335° to N 35° (Fig. 49). Width of the openings varied from a few centimeters to 100 cm and the downthrow of the ground towards west was noted upto 100 cm (Fig. 50). The fracture zone having a width of 10 to 15 m with individual fractures running en echelon to each other could be traced

Fig. 48. Ground fissure which cut across Kaurik village.

Fig. 49. En-enchlon ground fissures near Kaurik village. Individual fissures run for 15–20 meters separated by 10–15 meters.

Fig. 50. Vertical scarpment along a ground fissure at Kaurik village.

from the edge of the terrace in the south, to the hill slopes north of the village for more than one kilometer. Innumerable instances of sliding and fall of galcial moraine material from crest of the terraces were reported (Fig. 51, Fig. 5).

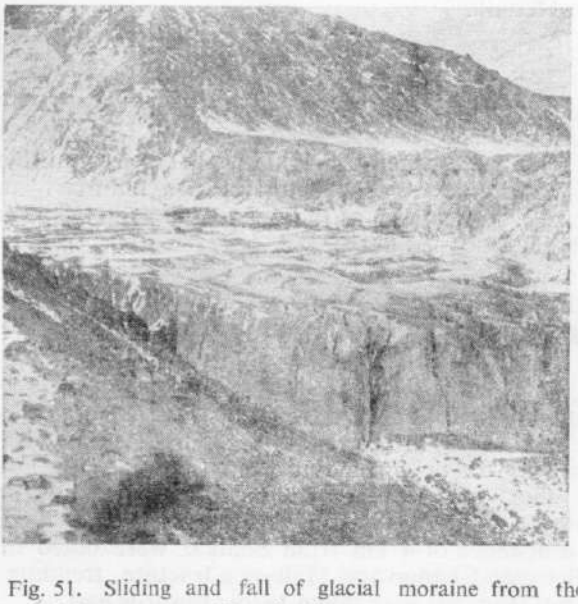


Fig. 51. Sliding and fall of glacial moraine from the crest of the terraces at Kaurik village.

At a place between Sumdoh and Kaurik the fissures in the ground with trend towards N 25°, transverse to the ridge covered with glacial moraine, were noted (Fig–52). The opening along the fissures were varying from a fraction of a centimeter to 15 cm.

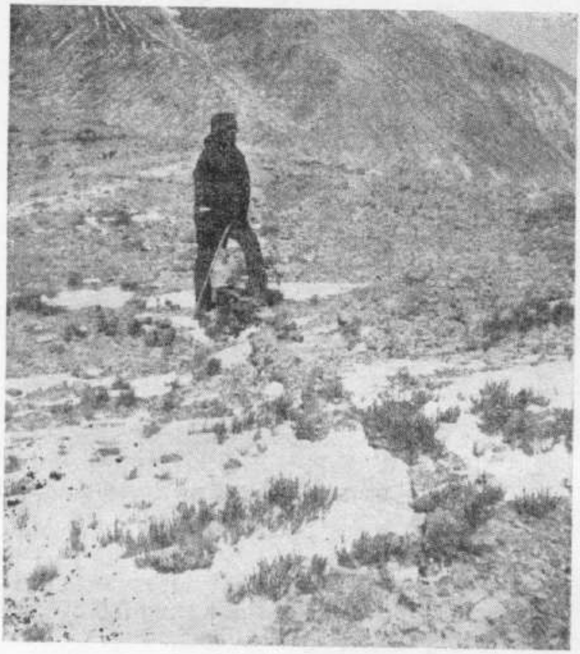


Fig. 52. Ground fissures on a ridge between Sumdoh and Kaurik.

Fissures trending *N* 350° transverse to the road, forming step faults with down throw side towards west were noted on Hindustan-Tibet road between Sumdoh and Kaurik (Fig. 53). The fractures extended towards the hill mass and had openings upto 60 cm in width (Fig. 54). The depth of the openings was noted to extend upto 4 to 5 m and the fissures probably extended deeper.

At Sumdoh fissures en echelon with each other were noted on the top of a river terrace with openings upto 5 cm in width and extending for nearly 50 m in *N* 40° to *N* 60° directions.

Fractures along pre-existing vertical joints in *N-S* direction in Carbonaceous shales on the left bank of Spiti river near Shalkar (Fig. 55) were observed. Similar vertical to steeply dipping fractures trending *N* 350° to *N* 5° were noted in lacustrine clay deposits (Fig. 56). Width of the openings along the fissures was upto 15 cm. Tabular slabs of clay were dislodged from vertical cliffs transverse to these fractures (Fig. 57). Similar fractures at a distance of 4 km from Shalkar were noted in limestones trending in *N-S* direction. Between Chango and Malling a fracture trending *N* 20° was observed in the river bed of Spiti (Fig. 58) with down throw towards east.

Fig. 53. Step faulting with down throw side towards west on Hindustan Tibet road between Sumdoh and Kaurik.

Fig. 54. Ground fissures transverse to the road with openings upto 60 cm in width between Sumdoh and Kaurik. The extension of the fissure in the hill mass covered with snow is seen in the background.

Fig. 55. Steeply dipping to vertical fractures along pre-existing joints in carbonaceous shales near Shalkar village.

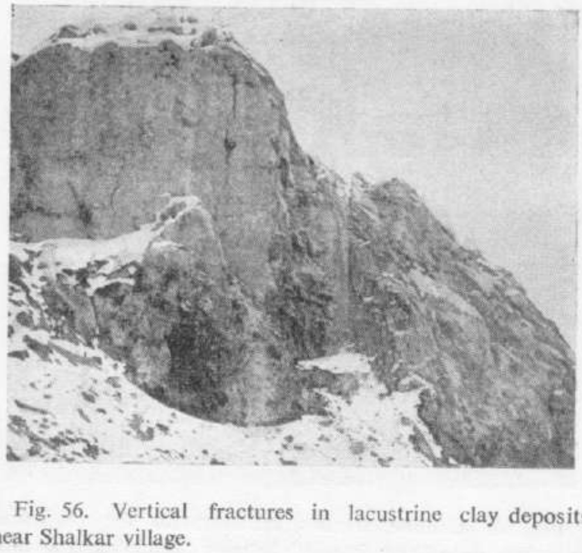


Fig. 56. Vertical fractures in lacustrine clay deposits near Shalkar village.

Fig. 57. Vertical fractures and dislodging of tabular slabs of clay (in the fore ground) near Shalkar village.

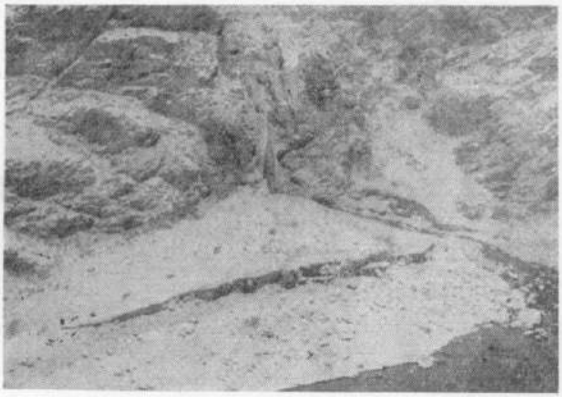


Fig. 58. Ground fissures along Spiti river trending N 20° between Chango and Malling.

Extensive fractures developed on the top of the glacial moraine ridge (Fig. 59) trending towards N 345°. A transverse natural subterranean water passage below the ridge was reported to have choked due to dislocation of the rock mass. The width of the fissures varied upto 75 cms (Fig. 60). Similar ground fractures were noted on the hill slopes above the Leo village (Fig. 61) with a trend towards *N* 10°.

Figure 62 shows the general trend of the ground fissures as described above. These trends are in general parallel and subparallel to Kaurik-Chango fault shown in Figure 2.

Fig. 59. Ground fissures along the top on a glacial moraine ridge near Leo village.

Fig. 60. Close up of a fissure with opening from 60-75 cm in width on glacial moraine ridge near Leo village.

Fig. 61. Ground fissure (covered with snow) along the hill slopes above the Leo village.

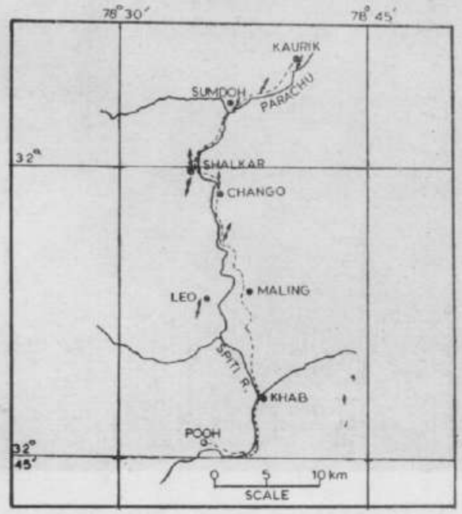


Fig. 62. General trend of ground fissures in the epicentral tract of January 19, 1975 Kinnaur Earthquake

Landslides: Landsliding in the area continued for several days along steep hill slopes. The badly affected regions were beyond Malling, wherein rock falls and landslides disrupted the traffic along the Hindustan Tibet road and at several location the road was completely obliterated.

Figure 63 shows extensive landslides along part of a four kilometer stretch of Hindustan Tibet road on the right bank of Spiti river. These hill slopes were composed

Fig. 63. Land slides in carbonaceous shales along the Hindustan Tibet road.

of thinly bedded black carbonaceous shales with close spaced jointing. No trace of the original pavement could be observed along this stretch. The steep rock slopes on the left bank of this stretch, however, did not show extensive landslide probably due to favourable attitude of the bedding and joint planes in relation to the hill slopes. Fig. 64

Fig. 64. Sliding of rock wedge in carbonaceous shale with scree at its bottom on H.T. road between Shalkar and Sumdoh.

shows a slided rock wedge with scree at its bottom at another site on the same road alignment. Fig. 65 shows rock fall debris in a steep slope composed of quartzites on the right bank of Spiti river. This fissure also shows extensive landslides and fall of scree material forming tallus fans on the left bank.

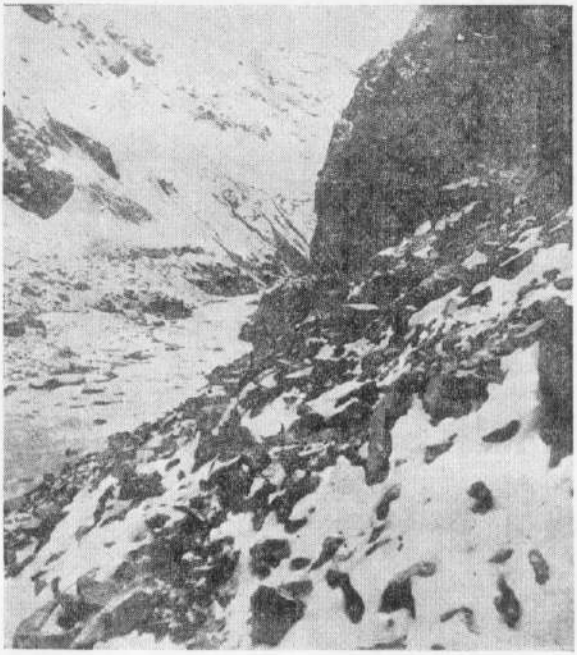


Fig. 65. Rock fall debris in a steep quartzite slopes along H.T. road between Shalkar and Sumdho.

Figure 66 shows rock slide in quartzites on a hill side between Chango and Shalkar. Telegraph poles were tilted and jumping of insulators was responsible for falling of the telegraph wires and breakdown of the communication lines. Figure 67 shows landslide mass in thinly foliated phyllitic schists which entombed three ponies and a cow moving on the road (which was completely obliterated by the slide). Fig. 69 shows debris from rock falls in interbedded quartzites and schists in hill road between Malling and Chango. Fig. 68 shows extensive rock slides along a road near Kah in granite gneisses between Pooh and Malling.

Loosening of the rock mass along pre-existing joints and fissures along steep slopes was observed in the region. Opening and widening of relief joints along cuttings transverse to the hill slopes was observed at several locations. Fig. 70 shows loosening of the rock mass and widening of openings during the earthquake along relief joints at a steep hill slope near Kah between Khab and Malling. Figure 71 shows similar opening of pre-existing discontinuity surface near Leo. The hill slope appears to be in a precarious equilibrium. Dislodging and shifting of the boulders (Fig. 72) at the crest of the hill slope was quite common in the region. These often fell on the road pavement blocking the traffic (Fig. 73). Boulders flying from the hill slopes hit the telegraph poles

Fig. 66. Rock slides in quartzites along H.T. road between Chango and Shalkar.

Fig. 67. Landslide in thinly foliated phyllitic schist on H.T. road between Chango and Shalkar.

Fig. 68. Extensive rock slide in granite gneises along H.T. road near Kah.

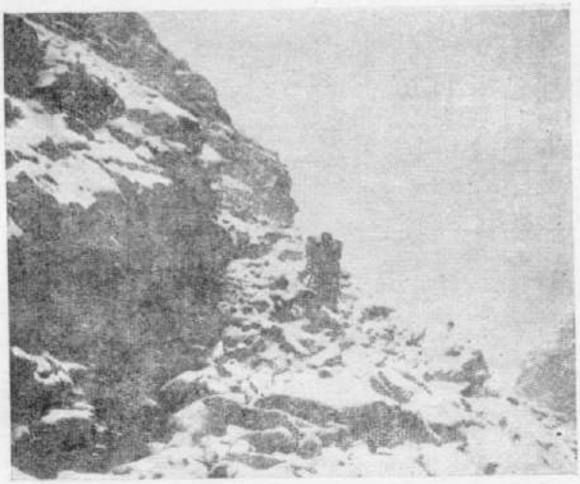


Fig. 69. Debris from a rockfall in interbedded quartzites and schists between Malling and Chango.

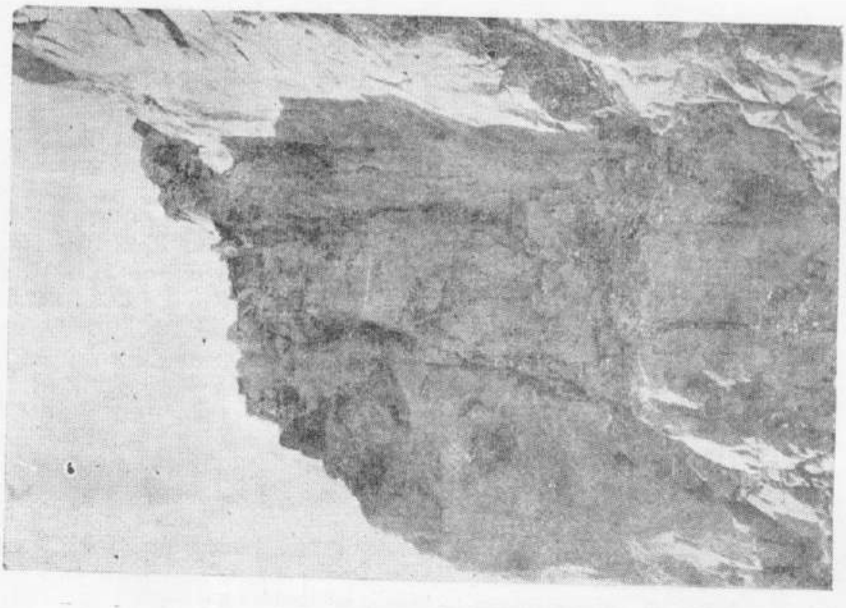


Fig. 70. Widening of pre-existing relief joints and losening of rock mass at a steep hill slope cutting near Kah.

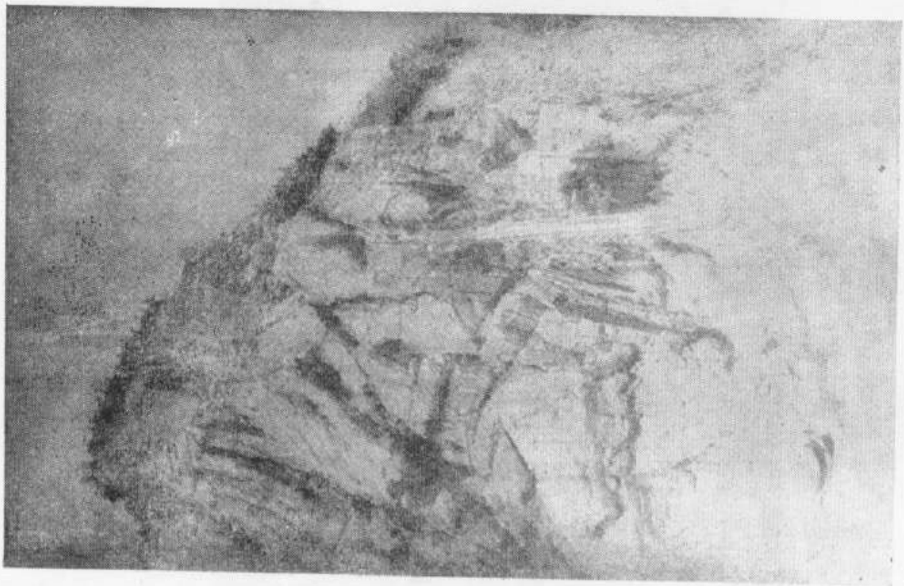


Fig. 71. Openings along pre-existing discontinuity surfaces along transverse cutting of a steep hill slope near Leo village.

Fig. 72. Huge boulder dislodged and shifted at the crest of the hill slope at Leo.

Fig. 73. Huge boulders fallen on road pavement between Malling and Chango. A huge landslide is seen in the background which has washed out the road completely.

resulting in damage to them. Fig. 74 show a telegraph pole bent due to impact of a flying boulder.

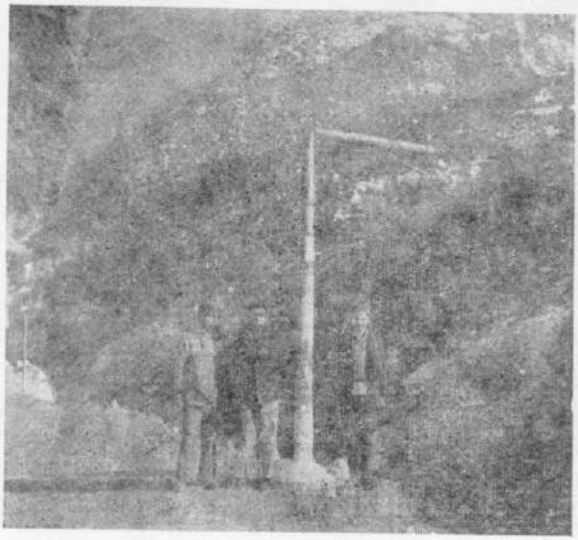


Fig. 74. Bending of telegraph pole resulting from impact of a flying boulder due to rock falls in the hill slope.

Flat topped hill slopes in glacial moraine developed extensive cracks at their crests indicating initiation of landsliding towards the valleys. Fig. 75 shows extensive

Fig. 75. Fissures developed at the top of a glacial moraine hill on the right bank of Parachu near Sumdoh.

fiussres which may lead to sliding of the level terrace in the river valley towards west. Similar fissures were observed along road pavement on glacial moraines (Fig. 76) with wide openings upto 50 cm in width.

Fig. 76. Fissures parallel to the road on glacial moraine hill side between Malling and Chango.

EFFECTS ON STREAMS AND NATURAL SPRINGS

Parachu valley was dammed by a major landslide on its right bank at a location between Sumdoh and Kaurik (Fig. 77). The debris filled the valley upto a height of about 60 m and blocked the flow of water and created a reservoir behind it. The dam so created during the earthquake in this valley is of approximately 60 m in height and 150 m in length (Fig. 77). A number of hot springs existed in this region, some of which have been buried by the landslide debris. In about six days the water impounded in the reservoir started flowing from the left bank and the overflow water made its own way as shown in Figure 77. This has resulted in the shifting of the course of Parachu by approximately 60 to 70 m from its original course towards the left bank within the flood plain of the valley. Downstream of this dam, the newly created meander joins the original course within a distance of 500 m from the dam. Ground fissures were also noted to have formed in the river bed as continuous lines of scarp with upthrows of 50 to 100 cms.

Loosening of the rocks along joints and other pre-existing discontinuity surfaces and movements along them have resulted in changing the seepage outlets in some of the surface springs in the area. Figure 79 shows the outlet of a natural spring in limestones near Shalkar village. This spring ceased to flow due to readjustment in the limestone along joints. However, this spring has emerged due to opening of joints at a lower

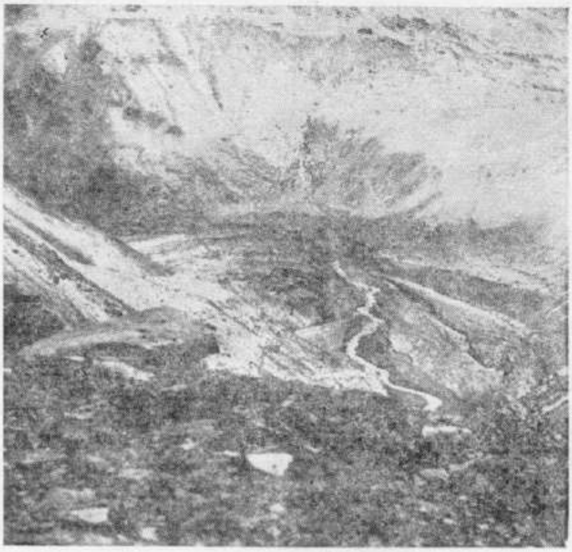


Fig. 77. Daming of Parachu river due to heavy land slide between Sumdoh and Kaurik. The new path carved out by the river along the left bank is seen in the middle. Fissures in the river bed are also seen in the right hand side.

Fig. 78. A view of Parachu gorge near Kaurik village.

Fig. 79. Stoppage of flow of water in a natural spring in limestones near Shalkar village.

elevation in the same area after the earthquake. Landslide debris was also reported to have buried many other surface springs in the region.

INTENSITY AND ISOSEISMAL MAP

The Modified Mercalli intensity scale given in Appendix B was used in preparing the isoseismal map. The earthquake was felt upto New Delhi, where residents in multistoreyed buildings on or above the fifth floor reported movement of furniture, swinging of fans and other suspended objects, and rattling of utensils in kitchen. The earthquake was felt strongly in whole of Himachal Pradesh and parts of Jammu and Kashmir, Punjab and Uttar Pradesh. A questionaire as given in Appendix C, was sent to the Post Masters of all the Post Offices in Himachal Pradesh, Jammu and Kashmir, and hill districts of Uttar Pradesh. Fig. 2 shows the isoseismal map based on the field observations of the behaviour of buildings and ground and data collected through the questionnaire.

The maximum intensity of the earthquake in epicentral tract has been estimated as Modified Mercalli (MM) Intensity IX. The fissures in the ground, with large opening upto 60 or 100 cms in width (Fig. 48, 49, 53, 54, 59 and 60), fractures and fissures in the river bed (Fig. 58 and 77) and landslides along Parachu and Spiti river valleys (Fig. 63, to 69) indicate a higher MM intensity X. But due to the prevalent damage of grade 4 and 5 to structures of A and B type (Appendix B) and absence of damage of grade 4 in the few structures of C type existing in the area a MM intensity IX appears to be more probable. Evidences of small landslids along road cuttings, cracks and fissures in the ground and along valley slopes and damage of grade 3 to B type structures was utilised to indicate MM intensity VIII in the region. The isoseismal map shows MM intensities from IX to V and slow a general N-S orientation parallel to Kaurik-Chango Fault.

In the absence of instrumental records from near seismological observatories an estimate of magnitude of the earthquake and depth of focus were made from macro seismic data using following empirical relationship (Gutenberg and Richter, 1954) between magnitude M, radius of perceptibility r, depth of focus h, and maximum observed MM intensity in the epicentral tract I_0,:

$$6 \log r/h = I_0 - 1.5$$
$$M = 3.6 \log r/h + 2.2$$

The maximum MM intensity in the region exceeded VIII and reached IX at the epicentre. The radius of perceptibility of the earthquake was about 450 km upto Delhi region. These parameters give magnitude of 6.7 and depth of focus about 25 km.

GENERAL GEOLOGICAL SET UP

Himalaya are composed of Pre-cambrian to Recent formations. The Laramide phase in Upper Cretaceous initiated the drama of diastrophism that climaxed in the emergence of Himalaya (Valdiya, 1964). The Pre-Laramide Himalayan "landmass" was probably in no way different from that of the Indian shield landmass, and stratigraphic succession in the Lesser and Main Himalaya show affinities with the Peninsular successions, to be justifiably named as Peninsular Himalaya (Auden, 1935). Marine succession from Cambrian to Cretaceous, north of Main Himalaya in the Tethyan basin appear to be similar to that developed during various geological times in the different basins in the Indian shield. The marine and terrestrial successions encountered in basins in both the landmasses developed depending upon the interconnections of the sea. Srivastava and Sinha (1974) suggest that this ancient Indian landmass extended towards north upto Baikal Rift zone and the lithospheric plate carrying this mass probably moved towards north along the transform faults extending from Owen's fracture zone to Baikal Rift zone in the west and the fracture zones following the 90°E Ridge in the Indian Ocean and Burmese Arc, and extending to Pohai Gulf of China in the east. According to them basification resulting in cymatogenic warping within this plate was probably responsible for the development of median and transverse fractures. These extend from surface to the interior, which on prolongation to great depths have also tapped the basic and ultrabasics at various geologic times, e.g. along Indus suture line. Main Central Thrust and other thrusts in Himalaya. The occurrence of earthquakes are genetically related with movements along these transverse and median fractures resulting from such a cymatogenic warping of the crust (overlying Moho) and upper mantle. Such a warping was probably initiated during the Upper Silurian times (synchorinizing with Caledonian disturbances) and attaining its climax in the Hercynian orogeny. This was responsible for development of Caledonites and Variscides in Mongolian and Tibetan regions, and effects of these are also noted in the Himalayan region. The migration of basification process towards south resulting in cymatogenic warping and uplifts in the Himalayan region during Laramide phase resulted in vertical uplifts forming Himalaya, and the process is noted to continue as evidenced by the median and transverse fracture patterns parallel and transverse to the main Himalayan trends respectively. Fracture zones transverse to the Himalayan trend, due to uplifts and block faulting have been responsible for truncating and offsetting the Kashmir Synclinorium, Tethyan Basin, Krol Basin and other basins. This has in some cases resulted into exposures of Pre-Cambrian in between them. These transverse fractures are also parallel and sub parallel to the trend of the Peninsular lineaments towards south and suggest participation of peninsular lineaments in the evolution of Himalaya.

Correlating the earthquake occurence with regional geology it appears that the tectonic blocks bounded by the transverse fractures parallel and sub-parallel to the tectonic lineaments of Peninsular shield demarcate the various seismic provinces in Himalaya. The Suleiman and Hindukush shear zone in the west and the extensions of "Delhi-Hardwar Ridge" or "Rajasthan Great Boundary Fault—Moradabad fault zone" towards east delineate the probable limits of the north-western seismic province of Himalaya. The January 19, 1975 Kinnaur Earthquake in Himachal Pradesh occurred near the eastern margin of this province. In the epicentral tract of this earthquake in Spiti river and Parachu valleys, a major fault transverse to the main Himalayan trend, with a general alignment towards N-S is noted (Gansser, 1964) along the contact of the Permo-Carboniferous (Tethyan) formations with the Late Pre-Cambrian to Lower Paleozoic Haimanta system. This fault is hereby named as Kaurik-Chango fault (Fig. 2).

Occurrences of gypsum deposited by thermal springs at the present time (Mallet 1866) are found along the Kaurik-Chango fault zone alongwith numerous hot springs in the two valleys of Parachu and Spiti river. These evidences show that the area along the Kaurik-Chango fault is active. The alignment of fissures developed in the ground (Fig. 60) due to the present earthquake, as discussed earlier, are parallel to sub parallel, to the alignment of the Kaurik-Chango fault. The damage to ground and buildings is also noted to be severe along the Parachu and Spiti valleys. These are surface manifestations of the operative seismotectonic movement along Kaurik-Chango fault. The Spiti valley, upstream of Sumdoh also appears to follow a shear zone, parallel to the Himalayan trend, along which aragonite (as reported by Mallet 1866) is deposited in the brecciated zones by thermal springs. No major damage is noted along this shear zone.

SUMMARY AND CONCLUSIONS

The Jan. 19, 1975 Kinnaur Earthquake in Himachal Pradesh caused severe damage in parts of Parachu-Spiti and Sutlej river valleys covering an area of about 800 sq. km. The earthquake was felt with violent intensity in the epicentral tract and was perceptible upto Delhi at a distance of 450 km. from the epicentre. Sixty people are reported to have lost their lives, a few hundred were severely injured and more than 2500 became homeless. Random rubble stone massonry as well as dressed stone masonry houses developed large deep cracks and parts of buildings collapsed. The mud houses suffered more serious damage. Small Chimneys were bent or fell down. Heavy flat roofs suffered greater damage. Buildings constructed in hollow concrete blocks or dressed stone masonry in cement mortar developed small cracks in walls with fall of plaster. Light structures made of corrugated iron sheets nailed on timber frames and arches did not suffer any damage. No damage was also reported in steel frame Baily bridges, suspension bridges and Reinforced Cement Concrete causeways. Stone masonry retaining walls in cement mortar suffered extensively along road cuttings and at many places were washed down with landslides.

Fissures in the ground with large openings, 60–100 cm wide, near the epicentre extending for considerable lengths were observed. Landslides and rock falls along hill slopes blocked the Hindustan Tibet Road and other important roads in the region. Telegraph poles were bent or broken. The temples (monastries) and monuments also suffered badly.

The intensity of the earthquake on MM intensity scale exceeded VIII and reached IX close to the epicentre. The magnitude and depth of focus based on macroseismic data is estimated to be 6.7 (Richter's magnitude) and 25 km respectively. Due to rugged terrain and sparse population it was difficult to have precise epicentral location from macroseismic data.

It is recommended that future construction in the region should be provided with adequate safety measures against damage during earthquake. Detailed geological mapping of the area should be carried out to delineate the various tectonic features to identify and demarcate seismotectonic lineaments. A systematic study of ground fissures, landslides and rockfalls in the region should be undertaken so that the safety and stability of the various road cuttings as well as the hillsides can be evaluated. Efforts should be made to carry out aerial survey of the area and take suitable arial photographs which can then be compared with those taken in the past. This will help in locating the earthquake affected sites as well as identify the potenital and slidel and rockfall zones which may affect surface streams and spring in future. This will also help in delineation of the probable seismotectonic features which may be genetically related with earthquake occurrence in the region.

A closer network of seismological stations should be installed in the region to have precise epicentre locations and better evaluation of depth of focii in the region, for delination and demarcation of seismotectonic lineaments and for an evaluation of seismic risks. In case of river valley and other important projects seismological instrumentation as per IS: 4967–1968 should be made mandatory.

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The Post Masters of the various post offices in Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh assisted in providing data on earthquake effects in their region through a questionnaire for preparation of isoseismal map.

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APPENDIX A

List of Important Earthquakes in Himachal Pradesh and Surrounding Regions

Sl. No.	Date	Origin Time GMT H	M	S	Epicentre Lat. °N	Long °E	Depth of Focus (Km)	Magnitude
1.	1842 March 05	—	—	—	Near Mussoorie		—	5.5
2.	1856 Apr. 07	—	—	—	Near Kotghur (Simla hills)		—	5.0
3.	1902 June 16	—	—	—	31.0	79.0	—	6.0
4.	1905 Apr. 04	—	—	—	32.25	76.25	—	8
5.	1906 Feb. 28	—	—	—	32.0	77.0	—	7
6.	1906 June 13	—	—	—	31.0	79.0	—	5.5–6
7.	1908 Dec. 11	—	—	—	31.0	79.0	—	5.0
8.	1930 May 11	11	30	36.0	31.7	77.0	—	5.6
9.	1937 Oct. 20	01	23	46.0	31.1	78.1	—	>6
10.	1940 Apr. 07	14	28	38.0	31.5	77.0	—	?
11.	1945 June 22	18	00	51.0	32.6	75.9	—	>6
12.	1947 July 10	10	19	20 0	32.6	75.9	—	6.0
13.	1948 May 05	08	31	46.0	30.5	78.5	—	>4
14.	1950 Aug. 12	03	59	06.0	32.6	75.9	—	5–6
15.	1950 Sep. 25	17	58	02.0	32.6	75.9	—	4.0
16.	1951 Sep. 20	23	19	33.0	32.6	75.9	—	4.0
17.	1955 March 10	21	16	21.0	33.0	76.5	—	>6
18.	1955 Apr. 14	01	00	46.0	32.4	76.1	—	5–6
19.	1955 June 27	10	14	09.0	32.5	78.6	—	>6
20.	1955 June 27	13	46	10.0	31.5	78.5	—	?
21.	1939 May 12	00	35	47.0	32.5	79.0	—	6.3
22.	1962 Sep. 15	12	35	08.0	31.9	76.2	—	5.5
23.	1963 Apr. 12	00	41	27.9	31.9	78.8	33	5.4
24.	1963 Apr. 12	00	41	29.0	32.0	78.79	36	>6
25.	1963 Jul. 14	14	48	28.4	30.3	78.5	—	?
26.	1967 Jan. 02	22	17	35.0	30.8	79.0	—	4.7
27.	1967 Feb. 10	05	46	27.9	33.0	75.5	27	4.9
28.	1967 Sep. 20	20	25	05.8	32.6	76.1	59	4.1
29.	1968 Nov. 05	02	02	44.2	32.4	76.4	30	4.9
30.	1968 Nov. 05	03	07	08.8	32.1	76.1	28	4.5
31.	1969 Jan. 23	20	01	19.6	32·2	76.1	—	4.0
32.	1970 Apr. 28	14	12	27.0	33.0	76.5	—	?
33.	1970 May 13	07	24	25.0	30.6	78.7	—	4.5
34.	1970 Sep. 07	21	19	12.0	33.8	75.3	—	4.6
35.	1972 Jan. 29	06	49	11.1	32 9	76.0	58	4.7
36.	1972 Sep. 06	02	51	32	32.5	78.3	44	5.3
37.	1973 Oct. 24	05	23	55	33.0	76.0	—	5.5
38.	1974 Feb. 13	20	39 (NDI)	10	31.1	77.4	—	?
39.	1974 Feb. 24	21	32 (US-NOAA)	08.8	30.9	78.1	45	4.7
40.	1974 Feb. 24	21	32 (NDI)	10	30.7	78.0	—	4.3

APPENDIX B

Modified Mercalli Earthquake Intensity Scale

Several earthquake intensity scales have been suggested during the last seventy years, the latest one in the field is the modified Mercalli scale suggested by Wood and Neumann (1931). This scale has been rewritten by various authors in more specific language defining the types of structures (buildings), classification of damage to building, and other terms so that reports could be interpreted without much ambiguity. The twelve-unit modified Mercalli scale with the explanatory classifications, main definitions, and revisions as described by Jai Krishna (1964) is given below.

DEFINITIONS

(i) Types of structures (buildings):

Structure A—buildings in field-stone, rural structures, adobe houses, clay houses

Structure B—ordinary brick buildings, buildings of the large block and prefabricated type, half-timbered structures, buildings in natural hewn stone

Structure C—reinforced concrete buildings, well-built wooden structures.

(ii) Definition of quantity:

single, few — 5 per cent

many — 50 per cent

most — 75 per cent

(iii) Classification of damage to buildings:

Grade 1—slight damage —fine cracks in plaster, fall of small pieces of plaster

Grade 2—moderate damage—small cracks in walls, fall of fairly large pieces of plaster, pan tiles slip off, cracks of chimneys, parts of chimney fall down

Grade 3—heavy damage —large and deep cracks in walls, fall of chimneys

Grade 4—destruction —gaps in walls, parts of buildings may collapse: separate parts of the building lose their cohesion, inner walls collapse

Grade 5—total damage —total collapse of building

Intensity	Classification	Description
I	Not Noticeable	The intensity of the vibration is below the limit of sensibility: the tremor is detected and recorded by seismographs only.
II	Scarcely noticeable (very slight)	Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.
III	Weak, partially observed only	The earthquake is felt indoors by a few people, outdoors only in favourable circumstances. The vibration is like that due to the passing of a light truck. Attentive observers notice a slight swinging of hanging objects, somewhat more heavily on upper floors.

Intensity	Classification	Description
IV	Largely observed	The earthquake is felt indoors by many people, outdoors by few. Here and there people awake, but no one is frightened. The vibration is like that due to the passing of a heavily loaded truck. Windows, doors and dishes rattle. Floors and walls creak. Furniture begins to shake. Hanging objects swing slightly. Liquids in open vessels are slightly disturbed. In standing motor cars the shock is noticeable.
V	Awakening	(a) The earthquake is felt indoors by all, outdoors by many. Many sleeping people awake. A few run outdoors. Animals become uneasy. Buildings tremble throughout. Hanging objects swing considerably. Pictures knock against walls or swing out of place. Occasionally pendulum clocks stop. Unstable objects may be overturned or shifted. Open doors and windows are thrust open and slam back again. Liquids spill in small amounts from well-filled open containers. The sensation of vibration is like that due to heavy objects falling inside the building.
		(b) Slight damages in buildings of type A are possible.
		(c) Sometimes change in flow of springs.
VI	Frightening	(a) Felt by most indoors and outdoors. Many people in buildings are frightened and run outdoors. A few persons lose their balance. Domestic animals run out of their stalls. In a few instances dishes and glassware may break, and books fall down. Heavy furniture may possibly move and small steeple bells may ring.
		(b) Damage of grade I is sustained in single buildings of type B and in many of type A. Damage in a few buildings of type A is of grade 2.
		(c) In a few cases cracks up to widths of 1 cm possible in wet ground; in mountains occasional land-slips; change in flow of springs and in level of well water are observed.
VII	Damage to buildings	(a) Most people are frightened and run outdoors. Many find it difficult to stand. The vibration is noticed by persons driving motor cars. Large bells ring.
		(b) In many buildings of type C damage of grade 1 is caused; in many buildings of type B damage is of grade 2. Most buildings of type A suffer damage of grade 3, a few of grade 4. In single instances landslips of roadway on steep slopes, cracks in roads; seams of pipelines damaged, cracks in stone walls.

Intensity	Classification	Description
VIII	Destruction of buildings	(a) Fright and panic, also persons driving motor cars are disturbed. Here and there branches of trees break off. Even heavy furniture moves and partly overturns. Hanging lamps are damaged in part.
		(b) Most buildings of type C suffer damage of grade 2, and a few of grade 3. Most buildings of type B suffer damage of grade 3, and most buildings of type A suffer damage of grade 4. Many buildings of type C suffer damage of grade 4. Occasional breaking of pipe seam. Memorials and monuments move and twist. Tombstones overturn. Stone walls collapse.
		(c) Small land-slips in hollows and on banked roads on steep slopes; cracks in ground up to width of several centimetres. Water in lakes becomes turbid. New reservoirs come into existence. Dry wells refill and existing wells become dry. In many cases change in flow and level of water.
IX	General damage to buildings	(a) General panic; considerable damage to furniture. Animals run to and from in confusion and cry.
		(b) Many buildings of type C suffer damage of grade 3, a few of grade 4. Many buildings of type B show damage of grade 4; a few of grade 5. Many buildings of type A suffer damage of grade 5. Monuments and columns fall. Considerable damage to reservoirs; underground pipes partly broken. In individual cases railway lines are bent and roadway damaged.
		(c) On flat land overflow of water, sand and mud is often observed. Ground cracks to widths of upto 10 cm; on slopes and river banks more than 10 cm: furthermore a large number of slight cracks in ground; falls of rock, many landslides and earth flows; large waves in water. Dry wells renew their flow and existing wells dry up.
X	General destruction of buildings	(a) Many buildings of type C suffer damage of grade 4, a few of grade 5. Many buildings of type B show damage of grade 4; most of type A have destruction of grade 5; critical damage to dams and dykes and severe damage to bridges. Railway lines are bent slightly. Underground pipes are broken or bent. Road paving and asphalt show waves.
		(b) In ground, cracks up to widths of several tens of centimetres, sometimes up to 1 metre. Parallel to water courses occur broad fissures. Loose ground slides from steep slopes. From river banks and steep coasts, considerable land-slides are possible. In coastal areas displacement of sand and mud; change of water level in wells; water from canals, lakes, rivers etc., thrown on land. New lakes occur.

Intensity	Classification	Description
XI	Destruction	(a) Severe damage even to well-built buildings, bridges, dams and railway lines; highways become useless; underground pipes destroyed.
		(b) Ground considerably distorted by broad cracks and fissures, as well as by movement in horizontal and vertical directions; numerous landslips and falls of rock. The intensity of the earthquake requires to be investigated specially.
XII	Landscape changes	(a) Practically all structures above and below ground are greatly damaged or destroyed.
		(b) The surface of the ground is radically changed. Considerable ground cracks with extensive vertical and horizontal movements are observed. Falls of rock and slumping of river banks over wide area; lakes are dammed; water falls appear, and rivers are deflected. The intensity of the earthquake required to be investigated specially.

APPENDIX—C

QUESTIONNAIRE ON EARTHQUAKE OCCURRENCE

1. An earthquake was felt/not felt, on *19-1-75 (Sunday)*
2. Date of shock *19-1-75* Time *1-30 (App.)/P.M.*
3. Place *NICHAR*
4. Motion was Rapid, slow* *Rapid*
5. Estimate of duration of shock *Ist Nearly 12 or 13 seconds but the Earthquake continued upto 2 P.M. and four other shocks were also felt during this time.*
6. Felt by several, many, all, by observer *By all*
7. In your home, in community, or *Everywhere*
8. In building, wood, brick, *Buildings*, strongly, weakly built., on ground, first, second, ... , floor, lying down, sitting, active
9. Outdoors, by observer, by others, quiet, active *By all*
10. Direction of motion felt outdoors, N, NE E etc. *NS*
11. Ground underneath locality: Rock, soil, Loose, compact, marshy, filled in, *Compact* level, sloping steep *Sloping*
12. Frightened no one, few, many, all (in your home) (in community) *All*
13. Rattling of windows, doors, dishes,
14. Creaking of walls, frame, *Walls*
15. Hanging objects, doors, etc. did, did not, swing, N, NE etc.
16. Pendulum clock did, did not, stop: clocks faced N, NE, etc. *No Pendulum clock was available*
17. Trees, Bushes, shaken slightly, moderately, *strongly*,
18. (a) Did you notice sliding of articles in your premises—Yes/No *No*
    (b) If yes, name the article slided—Table, Chair, bookcase, books on table, utensils bed, etc.
19. (a) Did you notice overturning of any article—Yes/No *No*
    (b) If yes name the article overturned:—
    Chair, flower vase, pedestal lamp, decoration piece, stool, ...
20. (a) Did you notice fall of any article—Yes/No *No*
    (b) If yes, name of the article, books, pictures, dolls, flowerwaves, glasses etc.
21. Did you notice *cracking of placter*, windows, walls, chimneys, ground, ...
22. Damage, none, Slight, considerable, great, total, in wood, brick, masonry, concrete,
    Any other Remarks *Shock were felt upto 2 P.M. and at every earthquake the Rocks from a mountains in our front on the other side of river satling continued to fall, five animals were killed.*

The completed questionnaire, may please be replied even if the earthquake was not felt at all.

*Please underline the words which best describe the shack.

AT YOUR LOCALITY as given above.

Signature *Sd/-O.P. Chauhan*
Name *O.P. Chauhan*
Address *S.P.M. Nichar (H.P.)*
Distt. Kinnaur