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WOOD-BASED PANELS FOR LAND TRANSPORT USES

Wood-based panels are widely used in the transport sector, thanks in particular to their properties in terms of lightness and mechanical strength. Furthermore, they offer additional benefits, such as sound insulation or fire resistance. The present paper takes into account the different wood-based panels used for building the main typologies of land transport vehicles: buses and cars, trucks and other commercial vehicles, motorhomes and caravans, and railways vehicles. The aim here is to give an overview of these products, their historical and current uses, as well as taking into account future developments.

Keywords: wood-based panels, transport, vehicles

Introduction

From the beginning of the 20th century wood has played an important role in the transport sector. In particular during World Wars I and II, a great amount of solid wood and a huge quantity of wood-based panels were used to build military vehicles [Risbrudt et al. 2007].

Nowadays, the use of solid wood is outdated for land vehicles, although plywood, Oriented Strand Board (OSB), Medium Density Fibreboard (MDF) and lightweight wood-based composites are still widely used, thanks to their high performance in terms of strength, stiffness, lightness and impact resistance [Youngquist 1999; Cremonini et al. 2009; Cai, Ross 2010].

Plywood is the wood-based panel most frequently used for building land transport vehicles [Baldwin 1995]. Structural raw and overlaid plywood panels, thanks to their strength, durability and smoothness, provide an excellent lining material for a wide range of vehicles, ideal for the manufacturing of floors, walls, roofs, doors etc. For some applications, raw panels represent the best

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choice, otherwise a panel overlaid with resin-impregnated fibre, metal, fiberglass-reinforced plastic or phenolic film can be more adequate.

Table 1. Wood-based panels used in transport sector

Vehicle type	Vehicle component	Main requirements	Panel type	Panel description
cars	trunk base rear decks, door panels, truck liners	lightness, stiffness, screw holding	poplar PW 636 2-G	Raw
			wood fiber/plastic composites	Raw
buses	floors	lightness, stiffness, fire resistance, screw holding	beech or birch PW 636-2G	film faced
animal trucks	floors, interior walls	impact resistance	PW 636-2G	raw/film faced
			OSB/3	Raw
delivery vans	floor	smoothness and resistance	PW 636-2G	raw/film faced
trucks/other vehicles	floor	stiffness, durability, thermal insulation, noise control	PW 636-2G	film faced
			PW sandwich	FRP faced
			PW sandwich	aluminium faced
			PW sandwich	synthetic foam cored
railway wagons	floors, partitions, walls	Strength, fire resistance, screw holding, and dimensional stability	PW 636-2G	aluminium faced
			exotic or beech PW 636-2G	synthetic foam/rubber cored
			beech PW 636-2G	film faced
caravans, motorhomes	floors, partitions, ceilings	Strength, screw holding, and dimensional stability	poplar or combi PW 636-2G	raw or film or HPL faced
			PW sandwich	synthetic foam cored
			PW sandwich	honeycomb cored

In general some basic requirements determine the design of the panel: vehicle usage, climate conditioning and physical environment. The development of high-performing wood composites or soundproof plywood, often derived from the boatbuilding industry, opens up new perspectives for the usage of these products in modern transport [Barbu et al. 2013].

The present work aims to illustrate the main wood-based panel currently used in modern land transport vehicles (table 1).

Buses and cars

From 1946 to 1949, various manufacturers built different models of station wagon with wooden bodies, known as “Break de Chasse”, “Shooting-brake” or “Canadienne” (fig. 1, left). Today wood fibre based/plastic composites are often used in cars as a substrate for interior door panels, roof headliners, seat backs, rear decks and trunk liners; the latter are also made of low density plywood [Youngquist 1995; Huda et al. 2006; Clemons 2012].

As for bus construction, plywood is still a common material; it is mainly used for floors or for frames and light partitions. Generally floors of buses consist of two layers: a subfloor made of exterior-grade plywood and a covering made of synthetic rubber floor, resistant to abrasion and treading.

Beech and birch, melamine or phenolic film-faced plywood (EN 636 [2012]) is frequently used for floors, usually with a thickness ranging from 10 to 20 mm (fig. 1, right).

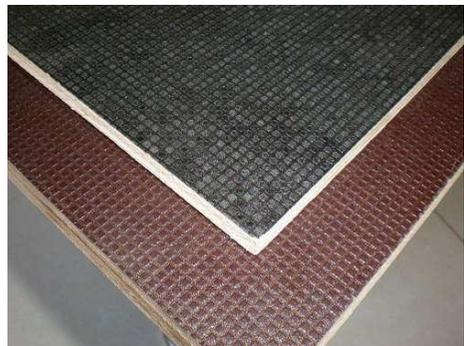


Fig. 1. Left: until WW II the use of solid wood and plywood for car construction was common. Right: birch phenolic film-faced plywood for floors. (Photos by Corrado Cremonini)

High quality veneers are used and are bonded using phenolic or melamine-urea-formaldehyde (MUF) adhesive systems complying with bonding class 3 of EN 314-1 [2004] part 1, EN 314-2 [1993] part 2 and EN 350-2 [1994] part 2.

Trucks and other commercial vehicles

Nowadays a relevant application for wood-based panels concerns the building of vehicles for animal transportation. The floors and interior walls of these vehicles are often covered with raw or film-faced plywood. In particular, the great resistance of plywood to continuous impact makes it suitable for every type of animal transportation. In some cases OSB panels are also used, representing a less effective but cheaper choice.

The use of plywood is also well suited for lightweight transport vehicles such as delivery vans. Raw or phenolic film-faced plywood, with a thickness ranging from 10 to 30 mm, guarantees a smooth and resistant surface with a limited number of joints for floor and wall applications. This makes it an ideal material for the sliding and skidding of palletised goods. The floor is occasionally still made of solid wood planks screwed on an aluminium frame.

Concerning the use of plywood for floor structures, phenolic film-faced plywood, either made of birch or beech, is a common solution. Film coatings play an important role, since they increase durability, prolong service life and reduce maintenance costs. Generally, the surface density of phenolic films ranges from 120 to 220 g/m². In this context, nowadays maxi-plywood is produced with dimensions up to 13,500 × 2,800 mm.

Several types of trucks and commercial vehicles are commonly manufactured using an engineered wood-based composite derived from the boatbuilding industry. This consists of a plywood core glued between two thin but strong layers made of glass fibre-reinforced plastic (FRP) [Triantafillou 1997; Hardeo, Karunasena 2002]. The bonding of plywood and fibreglass with resin produces a high-performing composite in terms of mechanical performance, moisture content and weather resistance. Moreover, the core of plywood constitutes a natural thermal insulator and a good sound barrier. The glass content and thickness of the FRP can be adapted in order to obtain a wide range of performances related to the end applications.

Finally, another reason for the large scale utilization of FRP plywood in the transport industry lays in its long-term cost advantage for equipment owners. Today maxi-composite panels are available with dimensions up to 15,400 × 3,000 mm and a thickness ranging from 11 to 25 mm. Their surface-weight ratio varies from 9 to 15 kg/m².

A further evolution in FRP plywood composites is represented by insulated sandwich floorings made of two faces of FPR bonded to a layered core. The latter is made of external layers of plywood (usually birch but also meranti or okoumé), a central layer of synthetic foams (polyurethane or polystyrene) and a solid wooden beam frame (in order to allow easy and secure fixation of the floor panel to the sub-frame).

Another interesting family of wooden composites is represented by metal-faced plywood. This combination offers advantages comparable to those of FRP plywood, but its enhanced characteristics make it suitable where high strength and long-term durability are required. Typically, metal-faced plywood has been used for the construction of the sliding doors of railway wagons, while today it is also used for flooring or interior walls. The metal surfacing can be of aluminium alloy, zinc-coated steel, phosphate-coated zinc or stainless steel, with a thickness ranging from 0.5 to 1.5 mm. The metal face is usually bonded to the panel through phenol or resorcinol adhesive systems; co-polymerised adhesive systems based on polyvinyl acetate (PVAc) and polymeric diphenyl methane diisocyanate (PMDI) resins are also suitable.

Finally, the last family of insulated wood-based composites used in the truck building industry is represented by sandwich panels made of a synthetic foam core covered with two plywood skins [Davies 2001]. They are used for floors and are suitable when high thermal insulation and soundproofing characteristics are required. Today a wide assortment of rigid foams is available, with densities ranging from less than 30 kg/m³ to more than 300 kg/m³. These foams are also available in a thickness typically from 5 to 50 mm, often with sealed edges.

Motorhomes and caravans

Nowadays motorhomes and caravans are built using different structures, the aluminium frame being the most effective. Aluminium tubing or extrusions are riveted or welded to form a frame for external aluminium cladding. This latter can be glued or riveted together with an insulating synthetic foam core and a decorative plywood, usually 20 to 25 mm thick for walls and ceilings and about 40 mm thick for floors.

Another structure uses a body of fibre-reinforced plastic over a wooden sandwich subfloor. In this construction, a timber or metal framework provides the base for a fibreglass shell. An interior lining made of plywood or other materials is attached to the structure to form interior walls and ceilings. The subfloor is made using a network of solid wood beams filled with insulating materials and covered with thin plywood. These structures are popular since they are very easy to build, although their long term durability is a critical issue and depends on the quality of the solid wood and on the assembling method.

Depending on the required finishing level, a decorative floor of rubber made of polyvinyl chloride (PVC) or high pressure laminate (HPL) may be used. The thickness of insulating wooden flooring ranges from 25 to 80 mm; exterior type plywood (bonding class 3 – EN 314) faces vary from 5 to 10 mm, and the most used wood species are poplar, okoumè or coniferous wood.

Finally, in cheap constructions some builders use other types of wood-based panel, for instance OSB, to create a subfloor fastened to an aluminium rigid frame. For ceilings and other lightweight non-structural elements, plywood made of poplar mixed with exotic wood species (ceiba, ilomba, okoumè, etc.), commonly named “combi plywood”, is also used.

Railway vehicles

Nowadays, plywood and lightweight wood-based composites (soundproof and/or fireproof) are mainly used as components of the structural insulated partitions, floors or elements for ceilings (fig. 2 and fig. 3) [Schonherr 1960]. In some applications, such as ceilings and light partitions, melamine poplar plywood overlaid with decorative HPL is used since it guarantees adequate reaction-to-fire behaviour. In particular, the structure of high-speed trains is made of extruded light aluminium alloy profiles, while the partitions are usually made of film-faced beech plywood and the floor of soundproof wood based composites.



Fig. 2. Left and Right: Plywood and solid wood are a cheap and enduring solution for the floors, walls, ceilings and interior furniture of light-rail public transport. (Photos by Corrado Cremonini)

In Europe, all wood-based panels used in railway wagons are of exterior grade according to the national standards for railway applications. Generally, plywood and composites are made of beech and birch having a natural durability rating of Class 4 (EN 350-2 [1994]). Low-density species, such as okoumè, with a durability rating of Class 4 may also be used and are especially suitable when a light weight is required. Plywood for railway applications is generally made of high quality veneers and is bonded using exterior adhesive systems complying with bonding Class 3 of EN 314 or two-component thermoplastic (PVAc)

adhesives (type D4 according to EN 204 [2001] and EN 205 [2003]). The thickness usually ranges from 8 to 30 mm. Raw plywood is rarely used, although the faces are often covered with a film and present a smooth and non-slip side. The latter offers an ideal surface for the adhesion of synthetic coverings, usually hard layers of durable rubber floor.



Fig. 3. Wagon type “GS” 12 Tons; in this and other similar wagons, after the '50s, beech plywood replaced the conventional painted European larch planking for the walls (Photo by Corrado Cremonini)

Railway passenger vehicles represent another relevant field; for this application, soundproof wood-based panels provide a good level of sound insulation and vibration absorption. For specific uses, additional requirements in terms of fire resistance may be stipulated according to national standards.

One of the most important uses of wood based panels, in particular plywood, is the construction of railway vehicles for the transportation of goods (fig. 3). Since the '60s painted plywood has substituted the conventional painted solid wood planking, usually in European larch. Previously the raw exterior plywood was painted, although today red/yellow melamine film faced plywood is used. The film-facing is red on the exterior and yellow on the interior in order to brighten the inside of the wagons. Depending on the required end-uses, the surface density (or area/surface related mass) of melamine film varies from 120 to 440 g/m².

A great number of high-capacity wagons with sliding doors and intended for the transportation of goods stacked on pallets have been equipped with sliding partitions made of 18 mm thick beech exterior plywood. In this case, plywood exhibits an excellent stiffness, which enables it to be used without framing or bracing, which is often required for other materials.

Finally, in all railway networks, several types of refrigerated wagons are used for perishable goods. Sandwich thermal insulation composites are specifically produced for these applications, as well as for refrigerated trucks.

The thermal insulation properties of the inner foam are the most important requirement, although these composites should also be very strong and impact resistant to prevent damage due to penetration by forklift tines.

Conclusions

Despite the recent development of various high-performing materials, wood-based panels are still important products for transport vehicles. They are widely used to construct the walls, floors, subfloors, ceilings and partitions of buses, cars, trucks, motorhomes and railway vehicles. Such a wide range of uses is mainly due to their remarkable properties in terms of lightness, mechanical performance and relative cheapness; moreover, the continuous development of new wood-based composites with enhanced properties may further increase the usage of wood-based panels.

On the whole, the current scenario indicates that wood-based panels will continue to play a relevant role in the transport vehicle sector.

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List of standards

- EN 204:2001** Classification of thermoplastic wood adhesives for non-structural applications
- EN 205:2003** Adhesives – Wood adhesives for non-structural applications – Determination of tensile shear strength of lap joints
- EN 314-1:2004** Plywood. Bonding quality – Part 1: Test methods.
- EN 314-2:1993** Plywood. Bonding quality. Requirements.
- EN 350-2:1994** Durability of wood and wood-based products – Natural durability of solid wood – Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe
- EN 636:2012+A1:2015** Plywood – Specifications

