The Physics Teacher

Breaking Bat

Isaac-Cesar Aguilar and David Kagan

Citation: Phys. Teach. **51**, 80 (2013); doi: 10.1119/1.4775523
View online: http://dx.doi.org/10.1119/1.4775523
View Table of Contents: http://tpt.aapt.org/resource/1/PHTEAH/v51/i2
Published by the American Association of Physics Teachers

Breaking Bat

Isaac-Cesar Aguilar and David Kagan, California State University, Chico, Chico, CA

The sight of a broken bat in Major League Baseball can produce anything from a humorous dribbler in the infield to a frightening pointed projectile headed for the stands. Bats usually break at the weakest point, typically in the handle. Breaking happens because the wood gets bent beyond the breaking point due to the wave sent down the bat created by the collision with the ball.[1] The kind of wood that is used plays a role in the manner in which the bat breaks—its "failure mode." We report on a simple experiment to compare the breaking strength and failure modes of ash and maple dowels. The results illustrate some of the features of breaking bats under game conditions.

The problem

Major league bats have changed shape, size, and type of wood over the years.[2] Until recently, ash bats were predominantly used, but maple bats started coming on to the scene in 1997.[2] They became very popular shortly after Barry Bonds used maple to blast a record 73 homeruns in 2001. There is a problem with maple bats, though. Unlike ash bats that tend to splinter, when maple bats break they become lethal projectiles with sharp-pointed edges.

There was a case involving former Chicago outfielder Tyler Colvin.[3] Colvin was running home from third when he was struck by the edge of a broken maple bat. He was taken to the hospital, where doctors took measures to prevent a collapsed lung. Since the failures of ash bats pose little threat to players and fans, why choose maple over ash?

Sluggers seem to think that maple bats can exert more force on the ball without failing. We'll test this idea with ash and maple dowels. The result will be many broken dowels, so we'll have the opportunity to see if the failure mode for maple and ash are as different for dowels as they are for bats.

The experiment

We used ¼-in diameter dowels[4] that were 9 in long and tested them using the apparatus shown in Fig. 1. There are two distinct orientations of a piece of wood, cross grain, and face grain. Since batters hold the bat in such a way that the cross grain strikes the ball, we chose to test how the cross grain holds up to an applied force. The dowel was set up across two two-by-fours. We aligned the wood so that the weight hanger was placed along the cross grain of the wood in the center of the dowel. We left the applied force on the piece of wood for 20 s and recorded the displacement (sag) of the wood at 20 s. The displacement was measured by eye, taking care to avoid parallax issues. Had we to do it all over again, we probably would use a depth gauge for additional accuracy. We added half a kilogram of mass after every 20 s until the dowel broke.

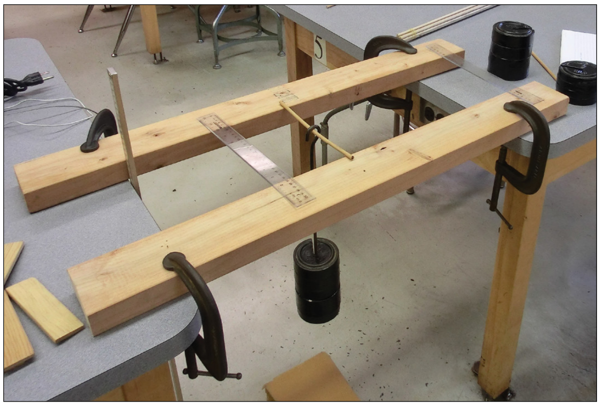


Fig. 1. A photo of the apparatus. The dowel rests between two-by-four supports.

Results

Eight trials were run for maple and eight for ash. Table I shows a typical set of data for maple and ash. The average deflection of the dowels was calculated using the maximum deflection before breaking from each of the eight trials for each type of wood. The results were:

Ash	2.31 ± 0.36 cm
Maple	1.69 ± 0.18 cm

This confirms that ash is noticeably more flexible than maple, as can be seen in Figs. 2 and 3.

The force that broke the dowel was also calculated by multiplying the maximum mass the dowel could support by $g = 9.80\ \mathrm{m/s^2}$. The breaking force from each trial was used to calculate the average force that broke the dowel. The results were:

Ash	78.5 ± 1.1 N
Maple	76.6 ± 0.8 N

The force to break these dowels is the same within the uncertainty. So, by the third law, the force that bats can exert on a ball before breaking should also be close to equal.

The failure modes were also demonstrated by the experi-

Table I. A typical set of data for ash and a set for maple.

Mass (kg)	Deflection	
	Ash (cm)	Maple (cm)
5.0	0.99	0.81
5.5	1.13	0.92
6.0	1.31	1.10
6.5	1.53	1.21
7.0	1.82	1.39
7.5	2.29	1.61
8.0	3.05	1.90
8.5	Break	Break

DOI: 10.1119/1.4775523

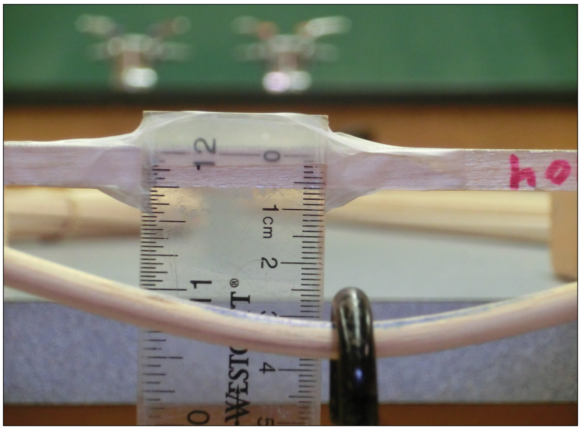


Fig. 2. Photo of the maximum bending of an ash dowel.

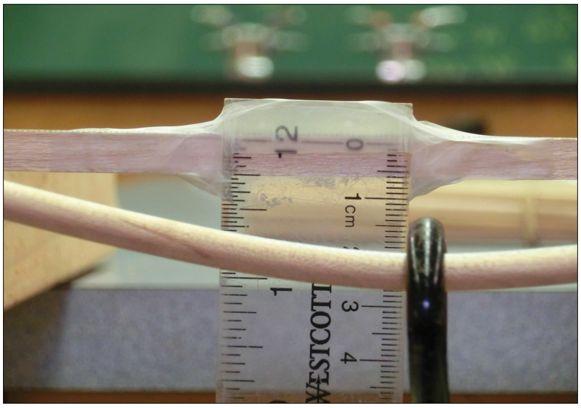


Fig. 3. Photo of the maximum bending of a maple dowel.

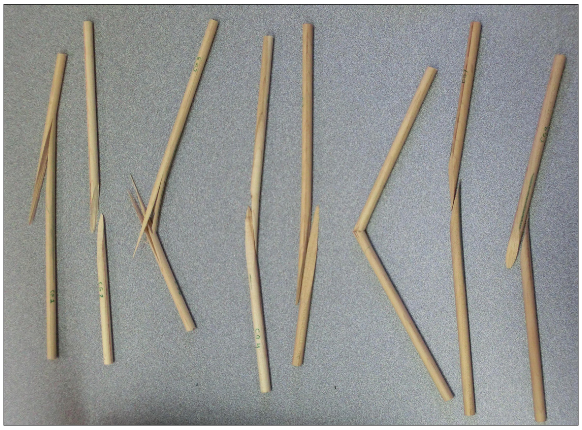


Fig. 4. The broken maple dowels. Note that seven of the eight broke along the grain leaving sharp edges.

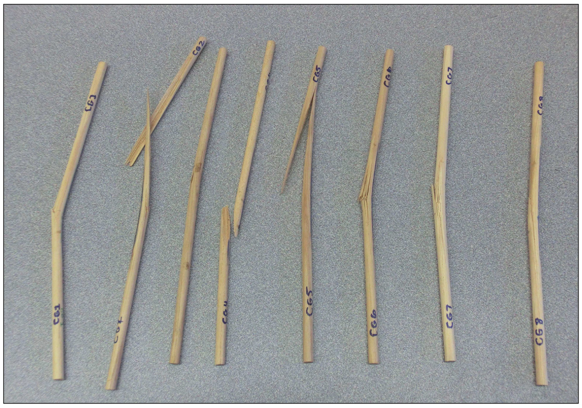


Fig. 5. The broken ash dowels. Note that only three of eight broke resulted in sharp edges.

ment. Maple broke with sharp-pointed edges seven of the eight times, and the break was always along the grain of the wood (Fig. 4). Ash, on the other hand, only produced three sharp-edged dowels out of the eight used, and generally the breaks were not solely along the grain (Fig. 5).

In summary, the three properties of the baseball bats were well demonstrated using the dowels:

1. Ash is noticeably more flexible than maple.
2. The force required to break them is about equal.
3. Maple consistently breaks along the grain, creating a sharp edge, while ash does not.

Before conclusions can be drawn, some limitations of this experiment should be mentioned:

1. The weights were added gently to the dowel. In a game, the force is certainly not exerted gently on the bat. There may be some significant differences between the slow breaks examined here and the fast breaks in a real game.
2. The actual breaking force on a bat depends upon the shape, most notably the thickness of the handle. Since we have used only dowels of the same diameter, our results may not necessarily generalize to real games with real bats.

Conclusions

If maple can't withstand (therefore exert) more force, why would players choose maple over ash? We speculate that maple feels better to the hitter because maple is less flexible. When the bat and ball collide, vibrations are induced in the bat.[5-7] This is especially true when the collision is away from the sweet spot. If you are as poor a hitter as we are, then we're sure you have felt these vibrations too. Ash's flexibility allows for higher amplitude vibrations than maple. This would give a batter the sense that he has hit the ball better with the maple bat. Another way to say it is that a maple bat gives the batter the sense that the bat has a wider sweet spot.

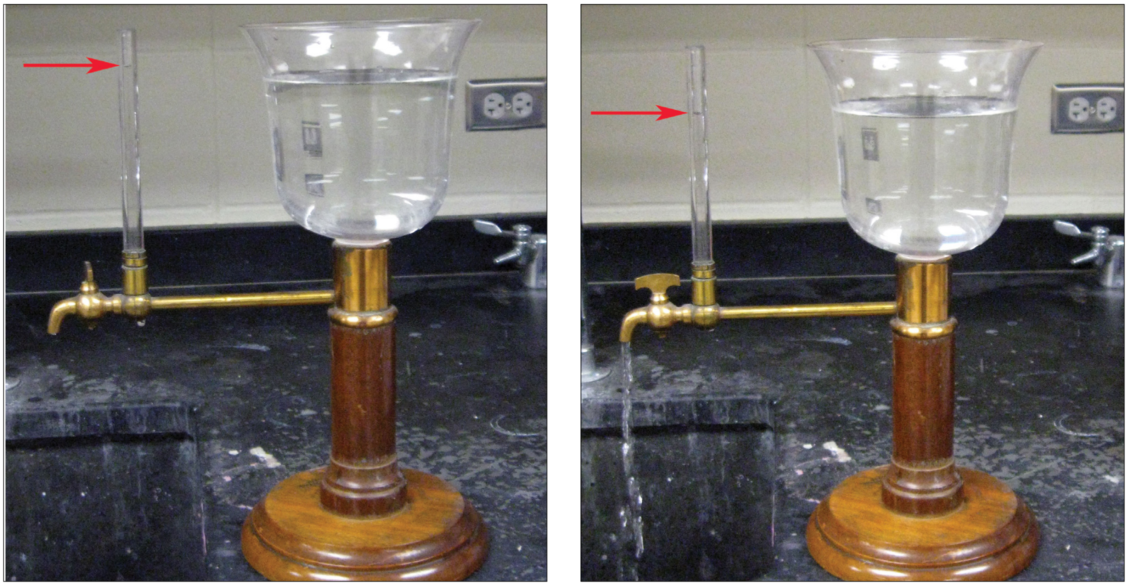
So what is the MLB doing about the dangers of maple bats? They are setting standards. In 2010 the MLB put restrictions on the maximum diameter of the barrel while increasing the minimum size of the handles.[8] They also put a ban on low-density wood. A principle feature that enables maple bats to break is "slope of grain," which the MLB has started regulating. "Slope of grain" in its simplest sense refers to how the fibers are aligned to the symmetry axis of the bat.[9] MLB requires this slope to be less than 2.86°.[10] Soon, we'll know if MLB has solved the "breaking bat" problem.

References

1. The breaking of a bat can be seen in super slow motion thanks to the Discovery Channel show "Time Warp" at www.youtube.com/watch?v=QFlEIybC7rU.
2. Bernie Mussil, "The Evolution of the Baseball Bat," www.stevetheump.com/Bat_History.htm.
3. Charlie Nobles, "Colvin in hospital after bat punctures chest," mlb.mlb.com/news/article.jsp?ymd=20100919&content_id=14847072&vkey=news_mlb&c_id=mlb.
4. The dowels were purchased from Midwest Dowel Works, MW-Dow@MidwestDowel.com, for under $30 including shipping.
5. David Kagan, "The vibrations in a rubber baseball bat," *Phys. Teach*. **49**, 588 (Dec. 2011).
6. A. M. Nathan, "Dynamics of the baseball–bat collision," *Am. J. Phys*. **68**, 979–990 (Nov. 2000).
7. L. L. Van Zandt, "The dynamical theory of the baseball bat," *Am. J. Phys*. **60**, 172–181 (Feb. 1992).
8. Carrie Muskat, "MLB, bat companies work to increase safety," mlb.mlb.com/news/article.jsp?ymd=20100920&content_id=14887794&vkey=news_mlb&c_id=mlb.
9. Victor Boyce, "Measuring Grain Slope," exp-aircraft.com/library/boyce/grain.html.
10. www.woodbat.org/ has a thorough discussion of the many aspects of wooden bats.

Isaac-Cesar Aguilar, California State University, Chico, Department of Physics, Chico, CA 95969-0202; iaguilarparallel@gmail.com

David Kagan, California State University, Chico, Department of Physics, Chico, CA 95969-0202; dkagan@csuchico.edu



Water Spout

During the AAPT summer meeting at Creighton University in 2011, Vacek Miglus and I took pictures of early apparatus at the Creighton physics department. The apparatus in the left-hand picture, shown with the spigot closed, appeared to be a liquid-level device: the water level was the same in both the narrow tube and the flaring glass vase. However, when I came back nine months later to give a talk about the apparatus, I realized that it was really an early Bernoulli effect demonstration. In the right-hand picture the spigot is open and water can be seen coming out of the spout. The water level in the narrow tube has fallen appreciably, thus showing that the pressure at this point has decreased, in agreement with the non-zero velocity of the water in the horizontal tube. The device was made ca. 1880 by E. S. Ritchie of Boston, MA. (*Photos by Thomas B. Greenslade Jr.*)