Observing and Applying Ancient Repair Techniques to Pisé and Adobe in Seismic Regions of Central Asia and Trans-Himalaya

John Hurd

Abstract: *The opportunity in the loess clay belt of China, Trans-Himalaya, and Central Asia to examine both highly sophisticated aseismic building techniques and repair techniques taps into a transmission of empirically learned skills and techniques going back at least three thousand years. In pisé construction across the Tibetan Plateau, in the southern Himalayan foothills, and in central and northern China, as well as in adobe construction across Central Asia, in the Turkic countries, and in the northern ranges of the Altai Mountains, the use and tradition of aseismic features and techniques survived until recently.*

Because these techniques come from a regional cultural understanding, they are often overlooked in favor of modern cement concrete solutions, or in favor of retrofitting using modern materials and techniques that are adequate but not necessarily suitable for the region. The ancient techniques known as "soft stitching" or "laminated stitches" and "dry packing" demonstrate their effectiveness by their survival over long periods in generally high seismic activity regions.

The author has examined repairs in Afghanistan, Pakistan, the former Soviet Central Asian Republics, the Himalayan chain states, and the Tarim Basin of western China. For the last fifteen years, he has been applying the observed techniques in cob structures in Britain, Central Asian archaeological structures, and Himalayan ruined structures, and he has built emergency shelters and used horizontal lifts of vegetable "mattresses" in the Badakshan 1998 earthquake in northern Afghanistan. The author had the opportunity to inspect these structures following another quake in 2000; the performance of the structures was adequate, and most occupants survived. In structures from the fourth century of the Christian era until the present day, there is demonstrated in the majority of traditional structures the use of aseismic ring beams of many types, incorporating timber, brick, and vegetation including woven sackcloth and straw. Repairs, including stitching repairs, show use of the same protocol of repeated ring beam lifts of different materials. Important techniques of dry packing still exist in the region today, and these long-practiced answers to seismic cracking and weakness deserve to be investigated, studied, and tested.

Background

During a "year out" after university in 1970, the author visited the northern Afghan, southern Pamirs city of Faizabad. During this visit he spent some days watching repairs being made to a bell-shaped circular watchtower to the west of the city. His interest was aroused, since the academic degree that he had just completed was in geology and focused on clays; the tower was built from adobe blocks. The tower had several almost-vertical cracks caused during an earth tremor the previous year, and it was these cracks that were under repair. Four circular chases had been cut into the tower, two internally and two externally. In the author's memory—he carried no camera—the chases were each about 0.5 m wide (about 20 in.) and perhaps 40 cm (about 16 in.) deep, cut into the wall, which was approximately 1 m (39 in.) thick. Only one chase was filled during his visit, an external chase that circled the central part of the whole tower. This chase was filled with flat adobe "bats," or thick tiles, and in between each lift were placed coarse

FIGURE 1 Stainless steel and adobe soft-stitch repairs to a corner and central end wall in Leicestershire, UK. The structure is an example of cob construction.

hemp fiber mats that were woven in situ, which made a complete circular “ring beam” around the tower. The author has no idea what happened to the other three chases formed, but he assumes that they were dealt with in a similar way. The masons made no explanation of what they were doing, but the activity remains vivid in the mind of the author.

In 1994 the author, by then a conservator of historic buildings, often of mud, cob, wattle and daub, or clay on posts, attended a conference on earthen architecture in Plymouth, UK. The Devon Historic Buildings Trust produced a leaflet (Keefe 1993) on repair techniques to cracks in cob that recognized a technique of forming chases filled with adobes, but replacing hemp matting with stainless steel expanded metal lath.

In 1995 the author repaired cracks in a cob barn in Leicestershire, England, using the same techniques (fig. 1). This barn was converted to a residence, and from completion of the work to the present day, the repairs have remained strong, and no further movement has occurred.

The Horizontal Ring Beam Principle

In 1998 a severe earthquake occurred to the west of the region of Faizabad in Afghanistan. The author—because of his familiarity with the region and because no infrastructure existed to access the earthquake area because of the proximity of the Taliban/Northern Alliance front line—took charge of rehabilitation on behalf of the Irish charity Concern Worldwide, which, together with the group Shelter Now International, was required to build emergency shelters for the homeless inhabitants prior to the onset of winter. A tower repaired in 1970 was at that time severely damaged by warfare, and no trace of the upper repaired area survived. In the village of Shar-I Berzerg, only one old house remained standing; it featured wooden horizontal ring beams in its construction. Survival houses were built using recovered material from collapsed homes and featuring plaited hemp and bamboo ring beams. These structures were replicated by local masons, and thousands were completed across the region. The survival houses withstood several strong tremors and a second earthquake in the region in 2000. The author experienced a strong series of aftershocks while in a survival house; it shook and moved, but no large cracks developed.

All documentation held by the author, including his camera and film, were confiscated when the region was overrun by the Talibs. All foreign workers were forced to exit the region. The Swedish Committee for Afghanistan retains some photographs and drawings of the emergency shelters. The author himself escaped by hitchhiking a ride on a United Nations helicopter to Islamabad in Pakistan, but he remained in touch with courageous representatives of the Afghan NGO Pamir Reconstruction Bureau, who continued the work and eventually walked out of the dangerous region to safety on the Pakistan side of the Hindu Kush.

Across the region from Armenia in the Caucasus, Central Asia, and Trans-Himalaya, the author has noted structures, both archaeological and standing, which demonstrate the “ring beam” principle. Some observers believe that the use of vegetable, wooden, turf, and even brick lifts in adobe and pisé construction is simply decorative. The author believes that these methods represent a sophisticated and ancient understanding of aseismic construction.

A selection of photographs and archaeological drawings demonstrate their use from the fourth to the nineteenth centuries (figs. 2–12). Locations include Turkey, where Ottoman stonework has continual and frequent lifts of brick tiles, and Armenia, where pisé structures have regular lifts of wood, bark, and other vegetation and also bear evidence of adobe repairs using the same protocols.

FIGURE 2 Pisé mosque with horizontal bark and twig ring beams in regular lifts, Armenia.

FIGURE 3 Mihrab of a pisé mosque in Armenia.

FIGURE 4 Pisé lifts in a mosque in Armenia. The visible lifts include organic fiber.

FIGURE 5 Bark ring beam, Armenia.

FIGURE 6 Timber-edged stitch with additional twig reinforcement, Armenia.

FIGURE 7 Pisé city wall, Yerevan, Armenia. There are regular horizontal lifts, each lift line concealing a turf lift.

FIGURE 8 City wall with pisé lifts, Armenia. A horizontal turf lift is revealed behind plasters on the lower wall.

FIGURE 9 City wall with horizontal turf ring beam, Armenia.

FIGURE 10 Byzantine city wall with brick ring beams, Istanbul.

FIGURE 11 Nineteenth-century wall with large-block ring beam, Kyrgyzia. These modern remnants show horizontal changes in block size.

FIGURE 12 Adobe wall with horizontal vegetation mattresses in Yazd, Iran. The tower, which has been rebuilt, has no ring beam.

In the Silk Road cities of Central Asia, the theme continues right across China (figs. 13–16).

Ancient Repair Techniques

At a recent summer school in Ladakh, on the western Tibetan plateau, the author had the opportunity to demonstrate repairs to pisé structures from the fifteenth century. Here the pisé was constructed in short lifts of approximately 15 cm (about 6 in.) each. In every third lift, a vegetable "mattress" was rammed into the construction (fig. 17). Here cracks were stitched in the same techniques examined by the author across Asia, and

FIGURE 13 Pisé on stone plinth castle and monastery at Basgo, Ladakh.

FIGURE 14 Pisé lookout tower in Ladakh, exhibiting typical tremor damage.

FIGURE 15 Stone and pisé castle in Ladakh.

FIGURE 16 Detail of pisé, Ladakh.

FIGURE 17 Detail of horizontal vegetation (*yagtsa*) mattresses at every third lift. Ladakh.

these were confirmed to have been described in cultural records both by Ladakhi monks and by Bhutanese builders. A Himalayan architect kindly made a drawing of the techniques used (fig. 18).

A chase is cut to almost half the thickness of the wall (fig. 19); this chase has deep returning ends in the form of a staple. The chase is continually wetted down with water during the construction process to eliminate suction leading to hairline cracks around the repair (fig. 20). The chase is then filled with alternative lifts of wet vegetation or woven matting with lifts of adobe bricks (figs. 21 and 22). The top course of the stitch some 10–15 cm (about 4–6 in.) deep is then wetted down and strongly but carefully mallet-dry-packed with loose material identical to that of the blocks (fig. 23). The dry packing presses down the whole stitch into a dense and strongly rammed fill (fig. 24). Alternate lifts are achieved at approximately 0.5 m (about 20 in.) intervals, internally and externally. The stitches are of varying length to allow for stitching of subsidiary cracks and to prevent the formation of new cleavage planes that may develop from stitches of regular length (figs. 25 and 26).

Internal walls can be reinforced with triangular stitches where cracks occur.

The author has added to the range of stitch forms by the invention of a capping stitch that uses the same techniques as other soft stitches but which is shaped like a butterfly and is rammed directly from above. This “butterfly cap stitch” can then be covered by a domed shelter coat, generally used by the author to protect historic structures from weathering erosion and decay. While the soft stitches need little maintenance, situated as they are within the body of the wall and having

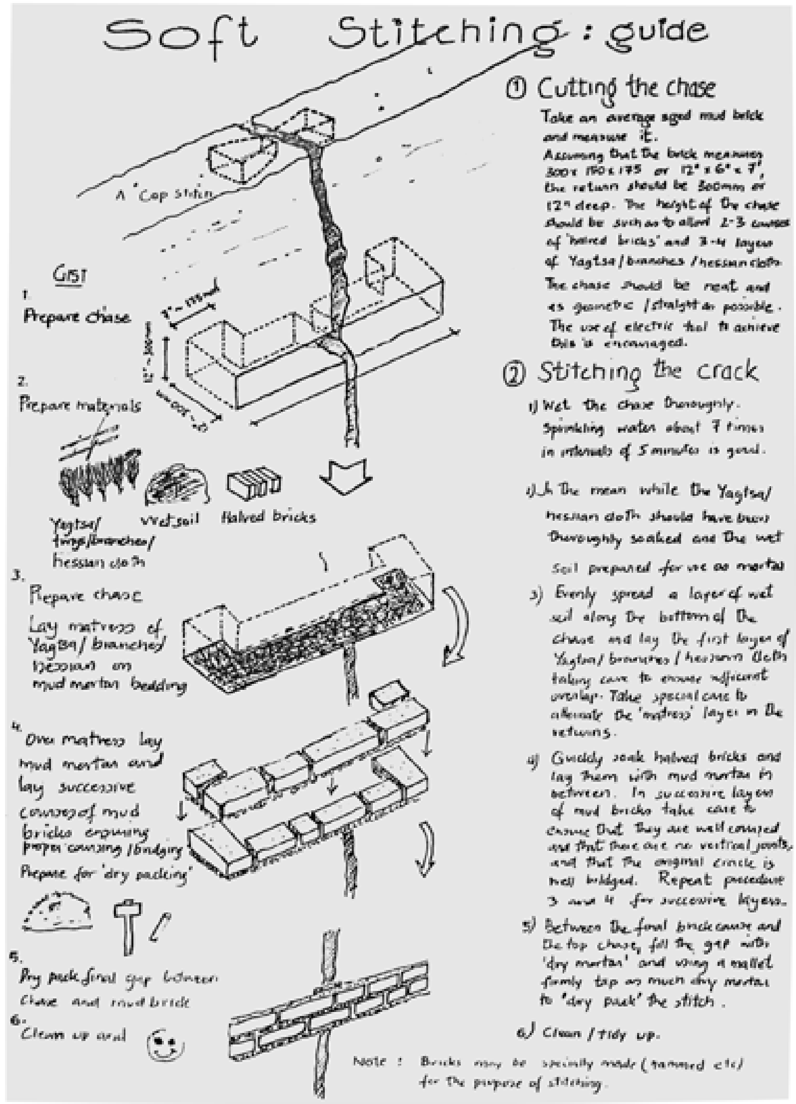

FIGURE 18 Soft-stitch crack repair techniques, including butterfly cap stitch. Drawing: Karma Gelay.

FIGURE 19 Cutting the chase in the shape of a staple.

FIGURE 20 Wetting the finished chase.

FIGURE 21 Filling the chase with *yagtsa* and hemp matting.

FIGURE 22 Filling the chase.

FIGURE 23 Dry packing the top of the stitch.

FIGURE 24 A completed stitch.

FIGURE 25 A second stitch above the preceding one.

FIGURE 26 Conservation work in progress, Ladakh.

a compaction similar to the rest of the surrounding masonry, the topmost shelter coat requires regular maintenance.

This soft stitching technique is recognized throughout the seismic regions of Asia and is empirically understood by masons, who frequently describe examples in their own regions. Many subsidiary craft skills were described to the author, including admixtures to the earth used for block repairs.

The author has not had the opportunity to test or to examine technically the engineering performance of the techniques, but he has observed the use of still-functional soft stitches on structures that have survived many earth tremors and quakes over the centuries. This paper is therefore a show-and-tell description of historical techniques observed and used by the author over the last twelve years. He has never read nor has he encountered any other description of the techniques that he has observed and applied.

References

Keefe, Larry. 1993. *The Cob Buildings of Devon 2: Repair and Maintenance*. Devon, UK: Devon Historic Buildings Trust. http://www.devonearthbuilding.com/leaflets/the_cob_buildings_of_devon_2.pdf [accessed 3 Oct. 2008].