Wood raw materials and wood waste use for the building materials production (on the example of the Republic of Karelia timber industry)

Alexander Kuzmenkov1, Oleg Galaktionov1, Maxim Karpov1, and Elena Emelianova1

1 Petrozavodsk State University, Lenin St., 33, Petrozavodsk, 185910, Russia

Abstract. The research is devoted to material resources analysis of the Republic of Karelia timber industry for the production of construction materials and to the optimal directions search for wood waste and illiquid wood use. The requirements for raw materials are analysed and inconsistencies in the classification of wood waste resources are revealed. Various methods of wood processing are considered and characteristic features and limitations on the applicability of raw materials in terms of size, quality, and breed characteristics are revealed. The conclusion is made about the main sphere of use of wood waste and illiquid wood, which is construction–civil, industrial, agricultural and architectural and aesthetic. The main directions of research are formulated to find ways to dispose of wood waste allowing for more complete use of their specific properties.

1 Introduction

The timber industry is one of the important sectors of the most Russian regions economy. Before the change in the geopolitical situation, the profit of timber industry organizations reached 2.9 trillion rubles, and the contribution of the timber industry to the country's economy reached 3% [1].

In 2022, after the introduction of sanctions by the European Union, the supply of wood and products of their processing to the usual markets of European countries practically stopped. Russia is faced with the problem of using excess wood raw materials formed on the domestic market. Timber companies have reoriented to new markets and sell some of their products, incurring significant logistical costs [2, 3]. However, a number of problems remain that have not yet been resolved [4, 5]:

1. The waste obtained during the processing of hardwoods is not used (torn veneer, "pencils", etc.). Waste from the processing of coniferous wood species is not used in existing industries;

2. There is a bias towards the use of coniferous raw materials, in which pulp and paper industries (balance wood) and sawmilling and woodworking industries (sawmill) are interested. At the same time, deciduous wood is practically not used. Only birch plywood
ridge is processed, and the rest of the hardwood has not found application, either in industry or in construction;

3. There are problems in the use of low-quality and low-value wood. Birch and aspen are not currently harvested, since the sale of such raw materials in the current conditions is difficult or impossible in principle;

4. Logging waste is practically not used. Tree greens, twigs, bark and stumps, as a rule, are simply left by logging companies at the logging site. Large waste, sometimes balance wood, is used as the underlying layer of forest roads.

In the current economic and geopolitical conditions, one of the most promising options for the sale of wood products is the production of building materials and wooden structures and products that meet the needs of the construction industry. Individual housing construction is actively developing in Russia [6, 7]. The development of this type of construction was influenced by the development of preferential mortgage lending. The share of wooden housing construction is growing in the total volume of individual housing construction [8, 9]. The number of houses built using frame technology is especially increasing [10]. The active development of wooden house construction was promoted by state support programs for manufacturers of wooden houses. Thus, there is a potential direction for the development of materials and products production for the construction industry, while it is necessary to know the structure of demand from construction companies in wood materials. To assess the prospects for the development of this direction, it is necessary to assess the possibilities of using wood in construction in modern conditions [11 - 13], as well as the need of the construction industry for such materials.

2 Materials and methods

The Republic of Karelia timber industry was chosen as the object of this study. The Republic of Karelia is a part of the northern economic region of the Russian Federation. 38% of the region's territory is included in the Arctic Zone of the Russian Federation. The republic timber industry is one of the basic elements of the economy of the region, the basis of which is an environmentally friendly and renewable resource in the form of wood.

The forests total area in the region is 14916.4 thousand hectares, the forest fund total land area is 14.5 million hectares, and the territory forest cover is 53.1%. The territory area covered with forest vegetation is 9.3 million hectares, of which 8.12 million hectares (87%) are dominated by conifers, and 1.16 million hectares (13%) – hardwoods. The volume of timber harvesting in the Republic of Karelia is 7.5–8 million cubic meters annually, and the estimated cutting area is represented in the amount of 12.4 million cubic meters. Valuable species for harvesting are represented by coniferous wood (common pine and common spruce) and deciduous wood (fluffy birch, warty birch, aspen, gray alder).

In 2022, the logging volumes in the region decreased by 21.8% compared to the level of 2021. At the same time, the woodworking volumes lumber and fuel pellets production volumes decreased by 18.8%, 25.8% and 31.9%, respectively. There was a wood raw materials surplus in the region and a glut of the market [3]. As of January 2023 the timber production volumes decreased by 34% compared to the same period in 2022. At the same time, the chipboard production increased by 1.2%.

One of the wood potential applications in construction is the use of from the processing of wood raw materials [14]. First of all it is necessary to classify wood waste to solve the problem of their efficient processing. The classification of wood waste is shown in Figure 1.

The presented classification (Fig. 1) is compiled according to GOST 56070-2014 (National standard of the Russian Federation GOST 56070-2014 "Woodwaste. Technical conditions"). The document provides a classification of wood waste, as well as methods of
their processing. However, it is worth noting that the regulatory document does not take into account the need for integrated waste processing and waste-free production. Thus, according to Table A.1 of Annex A, most of the solid waste is proposed to be processed into soft, namely, into technological chips for the production of slab materials. For all other types of waste, the broad terms "Consumer goods" and "Fuel" are used.

![Figure 1](https://example.com/figure1.png)

**Fig. 1.** Wood waste classification in accordance with GOST 56070-2014.

It is also worth noting the problem of lagging behind the process of developing regulatory and technical documents from the process of development of wooden house construction in Russia. The existing normative-technical and methodological documents do not contain technical requirements and recommendations for the use of specific types of wooden structures: log, frame-panel, structures using CLT wood, etc. For example, the development of multi-storey wooden housing construction is hindered by the lack of a regulatory framework for the use of CLT wood and structures made of it [15]. In low-rise and medium-rise wooden housing construction, there are difficulties with the correct application of thermal insulation, windproof and vapor proof materials in the layers of frame envelope structures. Thus, the regulatory framework for wood construction also needs to be revised and finalized.

However, despite the above problems, the use of wood materials in construction is steadily growing [16 – 21]. The purpose of this study is to search for new opportunities for the use of soft wood waste in building materials production. To achieve this goal, the following methods were used: comparison of characteristics and needs of various industries in wood raw materials; analysis of materials from previous studies; analysis of potential applications of finished products made from wood waste, as well as generalization of the materials obtained and development of recommendations on areas of activity and development of materials.
3 Results and discussion

3.1 Soft wood waste

There are the following types of soft wood waste:

- Technological wood chips are the largest type of woodworking waste in terms of dimension, which is obtained as a result of grinding wood raw materials. According to the purpose, fuel, technological and green chips are distinguished. Fuel chips cannot be used as technological chips for a number of parameters and are used as an energy resource. Green chips are distinguished by an admixture of greenery and needles, and bark is also present in the composition;
  - Wood shavings – thin long wood particles;
  - Sawdust – less long wood particles obtained in the process of sawing wood;
  - Wood dust – wood particles, less than 1 mm in size, which are formed when grinding wood.

Technological chips are the main raw material resource for the production of slab materials – oriented chipboard (OSB) and fiberboard (DVM). Soft fiberboard (MDF) is produced from technological chips brought to the state of wood tissue (fiber). In construction, such materials are used as a cladding material for frame structures, and soft fibre board panels is used as both a hydro-windproof layer of frame walls and a thermal rupture layer in the frame elements. These materials can also serve as a base for finishing and facing layers, as they have a smooth surface. For example, slab materials can serve as a base for plaster [22].

Wood chips and sawdust are used in the manufacture of medium-density fiberboard (MDF) and wood particle board. In construction, such materials are rare, but they are popular in the furniture industry. Laminated products based on MDF and wood particle board can be used in construction and as a finishing layer.

Wood dust is used in the production of wood-polymer composite (WPC). The production of WPC products makes it possible to solve a number of problems in the disposal of wood and polymer waste. The material obtained by extrusion (WPC board) is used as terrace boards and facade finishing.

As part of scientific research, Russian scientists continue to search for solutions to obtain environmentally friendly slab materials without the use of phenol-formaldehyde resins [23 – 25]. A scientific search is underway in the field of using composite materials without an additional binder, which include lignocarbon plastics and piezothermoplastics, as well as carbon materials obtained as a result of high-temperature processing of an organic base [26]. A relatively simple way to use soft waste is to use them as aggregates in the production of building wall blocks, for example, sawdust concrete and arbolite [27 – 29].

3.2 Hard wood waste

Hard wood waste, as a rule, is processed into soft waste for subsequent use in the production of the materials described above. However, it is worth considering their possible use in the timber chemical industry. The use of large branches is possible in structural building blocks production – branches blocks [30, 31].
3.3 Other related wood waste

Other related wood waste was used in the timber chemical industry. However, there is also a potential possibility of producing thermal insulation materials based on crushed bark and Portland cement – korolite [32]. The raw materials availability and manufacturing ease of such building materials meets the interests of the construction industry in reducing materials and products economic costs.

It is worth separately noting the glass wood panel’s production of [22, 26, 33, 34]. Based on them, it is possible to create environmentally friendly and safe in terms of emissions of harmful substances analogues of existing SIP panels consisting of OSB and expanded polystyrene. However, it is also necessary to solve the potential problem of the combustibility of such structures.

Logging waste consists of tree greens, twigs, bark and trunk tops. Most of such waste is left in logging areas and a small part is processed into wood chips. Woody greens were actively used in the forest chemical industry. However, at present, most of the timber chemical industry products are by-products and related products of wood processing at pulp and paper processing plants. Thus, the development of the timber chemical industry is not a promising option for the use of wood waste.

Separately, it is necessary to consider the use of waste in the production of fuel (fuel pellets and briquettes). There are not so many boiler houses in Russia designed to run on fuel pellets, and the boiler equipment itself is imported. Thus, fuel pellets are a commodity for export, practically not in demand in the domestic market. The production of fuel pellets (briquettes) was not effective in the conditions of the fuel market of Russia – recycled waste turned out to be more expensive than firewood. The production of fuel from wood waste is hampered by the inability of most domestic boiler houses to use such fuel and the economic inexpediency of producing such a product for the domestic market.

3.4 Waste of low-value and low-quality wood

Deciduous wood were popular in European countries, as the main pulp and paper mills in these countries use similar raw materials in production. In Russia, the opposite situation is observed – most pulp and paper mills use coniferous wood species. After the export restrictions introduction, there was an acute problem of using hardwood, since all unrealized raw materials remained on the domestic market. The opening of pulp and paper mills in Russia adapted for deciduous wood is impossible under the current conditions.

When processing birch plywood ridge, veneer flaw and "pencils" are formed. If the first type of waste is, in essence, a large chip, then the second is a solid log of small diameter. Veneer-flaw can be used in the production of glued slab materials [32]. At the same time, there are two main use cases for "pencils" – processing into technological and fuel chips and use as a structural material (for example, small architectural forms structures pillars).

The use of hardwood in construction is difficult for the following reasons:
1. Deciduous wood is less amenable to debarking and processing;
2. Deciduous wood is much more susceptible to the process of rotting and fungal infestation;
3. The drying of deciduous wood is greater than that of coniferous wood;
4. Deciduous wood is more complex in the structure of anatomical elements.

However, it is worth noting the advantages of deciduous wood.
1. Economically available raw materials;
2. The process of growth of deciduous trees is faster than coniferous;
3. High strength indicators.
The listed features of deciduous wood allow us to conclude the possibility of using this resource [35] as a finishing material and as a basis for non-responsible building structures. For example, shingles are obtained from aspen – a finishing material that is also used as an "eco-tile" [36], and the following range of facade and finishing materials are also produced: lining, block house, parquet, etc.

However, the problem of hardwoods is the high probability of biological damage to wood. If a small presence of rotten knots is allowed on finishing materials and lumber (with a decrease in grade and subject to wood processing), then it is forbidden to use heavily affected wood. Then there is only one possibility of using such raw materials – it is fuel.

As a structural material in construction, only an aspen massif is used for the construction of baths, saunas and wells. The use of aspen in this case is justified, since it is a rock resistant to rotting in water, also characterized by increased resistance to water passing through itself [37]. It is worth noting the increased density of aspen wood, as a result of which the thermal conductivity increases and the energy efficiency indicators of building structures deteriorate.

To ensure the use of hardwood in the construction of small architectural forms, it is necessary to properly process the wood with protective impregnations based on the purposes of its use [38]. The most appropriate use of such wood is the production of elements of playgrounds. The requirements for the equipment of playgrounds are reflected in the main regulatory document of the Eurasian Economic Union, the technical regulations of the EAEU TR 042/2017 (Technical Regulation of the Eurasian Economic Union TR EAEU 042/2017 “On safety of children's playgrounds”). Proper processing and protection of deciduous wood from biological damage will ensure that the material meets the requirements of the specified technical regulations.

It is also possible to produce small architectural forms from deciduous wood that are not subject to mandatory certification (for example, planters, benches, fences and other architectural elements) [39]. Also, one of the possible applications of hardwood is wooden decking production (sections of pedestrian paths) and wooden paving stones production.

There is an alternative to the use of deciduous wood in the form of use as load-bearing structures of agricultural structures (for example, the greenhouses construction). Birch wood is used as connecting elements – tongue pieces and wooden pin. Birch wooden pins are used in timber and log cabins construction, and tongue pieces – in furniture manufacture.

Glued wooden boards made of hardwood are used in furniture manufacture, mainly facades of cabinets, walls and other elements [40]. The volume of use of such boards is growing and, probably, the production of joiner's boards will be an important component of the use of illiquid wood.

In most logging companies, low-value and low-quality wood is used as the underlying layer of the roadway. The service life of such structures can exceed 20 years.

4 Conclusions

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The production of arbolite and sawdust concrete is technologically simple in terms of the use of wood waste. However, quite a lot of alternatives are used in construction, which surpass it in a number of parameters; the use of birch balance and hardwood in its whole or minimally modified form can ensure the use of deciduous wood as finishing materials, frames of non-responsible structures and the creation of elements of small architectural forms;

The problems of using low-quality and low-value wood are solved by sorting low-quality wood. Biologically affected wood can only be used as fuel, and wood with defects in shape and structure may find other practical applications;

Slab structural, finishing, thermal insulation, vapor barrier and wind-moisture-proof materials production is one of the most promising areas of application of wood and its processing waste in construction. The priority direction is the use of deciduous wood in the slab materials production.

Rational use of wood and its processed products will solve a number of economic and environmental problems. Wood materials are of interest to most economic spheres of Russia. Slab materials are used not only in construction, but also in a number of industrial industries (automotive, railway car building and shipbuilding).

5 Acknowledgements

This work was supported by the Russian Federation Ministry of Science and Higher Education (state research target, theme no. 075-03-2023-128)

References


