Thinking to Reconstruct Kashthamandap? Love Thy Mud, Brick and Wood First.

As the earth trembled violently on that day, a blood donation program was about to conclude at Kashthamandap with the participants collecting to line up for a photo session when the cherished heritage building which gave its name to the town and the valley, collapsed, killing 10 persons. Press reports indicate that there were over fifty persons in the monument at the time of the earthquake. "For a second I had no idea what was going on. I didn't know whether to run or sit, everything and everyone seemed to be moving. Bricks and mud started falling down on us and nearby temples began going down one by one, " recalls Amit Awale who was able to run before the Kasthamandap temple collapsed and rescued three others including a nurse, a colleague and a blood donation participant (News Report, 2015). Almost as immediately, calls for earthquake resistant reconstruction of the monument were made seeming as though a autopsy by those who knew had concluded that the building was inherently weak and our forefathers knew little more than nothing of earthquakes resistant construction! While the tragic collapse does demand setting performance standards of safety of life when reconstructing, it cannot be a foregone conclusion that the original structure did not do so. One should also not forget that Kashthamandap had been shaken several times and by much larger earthquakes earlier and had stood up well until 2015. such performance itself should be telling enough for experts not to decry its design but look elsewhere for the reason thereof. Moreover, if it is the Kashthamandap that we are thinking of reconstructing, protecting its values has to be the primary priority and increased earthquake resistance a desirable side gain.

The massively destructive Gorkha Earthquake of 25 April 2015 and its huge aftershock of 12 May 2015 destroyed more than 511, 390 buildings and partially damaged 286, 767 more. This building disaster killed over 8, 789 and injured 22, 309 more. Along with the huge human loss and suffering, the earthquake has also brought about a heritage emergency damaging more than 90% of listed monuments with 151 collapses, 474 suffering heavy damage and about 500 others suffering minor damage. All of the seven monuments zone of the KVWHS suffered similar damage, with as many as 38 monuments collapsing and 157 heavily damaged, potential enough to eclipse the national cultural identity of Nepal. This massive destruction of the attributes of the KVWHS property compromised the state of OUV of the property so much as to lead the 39th WH COM to conclude that 'the extensive damage of the earthquake to the property represents both ascertained and potential danger, in accordance with paragraphs 177 to 179 of the *Operational Guidelines'* (UNESCO, 2015). While the 'ascertained' danger relate to the actual destruction due to the earthquake, the added 'potential' danger relate to unacceptable nature and ineffectiveness rescue, rehabilitation and reconstruction actions that Nepal is expected to take towards protecting, conserving and restoring the KVWHS. While the international heritage conservation community requires and seeks of Nepal maximum efforts to retain and regain the OUV, authenticity and integrity of KVWHS in the rescue, rehabilitation and reconstruction works, the national discourse of post-disaster reconstruction has been dominated by unmitigated concern for building earthquake resistance as the primary requirement. Nepal's heritage architecture is pre-industrial and uses natural building materials and locally developed technology, all of which stand in stark contrast to the earthquake-resistant planning and building code requirements that are based on industrial materials like steel and concrete and the knowledge/analysis systems that promote them. These make reconstruction of Nepalese heritage buildings with cultural relevance greatly challenging and loss of material, technological and aesthetic values, its authenticity as well as integrity, looms large as an impending reality. In order that such a crisis is not precipitated in our heritage, reconstruction of heritage buildings need to be backed by a priority policy of promotion and use of indigenous building knowledge system and technology.

Indigenous building culture anywhere develops without the play of external processed knowledge. Its origins follow the dictates of local geology and building materials and progresses through technological trials to meet the demands of local natural environment. While Kathmandu Valley's deep past as a lake endowed it with lacustrine deposits that made possible the building materials of mud, brick and tile and its temperate climate and fertile land nurtured building timber providing trees, for the builder and their buildings the challenges of yearly monsoon, infrequent earthquakes and occasional fire added must have provided the creative tension and the disruptive environment needed for technological innovations and development. Indeed so many big earthquakes have shaken Kathmandu Valley over the two millennia long development history of Kathmandu Valley's heritage architecture, its building materials and technology could not but have been responsive to it. Within the constraints and limits of the building materials, the monuments of KVWHS have incorporated the summary knowledge and long experience of its builders in facing inclement earthquakes. Thus, even as destruction and damage wrought by this earthquake on our traditional architectural heritage has been massive, and has shocked and shaken our social, cultural and economic support systems, the indigenous knowledge and experience enshrined in the heritage need to be expounded, glorified and promoted in reconstruction.

Unfortunately, overtures on damage assessment and forthcoming reconstruction have not sounded helpful at all from the perspective of heritage of the valley and the most commonly used local materials. Although the Nepal Earthquake 2015 Post Disaster Needs Assessment names Cultural Heritage under Social Sector and places it as its sixth sub-head, it disastrously defines recovery needs of cultural heritage as 'to build back better through the use of high quality building materials and structural improvements for seismic strengthening' (NPC, 2015). A recent official document purportedly meant for Kathmandu Valley states that 'for the reason that old buildings built with brick in mud mortar are not earthquake-resistant structures, they were totally destroyed killing many lives' (JICA, 2015). When national policy, technical guidelines and projects to 'built back better' are informed by assessments so insensitive towards the values of the heritage, they make nothing less than sharp instruments of terror pointing at the architectural heritage of KV, at least those Malla period ones, whose structural system is largely load bearing brick wall built in mud mortar. Lack of established tools and computational coefficients to integrate property of specific type of mud mortar and such brick walls reinforced with a system of timber posts, plates and ties, aggravates the potential harm as the application of modern building system led damage assessment, vulnerability analysis and structural retrofitting/design/strengthening systems are preferred. Such incongruities are likely to add up when the other traditional elements of earthquake resistance such as solid brick terraced plinths, wooden collectors and packed joist floor diaphragms, connectors and wedges, double framing of doors and windows openings, symmetry, proportions and measures, cornices, ring ties and struts link between roof ends and walls, etc., are neglected. In the jargon and cacophony of alien knowledge systems, if such marvels of our heritage as Kashthamandap are devalued as weak-kneed imps ill with 'soft storey', 'heavy roof', 'loose struts', 'unanchored long columns', 'brick in mud-mortar', 'mud-floor diaphragm', why reconstruct at all?

The structural assessment of traditional architecture, which combines architectural design, construction technology and craftsmanship of building elements together to create a unitary effective and adequate performance capacity tested by practice and experience, has been problematic for 'vulnerability analysis' in other societies also. The Japanese researchers are still not able to analyse their traditional Pagoda using modern structural engineering tools of analysis and explain its earthquake resistant properties and behaviour. But it has not been construed there that structures are weak until proven safe according to the modern knowledge system of earthquake resistant building. 'The traditional Japanese Pagoda structure is too complex to analyse and we do not really know how it resists earthquakes. In big earthquakes, it makes a lot of squeaking and clattering noise and its central pendulum swings to bring the shaking building quickly to rest. It is a very good earthquake resistant structure. Do you know, how with all that brick, Nyatapola, the temple at Taumadhi, withstood the 2015 earthquake?' asked a Japanese recently rather amazed at its performance (Shimoda, 2015). Tanahasi's simple inference made about half a century ago can be instructive to answer why our very own Nyatapola continues to stand proud against massive earthquakes. We quote him, " This is not to suggest that tall and slender temples are naturally unsafe. Strength against lateral forces, amount of deformation possible and scale all combine to give a amount of potential energy. As long as this is larger than the kinetic energy imparted by the earthquake [m. (xg. t)^{2}], the building would not tumble down." (Tanahasi, 2070) Clearly, singling out and taking that brickwork in mud mortar as a masonry mass only contributing to generation of large lateral forces in case of earthquake would be a slander to our ancestors' structural acumen. A caring and sensitive assessment with love and respect, may be even pride, for that mud, brick and wood is a good starting point in thinking reconstruction of KVWHS. Let's hope at our conservation engineers will apply sensitive anamnesis, diagnosis and therapy (Rosso, 2015) while assessing our architectural heritage, material, technology and all just out of the recent extreme event, much like doctors handling precious life at risk of loss.

The damage to architectural heritage of Kathmandu Valley should be assessed distinctively in two broad groups - (a) the Malla period buildings in traditional Newar architectural style and technology and (b) the Rana period buildings in *Desikaida* architectural style and technology. While the damage to the Rana period buildings can be directly linked to its poor performance of both design and technology of building in the earthquake event, a quick but detailed damage assessment of the traditional Malla Newar heritage buildings of KVWHS indicated that their design and technology are quite responsive to earthquake action and that a general lack of maintenance of timber structural elements and their joints shows as the major cause of the massive damage seen in this earthquake. This becomes particularly evident as we find that temples with timber colonnaded circumambulatory and multiple plinths, both of which should have given these buildings greater earthquake resistance, have suffered greater loss. Many collapses appear caused by rotten and failed corner joints of plinth ties, cornice ties and eaves beam.

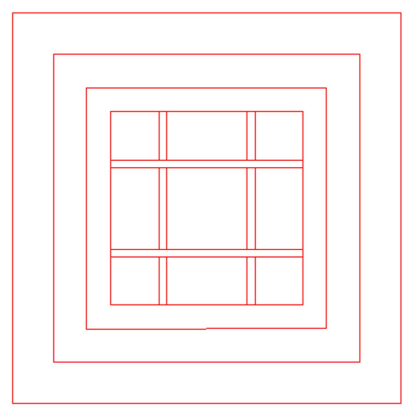

Fig. 1: The Foundation Works of Kashthamandap: Strips of Brick in Mud Mortar

Understanding the original building system, materials and methods and the state of decay of the constituent materials and the consequent capacity to perform various structural functions, through the study method of 'math and path' of loads, if you like, should be the first step. Idea should not be just to look for 'theoretical' weaknesses or weak components/constructs such as soft storey or mass irregularities or vertical discontinuities known to modern knowledge systems but also and more to critically identify the provisions made and possibilities for heightening building performances for resistance as also for absorption, dampening and dessipation of earthquake forces such as shear locking ties, ground amplification dampening mass terracing etc. It is as important to study behaviour of constituent elements as well as the synergy they accrue from their juxtaposition. Assessing and highlighting their uniqueness and worthiness should more important than finding weaknesses aimed at justifying strengthening through foreign implants, whether theoretical, material or technological. As a case in point, the analysis of values rather than just structural adequacy should be the outcome of the recent archaeological initiative on Kashthamandap.

A partial archaeological trench cut across the sanctum floor of Kasthamandap to study its geological setting and foundation has revealed that a deep strip foundation using brick and mud mortar and width equal to the thickness of the core walls that enclosed the sanctum had been provided and is in well preserved state. Another shallow brick strip foundation is provided for the plinth wall in the perimeter of the building. The bottom of the foundations appear sandy and wet. A one brick wide thin divider wall corresponding to the inner sanctum square formed by the massive timber posts appear to divide the building trench into nine pits as was ritual then. And the thin divider wall and the uniform backfill indicates that the whole sanctum area was dug out first, the ritual walls constructed and back filled as construction progressed so that these walls did not take any lateral pressure and had no retaining function. But the crossings of the divider walls so exactly define the position of the posts that they could well have supported timber plinth ties in the past. It is also clear that the foundations have been constructed at one time and there has been no change or additions during its long history. This attests that the building size has remained unchanged since its construction. The brick floor is recent and no sills of any kind is observed, both of which indicate compromising interventions. Like in the case of Mani-Mandap of Patan, here too, it appears that the base timber ties laid on floor to tie the sixteen pillars ('shorakutte'/ nine pit formations) were removed to make the modern floor paving severely compromising the stability of the columnar design and adding greatly to the vulnerability of the building.

The above discussion also shows how needful it is to study the history of renovations, interferences, additions and subtractions made (both prior to and after the advent of cement, concrete and rolled steel) on the heritage building and measure their contribution in the damage sustained by the monument in the extreme event. Indeed changes and implants made in the past with good intent of improving performance has often been responsible for the damage more than its original construct. Assessments indicate that some of the 'restored' heritage monuments suffered spectacular damages more due to poorly thought out recent post-concrete interventions than the defects or decay in historical design, detail or material itself in KVWHS. The reinforced concrete ties and other monolithic action precipitating interventions made during the1979 conservation works at Hanumandhoka's Lohn Chowk and Nautale Durbar, the consolidation of the cornice beams and upper roofs of Radhakrishna Temple in Patan with rich mortar generating monolithic strip joint, the asymmetry and monolith action affected by partial consolidation using over rich mortar at Batsala temple of Bhaktapur are some such striking cases.

It is therefore recommended that the assessments of earthquake damage take a three pronged basic stance and screen for strengthening while reconstructing our heritage monuments - (i) study, expound glorify and promote the traditional design and details, materials and technology and their performance, (ii) study, assess and avoid the mistakes and anomalies made in the past restorations such as introduction of incompatible elements and precipitating asymmetrical or monolithic action and (iii) state of maintenance and decay of wood connectors, collectors and ties and their joints. Using these three investigative departures will give us a more accurate sense of the capacity of the traditional monument and compatible structural strengthening approaches. If at all any retrofit is needed or strengthening elements are to be added, the principle must be to use traditional material and method and improving over their performance through innovative composite construction of wood and brick system. The excellent performance of the 55 Windows Palace of Bhaktapur (conservation completed in 2008), the five tiered temples of Nyatapola (major restoration completed 2000) as well as the three tiered temple of Bhagabati Bahal (reconstruction completed 2011) in this earthquake stand testimony to the fact that traditional materials and technology of construction, well maintained and repaired periodically, are able to withstand very strong earthquakes. The experience of conservation of the 55 Windows Palace has proven that such priorities and three pronged approach indeed make manna and mantra for the reconstruction of the fallen and damaged heritage of KVWHS. The debates over the 'choices' of approach and technology for restoration of the 2015 Earthquake ravaged heritage - between the application of traditional system, materials and methods and the modern system with use of industrial construction materials and methods - have such similarities with the debates of post 1988 earthquake conservation of 55 Windows Palace, that taking stock of this experience that took fifteen years to be resolved to the satisfaction of all and developed a now proven approach of conservation along with structural strengthening should be greatly well worth for the health of reconstruction of KVWHS monuments now!

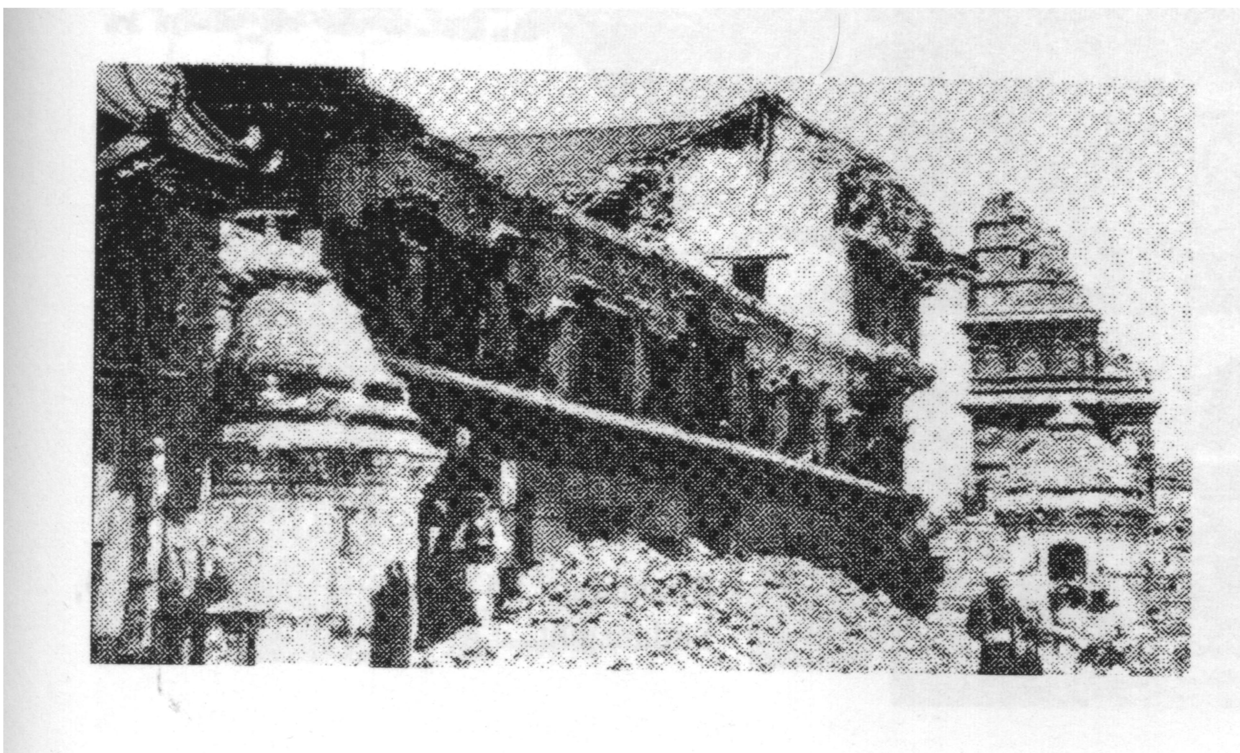

Fig.2: Brick wall in mud mortar of 55 Window Palace worked well against 1934 Earthquake.

The fall of *mikhafusi* bricks of the first floor *tikijhya* of the 55 Windowed Palace in the 1988 earthquake and its extremely leaning out and bulging main wall significantly had whipped up the cry for strong earthquake resistant intervention while restoring it. The first proposal (1993) had proposed structural consolidation by introducing three reinforce concrete slabs, one in each floor to tie the longitudinal walls, vertical stiffening of east and west cross-walls and diagonal steel rod or wire bracing of timber post-lintel framework in the second floor gallery of 55-windows! Local professionals and the Department of Archaeology rejected this proposal made by very well known foreign conservation experts of Nepal and so rightly as these were irreversible, extremely intrusive and went against the accepted ‘archeological standards’. In 1995, the engineers at the Department of Archeology, prepared and presented an ‘alternative’ which was largely similar to the earlier proposal except that in place of the concrete floor slabs the use of timber horizontal trusses was suggested - this alternative structural retrofitting was also not accepted as it was 'incapable of transmitting horizontal thrusts to foundations'. A day long discussion between national professionals in 1996 shot down yet another retrofitting proposal proposed by an internationally known expert which proposed to construct a transverse steel frame box in ground tied to a concrete slab on ground surface, a concrete slab in second floor and a steel or timber wooden framework in the gallery floor. It is notable that this massive intrusive retrofitting was fully supported by the UNESCO consultants as ‘best of all available option’. Finally a team of Nepalese specialists was appointed to assess all past proposals, the condition of the palace building and other relevant issues and to recommend the approach and action for the renovation of the building. This team submitted that conservation proposal could not be guided solely by the state of one or few important elements or their state and that conservation action could not be approached through systems derived from the state of the art knowledge about earthquake resistance borrowed from industrial societies. It made a holistic assessment of the extant building and used its understanding of the heritage building to develop the conservation proposal with broader objectivity and sensitivity towards conservation of traditional style and form, materials and methods of construction and its own traditional structural system to make as much gain in load bearing strength and earthquake resistance wherever possible within that system. In particular, it made full use of local and traditional technology, the indigenous knowledge system and the experience of local skilled workers and craftsmen, who embodied that knowledge. No industrial material like cement, steel and concrete and associated technology was introduced anywhere.

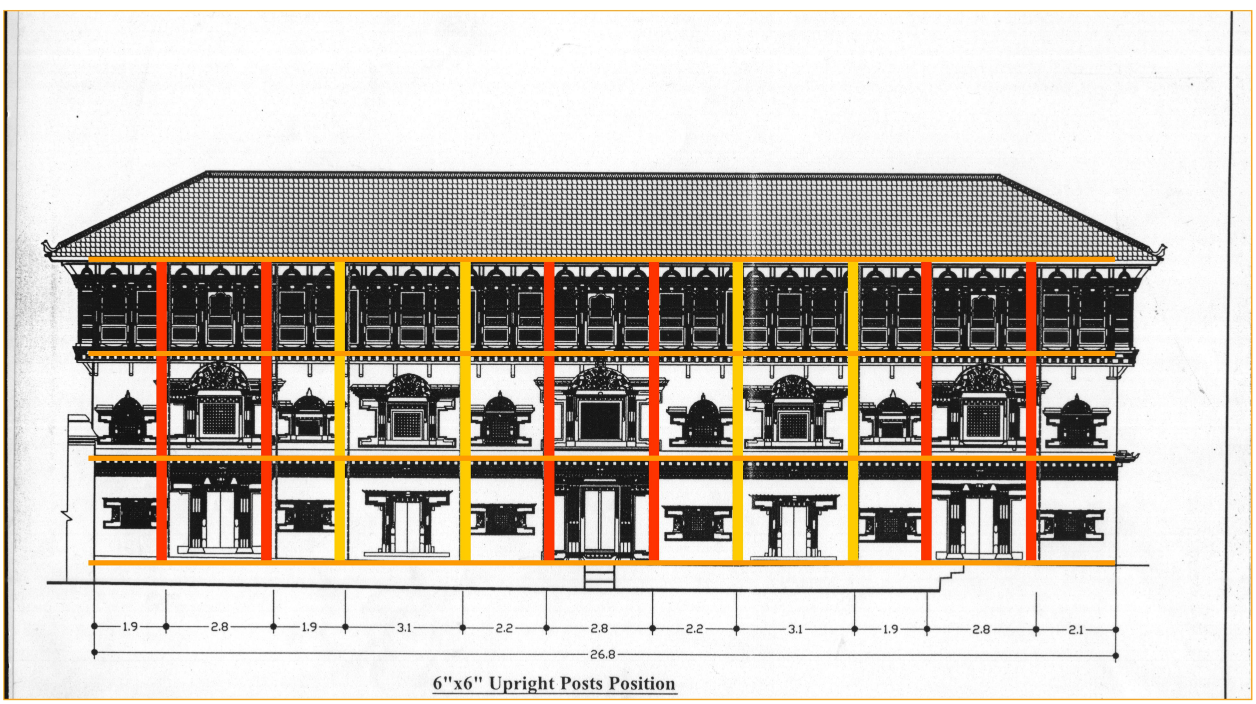

Fig.3: Timber uprights introduced for strength, connection and collection functions.

As part of the assessment a critical study of the reconstruction and repair history had been made along with archaeological investigation to inform and supplement structural assessments and strengthening inputs. Sophisticated contemporary tools and models were used to analyze and understand the building and its structural response.

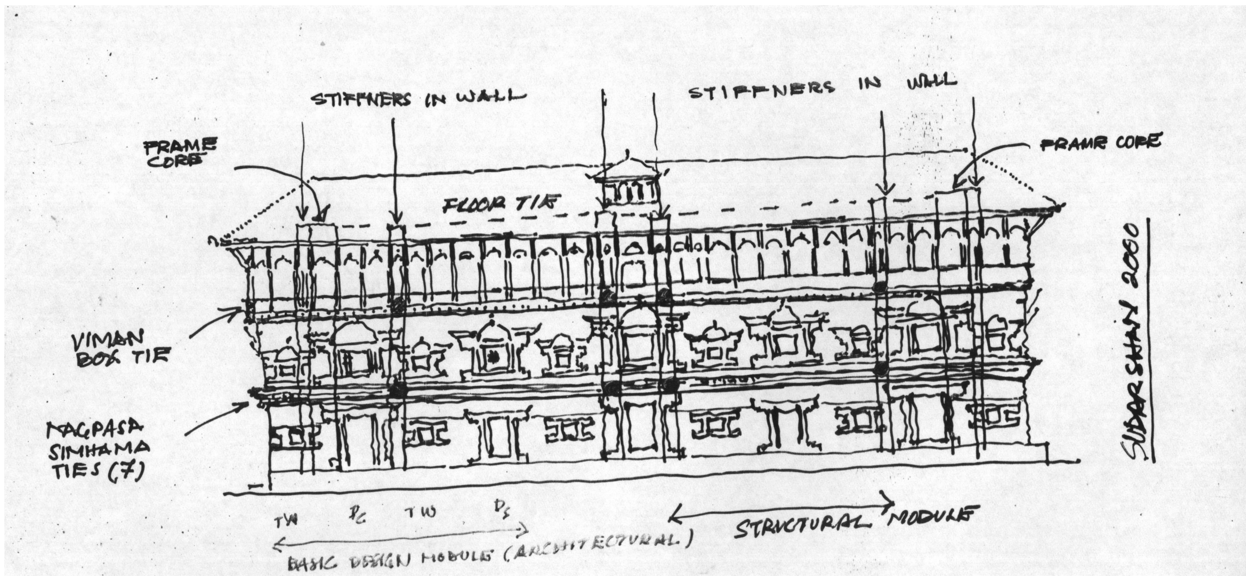

Fig. 4: Strengthening proposal using traditional materials and methods (of the author)

The Palace With 55-Windows was restored back to its original form preserving the wall murals in as is condition with maximum use of traditional materials, methods and knowledge system as possible. The interior of the first floor rooms were left untouched. All brickwork and Jhingati roof was done using mud mortar and mud of traditional specification. Along with straightening of the external face of the main southern wall and strengthening it through introduction of a timber-frame action in conjunction with floor joists and timber posts of the Dalan and *bardali* on the courtyard side and the restoration of the second floor with gallery of 55-Windows (*chota*) to its original shape, size, décor and character, the work also restored the eleven-bayed double-post *Dalan* in ground floor on the court side, the two corresponding *bardali* in the upper levels and cross-walls to their originals. All modifications and additions made post 1934 on to the building were removed and replaced by traditional elements.

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