KEEPING FEET ON THE WOOD

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ABSTRACT

Skateboarding has been around since the 1960s and has always been a popular alternative sport. With its inclusion in the Olympic Games, there is new focus on this sport and the production of skateboards. Among many materials, wood is an excellent choice because it has a suitable compromise between energy absorption, flexural strength and weight, making it a resilient, light and strong material that is sustainable and recyclable at the same time. In this chapter the history and the physical, mechanical and aesthetic properties of wood in the construction of skateboards are presented.

INTRODUCTION

This chapter is a review of the wood properties related to the skateboard, as of some of its characteristics, such as physical, mechanical, and aesthetic appearance, which are featured in skateboard manufacturing. The inclusion of skateboarding in the Olympic Games in Tokyo by the International Olympic Committee in 2016 legitimized skateboarding culture among the values shared by the high Olympic competition (Batuev and Robinson 2017). The article of Forbes (2019) cites that the global skateboard market is expected to reach a value of 2.4 billion USD by 2025, with an estimation of 100,000 boards being made per month, showing the importance of this sport for the wood industry.

The species typically used for the manufacturing of skateboards are *Acer saccharum*, *Fagus sylvatica* and *Betula pendula*, but there are alternative woods that have the potential to also be used in a sustainable way (Fotin et al. 2016, Liu et al. 2018, Sýkora 2021). TABLE 25.1 shows the most common materials used in skateboard production, highlighting their technical advantages and limitations as sustainable materials, and comments on their "pop" (the striking of the tail of the board against the ground to propel it upwards to do tricks). In general terms, wood is becoming more and more relevant thanks to the growing attention towards sustainability and recyclability, although the Olympic rules do not have material limitations (World Skateboarding Commission 2021). Reinforced composites with carbon or glass fibers improve the specific strength and stiffness and give higher durability to the skateboard (Endruweit and Ermanni 2002).

A skateboard is a well-researched device, used in competitive sporting events, with the recent Olympic Games as a prime example. Models on the current market are based on how the skateboard was created in its early days, as a simple wooden board with 4 wheels made of clay. Nowadays, they are usually manufactured from a deck of plywood and 4 steel wheels. The standard length is about 70 to 82 cm, and the structure can be divided into three parts: the front (also called nose), the wheelbase (the part between the trucks in the board) and the rear (tail of the skate), as shown in FIGURE 25.1. The deck structure could look like a simple remanufacture, but it must meet physical-mechanical requirements to support the weight of the skater and the skater's jumps during the typical maneuvers of a competition.

TABLE 25.1 Common skateboard materials (adapted from Waterman and Crease 1978).

Material	Advantages	Limitations
Wood laminates	Good compromise between strength and tailored construction. Recyclable. Relatively cheap.	Delamination. Heavy. Less durable pop.
Carbon fiber or glass fiber	Very-good compromise between strength and tailored construction. Durable. Light. Durable and quicker pop. Moisture proof.	Reduction in sustainability and recyclability. Expensive.
Reinforced wood laminate (carbon fiber, glass fiber, metal)	Good compromise between strength and tailored construction. Durable. Longer durable pop.	Some reinforced parts need longer time for biodegradation as a sustainable recyclable material. Relatively expensive.

Thus, it is necessary to develop an engineered structure that prevents deck failures or deformations: this is why the use of high-quality wood, and a proper design is required. Among the challenges of deck design, a relevant one is finding a suitable compromise between energy absorption, flexural strength and weight. In other terms, the deck must be resilient, light and strong at the same time. It cannot be too heavy, because this would limit the skater's maneuvers and would not be able to cushion the jump impact; neither too flexible, because in this case it would destabilize the skater during jump maneuvers. To meet such characteristics, the chosen wooden species, such as for example *Acer saccharum* (Ansell 2015), must give the skateboard a lightweight, compliant and impact tolerant structure.

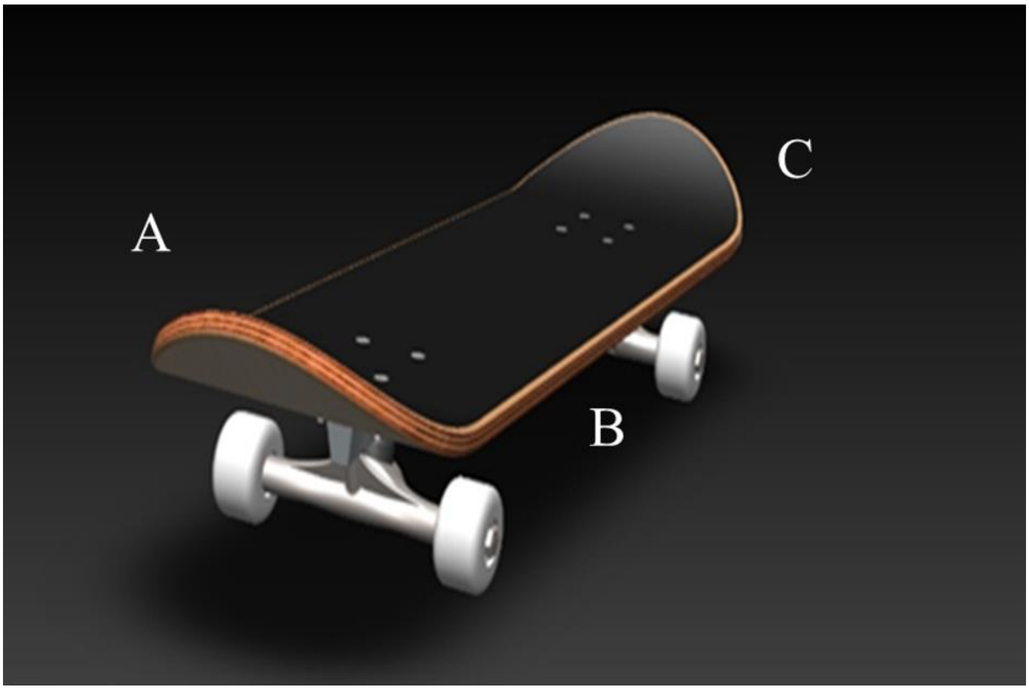

FIGURE 25.1 Example of a standard skateboard available on the market. A: Front part (nose). B: Wheelbase. C: Tail end (rear of the skateboard) [image J.A. Torres-Mella].

Color and graphics are also key to a good skateboard deck. A quality spray finish improves the aesthetic appeal, as does well-executed artwork intended to make skateboards look good (Waterman and Crease 1978). The shape will be slightly different depending on the envisaged use: for tricks or for cruising in the streets. Overall, a well-designed deck will be strong and incorporate a quality finish. Decks made of wood are manufactured with veneers, two for both faces of the deck (top and bottom), and the remaining for the core of the skate. Clearly, veneers that constitute the bottom and the top of the skateboard deck are important in terms of aesthetic appearance (Willard and Loferski 2018).

Last but not least, from a circular economy perspective the wooden components of skateboards that have been damaged or are at the end of their life cycle are well-suited for cascading usage and could be recycled for manufacturing new plywood products (Willard and Loferski 2018).

WOOD AND ENGINEERED WOOD-BASED PRODUCTS FOR SKATEBOARDS

Since the early 60s, wood has been an important material for the construction of skateboard decks. The first manufacturers used a solid flat wooden board. However, solid wood is not an ideal material for this purpose due to its rigidity/flexibility and, moreover, its use results in excessively thick and heavy decks. During the 1970s, innovation occurred in the construction of skateboard decks: the maple laminated construction enabled easy manufacture granting weight reduction, greater rigidity, strength, lightness and durability (Borden 2019).

At present, the skateboard deck is an engineered wood product that has evolved considerably over the years. To make a skateboard deck, layers of thinly cut wooden (known as veneers) are used based on the plywood technology. This involves the use of crossed veneers, which means the orientation of the veneer between layers alternates in order for the product to have sufficient strength in both directions of the plane. Any type of veneer would be suited for the manufacturing of a skateboard deck, however the best one for this application and the most used is the rotary cut veneer (Sýkora 2021).

The wood used to make skateboards requires certain important properties such as flexibility and strength because during use the deck is subjected to deformations and stress, mainly bending strains. Sugar maple (*Acer saccharum*) wood is the most used to manufacture skateboard decks: its hardness, lightness, density, and the possibility of obtaining veneers free from knots or defects make it especially suitable for skateboarding. According to Fotin et al. (2016), it is also possible to use beech and birch plywood for manufacturing skateboards, and the plywood of these species could even replace sugar maple wood. Marangon (2018) evaluated the quality of ten types of commercial skateboard decks with different combinations of wood, adhesive and reinforcement. The deck of seven sugar maple veneers with epoxy adhesive showed the best performance. An alternative is to use bamboo plywood, which is interesting due to its elasticity and hardness. Because it is very brittle, it needs fiberglass reinforcement or to be combined with sugar maple veneers (Linke 2011, Fotin et al. 2016).

A report by Liu et al. (2018) indicated that an ideal material for a skateboard deck shall have a fracture toughness of 5 MPa/m^2, a minimum lifetime of 10,000 cycles and must not experience brittle fracture, while maintaining an ideal weight.

Skateboard decks are mainly subjected to bending strain: whether they are made of plywood or other wood-based materials, the determination of the modulus of rupture (MOR) and modulus of elasticity (MOE) is recommended (Fotin et al. 2016) to test them. Some physical-mechanical properties of the most used wood species in skateboard manufacturing are given in TABLE 25.2.

TABLE 25.2 Physical and mechanical properties of wood species commonly used in skateboards (wood at 12% moisture content).

Wood species	**Density** (kg/m^3)	**MOE** (GPa)	**MOR** (MPa)
Acer saccharum	597[1]-700[2]	10.7[1]-12.4[2]	113.2[1]-123.6[2]
Fagus sylvatica	608[3]-632[4]	9.7[3]-10.9[4]	56.2[3]-104.3[4]
Betula pendula	512[3]-799[5]	9.6[3]-14.5[5]	58[3]-114[5]

[1]Duchesne et al. (2016). [2]Uzcategui et al. (2020). [3]Fotin et al. (2016). [4]Papadopoulus (2008). [5]Heräjärvi (2004).

CONSTRUCTIVE DETAILS OF WOODEN SKATEBOARDS DECKS

Veneers are commonly used to make plywood skateboard decks. For the manufacture of a skateboard deck, seven veneers of approximately 1.6 mm thick are used in most cases. Typically, three types of veneers can be distinguished: face (top and bottom of the deck), longitudinal, and perpendicular. The importance of the seven-layer composition is related to the strength it provides thanks to the orientation of the fibers of each veneer. Face and longitudinal veneers are oriented in the wood grain direction from nose to tail, where the face veneer is also selected based on the aesthetic qualities of the wood and is usually of a high-quality grade. The perpendicular veneers have, as the name suggests, perpendicular grain orientation, so they support the deck to uphold its concavity (Willard and Loferski 2018). Veneers are therefore layered in the following sequence: face (top), longitudinal, perpendicular, longitudinal, perpendicular, longitudinal, and face (bottom). There are five sheets oriented along the longitudinal direction: this is due to the fact that such direction has to withstand the greatest loads during use, particularly the bending stresses (Willard and Loferski 2018). The above composition helps to strengthen the board, which in turn prevents it from twisting. The main glue types used for the manufacturing of decks are polyvinyl acetate, polyurethane, and epoxy resin (Sýkora 2021).

PRODUCTION OF SKATEBOARDS

The deck flexibility varies, along with the wheels and their truck mountings, to adapt to the end use of the skateboard. To make it more stable and speedier, the deck is made stiffer; to use the skateboard for slalom, the board is usually made more flexible. The maneuverability, speed and stability of the skateboard, while retaining these properties when it is being used, will depend on the precise construction and processing of the components used to produce the deck (Waterman and Crease 1978).

To manufacture a deck, the universal constant is the pressing and forming of laminated veneers to generate what is called a deck blank (Linke 2011). Typically, the direct pressure (hydraulic system) is used. Molds are used to obtain the form of any kind of skateboard (longboards, cruiser boards or street decks), and to generate the characteristic upswept nose, tail, and the concavity of the skateboard. The molds are usually made from wood, concrete, metal (aluminum) or plastic. They can also be made utilizing computer numerical control machines utilizing a 3D model sketch to produce precise molds (Sýkora 2021). Vacuum mold compression is an alternative way to produce decks. It uses a foam mold made from high density foam, in which the veneer is placed and glued on top. A plastic sleeve is placed over the mold and the veneer, so that a vacuum pump can remove the air to compress the veneer over the mold (Linke 2011).

After producing and curing the blank deck, the truck holes are drilled (they vary depending to the final form of the skateboard), followed by cutting it to the final form, routing the edge, sanding the surfaces, lacquering, painting and staining (if desired). Finally, the deck is taped and assembled (Linke 2011, Sýkora 2021).

Failures of skateboard decks can be separated into three categories: focused, in which the fracture occurs when the board breaks right in the middle; delamination, which occurs when the sheets of wood detach from each other weakening the structure of the board. That can be caused by bumps on the edge of the board, the wear on the ends of the board due to excessive friction against the concrete, or fatigue from use; and shaft fracture, caused by the consumption of the material due to the constant use of the skateboard (Contreras et al. 2016).

COSTS

Liu et al. (2018) indicates that a price of $300 USD for a deck using alternative materials (carbon fiber) should be the limit, while Linke (2011) mentions that the average price of a wood skateboard is 70$ USD. Online resources mention that longboards can cost between $60 to $500 USD, classic cruiser skateboards between $60 to $400 USD and street skateboards (used mostly for tricks) cost from $70 to $200 USD. These prices can be taken as a rough reference when producing skateboard parts with alternative materials.

SKATEPARKS

Skateparks are built using a variety of materials, ranging from concrete, steel, phenolic wood fiber composite or wood. For our interests, we will focus on the skateparks made only from wooden materials. Usually, it is feasible to build a halfpipe, a ramp or a pyramid out of wood. The biggest advantage of using wood is that it is easier, faster and cheaper to build, but the maintenance cost of a wooden skatepark is higher than the other materials (Pender 2010); it can be relocated and adjusted, thus is mostly used for home and mobile skateparks (FIGURE 25.2).

FIGURE 25.2 Skateparks in a public open space of Santiago city (Chile), with a mobile fast ramp manufactured by radiata pine plywood (picture with permission of Castro-Aedo, 2021).

CONCLUSIONS

Wood in skateboarding has become relevant because it is the material chosen by skaters for competing in the recent Olympic Games of Tokyo 2020. Some physical-mechanical characteristics of wood, as well as its aesthetic appearance are relevant in skateboard manufacturing. The species that have usually been used for the manufacture of skateboards are *Accer saccharum*, *Fagus sylvatica* and *Betula pendula*, since they can provide the best compromise among the aesthetic quality, physical-mechanical properties and sustainability.

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