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## **DIAGNOSING TIMBER DEFECTS IN TRADITIONAL MALAY HOUSE: A CASE STUDY OF RUMAH KUTAI KAMPUNG SELAT**

**Haryati Mohd Isa<sup>1</sup>, Muhammad Ruzaini Ramlan<sup>2</sup>, Othman Mohd Nor<sup>3</sup>, Najat Affendy Dzulkifly<sup>4</sup>, Khairul Adham Ibrahim<sup>5</sup>**

*<sup>1,2,3,5</sup>Department of Built Environment Studies & Technology,  
Faculty of Built Environment*

UNIVERSITI TEKNOLOGI MARA, PERAK BRANCH, MALAYSIA

*<sup>4</sup>Creative Multimedia Department, Faculty of Art,  
Sustainability and Creative Industry*

UNIVERSITI PENDIDIKAN SULTAN IDRIS,  
TANJUNG MALIM, PERAK, MALAYSIA

### **Abstract**

Timber traditional houses can bring a significant image of the Malaysian built environment heritage. Indeed, it is one of the most valuable treasures that must be sustained for future global reference. The building owners and professionals are responsible for ensuring that these assets are in good condition and safe for its occupants. However, the occurrence of defects contributes to significant cost overrun. There are limited studies undertaken on diagnosing the nature of timber defects for traditional timber houses. Thus, it is crucial to systematically track and record these defects. This paper aims to identify the nature of timber defects that occurred in Rumah Kutai Kampung Selat. This house was selected due to its unique Perak traditional architecture. Three research objectives were established: (i) to identify the types of timber defects, (ii) to determine the causes of the defects, and (iii) to analyse the overall building condition rating. A qualitative research approach was adopted. The building inspection was carried out to record only architectural and structural defects. These defects were recorded in the conditional survey form via visual inspection and survey tools. The data were analysed using frequency analysis to measure the frequency of the defects manifested. In addition, the condition of the property was also evaluated using the Building Assessment Rating System. The findings revealed that there are 30 of these defects, primarily related to weather conditions, insect attack, and wear and tear. With a proper methodology adopted in studying defects, there is much to be learned to provide insights to the owner/caretaker in planning to repair and sustain their houses.

**Keywords:** Timber Traditional House, Rumah Kutai, Defects, Learned

<sup>1</sup> Corresponding author. Email: harya966@uitm.edu.my

## **INTRODUCTION**

There are many traditional Malay houses scattered around Malaysia. Although it had been built over decades to centuries, these houses created significant images of the Malaysian built environment heritage. According to M. Nurfaizal et al. (2020), a traditional Malay house portrays the uniqueness of Malay architecture and cultural value to the society. Indeed, it is one of the most valuable treasures that are sustained for future reference universally. According to this, the National Heritage Department Malaysia has outlined the process to investigate historic buildings, which includes architectural research, documentation on measured drawings, and dilapidation survey or building condition assessment with laboratory analysis Harun, 2020). Societies worldwide have recognized the need to preserve their valuable cultural heritage (Mustafa et al. 2020), and decision makers have emphasized heritage preservation as represented by the Sustainable Development Goals (SDGs) 2030. SDG 11 addresses sustainable cities and communities, with the aim to “make cities inclusive, safe, resilient, and sustainable”. It provides a comprehensive framework for heritage buildings, particularly Target 11.4, that seeks “to strengthen efforts to protect and safeguard the world’s cultural and natural heritage”. Heritage preservation also helps to reduce landfill waste, demolition energy use, and resource consumption for new constructions. This is consistent with SDG 12, Target 12.5: “by 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse”.

Nevertheless, Seo et al (2009) reported recently, the traditional Malay house has been affected by the rapid modern development and faces the threat of being demolished or transformed into a brick house. Nor Haniza et al. (2007) added that due to Malaysia's climate and location, in the tropics is classified as tropical with high temperatures, high humidity, and heavy rainfall. This will lead to timber defects and deterioration. Thus, the house owner and the professional must ensure that these assets are in good condition and safe for their occupants (C. Ani et al. 2009). One of the methods is by conducting a building condition survey to identify the type of defects, location of the defects, and causes of the defects so that an appropriate solution can be made. This paper aims to identify the nature of timber defects that occurred in one of the traditional Malay houses in Perak, i.e, Rumah Kutai Kampung Selat (RKKS). Three research objectives had been established (i) to identify the types of timber defects, (ii) to determine the causes of the defect’s occurrence and (iii) to analyse the overall building condition rating.

## **LITERATURE REVIEW**

### **Defects and Deterioration of Timber Buildings**

Defects are a common phenomenon that occurs on any structure or building (Mohd Khazli et al. 2024; Najihah et al. 2024; Kartina et al. 2018). Defects can

be defined as a failure or shortcoming in the building's function, performance, statutory or user requirements, and this may occur in its structure, fabric, services, or other facilities (Azni et al. 2025; Carillo, 2006; Peng & Wee, 2001). It occurs not only in the building operational phase but also before and during the construction stage (Lateef et al. 2010) and (Chong et al. 2005). Failure to address defects would most likely contribute to additional rectification costs, hamper the smooth operation of the building, and reduce its service life. In extreme cases, defects may even lead to accidents and disasters (Groblier & Pretorius, 2002).

Traditional Malay houses in Malaysia, famous for their uniqueness in design and aesthetic value, are mainly constructed with timber materials. There is a pressing need to conserve this valuable heritage, as these timber building structures and elements are subjected to decay and deterioration caused by environmental factors. Civil laws and other protective measures are necessary to save these heritage buildings and important timber structures from destruction. Nevertheless, preventive treatment alone does not promise to restore the timber buildings and structure to their former condition, but will at least stop further deterioration. Under proper conditions, timber provides excellent, lasting performance. However, it also faces several potential threats to service life, including fungal activity and insect damage, which can be avoided in numerous ways. Md Azree et al. (2016) explained that timber buildings are also exposed to several potential threats to service life, including fungus, insect damage, and the wear and tear process. In addition, M. Nurfaizal et al. 2020 highlighted other typical timber defects such as timber shakes, twisted, cup, bow, split, peeling off paint, and unwanted plant growth.

According to M. Nurfaizal et al. (2020), Ridout (2000) and S. Johar et al. (2013), these defects can be divided into four main wood deterioration agents, such as:-

- a) Biological agents are well known for their catastrophic attacks. These deterioration agents can be classified into two, namely fungi and insects/small animals. Soft, brown, and white rot are typically grouped into fungi. Meanwhile, beetles, termites, ants, bees, and birds are examples of insects/small animals
- b) Physical agents are imperfections and aesthetic defects in the wood itself. It was naturally born, known for its hollow, knots, and cracked features, before being consumed by users
- c) Chemical agents are acids that make the wood brittle and wood fibers become separated, resulting in a mass of sharpened filaments detectable on the surface. These defects can usually be found in industrial areas with high pollution
- d) Mechanical agents are commonly due to mechanical friction during handling and processing, such as cutting and drying. The combined effects

of light, wind, and water movement produced stresses resulting in small surface checks and cracks

Some of the agents are significantly less damaging and usually affect only the aesthetic value. However, the biological agents and moisture problems are the two most common defects that occur and cause serious wood deterioration (S. Johar et al. 2013). Visual inspection is the easiest and most fundamental method to use to inspect the existing structure. However, this method may not be applicable to the defects that do not appear on the surface. Hence, a non-destructive test will be used to assess the properties of a material, component, or system. Since most of the traditional timber houses use famous local hardwood with fine carpentry skills that are rarely seen today, thus, conserving timber houses is as important as conserving other heritage buildings. According to S. Johar et al. (2013), Harun (2011), Fielden (2000), conservation is a practice that highlights the importance of preserving cultural properties and safeguards the object from destruction, decay, and unintentional changes to prolong the life span of the existing cultural and natural importance.

Although building defects cannot be avoided, it need to be addressed in providing valuable insights to the industry (Haryati, 2016; Wardhana & Hadipriono, 2003; Ilozor et al., 2004; Samuel & Isaac, 2018). Findings from the surveys provided some insights to the owner/caretaker in planning the repair for replacement work to be undertaken to sustain the building. Nur Fadhilah et al. 2022 explored the possibility of building a condition assessment activity towards data creation for a database management system using geographical information. Thus, it will assist government ministries and local authorities to standardize tourism information data as well as facilitate them to monitor and update the latest data to re-boost the tourism industry in Malaysia. By systematically recording and tracking defects, the types, causes, and categories of each defect can be identified. Moreover, recurring defects can also be traced.

#### **Brief Description of Rumah Kutai Kampung Selat**

Rumah Kutai Kampung Selat is located at Kampung Selat, Bota, Perak Tengah, Perak Darul Ridzuan. This Kutai house is estimated to be almost 100 years old and was built in the 1920s. This house was built near the Perak River because the river was the main route in the old days.

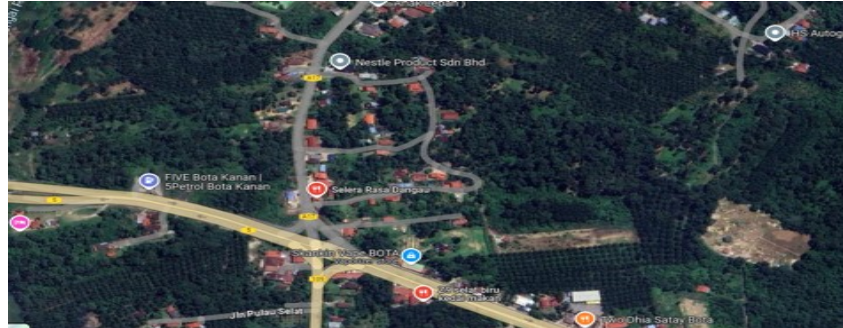


**Figure 1:** Location of Rumah Kutai Kampung Selat



**Figure 2:** Front and side elevation of Rumah Kutai Kampung Selat

The structure of RKKS, such as columns and walls, was originally built using the Cengal timber. The floorboard used Balau and Meranti Merah timber. Meanwhile, Kempas timber was used for roof trusses. This house was built with several main basic spaces such as foyer space, porch space, motherhouse, interval house, and kitchen.

## RESEARCH METHODOLOGY

A qualitative research approach was adopted for the present study. The crucial stage in this research is to assess the existing condition of the building through a building condition survey. A pro-forma survey was established as a checklist and was used to identify the types of timber building defects, the possible causes, and the location of defects. An inspection was carried out on 20th June 2024 using visual inspection to diagnose building defects for the traditional Malay house and was evaluated using the Building Assessment Rating System (BARIS) score. At the time of the survey, the weather conditions were sunny (28 degrees Celsius).

A few observations and procedures needed to be followed, such as a top-down approach, which starts the inspection from the highest level of the house, i.e roof space. Then, the survey will be moved from the internal building to the external façade with reasonable care. Several significant information on the building background were taken into consideration. Various tools and equipment,

such as a spirit level, digital caliper, moisture meter, laser distance, measuring tape, tapping rod, and L square, were used during the condition survey. The limitation of this research was that it was based only on visual observation without taking into consideration possible concealed and internal decay to timber elements, which would not be detected visually. For a more accurate diagnosis and verification of internal timber condition, non-destructive testing methods can be conducted in future research to strengthen the reliability of defect assessment outcomes.

The analysis was made based on element by element; the column, beams, walls, floors, windows, doors, roof, plinth, and stairs, diagnosing the type of defects and their possible causes. The reason that the ten elements are chosen is based on the severity of the element's condition, which is common defects that occurred to the elements, and the limitation of the inspection is the roof structure that cannot be inspected in detail due to the equipment shortage. The data recorded were then analysed using frequency analysis to measure the frequency of the defect's occurrence.

## **FINDINGS**

Based on the analysis of building defects obtained from the conditional survey, it was found that the RKKS was involved in several defective works. The types and causes of the defect's occurrence are illustrated below. The findings matrix was derived using the Building Assessment Rating System (BARIS), which is the system that is commonly used to calculate and obtain the result of building condition rating, as shown in Table 1 below.

### **Defects Analysis by Matrix and Element**

#### *Defects Analysis by Matrix*

Figure 3 depicts the percentage of defects for RKKS according to the matrix classifications as mentioned in CPBS 101: Code of Practice for Building Inspection Report, and evaluated using the BARIS score.

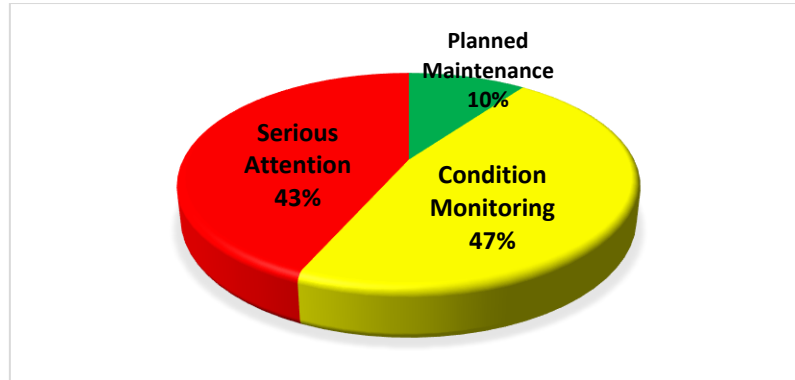


**Figure 3:** Defects Analysis by Matrix

The majority of the defects occurred under condition monitoring (47%). These defects need to be constantly monitored before they become major defects. The second highest is defects categorised as serious attention and needs urgent actions (43%). The defects under planned maintenance classification are the least defective matrix (10%), and they did not harm the occupants.

#### *Defects Analysis by Element*

Figure 4 represents the percentage of defects according to the 10 elements involved in the RKKS.

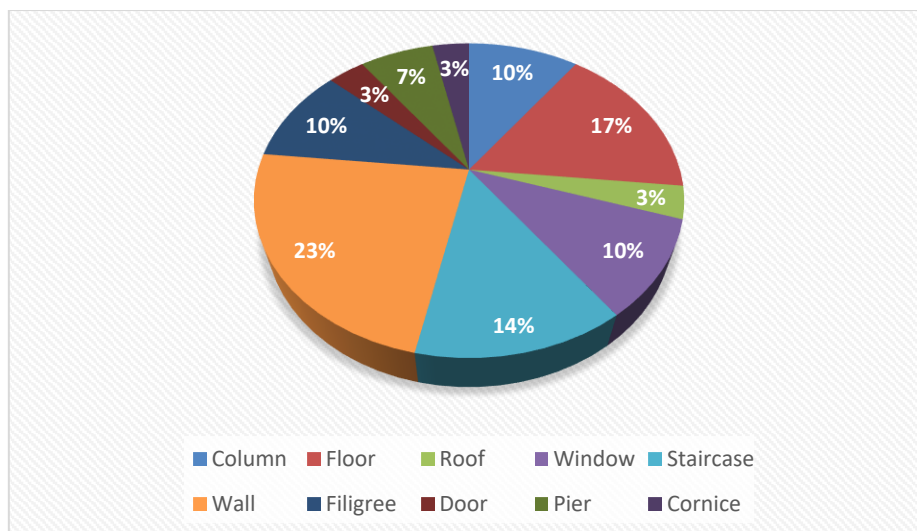


**Figure 4:** Defects Analysis by Elements

It is found that the wall is the most defective element (23%), followed by floor (17%), staircase (14%), and Others, i.e, window, filigree, and columns (10%). The least defective elements are the roof, door, and cornice, which represent 3% of the defects. Nur Fadhilah et al. (2022) stated that the wall is the most defective timber element in traditional houses. This will be dangerous to the occupants because it will decrease the timber building performance in terms of an aesthetic point of view.

The significant number of wall and floor defects observed in RKKS demonstrates the vulnerability of old timber structures to prolonged tropical exposure, particularly Malaysia's hot-humid climate with heavy rainfall and persistent moisture accumulation. Older Malay houses, particularly those over 70-100 years old, are naturally more vulnerable to biological agents and weather-driven deterioration, and this is in line with findings from traditional Malay buildings in Malacca (Nor Haniza et al. 2007) and Perak (M. Nurfaizal et al. 2020), wherein walls were likewise identified as the most defect-prone element. The findings confirm that climatic stressors and age-related stress remain the primary indicators of degradation trends in traditional timber buildings. Therefore, strengthening conservation practice for Rumah Kutai necessitates systematic preventive maintenance frameworks, rather than reactive repairs, to minimize moisture impact, prevent termite spread, and prolong the longevity of the original timber components.

### **Type of Defects**

It was observed that there are 30 types of defects that occurred in RKKS. The breakdown of the type of defects is illustrated in Figure 5. Table 1.

|                                                                                                                         |                                                                                                                       |                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
|  <p>Checks on the column surface</p> |  <p>Crack on the timber column</p> |  <p>Crack on the timber column surface</p> |
|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                               |                                                                                                                             |                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>Rotten of staircase</p>                  |  <p>Rotten rafter</p>                      |  <p>Rotten of timber floor joist</p>                            |
|  <p>Broken on the timber staircase tread</p> |  <p>Broken staircase newel</p>            |  <p>Broken timber frame on the internal wall</p>               |
|  <p>Loss of timber wall pieces</p>         |  <p>Rusting of the lock set</p>          |  <p>Discoloration of timber filigree at the internal wall</p> |
|  <p>Broken concrete on the staircase</p>   |  <p>Knotted holes in the wall frames</p> |  <p>Crooked on the timber floor</p>                           |

|                                                                                                                                 |                                                                                                                                |                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>Broken timber floor joist</p>              |  <p>Broken of the external timber cornice</p> |  <p>Broken on top filigree</p>                          |
|  <p>Mould growth on the timber floor joist</p> |  <p>Mould growth on the foundation pier</p>   |  <p>Fungus attack</p>                                   |
|  <p>Missing of timber window</p>             |  <p>Missing of window panel</p>             |  <p>Missing timber floor on the staircase landing</p> |

**Figure 5:** Type of Timber Defects in RKKS

The table above illustrates the type of timber defects manifested in RKKS, particularly at the column, floor, roof, wall, and staircase. These defects were further tabulated and ranked as in Table 1.

**Table 1:** Types of Defects

|     | Type of Defects                                                                                                                                                                    | Percentage (%) | Rank |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------|
| 1.  | Checks on the column surface                                                                                                                                                       | 4              | 5    |
| 2.  | Decay/Rotten of timber floor joist, staircase, carriage, and rafter                                                                                                                | 10             | 3    |
| 3.  | Crack on the timber column, the foundation pier, and the timber column surface                                                                                                     | 10             | 3    |
| 4.  | Missing timber floor on the staircase landing, timber window, and window panel                                                                                                     | 10             | 3    |
| 5.  | Knot holes in the wall frame                                                                                                                                                       | 3              | 6    |
| 6.  | Broken of timber frame on internal wall, external and top filigree, timber floor joist, external timber concrete, timber staircase tread, staircase newel, external timber cornice | 30             | 1    |
| 7.  | Discoloration of timber filigree                                                                                                                                                   | 3              | 6    |
| 8.  | Rusting of the lockset                                                                                                                                                             | 3              | 6    |
| 9.  | Loss of timber external wall panel                                                                                                                                                 | 7              | 4    |
| 10. | Crooked on the timber internal floor                                                                                                                                               | 3              | 6    |
| 11. | Mould growth on timber foundation pier, external timber wall, timber floor joist, filigree joist                                                                                   | 14             | 2    |
| 12. | Fungus attack on the window surface                                                                                                                                                | 3              | 6    |

Broken is recorded as the most frequent type of defects and mould growth as the second most type of defects (14%). Missing, crack and decay/rotten represent 10%, followed by loose (7%) and checks (4%). Fungus attack, crooked, rusting, discoloration and knot are the five least type of defects (3%) recorded at RKKS. With all the necessary information have been gathered, therefore, the building evaluation using BARIS method as per stated in CPBS101 has be done. Thus, the summary of the result is:

|                                |             |
|--------------------------------|-------------|
| Total Marks (d) x Total of (c) | 372         |
| Number of Defects (c)          | 30          |
| Total Score (d/e)              | 12          |
| Overall Building Rating        | <b>FAIR</b> |

The FAIR rating indicates that RKKS is still functional, but repair intervention is required to prevent further degradation, particularly since termite-related and weather/moisture-driven defects are already apparent in main structural elements. This is aligned with the historical age of RKKS and the environmental exposure pattern in tropical climates, where wall and floor elements often exhibit early-stage vulnerability.

### Causes of Defects

Table 2 presents the causes of defects occurred in RKKS. Among the main causes of the defects are age of material, termite attacks, weather conditions, old material effect, mould growth, checks, wear and tear, human activities, insect attack and crack.

**Table 2:** Causes of Timber Defects

|     | Type of Defects                                                                                                                                                                    | Causes of Defects                                                            |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| 1.  | Checks on column surface                                                                                                                                                           | Age of material                                                              |
| 2.  | Decay/Rotten of timber floor joist, staircase carriage and rafter                                                                                                                  | Termite attacks, weather condition, old material effect                      |
| 3.  | Crack on timber column, foundation pier and timber column surface                                                                                                                  | Age of material, mould growth, checks                                        |
| 4.  | Missing of timber floor on staircase landing, timber window and window panel                                                                                                       | Wear and tear, human activities, weather condition                           |
| 5.  | Knot holes on wall frame                                                                                                                                                           | Insect attack                                                                |
| 6.  | Broken of timber frame on internal wall, external and top filigree, timber floor joist, external timber concrete, timber staircase tread, staircase newel, external timber cornice | Insect attack, termite attack, weather condition, old material effect, crack |
| 7.  | Discoloration of timber filigree                                                                                                                                                   | Weather condition                                                            |
| 8.  | Rusting of lockset                                                                                                                                                                 | Weather condition                                                            |
| 9.  | Loose of timber external wall panel                                                                                                                                                | Old material effect, weather condition, wear and tear                        |
| 10. | Crooked on timber internal floor                                                                                                                                                   | Weather condition                                                            |
| 11. | Mould growth on timber foundation pier, external timber wall, timber floor joist, filigree joist                                                                                   | Weather condition                                                            |
| 12. | Fungus attack on window surface                                                                                                                                                    | Weather condition                                                            |

These defects are mainly due to poor maintenance by homeowner (Kay et al. 2023; Hassanain et al. 2021; Ortiz et al. 2020) and continuous exposure to extreme weather condition (Nur Fadhilah et al. 2022).

### CONCLUSION

The research addressed the mentioned objectives by identifying the various types of timber defects identified at RKKS as well as the underlying causes of their occurrence. The most significant defects were damaged timber elements triggered mostly by termite infestation, prolonged weather exposure, material aging, and crack formation. The presence of such defects on main structural elements indicates a significant vulnerability to safety and health hazards. Simultaneously,

homeowners or caretakers must prioritise constant preventive maintenance, since it has been identified as the primary factor of timber deterioration. Essential repair procedures, particularly for historic buildings, should adhere to a minimal intervention conservation approach. Consequently, local authorities must establish an adequate data management system for traditional Malay houses to monitor performance and track degradation patterns. In addition, the defect mapping outcomes can be used as criteria for curating heritage tourism trails that highlight both cultural value and conservation urgency, thus strengthening tourism planning, resource allocation, and public heritage appreciation.

Notably, this research contributes insights by operationalizing defects diagnosis using the BARIS score matrix along with frequency-based severity classification – an approach rarely applied to timber heritage assessment. This provides a measurable empirical framework for future benchmarking across Rumah Kutai and other Malay timber heritage typologies, enabling conservation stakeholders to compare cases more consistently and make better decisions. This research could be expanded further through advanced statistical modelling and "ripple effect" causal analysis to better trace deteriorating processes. Future research should also integrate non-destructive testing techniques to discover hidden interior damage that visual inspection alone might overlook, improving diagnostic reliability and strengthening long-term heritage conservation strategies.

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