KAPKOTE EARTHQUAKE OF DEC. 28, 1958

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At 11.16 A.M., on December 28, 1958, the town of Kapkote and neighbouring places situated on the sides of the valley of the river Sarju, about 70 miles north-east of Almora (See Fig. 1) was subjected to an earthquake of moderate intensity (Richter magnitude approximately 6.25). Though the Almora district is situated in the epicentral tract in the Himalayas, this quake was first one to have the epicentre so close to the town of Kapkote. There had been numerous instances of landslides (Photo 1) in the area indicating the disturbance of the earth structure. Subsequent to this shock there had been several aftershocks in the year 1959.

The newspapers reported the damage caused due to the earthquake. The damage was mostly local as the magnitude of the shock was only 6.25, and its focus was located at a depth of about 20 to 25 miles. Even so, as far away as 150 miles, structural cracks at Junctions widened in certain buildings. At Roorkee, about 200 miles from the epicentre, people ran out of the buildings, vibration of three storeyed buildings could be seen, lamp holders oscillated and the pendulum clocks stopped clicking. A few mud houses collapsed as their walls were wet due to rain that fell the previous day (Photo 2).

GEOLOGY OF THE REGION

Like any other regions of the Himalayan zone, the area is extremely complicated by crushing, crumpling and local faults in different directions, as a result of which the rocks between the plains of India and the tableland of Tibet are highly folded and thrusted. The different rock formations are tectonic units between the Siwaliks and the Himalayan ranges can be summed up as below: -

Region	Major Tectonic Units
Tibet	Conglomerates and Gravels of Pleistocene, Kailash Conglomerates and Sandstones of Tertiary, Granite Gneiss, Exotic Region Flysch, Semi Metamorphic Schists Folded Mesozoic of Chilam Kurkur Young basic igneous rocks Crystalline pitching anticline of Gurla

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[illegible] (Central) Himalayas	{ Northern Thrust Sheet Ralam-Garbyang Series
Inner Himalayas	{ Martoli Series Central Crystalline zone including the metallic quartizites. Quartzite Series.
Outer Himalayas	{ Calcareous Series Main basic intrusives
Siwaliks	{ Siwalik, Formation of Sandstones and shales.

ROCK FORMATIONS OF THE REGION

The rocks of the area (Bagheshwar-Kapkote-Loharkhet) include a thick (several hundred meters) series of limestones, dolemiters, intercalated with or underlain by calcareous shales, dark slates and chocolate brown shales of the Calczone of Tejam' and grouped under the common name Central Crystalline Zone of the Inner Himalayas.

All over, the calcareous series is overlain by a thick massive quartzite-best developed at Loharkhet.

The limestones and dolomites, exposed at Kapkote are several hundred meters in thickness and are partly non-metamorphic.

The calcareous rock series is finely banded and shows a repetition of thin limestone and dolomitic layers or little or no metamorphism. The strike is E-W- or NW-SE. Close to Kapkote, along the road and up the river Sarju, the dip of the limestone varies from 20° - 30° to south or in S 30° W direction, but at some localised patches up to Rithabagar steep, dips to 80° or more and also some in opposite direction are met which indicates that the competent limestone are also deformed by the tectonic movements. Though uncommon, but at some freshly cut faces in the limestone the thin bands are intensely folded and sometimes drag faulted with development of slickensides and intersected by fine talcose layers.

The intercalated argillaceous shales or slates are also finely colour banded and are comparatively much thinner. These, sometimes, weather as splintary shales and are striated in S 30° W. and occasionally the individual bands are folded and twisted in all directions and a single fine band may be pinched or swelled.

North of Rithabagar and up to Loharkhet the limestone and the shales dip to the north or NNE and the dip varies from 45° - 65°. On the north the series is overlain by a massive quartzite more than a thousand meters in thickness and is underlain by a green chlorite schist, derived from a basic sill. The Quartzite, except for its lower horizon is pure and well bedded and dips 35° to 40° in NE or NNE direction. Towards the base the

rock is greenish and is rich in sericite arranged parallel to the bedding planes. The chlorite schist and the green quartzites are also lineated in S 35° W.

Immediately below Loharkhet the quartzites, make a sharp by the weathering and loosening of joint blocks mainly due to steep SW facing "cross and strike" joints.

At no place the quartzites were sheared or shattered as the limestone group but slickensides and smooth surfaces were observed along the bedding planes and the surface of the vertical cross joints.

Folds: - As would appear from the foregoing paragraphs the rocks of this calc zone of Tejam between Bageshwar and Loharkhet are thrown into an anticline, the axis of which appears to run EW and along the river Sarju for more than 3 miles. The dip of the southern limb, though variable, but is regular while the northern arm is more deformed into minor anticlines and synclines. The limbs of these are faulted, slipped, drag folded and sometimes are thrusted with minor thrusts. The village Kapkote is situated on such a synclinal depression (see fig. 2).

Faults: - A little north of Kapkote two valleys join, one NS of river Sarju and another in almost EW direction. Both these valleys are filled with river gravel and alluvium. On the eastern side of the river Sarju, the limestone is overlain by then gravel terrace and make the high cliffs up to 100 ft. in height while the limestone on the western side is either lower in level or the gravel occurs at the level of the river water. Though definite evidence of a fault except for minor slickensides are lacking yet the low terraced agricultural land may be at the crossing of two faults or thrusts almost at right angles-one through which the river Sarju is flowing and the other making the EW valley with minor streams flowing into the river Sarju. By about 3 furlongs towards Loharkhet along the road, the newly cut limestone escarpment is seen to be highly jointed (Photo 3) fractured, broken and a granulated mass with steep inclinations of about 80 to 100 yds. in width and lying in an EW direction. Further up to Rithabagar such meshed belts (in EW direction) are seen to have affected the calc. rocks at several more localities and at short intervals. On an examination of the massive and cleared rock the slickinsides and the smooth surfaces were actually found on two sides of the fragmented rock almost right angles to each other. From the nature of the silckensides and the drag faults present in the jointed rock, it was confirmed at all places that these are developed due to tectonic disturbances in two directions; one NS due to some EW thrusts (Himalayan movements) being better developed than the other due to vertical movements (Photo 4).

On the south facing cliffs below Loharkhet, the massive quartzites also seem to be fractured and affected by such EW thrusts when the jointed rock is crumpled in thin belts. In this connection it may be added that Heim and Ganssar[1] also marked and noted such EW thrusts.

From the nature and trend of these granulated and crumpled thin belts in the limestones and quartzites along with the silckensides and the smooth surfaces, it can be inferred that these have originated due to thrusting along the limbs of the Bageshwar-Loharkhet anticline due to movements and

Earthquakes originating in deeper zones and these thrusts may be still active.

It is, therefore, not surprising that the earthquake of Dec. 28, 1958 had its epicentre in this region. The activity evinced by the formations points out to the possibility of occurence of earthquakes in future. According to the India Met. Deptt., the epicentre, the time of origin etc. for the main shock are:-

Date	28th. Dec. 1958.
Epicentre	Lat. 30° 00 ' N. Long. 79°58 'E.
Origin time	05h: 34. min. 42. sec. GMT.
Magnitude	6 + 1/4: 34 min. 42 sec. GMT.
Depty of forces	30-35 kms - (7)

Shock Nos.	Date	Time	Nature of shock and effects
Main shock	28.12.58	11.16 A.M. 3.00 P.M.	Min shock felt by all; accompanied with rumbling noise and oscillations of ground in NS and NE-SW. Ground ruptures at Kapkote Loharkhet etc. Sinking of ground floors at Loharkhet. Severe damage to buildings in the region.
Many shocks a day	Between 28th. Dec. and 2nd. Jan. 1959	Several times a day and at short intervals.	Gentle shocks with rumbling noise throughout the region.
2 (Two)	4th Jan. 1959	3.30 A.M. 4.30 P.M.	Shocks felt by all in the Kapkote region.
1 (One)	5th Jan. 1959	-	" " " "
2 (Two)	11th Jan. 1959	12.30 P.M. 4.30 P.M.	" " " "
1 (One)	13th Jan. 1959	9.30 A.M.	" " " "
1 (One)	1st Feb. 1959	0.30 A.M.	" " " "
One	2nd Feb. 1959	6.30 P.M.	Felt by all in the Kapkote region.

Shock nos.	Date	Time	Nature of shock and effects
One	3rd Feb. 1959	9.00 A.M.	Felt by all in the Kapkote region.
One	5th, 9th and 10th Feb. 1959	1.00 P.M.	Few gentle shocks felt by some.
One	20th Feb. 1959	3.00 P.M.	Shock felt by many and with rumbling noise.
One	20th Feb. to 14th May 1959	-	Several shocks reported.
One	15th May 1959	7.30 A.M.	Felt by some with rumbling noise.
One	16th May 1959	5.30 P.M.	" " " "
Two	22nd May 1959	6.30 A.M. 7.30 A.M.	Felt by many.

Earthquake Effects: -

The earthquake caused ground ruptures with gaping cracks and few landslides etc. in an area more than 100 sq. miles around Kapkote, and cracking of buildings had taken place at several localities including Hatsila, Pharsali, Bhainsoyi, Sulmati etc. and at few places north of Loharkhet (See map attached). It seems to be obvious that the cracks and ruptures due to ground motion were more prominent at places where ground is loose and infirm such as the alluvial and gravel terraces, river detritus or the scree etc. Elsewhere the cracking did not occur.

In this connection it may be worth mentioning that the whole of the region between Bagheshwar and Pindari Glacier suffers from ground slumping and sinking of land and villages during and after the rains. It has been observed these disturbances are most common in the schistose rocks though the phenomena is not lacking in limestones and the quartzits which are also effected e.g. north of Loharkhet. On the night of 11th. August, 1957, during rains, a part of the village Loharkhet called Sunding situated at the junction of schists and quartzites got sunk by about 25 ft. and the right abutment of the suspension bridge at Kapkote slipped and titled to the South (Photo 5). It is also reported that during the 1958 earthquake the abutments of this bridge were further dislocated and cracked. The question now arises as to whether all these slips, slides and sinking of the region are due to slipping along the bedding joints of schistose planes lubricated by the rain water or these are due to tectonic movements or due to both? To the authors it appears that these occurrences are due to both as the rain water lubricates the already existing tectonic surfaces. In view of this, therefore, the aftershocks of the earthquake of Dec. 28 were mere adjustments along the tectonic planes during the dry months of

the year.

STRUCTURAL DAMAGE

Kapkote is a small residential town consisting of a hospital, school and houses catering to the needs of a small community. There are no special structures in the area and the buildings are not designed to resist lateral forces.

Most of the buildings are made of stone masonry, a few of them being two storeyed and built in timber. Concrete or steel construction is totally absent in the area.

The foundations are usually built of stone masonry in lime mortar 1:2 or cement mortar 1:6. Sometimes mud mortar is also used in foundation masonry. Generally the superstructure is in mud mortar all through, the door jambs etc. being in lime or cement mortar. The lintels are made of timber. The roofs are sloping consisting of timber trusses, plankings, purlins and G.I. sheets or slates.

The bridges are of single span as the stream is fast flowing, the valley deep and the foundation unstable. The reasons of the strata being unstable is already explained in earlier paragraphs.

The earthquake of Dec. 28, 1958 caused extensive damage, as could be expected, to the stone masonry buildings made in mud mortar. Comparatively the timber buildings were unaffected and the bridges also escaped damage.

As regards buildings following points were observed: -

(i) In areas like Loharkhet and Hatsila, the shock aggrevated the unstable conditions of the hill side caused by scouring action of the stream and even better constructed buildings were damaged. The subsidence combined with earthquake forces caused the buildings to be split vertically (Photo 6, 7 & 8).

(ii) In Kapkote, where the foundation is stable, the damage is only due to the earthquake. Buildings which were constructed on systematic courses of masonry in lime or cement mortar developed minor cracks (Photo 9). Walls constructed of irregular courses and in mud mortar collapsed completely (Photo 10). The mud mortar filling round the jambs of wooden lintels offered no resistance to twisting of lintels caused by waves travelling at an angle to the axis of the lintel and they twisted by 3° to 4° (Photo 11). There were diagonal cracks in the walls above lintels and combined with the action of twisting of the lintels, at places the whole filling above fell off (Photo-12).

Normally one would expect that a properly constructed random stone construction with joints well-filled with mortar should stand a lateral force and torsion better than a regularly coursed construction, because of the interlocking that the random construction offers. At Kapkote the random construction was very poor and this offered even less resistance than the regularly built construction.

As Kapkote is located in the interior of a hilly region and is not likely to gain importance at least in the near future, steel or R.C. construction may be too expensive to adopt due to cost of transporting raw materials being high. Further skilled labour is not available locally. Hence for earthquake resistant design best use has to be made of local materials and local labour. Timber construction may be popularised. The stone masonry may be laid in lime or cement mortar. Bands of masonry at small intervals of height may be built in cement mortar along with door and window jambs as well as corners and junctions. These will act as frames and will offer better resistance to earthquakes without adding appreciably to the cost.

REFERENCE

1. Central Himalyas, A. Heim and H. Ganssor, Mem. Helr. Geol. Soe. 1936.

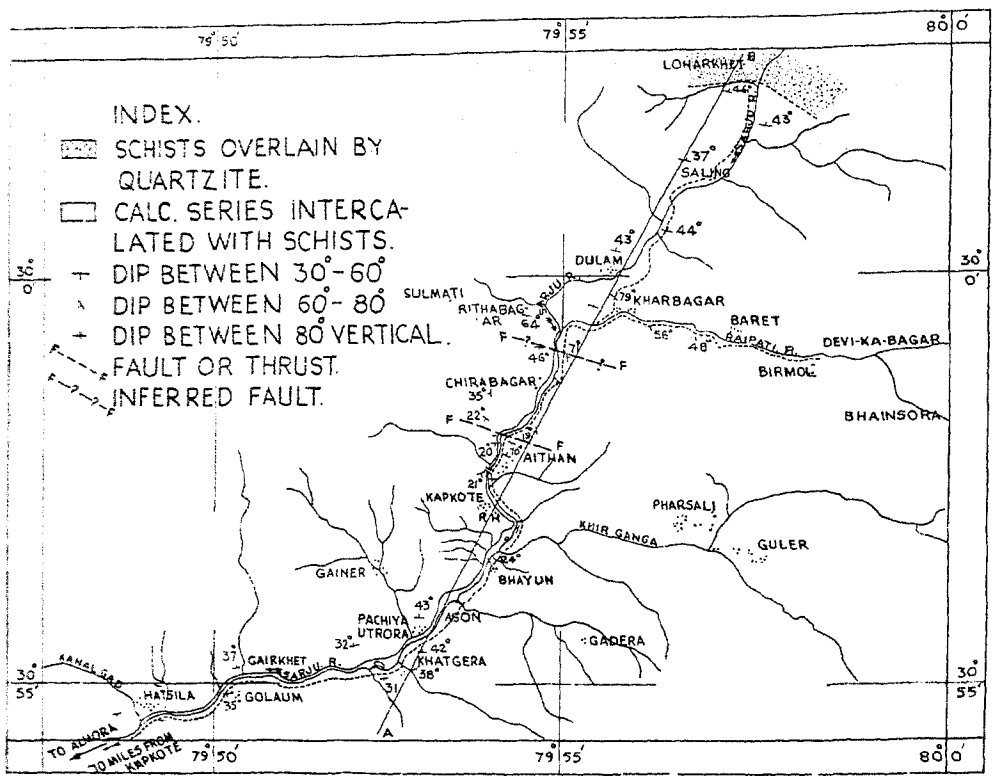

Fig. 1 Giological Map along Sarju Valley in Danpur Kapkote Region, Almora District

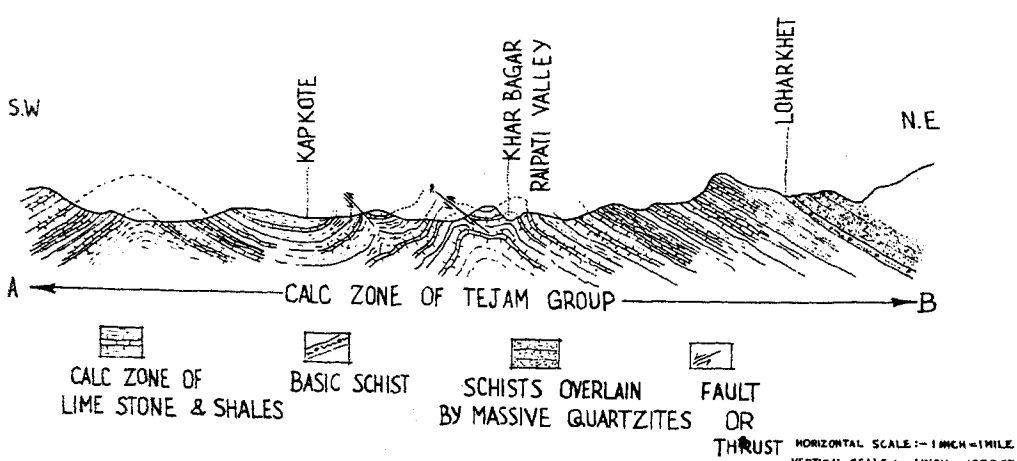

Fig. 2 Structure along R. Sarju (Kapkote-Loharkhet) Section Line A-B on the Map

Photo. 2 Mud House Collapse

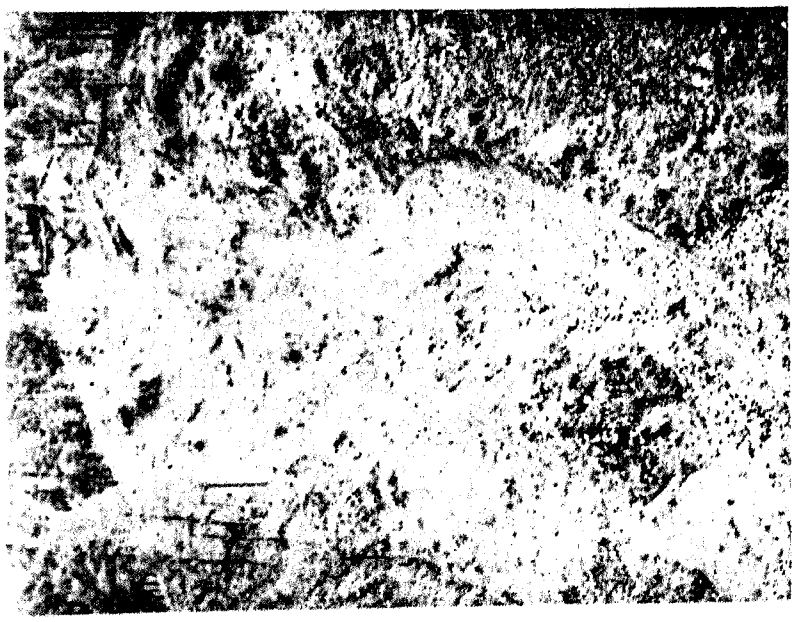

Photo. 1 Landslide

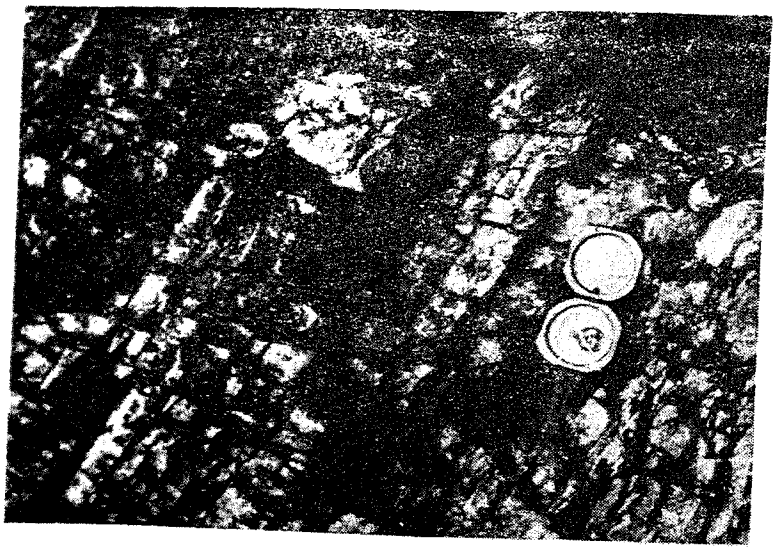

Photo. 3 Highly Jointed Rock

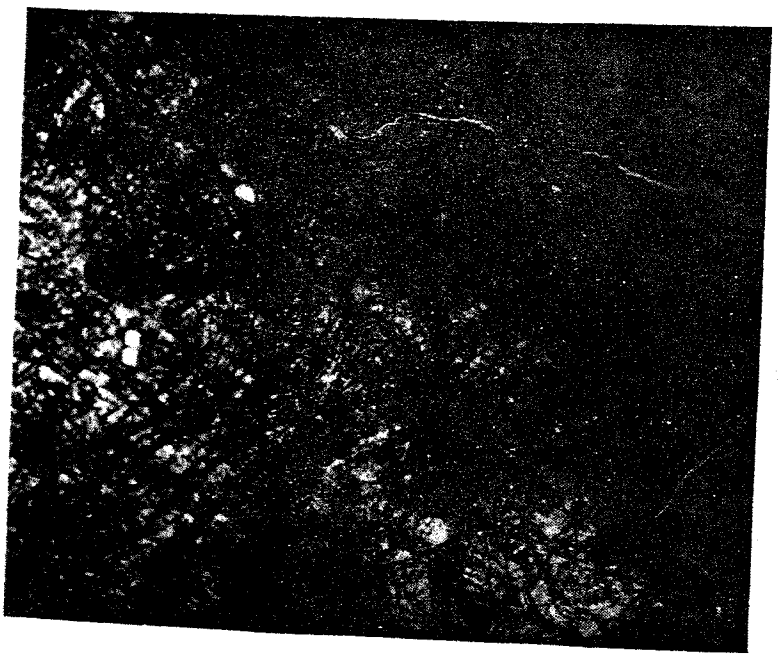

Photo. 4 Fault

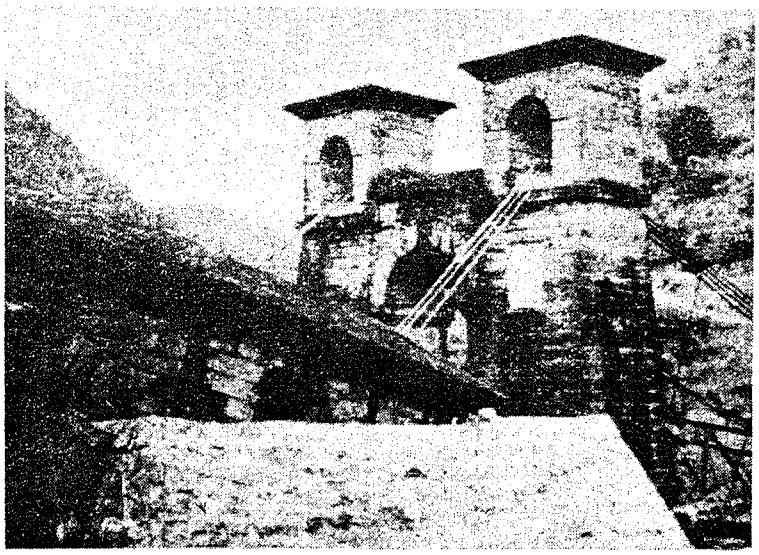

Photo. 5 Damaged Bridge

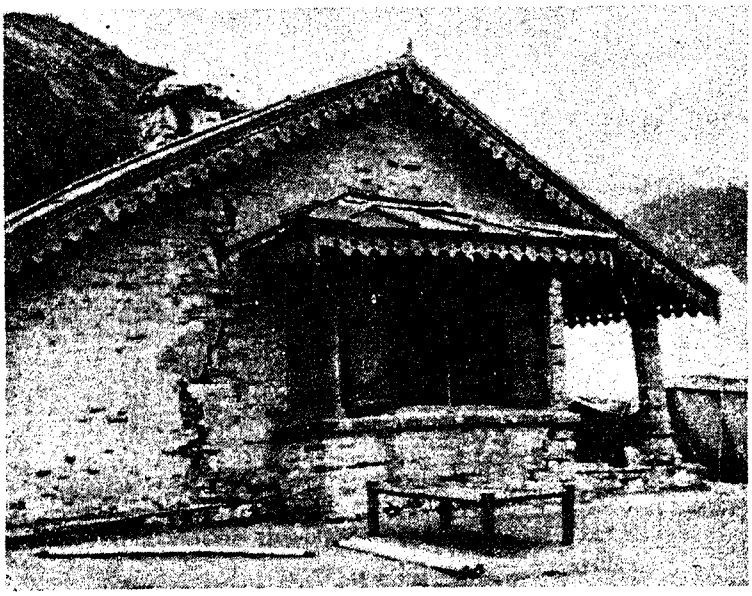

Photo. 6 Damage due to Sinking

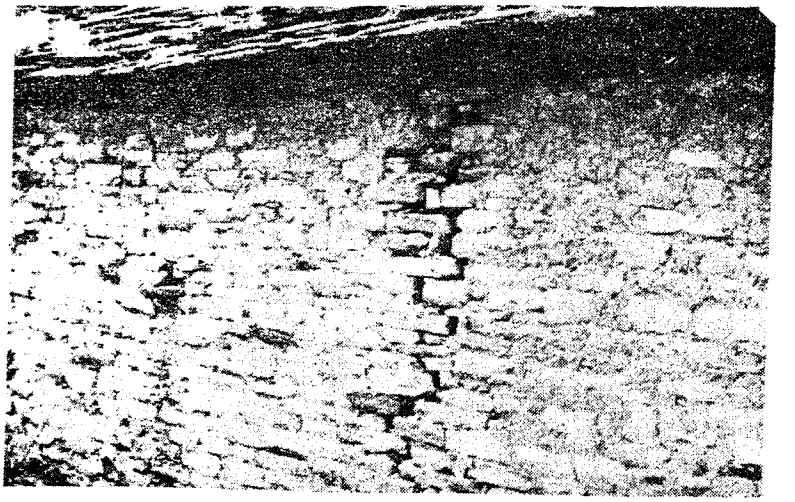

Photo. 7 Damage due to Sinking

Photo. 8 Damage due to Sinking

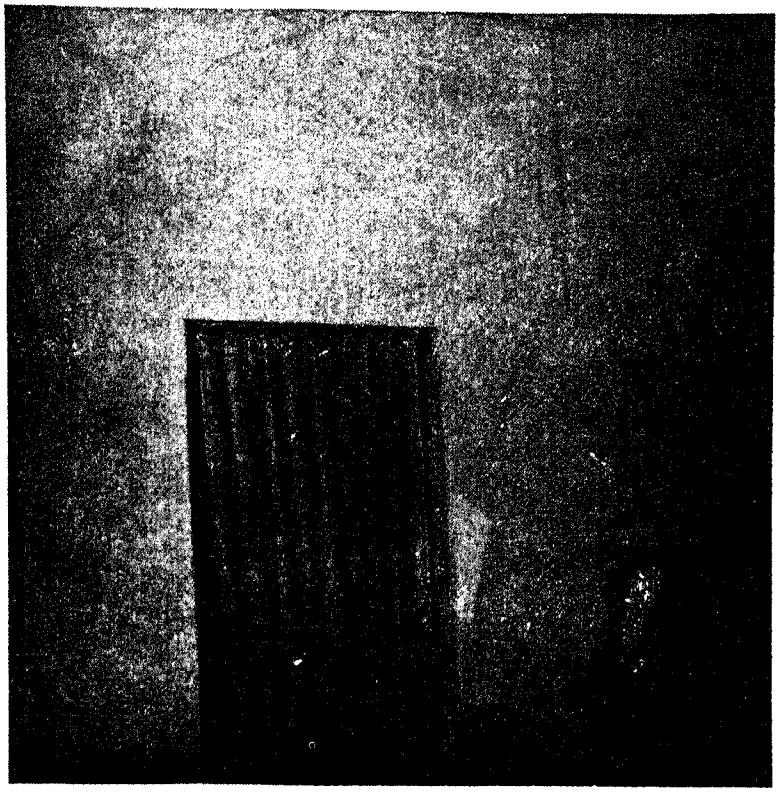

Photo. 9 Wall Constructed Building
Little Damage

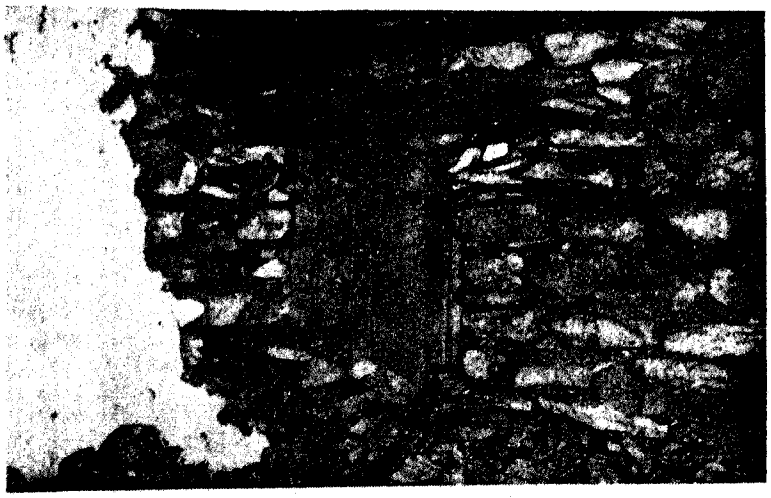

Photo. 10 Poorly Constructed Building

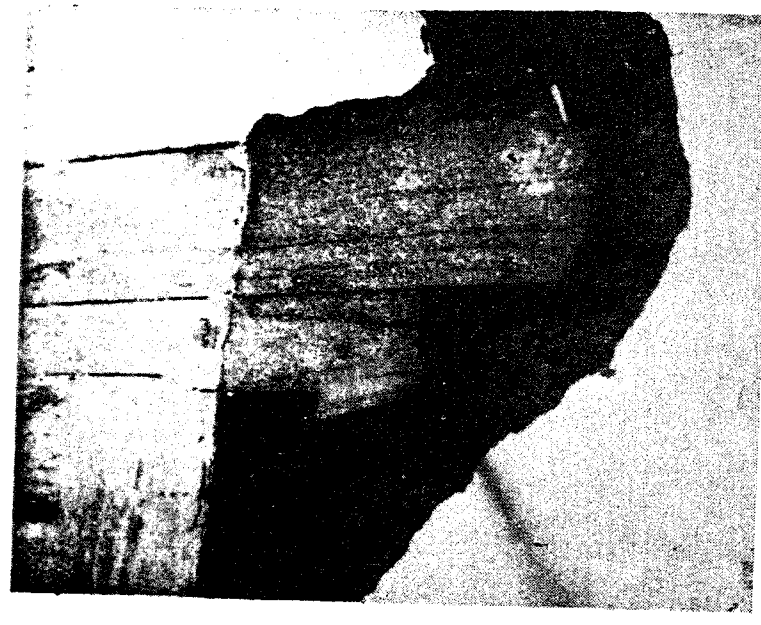

Photo. 11 Twisting of Lintel

Photo. 12 Damage to Lintel