Significance of a Mughal Mall and its role in achieving safety

Saptarshi Sanyal
School of Planning and Architecture, New Delhi, India

ABSTRACT: The fascinating and unique covered market, Chatta Chowk Bazaar, was designed for the fortress-palace, Redfort, the magnum opus of 17th century Mughal Emperor Shahjahan’s new capital in Shahjahanabad, Delhi. This building was the subject of documentation and comprehensive qualitative studies, undertaken by architectural conservation students of School of Planning and Architecture in 2006–07. The direction and approach given by the conservation studio’s faculty, one of knowledge systems, was significant in guiding the studies selected and the way the structure was analysed, resulting in an appreciation of the many dimensions of the historic building. These revealed architect Shahjahan’s immense knowledge of architecture, qualified through primary studies of Mughal architecture in Delhi including the palace-complex and secondary studies of his other projects. This paper attempts to illustrate, through this case, how superior structural know-how and stability, are integral to a significant historic building, which is a knowledge system, and how an essential consequence of such significance, is safety.

1 INTRODUCTION

In Aug-Dec 2006, the Conservation Studio team of School of Planning and Architecture in an exercise “The Past, Present and Future of the Mall that Shahjahan built”, documented and analysed the Chatta Chowk Bazaar, an imperial marketplace at Redfort in Shahjahanabad, the erstwhile Mughal capital at Delhi. This building was built by the fifth Mughal Emperor, Shahjahan, remembered globally because of his conception and architectural accomplishment of the world famous Taj Mahal at Agra.

The objective of this project was to formulate a conservation proposal for the building addressing the aspects of reuse and historic fabric. Guided by Prof. Nalini Thakur and Ar. Sanjay Bharadwaj, the Mughal architectural context in Delhi was studied, including the role of Shahjahan as an architect-planner in his works, which revealed that while his contribution to architecture was quite significant, this Bazaar is typologically unique in this part of the world. As a part of property inscribed in the recent inclusion of Redfort in World Heritage, the Bazaar is also the significant “living” heritage in the Redfort.

In this exercise, the architectural Knowledge Systems approach applied to this case helped the appraisal of its embedded values as being very relevant in conservation for future use. While present usage is in conflict with these values, causing degradation of its technological and structural memory, the building in question still survives “safely”.

This paper firstly addresses the structural significance of the building, as revealed through the primary and secondary studies of the building and its context. Secondly, it suggests how the aspect of structural significance compliments and informs the knowledge required to achieve safety in historic constructions, as revealed in this case, in the context of the observed situation and its current issues.

2 THE KNOWLEDGE SYSTEMS APPROACH APPLIED

2.1 Contextual studies: Mughal Delhi, Shahjahan, Shahjahanabad and Redfort

The generation of knowledge started by looking at the historic city itself, here Mughal Delhi and its architecture, as it existed on the ground. The secondary studies on the cultural upbringing and achievements of the architect of the Bazaar, Shahjahan, corroborated inferences about his contribution to Mughal architecture, and the significance of his buildings, most of which could be appreciated as outstanding knowledge systems. Moreover, it was found that Shahjahan’s knowledge was not restricted to individual buildings but encompassed palace and city planning, as demonstrated by the Redfort and his capital of Shahjahanabad, with the Chatta Chowk Bazaar as an integral part of both (Figure 1).
2.2 Primary studies of the building

The documentation of the Bazaar was through architectural drawings of the existing state. With the advantage of having a modular system, the ‘original’ designed structure was deciphered by removing the accretions and alterations from the measured drawings (Figure 2).

These preliminary exercises helped in identifying the structural form of the building holistically. The term “Mall” thus addressed the fundamental characteristics of the building, functionally, architecturally and formally. This building can be described as a two-storied linear arcaded structure with an octagonal court halfway through its length, with eight arcade bays on either side, contiguous with the western entry of the Redfort, the Lahore Gate (Figure 3).

Secondary studies indicated that, though inherited typologically from central-Asian counterparts of the “souk” or Bazaar, integral to Persian and Arab cities, the Chatta Chowk Bazaar responded to the specificities of climate, cultural context as well as to Shahjahan’s own design of the Redfort and Shahjahanabad, all of which is a complex design synthesis.

2.3 Structural analyses and technical studies

From the structural form of the building that emerged, critical areas were zoned and their behaviour analysed. Unfortunately, owing to logistical limitations, the foundation could not be examined and the formal analyses are restricted to the superstructure alone.

Technical studies were carried out from the reading of exposed areas of the building fabric, and samples were qualitatively studied to understand the construction system in terms of the constituents using secondary references from similar constructions. Moreover, a similar building by Shahjahan, a hunting-lodge at Jaunti village near Delhi, was studied insitu to understand construction. This building’s collapse due to unknown reasons exposed a lot of the brick masonry that is similar to the Chatta Chowk Bazaar and this helped in building the knowledge base.

2.4 Chatta Chowk Bazaar as a knowledge system

Through studies of the context and the building itself, information related to the Chatta Chowk Bazaar revealed many facets of this structure. Primary and secondary studies of the architecture and its history, as well as its technology presented disaggregated information. Amalgamating this information with the specific purpose of conservation, helped to appreciate this building as a knowledge system, from contextual to component levels. This knowledge system has subsystems of architectural design, structure, construction etc. defining its values. For the purpose of this paper, although the formal structural knowledge is highlighted qualitatively, the values revealed by the analyses shall be critical in guiding still more detailed, quantitative structural analyses.
3 STRUCTURAL VALUES IN THE BUILDING

3.1 Components of the structure

Before proceeding to the formal aspects of the structure and their analyses, it is necessary to briefly look at the types of constituent structural components or structural elements in this building, along with their basic materials. These components and their behaviour in the whole structural system allow us to divide them into three logical groups.

The first of these, vertical elements, have either resultant or primary load lines or both which are vertical. These elements are subject to buckling under stress. They are morphologically in the vertical plane and include walls and piers. In Chatta Chowk Bazaar, these are built in brick with mortar.

Secondly, horizontal elements carry uniformly distributed loads or point loads and are morphologically horizontal or in the horizontal plane. They are subject to bending when loaded. As spanning in Chatta Chowk Bazaar uses predominantly arcuate systems, the presence of these is rare. These elements are lintels in most small openings and mezzanine floors in the western gate. They are built in red sandstone.

The most important and commonly used, composite elements dissipate horizontal, vertical and lateral loads in one or more planes. These elements are morphologically more complex and the loads in them are indeterminate due to three-dimensional geometries. However, it was possible to qualitatively map the load transfer lines in them. These are also built in brick and mortar and include large arch-ribs, domes, segmental domes and pendentives that support domes or flat ceilings.

3.2 Formal structural systems and zones

In discussing the findings of qualitative structural analyses, the major aspects covered include the spatial zones, structural systems and sub-systems and their interfaces and how they contribute to safety.

Spatially speaking, the entire building can be divided into three distinct zones, each of which incorporates a particular structural system. These systems incorporate combinations of the aforementioned elements and structural subsystems, both intrinsically and in their physical interfacing. These critical zones, namely the arcade, the octagonal court and gateways are explained below with their interfacing.

3.3 Arcade modules

These fundamental units, 16 in number, are repeated on either side of the octagonal court to give this building its most identifiable architectural form: they articulate the mall character (Figure 4).

The central space of a typical module is a covered street, roofed by a segmental dome at a height of 10.5 m. Along the length of the street of width 8.3 m, each arcade segment is bound by a combination of two arch-ribs of depth 1275 mm. and four piers of section $900 \times 1200$ mm. (Figure 5).

The arch-ribs are subject to smaller lateral thrusts from the roof (Figure 5, A) and larger arch-actions resulting in cumulative horizontal and vertical components at the springing point that exerts an outward horizontal thrust at this point. This thrust is contained by the stepped section of the transverse wall (Figure 5, B) of the building on either side and the piers accommodate the vertical loads. In effect, shoring these piers today couldn’t render the extent of safety to the covered street that the original design of these walls deliver.

An important subsystem here is formed by the arches that are along the length of the street on each floor. These are designed to span 3 m and rise to heights of 1.5 m on the lower storey and 1.35 m on the upper.

The first floor arch accommodates the load of the roof in excess of that carried by the arch-rib of the street while the lower arch, along with defining the cell’s...
opening, acts with the pier in supporting the intermediate floor. The lower floor arch, characteristic to Shahjahan’s design, is clearly designed for structural safety, as suggested by the absence of a wall on the upper floor; the first floor arch overlooks the street over a low sandstone parapet (Figure 6).

In the arcade module, it is also necessary to refer to the structural subsystems that spatially form two cells on the lower storey and one on the upper. Each of these measures 9 m. square. Roofs of these completely enclosed cells are supported by the technically superior elements of pendentives (Figure 7), as opposed to squinches or trabeate devices. On the first floor, a semi-covered projection at the entrance inverts access of the cells. They are approached from the outer sides of the building. Here also, a half-dome is formed by pendentives that partially enclose this space. This kind of a design detail, for a small span of 3 m, demonstrates technical knowledge, which today makes these areas safe.

When symmetrically arranged, these arcade systems in the building cancel any possibility of unbalanced stresses or lateral thrusts. The following sections examine the design of the critical asymmetrical junctions of these with morphologically distinct spatial zones to dissipate extra stresses.

3.4 Octagonal court and arcade module interface
The “Chowk” or court at the centre of the long Bazaar, is both visually and spatially conspicuous by being a source of light for the otherwise covered street. Besides this significant environmental function, its role as a structural system contributing to safety by design is far from negligible. To appreciate this point, refer to Figure 8 below, where the terminating arcade system may be viewed in the absence of the built elements contiguous with this open space. Taking this perspective, it becomes clear that the springing point of the last arch-rib is thrust outward by the lateral stresses caused due to the arcade’s roof.

The plan (Figure 8, B) shows us how this very line forms the shorter edge of the octagon that, in the vertical plane has a solid wall mass, adding a vertical component. This is in supplement to the wall above half of the arch-rib span, as part of a long edge of the octagon. The vertical component thus added, is transferred to the arches in the shorter faces and subsequently to piers that form the verticees (Figure 8, A–B). The lateral (non-orthogonal) component is then dissipated along the staircase block down to the arched opening on the outer edge of the building, beyond the octagon at the lower level.

The massing of the building around the octagonal court suggests that risk of failure at all points is eliminated by increasing the vertical loads at all nodal points that are prone to asymmetric loading. This is a demonstration of the building design achieving safety through elements in vertical planes. However, it should be appreciated that the outer built areas of this
Figure 9. “Safe” structural design of Lahore Gate and arcade interface highlighting the critical components in the diagram.

space, owing to planar design of the elements, are the structurally the most fallible.

3.5 Gate and arcade module interface

The longer ends of Chatta Chowk Bazaar are defined by two distinct gateways. These are the Lahore Gate and the “Darwaza-i-Chatta-Chowk”, the Bazaar’s entrance and exit points respectively as one walks into the palace-citadel. Though different in scale and mildly different in design, the structural behaviour of these two spatial zones is quite similar. The more elaborate and larger of the two, the Lahore Gate and its junction with the arcade system, shall be discussed here.

Being a complex structural system in itself, this needs to be described briefly prior to the examination of the intersection with the arcade. Spatially, the internal clear area of this gate is an irregular octagon (Figure 9, C) that is spanned by a dome (Figure 9, B) touching its longer edges over a distance of 9.3 m. The vertices of the octagon are defined by eight piers that rise to form, two vaults laterally and two arch-ribs longitudinally, along the longer edges of 4.8 m each. Four pendentives are formed along the shorter edges of 2.7 m each. These support the large dome overhead while along the transverse direction, smaller stone columns support a mezzanine spanning the length of the vault. The significant transverse depth of the gate, largely of solid masonry, accommodates any lateral thrust.

The presence of the pendentives in this system, illustrates a magnified, finer resolved version of the sub-system described earlier for the cells. Here, all walls in the cells are replaced by piers, and their corners, by the shorter edges of the octagon. This is a visible sign of structural respect warranted by the threefold span. Again, structural reliability of the pendentives has been employed; this also minimizes threat to structural safety through equitable distribution of stresses.

Examination of the intersection with the arcade system reveals the use of a combination of a segmental dome, which is a three-dimensional composite element and dual piers at each end (Figure 9, A) of spans of 4.8 m (gate octagon) and 8.3 m (arcade). The dimensions of the pier sections designed in the octagon are roughly 1.1 m square, qualifying the extra load taken by them from the arcade arch. The horizontal thrust of the arch-rib of the arcade is directed vertically over the curved surface of the segmental dome that links the two differently sized arches. This intersection thus demonstrates an elimination of unbalanced thrusts, arising in two very different structural systems.

Apart from the Lahore Gate, it is also noteworthy that the opposite gateway to the east the “Darwaza-i-Chatta-Chowk”, responds to safety in massing. This is done by sinking the floor above the dome to make the roof light (Figure 10), a balance between smaller span, lower rise of its dome and dead-load of roof.

3.6 Salient aspects in construction

Formal aspects in structural values in Chatta Chowk Bazaar are reinforced by certain very significant built-in values in construction. These are the links to the building’s stability, durability and timelessness.

Along with secondary technical sources, the primary information on construction was extracted from exposed parts of the building’s fabric itself. As mentioned earlier, the hunting lodge at Jaunti, a technological contemporary to Chatta Chowk Bazaar, was used as a resource to understand construction through its exposed details.

Though the discussion on this aspect is limited by sources of information, logical conjectures were drawn to answer questions of longevity and durability of the building’s fabric. As mentioned earlier, the Bazaar is, with rare exceptions, a compressive brick masonry structure. Two observations described
below, one about purely compressive elements and the other about composite elements, indicate the historic durability of this building’s fabric vis-à-vis brick construction.

In walls and piers of the Chatta Bazaar, brick coursing in the core is very different from what it appears to be on the surface. An interlaced coursing system is followed that avoids both vertical as well as horizontal joints (Figure 11).

Such brick coursing to form walls or piers of the different sizes mentioned earlier, makes these structural elements behave as conceivable monoliths when loaded vertically, thus making them extremely stable.

With reference to floors, domes and pendentives, a consistently alternating radial pattern is followed in brickwork. In floors, the smallest faces extend outward (Figure 12), causing contact of the largest faces to form flat arches; in domes, they are radially laid, each course at a time along the largest face – a method that eliminates formwork. In pendentives, they are interlaced, similar to that in the walls.

In such coursing also, a high degree of stiffness is achieved in each structural element, intrinsically and presumably, in their interfaces, or in subsystems. These coursing patterns ensure substantial structural safety due to a distributed load transfer that takes place from one structural element to another.

4 VALUES CURRENTLY THREATENED

In spite of the values as explained above, the Bazaar is currently endangered by interventions arising from lack of information about these. Observations of the alterations that have occurred in this building indicate a lack of knowledge of significance.

While the implications on the structure per se are not visible, the building lacks severe structural cracks or deflections as yet; they may be anticipated if these practices continue. It is essential to see what these issues are at this juncture, given the significance of the building.

Though the logic for its use has changed over its three hundred and fifty odd years of history, it has functionally more or less served as a covered market street in its lower storey. A marked transformation in use of the building was the housing of soldiers on the upper floors, both in pre-independence (1857–1911) and post-independence times (1947–2003).

The introduction of new masonry viz. walling of the balconies facing the street to form rooms, building of bathrooms and toilets on the first-floor terraces (Figure 13, B) were some consequences of this.

Toilets were also introduced in the southern part of the building at the octagon on the first floor, mentioned earlier to be a structurally vulnerable area, consequently leading to the collapse of the arches on the ground floor (Figure 13, A).

A major periodic intervention is the annual renewal of the tar layer covering the arcade’s central street as well as on the exterior of the building, catering to the national Independence Day celebration that happens atop the Lahore Gate. Due to this, the shallow platform, traditionally used as a seat for the shopkeepers, is almost flushed with the ground today, suggesting no less than 450 mm. of rise in level. In addition to this, the roof of the entire structure was covered with tar-felt in 1911–12. The use of the upper floors as soldiers’ quarters caused puncturing of windows through the
external historic walls (Figure 14, A). Since 1992, foliated arches that form the shop openings were also gradually walled for signboards.

Electrical interventions have been the most marked where ceiling fans and other such fixtures have been hung from tubular steel rods that puncture the pendentives in the cells on the first floor. In some cases, the buttressing wall has also been punctured to link two or more cells from the inside.

Apart from the synthetic interventions mentioned above, the southeast corner of the building is also threatened by roots of a large tree that has grown into the wall (Figure 14, B).

5 CONCLUSIONS

The Chatta Chowk Bazaar today is an expression of a unique technological memory. Historically conceived and built with cognizance of processes, techniques and systems evolved and perfected over time, it is also significant in its geographical (here, Indian) context by being a lone example of a building type. This typological significance was achieved through the architect’s knowledge of the structural and construction systems, amongst other things, that could make this architecture not just possible, but also durable and timeless.

For substantive knowledge generation as explained above, the Chatta Chowk Bazaar and its context on the ground were used as resources to firstly inform its typological significance and then extend it to include structural values. It substantiates how the building’s values are linked to the contemporary need for its safety and the safety of its users. The issues also indicate that the practices that undermine the Bazaar’s typological significance as a historic mall also undermine its safety because of this significance embodying numerous structural values.

The above definition of significance notwithstanding, the scope for further enquiry is immense and will contribute further to the body of knowledge about Chatta Chowk Bazaar. This building is an irreplaceable and timeless resource in this regard and will have to be treated with its due respect. The knowledge systems approach has helped acknowledge the value of this resource comprehensively and direct an attitude for best practices in the future.

In the debate between safety and significance, cases like Chatta Chowk illustrate that they are actually sides of the same coin. The most effective route to achieve safety in such outstanding knowledge systems, is thus through authentic structural conservation, informed by a systematic method to generate knowledge, given the significance of these structures.

ACKNOWLEDGEMENTS

The author immensely thanks Prof. Nalini Thakur, School of Planning and Architecture (SPA), for critical guidance, encouragement and contribution in the work on which this paper is based, especially on using the Knowledge Systems approach that greatly helped the studies. Sessions with co-faculty of studio, Ar. Sanjay Bharadwaj, Morphogenesis, Delhi and on site resource person, Ar. Rachna Vishwanathan were also instrumental in guiding the documentation and analyses. The Archaeological Survey of India (Delhi Circle) and the Chatta Chowk Bazaar Traders’ Welfare Association were very helpful and cooperative during the site work. Further, the author thanks all his colleagues who worked on this project, batch of 2006–08, Masters in Architectural Conservation, SPA: Allahyar Allahyari, Bhavesh Patel, Moinak Bose, Muzakkir Bijli, Sidharth Roy & Sonal Chitnis.

REFERENCES