

An Education Program “Building Pathology for Timber Architecture”

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Summary

This paper discusses new approach to education program for sustainable timber architecture. Due to global concerns for environmental sustainability, conservation of timber for future built environment had become a key research topic. However, for a long time, there is a gap in the tertiary education program for timber architecture that has been discovered due to the Kobe earthquake in 1995. The Gifu Academy of Forest Science and Culture has proposed a new architecture program called “Building Pathology for Timber Architecture”, consisting of four critical assessment/rehabilitation criteria: 1) earthquake-proof, 2) energy-saving, 3) durability and 4) habitability. The purpose of this program is to achieve building conservation for the sustainable future. This paper documents the outcome of this new research approach to utilizing timber architecture program for environmental, social and cultural sustainability.

1. Introduction

Due to emerge for sustainable future, three upcoming main challenges have been identified for building production sector. Firstly, to lower building impact on environment has to be proposed, through selecting low impact building materials as well as the appropriate construction method, and to recycle demolished building materials. Secondly, to conserve energy usage is critical by adapting sustainable building systems and changing occupants’ life styles. Lastly, prolonging lifespan of existing building stock is emerged to conserve embodied energy, building materials and resources for other uses. A sustainable solution of existing building environment can be achieved through improving adaptable and flexible design feature of existing buildings. The Japan Institute of Architects has listed building adaptability and flexibility as part of their global sustainability theme in Global Environment 2050 [1] and Union Internationale des Architectes (UIA) 2011 Tokyo Congress will focus same theme with its Environmental Architecture Group.

However, the Japanese building industry had been focused mainly on constructing new buildings instead of remodeling existing buildings [2]. Thus the building industry, such as construction companies, carpenters and so on, did not have much opportunity to update skills and improve methods in assessing and adapting existing buildings. Therefore it is important to investigate into building pathology now towards the sustainable future.

2. Building Pathology Program for Timber Architecture

2.1 Background

There are four key factors in building pathology in Japan. They are; a shortage of resources, its impact on environment as waste, number of new building construction and workforce issue due to less construction, and aging society. Following the aftermath of the Second World War, there were dramatic increases in amount of new housing construction in 1950s [3]. The former extended family structure changing into nuclear family, the societal demand has made the building industry to use mass production methods and synthetic building materials.

The synthetic building materials are difficult to recycle and have short life expectancy as well as of lower quality compared with traditional building materials such as timber, soil and paper. Current building production methods consume lots of raw materials and generate huge amounts of waste as by products.

The number of new building construction peaked in 1973, decreased by 500,000 per year in the next 15 years, and plateaued since 1988 till present time. This tendency of plateau will be estimated in next few decades [4], because of our population issue and its economic situation. Therefore, the building industry has hit a point whereby it is necessary to maintain existing building/ material production levels and agenda to retain current workforce in anticipation of future building demand.

The shrinking population in Japan indicates an aging society with overwhelming percentage of 60 year-olds and above in the society [2]. Since aged groups tend to live in their own housing for long time, this means that such buildings were built before the latest building codes, and so are not up to date structurally as well as in terms of energy efficiency. Therefore those aged groups are living in high risk built environments. According to a study by Ono [5], 94% of housing does not meet with the latest structure code that was updated after the Awaji-Hanshin great earthquake in 1995. Furthermore, many buildings fail to comply with the Building Law for Energy Saving stipulated in 1980[3].

Therefore it is urgent to establish a suitable building pathology method for Japanese housing stock, which achieves 1) identification, investigation and diagnosis of defects in existing buildings, 2) prognosis of defects diagnosed, and recommendations for the most appropriate course of action having regard to the building, its future and resources available; and 3) design, specification, implementation and supervision of appropriate programmes of remedial works, and monitoring and evaluation of remedial works in terms of their functional, technical and economic performance in use[6] in the specific context.

2.2 The Gifu Academy and Its Building Pathology for Timber Architecture

The Japanese building industry has neglected existing building stock, its adaptability and flexibility and the appropriate technology. This indicates a gap in the existing architecture education program in tertiary education system. Therefore, the Gifu Academy of Forest Science and Culture has attempted a new approach to a building pathology program based on a curriculum by UK Reading University [7] and a theory by Nakajima [2].



Fig. 1 Gifu Academy Building Facilities



Fig. 2 Streetscape: Mino City

Due to global concerns of sustainability, forestry and timber architecture as critical factors of environmental sustainability have been chosen as key building environments, therefore especially it specialises building pathology for timber architecture. From the current situation of old timber buildings in Japan, housing was chosen as the building type for this program focus. In order to link with strong local context as well as students' familiarity to this program, the Gifu Academy's school facilities and Mino city where the Gifu Academy is located in were targeted for this study theme.

The facilities of the Gifu Academy is famous for the timber design, and the surface of this school is covered with full of timber surfaces and details (Fig.1). Therefore the building maintenance and management have been crucial issues to Gifu Academy from the beginning. The architecture education programs were designed to deal with such issues directly with some curriculum focused on the actual maintenance process. The second study theme is Mino city, an ancient Japanese merchandise city famous for traditional papers since sixth century (Fig.2). The local residents

have awarded of the historical value, and are determined to preserve and to pass on such unique townscape and streetscape to future generations. Therefore local buildings in Mino city and the city itself have been selected as appropriate study samples for discussions in building pathology.

2.3 Education Program “Building Pathology for Timber Architecture”

The Gifu Academy has programmed building pathology for timber as a two year subject collaborating with Nakajima [8][9]. The program consists of two curriculums; building pathology for timber architecture and local building conservation.

Table 1 Focus Area for Building Pathology

Focus Area	Sub-Focus
Structure	Assessment of Structural Problems
	Cause
	Solution
Defects	Timber Decomposition and Mold
	Foundation and Main Structural Members
	Roofs/Walls/Floors
	Damages by Insects
	Termite
	Preservatives and Pest Control
Indoor Environmental Quality	Indoor Climate
	Indoor Air Quality
Reporting Method	Assessment Equipments
	Assessment Process
	Building Codes
	Contract
	Laws and Regulations

The building pathology curriculum deals with four types of structure, defects, indoor environmental quality and reporting method. It instructs students on building pathology related theories, assessment methods of old timber building based on these theories and a design/rehabilitation approach to improve its 1) earthquake-proof, 2) energy-saving, 3) durability and 4) habitability. It consists of lectures and workshops. The lecture series intensively discuss the four focus areas as Table 1. The part of the workshop involved students in the actual assessment process, such as briefing session with a real client (Fig.3), operation of assessment equipments, data samplings (Fig.4&5), data analysis, identification of defects, documentation of assessment report, and finally report presentation to the client (Fig.6) in the local Mino area.

The following process of defect solution, design application and holistic building conservation plan are programmed as a local building conservation curriculum (Fig.7). The methods and the outcomes are designed to be feedback and input into the building pathology curriculum later.



Fig.3 Briefing Session with Client



Fig.4 Structural Assessment: Micro-Tremor Test



Fig.5 Floor Assessment



Fig.6 Final Report Presentation



Fig.7 Student Construction Site for Timber Housing in Mino City

3. Building Pathology Project: Timber building H

3.1 Study Sample

Timber building H was an assembly of 98 year-old two storey height tea house and single storey extension part built in 1960s. The total floor area is 228.88m². The client has awarded of weakness for earthquake-proof after the Awaji-Hanshin great earthquake in 1995, therefore he was looking for a holistic building rehabilitation together with improvement of energy-saving, durability and habitability. Moreover, another aim was to retrofitting this building into a museum of his great grandfather who was a significant Zen philosopher in his time.

3.2 Method and Project Procedure 1: Building Pathology Curriculum

Project period was 11 weeks. 18 investigators including 11 students assessed the building by using criteria of earthquake-proof, energy-saving, durability and habitability within a day (7 hours work).

The procedure is as follow.

1) Briefing Session and Pre-assessment

First of all a meeting with clients is hold to explain the whole procedure and to book the assessment days. At the same time, pre-assessment is carried out in order to plan the detailed assessment schedule and to make a quote.

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4) Building Assessment

The building assessment is carried out by observation, testing and sampling the focus areas (Table 1). The test equipments are shown in Table 2.

Table 2 Testing Equipments

Assessment Criteria	Equipments
Building Conditions	Surveying instrument: Transit
Materials	Water content measure: for timber and concrete
	Digital camera
	Spot lighting system
	Claw hammer
	Tape rule
Structure	Geological survey test kit: SS kit
	Micro-tremor monitor
	Digital gradient monitor: Smarttool
Indoor Climate	Digital camera
	Data Logger (room temperature and humidity)

5) Producing a Report

A report consisting of four focus areas is produced.

6) Report Presentation

As the last phase of this curriculum, the student project leader presents the results of assessment, and hand over the report after the verbal explanation.

3.3 Method and Project Procedure 2: Local Building Conservation Curriculum

Based on the building pathology report produced during the building pathology curriculum, this curriculum aims to teach students a method of rehabilitation design and its construction supervision. Depending on sample conditions, however, it takes about 1 year to complete this whole subject.

The procedure is as follow.

1) Briefing Session and Pre-assessment

Based on building pathology report, a discussion is held in order to confirm the client's agreement on the rehabilitation project.

2) Briefing Meeting

Another meeting is held with clients for the design brief.

3) Design Stage

A report for the rehabilitation plan and a set of preliminary rehabilitation design are prepared.

4) Presentation

The student project leader repeats the current problems and presents the solutions as a rehabilitation plan and set of design.

5) Construction Documentation: Design only

A set of construction documentation is prepared in order to get a final design confirmation from the clients.

6) Final Presentation to Clients

7) Construction Documentation with Structure and Service Design

Students experience to work with technical experts in structure, electrical, water and air system engineers. Full set of construction documentation is prepared for the following stage of tender.

8) Tender

9) Construction Supervision

Usually architects visit a construction site for building a new timber housing once a week. However, this is rehabilitation, therefore unexpected defect problems often come up. In order to deal with this type of problem, architects and carpenters have to solve them on the site without any waiting time. Therefore at least the students have to visit the site twice a week.

4. Results

4.1 Briefing Session and Pre-assessment

Results of the briefing session with clients and the pre-assessment are mainly described in the following six points.

- 1) Together with earthquake-proof, the client did not want to change the atmosphere and characteristics of the interior. It is necessary to look into cultural sustainability in terms of design.
- 2) The openings were paper sliding doors and wooden sliding shutters. So there was not air-tightness. Beside there was a security problem.
- 3) The original building materials are shown in Table 3.

Table 3 Original Building Materials

	98 years-old part	Extension part
Structure	Traditional timber structure	Traditional Post and Beam
Roofs	Clay tiles on roofing boards with soil	Clay tiles on roofing boards with soil
Walls	Mud walls	Mud walls and partially printed plywood
Foundations	Rocks	Strip Footings without reinforcement
Openings	Paper sliding doors and wooden sliding shutters (GF)	Wooden frames with single glass
	Aluminum Sash (1F)	
Insulation	Not existed	50mm glass wool with ceilings

- 4) The structure does not meet with the current Japanese structural code.
- 5) There was a lack of insulation.
- 6) The indoor climate was tough.

4.2 Proposed Design Solutions

The design was proposed in order to improve the four main assessment criteria, earthquake-proof, energy-saving, durability and habitability. In order to achieve earthquake-proof, the timber footings were exchanged to H steels connected with reinforced concrete floor beams. Also the numbers of bearing wall were provided. Because high insulation building is able to achieve energy-saving, 110mm, 60mm and 110mm of wool insulation were inserted into floors, walls and ceilings. Also openings were changed to double glazing or single wooden framed window with a paper sliding. Extra timber frames were inserted between the existing beams for further durability. Finally the habitability was designed to improve at several conceptual levels. Culturally the concept of building plan was to create two different spaces of tea house and comfortable residential area. The tea house

area was provided less insulation and minimal amount of bearing walls in order to reflect on the Japanese tea philosophy associated with Zen notion.

On the other hand, extra courtyard facing to south was designed for the residential area. The wooden shutters facing to the courtyard were exchanged to staggered grid sliding doors for a security purpose. The new south orientated entrance was designed as a sun room where is able to take advantage of natural sun light in and to be used as drying area during rainy season. Moreover the kitchen in the residential area was increased. A hearth like wooden heater with brick walls in the kitchen area was provided next to the living and dining area, so it has created a sense of centre in this house.

4.3 Final Building Capacity

Improvement of all of the main four categories was monitored and/or measured.

5. Conclusion

The methodology of building pathology described in this paper was designed to develop a sustainable and experimental design process while keeping up technological development, latest alternative energy information as well as sensitive traditional and cultural design issues in our modern lifestyle. This program aims to teach a method of holistic building conservation for the sustainable future to future architectural professionals. Because the final results of building capacity has achieved the improvements, even though this is nearly 100 year-old timber building. The method for the rehabilitation has worked, while there is a few other possible assessment criteria for further improvement. Those past students who had involved this project were able to gain the new method as well as techniques by their real experience during this program. This educational knowledge management method may promise an additional expert profession called “ Housing Pathologist “, and this is a hope for long lifespan housing production in terms of environmental, social and cultural sustainability.

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