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CONSERVATION, MAINTENANCE AND REPAIR OF THE OLD BOMA HISTORIC BUILDING IN BAGAMOYO, TANZANIA

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Abstract

Good conservation, maintenance and repair of historic buildings to preserve their integrity is very important in order to protect and promote built heritage. Despite this widespread agreement on the importance of maintenance and repair, many historic buildings do not receive the attention they arguably deserve in their own right. Although maintenance theory currently exists, yet the maintenance of historic buildings is always understated and is considered as a low-status. This paper therefore sheds right on the history, legal protection, values, ownership, characterization of materials (i.e. Physical properties such as bulk density and water absorption; mechanical properties such as compressive and tensile strengths and chemical properties), condition, maintenance requirements and appropriate conservation materials of one of the significant historic buildings, the Old Boma in Bagamoyo in Tanzania. The characterization of historic building materials is very important in judging the quality and capacity of the materials in order to decide which material is appropriate for conservation purpose The material's behavior of the conservation should be closely compatible with the existing ones in terms of physical and chemical properties in one unified and all-embracing approach. Indeed, the building in question calls for intensive restoration before the values attached to it are completely demised in a sad state of disrepair.

Keywords*: Historic building; Heritage; Conservation; Maintenance; Restoration*

Introduction

Conservation, maintenance and repair of historic buildings in Tanzania have to some extent challenged our established conservation approach and eroded to a certain degree the integrity and authenticity of heritage places in the process [1]. Although maintenance of historic building plays an important conservation role in preventing the building from potential defects [2-4], it has received relatively little attention in the context of most developing countries. Conservation, as defined by many writers, is an action taken to minimize the deterioration and damage of heritage so as to avoid major restoration [5-9]. On the other hand, maintenance of historic building essentially means preserving it in its initial state for as long as practicable, thereby preserving historic character and integrity, cultural or architectural values, materials and craftsmanship [10]. Furthermore, [11] argue that in an historic building context, the terms maintenance and repair are not synonymous as they might be for other building types. While repair is justified to preserve the integrity and architectural character of historic building with sympathetic alterations, maintenance strives to protect the cultural identity, integrity, architectural character and authenticity of it without alterations.

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Normally, the service life of a building can be optimised through adequate and timely maintenance and repairs as illustrated in Figure 1. The building that is not adequately maintained will eventually suffer substantial premature deterioration resulting into a state of completely irreversible loss of service life. The best practice approach for enhancing the best service life of a heritage building should address the full range of successful maintenance plan generated from bona fide preventive maintenance inspections. The maintenance plan is for the reason of guaranteeing cost-effective way to maintain the value of the building. Furthermore, good maintenance is most effective when carried out regularly. Regular maintenance is the best way to ensure the continued conservation and future use of a building because less historic fabric is lost in regular, minimal and small-scale work than in disruptive and extensive repairs

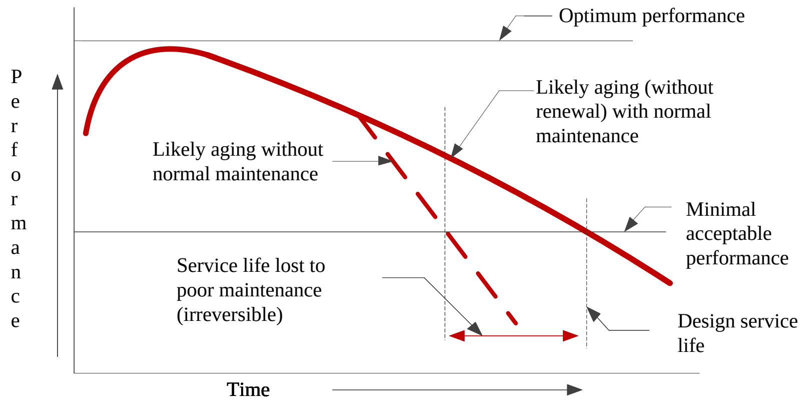

Fig. 1. Effect of adequate and timely maintenance and repairs on the service life of the building [12]

Any historic building calling for conservation, a comprehensive data on the nature and condition of the buildings is required [13-19]. Thereafter, conservation and management of the building should be related to the aesthetic and historic values**,** historical authenticity, identity, integrity of the building, and preservation of authentic patina of age, originality and surviving significant and original elements. The traces of time and natural patina are important to the authenticity and historical process of the building [20, 21]. The original use is generally the best for conservation of the fabric, as it means fewer changes. During restoration, every attempt should be made to retain or restore as much of the original building fabric as possible so that the building continues to carry its original history. For this particular case study, the basic properties of materials used in the building are therefore investigated as guide towards restoration of the building. These include the bulk density, basic mechanical strength (uniaxial compressive strength, tensile strength and modulus of elasticity) and gradation test

Metodology

To get detailed information about this important historic building, it was deemed of interest to base this study on condition monitoring by consulting existing literature and in-depth archival records to reveal the history of the property, completing standard checklists, base-line visit or survey, monitoring visits, recording new observations, annotating measured drawings, extensive photographic documentation of the material features and condition of the building, and mapping the building layout and landscape features of the property. Likewise, the condition monitoring was supplemented by key informant interviews and historical narrative, and laboratory tests.

The literature review was mostly acquired from published books, research papers, seminar papers and journals mainly from the archival records of the Department of Antiquities. It was from the archival records that consistent and accurate identification of historic record to form the base drawings for a proposed program of maintenance and conservation were obtained. The literature review was supplemented with the in-depth physical investigation of the building in question to go on with the building's history. The in-depth physical observations were carried out through site survey/pilot survey where data was obtained from a visual inspection of defects at its exact location or based on building elements. Measurements, construction details, foundation survey, identification of major alterations and documentation of condition of the building elements were detailed step-by-step with sketches and digital photographs where necessary. Laboratory experimental tests included bulk density, basic mechanical strength (uniaxial compressive strength) and water absorption test. Most of the specimens for laboratory tests were taken from the building by using a cutting machine. Specimens (60×60×60 mm) for uniaxial test were dried for 24 hours in oven at 60ºC. For the mortar, only cylindrical specimens of 30 mm in diameter and 60mm in thickness could be drilled.

Compressive strength

The compressive strength of the wall is more closely related to the strength of the wall. This compressive strength of a masonry wall depends on both the unit (stones, blocks or bricks) and the bond between them as well as the mortar. However, the strength depends largely on the interlocking mechanism of masonry in order to provide resistance to applied loads. Because both wall units and mortar work together to ensure stability of the wall, it is imperative to work out the relationship between the masonry compressive strength and the compressive strengths of both stones and mortar. Many authors have noted significant correlations between the masonry compressive strength and average compression strength values of both the stones and mortar. Many researchers [22-25] have developed an exponential equation to calculate the masonry compression strength f_m using the stone compression strength f_b^{α} and mortar compression strength f_j^{β} as given in equation 1, where: K , α and β are constants. According to Eurocode 6 [26] K is the factor of various ranges depending on the brick unit properties and the brick/mortar bond configuration, while α and β are about 0.7 and 0.3 respectively. The value of β is less than that of α indicating that the masonry compressive strength (f_m) is influenced to a greater extent by the brick unit compressive strength (f_b^{α}) than by the mortar compressive strength (f_j^{β}). Finally, the Eurocode 6 [26] developed an empirical expression relating the brick unit, mortar and masonry compressive strengths in MPa as shown in Equation 2. However, in ordinary masonry usually the units are stiffer than mortar, thus the main feature of compression failure of units is due to lateral deformation of the mortar. The first attempt trying to capture such feature is that proposed by [27] as shown in equations 1-3:

$$f_m = K.f_b^{\alpha} f_j^{\beta} \tag{1}$$

$$f_m = 0.75 f_b^{0.75} f_j^{0.31} \tag{2}$$

$$f_m = \frac{f_b\left(f_{bt} + f_j \rho / 4.1\right)}{U_u\left(f_{bt} + f_b \rho / 4.1\right)} \tag{3}$$

where: ρ - *tj*/*tb*, ratio between the thickness of the bed joint and the height of the unit, *fbt* - unit tensile strength, *Uu* - non-uniformity coefficient, function of quality of workmanship, type and compressive strength of mortar, type of brick, pattern of masonry, thickness of joints; a value $Uu = 1.5$ is assumed for the non-uniformity coefficient.

On the other hand [28], proposed an elasto-brittle model (equation 4) which assumes a linear interaction domain at failure between compressive and tensile strengths to encounter the three-dimensional stress state implicitly present in model [27].

$$f_m = \frac{f_b}{1 + \frac{\rho}{\lambda} \frac{\nu_j - \zeta \nu_b}{1 + \rho\zeta - \nu_j - \rho\zeta\nu_b}} \quad (4)$$

where: ν - Poisson's coefficient. For most rocks, μ varies between 0.8 and 0.5; a value of 0.60 would be a good number for general use, λ - fbt/fb ratio between tensile and compressive strengths of the unit, $\zeta = Ej/Eb$ ratio of mortar and unit elastic moduli, to be assumed < 1.

Water Absorption

Water penetrates into building material in various ways through the material pores and fissures. A high proportion of water penetration into building materials is caused by condensation of air humidity, rain penetration or raise of ground water by force of capillary action [29; 30] Capillarity, material porosity, diffusion, absorption and gravity are the most usual mechanisms controlling water penetration into building materials. Capillary action, also referred to as sometimes capillarity, capillary motion, capillary effect, or wicking is a combination of cohesion/adhesion and surface tension forces. Capillary and absorptive forces, together result into matric potential or matric suction. The capillary force (matric suction) are in turn controlled by the pore size distribution, porosity, pore number, pore size (cross-sectional diameter) and pore continuity (total volume of all pores). Similarly, the total water absorption is a function of the pore size distribution, pore quantities, pore volume, pore coordination, pore geometry and pore network connectivity

An absorption test was carried out in accordance with [31]. The dry masonry samples of specified weights and dimensions were first heated, ventilated, dehumidified at 60°C (+/-2°C) for a period of 48 hours and then were immersed into filtered, circulating water at 22°C (+/-2°C) for a period of 48 hours. The samples were then removed from water and weighed to determine the water absorption in percent as follows:

$$W = \left(\frac{wet\ mass - dry\ mass}{dry\ mass} \right) \times 100 \quad (5)$$

Information about the building

History of the building

The Boma building is found at the heart of the old town conservation area of Bagamoyo within a walking distance from most of the major historical landmarks of the town such as the Old Custom House and the Old Fort. Bagamoyo is a small wonderful historic township located within a bay along the splendid sandy beach of unpolluted water of the Indian Ocean in Coast region, at a distance of approximately 75km, north of Dar es Salaam (the capital city of Tanzania). Bagamoyo is one of the most fascinating towns in East and Central Africa, with a myriad of historical associations with the slave trade that drew African societies into the international Economies and promoted exports and infrastructure.

The Old Boma of Bagamoyo is a two-storey impressive building constructed in a U shape floor plan with monumental symmetry and arrangement of the rooms and spaces. The building exhibits strong tangible evidence of colonialism in Tanzania. The architecture of this great monument is typical of German architecture mixed with a strong unique blend of Islamic-Arabic and vernacular techniques by this period. It was a sophisticated design of an authentic resemblance of neo-classical buildings of that time in Africa with high quality workmanship and materials available locally to meet climatic condition effectively (Figs. 2, 3 and 4). It has thick walls constructed of coral stones, filled with lime mortar and plastered with lime from the renovation that started in May 2009 and ended few months later. The building is supported on an old stone foundation partly covered with concrete. The slabs are of a specific German type: I-beams with vaulted stone slabs. Following the roof leakage during British rule, the original pitched roof construction was extensively altered into flat roof, thus the roofline undoubtedly changed significantly, which created maintenance problems. The balcony to the building collapsed in 1997 due to heavy weight imposed by heavy downpour. The Boma had beautiful, finest quality custom handcrafted wooden doors and windows but all these had experienced decay and vandalism, thus they were removed during the 2009 renovation. However, the building was partially renovated by the 2009 restoration, thus the building now stands semi-finished. Apart from extensive plastering of the walls and refurbishing of the deteriorated roof top, the renovation introduced no major changes in the building structures, layouts, functions and values, thus it still mostly appears as it was originally constructed.

Fig. 2. Front View of the Boma

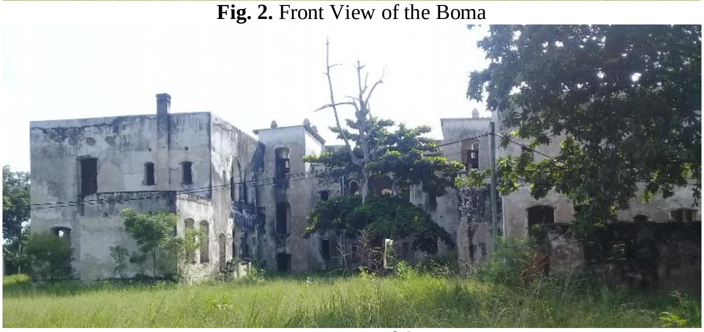

Fig. 3. Rear View of the Boma

Fig. 4. Left Hand Side View of the Boma

Legal Protection

The national cultural heritage in Tanzania is conserved, protected and developed by the Department of Antiquities, a department in Ministry of Natural Resources and Tourism for the present and future generation and promotion of recreation and tourist attractions, and centres for education to the people. The preservation Act dates back 1964 and was amended in 1979 (published by [32] as the Protection of Movable Cultural Property, Collection of legislative texts) empowering the Minister to declare any place or structure of valuable national heritage for the historical, architectural, social, aesthetical or cultural value as a monument. Therefore, the building is protected with the national antiquities act of 1964 with its amendments of 1979 stating that " No person or institution whether beneficially, interested therein or not, shall do any of the following acts; destroy, injure or deface the same or make any alteration, addition or repair without a permission from the Director of Antiquities department". This means that the departments of antiquities has a big role on managing and conserving this building

Ownership and Uses

The Old Boma Building**,** like most of historic buildings in Bagamoyo, is owned and operated by the Tanzanian government. The Old Boma is presently deserted. However, if the restoration had been completed, the building could probably be used as a school to train craftsmen or a commercial centre (tourist hotel, museum or shops to small scale traders of arts and crafts).

Values

The Old Boma Building is one of the known oldest man-made unique examples of surviving standing stone heritage structures in the conservation town of Bagamoyo. It is the very attractive structure that commands clear view of the Indian Ocean. It was built by the Germans at the end of the 19th century, with the sole purpose of being a residence for its leaders in the area before it was converted into state house. The Germans used it only for a few years before their colonial capital was moved to then Mzizima (currently known as Dar es Salaam), due to the shallow coastal water depth of the Bagamoyo port. It was once again used by the British as the state house after they won the surrender of the part of German East Africa colony, Tanganyika from 1919 until 1961 when the country got its independence. Therefore, it is the most notable reminder of the colonial period used by both Germans and British as the first state house of the country. It also served as the District Commissioner's office after Tanzania gained its independence in 1961. Clearly, the building embraces a historical perspective in order to trace the pre-colonial**,** colonial and post-colonial independent historical values. Consequently, it represents European contact with Tanzania and European identity in the country. In addition, it binds the past and the future and provides visible evidence of the continuity between past, present and future. The building is the pedagogical in itself, thus the architectural style of that time, customs and lifestyle of the people and events associated with it and materials used can be visualized. Undoubtedly, the building has a unique archive material and it is well documented in the history of Bagamoyo town. It has a quality as a monument and cultural value in itself which evidently justify a comprehensive restoration and conservation.

Characterization of the Building Materials used in the Old Boma

Stone fragments and mortar pieces were drilled and tested in the laboratories at the University of Dar es Salaam and at African Minerals and Geosciences Centre (AMGC) formerly known as Southern and Eastern African Mineral Centre (SEAMIC) for physical properties and chemical properties respectively. The tests were conducted so that the repair should strive to use only similar materials which were used originally or materials with comparable physical characteristics to the original materials so as to preserve the authenticity of the property as a historic resource. Compressive strength, density and water absorption were three major properties tested.

The compressive strength was tested according to [33] on samples size 60×60×60mm and the absorption and bulk density was carried out according to [30]. On the other hand, X-

Ray Diffraction (XRD) technique following the method of [34] was employed to identify and quantify the minerals and the chemical composition were determined by performing Scan Electron Microscope (SEM) on both lime stones and coral stones. The results of chemical composition are presented in Table 1. Both stones composed of high amount of calcium oxide (CaO) with an approximate proportion of more than 50%. Thus, the stones used in this building are considered to be limestones and coral limestones (formed from corals and coral fragments).

Table 1. Chemical Composition of Coral and Lime Stones [35]

Component	Content, % (weight in percent)		
	Lime	Coral Stone	Lime Stone
CaO	42.19	52.98	53.83
SiO_2	17.2	2.93	0.51
Al_2O_3	4.5	0.91	0.14
Fe_2O_3	0.07	0.03	0.95
MgO	0.52	0.35	0.41
Na_2O	0.39	0.33	<0.01
K_2O	0.89	0.1	<0.01
SO_3	0.54	0.41	0.11
P_2O_5	0.15	0.07	0.09
SrO	nd	0.95	0.25
Cl	0.25	nd	nd
Cr_2O_3	0.04	nd	nd
MnO	0.02	nd	nd
TiO_2	0.19	0.06	0.03
ZrO_2	nd	0.18	<0.01
LOI	32.83	40.7	43.68

Table 2. Compressive strength a, bulk density and water absorption of Lime and Coral stones [35]

Category	Compressive strength (N/mm^2)	Bulk density (kg/mm^3)	Total water absorption, % (weight percent)
Lime stone 1	15.1	2,481	5
Lime stone 2	17.2	2,354	6
Lime stone 3	20.1	2,100	8
Coral stone 1	7.5	1,350	28
Coral stone 2	7.2	1,015	32
Coral stone 3	10.1	1,204	34

The average compressive strength of limestone was 20.8N/mm^2 (ranged from 17.1 to 25.1N/mm^2) while that of coral stone was 10.3N/mm^2 (ranged from 9.2 to 12.1N/mm^2) and that of mortar ranged from 0.61N/mm^2 to 0.82N/mm^2 with an average of 0.75N/mm2. It is from these results (Table 2) that the compressive strength values of limestone are greater than that of coral stones. Tensile strengths for the tested limestone and coral stones were mostly around 7N/mm^2 and 3N/mm^2 respectively. The measured strengths using different equations are in good agree with calculated strengths (Tables 3 and 4). According to [36] the strength classification of coral stone is very weak while that of limestone is weak. The calculated compressive strength of the masonry ranged between 3N/mm^2 and 9N/mm^2 mainly falling in the weak zone (Table 5).

Table 3. Measured Stone Compressive Strenght vs Calculated Masonry Compressive Strength

Category	Compressive strength (N/mm^2)	Eurocode 6 [25] (N/mm^2)	[26] (N/mm^2)
Lime stone 1	15.1	5.25	7.41
Lime stone 2	17.2	5.79	8.14
Lime stone 3	20.1	6.51	9.06
Coral stone 1	7.5	3.11	4.26
Coral stone 2	7.2	3.02	4.11
Coral stone 3	10.1	3.89	5.44

Table 4. Measured Stone Compressive Strenght vs Calculated Masonry Compressive Strength

Category	Compressive strength (N/mm^2)	Eurocode 6 [25] (N/mm^2)	[26] (N/mm^2)	[27] (N/mm^2)
Lime stone 1	15.1	5.25	7.41	6.21
Lime stone 2	17.2	5.79	8.14	6.83
Lime stone 3	20.1	6.51	9.06	7.63
Coral stone 1	7.5	3.11	4.26	3.61
Coral stone 2	7.2	3.02	4.11	3.50
Coral stone 3	10.1	3.89	5.44	4.57

Table 5. Engineering Classification of Rock by Strengths [36] Recommended in [37]

Strength			
Grade	Classification	Field Identification Method	Range of Uniaxial compressive Strengths (MPa)
R0	Extremely weak	Indented by thumbnail	<1
R1	Very Weak	Crumbles under firm blows of geological hammer; can be peeled with a pocket knife	1 - 5
R2	Weak	Can be peeled with a pocket knife with difficulty; shallow indentations made by a firm blow with point of geological hammer	5 - 25
R3	Medium strong	Cannot be scrapped or peeled with a pocket knife; specimen can be fractured with a single firm blow of geological hammer	25 - 50
R4	Strong	Specimen requires more than one blow of geological hammer to fracture	30 - 100
R5	Very strong	Specimen requires many blows of geological hammer to fracture	100 - 250
R6	Extremely strong	Specimen can only be chipped by geological hammer	>250

Condition

The structure in case point has a very complex load carrying behaviour originating from continuous interaction of the massive and statically indeterminate walls penetrating into the sub-soil to save equally as massive foundations. The action loads are primarily carried in compression enhanced by the characteristics strength and stiffness of the materials in the massive walls aimed to disperse rather than concentrate forces. So far, the massive walls are still capable of resisting compression, tension and shear stresses from imposed load, self-weight and wind loads. Luckily, the building was unwittingly overdesigned thus it has reserves of strength.

The building, like a host of other historic buildings in Bagamoyo, was at one time badly neglected. It had therefore born too much stamp of wear and tear because of dearth of serious maintenance for centuries. The lime washed plastered walls had eroded and lost their outer skins due to the action of climate mainly wind, temperature and rain.

Most of the wooden features of the structures such as windows, doors, frames, sidings and their paints and finishes or colours defining the overall heritage value of the building deteriorated extensively due to decay, neglect and dry rot and are now completely missing. In May 2009, the city of Humburg, Germany together with the Ministry of Infrastructure Development in collaboration with the Ministry of Natural Resources and Tourism came to the rescue of the building by initiating the restoration of the building. The restoration went to the extent of re-plastering the walls and concreting the I-beams in the upper floor only. It was during the restoration the rooftop was provided with downspouts on both sides of the building to direct water away from the roof. Indeed the restoration was therefore partially done for two months and it stopped temporarily due to mismanagement of fund. The windows, doors, fittings and fixtures, electrical systems and water systems are therefore completely missing and the building is in the state of abandon. The surroundings of the building are grown with the expanse of rapidly growing native and indigenous grass species, rushes, small plants, shrubs and trees.

Description of Special maintenance Requirements

For many years the Boma has never received intensive restoration. In May 2009, the city of Humburg, Germany initiated and financially supported the restoration of the building together with the Ministry of Infrastructure Development in collaboration with the Ministry of Natural Resources and Tourism. The restoration run for two months and it stopped temporarily due to mismanagement. Before the halt of the restoration, the exterior worn out limestone and flaking plasterwork was imperfectly noted as a fundamental part for restoration. However, to respect the character and integrity of the original structure, materials similar to the original ones were used to fill the lacunae so as to preserve structural, typological and colour characteristic of historic renders. Some materials were obtained from the ruins of old deserted houses which are not listed by the government as part of our cultural heritage. This is in line with the Venice Charter which stresses the importance of setting, respect for original fabric, precise documentation of any intervention, the significance of contributions from all periods to the building's character, and the maintenance of historic buildings for a socially useful purpose [38, 39]. The restoration was carried out by skilled local craftsmen under the supervision of specialized resident engineer in conservation. However, the restoration was carried out in absence of systematic restoration schedule and maintenance costs. It is our opinion that the maintenance plan should have started with the main load carrying structures such as walls, beam and slabs instead of minor work like face-lift.

After fortification of the property by strengthening the walls, beam and slabs, the parts of the collapsed roof should come next at the top agenda of consolidation. Already, props have been used to stabilize the floor and roof slabs during the consolidation. Some parts of the collapsed flat roof are to be replaced with the pitched roof covered with corrugated iron sheets. However, as a temporary measure, we recommend the whole roof to be temporary covered with the transitory pitched roof to guard the structure against adverse weather elements such as rain, sun and wind. Fortunately, already parts of the slabs have been completely removed and replaced with the new compatible materials. However, it is vital that the conservation of the entire slabs is executed to the letter rather than in piecemeal fashion as is the case in point. Furthermore, the deteriorated windows and door elements call for complete replacement matching the old in form and detailing. Materials for conservation should conform to the physical and chemical properties of those found in the building.

Conclusion

This paper has traced back the preservation and conservation of historic buildings for the Old Boma of Bagamoyo. It has identified among others the building’s historic character and authenticity, legal values, utility value, character of the original historic building materials and construction, and photographic documentation of existing condition of the building. A number of issues have been raised such as construction details, authenticity, originality, reversibility, condition, patina etc. The identification of values combined with the prognosis of defects has provided a framework for conservation strategies.

In order to protect the historical and architectural importance and keep the originality of the building, the conservation should as much as possible preserve the original structural and architectural integrity of the historic building by using only well tried, tested and established materials and methods of repair. The material's behavior of the restoration should be closely compatible with the existing ones. Both physical and chemical properties of the existing materials should be maintained during restoration. The results of chemical composition indicate that both stones composed of high amount of calcium oxide (CaO) with an approximate proportion of more than 50%. It is from this contextual that the stones used in this building are considered to be limestone of sedimentary origin, thus the same stones should be continuously used whenever restoration is called for. Similarly, the results of water absorption indicate that coral stones have higher rates of water absorption than lime stones. The high rates of water absorption imply that water moves easily inducing physical-chemical reactions (dissolution, crystallization) leading to textural changes and deterioration. Based on this outcome, the coral stones should be replaced with limestone whenever restoration is carried out.

Indeed, the building in question calls for another additional restoration following the previous botched restoration before the values attached to it completely fall into disrepair. The current restoration is to be directed to finishes such as positioning fixtures and fittings, and fitting doors and windows and whitewashing the walls, thus concerted efforts from various stakeholders are urgently desirable before it falls in complete disrepair. Unfortunately, conservation as well as maintenance plans in Tanzania have met challenges that include: absence of universally accepted principles, missing guidelines and standards in the field, inadequate financial resources, inadequate number of professionals with conservation expertise, mismanagement of historic buildings, misappropriation of funds and lack of public awareness regarding heritage value. Therefore, it is the central task of Tanzanian government and all stakeholders to collaborate together by sharing the available best practices, ideas and expertise in order to stimulate greater awareness of maintenance, conservation culture and honest in the heritage sector in order to increase confidence in the use of historic places.

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References

[1] A. Lucuan, Conservation and Maintenance of the Old Boma Building in Bagamoyo (Tanzania). *Conservation and Management of Historic Buildings - Advanced International Training programme – 2009/2010,* Sida & Lund University. http://www.hdm.lth.se/fileadmin/hdm/alumni/papers/CMHB_2009/Tanzania_-_Charles_Lucian_-_The_Old_Boma.pdf
[2] D. Worthing, N. Dann, S. Bond, *Issues in Conservation Maintenance Management*. **Proceedings of the CIB W070 2002 Global Symposium**, 2002, pp. 283 – 302
[3] S.B.H.S. Mohamad, Z.A Akasah, M.A.A. Rahman**,** *A Review of the Maintenance Performance Factors for Heritage Buildings,* **Proceedings of the International Civil and Infrastructure Engineering Conference,** Malaysia, 2014, pp. 177 – 188
[4] S. Bond, D. Worthing **Managing Built Heritage: The Role of Cultural Values and Significance**, 2nd Edition, John Wiley & Sons Ltd, London, 2016.
[5] A. Dobby, **Conservation and Planning**, Hutchinson, London, 1978.
[6] B. Feilden, **Conservation in Historic Buildings** (3rd Ed). Butterworth-Architectural Press, Oxford, London, 2003.
[7] K.E. Harris, S.E Schur, *A Brief History of Preservation and Conservation at the Library of Congress.* **Library of Congress. Preservation Directorate**. www.loc.gov/preservation/ 2006, pp. 1 – 30.
[8] A.M. Forster, B. Kayan, *Maintenance for historic buildings: a current perspective.* **Journal of Structural Survey**, **27**(3), 2009, pp. 210-229.
[9] S. Lambert, **Italy and the History of Preventive Conservation**, CeROAr 6, 2010, pp. 1 – 15.

[10] M. Petzet, *Principles of conservation: An introduction to the International Charters for Conservation and Restoration 40 years after the Venice Charter*, **Monuments and Sites**, Vol. I: International Charters for Conservation and Restoration, 2004, p. 7-29.
[11] N. Dann, D. Worthing,. S. Bond, *Conservation Maintenance Management – Establishing a Research Agenda*, **Structural Survey**, **17**(3), 1999, pp. 143 – 153.
[12] ** * *, A Proactive Strategy for Managing the Nation's Public Assets*, **Board on Infrastructure and the Constructed Environment,** NRC, Stewardship of Federal Facilities, D.C. National Academy Press, Washington, 1998.
[13] D.W. Kay, A.E. Grimmer, **The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings,** U.S. Department of the Interior, National Park Service, Washington D.C., 1995.
[14] *** * *, Guide to the Principles of the Conservation of Historic Buildings**. BS7913, British Standards Institution (BSI), London, 1998.
[15] C. Brereton, *The Repair of Historic Buildings: Advice on Principles and Methods,* **Aspects of Conservation** No. 3, English Heritage, London, 1991.
[16] ** * *, Swanke Hayden Connell Architects*, **Historic Preservation: Project Planning & Estimating,** R.S. Means Company, Inc., Kingston, M.A., USA, 2000.
[17] P. Beckmann, Bowles, R. **Structural Aspects of Building Conservation**, 2nd edn, Butterworth Heinemann, Oxford, London, 2004.
[18] M. Forsyth, **Understanding Historic Building Conservation**, Blackwell Publishing, Oxford, London, 2007.
[19] R.A. Rashid, A.G. Ahmad, *The Implementation of Maintenance Works for Historical Buildings – A Review on the Current Scenario,* **Procedia Engineering** (Elsevier), **20**, 2011, pp. 415-424
[20] S.M. Zancheti, A. de Figueirôa Silva, A.C. Braga, F.G. Gameiro, F.B. Lira, L.S. Costa,). *The patina of the city.* **City & Time**, **2**(2), 2006, pp. 11 - 22.
[21] N. Stanley-Price, *The Reconstruction of Ruins: Principles and Practice*. **Conservation: Principles, Dilemmas and Uncomfortable Truths,** Edited by Alison Richmond and Alison Bracker Publisher, Elsevier, 2009, pp. 32 – 46.
[22] S.V. Deodhar, *Strength of Brick Masonry Prisms in Compression*, **Journal of the Institution of Engineers (India)**, **81**(3), 2000, pp. 133-137.
[23] K.S. Gumaste, K.S.N. Rao, B.V.V. Reddy, K.S. Jagadish, *Strength and elasticity of brick masonry prisms and wallettes under compression*, **Materials and Structures**, **40**(2), 2006, pp. 241-253.
[24] H.B. Kaushik, D.C. Rai, S.K. Jain, *Stress-Strain Characteristics of Clay Brick Masonry under Uniaxial Compression*, **Journal of Materials in Civil Engineering**, **19(**9), 2007, pp. 728-738.
[25] H.B. Kaushik, D.C. Rai, S.K. Jain, *Uniaxial compressive stress-strain model for clay brick masonry,* **Current Science**, **92**(4), 2007, pp. 497-501.
[26] * * *, CEN, *Eurocode 6: Design of masonry structures - Part 1-1: General rules for reinforced and unreinforced masonry structures,* **EN 1996-1-1:2005**, European Committee for Standardization, Brussels, Belgium, 2005.
[27] H.K. Hilsdorf, *An investigation into the failure mechanism of brick masonry under axial compression in designing,* **Engineering and Constructing with Masonry Products** (Editor: F.B. Johnson), Gulf, Houston, 1969, pp. 34-41.
[28] A.J. Francis; C.B. Horman, L.E. Jerems, *The effect of joint thickness and other factors on the compressive strength of brickwork.* **Proceeding of the 2nd International Brick Masonry Conference (**Editors**:** H.W.H. West and K.H. Speed), British Ceramic Society, Stoke-on-Trent, 1970, pp. 31-37.

[29] A. Arnold, *Rising damp and saline minerals*, **Fourth International Congress on the Deterioration and Preservation of Stone Objects,** Louisville, 1982, pp. 11–28.

[30] M. Karoglou, A. Moropoulou, A. Giakoumaki, M. Krokida, *Capillary rise kinetics of some building materials*, **Journal of Colloid Interface Sciences**, **284**(1), 2005, pp. 260–264.

[31] * * *, **Absorption and Bulk Specific Gravity of Natural Building Stone**, ASTM C97, 1990

[32] * * *, *The Protection of Movable Cultural Property,* **Collection of Legislative Texts**, Tanzania, CLT-85/WS-25, UNESCO, 1985

[33] *** * *, Compressive Strength of Natural Building Stone**, ASTM C170, 1990

[34] G. Brown, G.W. Brindley, *X-ray diffraction procedures for clay mineral identification.* G.W. Brindley, G. Brown (Eds.), **Crystal Structures of Clay Minerals and Their X-Ray Identification**, Vol. 5, Mineralogical Society, Monograph, London, 1984, pp. 305-360.

[35] C. Lucian, *Characterisation of Mortar Deterioration in Historic Buildings in Bagamoyo, Tanzania*. **International Journal of Engineering and Advanced Technology Studies, 3**(4), 2015, pp. 1-12.

[36] * * *, ISRM (1978a), *International Society of Rock Mechanics, Commission on Standardisation of Laboratory and Field Tests,* **Recommended in the Canadian Foundation Engineering Manual** (CGS 1992).

[37] * * *, CGS **Canadian Foundation Engineering Manual**, 3rd Edition, Canadian Geotechnical Society, BiTech Publishers, Richmond, British Columbia, 1992

[38] * * *, ICOMOS, **Charter for the Conservation and Restoration of Monuments and Sites**. (The Venice Charter), International Council on Monuments and Sites, Venice, 1966.

[39] * * *, ICOMOS, **Charter for Places of Cultural Significance** (The Burra Charter), International Council on Monuments and Sites, Canbera, Austratia, 1966.

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