Pak. J. Engg. & Appl. Sci. Vol. 3 Jul 2008 (p.8 – 18)

Building Stone and State of Conservation of the Built Heritage of Pakistan

M. Y. Awan[1]

[1] *Department of Architecture, University of Engineering & Technology, Lahore, Pakistan*

Abstract

The conservation of Historic Monuments is a means of continuity of history as it keeps alive the cultural scene of that historic period to which it belongs. Pakistan is rich in a variety of built heritage and a large proportion of the valuable Heritage is the monuments built with stone.

All components of materials, used in the construction of historic buildings, can be categorized as being either organic or inorganic in nature/origin. Organic materials are derived from living things such as wood whereas inorganic materials are obtained from non-living substances such as stone and metal.

The Earth's crust is composed of minerals associated together to form rock. Certain of these minerals have attracted the artists / craftsmen from the earliest times, to use them in buildings and sculpture, because of their special qualities for fine work, e.g. hardness, texture, color and durability. Egyptians were the earliest people who used stone in large quantities in construction of monumental building. The Pyramids of Egypt are estimated to contain more than two million blocks of limestone, each weighing approximately 2.5 tones. Other important examples of the use of stone are Greek and Roman structures, Buddhist buildings etc. The massive and beautiful buildings built by the Mughals in India and Pakistan are examples from not too remote a past. Stone was considered to be so important that at one time all the quarries were in royal ownership.

This paper is basically focused on theoretical research regarding scientific knowledge of stone and its use in the buildings, which is essential to be understood, as all the conservation work rests upon it. The information given in this paper has been collected from already published literature on stone and duly referred. This scattered information has been put together for ready reference for the conservationists. Thus the paper provides, in an analytical way, all necessary information on Stone which was found in various pieces of literature. The paper also briefly discusses the Stone heritage of Pakistan and properties included in the list of World Heritage. It is found that 83% of these properties were built with stone. The paper further describes the State of conservation of built heritage in the country. It has been found that a significant part, more than 60%, of the built heritage belongs to stone. Thus the paper gives all the required basic information to the Stone conservationist.

Keywords: Stone; Rock; Minerals; sand stone; Lime Stone; Marble; Masonry Techniques; Built Heritage; Archaeology; Monuments; Conservation

1. Introduction

Stone is the oldest material used in the construction of buildings. With the help of this material monumental and durable architecture of the past had been produced. Due to the use of stone, a durable and lasting material, many of the centuries' old buildings are still surviving. There are numerous varieties of stone which are required to be understood and analyzed for the purpose of proper conservation of the historic buildings.

With regard to stone this paper is focused to collect, systematically arrange, analyze and provide necessary information on Stone. This is followed by description

Corresponding Author: M. Y. Awan (awan-yusuf@hotmail.com)

of Stone Heritage and State of Conservation in Pakistan. The paper provides useful and necessary information on Stone, its properties and classification. It further gives details such as, Common Minerals in Building Stone, Geological Classification of Stone, Scientific Classification of Stone and Determination of a Sample, Important Building Stones and Masonry Techniques.

The paper then discusses the Stone Heritage of Pakistan and provides information on the use of stone in construction of significant buildings of various historic periods. It follows a brief and comprehensive description of the State of Conservation of architectural and cultural heritage in Pakistan. At the end conclusions are drawn and references are provided.

2. Stone

Stone is basically a rock and rock is the name given to the mass of minerals that constitute the crust of the earth. Small pieces of this rock, as such used in building construction or for other purposes are generally referred to as stone.

2.1 Common Minerals in Building Stone:

Stone is inorganic material which is composed of one or more of the minerals such as Quartz, Feldspar, Mica, Amphibole, Pyroxene, Olivine, Garnet, Calcium carbonate etc. [1]. These minerals are now briefly described below with reference to their properties/characteristics required to be known to the conservationists, architects and structural engineers: [2]

(a) Quartz: Silica is much abundant in sand-stone and granite. It is white but often colored in various shades due to the presence of small amount of metallic oxide. Common sand is a form of quartz. Flint, Jasper, Agate and Chalcedony are different varieties of colored quartz. It cannot be scratched by steel.

(b) Feldspar: It is a silicate of aluminum, with silicate of sodium or potassium or a mixture of the two. Granite and other igneous rocks contain feldspar. It is often colored due to the presence of a small quantity of oxide of iron. When feldspar contains large proportion of calcium, potassium or sodium, it is liable to cause quicker decay. It can be cut by knife with great difficulty.

(c) Mica: It is composed of complex silicates. It has a perfect cleavage and splits rigidly into thin elastic leaves. Mica is a source of weakness, as it disintegrates quickly and stones containing over 2% mica are considered unsuitable for structural purposes.

(d) Hornblende: It is a very tough and heavy mineral and is usually present in igneous rock. It weathers fairly well.

(e) Calcium Carbonate ($CaCO_3$): This is the basic of limestone. It may occur as a cementing material of sand stone and shale.

(f) Gypsum ($CaSO_4.2H_2O$): This is Hydride calcium sulphate having Hardness 2 and Specific gravity 2.32

(g) Alumina (Al_3O_3): This is an oxide of aluminum combined with silica and is the chief constituent of clay.

(h) Kaolin (Al_2O_3 $2SiO_2.2H_2O$): This is pure white clay formed by the decomposition of feldspar.
The minerals chiefly composed of aluminum, potassium, calcium magnesium, or barium are frequently colorless, while those with much chromium, iron, manganese, cobalt, titanium, vanadium or copper are colored [3].

2.2 Geological Classification of Stone

All of the types of stone can be placed, into one of three big groups which form the primary classification of rocks: Igneous rock, sedimentary rock / stratified rock and metamorphic rock.

(a) Igneous Rock: Igneous rocks are formed by the rapid cooling of the lava / molten material from inside the earth and are volcanic in their origin. These rocks are generally crystalline, strong, non-porous, durable and very stable under a wide variety of conditions. Trap, granite, syenite, basalt etc. are igneous rock [2]. As a result of volcanic eruptions when lava comes out and cools rapidly, it forms glassy and finely crystalline rocks. Whereas lava cooled within the earth's crust forms coarsely crystalline rocks [4].

Igneous rocks therefore can be classified on two basis, Composition (What they are made of) and Texture (how big the crystals are). Deep seated igneous rock will be of coarsely crystalline nature and shallowly emplaced igneous rocks will be fine grained or at the extreme glassy. The feldspar determines the over all color of stone and the quartz makes the stone tough and intractable [5].

(b) Sedimentary Rock: Sedimentary rocks are formed by the consolidation of particles of decayed rocks, which have been deposited in layers by streams of

water. These layers are pressed down more and more through time, until the bottom layer slowly turns into rock. Limestone and sand stone are common examples of such rock. Others includes shale, conglomerate, gypsum etc. [2]. Sedimentary rock should always be placed in bed. Variation in colors of these stones is due to the presence of carbon or various compounds of iron [4].

Sedimentary rocks can be classified on the basis of their composition, grain size, color and their cementing material. The cementing material may be siliceous, calcareous or argillaceous. Three main types on the basis of their composition are as following: [5]

(i) Organic Sedimentary: Any accumulation of sedimentary debris is caused by organic processes. Many animals use calcium for shells, bones, and teeth. These bits of calcium can pile up on sea floor and accumulate into a thick enough layers to form an organic sedimentary rock.

(ii) Chemical Sedimentary: Many of these form when standing water evaporates, leaving dissolved minerals behind. Thick deposits of salt and gypsum can form due to repeated flooding and evaporation over long periods of time.

(iii) Clastic Sedimentary: These types are formed by accumulation of little pieces of broken rock, which have piled up and have been lithified by compaction and cementation.

(c) Metamorphic Rock: Metamorphic gets its name from "meta" (change) and "morph" (form). Metamorphic are either igneous or sedimentary in their origin. But these rocks become buried under the earth and owing to intense pressure and heat. They have undergone structural changes in their form and color. These rocks are hard and durable. Slate, marble, schist and gneiss are example of such rocks [2]. The resulting composition of rock depends on the original composition and on the type and intensity of metamorphism. The length of time that the rock is subjected to metamorphic processes determines the coarseness of the grain size, the longer the time the coarser the grain size [6].

The term marble and limestone are wrongly and commonly confused. In marble the calcite is re-crystallized to produce an interlocking granular mosaic of roughly equal sized calcite crystal. (Calcite is the name given to calcium carbonate when it is in crystal form.) No true marble will have fossils [6]. If samples of metamorphic rock are examined closely, it will be discovered how flattened and roughly aligned some of the grains in the rock are. Slate is sand free sediment, which has very fine grains, while the grain size increases respectively in phyllite, schist, and gneiss [5]. The following are a few metamorphic compositions: [5]

Table 1: Few metamorphic compositions

Parent Igneous or Sedimentary Rock	Metamorphic Equivalent
Sand stone	Quartzite
Lime stone	Marble
Shale	Slate
Basalt	Green stone

2.3 Scientific Classification of Stone

Building stones are also classified under the following categories, depending upon their composition: [2]

(a) Siliceous Stone: Where the base is silica e.g. sand stone, granite, trap etc.

(b) Argillaceous Stone: Where the base or principal constituent is clay e.g. slate, laterite etc.

(c) Calcareous Stone: Where the base is carbonate of lime e.g. limestone, marble, etc.

2.4 Determination of a Sample

The common question asked of a geologist by an architect is "what stone is it?" Rocks are aggregates of minerals and require Laboratory tests to determine the proportions of its constituents. There are a few simple observations and analyses, which may help the

architect to determine the type of stone, whether it is sand stone, marble or lime stone.

With a hand lens it is possible to decide whether the stone is igneous, sedimentary or metamorphic. However some igneous rock may be very fine grained and grain size may be too fine to be properly resolved with a hand lens. Sedimentary rocks have layers of deposited fine particles whereas metamorphic rocks have crystalline structure of roughly aligned grains of equal size. The granular structure of marble has sugary mass. This feature may be used as one of the criteria used to decide whether a stone is a marble or limestone [6]. A thin section of marble also allows light to enter in it but other stones will not. Scratching with a knife (blade of hardness H= C 5-1/2) will give an indication: Limestone will scratch but sandstone and most igneous rock will not [6].

A carbonate will be effervescence** when tested with 5 % Hydro Chloric Acid.

The effervescence indicates only that carbonate is present (a lime stone or marble). However a dolomitic limestone will show effervescence with 20 % HCl. Copper carbonate is green and magnesium carbonate is pink [6]. Although an architect with experience can determine the type of stone but a geologist is best person to determine geological and scientific classification of stone.

2.5 Important Building Stones

In Pakistan, mainly three types of stones have been used in historic buildings for architectural purpose, Sand Stone, Limestone and Marble. The semi precious stones used for decoration purpose (in the form of pietra-dura work) do not get decayed but are always affected due to willful destruction by human actions.

The characteristics of various building stones are now discussed in the following paras:

(a) Sandstone: It is sedimentary rock, which consists of grains of sand or quartz, cemented together by Silica in the form of silicic acid, calcium or magnesium carbonate, clay or lime combined with oxide of iron etc. Sometimes it contains a little mica also. The durability of sandstone depends upon the quality of cementing material. When the cementing material is carbonate of calcium (lime) the decay in the stone is likely to be speedier. The durability of sand stone is very much increased when sand itself forms the cementing material. Weak sandstone has a life of about 50 years while the life of good quality is over 200 years [2].

Sandstones consist of round or angular grains of quartz. The size of the grains determines the texture of the stone, which can vary from fine grained compact stone to a coarse grit [4]. When the cementing material is silica, the stone usually has a light grey color, but if the grains are cemented by oxide of iron, the stone is either red or brown and is much softer. With carbonate of lime as cement, the result is a light colored, which does not weather well [1].

Sand stone is a porous stone, when subjected to abrasion; it does not stand very well. The weight of stone is 140 – 180 lbs per cubic feet. Its crushing strength ranges from 3800 – 27500 per square inch (psi) [7].

The finer grained stone can be worked more easily than the coarser varieties. Proper seasoning is also needed before its use. Sandstone is found in great variety of colors, such as grey, brown, red, pink, buff, blue, drab etc. In Pakistan it is abundantly found in Jungshahi near Hyderabad, Karachi, Jutana, Jhelum etc.

(b) Limestone: The chief constituents of limestone are the crystallized grains of calcium carbonate which are cemented by a matrix of the same material, with small proportions of silica, magnesium, iron and clay. Lime stone is stratified in structure [2].

These are made from the mineral calcite, which are obtained from the beds of evaporated seas and lakes and from sea animal shells (called oolitic). Lime stones containing 10 per cent or more of magnesia are called magnesian and those having over 45 percent of that substance are termed as dolomites. Dolomites are magnesian and those with over crystalline and granular in structure usually are nearly white or of a yellowish tinge [1].

The crushing and tensile strength of dolomitic limestone are greater than oolitic limestone, and they exhibit greater variety in texture. Some partially metamorphosed limestone, known as crystalline lime stone, like travertine, is also classed as marble [4]. Its crushing strength ranges from 1070 to 17500 psi. However some dolomatic lime stones have up to 35,000 psi crushing strength. The average weight of lime stone is 119 – 185 lbs per cu ft. Soft limestone can be scratched by human nail and even the hardest variety can be scratched by pen knife [7].

Limestone is a porous stone and can absorb oil and water easily. It can be easily attacked by carbonic acid gas and other acids dissolved in rainwater from the air, especially in industrial cities, where coal is burnt in factories. It is an excellent stone for humid regions.

Limestone often contains fragments of fossils, which may give it an attractive appearance. Limestone is weak in abrasion and its color varies from white to grey, bluish, yellowish etc. In Pakistan it is found in Karachi, Hyderabad, Sukkur, Jhelum, Kohat, Hazara, and in areas of Baluchistan.

The term limestone is very general and includes many varieties that differ from one another in characteristics and qualities. The following are important varieties of limestone: [2]

(i) Argillaceous or Clayed Limestone or Kankar: These stones are found generally in a nodular form of ½ to 4 inch size. They are composed of nearly pure compact carbonate of lime, but their upper surface consists of a mixture of carbonate of lime with sand and clay. Kankar is often found in large quantities in the bed of streams where it has been deposited by water holding it in solution.

(ii) Siliceous Limestone: These are similar to argillaceous limestone with the exception that they contain silica instead of clay, and therefore they are better suited for building.

(iii) Magnesium Limestone: Calcium and magnesium carbonates are found practically in equal parts in this variety of limestone. It is heavy and compact.

(iv) Marble: When lime stone becomes crystallized through the combined influence of great heat and pressure it is called marble. Marble is therefore the metamorphosed stone, which has retained its chemical composition of limestone. Calcite and calcium carbonate are main constituents [2]. The average weight of marble is 155 – 169 lbs per cu ft. Its crushing strength ranges from 10356 – 18000 per square inch [7].

Marble is very compact and dense and it can resist weathering action very well. It can take polish very well and is easy to carve as such it is mainly used for decorative purpose. Although its porosity is very low but it can absorb oil and water. It is also acid sensitive.

It is white in color when pure, but is found in various shades, depending upon the nature of impurities. Most common colors are grey, black, green, pink, blue, red etc. Most marbles show a graduation in color tone. Nearly all varieties of marble are beautifully veined with lines or streaks of variegated colors [1]. True marble has no fossils and its calcite grains make it highly colored such as black, grey, green, pink, red and yellow.

2.6: Masonry Techniques

Masonry buildings can be understood as assemblages of stone, bricks or concrete masonry units to form a stable structure. Mortar or grouting may or may not be used between the masonry units [4]. Traditionally three types of masonry techniques are used: Rubble Masonry, Ashlar masonry and stone veneering / cladding.

(a) Rubble Masonry: Walling composed of rough irregular stones which have not been dressed with hammer or chisel. Stone work, constructed with irregular size and shape of stones. The exact character of a wall depends upon the stone mason, who would select and arrange stones to fill the gaps, according to his experience and judgment [4].

(b) Ashlar Masonry: A wall constructed in regular course of dressed stone blocks that have been squared and finished with a smooth surface.

(c)Stone Veneering / Cladding: It is defined as an external or internal covering to a structure with stone, which is designed to carry no load other than its own weight. Cladding of building was an extension of traditional masonry [4].

3. Stone Heritage of Pakistan

Pakistan occupies land, which has a long history of Human Civilization, going back to Stone Age. It has evidence of early Stone Age Man at "Soan Valley", near Rawalpindi. The traces of Neolithic Men (men of Stone Age, who cultivated land, kept domestic animals) have been discovered at Sheri Khan Tarakai in the District of Bannu. The site represents a village having mud walled houses with stone foundation [8]. The excavations at Serai Khola near Taxila have revealed a late Stone Age community in which houses were built with mud walls on rubble stone foundation [9].

Kotdiji in Khairpur District (Sindh) has produced the first antecedent of Indus Valley Civilization. The most impressive structural feature of the citadel of this period was the defensive wall. The lower part was built of undressed blocks of lime stone [9].

The area belonging to Pakistan has seen Rise and Fall of various civilizations, which shaped the art and architecture of this area. The earliest flourishing civilization is about five thousand years old (2500 BC) known as "Indus Valley Civilization". At the decline of the Indus Valley Civilization the traditional built environment of the region underwent a change with the

invasion of Aryan and then by Indo Greek civilization of Gandhara.

The architectural heritage from the ancient civilizations such as those of Indus valley and Gandhara does not remain in the form of complete buildings. The influence of Aryans, Persians, Greeks, Buddhists and Arabs is also found in form of ruined sites [10]. The richness of architecture particularly in the Punjab, is greatly influenced by various historic periods such as Hindu (before c.1000AD), Pathan (1000 – 1526 AD), Mughal (1526 –1759 AD), Sikh (1759 – 1849 AD) and British (1849 – 1947 AD). In different historic periods, a variety of buildings were constructed with a variety of materials [10].

Since concern of this paper is confined to stone, therefore only stone monuments have been considered in the following sections:

1. The most modern feature of Indus valley city "Moenjodaro" is with its remarkable drainage system. The traces show that the drainage channels were covered with slabs of limestone.

2. The city of Taxila developed in three stages: Bhir Mound from 6th to 2nd century BC, SirKap Mound from 2nd century BC to 2nd century AD and SirSukh Mound from 2nd century AD to 5th century AD. The earliest structures on the original site employed a rough masonry of limestone and river pebbles for their walls and pillars. Later the lime stone was replaced by Kanjur stone [9]. Taxila, "the city of cut stones", is regarded as holy land of Buddhism. Its stability is threatened by climatic hazards and human actions.

3. The complexes of stupas and monasteries at Takhat-i-Bhai in the District of Mardan, NWFP, are also imposing monuments of Buddhism. These are built in grey dolomite limestone. Due to long exposure to tropical climate they have lost their shape.

4. Bambhore is an early Islamic and Hindu period site of mid 7th Century. The traces show that the houses were built in semi-dressed limestone blocks or made of mud brick with stone foundations. The site is deteriorating due to acidic windy conditions of the Arabian Sea.

5. The temples of Hindu period are situated at Kafirkot, Billot in district D.I. Khan, Tharparkar, and at Katas, Mallot and Amb in salt range. These temples have decorative features of stone.

6. The monuments at graveyard of Makli Hill in Thatta belong to local rulers and nobles of Sindh. It is the largest graveyard of the World. The monuments are both in stone and brick, but the stone monuments surpass in beauty and variety of carved sandstone of yellow color. The carved sandstone tombs are known as Chaukhandi, and the stone is also called Jang Shahi stone.

7. Rohtas Fort near Jhelum is a monument of Sultan Sher Shah Suri period (1541), which is entirely built in greyish green ashlar masonry of sand stone known as Taraki stone.

8. The grand monuments of Mughal period (Lahore Fort, Shalimar Gardens, Jahangir's Tomb, Badshahi Mosque) are finest example of architecture in Pakistan. Marble and red sandstone have been lavishly used in these buildings. These buildings are rapidly deteriorating due to lack of funds and absence of comprehensive conservation plan [10].

9. Baradari of Hazuri Bagh is most significant stone building of the Sikh period. The pieces of marble used in this building were brought from different Mughal buildings. This building was originally double storey but the upper storey was struck by lighting in 1932 and collapsed. Since then no effort has been made to restore its upper storey.

10. The colonial rulers have left some beautiful stone buildings in metropolitan cities of Lahore and Karachi. The structure of Aitchison College is in brick but at some places red sand stone has been used for decoration purpose. In Karachi, Flag staff house (Quaid-e-Azam House museum) and Mohatta palace are fine examples of stone buildings.

Six of the most significant monuments and archaeological sites of Pakistan had also been included as part of the World heritage. According to the Department of Archaeology and Museums these properties of Pakistan included in the World heritage list are as under: [11]. See Figures 1 to 14.

Table 2: Six most significant monuments and archaeological sites of Pakistan.

Sr. No	NID	Name of property	Material used in construction
1.	C 138	Archaeological Ruins at Moenjodaro, Sindh	Burnt Brick, some slabs of stone to cover drainage channels
2.	C-139	Taxila Archaeological Sites, Punjab	Stone
3.	C 140	Ruins of Takhat-i-Bhai and Neighboring City Remains at Sahr-i-Bahlol, NWFP	Stone
4.	C 143	Historical Monuments of Thatta, Sindh	Stone
5.	C 171-172	Fort and Shalamar Gardens at Lahore	Major buildings with Stone but pathways and enclosing walls with burnt Brick
6.	C 586	Rohtas Fort, District Jhelum	Stone

This should be noted here that five out of total six properties (83%) had been constructed with stone as principal material.

Figure 1: Moenjodaro Ruins

Figure 2: Great Bath Moenjodaro

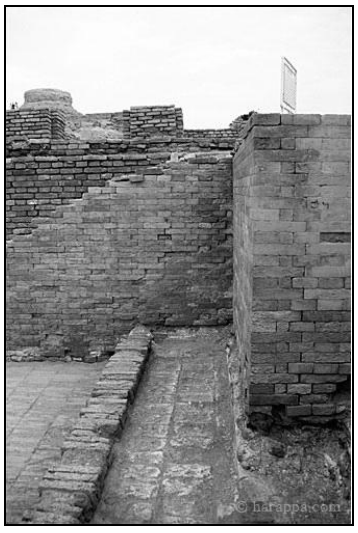

Figure 3: A Street of Moenjodaro

Figure 4: A Well at Moenjodaro

Figure 5: Sirkap Remains, Taxila

Figure 6: Dharma Rajika Site, Taxila

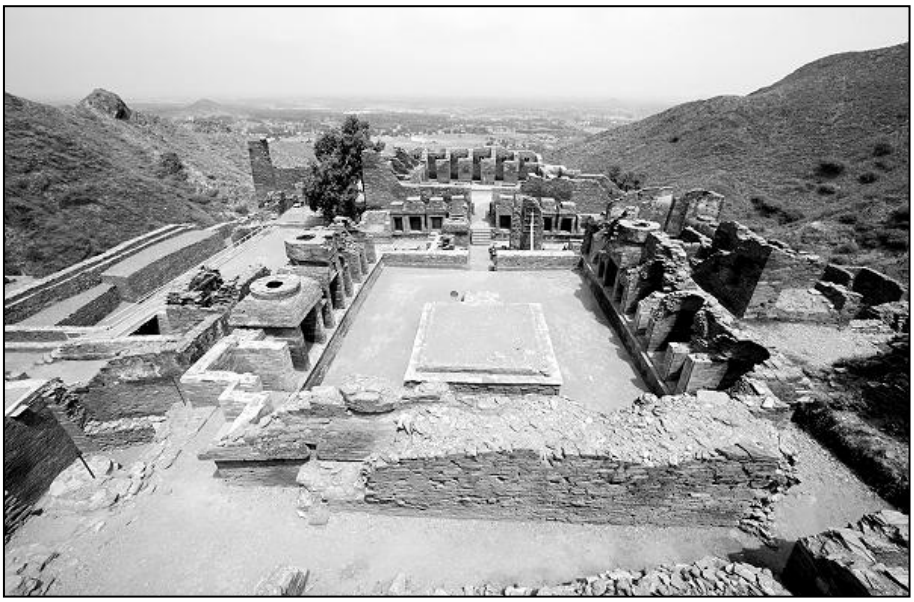

Figure 7: Ruins at Takhat-E-Bhai, Mardan

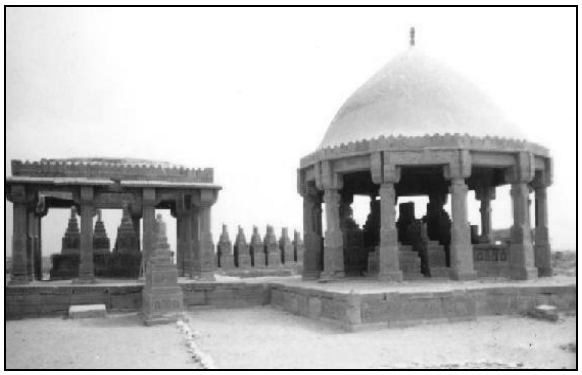

Figure 8: Chokhandi Tombs, Thatta

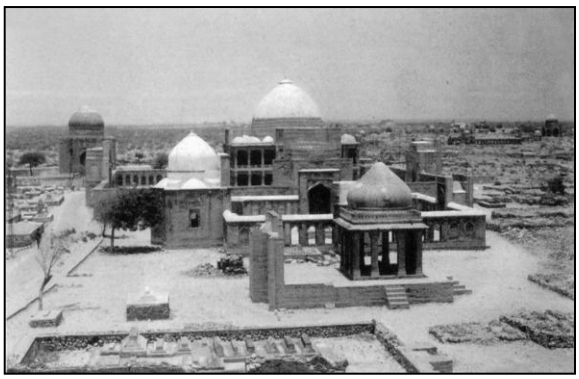

Figure 9: Makli Hill Monuments, Thatta

Figure 10: A Pavillion at Shalamar Garden, Lahore

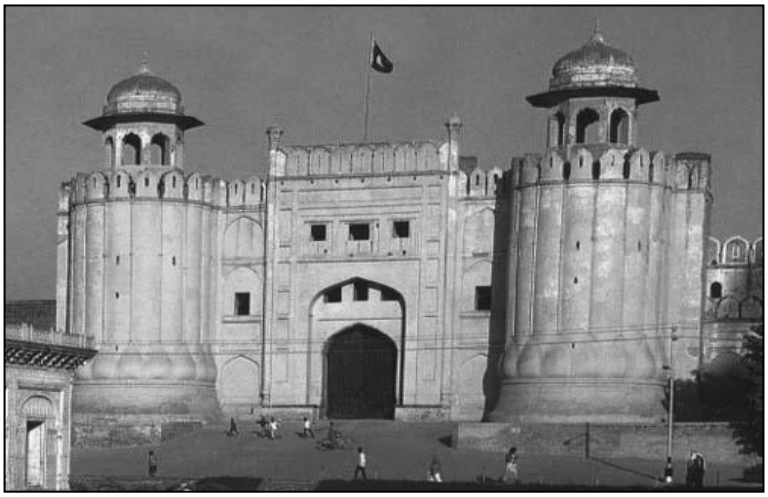

Figure 11: Alamgiri Gate Lahore Fort, Lahore

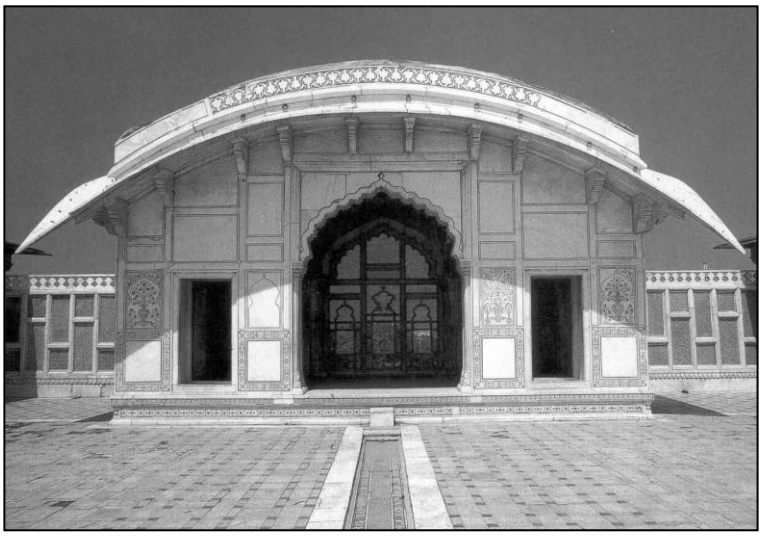

Figure 12: Naulakha Pavillion Sheesh Mahal Lahore Fort, Lahore

Figure 13: The Rohtas Fort, District Jhelum

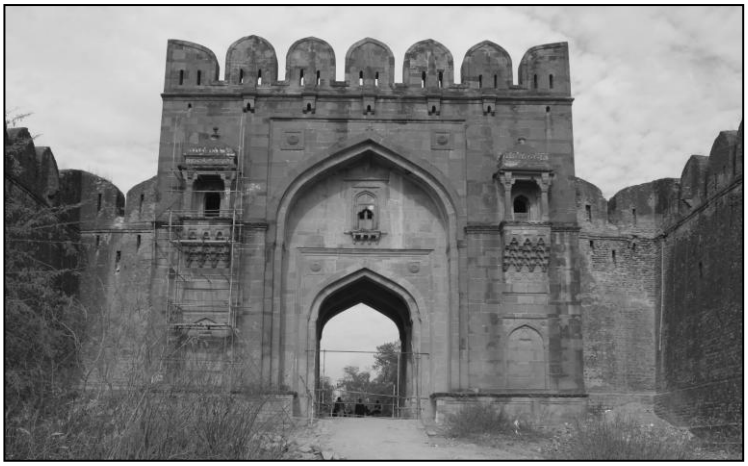

Figure 14: The Rohtas Fort: A Closer View of the Main Gate

4. State of Conservation in Pakistan

Conservation of cultural heritage in Pakistan is primarily the concern of Federal Government. The first legislation was "Ancient Monuments Preservation Act 1904" during the British period. The Antiquities Act of 1947, after Pakistan came into being, replaced it. After a series of minor amendments, conservation related legislation of national level is now contained within the "Antiquities Act 1975" [12].

Department of Archaeology and Museums is chief custodian of the built heritage in Pakistan and functions under this Act. The Provincial Governments were not involved until 1985 and yet they are not actively involved in conservation responsibility. The Auqaf Department at provincial level, has been given the custody of shrines which also undertakes its conservation work. There are a few voluntary organizations e.g. "Lahore conservation society" and "Anjuman-e-Mimaran", which play a role in creating awareness among society. There is no comprehensive conservation policy in Pakistan. However there is a listing system and 394 ancient monuments and archaeological sites (including national monuments) have been listed and protected. [12]

The present listing and grading system developed by the Archaeology Department is not considered to be fully adequate. The criteria only emphasize the historical value of buildings and grading of listed building is mainly based on the condition of building whereas architectural value of building has been largely ignored in listing and grading. Therefore a new

grading system should be developed on the basis of a combined historical and architectural value for each building.

A field survey was conducted by the author of this paper in 1991, under which 283 significant buildings in Lahore were studied. All of these buildings were in good condition in 1892. These included all the listed and some other significant historic buildings. The survey revealed that, "of the 283 buildings forming the subject of the study, 91 had totally disappeared by 1991 and another 6 had virtually disappeared, with very few remains in existence. It may be thus assumed that a loss of 97 buildings, 34 per cent of the total, had occurred during a period of nearly one hundred years, and an average of about one a year. It is also found that more than 60% of the surviving structures were built with stone as a major building material. [10]

Lack of resources and shortage of manpower has limited the conservation and maintenance work of the Archaeology Department to only few main historical monuments and archaeological sites. Archaeological conservators and archaeological engineers mainly run the department. The department is also without architects and civil engineers who may be engaged on building conservation. [12]

In general, there are so many other problems and constraints, which hinder the process of conservation in the country such as neglect, lack of awareness, political factors, urbanization pressure, etc. In addition an appropriate knowledge of material used in conservation/repair work is also lacking.

5. Conclusions

Pakistan possesses rich cultural heritage represented by a wide variety of standing monuments and archaeological sites in different parts of Pakistan. It is sad to realize that it is tended to value the things around us only after they are lost. This is observed that there is a notable lack of ability to appreciate and conserve the monuments, in their true worth; resultantly most of built heritage of great value has been lost but still there is a lot to save. The material used for the construction of monuments and archaeological remains is of three types: stone, burnt bricks and un-burnt bricks. A significant part of the built heritage in Pakistan is made of the stone. A large number, 83%, of the built heritage of Pakistan included in the World heritage belongs to stone. The survey of significant historic buildings of Lahore carried out in 1991 has revealed that more than 60% of surviving buildings were erected with stone. Therefore a knowledge about stone, its characteristics and classification, as collected from the literature and systematically provided in this paper, would be readily available to the conservation architects. It would help him in choosing correct material and conservation techniques in repair and restoration works which will also slow the rate of decay in the historic monuments.

REFERENCES

[1] www.buildingstone.org accessed on 15-05-2007.

[2] Syed, Z. H.; *Materials of Construction*, Oxford University Press, Lahore, (1967), 2-4, 11-14.

[3] www.jersey.uoregon.edu accessed on 17-05-2007.

[4] Derine, David; *New Stone Architecture*, Laurence King Publisher Ltd, London, (2004), 40-41, 49, 50, 58.

[5] *Institute of Archaeology, Stone: Technology Deterioration and Conservation*; Course Hand Book, University of London, (1989), 2-4, 8.

[6] Ashurst, John, Dimes and Francis, G.; *Conservation of Building & Decorative Stone*, Butterworth Heinemann, England, (1998), 144-145, 151.

[7] Callender, John, H.; *Time Saver Standards for Architectural Design Data*, Mc.Graw Hill Book Company, New York, (1974), 507-508.

[8] Hassan, S. K.; *The Islamic Architectural Heritage of Pakistan*, Royal Book Company, Karachi, (2001), 3-4.

[9] Mumtaz, K. K.; *Architecture in Pakistan*, Concept Media Ltd. Singapore, (1985), 6-7, 19.

[10] (a) Awan, M. Y.; *UET Research Journal*, 8(Jan–Jun 1994) 2.
(b) Awan, M. Y.; *UET Research Journal*, 8(Jan–Jun 1994) 165.

[11] This information was provided by the Department of Archaeology and Museums, Pakistan, Lahore Fort, Lahore.

[12] Awan, M. Y.; *PhD Thesis*, A Study of Significant Historic Buildings in Lahore leading towards the Formulation of a National Conservation Policy for Pakistan, University of Sheffield, Sheffield, UK, (1993) 57-78, 386-405.