Key Issues: **15- Others**

Climatic Zone:
Cf : Temperate humid climate

Subjects:
- Recycling of trees in a storage reservoir

Effects:
- Effective utilization of resource and cost reduction by recycling of trees

Project Name: Tomisato Dam
Country: Ehime Prefecture, Japan (Asia) (N33°53′, E133°29′)

Implementing Party & Period
- Project: Water Resources Development Corporation (present Japan Water Agency)
From 1998
- Good Practice: Water Resources Development Corporation (present Japan Water Agency)

Keywords:
Standing tree felling, recycling, chips (bark), biomass energy

Abstract:
At Tomisato Dam, in preparation for the start of experimental ponding (March 24, 1999), it was planned at the end of FY1997 to fell the trees standing in the reservoir, and to burn them in the reservoir as is done at other dams. However, the December 1, 1997 revision of the Enforcement Ordinance and Enforcement Regulations for the Waste Disposal and Public Cleansing Law intensified the regulation on incineration of waste, and since the felled trees are specified as general waste, open burning of them has become illegal. For this reason, the trees felled at Tomisato Dam were processed into chips for recycled use as chip fuel and bark compost, as effective use of resources and for cost reduction. This case is reported hereunder.

1. Outline of the Project

The Dozan River is located in Toyo District of Ehime Prefecture and joins the Yoshino River in Tokushima Prefecture. It is a first-class river with a stream length of 64.2 km and a catchment area of 316.5 km^2.

Tomisato Dam is a concrete gravity dam with a height of 106 m, a crest length of about 250 m and a dam volume of about 510,000 m^3, constructed for the multiple purposes of flood control, urban water supply and power generation. The specifications of the dam are shown in Table 1.

In 1974, the investigation for the execution plan started, and in 1982, the construction began. In September 1992, the main body construction was

Map 1 Location of Tomisato Dam

ordered, and the placing of concrete for the dam body started in April 1995. The dam was completed in December 1997.

In March 1999, thorough anti-landslide measures were taken in preparation for experimental ponding, which began on March 24, 1999. The disposal of standing trees in preparation for the experimental ponding took 13 months from March 1998, and the miscellaneous trees, bamboos and the like from an area of about 65 ha were processed into chips for recycled use as chip fuel. The processing took place in a yard that remained after removing the temporary facilities in the reservoir.

2. Features of the Project Area

In the western part of Japan, warm temperate forests composed of laurilignosa including live oak (Cyclobalanopsis spp.) are widely distributed, and the area surrounding the Tomisato Dam reservoir is included in these forests. Before the start of dam construction, forestry, one of the key industries of Ehime Prefecture, was thriving, and sawn timber including Cryptomeria japonica, Chamaecyparis obtusa and Pinus spp. had been abundantly silvicultured in the reservoir-planned site area.

After dam construction started, the sawn trees were felled, and miscellaneous trees were also once felled. Almost 10 years have passed since then, and miscellaneous trees 4 to 7 m in height and 2 to 15 cm in diameter are growing again together with bamboos.

Standing trees in the reservoir can be generally classified as shown in Fig. 1, and their distribution in the reservoir is as shown in Fig. 2. The area occupied by standing trees and areas by type of felled trees are shown in Tables 2 and 3, respectively.

Table 1 Specifications of Tomisato Dam

River name	Dozan River of the Yoshino River System
Type	Concrete gravity dam
Height	106 m
Crest length	Approx. 250 m
Crest width	7 m
Dam volume	Approx. 510,000 m^3
Catchment area	101.2 km^2
Ponding area	1.5 km^2
Elevation of crest	EL 456.0 m
Surcharge water level	EL 454.0 m
Full reservoir level	EL 445.0 m
Minimum reservoir level	EL 400.0 m
Gross capacity of reservoir	52,000,000 m^3
Active capacity	47,600,000 m^3
Flood control storage	12,500,000 m^3
Water utilization capacity	35,100,000 m^3

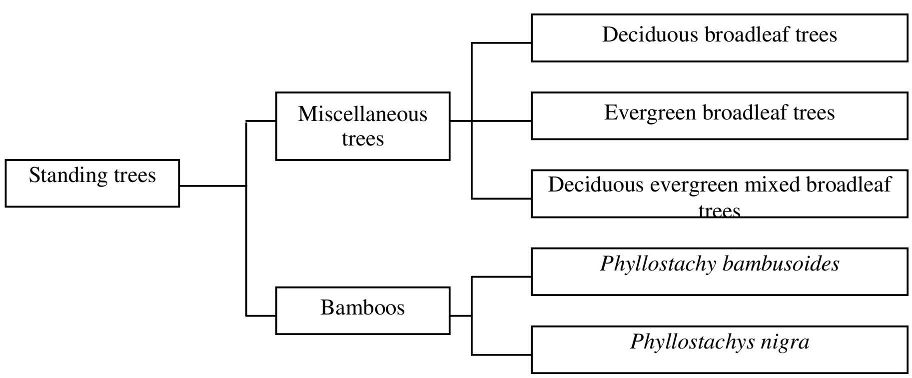


Fig. 1 Classification of Standing Trees

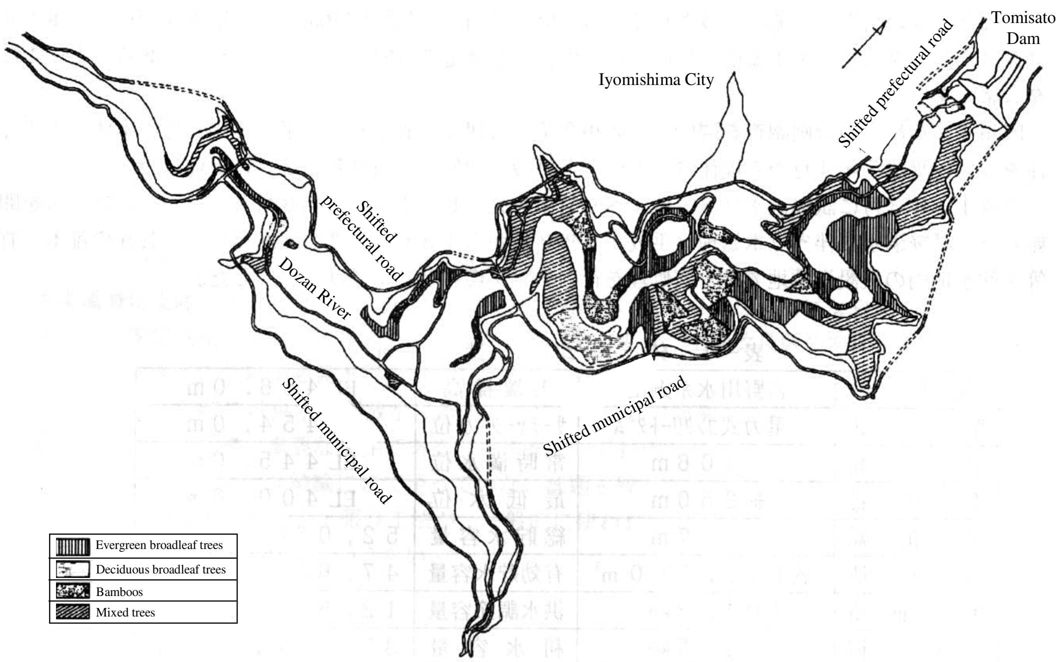


Fig. 2 Distribution of Standing Trees in the Reservoir

Table 2 Area Occupied by Standing Trees and Cleared Area in the Reservoir

Type	Area (ha)	Rate (%)	Remarks
Reservoir area	150	100	
Standing tree area	65	43	
Cleared area	85	57	Cleared area for construction work, riverbed and weeds

Table 3 Areas by Type of Felled Trees

Classification	Type of trees	Area of felled trees (m^2)
Miscellaneous trees	Deciduous broadleaf trees	70,730
	Evergreen broadleaf trees	187,910
	Deciduous and evergreen mixed broadleaf trees	305,990
	Total	564,630
Bamboos	*Phyllostachy bambusoides*	85,520
	Phyllostachys nigra	4,250
	Total	89,770
Grand total		654,400

3. Examination of Tree-Disposing Methods

3.1 Tree-Felling Range

A plan was formulated to fell standing trees in the range from the riverbed portion to the full reservoir level (EL 445.0 m) in view of maintaining good waterfront landscape and erosion control for the slopes of the reservoir, and to leave standing trees in the range from the full reservoir level to the surcharge water level (EL 454.0 m). The reason for this decision is that the range above the full reservoir level can be submerged only temporarily during flooding, but the range below the full reservoir level can be submerged for long periods of time due to periodic water level changes in the range. Therefore, if the trees in the range below the full reservoir level are not felled, they could eventually die, causing management problems due to eutrophication, driftwood, etc.

3.2 Applicable Laws

Felled trees are obsolete scraps in view of dam construction, and their disposal must conform to both the "Waste Disposal and Public Cleansing Law" under the jurisdiction of the Ministry of Health and Welfare and the "Law concerning the Promotion of Use of Recycled Materials" under the jurisdiction of eight ministries including the Ministry of Construction and the Ministry of International Trade and Industry.

The standpoints of these two laws for obsolete scraps are different. The "Law concerning the Promotion of Use of Recycled Materials" is intended to positively use obsolete scraps as byproducts of construction as long as they do not include any hazardous material. On the other hand, the "Waste Disposal and Public Cleansing Law" is intended to regulate obsolete scraps as industrial waste for the reason that if they are disposed of inadequately, they could pollute the environment. So, obsolete scraps could be waste or byproducts.

In the past, felled trees were disposed of by means of open burning at the sites, unless they were sawn timber. However, at present, the "Waste Disposal and Public Cleansing Law" inhibits the open burning of waste in view of health and environment concerns. In the case of burning, it is stipulated that an incinerator must be used for the process.

The "Waste Disposal and Public Cleansing Law" was revised on December 1, 1997, and according to the revision, in the case where an incinerator for waste such as waste wood is installed, even a small-scale incinerator with an incineration capacity of 200 kg/hour or with a fire grate area of 2 m2 is subject to permission by the competent prefectural governor. Furthermore, permission is subject to the results of environmental assessment and to consent by the local inhabitants, and therefore requires a considerable period of time.

The administrative staff in charge of health and environment, in the competent prefectural and municipal governments for Tomisato Dam, judged that the felled trees of Tomisato Dam were industrial waste partly because of the problem of quantity. Therefore, it was decided that the felled trees should be carried out of the reservoir for incineration or other disposal by any disposal company or for recycling, without being disposed of by means of open burning. Fig. 3 shows the study flow for disposal.

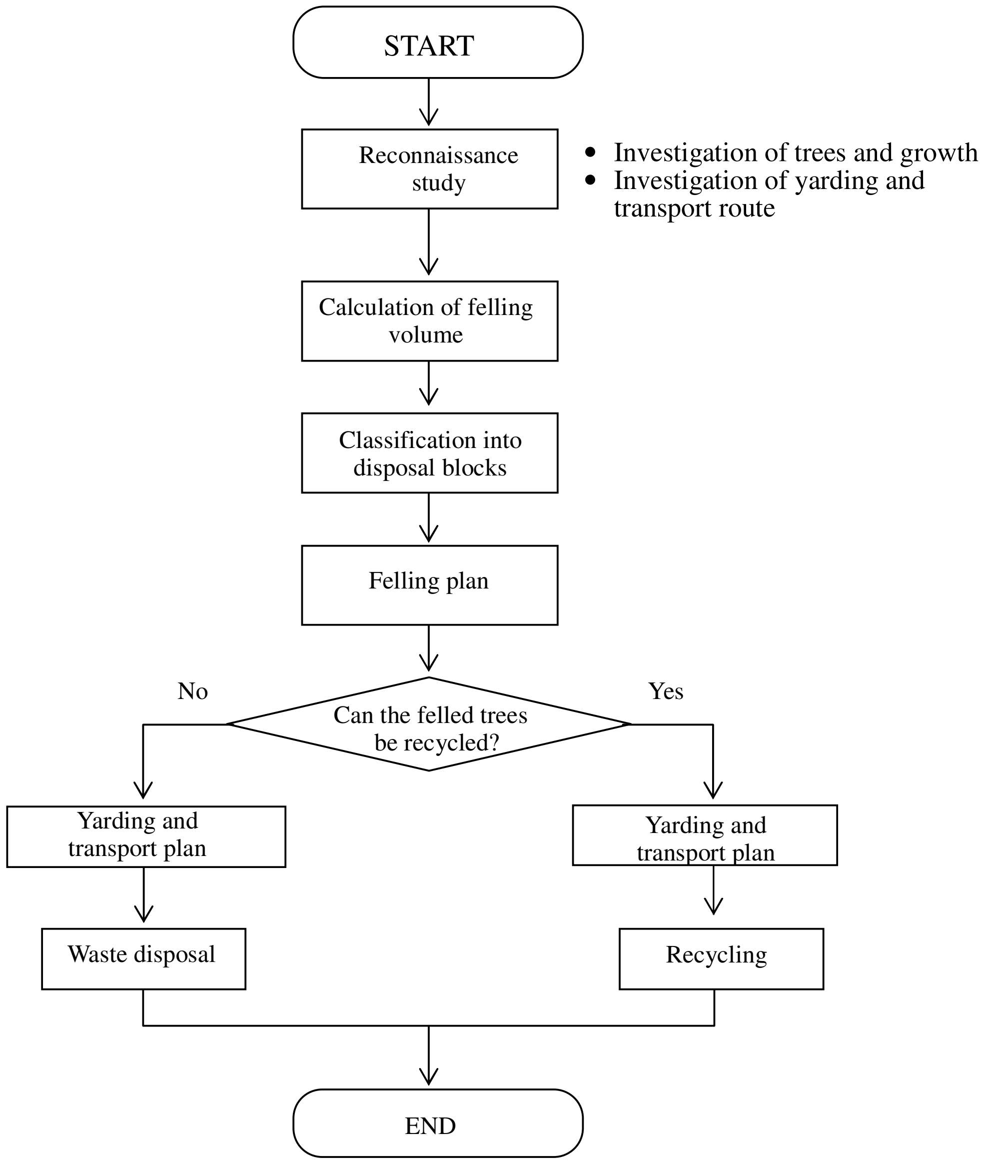


Fig. 3 Study Flow for Disposal of Trees of Tomisato

3.3 Study on waste disposal

In the case of waste disposal, since the Iyomishima City disposal plant can handle only household waste, it cannot dispose of the tress, and there is no other way than to ask a waste disposal company of Matsuyama City or another city. The capacity of a disposal company who is ready to accept unseasoned wood is shown in Table 4, and the expenses for disposal of felled trees are shown in Table 5. So, recycling was studied for disposal.

Table 4 Capacity of Disposal Plant and Disposal Expense

Transport distance (km)	Accepted state	Disposal capacity and disposal expense
40	Unseasoned wood (as chips)	Disposal capacity: 190 tons/day Disposal expense: 20,000 yen/ton

Table 5 Expenses for Disposal of Felled Trees

Transport distance from dam	Disposal volume (m^3)	Disposal expenses (in 1000 yen)				
		Felling and yarding	Processing into chips	Transport expense	Disposal expense	Total
40km	23,000	308,000	96,000	25,000	173,000	602,000

3.4 Study on Recycling

The major portion of timber resources are generally used as structural materials in houses and as pulp. The structural materials are called sawn timber, and few miscellaneous trees are used for this purpose. Furthermore, few miscellaneous trees other than pine trees are used as pulp. Miscellaneous trees and bamboos are used by various methods as shown in Fig. 4. If the felled trees placed in a temporary yard are disposed of freely, they could be used only for producing charcoal or culturing shiitake mushrooms (Lentinus edodes).

However, if the felled trees are processed into chips, they could be reused in a wider range of applications. So, with the cooperation of the Forest Owners' Association of Iyomishima City, a study on reuse as chips was conducted. As a result, it was discovered that the power plant of a papermaking company who also uses Tomisato Dam could use the chips as a fuel. It was also decided to experimentally produce bark compost. Table 6 shows the expenses needed for recycled use of felled trees as chip fuel.

- Fuel
  - Firewood
- Culturing mushrooms
  - Culturing *shiitake*
- Carbonization
  - Charcoal fuel
  - Raw material of active carbon
  - Pyroligneous liquor
  - Reducing agent for steel making
- Processing into chips
  - Pavement material
  - Compost
  - Carbonization ---------- Active carbon
  - Fuel (biomass power generation)
  - Mushroom beds for *Lyophyllum*, *Flammulina velutipes*, *Pleurotus eryngii*, etc.
  - Bark compost
  - Horticultural base material
  - Construction material (processing into boards for use as the cores of *tatami* mattresses)
- Bamboo wares
  - Bamboo products (round fans, baskets, etc.)
  - Toys
  - Construction materials (fences, etc.)

Fig. 4 Methods for Using Felled Trees

3.5 Effect of Recycling

Compared with the expenses needed for processing felled trees into chips for disposal as waste at an industrial waste disposal plant (602 million yen), the expenses for recycled use as chip fuel were found to be 404 million yen. So, a cost reduction of about 200 million yen could be achieved.

Table 6 Expenses for Recycling of Felled Trees (as chip fuel)

Disposal volume (m^3)	Disposal expenses (in 1000 yen)			
	Felling	Yarding and transport	Processing into chips	Total
23,000	308,000	214,000	96,000	404,000

4. Outline of Recycling

4.1 Processing into Chips for Use as Chip Fuel

The felled trees were disposed of according to the following flow: manual felling, manual yarding, cable hauling to a truck-loading yard, transport to a disposal plant by truck, processing into chips, and transport to a power plant by truck. The equipment used to produce chips from the felled trees consisted of three chippers, which were installed in the land left after removing the secondary and tertiary aggregate production apparatuses in the center of the reservoir.

The specifications of the three chippers are shown in Table 7. The average processing capacity of three chippers in total was about 37 m3/hr. The respective machines were used as follows: Models 250 and 1100 for trees and dry bamboos, and Model 395 for tenacious raw bamboos. The Forest Owners' Association of Iyomishima City, who owns the machines, established a chipping plant near Tomisato Dam for recycled use of thinned logs, driftwood from nearby dams, etc. Chips produced by the respective chippers are shown in Photos 2 and 3. The tree disposal flow is shown in Photo 4. The chip fuel was burned as power generation fuel at a thermal power plant (output 500,000 kW) of a papermaking company. The power plant had four types of power generation boilers: recovered chemical-fired boilers, fuel oil-fired boilers, coal-fired boilers and sludge-fired boilers. The chip fuel was burned in the three sludge-fired boilers used for burning pulp sludge. The power generated by the chip fuel in kWh was unknown since the output of the power plant was adjusted using fuel oil-fired boilers and coal-fired boilers while the recovered chemical-fired boilers and sludge-fired boilers were used as secondary boilers. The exhaust gas treatment facilities of the power plant consist of environmentally adapting equipment such as desulfurizing and dedusting apparatuses, which are fully installed to allow pollutionless burning.

Photo 2 : Chips Produced by Green Shredder Model 1100

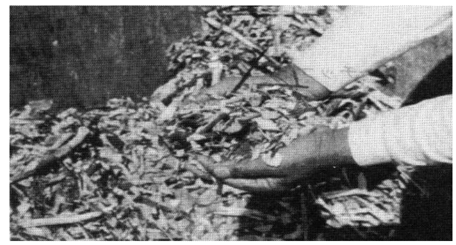


Fig. 3 : Study Flow for Disposal of Trees of Tomisato Dam

Tree disposal at Tomisato Dam was selected as "a construction byproduct recycling model project" of the Ministry of Construction (present Ministry of Land, Infrastructure and Transport), and a stage for general visitors was constructed at the site, and pamphlets were prepared to promote public relations (Photo 5).

Table 7 Specifications of Chippers

Model		Model 250	Model 395	Model 1100
Engine horsepower	PS	113	40	160
Chip production capacity	m3/H	6~11	3~5	30~60
Feed rate	m/min	0~36	0~50	0~60
Size of crushing port	mm	490×305	240×240	1100×400
Maximum crushable trunk diameter	mm	300	200	400
Overall width	mm	2360	1880	2200
Overall height	mm	2540	2200	3300
Overall length	mm	4560	3600	7500
Weight	kg	2268	1234	8500
Cutting method		Knife cutting	Knife cutting	Knife cutting
Made in		USA	USA	Germany
Trees to be chipped		Trees and dry bamboos	Raw bamboos	Trees and dry bamboos

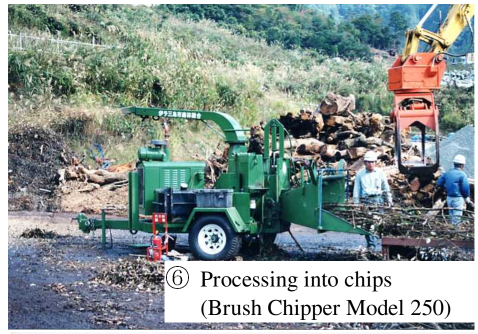

① Felling


② Felling and yarding


③ Cable yarding


④ Loading on truck


⑤ Yarding for disposal


⑥ Processing into chips
(Brush Chipper Model 250)


⑦ Processing into chips
(Green Shredder 1100)


⑧ Chips (bark)


⑨ Chips (bark)


⑩ Transport of chips

Photo 4 Disposal Flow for Trees

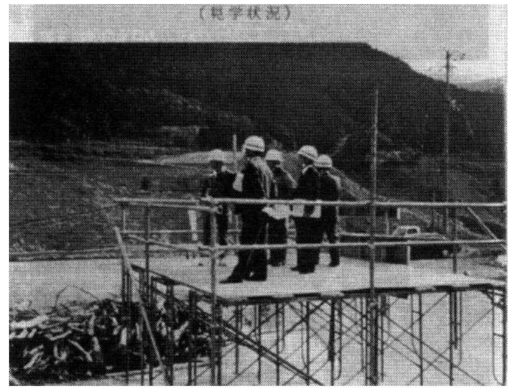


Photo 5 Stage and Visitors

4.2 Recycling as Other Than Chip Fuel

If the chips produced from trees are treated for fermentation, they function as a fertilizer due to moisture retention (water content adjustment), air layer retention, ligneous decomposition accompanying the growth of fermentation bacteria, offensive odor adsorption, etc. So, bark compost was also experimentally produced. The bark compost produced recently was a product fermented to a primary level, so that it could be used for such purposes as preventing soil from drying out or hardening, enhancing air and water permeability, and preventing the growth of weeds. The amount of experimentally produced bark compost accounted for about 3% of the total amount of chips. The Iyomishima Municipal Government, Besshiyama Village Government, Japan Highway Public Corporation, and nearby farm households were the primary users. For producing well-ripened bark compost, a fertilizer production plant is necessary, and if the chips are further transformed into smaller grains (about 5 mm) as a pre-stage for fermentation treatment, and the treatment is carried out under control of water content and fermentation heat with a fermentation accelerator added, then the bark compost can be produced in about 3 months. As recycling for other than bark compost, a construction material manufacturer experimentally transformed the crushed material into boards for use as the cores of *tatam*i mattresses.

5. Reasons for Success

For recycling of felled trees in the reservoir of Tomisato Dam, a power plant existed nearby as a chip fuel-using plant, and the cost borne by the user (transport expense) was commercially acceptable. This site condition was favorable for successful recycling efforts. Due to its success, this project was awarded the "FY1998 Recycling Promotion Council Chairman Prize" as a recycling promotion contributor.

At general dam sites, however, it is rare that conditions are as favorable as at Tomisato Dam. So, it can be considered that felled trees will be disposed of for use as bark compost in future. If felled trees are left in natural conditions to produce bark compost, the process takes about one year. However, earth-dumping areas, ancient quarry sites and the like can be effectively used as disposal sites, and felled trees can be converted into bark compost in about 3 months by using a fermentation accelerator and establishing a fertilizer production plant. Therefore, bark compost can be considered as a sufficiently feasible recycling technology even for future dam projects.

Furthermore, in view of cost, compared with disposal at an industrial waste disposal plant, disposal as bark compost is economical. Henceforth, it is necessary to treat the recycling of felled trees produced in dam sites in the same manner as the recycling of PET bottles, for "volume reduction of refuse" without treating felled trees as organic refuse.

6. Further Information

6.1 References

1) Outdoor Handbooks for Trees (Parts 6 and 7), Trees (Part 1), Trees (Part 2) (respectively in

Japanese), Yama-to-Keikoku-sha
2) Energy Conservation Center: Resource Recycling Series (Parts 4 and 5) (respectively in Japanese)

7.2 Inquiries

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