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Condition Assessment of Heritage Structures: The Case of Fort Ikoma Historical Building in Serengeti National Park, Tanzania

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ABSTRACT

The Fort Ikoma Historical Building, initially constructed by the Germans in 1905 and repurposed several times, holds significant cultural and military importance. Over the years, the fort has served as a hotel, an army-training centre, and an administrative centre and has undergone various structural and architectural changes. The main objective of this study was to assess the physical condition of the Fort Ikoma historical building in Serengeti National Park. This study assessed the fort's architectural and structural conditions through historical surveys, visual inspections, and materials analyses. The findings revealed significant deterioration due to weather exposure, lack of maintenance, and inappropriate interventions, leading to extensive decay in walls, roofs, and other structural elements. Nevertheless, a comprehensive Building Condition Assessment Rating System (BCARS) has revealed that the fort severely deteriorated with significant structural, architectural, and service-related defects. The building is rated five at a critical condition level, requiring urgent and extensive restoration work to preserve its historical value. This study recommends promptly initiating a comprehensive rehabilitation plan using historically appropriate materials and techniques alongside modern reinforcement methods to preserve the fort's historical and cultural significance.

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1.0 Introduction

Building maintenance can be categorised into three primary strategies: corrective, preventive, and condition-based. Preventive maintenance is also commonly called time-based, planned, or cyclic maintenance. Condition-based maintenance, on the other hand, involves preventive actions guided by performance and parameter monitoring. Essential processes in condition-based maintenance include condition assessment, maintenance planning, and performance control. To carry out building maintenance effectively, technical data from on-site condition surveys are required (Straub, 2009). All building components face performance deterioration due to ageing, usage, and external factors, with defects being measured during condition assessments or surveys. However, the outcomes of these assessments often vary due to the subjective judgements of building inspectors. This variability among surveyors, known as surveyor variability, occurs when multiple inspectors evaluate the same building but reach different conclconclusions (Straub, 2009 & Yacob *et al.,* 2016). Factors contributing to this inconsistency include individual experience, risk perception, heuristic use of rules of thumb, and inherent biases that affect decision-making regardless of the evidence presented. A building inspection is conducted to evaluate the condition of a building and identify any defects. Defects often exhibit symptoms before they worsen, leading to more severe issues, making regular inspections essential throughout an asset's life cycle. Traditionally, building surveyors have used detailed, descriptive, longhand surveys, manually recording observations during on-site inspections. This method is commonly used in building surveys, particularly when inspecting properties in poor condition, such as abandoned, vacant, or dilapidated buildings (Hamzah *et al.,* 2010). Building inspection must be done according to the standards set by the building inspector (Yacob *et al.,* 2016). The different results of various condition assessment methods are not a drawback in practice, and it is essential that within the organisation, all building inspectors handle their method the same way (Yacob *et al.,* 2016). A Building Condition Assessment (BCA) is a tool to evaluate the physical condition of the building and its performance. Building condition assessment is the right method for carrying out conservation improvements in cultural heritage buildings, shortening time, saving money, and being economical (Muhammad et al., 2023). BCA is an assessment to identify whether the structural components in a building are in excellent condition or need any maintenance or replacement. Each flaw and problem in the building's structure is given a score based on how bad it is and what negative effects it could have. This could help the people in charge figure out what they should do to avoid major flaws or structural failures. BCA is an assessment tool that identifies whether the structural components in a building are in good condition or wrong. It gives valuable and necessary information regarding the performance of building materials and for future planning of maintenance work. The purpose of conducting BCA is to determine the condition of major building elements such as columns, beams, slabs, walls, etc., and also to quantify the defects and deterioration of each component. In addition, BCA provides the information that may be used to prepare a budget outlining deficiencies and maintenance costs (Mohd Noor *et al.,* 2019). Naturally, BCA includes a review of all available documents, such as the architectural and engineering drawings of the structure, including warranties and service contracts. However, a few cases exist where design drawings no longer exist and are commonly observed in old or heritage buildings. Moreover, BCA should develop a building condition assessment report, which includes all the structural and architectural defects, their severity ratings, and the overall rating of the building. Building condition assessment reflects the original quality, age, environmental influences, and previous maintenance maintenance (Mohd, 2019). Assessing condition of heritage buildings is imperative, as many of these structures have stood for centuries and suffered considerable damage. To ensure the safety and preservation of these historical landmarks, regular inspections should be conducted to evaluate their current state and identify any necessary remedial action (Zuraidi *et al.,* 2018).

The Fort Ikoma Historical Building faces significant deterioration due to various causes. Unfortunately, the problem is the lack of technical-based studies conducted to understand the types of physical defects in a building and to conclude with appropriate solutions. Before assessing the physical defects of a building, it is beneficial to understand its construction history and intervention strategies, as this will facilitate a better understanding of its causes and potential restoration strategies. This study aims to identify the rating of each defect according to its condition and maintenance priority.

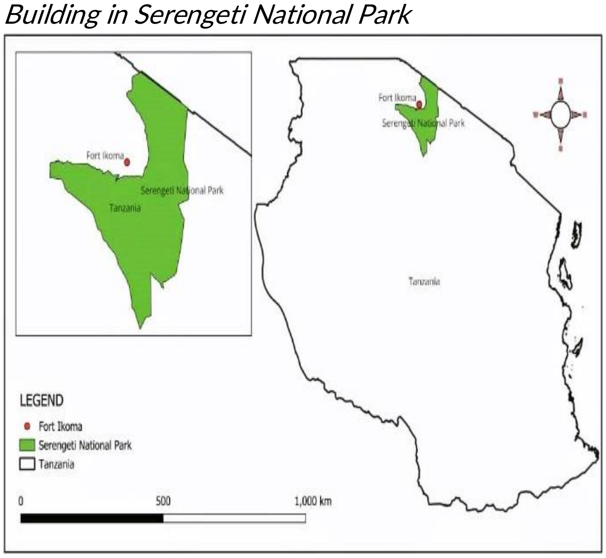
2.0 Material and Methods

2.1 Description of the Study Area

Geographically, fort Ikoma is located in the Ikoma ward of the Serengeti district in the Mara region (36M 0682369 UTM 9769712, Map Datum Arc 1960), as shown in Figure 1. It is one of many forts built across Tanzania during the German colonial rule from 1885 to 1918. Unlike other German forts built in urban areas, the Fort Ikoma is situated in an area abundant with wildlife. Administratively, the fort is owned and overseen by Tanzania National Parks (TANAPA) through Serengeti National Park (SENAPA).

Figure 1

Map Showing the Location of Fort Ikoma Historical Building in Serengeti National Park



2.2 Construction History and Geometric Survey

The construction history of the Fort Ikoma Historical Building and its interventions were obtained through a literature review, unstructured interviews of stakeholders, and internet surfing. Besides, the geometric survey was conducted using a measuring tape to measure distances, a pen, a notepad for writing down the measurements, and ArchiCAD software for drawing the ground floor and roof plans.

2.3 Visual Site Survey

Numerous inspection stages were conducted through this research to achieve the established objectives. A visual inspection was systematically performed across the entire building, focusing on architectural and structural components. Each defect was identified and assessed based on its condition and maintenance priority. The visual inspection process comprised systematic documentation using photographs, detailed note-taking and expert evaluation of the observed defects. The visual site survey was categorised into three building components: the building structure, building fabric, and building service of the Fort Ikoma Historical Building.

Table 1

Building Physical Condition Rating (Mohd and Deraman, 2023)

Rating	Classification	Description
1	Very Good	No defect In very good condition Works well
2	Good	Minor defect In a good condition Works well
3	Fair	Major defect Moderate condition Still, function but with supervision
4	Critical	Major or minor defect Critical Unable to function according to the agreed level of service
5	Very Critical	Unable to function Very critical At the risk that could lead to injury and accident

The assessment of physical conditions must be connected with the maintenance actions prioritised based on identified defects. These assessments are categorised as shown in Table 2. The condition's extent, along with maintenance priority, is combined into a defect score or matrix analysis, highlighting varying levels of severity as illustrated in Figure 2 and Figure 3 (Mohd Noor et al., 2019).

Table 2
Maintenance Priority Ratings (Mohd Noor et al., 2019)

Rating	Description	Condition
1	The defect does not affect the structure and structural components and other building services	Satisfactory
2	A minor defect, which has almost no impact on the structure and structural components functionality but still should be maintained	Slight
3	The structure and structural components show unnatural behavior, but the functionality as a whole does not affect	Moderate
4	The functionality of structure and structural components is affected and may cause injury to the occupants	Poor
5	The defect may cause structural failure and service failure if not repaired or maintained	Severe

Figure 2
Matrix Analysis (Mohd Noor et al., 2019)

Matrix Analysis		Maintenance Priority Rating				
		5	4	3	2	1
Condition Rating	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3
	2	10	8	6	4	2
	1	5	4	3	2	1

Figure 3
Maintenance Action (Mohd Noor et al., 2019)

21-25	Very severe and require immediate actions
16-20	Severe and require further detail investigation
11-15	Major defect and require further detail investigation
6-10	Minor defect and only require easy redecoration
1-5	No maintenance required

2.4 Analysis

Building conditions were evaluated and documented in reports based on functionality, security, maintainability, and sustainability criteria. Findings were recorded in a building condition schedule and defects sheets, with photographic evidence provided for each defect. Detailed defect inspections were completed using the BCA form. Figure 4 outlines the process of assessing building conditions. Defect data was analysed, major defective elements were identified, and the findings were organised for rating and further analysis. The scores from the building condition schedule determine the severity of defects. Mohd and Deraman (2023) calculated the matrix analysis using equation (1) as the basis.

$$Matrix\ Analysis, (c) = (a) * (b) \quad (1)$$

Where (a) is the physical state level of building components, and (b) is the priority level of maintenance action.

The overall building rating was calculated by dividing the total matrix analysis score by the number of defects, as Figure 5 and Equation (2) outlined. This calculation method aligns with the approach by Hamzah et al. (2010). This rating system minimises subjective judgements, making it reliable for predicting future conditions (Mohd Noor et al., 2019).

$$Building\ rating = \left(\frac{\sum Matrix\ Analysis}{\sum Defects}\right) \quad (2)$$

Figure 4
Condition Assessment Process (Mohd Noor et al., 2019)

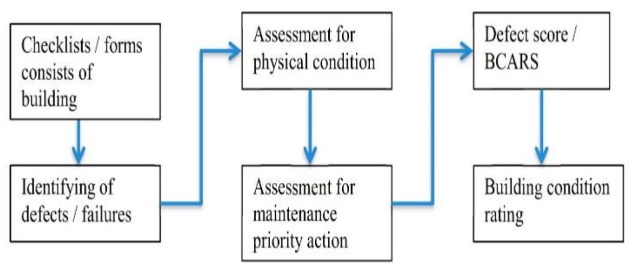


Figure 5
Building Rating and Maintenance Action (Mohd Noor et al., 2019)

Rating	Condition	Maintenance Action	Score
1	Very good	Preventive maintenance	1-5
2	Good	Condition based maintenance	6-10
3	Moderate	Repair	11-15
4	Critical	Rehabilitation	16-20
5	Very critical	Replacement	21-25

2.5 Schmidt/Rebound Hammer Test

The surface hardened concrete for the curved dome/entrance slab was determined using a rebound hammer. Other tools used during the execution were a scraper for removing paints and other undesired materials on the tested surface, medium-grain abrasive stone in carborundum, a station template for measuring, marker pens for marking, and a notepad for test remarks. A rebound hammer, also known as a Schmidt hammer, is a non-destructive test used to measure the surface hardness of the materials. It is commonly used to evaluate concrete and to identify variations in masonry materials' uniformity. It only takes a few seconds to do each reading of the Schmidt hammer test, which can be used to describe areas of fire damage or otherwise deteriorated masonry and find differences in unit hardness that may show flaws or previous repair work (Schuller, 2003). To perform the Rebound Hammer Test, the inspector held the instrument firmly and ensured the plunger was perpendicular to the tested surface. The orientation of the instrument was recorded concerning horizontal to the nearest 45-degree increment. When the instrument pointed upwards, a positive angle was used, and when the instrument pointed downwards, a negative angle was recorded. The concrete strength was estimated using an experimental calibration curve supplied as support by the rebound hammer manufacturer, which correlates the strength of the concrete to the bounce index. The testing procedures used during the test were in accordance with BS 1881-202, 1986.

2.6 Reinforcement/Bartracker Covermeter Test

The Bartracker Covermeter conducted a reinforcement/rebar detection test of a curved dome/entrance slab. A covermeter is a device used to measure concrete cover thickness over steel reinforcement bars and metal pipes. It can determine the location and orientation of the reinforcement bar (rebar) or metal pipe, and it can even ascertain the diameter of the rebar. This eliminates the guesswork about rebar and pipe locations (Controls Group, 2007).

3.0 Results and Discussion

3.1 Building Historical Survey

The Fort Ikoma Masonry Building, built by the Germans in 1905 during their colonial rule over present-day Tanzania, was a strategic military outpost. Positioned on Nyabuta Hill, nearly 2 km from the Grumeti River, it offered a defensive advantage against local opposition. 1901 German troops had to retreat into the fort after a day-long battle with a notable Maasai attack. The fort's design, featuring thick walls and a vantage point on a hill, allowed for excellent visibility and defence against invasions, marking a tactical innovation at the time (GeoParks Africa, 2024). In the late 19th century, Dr. Oscar Baumann, a German explorer and naturalist, was the first European to pass through the area as part of an anti-slavery expedition before the construction of Fort Ikoma. The fort later became an administrative centre until it was taken by the British in 1917 during World War I.

3.2 Building Intervention

Based on the little information we have from secondary sources and unstructured interviews, the Fort has gone through different functional changes. As a result, the building structure has also gone through different structural additions within its parameters, or even the building itself. These interventions were mainly due to the addition of function or change of uses.In 1969, two foreign citizens, Mr. SkippLevit and Mr. Will Wodritch, renovated it and established a tourist hotel, Fort Ikoma Lodge. The renovation also involved the construction of a hall for a food and beverage restaurant on the southern side of the Fort. The government of Tanzania had previously converted the fort into a military training institute before moving the said facility to the now-known Tanzania Military Academy (TMA) in the Monduli District of Arusha around 1979 (Geoparks Africa, 2024). The fort underwent several interventions, including constructing 1.5m-high walls with crenulations on the western side. Additionally, a canteen (hall) on the southern side originally had an open ceiling, but a wooden ribbed ceiling was installed during the occupation of the Tanzania People's Defence Force (TPDF). TPDF also added a new fence wall around the swimming pool area using concrete/sand cement blocks, featuring crenulations similar to those on the fort. During significant renovations, TPDF redid most plaster works with cement render and sealed previously open areas with dressed stones.

3.3 Geometrical Survey

The building area was approximately 2.71 m². The average height of the rooms and hall was about 2.50 m, the average height of the two entrance towers was nearly 5.00 m, and the average height of the two corner towers was almost 7.50 m.

Following what was seen of the existing Fort Ikoma Historical Building in Serengeti National Park (Figure 6), its measurements were used to make the ground floor plan and roof plan shown in Figures 7 and 8. In Figure 7 and Figure 8, the green line colour meant the total collapse of the building; the black line colour meant the available solid wall; and the green line colour meant the available concrete slabs.

Figure 6
The Existing Fort Ikoma Historical Building in Serengeti National Park

Figure 7
Existing Ground Floor Plan of Fort Ikoma Historical Building in Serengeti National Park

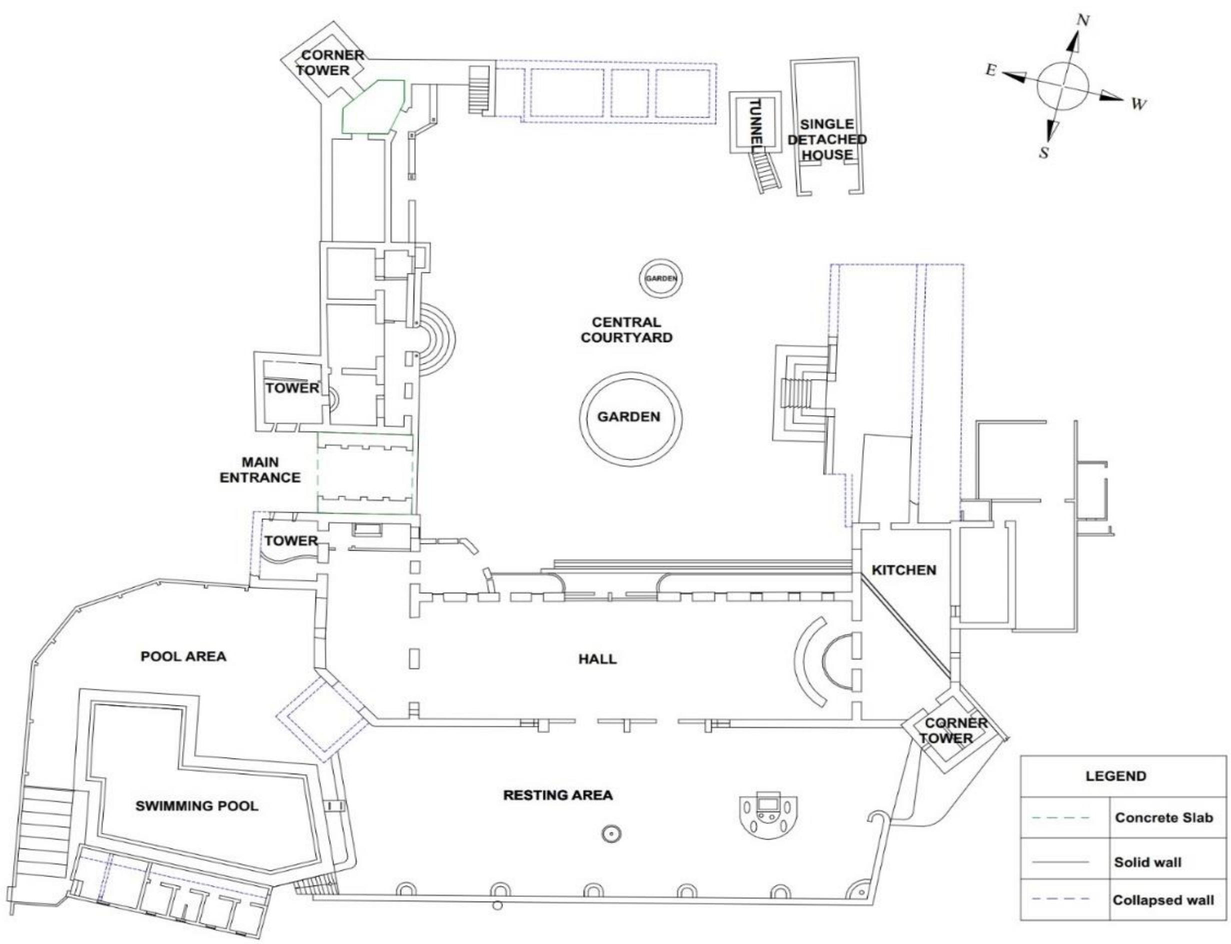
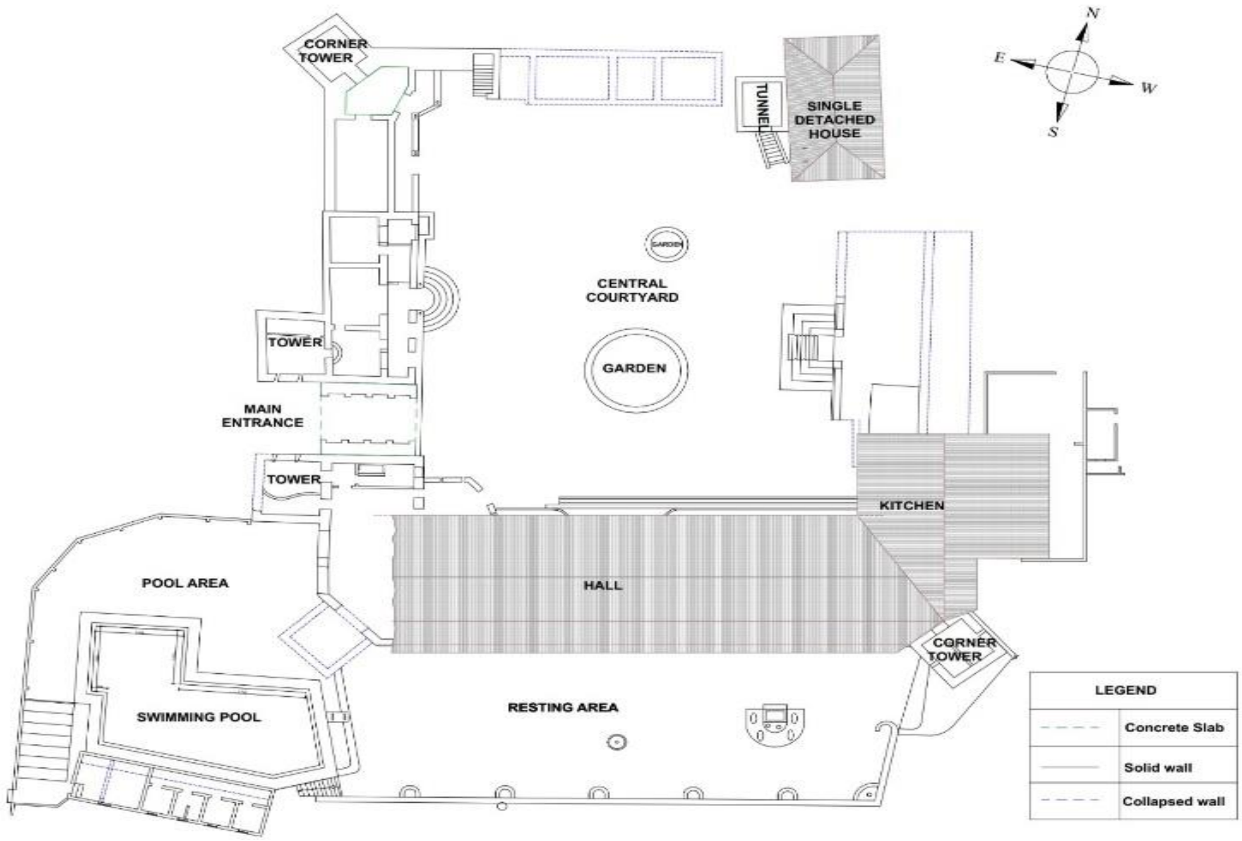


Figure 8
Existing Roof Plan of Fort Ikoma Historical Building in Serengeti National Park



3.4 Visual Site Survey

3.4.1 Physical Condition of the Existing Fort Ikoma Historical Building

This part of the physical condition assessment of the fort highlighted every part of the building, stating the condition and its cause of decay. The building was sectioned into various parts for further understanding and elaboration.

3.4.1.1 Main Entrance

This area included the entrance porch/concrete curved dome, two entrance towers, and an adjacent office building on the northern side neighbouring the northeastern tower, as indicated in igure 9. The southern tower at the entrance porch had partially collapsed, and two side walls were severely damaged, and this is due to the exposure of these walls to harsh weather. The same effect has caused the small observation windows made up of wood to rot and some of the members to be missing. The northern tower was intact, but various minor cracks were visually inspected during the site survey. Nevertheless, the remaining plasterwork has many indications of ageing because it has not been replaced and has been exposed to harsh weather for a long time. The neighbouring office area has been observed to have rotten corrugated sheet roofing materials that allow water to infiltrate the building area, causing the ceiling to get wet and rot. Also, because the building was abandoned, there were several areas where the roof timber structure had decayed due to the effects of insects (dry rot).

Figure 9
The Main Entrance of Fort Ikoma Historical Building in Serengeti National Park

3.4.1.2 Northern Office Structures

This part formulated the collapsed area of the fort at the northern side, an underground tunnel, a northern observation corner tower, and an in-use/habitable single detached house. The collapsed area was in a catastrophic condition with only traces of foundation walls and areas where the portion of the wall stood, as indicated in Figure 10. The reason for this collapse was possibly due to a lack of protective roof cover that allowed rainwater to attack the massive walls put together by mud mortar. The northern observation tower was intact but exhibited numerous cracks in the plaster, and some vegetation grew on one side of the tower.

Figure 10
The Northern Office of Fort Ikoma Historical Building in Serengeti National Park

3.4.1.3 Western Office Structures

This part consisted of newly constructed short walls and a collapsed fort on the western side. The collapsed area was ruinous, with only traceable foundation walls and a few small portions of the fortified wall still standing. This was because the area was covered by a rotten roof that could no longer protect the building from rainwater, and ultimately, the condition caused the building to collapse. The newly introduced walls on the western side were still standing, but they needed protection as they were not covered against weathering. The structure has endured harsh weather and formed a blackish burnt fungus, as depicted in Figure 11.

Figure 11

The Western Office Structures of Fort Ikoma Historical Building in Serengeti National Park

3.4.1.4 Hall and Kitchen

This area included the hall, kitchen, Southeast and Southwest towers, and the total area of the hall and its resting area. This part experienced maximum damage, and the southeast tower and its adjacent structure collapsed. During the collapse, some of the nearby elements of the building were downed by the tower's debris. The tower was in a state of disrepair. The hall and the kitchen were in good condition, with the 28-gauge metal corrugated sheets of the roof causing only significant visible harm. The roof has been laid for a very long time. As it is exposed directly to weathering conditions, the roof has started to corrode, forming holes that allow rainwater infiltration to structural wooden members of the roof, as illustrated in Figure 12.

Figure 12

The Hall and Kitchen of Fort Ikoma Historical Building in Serengeti National Park

3.4.1.5 Pool Area

The pool area covers the pool's location and its surrounding open area, swimming pool facility building, and newly introducedfence wall. The swimming pool structure was intact, but some service systems, including drainage, clean water supply, and electrical systems, have not been used long. This may probably cause the system failure or disconnection. The poolhouse facilities were also intact, but various non-structural cracks were visible on the surface of the plasterwork. Also, the fencewas in fair condition, but the harsh tropical weather seemed to affect concrete blocks where burnt black fungus was visible. The pool's surrounding area was covered by square concrete pavements of approximately 400mm x 400mm x 10mm in size that were unclean due to prolonged use and exposure to weathering conditions, as shown in Figure 13.

Figure 13
The Pool Area of Fort Ikoma Historical Building in Serengeti National Park

3.4.1.6 Central Courtyard
The central courtyard does not contain any structure; the only visible construction was a round curb wall surrounding a garden. Other parts were open and mainly made for landscape purposes.

3.5 Materials and Construction
3.5.1 Roofs
The roof types used were gable, flat, and hipped roofs; timber trusses; and corrugated iron sheets for roof covering. The observed ceiling was a wooden ribbed ceiling. The roof was only observed in the hall, kitchen, and single detached house, and the remaining places of the Fort masonry buildings were missed.

3.5.2 Walls
Most masonry walls were single-leaf and multi-leaf and consisted of three leaves. Two outer leaves (superstructure walling) were well-dressed reddish-brown stones and jointed by mud mortar; the outer-leaf stones were either pointed by cement/sand materials or fully plastered by cement/sand materials of about 30 mm thick for internal and 50 mm thick for external building to protect the wall against weathering effects. The inner core was filled with different samples of light grey and reddish-brown stones, but mostly reddish-brown. The average wall thicknesses from end to end of the outer leaves were about 800 to 1200 mm, with a thickness range between external and internal leaves of about 100 to 250 mm. The walls were much thicker at the foundation and floor levels, and wall thickness started to reduce as the height of the superstructure increased. Light grey stones were mainly used on foundation and floor-level walling, and reddish-brown stones were mainly used on superstructure walling, floor slabs, stairs, and foundation walling. Some stone walls were observed to be weathered, and some collapsed due to prolonged exposure to weather. Also, some parts of the building were constructed with block masonry, done through building interventions by different people and authorities.

3.5.3 Slabs
Only two types of slabs were observed: concrete and wooden slabs. The concrete curved dome/main entrance slab observed on the main entrance of the building had approximate dimensions of 6678 mm in width, 7050 mm in length, and 100 mm in thickness, supported on two sides by five (5) plastered block columns, approximately 240 mm x 480 mm, and a 1140 mm stone masonry wall on each side. The top surface of the main entrance slab was plastered with two (2) cement/sand layers; the first layer had a thickness of 40 mm, and the second layer had an inner thickness of 20 mm. Besides, the other concrete slab was observed near the corner tower on the eastern side of the building, as shown in green colour in Figure 7. Nevertheless, the corner towers were 7500mm high, and a wooden slab was observed on the corner towers, which were approximately 3200mm high from the ground; a wooden slab was used to separate the tower and be a multi-story tower supported by stone masonry walls of thickness ranging from 800mm to 1200mm thick.

3.5.4 Columns
Initially, it seemed like the Fort Ikoma Historical building was only supported by stone masonry walls as load-bearing walls, and no single column was used. However, after the intervention, the renovation was conducted using a block column of approximately 480 mm and a width of 240 mm on the main entrance to retrofit the existing foundation and strengthen the load-bearing stone masonry walls to carry the concrete curved dome on the main entrance.

3.5.5 Beams and Arches
The building was only supported by the load-bearing walls, and only after intervention were some parts of the beams and arches constructed with reinforced concrete. An example of a reinforced beam of thickness 300 mm was

observed at the main entrance of the Fort Ikoma Historical Building.

3.5.6 Floors

Before the intervention, all floors were constructed with reddish-brown stones. However, in intervention, some parts of the building were constructed with cement/sand screed, such as the kitchen room.

3.5.7 Plasters

Initially, the building was constructed with stones, and all wall finishing was done by mud mortar, but after the intervention, the parts of the walls were plastered with cement/sand; the internal layer thickness was 30 mm, and the external plaster thickness was 50 mm.

3.5.8 Windows and Doors

All doors and windows were constructed with wooden materials; only after intervention were some members constructed with metal and glass.

3.6 Building Condition Assessment Rating System (BCARS)

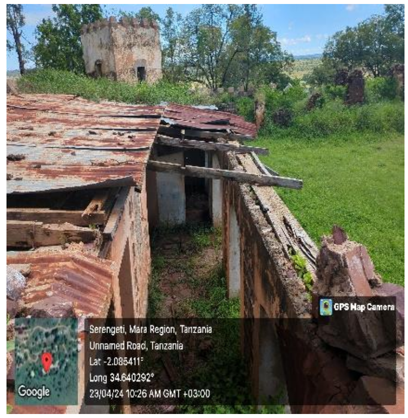
A Building Condition Assessment (BCA) was conducted on all structural and architectural aspects of the Fort Ikoma Historical Building. The on-site visual survey found a summary of defects in Table 3, and the Building Condition Assessment Rating System (BCARS) for the Fort Ikoma Historical Building is shown in Table 4. Figure 14 shows that the most defects are in the 21-25% range, which means they are at the very critical level. The average high percentage of defects for building structure components was 47%, falling within the 21-25 range, indicating a critical condition as shown in Table 5. Similarly, building fabric components exhibited an average high percentage of defects at 64%, falling within the 21-25 range, as depicted in Table 6. Building service components showed an average high percentage of defects at 89%, with a building condition range of 21–25, indicating a very critical condition, as outlined in Table 7. Also, looking at defects based on building parts showed that the fabric of the building broke down the most (49%), then the structure (42%), and finally the service (9%), as shown in Table 8.

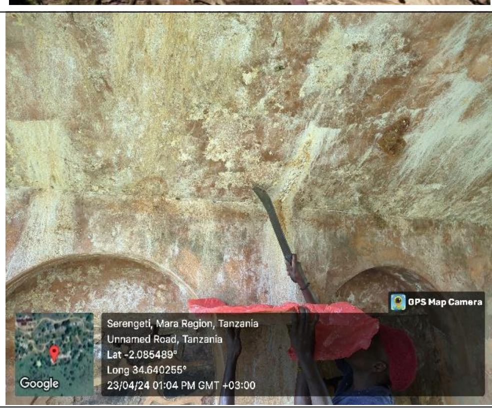
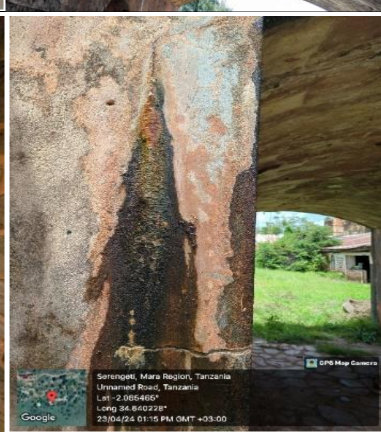
Table 3

Summary of Defects found at Fort Ikoma Historical Building during Visual Site Survey

No	Types of Defects	Descriptions
1	 	Breakage/Collapse and Vegetation of Foundation

2		Crack or Fracture, Deflection, and Efflorescence and Delamination of Columns
3		Breakage/Collapse and Textural Features of Wooden Slab
4		Breakage/Collapse and Vegetation of Concrete Slab
5		Flacking of Paints

6	 	Breakage/Collapse, Corrosion, and Missing of Roof Covering
7	 	Breakage/Collapse of Ceiling
8	 	
9	 	Spalling,Vegetation,Dampness, Fungus, and Efflorescence of Walls

<table>
<tr><td>10</td><td></td><td></td><td>Cracks or Collapse of Walls</td></tr>
<tr><td>11</td><td></td><td></td><td>Missing of Roof Covering</td></tr>
<tr><td>12</td><td>
</td><td></td><td>Efflorescence of Concrete Slab</td></tr>
<tr><td>13</td><td>
</td><td>
</td><td>Dampness of Columns</td></tr>
</table>

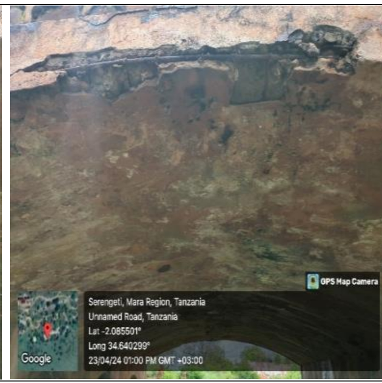
14			Crack or Fracture, and Corrosion of Reinforcement of Arches

Table 4

Building Condition Assessment Rating System for the Fort Ikoma Historical Building

COMPILATION OF ON-SITE OBSERVED DEFECTS			DEFECT SCORE or BCARS		
No	BUILDING COMPONENT	DEFECTS/DEFICIENCY	CONDITION RATING (a)	MAINTENANCE PRIORITY RATING (b)	MATRIX ANALYSIS (C)=(a)*(b)
1	**Building Structure**				
1.1	Foundation	Breakage or collapse	4	5	20
		Termite attack	5	5	25
		Missing	3	4	12
		Vegetation	5	5	25
		Dampness	5	5	25
		Fungus	5	5	25
		Deformation or deflection	3	5	15
	Sub-total number of Defects	**7**	**Sub-total of Matrix Analysis**		**147**
1.2	Column	Crack or fracture	3	3	9
		Moss	2	3	6
		Dull	2	3	6
		Dampness	4	5	20
		Efflorescence	2	3	6
		Vegetation	2	3	6
		Delamination	2	3	6
		Deformation or deflection	4	5	20
	Sub-total number of Defects	**8**	**Sub-total of Matrix Analysis**		**79**
1.3	Beam and Arches	Crack or fracture	3	4	12
		Moss	3	4	12
		Dull	3	4	12
		Dampness	5	5	25
		Efflorescence	3	4	12
		Vegetation	3	3	9
		Delamination	2	3	6
		Corrosion	4	5	20
		Deformation	3	4	12

	Sub-total number of Defects	**9**	**Sub-total of Matrix Analysis**		**120**
1.4	Concrete slab	Breakage or collapse	3	4	12
		Vegetation	5	5	25
		Dampness	5	5	25
		Efflorescence	5	5	25
		Fungus	5	5	25
	Sub-total number of Defects	**5**	**Sub-total of Matrix Analysis**		**112**
1.5	Wooden slab	Breakage or collapse	5	5	25
		Rot	5	5	25
		Termite attack	5	5	25
		Textural features	5	5	25
		Missing	5	5	25
	Sub-total number of Defects	**5**	**Sub-total of Matrix Analysis**		**125**
1.6	Roof truss	Breakage or collapse	5	5	25
		Rot	4	4	16
		Termite attack	3	3	9
		Textural features	4	4	16
		Missing	5	5	25
	Sub-total number of Defects	**5**	**Sub-total of Matrix Analysis**		**91**
1.7	Roof connectors (Nails and bolts)	Missing	5	5	25
		Breakage or collapse	5	5	25
		Rusting	5	5	25
		Corrosion	5	5	25
	Sub-total number of Defects	**4**	**Sub-total of Matrix Analysis**		**100**
2	Building Fabric				
2.1	Floor	Breakage or collapse	3	4	12
		Moss	5	5	25
		Dull	5	5	25
		Dampness	5	5	25
		Vegetation	5	5	25
		Deformation	5	5	25
		Termite attack	5	5	25
	Sub-total number of Defects	**7**	**Sub-total of Matrix Analysis**		**162**
2.2	Interior Wall	Spalling	4	4	16
		Vegetation	4	4	16
		Dampness	5	5	25

		Efflorescence	5	5	25
		Crack or collapse	3	4	12
		Fungus	5	5	25
		Missing	5	5	25
		Deformation	4	4	16
	Sub-total number of Defects	**8**	**Sub-total of Matrix Analysis**		**160**
2.3	Exterior Wall	Spalling	5	5	25
		Vegetation	4	4	16
		Dampness	5	5	25
		Efflorescence	5	4	20
		Crack or collapse	4	4	16
		Fungus	5	5	25
		Missing	5	5	25
		Deformation	4	4	16
	Sub-total number of Defects	**8**	**Sub-total of Matrix Analysis**		**168**
2.4	Staircase/Steps	Breakage or collapse	4	5	20
		Missing	4	5	20
		Spalling	5	5	25
	Sub-total number of Defects	**3**	**Sub-total of Matrix Analysis**		**65**
2.5	Roof covering	Missing	5	5	25
		Corrosion	5	5	25
		Breakage or collapse	5	5	25
		Rusting	5	5	25
		Leakage	4	4	16
	Sub-total number of Defects	**5**	**Sub-total of Matrix Analysis**		**116**
2.6	Ceiling	Rot	5	5	25
		Fungus	4	5	20
		Missing	5	5	25
		Breakage or collapse	5	5	25
	Sub-total number of Defects	**4**	**Sub-total of Matrix Analysis**		**95**
2.7	Door	Missing	5	5	25
	Sub-total number of Defects	**1**	**Sub-total of Matrix Analysis**		**25**
2.8	Window and ventilation	Missing	5	5	25
		Rusting	5	5	25
		Deformation	5	5	25
	Sub-total number of Defects	**3**	**Sub-total of Matrix Analysis**		**75**

2.9	Painting	Missing	4	5	20
		Dull	5	5	25
		Flaking	5	5	25
	Sub-total number of Defects	**3**	**Sub-total of Matrix Analysis**		**70**
3.0	Plaster	Missing	3	4	12
		Spalling	5	5	25
		Dampness	5	5	25
		Moss	4	5	20
		Dull	5	5	25
		Fungus	5	5	25
		Breakage or collapse	4	4	16
		Efflorescence	5	4	20
	Sub-total number of Defects	**8**	**Sub-total of Matrix Analysis**		**168**
3	Building Service				
3.1	Electric	Missing	4	5	20
		Damage/Faulty wiring	5	5	25
		Damage/Faulty electrical fittings	5	5	25
	Sub-total number of Defects	**3**	**Sub-total of Matrix Analysis**		**70**
3.2	Sanitary	Missing	5	5	25
		Deformation	5	5	25
		Rusting	5	5	25
		Corrosion	5	5	25
		Breakage or collapse	5	5	25
		Damage/Faulty plumbing	5	5	25
	Sub-total number of Defects	**6**	**Sub-total of Matrix Analysis**		**150**
	SUM OF DEFECTS	**102**	**SUM OF MATRIX ANALYSIS**		**2098**

Table5

The Number of Defects based on Building Structure components

Condition	Number of Defects	Percentage
1-5	0	-
6-10.	9	21
11-15.	8	19
16-20	6	14
21-25	20	47
TOTAL	**43**	**100**

Table6

The number of Defects Based on Building Fabric Components

Condition	Number of Defects	Percentage
1-5	0	-
6-10.	0	-
11-15.	3	6
16-20	15	30
21-25	32	64
TOTAL	**50**	**100**

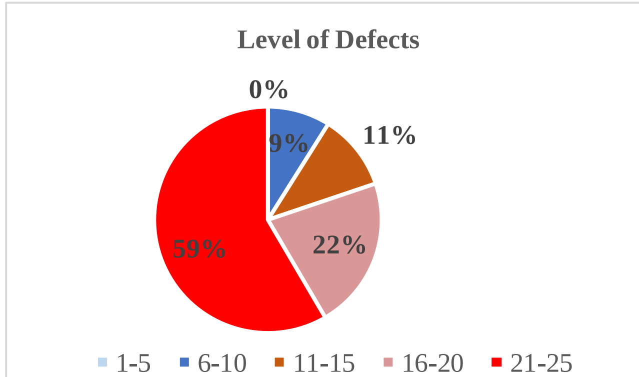
Table 7
The number of Defects Based on Building Service Components

Condition	Number of Defects	Percentage
1-5	0	-
6-10.	0	-
11-15.	0	-
16-20	1	11
21-25	8	89
TOTAL	9	100

Table8
The Number of Defects based on Building Components

No	Building Components	Number of Defects	Percentage
1	Building Structure	43	42
2	Building Fabric	50	49
3	Building Service	9	9
	TOTAL	**102**	**100**

Figure 14
Defects Level Percentage for the Fort Ikoma Historical Building



Building rating $= \frac{2098}{102} = 20.57 \approx 21$ (1)

Therefore, 21 Building Rating equals Rating 5.

Based on the data collection and analysis, the building has received an overall rating of 5. The assessment indicates that the building is in a highly critical condition, requiring extensive maintenance and replacement.

3.7 Rebound Hammer of Hardened Concrete

Figure 15 shows that the average obtained compressive strength of the concrete curve dome/main entrance slab was 38.38N/mm2.

Figure 15
Rebound Hammer Results of the Concrete Curved Dome/Entrance Slab of the Fort Ikoma Historical Building

POINT	DATE OF CAST	DATE OF TEST	REBOUND NUMBER 'R'										MEAN REBOUND NUMBER	MEASURED VALUE N/mm^2	CALIBRATION CORRECTION FACTOR	MOST LIKELY VALUE OF CUBE COMPRESSIVE STRENGTH IN N/mm^2
1	Unknown	18/05/2024	35	35	38	37	38	38	38	36	38	38	37.1	28.7	1.3164	37.75
2	Unknown	18/05/2024	38	37	38	38	37	37	38	38	38	38	37.7	29.6	1.3164	39.01
AVERAGE COMPRESSIVE STRENGTH IN N/mm^2																**38.38**

3.8 Reinforcement Detection/Bar Tracker Test

The thickness of the concrete curved dome/central entrance slab was 100 mm; the diameters of the reinforcements found were 16 mm, 10 mm, and 5 mm; the average distance between bottom bars was 200 mm, and the average distance between top bars was 200 mm. The average concrete cover was more than 30 mm.

4.0 Conclusion and Recommendations

There is a lot of historical value to Fort Ikoma, but its structure and architecture have been badly damaged over the years by weather exposure and moisture in the masonry walls (mostly because more than 75% of the Fort Ikoma Historical Building doesn't have a roof), poor maintenance, and changes that weren't needed. The fort is in a critical state and requires immediate intervention to preserve its historical and cultural value. It is recommended that a comprehensive restoration plan be developed, prioritising urgent structural rehabilitation of the foundation, walls, and roof to prevent further collapse. Restoration efforts should aim to conserve historical elements using materials and techniques that align with the fort's original construction. In contrast, modern reinforcement methods should enhance stability and durability. Furthermore, a preventive maintenance schedule should be established to ensure the long-term preservation and sustainability of the fort as both a heritage site and a potential tourist destination.

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