Title: Choosing Brick Breaking Materials
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Abstract:

Breaking bricks and boards is a very dangerous part of the martial arts culture and should always be monitored very carefully. This paper shows that while one brick might require 120 pounds of force, a brick of identical dimensions and type could require 1200 pounds of force to break. If this huge difference in breaking forces isn't recognized then breaking becomes a ridiculous exercise in chance. The following four rules should be considered when choosing bricks for breaking.

1. Bricks should be chosen based on weight. The lighter the brick on average the easier it is to break. Gray capstone bricks are nominally 16 inches long, 2 inches thick and come in 4 inch, 6 inch and 8 inch widths.
   8 inch bricks should be less than 13.5 pounds
   6 inch bricks should be less than 9 pounds
   4 inch bricks should be less than 6 pounds
2. Since cement cures and strengthens over time, bricks should, when possible, be chosen from the freshest that can be located.
3. In general, bricks with smooth surfaces are denser and bricks with rough surfaces are less dense. If scales are not available this rule of thumb can be used.
4. 4 inch bricks tend to be thicker than 6 and 8 inch bricks (to avoid excessive breakage in shipping). In general 6 inch bricks are easiest to break.

Introduction:

Brick breaking is a dramatic but inherently dangerous part of the martial arts culture. Far too often breaking is practiced in unsafe and/or unsupervised conditions. A further danger is that bricks and boards, while looking remarkably similar, can exhibit wildly different breaking characteristics.

Given the extreme variation in brick strengths and the dangers they present to martial arts practitioners who break bricks for demonstrations and promotionals, it is obviously very important that students understand what to look for when buying breaking materials. This paper shows that for standard 8î wide, gray capstone bricks that the force required to break a single brick varies from 223 pounds to over 710 pounds. The most important single factor that correlate with this dramatic variation in strength is the brick's weight (density is actually a more universal parameter but is more difficult to calculate).

Gray capstone bricks of the variety that nominally measures 15.6"x 7.6" x 1.6" should be selected for breaking only if they weigh less than 12 pounds. While bricks from a

single batch often have similar characteristics, they should be checked before breaking as a
safety precaution.

Methods:

Bricks from three different sources were tested in trial one and five batches representing 8 by 6 by 2 inch wide samples were tested in a second trial. Each brick had its height, width, thickness and weight measured. The brick was then placed in a three point stress rig (see figure 1) and broken. The static force required to break the brick was recorded.

Figure 1: Mechanism used for breaking bricks. The force on the brick is equal to the Lever Force multiplied by the length of the Full Lever Arm divided by the length of the 1st Lever Arm. (Forces are reported in pounds)

Data:

The following are the results of brick breaking trials.

Figure 2: Bricks of different widths are grouped together and show a marked correlation between weight and breaking force. Bricks from a single production run are grouped by symbol. Note the 15 pound brick that broke at over 1100 pounds of force. It was from a batch that cured for two years in hot (Sacramento CA) weather conditions. All the bricks in that batch were found to be very strong.

Analysis:

Three calculations were made based on the data. The first is the volume of the three types of bricks which is reported in units of cubic inches. The second calculation is of the density of the brick (the result of dividing the brick's weight by its volume) which is reported in units of pounds per cubic inch (x1000). The third calculation was for the total force exerted to break the brick (the result of multiplying the lever force by the ratio of the
full lever arm length divided by the first lever arm length) which is reported in units of pounds.

The results of this analysis is summarized in the graph below.

Figure 3: Breakage Force versus Brick Density. Bricks with a density above 7.0 have a dangerously variable Breakage Forces.

While the width and length of the bricks varied only by 1.7% and 0.4% respectively the critical dimensions of thickness and weight varied 11% and 32% respectively. Due to the non-linear nature of brick strength (see a discussion of curing times below) this translates to a difference in breaking forces of over 500% between similar looking bricks. Even bricks from a single production run ranged in breaking force by almost 200%.

It is of great importance to note that the 4 inch bricks have a larger variation in

breaking strength than the 6 inch bricks. This is due to the greater thickness of the 4 inch bricks. The cement companies that we discussed this with said that they purposely make the 4 inch bricks thicker to decrease the probability of the bricks being broken during shipping and handling.

Finally, it should be noted that the strength of cement goes up non-linearly with curing time. A brick that cures for three days is about twice as weak as a brick that cures

for a month and four times weaker than a brick that has cured for six months. The curing strength varies greatly depending on the average ambient temperature and humidity. Since it is difficult to ascertain when bricks were made and under what conditions they were cured, we now have some parameters of brick strength over which we have almost no control. As noted in figure 3, bricks which have had long curing times (over six months) and or were left out in very hot weather were found to be very strong when compared to other bricks.

Conclusions:

Extreme variations in breaking strength, even within a single production run, makes breaking demonstrations less an act of skill and more an exercise in chance. We must evaluate the immediate danger of injury to students as the most obvious problem plus
the long term medical problems inherent with breaking bricks (arthritis and other joint disorders). Factoring in the limited value breaking has in judging a student's physical and mental skills leads us to recommend that the breaking of bricks and boards be carefully supervised by instructors and allowed only sparingly for people under 18 years of age. Padded targets, plastic break-apart boards, pie pans and other less dangerous targets can
be used in place of more hazardous materials.

If bricks and boards must be broken then they should be carefully inspected before breaking. Furthermore all breaking should be properly supervised. For example, if standard 8î wide gray capstone bricks must be used then they should be measured and weighed before purchase to make sure that they weigh under 13.5 pounds. Alternatively bricks that are either 6 or 4 inches wide should be considered. Note that even these lighter
bricks are inherently dangerous and that serious injury can result from trying to break them.

Recommendations:

The authors have between them broken hundreds of bricks and boards over the past 25 years and based on this experience and upon completing this study, recommend that all breaking activities in martial arts be practiced only under strict supervision by qualified instructors. Due to extreme variations in the breaking characteristics of bricks considerable care should be taken when purchasing them. The following are four easy to follow rules of thumb.

1. Bricks should be chosen based on weight. The lighter the brick on average the easier it is to break. Gray capstone bricks are nominally 16 inches long, 2 inches thick and come in 4 inch, 6 inch and 8 inch widths.

8 inch bricks should be less than 13.5 pounds
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2. Since cement cures and strengthens over time, bricks should, when possible, be chosen from the freshest that can be located.
3. In general, bricks with smooth surfaces are denser and bricks with rough surfaces are less dense. If scales are not available this rule of thumb can be used.
4. 4 inch bricks tend to be thicker than 6 and 8 inch bricks (to avoid excessive breakage in shipping). In general 6 inch bricks are, pound for pound, easiest to

break.

It is important to remember that even with the careful selection of breaking materials that
breaking can cause major injuries. Care should be taken when attempting even the simplest of breaks.

Authors' Note:

This paper is based on Norman Link's 1995 paper, "Selecting Bricks for Breaking in Martial Arts Events". This paper has a significant amount of new material and its conclusions supersede those of the earlier paper.

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