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Wood Utilization in Sustainable System

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To be a sustainable cycle of resources, forests and wood play important role for the future. The urban areas will have to carefully examine the role of forests and wood products. The utilization of wood for reducing energy consumption, expanding life span and recycling will lead to a marked effect in carbon dioxide emission issues.
Key word: recycle, cascade utilization, carbon dioxide, planted wood, life span

1. Wood's Role in the "Sustainable System"

In recent years, the terms "Zero emissions" and "Sustainable System" have become everyday expressions, because of the increased awareness concerning the issues of resources and energy conservation, environmental preservation, and waste disposal. However, among these issues the tremendously important role which forests and forest products plays has less awareness. To be a sustainable cycle of resources, there must first be the initial production of the resources in the first place, that is, renewable resources. Since there is no new production of resources such as metals or fossil resources from which today minerals and plastics are generally recycled, these original resources will eventually become depleted. Thus, recycling merely slows the pace of resource depletion through the cycle. Biological materials which are produced by the solar energy are fundamentally different in that the cycle of resources, are continuous and sustainable.

Looking far back in time, a large transformation occurred when mankind went from a hunting society to a farming society, and consequently, the earth now supports a population of over six billion people. The driving force which enables maintain such a large population is the continuous cycle of food production. As long as humans continue to consume biological resources, there will be no change in this. Likewise, at the same time, mankind has also effected large changes in areas other than food, such as clothing and shelter. It can be said that mankind is unique among living creatures in this respect, in that basically, resources are consumed which gives rise to the issues of resource depletion and the disposal of wastes. The consumption of energy is an illustrative example of the accelerated depletion of resources, and where the burning of fossil fuels has led to a marked increase in carbon dioxide in the earth's atmosphere.

Also, a look at history will show that the growth of cities has often been at the expense of forests. In this course of events, it may appear that there was production of products, but in effect, it was merely the harvesting of resources. The loss of forests speaks to this. However, there is still considerable room for improvement in the production and use of forest resources such as wood. This is fundamentally different than the use of resources where depletion is unavoidable. Needless to say, forests are blessed with the functions of protecting biological diversity and watersheds, and these forests also support continuous resource production such as those associated with forestry and the wood products industry. The coexistence of forest should be focused.

When viewed from the dependence upon fossil resources, resource depleting urbanization, and the pursuit of wealth in recent years, it has become possible to move towards coexistence with renewable resources like the forests and wood products. When looking at the activities of mankind in the future and the continuous survival of mankind, the urban areas will have to carefully examine the role of forests and wood products. However, up to present, the urban areas appear as if they exist completely separated from the forests and wood products.

2. Wooden Construction as "Urban Forest Reserves"

Quite a long time ago, I referred to wooden housing and wooden construction as an "urban forest". The volume of wood presently occupying the wooden structures of Japan account for 48% of the wood in the country's plantation forests and 20% of the total volume of all forests in Japan, which occupy about two thirds of the land mass.

Turning our attention to housing, on a one hectare parcel of land (100m x 100m), if 20 two-story houses of approximately 140 m2 and each containing about 20 m3 of wood are built, the one hectare of land would contain approximately 400 m3 of wood. This volume of wood is equivalent to over 40 years of growth for a hectare of planted forest which grows at a rate of 10 m3 per year. When looked at in this way, area which are populated with wooden housing and wooden construction can be very appropriately called a "forest".

However, in the crowded building conditions at present, the volume of wood stock is certainly greater than in the previous example, but one would be hard pressed to call present conditions a bountiful forest. This is due to the short life span of the wooden house; in other words, the phenomenon called "scrap and build". The short life spans of the houses are not due to structural degradation, but are due to the new living styles, current management and maintenance practices, and houses which are just not functionally flexible nor well adaptable for modern living. Under these conditions, the occupants may not feel that they are essentially custodians of the blessings of nature, which is the wood nurtured in a forest, and then the distance between the forest and the residential areas becomes more distant. Naturally, the purpose of calling wooden housing and wooden construction a "forest" alludes to the " Sustainable System " which should be strived for and would be unthinkable without the connection between the forests and the city.

3. Prevention of Carbon dioxide Emission and the Use of Wood

As described in the previous paragraph, urban areas contain a considerable amount of wood resources in wooden structures. However, are these wooden structures to be looked at as resources or just simple boxes where people live? And then when wood's role is finished and the houses are demolished, is the wood to be looked upon as garbage? In other words, atmospheric CO2, which was locked up in wood after being converted with the help of solar energy, remains locked up for long periods of time in wooden construction, and is only released when the wood itself is broken down by fire or decay. After being disposed of, the wood is put somewhere where it decomposes or it is incinerated, at which time CO2 is released into the atmosphere. The urban areas are burdened with the resource and environmental issues of recycling and reusing the wood as part of a cascade cycle. By making effective use of recycled wood, the carbon can be kept locked up in "carbon storage". This, too, is a growing urban issue.

Global climate change and plans to reduce emissions of CO2 in order to stop projected global warming have become important topics on an international scale. CO2 emissions are largely the result of burning fossil fuels to produce energy for electricity, heat, transportation, etc. Accordingly, objects that require the use of large amounts of energy produce large CO2 emissions and place an increased burden upon the global environment. Wood has a unique position among natural resources. This is because trees have the ability to fix or store carbon by absorbing CO2 from the atmosphere as shown in Fig.1. Eventually, when wood is incinerated or decays, the CO2 and water are released back into the environment. In harvested areas where there exists forest management and the rudiments of a forestry industry, new trees will begin to absorb and store CO2 again as the trees grow. When looking at the inflows and outflows of carbon in this way, utilizing wood products gives rise to three effects.

The first effect is when CO2 stored in the forest and in the wood used in wooden structures, a "stored carbon effect" result. In the second case, there exists a great difference in the amount of energy required to produce wood products compared to the amount of required energy to produce substitutes for wood of other materials and this difference can be called an "energy conservation effect". Lastly, when wood is incinerated and the energy is used effectively, there is a corresponding reduction in the consumption of fossil fuels, which leads to the "energy substitution effect".

As can be ascertained from the low amounts of energy necessary to manufacture wooden construction material for wooden housing, the level of CO2 emissions associated with construction is very low. Also, the amount of CO2 emissions associated with the structural wooden members which comprise the frame of the house is extremely low. Materials other than wood are recognized to account for a large portion of CO2 emissions associated with wooden housing. If the figures are adjusted to account for the CO2 that was reduced from the atmosphere by the fixing of carbon in the wood, the differences become even greater.

4. Cascade Reuse of Wood and the Carbon Cycle

Atmospheric CO2, which was locked up in wood after being converted with the help of solar energy, remains locked up for long periods of time in wooden construction, and is only released when the wood itself is broken down by fire or decay. After being disposed of, the wood is put somewhere where it decomposes or it is incinerated, at which time CO2 is released into the atmosphere.

On the other hand, if the harvested forests are managed for wood resource production, the replanted forests will produce the next generation of trees. This is where plantation forests take on meaning for as the forests are growing, the forests can comfortably provide wood for construction and wood products with a long useable life span. As shown in Fig.2, the plantation forests in Japan is growing, but serious for distribution of age.

The urban areas are burdened with the resource and environmental issues of recycling and reusing the wood as part of a cascade cycle. The scrap wood from demolished structures will be reused in a series of steps in the "cascade" or flow from solid wood to the complete breakdown into CO2 and other components. This cascade may take the form of solid wood to chips for paperboard or other products and lastly as fuel. Presently, the technology in the wood products industry is nearly in place to accommodate the cascading reuse or recycling of wood. In other words, the wood from demolished structures is not a garbage problem, but an issue of resource utilization. It is absolutely necessary to move towards a society structure where efforts are made to ensure a perpetual supply of resources through the increased longevity of wood products and the formation of " Sustainable System " through the appropriate use of resources. The "urban forest" presents itself as energy resources for the next generation and presents the question for looking at environmental preservation.

5. Wood Resources from Demolished Buildings

An outline of the use of wood wastes from wood industries is shown Fig3. The breakdown of raw material form basically follows in a sequence of steps in change of form from the unprocessed or semi-processed state (such as logs or large timbers to be further processed) to lumber to chips and finally to fibers. One can imagine this process as a kind of "cascade" as the material sequentially gets broken down into smaller units. Wooden chips are generally segregated for utilization in pulp, wood-based composite boards or fuel production.

After wood based products such as building products, furniture, paper, etc. leave the factory, they will be utilized and eventually disposed of. And with disposal, they again become available as raw materials to various wooden industries if they are collected, shipped and reprocessed. However, when the recycling conditions are not met, the wood material will simply be thrown away or incinerated along with other garbage. The essential point is to adequately address the problems of useable life spans of wooden materials such as furniture and building materials, their subsequent quality considerations as a recyclable raw material including the removal of foreign debris, and the collection of the wood material. It is vital that this should be effectively coordinated to the issues of environmental protection and energy concerns.

Below, the desired situation and problem of recycling or cascade use of wood demolition material is stated.

(1) The nature of the wood waste is changed, in other words, the wood particles become smaller, become mixed with foreign matter and are of many varieties. The use of a magnet can easily remove the steel objects such as nails, but other nonmetallic objects such as aluminum, plastic, cement, gypsum board, etc. present difficult technical problems in the sorting and selection of chips which need to be solved.

(2) The condition and amount of the chips is determined by the manner in which the building is demolished, primarily whether it was done by machine or by hand. As shown in Table1, this determines whether the chips are of suitable quality for pulping, board production, fuel chips or just plain garbage and has a tremendous effect on the price and volume of chips obtained. Therefore, it is necessary to establish a means of sorting the chip according to quality so that they can be properly utilized to their maximum potential. Already,

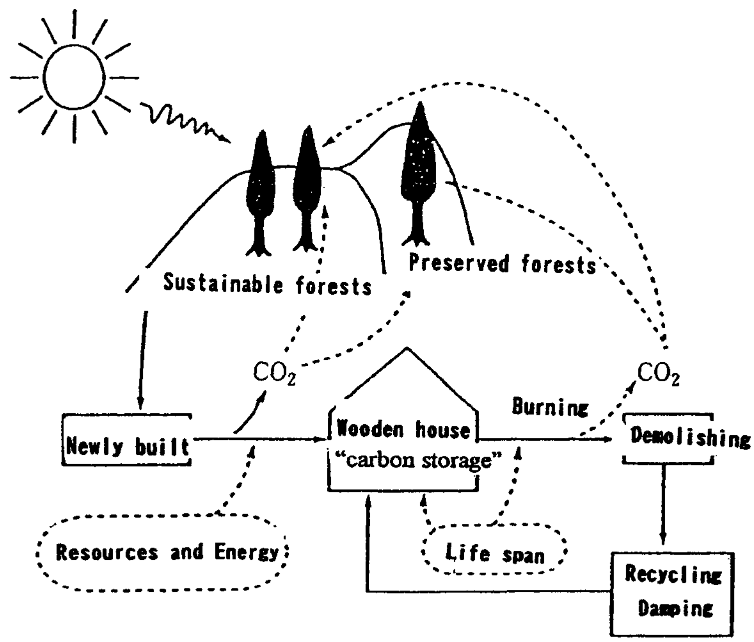

Fig. 1 Flow of wood resources

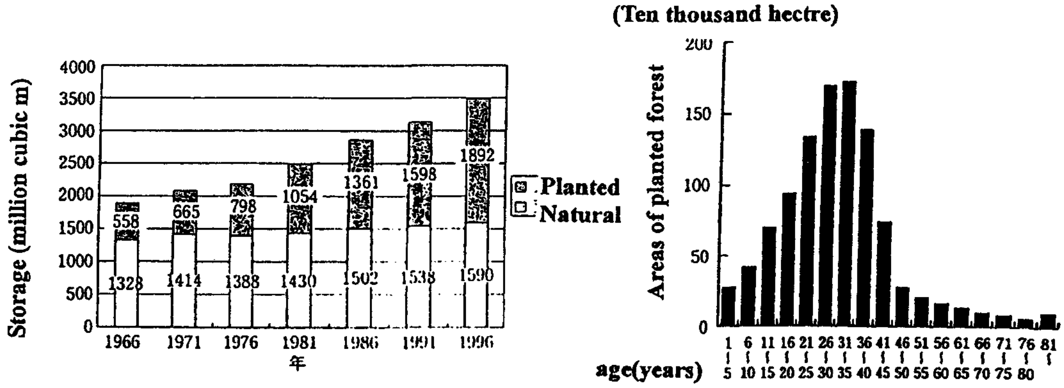

Fig.2 Storage of wood resources and ages of distribution planted forest in Japan

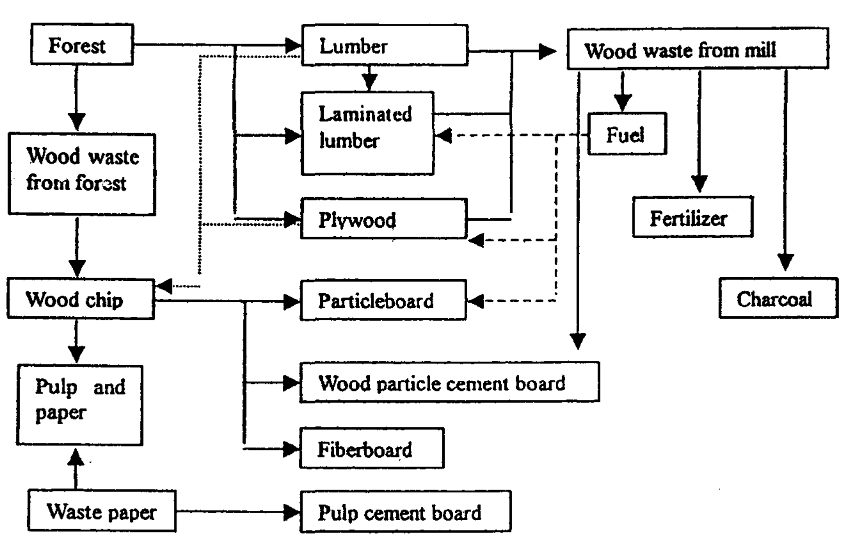

Fig. 3 Brief outline of distribution of wood waste

there is a slowly growing trend at the chips collection sites to accept only a minimum acceptable level of chip quality. On a regional basis, there are both instances where one can see where thought has been put into there cycling of demolition material as well as cases where there appears to be no consideration at all as to the reuse of the recovered wood waste. The important deciding factor seems to be whether there is a facility or means to handle the wood waste in the locality.

(3) Ideally, the demolition and site preparation would be done carefully, but in many instances these steps are rushed, exacerbated by a shortage of labor not allowing for hand demolition and wood waste segregation. As a result, the reliance upon machine demolition damages much of the material and introduces much foreign matter into the wood waste. Additionally, this also adversely affects the efficiency of the waste transport as it becomes impossible to neatly load the machine demolished and loaded material in a way which maximizes the use of the truck. This adds further cost to a lower value waste.

(4) The generation and collection of waste material varies wildly across regions and also by seasons, making it very difficult to obtain a stable supply and quality. Therefore, individual companies who must consider profit implications of using a new material will be reluctant to do so unless the supply is stable and the costs low. Presently the price of chip from demolition material is determined by their quality and suitability for fuel, board, or pulp production. At the same time, chips of pulping quality must compete with chips of a virgin nature while fuel chips must compete with fossil fuels. The foreign currency has a huge impact on the competition of these materials. However, in the present market pricing conditions, even the anticipation of greater recycling will not lessen the garbage burden.

The wood products industry has accepted the inevitability of using demolition from only a cost and supply viewpoint, but the usage will be determined by a balance of technological risk associated with manufacturing and the cost of raw materials. Accordingly, if a new raw material were to have a stable price and supply, the wood products industry would naturally tend to use the new material and the recovered wood waste would tend to become unutilized garbage. The important factor for reusing and recycling resources is what customer buy and use the recovered goods,

(5) With greater urbanization, it has become very difficult to build recycling facilities due to site restrictions, operating hours, and noise prevention problems. For more distantly located sites, working hours and transportation considerations create a large burden, making it unprofitable and infeasible to collect and process the waste wood material. Because efforts on behalf of the government and individual companies is being conducted piecemeal and according to their own individual agendas, there is little active effort at coordinating the policies of recycling and garbage disposal.

(6) From this background, the goal is to develop further the reuse and recycling alternatives while simultaneously reducing the volume of wood waste and keeping the CO_2 in a stored form by converting waste wood resources into wood-based materials. Wooden chips are generally segregated for utilization in pulp, wood-based composite boards or fuel production. Particleboard use recycling chip materials mostly as raw material. Table2 shows the comparison of carbon stock and emission simulated for utilizing wood waste from demolished houses.

The scale of wood-based material factories, such a particleboard, is limited due to site restrictions among other factors, geographic factors become important when considering the use of demolition chips for board production. In the wood industries, the waste raw material which does not find its way into pulp or board production is often burned to supplement energy requirements of the mills or sent for incineration elsewhere.

As a consequence, the burning of wood waste should be the last step in a series of steps which utilizes the wood through a cascade type recycling process. In this vein, it is necessary to give due consideration to effective use of waste materials, including the safety of the waste and any byproducts from utilizing that waste. In other words, simply incinerating wood waste materials should be avoided to utmost possible, and at the very least, consideration should be given to systems which can capture and utilize the energy contained in the wood.

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Table 1 Wood waste from demolished timber structure by machine or by hand [4]

Volume / floor area (m^3/m^2)

	Mixed wood waste with debris	Wood waste without debris	Total
Demolished by machine	0.038	0.070	0.108
Demolished by machine and hand	0.033	0.100	0.133
Demolished by hand	0.071	0.120	0.191
Potential for raw material	Fuel, Particleboard	Paper, Fiberboard, Particleboard	

Table 2 Environmental Assessment of utilizing wood waste for particleboard (Carbon dioxide emissions, Ash, Saving of fossil)

Scenario	Incineration	Raw material (Stocking carbon)	Production Energy (CO2 Emission)	Net	Ash	Fossil
	tonC	tonC	tonC	tonC	ton	tonC
1. Burning	5000			5000	500	
2. Particleboard		-5000				
using fossil			2000	-3000	0	2000
3. Particleboard		-2777				
using wood fuel			2223	-554	222	-1112.
4. .Half						
Particleboard		-2500				
Using wood fuel			2000		200	-1000
Burning	500			0	50	
5. Half						
Particleboard		-2500				
Using fossil			1000			1000
Half burning	2500			1000	250	

Production energy: 100kgC/cubic m for using fossil, 200kgC/cubic m for using wood fuel
Raw material : Negative value in Net is carbon stocking.
Fossil : Negative value in Fossil is fossil saving.

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