STRENGTHENING OF HIMALAYAN BUDDHIST MONASTRIES - A CASE STUDY

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SUMMARY

Tabo is a small and remote village in the Spiti Valley in the Himalayan region of India. It is situated at a distance of about 341 km to the North-East of Simla and is at an altitude of about 3200 m. The climate is cold and dry, there being lot of snow fall but very little rain. The area looks like a cold desert with lot of soil erosion and little vegetation. The place is famous for its complex of Buddhist Monastries, otherwise known as 'GOMPHA'. This Gompha contains exquisite paintings of the period ranging between 11th to 15th century. They also contain sculptures attached to the walls and in one particular temple, there is a fairly big statue of Lord Buddha in sitting position. This Gompha is considered to be 'Himalayan Ajanta' and the Department of Archaeological Survey of India is engaged in preservation of the paintings and sculptures contained therein. Due to the 1975 Kinnaur earthquake, some cracks were caused in the painted wall surface and in the stucco figures. Consequently, on an sponsorship by the Department of Archoeological Survey of India, the author visited the Gompha on June 6, 1977. This paper describes the seismic status of the site, the state of the Gompha and recommendations for strengthening of temples from the earthquake view point.

SEISMICITY OF THE AREA

The Kinnaur and Lahul-Spiti area forms a part of the global Alpine-Himalayan seismic belt. As such, earthquake occurrence is quite a common phenomenon. Tabo town lies in zone IV of the Seismic Zoning Map of India, (1).

Table 1 shows the damaging earthquakes that have occurred in the vicinity of Tabo. These have been recorded by the seismological observatories in the country and the world wide network of seismological observatories.

More recently, this area was rocked by a severe earthquake in the early afternoon hours of January 19, 1975. The main shock has been assigned a magnitude of 6.7 on Richter's Scale. Fig. 1 shows the isoseismals of this earthquake on the Modified Mercalli scale. It is seen that a Modified Mercalli Intensity VIII occurred at Tabo during this earthquake (2). It is indeed remarkable that the Gompha constructed in Adobe several centuries ago have admirably survived this and the previous earthquakes. For structural design purposes, M.M. Intensity VIII and seismic zone IV as referred above are considered appropriate for Tabo area.

GENERAL DESCRIPTION OF GOMPHA COMPLEX

The Gompha Complex consists of eight distinct temples enclosed within a boundry wall. All the temples are roughly east facing. A general plan of the complex is shown in Fig. 2. The walls are made of pressed clay laid in horizontal layers. The pressed clay blocks are roughly 13" x 13" (33 cm x 33 cm) and the wall thickness varies from 36" (91 cm) to 40" (110 cm).

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The roof consists of wooden ceiling covered with compacted clay which has hardened with passage of time. The ceiling is supported by means of wooden columns, beams and joists. The inner surfaces of the walls and the ceilings are covered with paintings. Most of the sculptures are placed on wooden brackets projecting from the walls. Besides the bottom supports, wooden stays fixed into the wall pierce into the back of the figures. All brackets are also covered with clay and painted.

CONSTRUCTION TECHNIQUE AND DAMAGE

A few important aspects of the construction technique used in the Gomphas are as follows :

1. The walls are made tapering in thickness. The thickness at the base is 1 to 1.2 m and reduces towards the top. The taper along height is of the order of 1 in 8.

2. At the corners after every few layers of pressed clay, wooden planks are seen to be inserted in both the walls meeting at the corner.

3. Below the lintels and beams, wooden planks or rounds are seen to be inserted which extend over the thickness of the wall. These members help in distributing the lintel load over clay blocks.

4. The ceiling is supported by means of wooden beams and columns. At some places the beams are placed on brackets extending from the wall. In between, the beams are simply supported over wooden columns. These columns appear to be just resting on the stone blocks below. Over this frame work of beams and cross beams in the ceiling, wooden planks are placed. These planks are covered with a mixture of clay and straw about 12" (25 cm) thick to provide water proofing and thermal insulation.

The cracks could be noticed at various points in the walls. At some places, the inner surface appears eroded causing damage to the paintings. In recent earthquake of 19th January, 1975 one statue got detached from the wall and fell down. The ceiling has sagged at some places but this is due to age and moisture penetration from the roof rather than due to earthquake. In temple no. 6 (Fig. 2), the middle portion of the south wall looks depressed by as much as about 6" (15 cm) causing cracks in the wall and consequently damage to the paintings. Since the rainfall in the area is meagred, the moisture in the wall must have penetrated from melting of snow on the roof some time during the long past.

RECOMMENDATIONS

1. Water Proofing

The most important task for pereserving these old adobe temples appeared to be to prevent the moisture from the roof getting into the ceiling and the walls. For achieving this (a) snow should not be allowed to accumulate on the roof and melt there but it should be removed as soon as possible without melting, (b) water proofing of the roof may be carried out by using suitable materials.

2. Strengthening Against Earthquakes

Since the walls are of adobe, the modern concepts of strengthening like introduction of vertical and horizontal steel bars in the walls and covered by cement concrete in the form of vertical posts or horizontal bands are not appropriate. They are not desirable either since their introduction will change the character of the construction. Therefore for adding to the stability of the temple buildings during future shocks the addition of buttresses is suggested which will go well with the original construction. The greatest danger of collapse of adobe buildings arises if the walls get separated at the corners during the earthquake motion, since then they tend to move to and fro and overturn. For bonding the walls together at right angles, shear keys in the form of timber runners are suggested. The timber should be of the same variety as used originally for the temples which is available locally. Due to cold dry climate there is no danger of its rotting with time.

a) Buttresses : The buttresses are to be added at all the intersections of walls, that is at the corners as well as intermediate junctions as shown in Fig. 3. The existing wall should be notched to make toothed shape to receive the new blocks as well as notched to receive the wooden keys.

b) Wooden Keys : The shear keys are to be prepared in the form of planks of wood as shown in figure (3). The planks are about 350 cm long, 10 cm wide and 5 cm thick having indentations on both the surfaces. The indentations are 10 cm long and 1 cm deep.

The existing walls are to be notched to a depth of 20 cm from the surface and the timber planks are to be placed in this notch. These bonding timbers are to be inserted every course of about 33 cm alternately in the two walls so that the vertical spacing in each wall will be about 66 cm. After placing the planks in the notch it should be throughly caulked with the same clay mud as used for making blocks.

ACKNOWLEDGEMENTS

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REFERENCES

1. IS:1893-1975, 'Criteria for Earthquake Resistant Design of Structures' Indian Standards Institution, New Delhi.

2. S. Singh et al., (1977), 'Damage During Kinnaur Earthquake of January 19, 1975 in Himachal Pradesh, India', Proceedings, Sixth World Conference on Earthquake Engineering, New Delhi, Jan. 10-14.

TABLE - 1

DAMAGING EARTHQUAKES IN THE VICINITY OF TABO

Year of Occurrence	Location of Epicentre Latitude	Longitude	Richter's Magnitude	Distance from Tabo in km	Approximate Value of M.M. Intensity that may have occurred at Tabo
1902	31.0	79.0	6.0	162	VIII
1906	32.0	77.0	7.0	161	IX
1906	31.0	79.0	5.7	162	VII
1908	31.0	79.0	5.0	171	VI
1930	31.7	77.0	5.6	138	VII
1937	31.1	78.1	6.0	138	VIII
1939	32.5	79.0	6.3	85	VIII
1955	32.5	78.6	6.5	54	VIII
1963	31.9	78.8	5.4	55	VII
1963	32.0	78.8	6.5	45	VIII
1972	32.5	78.3	5.3	54	VII
1975	32.4	78.6	5.3	41	VII
1975	32.5	78.6	6.2	51	VIII
1975	32.1	78.6	5.0	19	VI
1975	32.5	78.7	5.0	63	VI
1975	32.6	78.5	5.1	66	VI
1975	32.1	78.6	5.2	19	VI
1975	32.4	78.2	5.3	47	VII
1975	32.7	78.4	5.1	80	VI
1975	32.0	79.0	5.2	70	VI
1975	32.6	77.3	5.5	141	VII
1975	32.2	78.7	6.7	26	

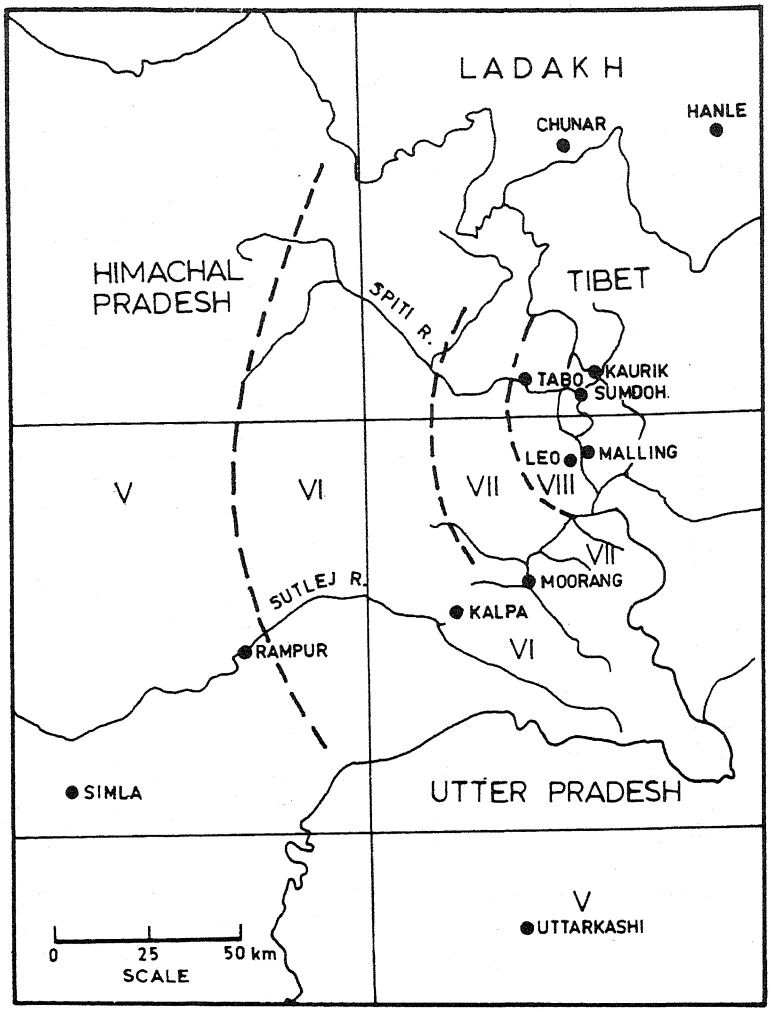
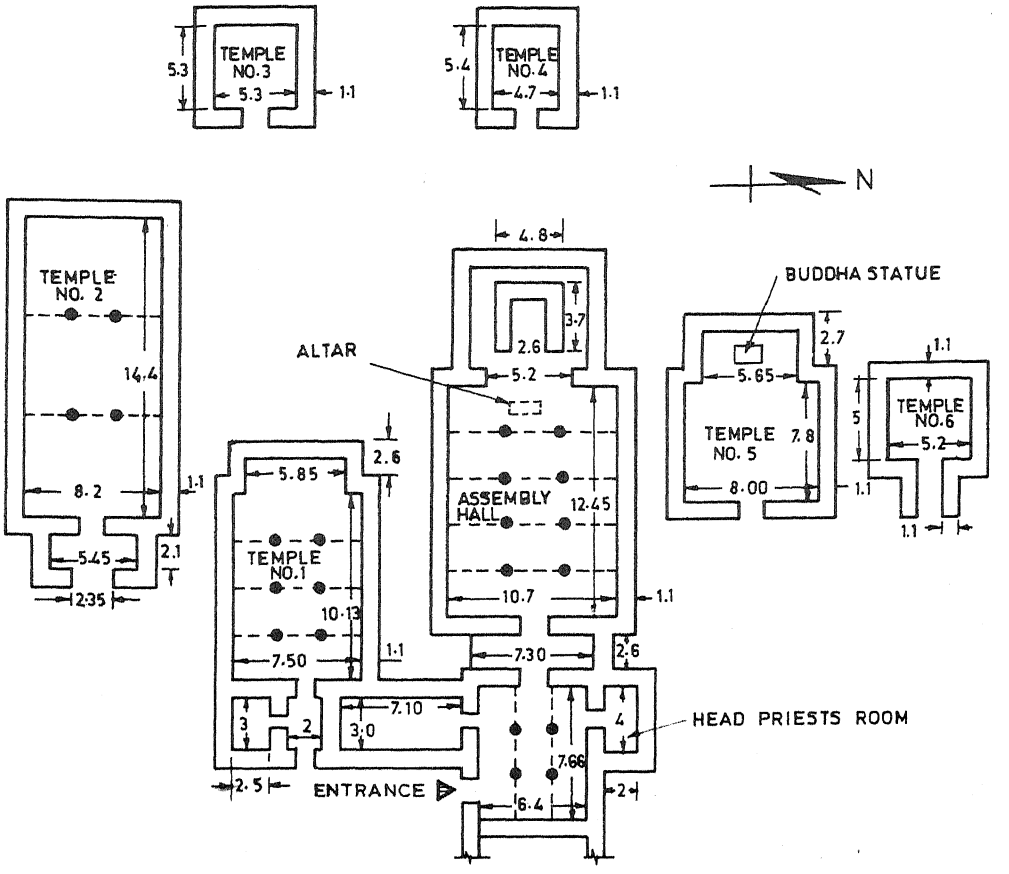


Fig.1 _ Isoseismals of January 19, 1975 earthquake on M.M. Intensity scale



NOTES

1_ THE DIMENSIONS ARE IN METERS

2_ THE DISTANCE BETWEEN BUILDINGS ARE APPROXIMATE AND ARE NOT TO THE SCALE

3_ THE LOCATION OF BEAMS AND WOODEN POSTS IS SHOWN AS ---●---●---

Fig. 2_ General lay out plan of the GOMPHA COMPLEX at TABO

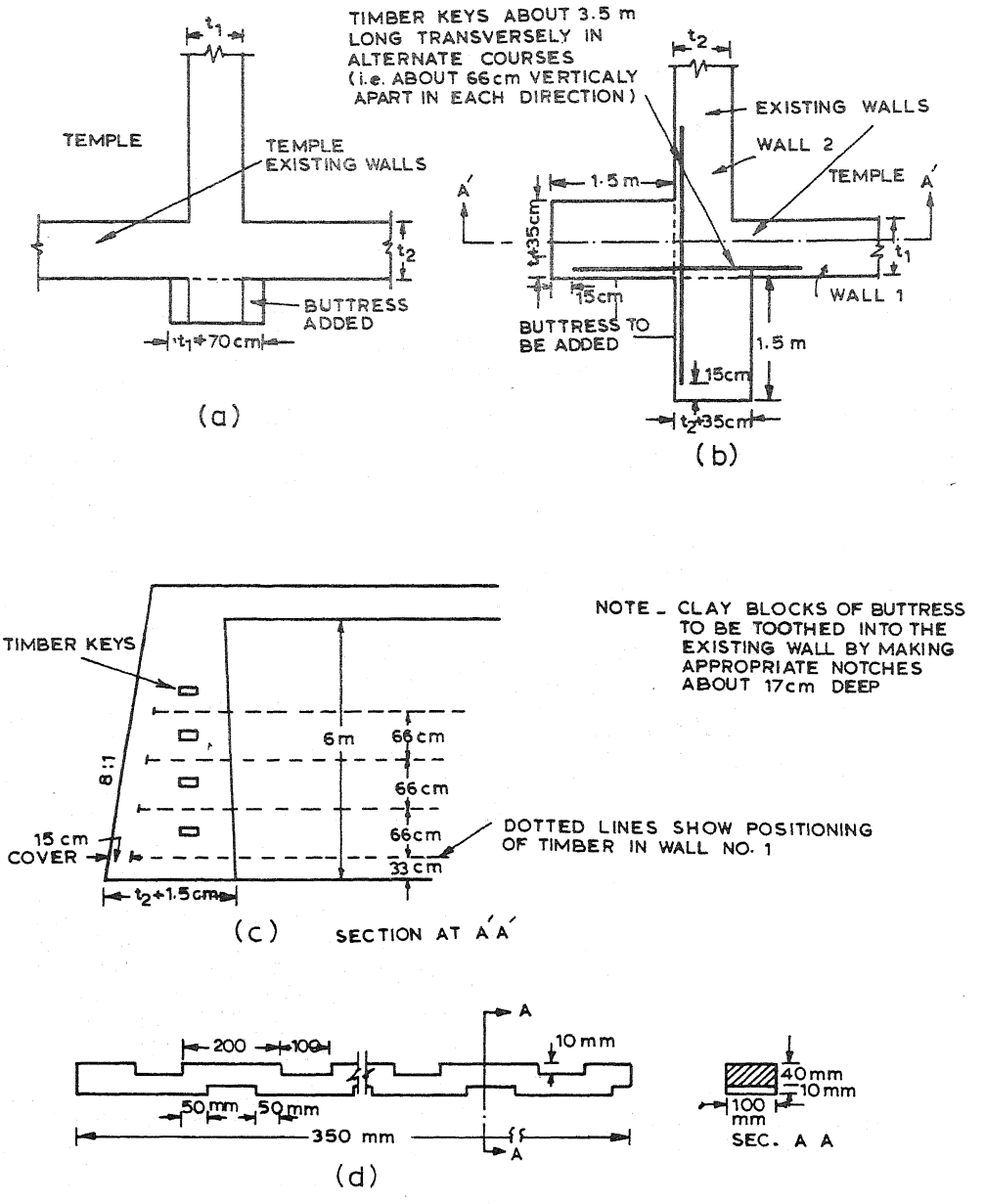


Fig. 3 - Showing the strengthening arrangements