

NATIONAL R&D PROJECT TO PROMOTE RECYCLE AND REUSE OF TIMBER CONSTRUCTIONS IN JAPAN

Shiro Nakajima and Mikio Futaki (Building Research Institute, Tsukuba, Ibaraki)

SUMMARY

The volume of waste generated in the process of dismantling wooden buildings is increasing year by year in Japan and the resulting wood waste is having serious local environmental impacts. To improve this situation it is necessary to promote the recycling and reuse of the resources used in the process of building wooden structures. It is also necessary to develop new systems and technologies that enable the reduction of the volume of the waste generated in construction activities.

A new national research project was started in 2000 to reduce waste generated in the process of dismantling wooden buildings. In this research project, new technologies and new social systems will be developed to reduce the waste products over the life cycle of wooden construction. The project deals with three main research subjects. The research subjects are as follows:

- (1) Development of design and construction methods to reduce waste in the construction of wooden buildings.
- (2) Development of the recycling and reuse technologies for building materials and components.
- (3) Development of social systems to disseminate the developed technologies.

The final objective of the first research subject is to propose technical guidelines for choosing low environmental impact building materials and components and to develop design and construction manuals for recyclable, sustainable wooden buildings. The final objective of the second research subject is to develop recycling technologies and to propose reuse and recycle systems for building materials and components. The final objective of the third research subject is to develop a system dynamic model to simulate the effects of technologies and policies on materials flows in the construction of wood buildings.

KEYWORDS: Waste products, Wooden Buildings, Dismantling, Recycle, Reuse, Construction Methods

1. INTRODUCTION

Each year, there is an increasing amount of wooden materials left behind from the renovation or dismantling of timber structures. A large portion of these wood materials become waste rather than being recycled, thereby damaging the local and global environment and creating serious community issues. In order to sustain the timber construction business into the 21st

century, including the construction of wooden houses, broad-ranging recycling technologies that reuse materials removed throughout the life cycle of buildings should be developed.

Large quantities of resources are consumed in the process of building wooden houses and, as the life spans of these wooden houses are very short in Japan, these resources are disposed of over a short period of time. There is a pressing need for the development of technologies to increase the life span of wooden houses and to create a large stock of wooden houses.

Because the waste generated by the construction industry is becoming a serious social problem in Japan, several organizations and groups have started new projects to reduce the production of waste and to promote the reuse and recycling of construction and demolition waste. In May 2000 the Ministry of Construction officially announced a new law that stipulates the deconstruction process and promotes the recycling of construction and demolition waste.

In the Building Research Institute three R&D projects that concern reducing, reusing and recycling of the timber buildings are now ongoing. The titles and the research periods of the three R&D projects are as follows:

- (1) Development of technologies for increasing the life span and the stock of wooden houses. (From year 1998 to 2001)
- (2) Research and technological development for the prevention of dioxin contamination and waste reduction in the construction industry. (From year 2000 to 2003)
- (3) Development of advanced technologies for recycling building materials and components. (From year 2000 to 2002)

The final target of these R&D projects is to reduce the amount of waste and also to promote the recycling and reuse of construction and demolition waste during the life-cycle of timber buildings.

2. CURRENT SITUATION OF C&D WASTE IN JAPAN

There are several recent reports on the current situation of C&D waste in Japan [1][2]. The summaries of these reports are introduced in this section.

Almost 45 percents of the natural resources extracted in Japan are consumed by the construction industry and almost 20 percent of Japan's waste is produced by construction activities. Almost 45 percents of the waste that goes to the landfill site is produced in the process of construction and demolition of buildings and civil structures. And the construction industry is responsible for almost all of the illegally disposed waste. (See Table.1)

Table 1 Resource consumption and waste discharge.

		All Industry (billion tons)	Construction Industry (billion tons)	Ratio (%)
Natural Resource	Consumed	2.40	1.10	46
	Discharged	0.40	0.08	21
Waste	Recycled	0.31	0.05	15
	Legally disposed	0.08	0.04	44
	Illegally disposed	3.90	3.40	87

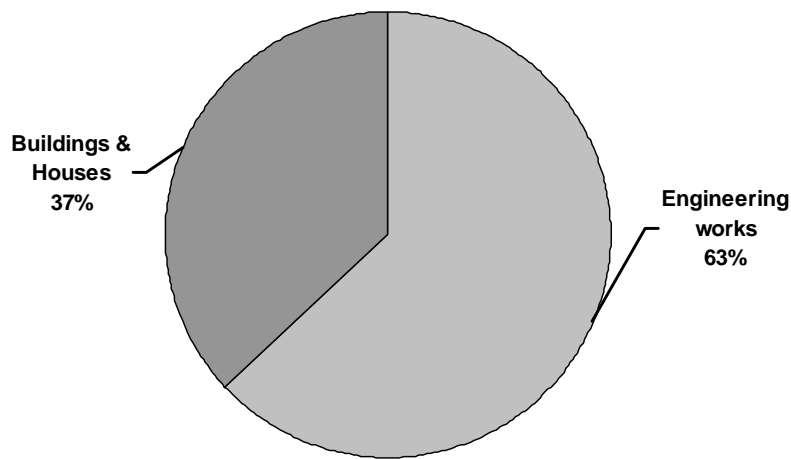


Figure 1 Waste discharged from the construction industry.

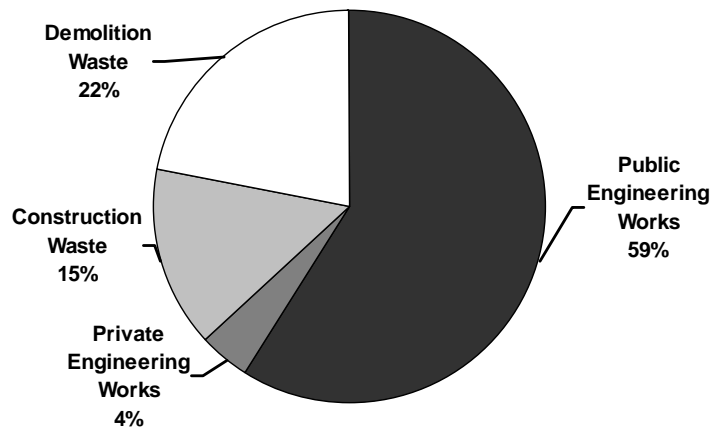


Figure 2 Details of the waste discharged from the construction industry.

The total weight of the waste discharged by the construction industries in 1995 was

approximately 100 million tons and three fifths of the waste was from the civil engineering activities and two fifths of the waste was from the building activities. And as to the waste from the building activities two fifths of the waste was construction waste and three fifth of the waste was demolition waste. (See Figure 1 and Figure 2)

Table 2 shows the type, amount and recycle ratio of the waste discharged by the construction industry in 1995. The waste from the building activities is mainly composed of concrete aggregate, mixed waste and wooden waste. And the mixed waste and the wooden waste show the lower recycle ratio than concrete aggregates. The waste from the building activities is not so much recycled as the waste from the civil engineering activities.

Table 2 Type, amount and recycle ratio of the waste

Type of waste	Civil engineering		Building	
	Weight (million tons)	Recycle ratio (%)	Weight (million tons)	Recycle ratio (%)
Construction waste	61.6	68	37.6	42
Asphalt and Concrete	34.5	80	1.2	62
Concrete	17.8	69	18.6	60
Mixed	1.6	8	7.9	11
Wood	0.6	69	5.7	37
Soil and rock	7.0	14	2.7	14

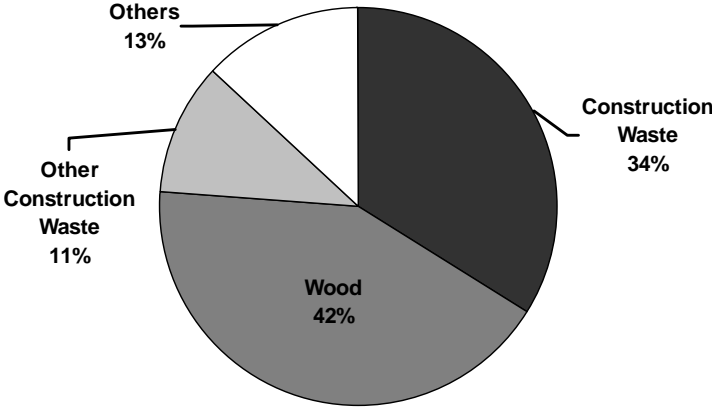


Figure 3 Types and amount of the improperly disposed waste.

Figure 3 shows the types and amount of the improperly disposed waste. In 1995, studies showed that 389,507 tons of wastes were improperly disposed in 1995 and more than 40 percent of this improperly disposed of waste was wood. It is thought that this improperly disposed of waste was generated in the process of constructing and dismantling wooden houses.

Figure 4 shows the projected amount of the building waste in the next 25 years. The

amount of the waste will increase year by year and in the year 2025 the total amount of building waste is forecast to be approximately 50 million tons. Though the amount of the building waste generated in the process of constructing or dismantling wooden buildings will not increase, as constant volume of waste will still be generated during the process of constructing, renovating and demolishing wooden houses. And it is estimated that the landfills have their capacities to accept waste no longer than 0.9 years in the Tokyo area and 2.6 years in the whole country.

Figure 4 Estimated amount of the building waste in the next 25 years.

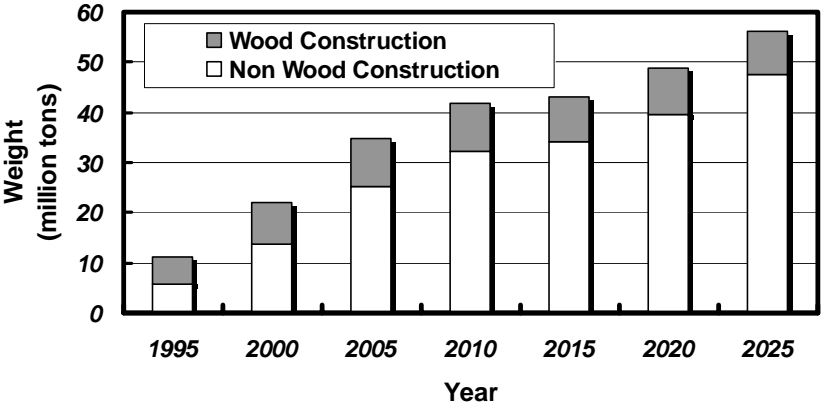


Photo 1 shows the deconstruction site of the post and beam wooden house in Japan. There are three methods for dismantling wooden houses in Japan: by hand, by machine and by machine and hand. The ratio of the wooden waste that is discharged in the process of dismantling post and beam houses is approximately 20% in weight and 45% in volume. And the ratio of the mixed waste is approximately 20% in weight and 10% in volume.



Photo 1 Deconstruction site of the post and beam wooden house.

To improve the current situation and to give a hopeful light to the next generation the government worked on a new law that stipulates the deconstruction process and promotes the recycling of construction and demolition waste. The details of the law were officially announced in May 2000. The law is roughly composed of five items as follows:

- (1) Requirement for selective dismantling and recycling.
- (2) Action to promote recycling and demolition.
- (3) Adjust the contract between the owner and the dealer.
- (4) The establishment of registration system to demolition dealer.
- (5) The setting of objective concerning recycles.

To improve the current situation and to give a hope to the next generation, the government passed on a new law that requires the deconstruction process and promotes the recycling of construction and demolition waste. The details of the law were officially announced in May 2000. The law is roughly composed of five items as follows:

- (6) Requirement for selective dismantling and recycling.
- (7) Action to promote recycling and demolition.
- (8) Adjust the contract between the owner and the dealer.
- (9) The establishment of registration system to demolition dealer.
- (10) The setting of objective concerning recycles.

Requirement for selective dismantling and recycling

For buildings beyond a certain minimum size, selective dismantling to recover specific materials such as concrete, asphalt and wood is required. It is expected that these requirements will be expanded and increased in the future.

Action to promote recycling and demolition

The owner of the building scheduled for removal is required to report the removal prior to demolition and the results of dismantling and recycling of materials at the end of the process.

Adjust the contract between the owner and the dealer

The subcontractor undertaking deconstruction must provide a plan for selective dismantling to the owner. The method of selective dismantling and the expense must be specified for the demolition work.

The establishment of registration system to demolition dealer

The subcontractor undertaking demolition needs to register with the municipality and local district. The demolition subcontractor must engage an engineer who manages the various technologies for demolition. Because the budget for demolition is typically small, it is not necessary to get the permission of local government. Thus it is easy for an unqualified and unlicensed contractor to provide demolition services. This is one of the reasons why illegal dumping of waste occurs as well as indiscriminate dismantling of structures.

The setting of objective concerning recycles

As the basic policy, the recycling and the reuse of construction materials are promoted by creating an action plan. Getting the cooperation of the owner is very helpful in recycling and reuse.

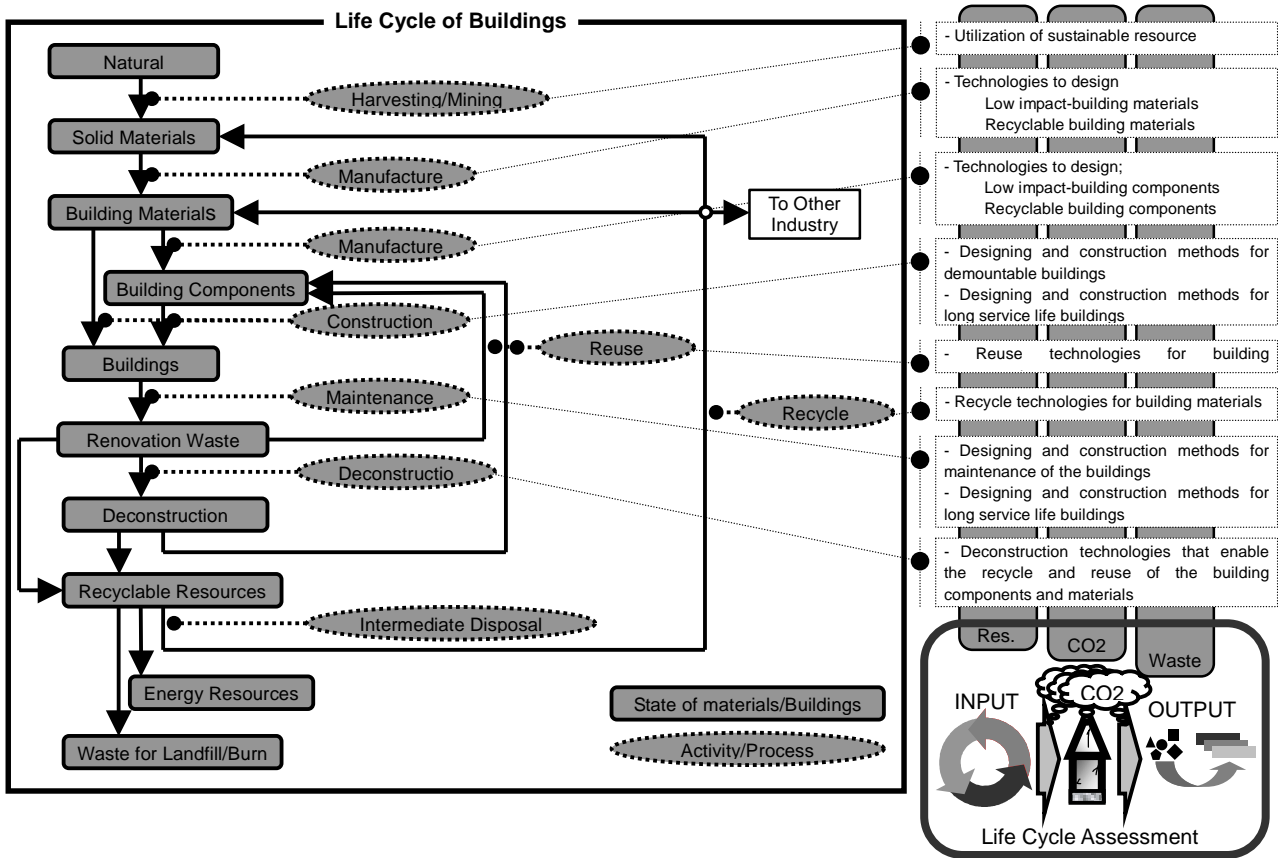


Figure 5 Life cycle of buildings

3. R&D PROJECTS

In the Building Research Institute we are working on three R&D projects to develop technologies to reduce the waste from the wooden houses and to promote the reuse and recycle of C&D waste. Figure 5 shows the life cycle of buildings and the technologies needed to reduce the environmental impacts. In these R&D projects we are planning to develop almost all of the necessary technologies to reduce environmental impact of the wooden buildings listed in the left part of the figure. The outline of each project is introduced in the following paragraphs.

3.1 Development of technologies for increasing the life span and the stock of wooden houses

Backgrounds

The service life of the wooden residential houses in Japan is about twenty-five to thirty five years and in most cases wooden residential houses are in use for only fourteen to seventeen years. Wooden houses are easily constructed and easily demolished in a short period and a huge amount of resources is consumed and a huge amount of waste is generated. These activities disrupt the global and local environment. In other cases we are forced to reduce the scale and the quality of the houses for social reasons and according to the reduction of the

scale and the quality of the residential houses the residential environments can be poor.

On the other hand, in advanced countries, for example in North America and in Europe, the service life of the wooden residential houses is far longer in comparison with that of the wooden residential houses in Japan. In the North American countries wooden residential houses are in use almost forty five to sixty years and this use period is almost three times longer than that of the wooden residential houses in Japan. As the improvement of the quality of the residences is appropriately evaluated in the North American countries it is quite easy in these countries to use the wooden residential houses continuously for a long period. For example, upgrade in the quality of a residence is appropriately evaluated according to the quality of the maintenance and remodeling. And the quality of the residence is reasonably reflected to the price of the residence. The prices of the residence and attention to the quality of the residence and the lifestyles in the North American countries also have something to do with the long service life of the wooden residential houses. The situation with wooden houses in Japan is quite different from that in the North American countries and in most cases houses are rebuilt within a short period in Japan.

Although there is little economic difference between Japan and North America, the service life of wooden residential houses is quite different between Japan and the other developed countries. It is becoming a very important task for us to propose technology systems that will prolong the service life of wooden residential houses in Japan. And we have to develop a new technology that will improve the quality of the residential houses drastically.

Summary of the Research Project

The project is a three years project and it started in 1998 and the annual research budget is approximately 15,000,000JPY. The outline of the research project is shown in Figure 6. The aim of this project is to promote the effective use of resources and enhance the residential environment. The research project is a joint project with private companies and associations and organized by the Ministry of Construction and the Building Research Institute. The main items of this research project are as follows:

- (1) Development of technology for reusing the wooden residential houses and upgrading the quality of the stock of the existing houses.
- (2) Development of design and construction technology to produce long lasting wooden residential houses.
- (3) Development of a system to disseminate the developed technologies.

In the first research subject we developed the technologies that will promote the reuse of the exiting wooden residential houses. These technologies are quite necessary to increase the quantity of high quality wooden residential houses. In detail we developed the following two new technologies:

- Practical building diagnosis technologies that enable the evaluation of the quality of the existing wooden residential houses.
- Maintenance and repair technologies for the existing wooden residential houses.

In the second research subject we proposed new designing methods for newly constructed, long lasting houses. We discussed the necessary performance of the materials and components and decided the designing methods and also developed the maintenance and repair technologies. In detail we developed the following four new technologies:

- Wooden materials and components adequate for the long lasting wooden residential houses.
- Design methods.
- Technology for evaluating the durability of long lasting wooden houses.
- Maintenance and repairing technologies.

In the third research subject we proposed a system for disseminating the newly developed technologies. To do this we prepared the following documents and software:

- Software to use when inspecting the quality of existing wooden residential houses.
- Manual to use when maintaining and repairing existing wooden residential houses.
- Technical manual book for use when constructing a long lasting wooden residential houses.

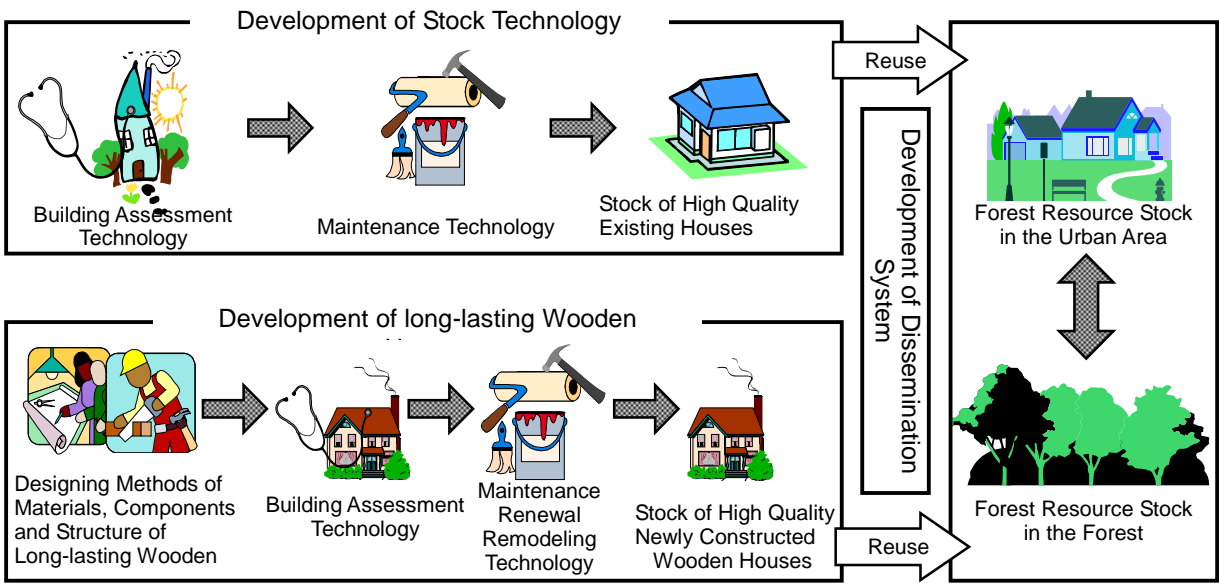


Figure 6 Summary of the research project. (Development of technologies for increasing the life span and the stock of wooden houses)

3.2 Research and technological development for the prevention of dioxin contamination and the waste reduction in the construction industry

Background

The volume of waste generated in the process of dismantling wooden buildings is increasing yearly. It is necessary to promote the recycling and reuse of the resources consumed in the process of building wooden structures. And new systems and technologies that enable the

reduction of the volume of the waste generated in the building activities are also strongly required.

Summary of the Research Project

The project is a three years project and it started in the year 2000. And the annual research budget is approximately 50,000,000JPY. In the project we will develop new construction methods, formulate technical guidelines and compile design and building manual for remountable wooden constructions and we will also develop recycle and reuse technologies to reduce the waste products in the process of dismantling wooden buildings.

The project is composed of three research subjects. The research subjects are as follows:

- (1) Development of design and construction methods to reduce the waste products in the wooden building activities.
- (2) Development of recycling technologies for building materials and components.
- (3) Development of dissemination system to disseminate the developed technologies.

Figure 7 shows the outline of the research program of the first research subject. In the first research subject we will develop the designing and construction technologies for recyclable and remountable wooden constructions. The current designing and construction methods for the 2 by 4 construction and the post and beam construction will be modified and new design and construction technologies will be proposed. In detail we will develop the following three new technologies.

- Technologies to design and evaluate low environmental impact building materials.
- Technologies to design and construct recyclable and remountable wooden buildings.
- Technologies to design and construct sustainable wooden buildings.

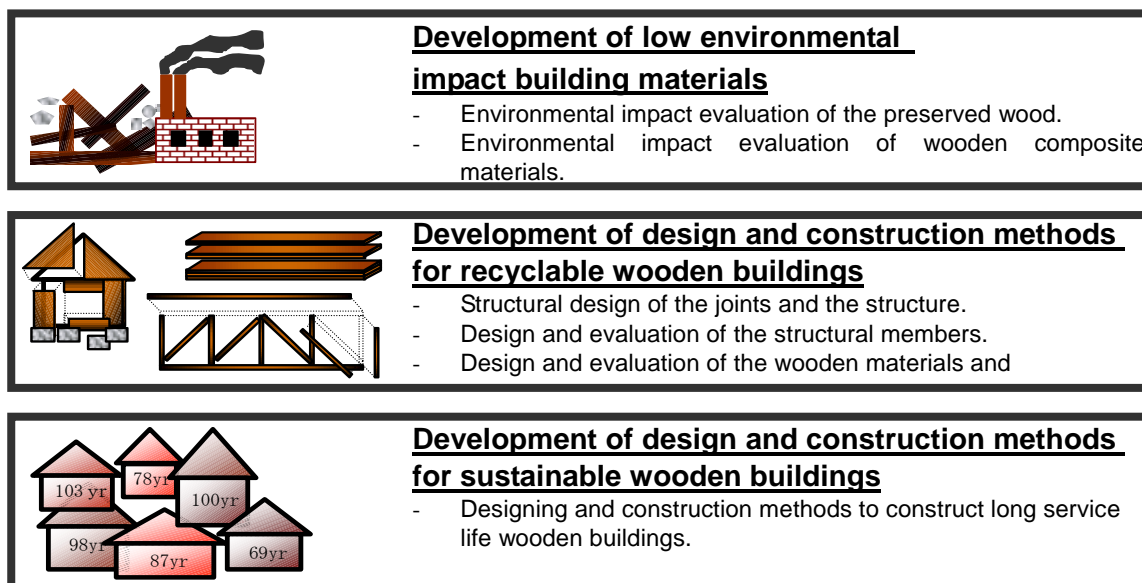


Figure 7 Outline of the research program of the first research subject.

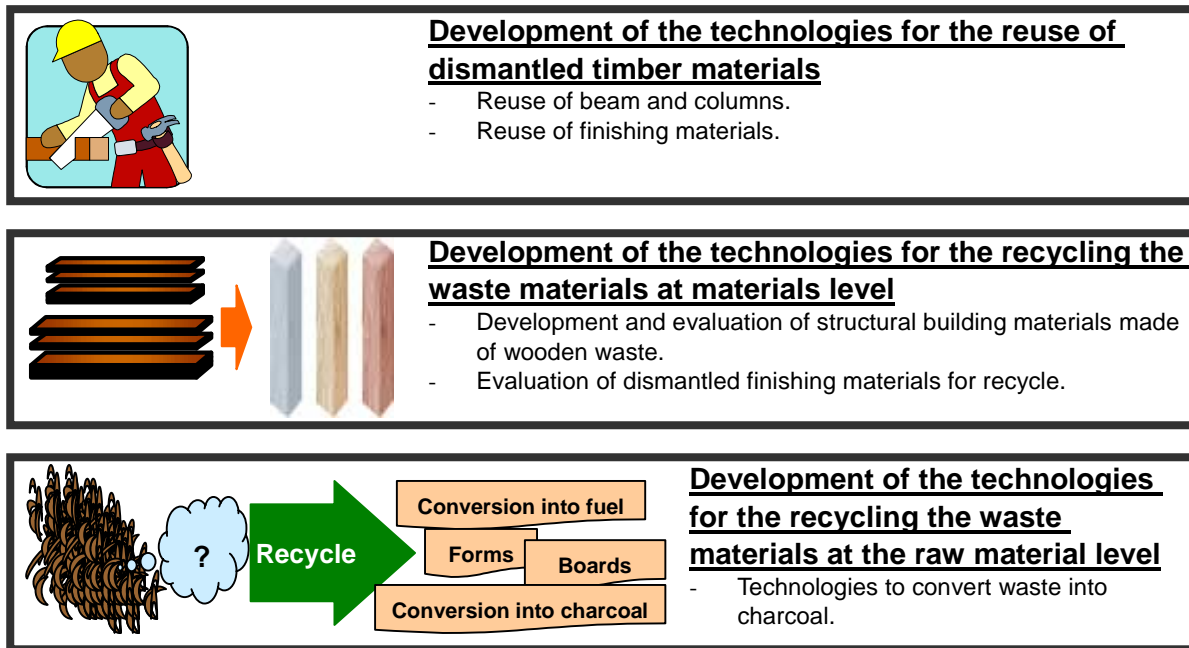


Figure 8 Outline of the research program of the second research area.

Figure 8 shows the outline of the research program of the second research area. In this research area, we will develop new technologies for reusing and recycling wood waste materials and other waste materials. In detail we developed the following three new technologies:

- Technologies to reuse the dismantled timber materials.
- Technologies to recycle the waste at the materials level.
- Technologies to recycle the waste at the raw materials level.

We will also propose a reuse and recycle system that will work well to reduce the landfill waste.

In the third research area we will discuss the factors inhibiting waste reduction and recycling of waste and also propose a simulation model to estimate the waste produced in the future. And we will do some case study to make clear the possibility of the newly developed technologies and social systems to reduce the waste coming out from whole life cycle of the wooden buildings.

3.3 Development of advanced technologies for recycling building materials and components

Backgrounds

This research project was proposed to develop broad-range recycling technologies to reuse and recycle the dismantled materials that appear throughout the lifecycle of wooden buildings. In this research project, technologies for reusing wood construction waste and technologies for recycling waste materials at the materials and raw materials level were

collected publicly from the whole country. Two proposals were selected from among 10 proposals. The target of this research project is to radically reduce waste materials by establishing broad-ranging and advanced recycling technologies for timber structures.

Summary of the Research Project

The project is a two years project and it started in the year 2000 and the annual research budget is approximately 15,000,000JPY. Figure 9 shows the outline of the research project. The technologies that will be developed in this project are as follows:

- Technologies to produce charcoals from wood and ceramic mixed waste.
- Technologies to produce wood fiber insulation materials from waste wood by the dry manufacturing process.

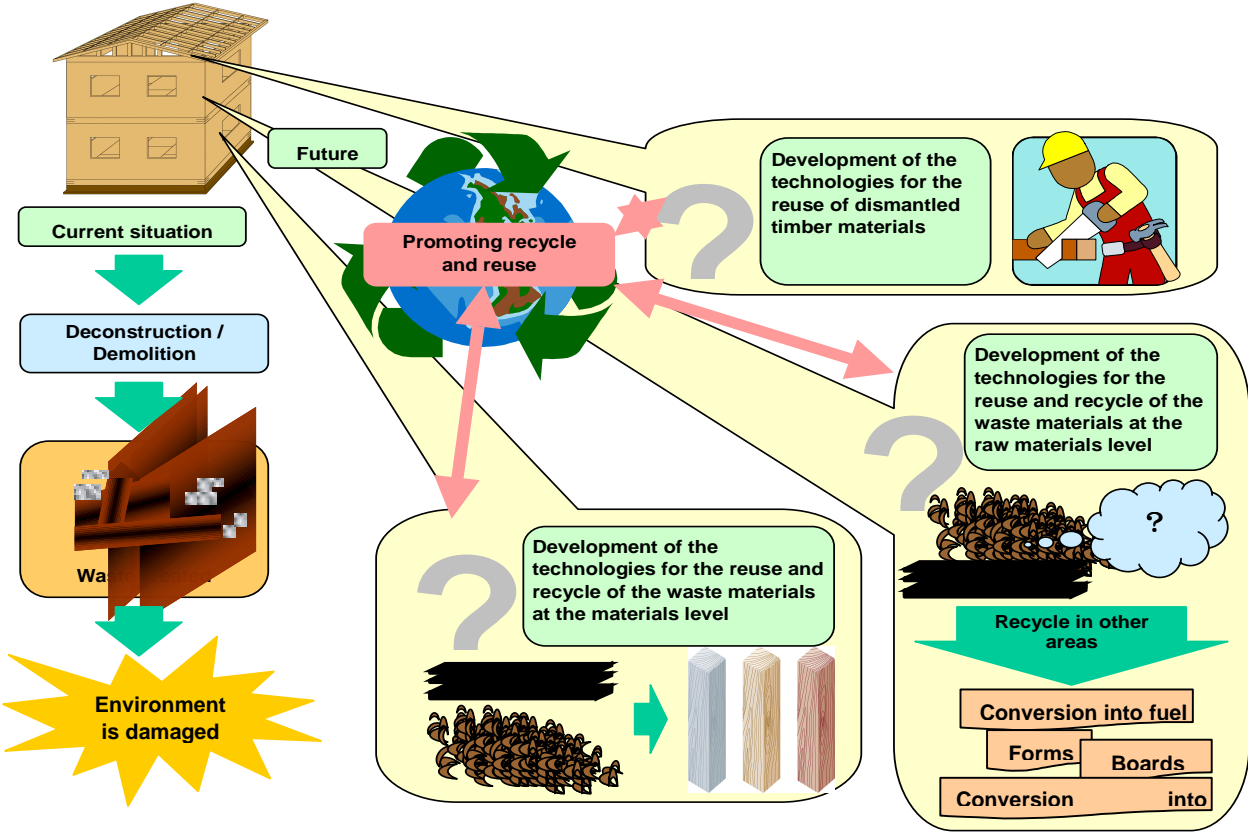


Figure 9 Outline of the research program of the third research subject.

4. CONCLUSION

Our country is now experiencing a very serious waste problem that is caused by the huge volume of construction waste produced day by day. The results of the three research projects described in this paper may provide some good solutions for improving this situation. We have just reached the starting point and we have to make every effort to make the situation better.

5. REFERENCES

- 1 **Sakamoto I.** Present condition and problems of dismantled materials of wooden houses. Wood Industry, Vol.54, No.11, Tokyo, 1999.
- 2 **Dismantle and recycling system research committee.** Report of dismantle and recycling system research committee, Building Center Japan, Tokyo, 1998.