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EXPERIMENTAL INVESTIGATIONS ON DETERIORATION OF HISTORIC BRICKS FROM SELECTED MUGHAL MONUMENTS OF KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT
Over the years, buildings made of bricks and other porous materials suffer physical and chemical damage while exposed to weathering. Deterioration then occurs due to various intrinsic and extrinsic factors and urban environmental damage is very extensive, altering material's form. The Mughal monuments in the Khyber Pakhtunkhwa Province of Pakistan are exposed to similar environmental threats and is an experimental ground of inadequate conservation due to which these historic structures are rapidly and irreversibly decaying. This work is based on the study and analysis of various brick samples from selected monuments. Many of its elements and features are vanishing with time as observed at various locations. It is therefore necessary to develop a conservation strategy for these monuments by characterizing the materials, identifying the environmental impacts, and evaluating/developing the conservation scenarios for the preservation of this irreplaceable heritage asset.
Keywords: Heritage; Historical buildings; Bricks; Physical, chemical, and biological weathering.

INTRODUCTION
Many deteriorating processes that afflict historic buildings are further amplified by harsh environmental variables that have an impact on their resilience and preservation (Charola, 2000). Clay brick has been the main and most traditional building material utilized throughout history. Historic city walls, culverts, bridges, brick slings on roads, building facades and streets, and arches are a few examples. New ideas for burned bricks have developed throughout time, and they have been shown to be more durable and weather-resistant in states with harsh climates than the original sun-dried brickwork (Kornmann, 1986).

The Mughal emperor left monuments with a distinct and enduring aesthetic legacy. Burnt clay brick and multicolored materials were utilized to construct structures during the early Mughal era, while pink, white, and red sandstone were employed in late Mughal architectural works. A crucial balance between the heavy structure and the light and translucent screen walls were preserved in both instances by the architecture. In Mughal architecture, proportion, balance, and symmetry played key roles as structuring principles. The typical Mughal brick is 8 inches by 4 inches by 13 and has lime mortar that is almost an inch thick. Since it provided a smooth and durable foundation for the finishing, rich gypsum plaster was utilized in Mughal architecture.

Due to ravages of time, poor management, lack of awareness, and inadequate conservation knowledge, archaeological sites all throughout Pakistan are degrading severely. It is heartbreaking to think that the beautiful structures and architectural wonders all around us will vanish overnight. As a result, many priceless artifacts from the past have entirely vanished and will never be found. The majority of those still standing have been relegated to serving as

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favorite hangouts for school youngsters, a small number of picnicking families, and the smaller number of tourists.

Even though the Mughal monuments in Khyber Pakhtunkhwa have been the subject of much investigation, their bricks state has not been fully examined. For instance, the existing method of restoring damaged bricks in a Mughal monument involves replacing them with new ones, which uses up a lot of resources, deters tourists from visiting deteriorating buildings, and, most significantly, compromises the authenticity of the monument. As a result, different environmental and other aspects were not examined in earlier investigations. There have never been enough research-based conservation measures in Pakistan.

Since the history and significance of Mughal architecture have already been the subject of numerous books (Alfieri and Borromeo, 2000; Ardalan and Bakhtiar, 1999; Brown, 2013; Dani, 1995; Foster, 2004; Frishman, Khan, and Al-Asad, 2002; Hussain, 1998), it is sufficient to concentrate on those works that are specifically relevant to the monuments from the Mughal period. The most significant of them are Shah's writings from 1996, 1997, and 1999. Older research on the issue includes a record by Jaffar (1940) from the middle of the 20th century.

This study was aimed to focus on deterioration mechanisms of brick at the archaeological monuments varying in their respective geographical and historical context. These archaeological monuments are not only of utmost importance at the national level but a few of them have significant historical value.

REVIEW OF LITERATURE

Materials gradually alter in physical and chemical properties with age, and this is a widespread occurrence seen all around the globe. Porous materials were often employed in the past because they were accessible and simple to deal with.

During the Mughal era in Pakistan, glazed tiles were extensively used as an ornamental technique for grand buildings. For Mughal structures in Pakistan, one of the often-employed ornamental methods was glazing tiles. Researchers looked through colored tile fragments from Jahangir's tomb to figure out the glaze's composition and the colouring processes that were in use at the time. Light microanalysis, SEM-EDS (scanning electron microscopy with energy dispersive X-ray analysis), Raman spectroscopy (RS), and electron microprobe analysis (EMPA) were all used in the investigation. The samples were recognized as plant-ash-based alkali glazes thanks to the complimentary analytical techniques. The results show that lead-tin yellow type II was used to produce yellow glazes, copper and cobalt were used to produce blue glazes, yellow and blue glazes were combined to produce green glazes, and manganese was used to produce purple glazes (Gulzar et al; 2013).

Materials used in conservation of Shish Mahal, where dampness on the walls was attributed to exposure to weather conditions. Mortar erosion in different places of the masonry joints was also observed, leading to the deterioration of bricks due to water penetration, moisture concentration, plant growth, and salt crystallization. The use of inappropriate materials and inadequate restoration worsened the situation. Poor drainage was also identified as a major cause of brick deterioration during the rainy season, with water collecting along the walls and promoting unwanted plant growth. To restore Shish Mahal's walls to their original condition, bricks of the same size and strength as those used by the Mughals should be manufactured with care, considering the choice of raw materials, and burning process, and managed by skilled workers (Kamran, 2015).

METHODOLOGY

The methodology employed was to conduct systematic archival research followed by surveying the fieldwork sites and to pinpoint key types of deterioration present in these Mughal monuments. To gather information about the factors causing and contributing to the deterioration, a plan of chemical and physical characterization and non-destructive testing of the building materials, particularly historic bricks, and monitoring and visual inspections at the site was implemented. The findings enabled guidelines to be made about the handling of these monuments and the individual monuments treatment, and they are applicable to other historic buildings made of bricks that are likely to deteriorate in a similar manner.

SITE SELECTION

Gor Khatri Archaeological Complex

A fortified complex of 160x160 square meters with two noticeable gateways—one in the east and one in the west Gor Khatri is situated on one of the highest points on a hill on the Southeast side of the city. The Mughal era, which is the most considerable time, may be divided into two primary periods: before and after the building of the caravanserai in 1641. When Babar, the great conqueror, traveled through this location in 1526 on his way from Uzbekistan to Kabul, he noted its importance in his memoirs, The Tozuk.

Dilazak Tomb (Shaikh Qutb-ad-Din's Tomb)

One of Peshawar's oldest Mughal religious monuments is the tomb of Shaikh Qutb-ab-din. (Rahman, 1984). On the Peshawar-Dilazak Road, in the community of Gumbad Killi. The tomb was formerly elevated on a twelve by 12-meter platform, but it is now level with the ground. The tomb is 14.30 meters tall and is constructed of solid brick and lime plaster. The tomb has three levels, the lowest of which is octagonal, the center of which is a sixteen-sided drum of the second floor, and the top of which is a modest hemispherical dome made of a single shell.

Guli Bagh (Tomb of Sultan Mehmood Khurd)

The mausoleum was constructed during the lifetime of Sultan Mahmud Khurd, the last Turk to govern Pakhli after his father, Sultan Shadman Khan, died during Shahjahan's reign. With a total covered size of 5.5 by three miles, the fort was comparable to the other Mughal forts. (Rehman 1989). The structure is a unique landmark and the only instance of Muslim tomb construction in the vicinity (Shakir, 2017).The bricks are a different size from standard Waziri bricks (Fazal & Shakir, 2014).

Mahabat Khan Mosque

The mosque was constructed in 1670 AD by Mahabat Khan, the governor of the Peshawar Valley, during the reign of the Mughal Emperor Shah Jehan. It bears the name of Nawab Mahabat Khan, the governor of Peshawar during the reigns of Shah Jehan and Aurangzeb and the grandson of Nawab Dadan Khan. A large prayer hall is located on the western side of the courtyard, with a series of chambers on each side and a cold blue ablution pond in the center. (Shah, I. 1999) The interior of most of the halls are richly decorated with floral art and Islamic calligraphy. Lime surkhi mortar was used to elevate the masonry in brick. Brick dust, tiny smash stone, and jute are the ingredients that make up plaster (Shah, 1996;1997).

Figure 1: Map of selected cities for Mughal monuments across Khyber Pakhtunkhwa (Source: Wikimedia, 2023).

Following preliminary field surveys, in May 2021 the historic structures visual examination analysis started. Historic materials in situ were analysed by macroscopic analysis. The nature of various historic materials, such as paints, stones, bricks, motors and plasters were studied and identified. The mudbricks, motors eristics of the historic fabric was thoroughly examined, including all factors such as colors, textures, and types. The initial errors caused by deteriorated building surfaces, the macroscopic inspection was carried out in two stages (2021 & 2022); the initial phase was to selection and categorization of the materials, its basic feature was then explained with the verification stage. A representative sampling of each monument for further micro analysis required the macroscopic identification of the material types.

To conduct effective conservation interventions, condition assessment is a fundamental step within the field of archaeological conservation. In this study, apart from hardness and water absorption no other testing or analysis for the repair of historic bricks and mortar was performed. The most basic reason is that most tests and analyses take time, require instrumentation and interpretation, and necessitate destructive sampling, which must be restored. This framework is intended to be quick, and the testing requirements are a disadvantage. Other testing and analysis are inappropriate for this study for other reasons. Because durability and compatibility are intricate physical properties that interact with the substrate, therefore, testing of mortar cannot directly reveal either.

To gain an overview inside the conservation area of the preservation, the condition of the chosen building was only evaluated regarding its facades. Additionally, this analysis enables explicit suggestions to be made in accordance with several factors, leading to a general statement of the significance of culture.

Figure 2: Field Surveys and Sample Collection from various monuments across Khyber Pakhtunkhwa.

RESULTS & DISCUSSION

Bricks morphological and chemical composition

The microstructure of bricks was analysed by Scanning Electron Microscope (SEM). Figure 1 displays the SEM images of bricks samples collected site from Khyber Pakhtunkhwa province of Pakistan. (a) SEM micrograph of Dilazak Tomb (east) named DT-02. The image reveals that bricks used in Dilazak Tomb showed macropores due to deterioration, (b) SEM micrograph of from Gor Khatri Archaeological complex (west) named GK-01. Micrograph reveals that some scaling appears on the surface of the bricks due to incrustations, (c) SEM micrograph of Mahabat Khan Mosque (North) named MMK-01. Like above some deposits are shown on the surface of brick sample while (d) SEM micrograph of Guli Bagh (South) named GB-01displays larger voids and scaling on the brick surface. Raw minerals displayed various states of decomposition depending on the dimension of the grains in the groundmass, which was highly dense (sintered) and reactive. Reaction rims were frequently present, where new silicates were formed. Carbonate relicts were also present, although the high degree of textural evolution which suggested high temperature was reached during firing.

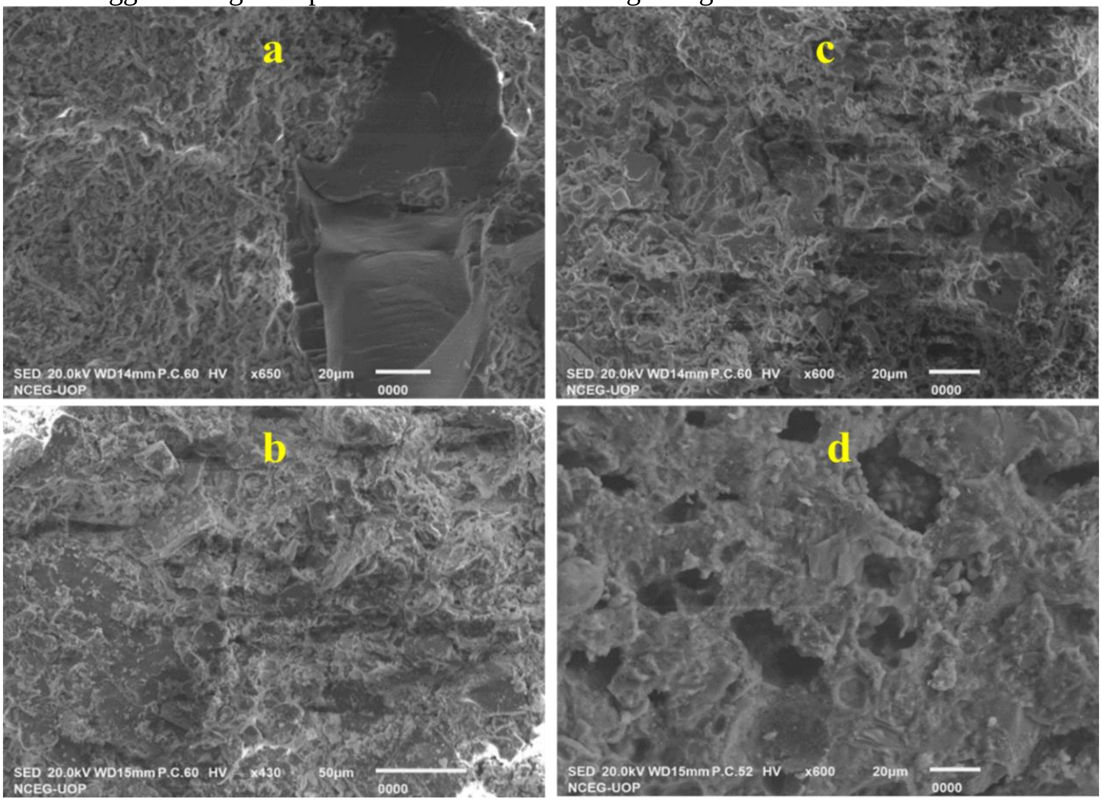
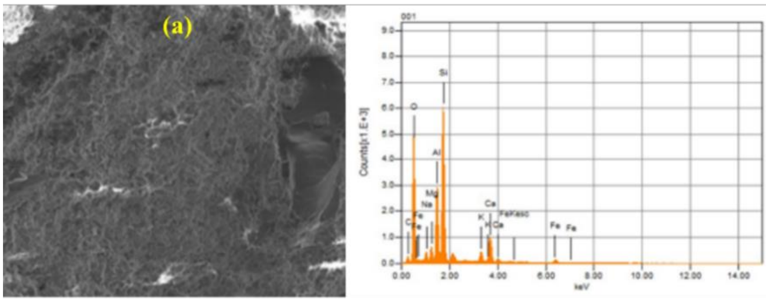
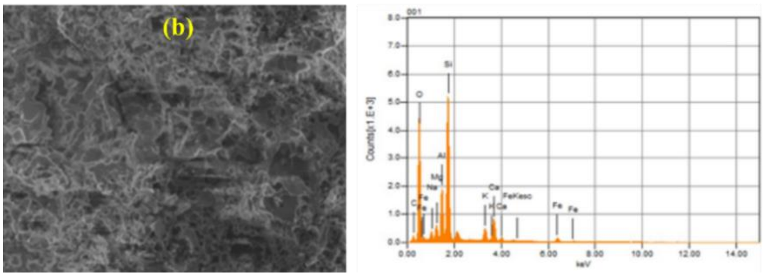


Figure 1: displays the images of bricks samples collected site from Khyber Pakhtunkhwa province of Pakistan. (a) SEM micrograph of Dilazak Tomb (east) named DT-02. (b) SEM micrograph of from Gor Khatri complex (west) named GK-01. (c) SEM micrograph of Mahabat Khan Mosque (North) named MMK-01. (d) SEM micrograph of Guli Bagh (South) named GB-01.

To understand the textural and mineralogical changes, EDS analysis of bricks was conducted by spot analysis at various locations. Figure 2 shows the EDX analysis of the brick's samples taken from Khyber Pakhtunkhwa province of Pakistan. (a) EDX analysis of sample taken from Dilazak Tomb (east) named DT-02. Chemical composition of bricks taken from Dilazak Tomb showed 17.81% Si which reveals that clay used to make these bricks contains higher amounts of silicon. Al, Ca, K and C were also in considerable quantities, oxygen being the highest in quantity up to 53.25%. While in (b) EDX analysis of sample taken from Gor Khatri Archaeological complex (west) named GK-01. These bricks of Gor Khatri Archaeological complex contain mineral salts like Si, Ca, Mg, Fe along with C were higher than Dilazak Tomb. Presence of mineral salts in the brick samples including silica, Alumina, Iron etc. has been verified by SEM analysis. Moreover, during the firing of clays containing carbonate grains (calcareous clays) produces carbonates and calcite as a result of lime carbonation “lumps” produced



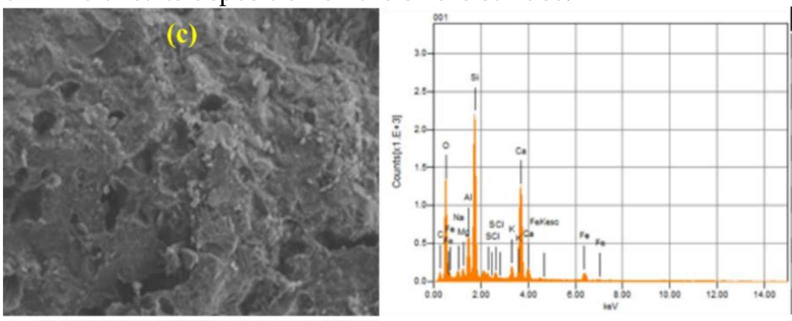
Elements	Mass%
C	7.74
O	53.25
Na	1.62
Mg	1.63
Al	8.79
Si	17.81
K	2.05
Ca	5.12
Fe	1.98



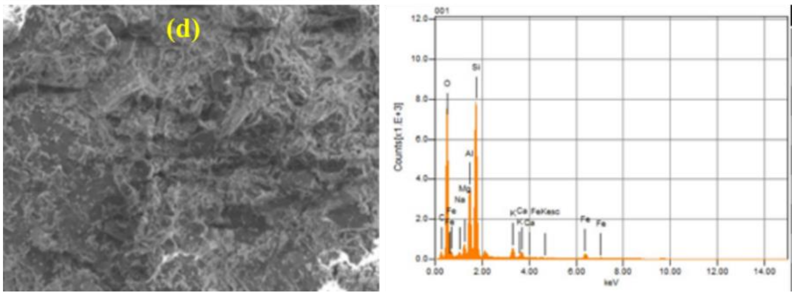
Elements	Mass%
C	7.03
O	54.12
Na	1.76
Mg	2.06
Al	6.53
Si	18.43
K	2.57
Ca	4.87
Fe	2.64

Figure 2: shows the EDX analysis of the brick's samples taken from Khyber Pakhtunkhwa province of Pakistan. (a) EDX analysis of sample taken from Dilazak Tomb (east) named DT-02. (b) EDX analysis of sample taken from Gor Khatri Archeological complex (west) named GK-01

Figure 3 (c) also show the EDX analysis of the brick's samples taken from Khyber Pakhtunkhwa province of Pakistan. (c) EDX analysis of sample taken from Mahabat Khan Mosque (North) named MMK-01. These bricks samples contain 7% C, up to 48% O, up to 16% Si, while Ca is up to 17% with 4.16% Fe contents. While (d) EDX analysis of sample taken from Guli Bagh (South) named BG-01. Similarly mineral salts with somehow same quantity are present in bricks samples taken from Guli Bagh. According to analysis it can be concluded that all the bricks were synthesized from the clay containing mineral salts like Si, Ca, Fe, K, C and Al in considerable amounts. SEM micrographs of these samples also wetted the presence of mineral salts deposition on the bricks surface.



Elements	Mass%
C	7.03
O	47.87
Na	1.13
Mg	1.07
Al	4.36
Si	15.79
S	0.37
Cl	0.81
K	1.80
Ca	16.61
Fe	4.16



Elements	Mass%
C	8.48
O	56.15
Na	0.77
Mg	1.50
Al	8.33
Si	18.73
K	1.97
Ca	1.09
Fe	3.00

Figure 3: (c) EDX analysis of sample taken from Mahabat Khan Mosque (North) named MMK-01. (d) EDX analysis of sample taken from Guli Bagh (South) named GB-01.

Strength testing

The scatter of old bricks makes it challenging to assess their mechanical strength. In addition, they may deteriorate because of environmental factors or chemical agents like soluble salts, ice-thawing cycles, or load-unload cycles. The sample's dimensions and moisture content, the boundary conditions, the temperature, and other experimental setup factors can also affect the outcomes of an experiment. Old clay bricks compressive strength is typically reported with values spanning a wide range (from 4 to 32N/mm2). The compressive strength showed significant variability, with coefficients of variation reaching 50%. It is possible to see that the dispersion is higher in the bricks with lower fc. Between 6.7 and 21.8 N/mm2 of strengths were found, with an average of 11.6 N/mm2 for the entire sample and 8.3 N/mm2 for the four weakest bricks.

The elastic modulus is another important mechanical parameter. Even though most standards recommend using the linear portion in the range of 10% to 50% of the maximum stress value of the stress strain curve, which is also characterized by a large variability, it is not always clear how authors measured the values presented. The values noticed fall between 1 and 18GPa, or 125 and 1400 fc, where fc stands for compressive strength.

Due to the various shapes, materials, manufacturing processes, and number of perforations, it is challenging to relate the masonry unit's tensile strength to its compressive strength. In-depth testing for the clay longitudinal tensile strength, calcium-silicate, and the results showed that the ratio of tensile to compressive strength ranged from 0.03 to 0.10.

Table 1: Compressive strength of waziri bricks from Khyber Pakhtunkhwa.

To:		Tehmash Khan								
Our Ref. No.		NICE/STR/							Testing Date:	November 26, 2022
Your Ref. No.		Nil							Receiving Date:	November 24, 2022
Testing Standard:		ASTM C67-16								
Compression Test Report										
Historic Bricks from various Archaeological Monuments										
Specimen Received on:		November 24, 2022				**Tested on:**	November 26, 2022			
Sr.No	**Mark**	**Sampling Date DD/MM/YYYY**	**Length (mm)**	**Width (mm)**	**Height (mm)**	**Weight (kg)**	**Area of x-section (mm^2)**	**Ultimate Load (KN)**	**Ultimate Stress (Mpa)**	**Ultimate Stress (Psi)**
1	GB-04	13/11/2022	220	120	30	1.418	26400	238.9	9	1305
2	MMK-03	11/11/2022	220	120	30	1.418	26400	267.5	10.1	1465
3	DT-02	11/11/2022	220	120	30	1.418	26400	226.3	8.6	1247
4	GK-03	11/11/2022	220	120	30	1.418	26400	245.5	9.3	1349

For the historic bricks, the load against displacement graphs typically displayed a period of linear behaviour followed by a collapse. As a result, they were classified as brittle materials that break quickly after reaching their elastic limit. The load against displacement graphs for the brick samples frequently progressed in stages, with the load rising initially, then slightly falling, and then increasing again before beginning. This corresponds to the sudden spread of cracks through the bricks. There was a significant spread in the strength measured for some of the samples, according to the complete results for all the samples, which are presented in Table 1. For instance, the tensile strength of the four samples from Khyber Pakhtunkhwa ranged from 8.6 to 10.1 MPa. The samples that failed quickly typically had cracks that were visible before testing, whereas the samples for which higher strengths were measured did not have any cracks that could be seen. Given that historic brick would be anticipated to be weaker, the tensile strength values obtained here were rather high. The tensile strength of modern brick is typically in the range of 3.7-4.5 MPa. The compressive strengths that were calculated were also high. As a result, it was determined that the bricks' strength was compatible with that of the well-graded mortar, which meant that they would typically experience comparable distortion from loading and fail at the same location.

The characteristics of the constituents that make up brick masonry have a significant impact on those characteristics on the brick masonry. Traditional masonry is subjected to compressive stresses, and the compressive strength of masonry in the normal direction to the joints of bed is necessary for design and safety assessment purposes. Experimentally, it is possible to achieve this property in accordance with European Standard EN 1052-1.

The interaction between units and mortar is the main factor controlling compressive failure in masonry. The unit's and mortar's different elastic properties are an important consideration. The difference in stiffness results in a state of stress that is characterized by compression/biaxial tension of the units and triaxial compression of the mortar, assuming compatibility in the deformation of the components and a mortar that is more deformable than the units. This phenomenon was described in the pioneer work of Hilsdorf, who also developed an equilibrium approach to anticipate the strength of the masonry, presuming that mortar failure also occurs in the presence of masonry failure. Later, a limit strain criterion based on the lateral strain displayed by brick units at failure is taken into consideration to disprove this hypothesis.

Water absorption tests

The bond between bricks and mortar, the resistance of bricks to freezing and thawing, and the chemical stability of bricks are all significantly influenced by the porosity, permeability, and absorption of bricks.

The values at a given porosity can differ significantly from one another. Water absorption coefficient values for specimens with compressive strengths greater than 9 MPa were less than 50 g/m2s 0.5. There are the same number of pores inside the samples after 24 hours of soaking in the pore space that is not occupied with water. The porosity of the samples has no effect on this volume. This suggests that each batch of bricks from a particular source has unique properties in terms of compressive strength and the capacity of the material to absorb moisture through capillary rise. Additionally, the capillary rise phenomenon can be significantly impacted by brick flaws (cracks, voids, etc.). The experiment's results on the water absorption coefficient were unique and related individually to each brick.

The most common range of values for the sample bricks, which accounts for about 85% of the total number of brick specimens, is between 11% and 12%, (Table 2) even though the bricks were manufactured in various locations that are distant from one another geographically. Like this, 2 out of every 4 brick samples—or 85% of all brick specimens—have the water absorption value range that occurs most frequently, which is 12% to 13%. Regarding water absorption and porosity characteristics, it represents homogeneous manufacturing samples.

Given that the average compression strength is 2266 psi for mughal brick, which is higher than the standard compression strength required that is 2000 psi, and colonial brick's water absorption ranges from 12.33% to 14.7% with respect to its weight, which is in accordance with the standard required for first-class bricks, it can be concluded that the bricks used in Mughal monuments are more durable.

Table 2: Water Absorption Tests of bricks from Khyber Pakhtunkhwa

To:	Tehmash Khan	
Our Ref. No:	NICE/STR/	
Your Ref. No:	Nil	
Testing Standard:	BS 3921 : 1985	
Testing Date:	November 25, 2022	
Receiving Date:	November 24, 2022	
Water Absorption Test		
Historic Bricks from various Archaeological Monuments		
S.No	**Sample**	**24 Hour % Absorption**
1	DT-02	12.58
2	GB-01	12.63
3	GK-01	12.55
4	MMK-01	12.98

Note:
The above results pertain to the unsealed sample/s supplied to the laboratory. The laboratory does not accept any responsibility regarding the representativeness of provided samples for testing.

CONCLUSION

The Mughal monuments in Khyber Pakhtunkhwa and its potential for conservation are explored. Reviewing the research design and suggesting areas that merit more investigation. The suggested materials conservation strategy's main goal is to preserve and repair the cultural site's original historic fabric while using the fewest possible substitutes. Locally produced bricks were utilized in these monuments, and investigations have identified three main reasons of deterioration: manufacturing flaws, inadequate detailing, and intentional decay. In Pakistan, the old conventional manufacturing method is still in use in the brick sector, which has not developed (Amjad, 2000). Therefore, it is necessary to unite historic talent with improved modern technical interpretations to produce new bricks with the same compositions.

The thorough format-based documentation should come primarily, then all historic structures should have condition surveys done. The next phase in determining the specifications for the suggested conservation action plan will involve comparing the information that has been obtained with the data that has been recovered from the history of interventions. Along with the current state of each structure as documented in the baseline investigations, the proposed work and approach to maintaining the original character of the structures should be clearly shown in the documentation. To uphold the high standards of quality and accuracy set by the world community, these should be prepared under the direction of qualified and experienced individuals. The conservation and restoration procedures must be technically sound, guarantee reversibility, secure all original components, and be certified. The final and most important step should be the thorough documentation of the intended activity, including the specifications, method employed, and work performed. (Gulzar, 2012)

By defining the materials, identifying the deterioration processes, and designing the conservation plan to limit degradation under systematic process, the goal of this research was to develop a conservation strategy for the heritage sites of Khyber Pakhtunkhwa.

The research leads to the following findings:

i. There is a significant variety in the sizes, bearing capacity, water absorption, and quality of current bricks since brick makers are unaware of new techniques and technology.

ii. Efflorescence crystallization, which forms on the face of brickwork after a moisture effect, degrades the brickwork of modern buildings. The pricing and quality of bricks also vary significantly. The sizes of bricks that are readily available in the market are not in accordance with standards; they are frequently undersized or have had their sizes lowered, and they are sold for less money.

iii. Due to their endurance, it is advised that the bricks used in Mughal monuments be reused for restoration work on these buildings. We can also use modern bricks, which are made specifically using the right clay in accordance with specifications, long-lasting, and sustainable for high-quality brickwork in building construction.

iv. It is also advised that modern brick makers be made aware of the significance of appropriate soil selection, chemical makeup, and soil ingredient ratio. They should take the necessary measures to produce high-quality brick, such as maintaining the kiln's temperature.

v. The bricks of the Mughal structures have also suffered substantially from the impact of moisture inside the cross section of the bricks, which causes efflorescence to form on the worn-out brick work. Eliminating the sources of moisture will prevent and regulate the moisture-induced efflorescence. ure while the bricks are being fired, employing skilled and knowledgeable staff, utilizing salt-free water to prepare the clay, and using high-quality fuel to fire the bricks.

vi. Structures should be preserved just as they are. They should not be "improved" without sufficient reason, nor should they be returned to the state that is thought to have existed at some point in their history. A historic building's worth is derived in part from the fact that it preserves a record of the changes that have occurred throughout its history.

vii. Changes should be minimally implemented as possible. Any technique that is suggested for the consolidation of historical fabric should first be evaluated for effectiveness.

viii. If repairs must be undertaken, it is desirable to use the same materials used in the building's initial construction.
ix. If repairs are necessary, they should be planned and executed with eventual removal in mind. In fact, it will not always be able to perform modifications that are logically reversible.
x. The repairs must fit the style of the building. This is not to suggest that they must be made to look old—this is not at all advised—or that they must faithfully reproduce the building's original characteristics. If new materials are chosen for the repair, it is best if the design complements the original building's overall aesthetic.

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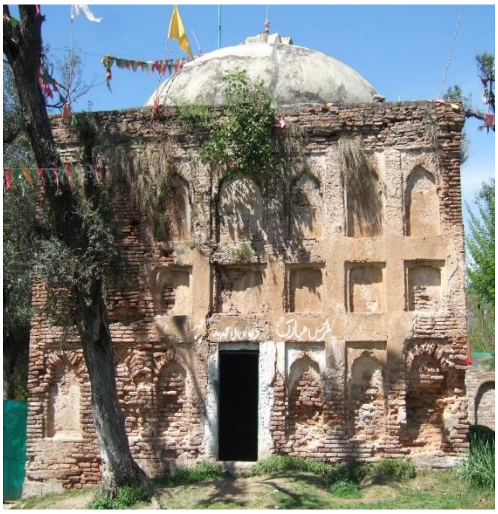
PLATES

Pl-I: Peshawar (Khyber Pakhtunkhwa): A view of standing monuments at Gor Khatri Complex.

Pl-II: Peshawar (Khyber Pakhtunkhwa): A general view of Mahabat Khan Mosque.

Pl-III: Peshawar (Khyber Pakhtunkhwa): A view of Shaikh Qutb-ad-Din's Tomb at Dilazak.



Pl-IV: Mansehra (Khyber Pakhtunkhwa): A view of Sultan Mehmood Khurd's Tomb from the western side.

FIGURES

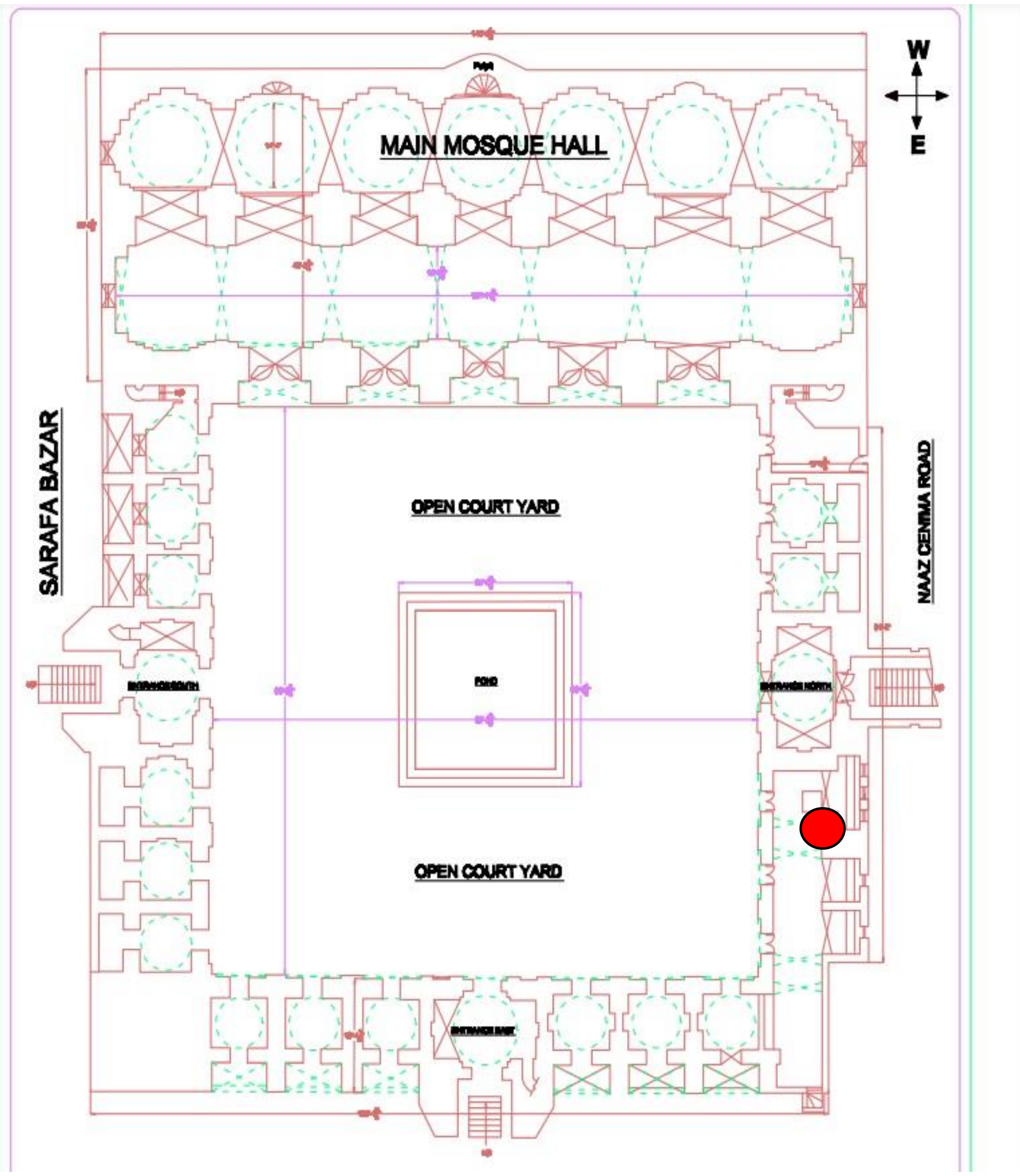


Figure.a: Mahabat Khan Mosque, Peshawar: Layout Plan and sampling area (encircled) (After DOAM KP, 2022)

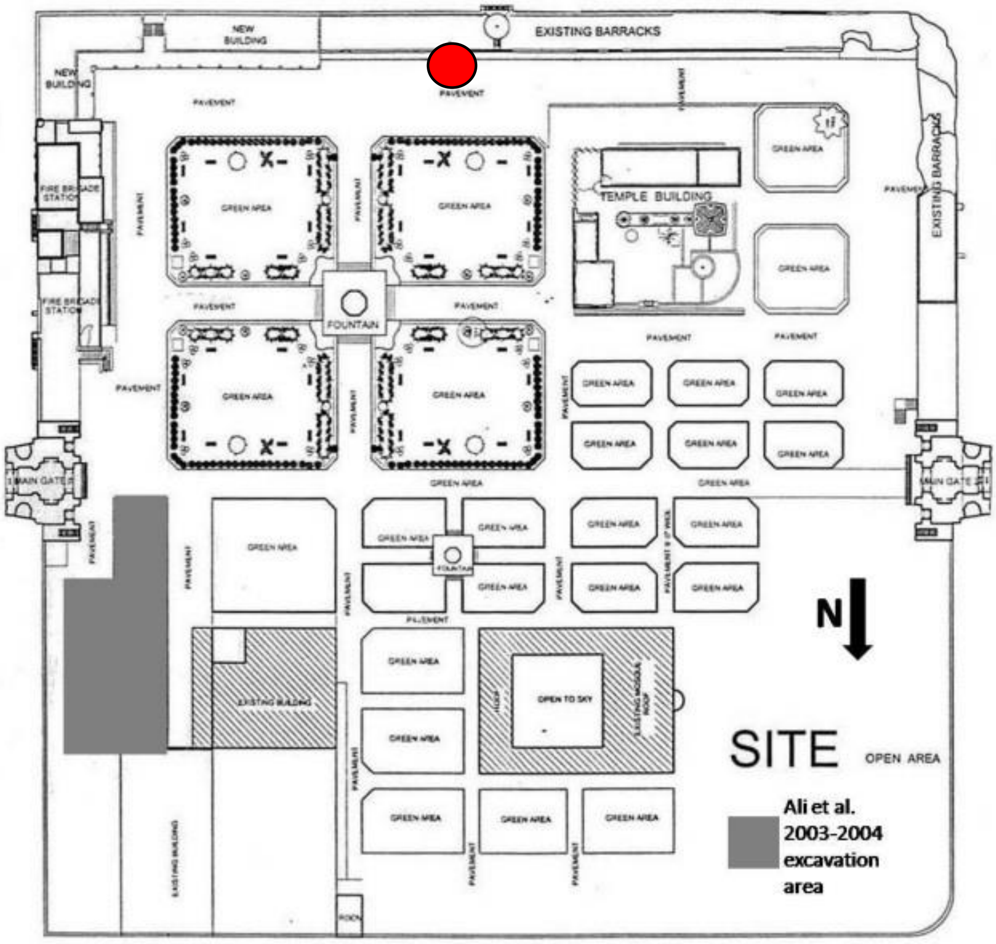


Figure.b: Gor Khatri Complex, Peshawar: Layout Plan and sampling area (encircled) (After Ali et al. 2005:271)

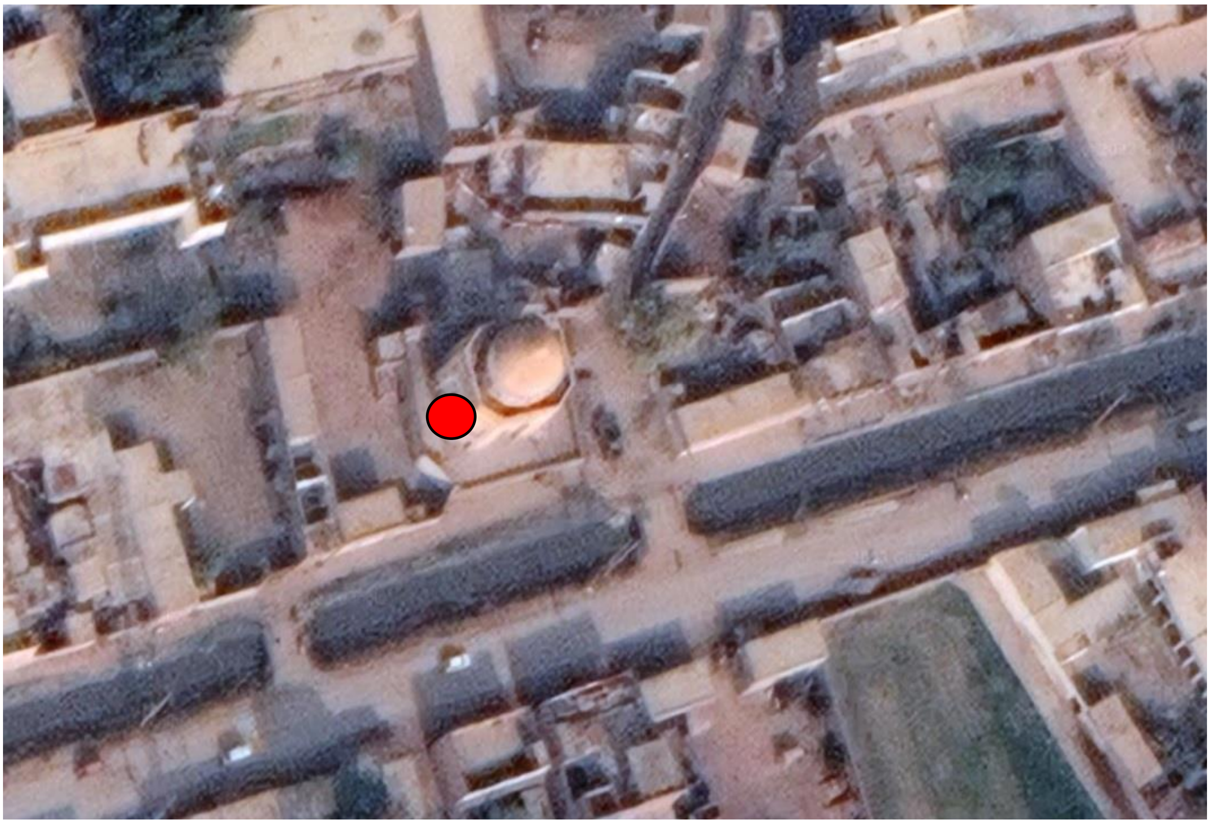
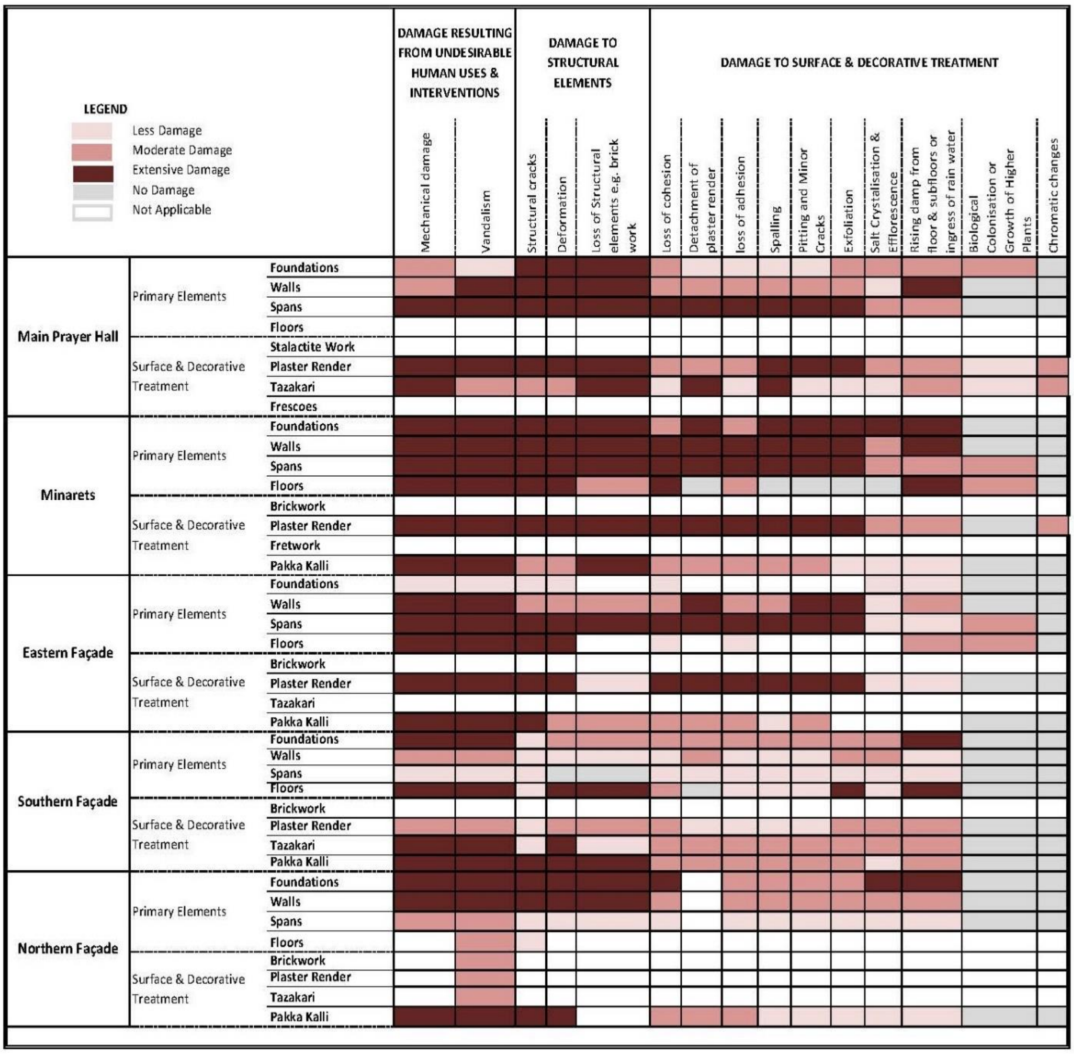


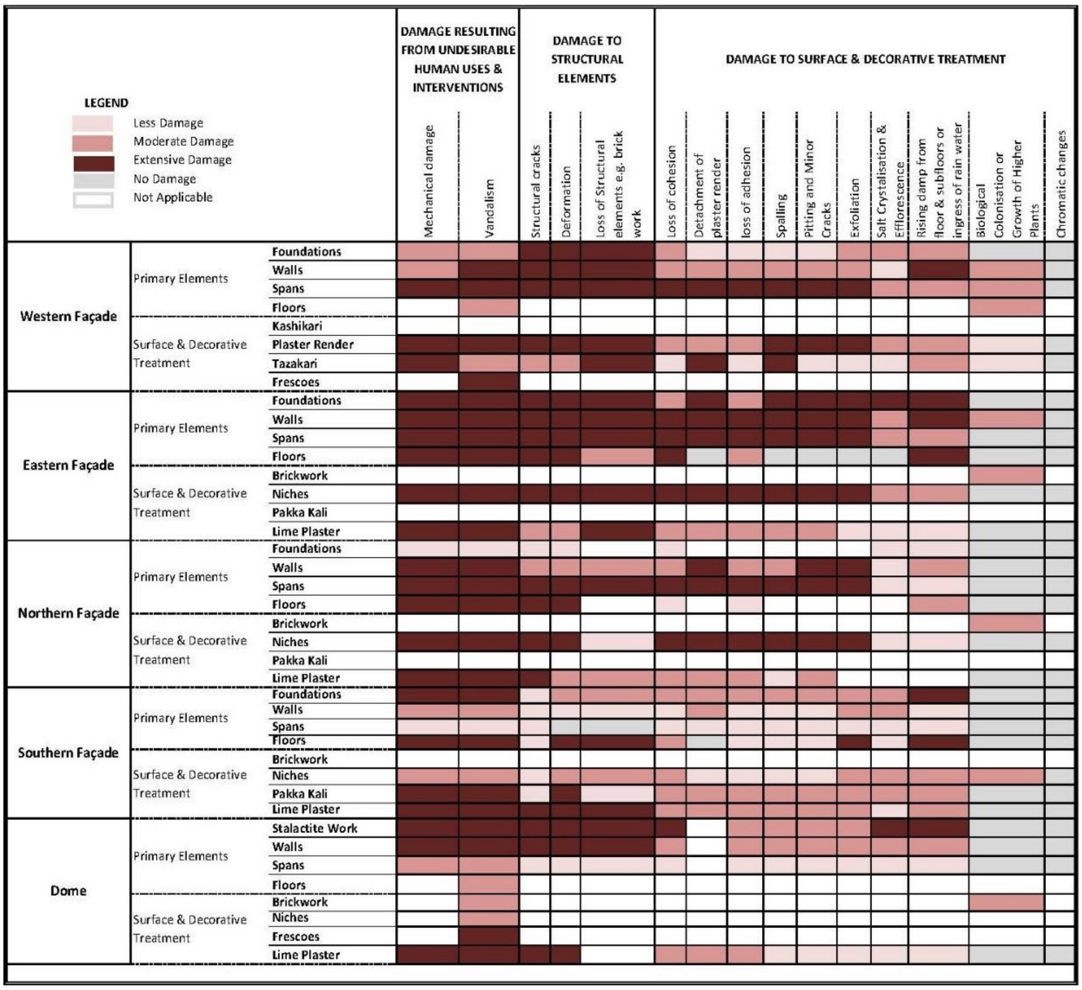
Figure.c: Dilazak Tomb, Peshawar: Layout Plan and sampling area (encircled) (After Google Maps, 2023)

Figure d: Guli Bagh, Mansehra: Layout Plan and sampling area (encircled) (After Google Maps, 2023)

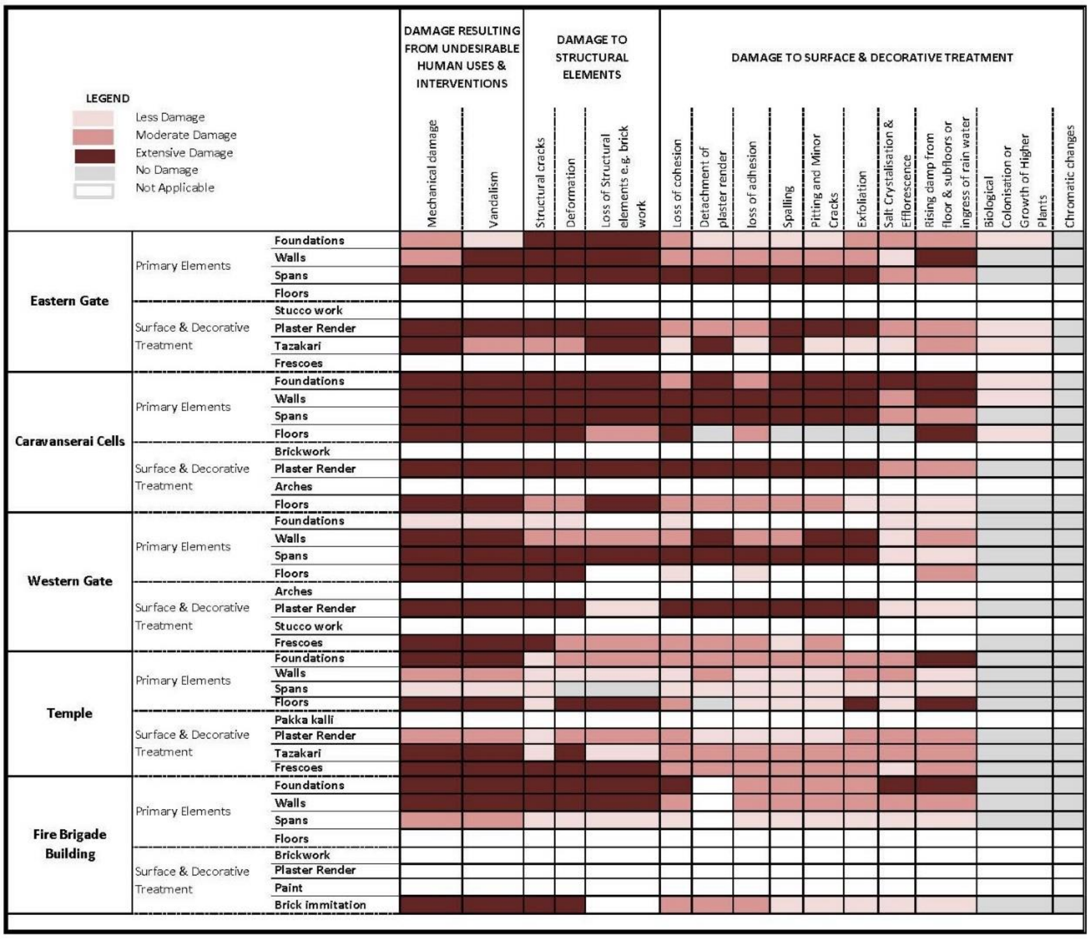
Appendix I: Condition Assessment/Weathering Forms of each Monument



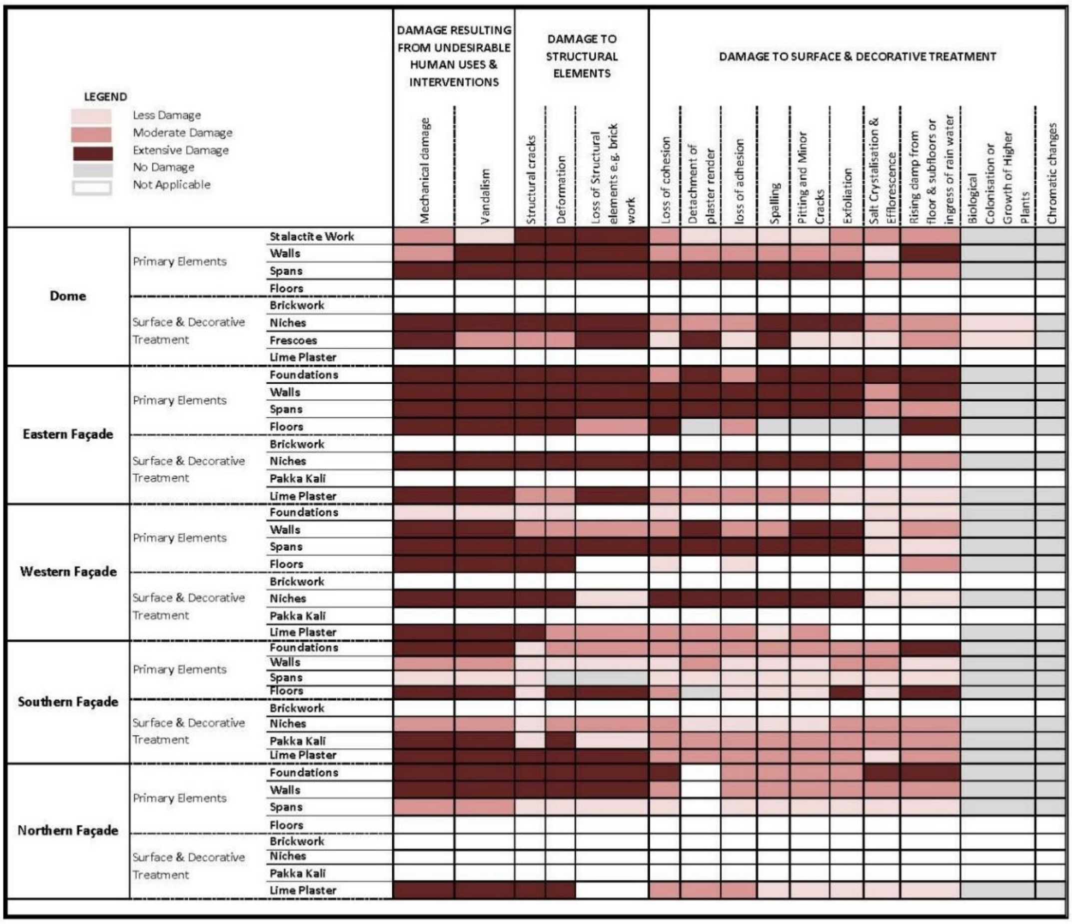
Documentation of Instances of damage, weathering, and deterioration. (Mahabat Khan Mosque, Peshawar)



Documentation of Instances of damage, weathering, and deterioration. (Guli Bagh, Mansehra)



Documentation of Instances of damage, weathering, and deterioration. (Gor Khatri Archaeological Complex, Peshawar)



Documentation of Instances of damage, weathering, and deterioration (Dilazak Tomb, Peshawar)