ABSTRACT: In Indonesia, a number of race people have their original architectural culture of traditional timber houses. The scope of the present research is to evaluate the structural characteristics specific to the traditional wooden houses in South Nias, located to the west off-shore of Sumatra Island (See Fig.1). The elevated-floor structure with large diameter columns under the floor. In the present international collaborative study, micro-tremor measurements were performed to evaluate their fundamental dynamic characteristics. Furthermore, earthquake response analysis was conducted to discuss the seismic safety. Architectural structural survey was also conducted to study the structural characteristics and to detect the material’s deterioration. Monitoring of temperature and humidity in the structures was performed to know effect of the roofing materials on the climate conditions that would cause deterioration.

KEYWORDS: Structural conservation, Heritage structure, Groups of Traditional Houses, Earthquake, Indonesia

1 INTRODUCTION
Indonesia has long history of timber buildings, where a number of race people have their original architectural culture of traditional timber houses in rural areas. Most of them have survived against large earthquakes in such seismic areas. However, those heritage structures are threatening to not only difficulties in maintenance due to material deterioration but also people’s preference that they want to live in modern houses. From a historical cultural point of view, it is worth preserving them. The present study focusses on one of the most unique traditional architecture in Indonesia, the group of traditional timber houses in Bawomataluo in South Nias, located to the west off-shore of Sumatra Island (See Fig.1). The scope of the present paper is to introduce this unique architecture from a structural point of view and to show the dynamic characteristics of the heritage structures. As well as, the present paper describes the present state of the deterioration together with environmental monitoring in the house. Seismic safety was discuses on the basis of the earthquake response analysis.
2.1 DESCRIPTION OF ARCHITECTURES
The village of Baomataluo was constructed as a fortress in the middle of 19th century. Shown in Fig.2, the traditional timber houses are arranged as a group along the crosswise street. Our site survey revealed that 124 houses of traditional timber architectures remain among a total of 254 houses in the village. Those traditional timber houses are characterized by elevated-floor structures, shown in Fig.2. Large-diameter columns and braces support the living space surrounded by timber side walls. Photo.1 and Photo.2 show “Omo Sebua” the village chief’s house and “Omo hada” commoner’s house with the continuous row of houses, respectively.

2.2 STRUCTURAL SURVEY
As no nails were used to construct the timber buildings, the joints were investigated from a structural point of view. The present survey showed that the joints characterized by simple models were categorized into 4 types. In order to study the fundamental characteristics of the traditional structure, mechanical tests of the timber materials were performed. The strength and the stiffness of the local tropical woods used for construction, Afoa, Berua and Manawadano were shown.

2.3 INSPECTION OF DETERIORATION
To discuss necessity and methods of restoration, inspection of deterioration and deformation was conducted to fine damaged parts of the timber structures. Degradation survey was performed by the following procedures as; Visual inspection, Percussion test with a wooden hammer, Laser marking test to measure tilting and differential settlement. The inspection revealed that the timber members were so damaged by material decay and harms by termites. The maximum tilting of the column was as large as 1/10 at the pilaster. This deformation was caused by the Great Sumatra Earthquake of December 2004. As those damage indicated the necessity for restoration as early as possible, the present international research project proposed the method for restoration of the heritage timber structures on the basis of Japanese experience.

3 SEISMIC RESPONSE CHARACTERISTICS
3.1 MICROTREMOR MONITORING
Microtremore measurements were conducted both at both Omo sebua and Omo hada. The measurements showed the natural period and the vibration mode. In addition, man-power exciting tests were carried out to know the damping factor. Dynamic coupling effect was observed during the man-power exciting tests, which suggested that the earthquake response would be reduced by this effect.

3.2 EARTHQUAKE RESPONSE ANALYSIS
Based on the fundamental dynamic properties obtained from the microtremore measurements, a simplified SDOF model of the group of traditional houses “Omo hada” was made, shown in Fig.4. Earthquake response analysis utilizing the present model demonstrated that the dynamic coupling effect would contribute to improvement of seismic safety. In the present study, earthquake response analysis of “Omo sebua” was performed to discuss the damage to the Sumatra Earthquake.

4 CLIMATE MONITORING
Temperature and humidity monitoring was performed to investigate the climate condition in the houses. In particular, the effect of the roofing materials, traditional Sago leaves and modern GI sheets, on the climate condition was focussed. The monitoring indicated that the climate condition in the roof structure of GI sheets would cause worse deterioration than that in Sago leaves.

5 CONCLUSIONS
Structural characteristics of the groups of the traditional timber houses in South Nias in Indonesia were described. The present paper shows the present state of the deterioration. Climate monitoring indicated that, to protect wooden members against deterioration, GI sheets should be replaced by Sago palm tree’s leaves. Fundamental dynamic properties were evaluated from the microtremore measurements. Earthquake response analysis using the model derived from the measurements demonstrated the dynamic coupling effect of the continuous houses.