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A Comparison of Traditional Grass-Twist Backstops to One of Corrugated Cardboard Design Use on Indoor Ranges

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A COMPARISON OF TRADITIONAL GRASS-TWIST BACKSTOPS TO ONE OF CORRUGATED CARDBOARD DESIGN FOR USE ON INDOOR RANGES

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A COMPARISON OF TRADITIONAL GRASS-TWIST BACKSTOPS TO ONE OF
CORRUGATED CARDBOARD DESIGN FOR USE IN INDOOR RANGES

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Charles T. Crume, Jr. April, 1979 Pages 29

Directed by: Doctors Emmett Burkeen, Seth Farley and Carl Kreisler

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This study presents the results of a comparison of traditional grass-twist backstops frequently used on indoor ranges with one of corrugated cardboard design. The findings indicate that the corrugated cardboard design is substantially superior.

The four factors selected for testing were:

1. arrow pass-through levels and subsequent arrow repair costs

2. arrow penetration levels, tested over several distances and using several bow weights

3. arrow-stopping potential with beginning and inexperienced archers

4. storage

Testing showed the first three factors supporting the corrugated cardboard design. The last factor, storage, was found to be about equally supportive of both designs.

Several recommendations are made. These recommendations include the adoption of the corrugated cardboard backstop design for use on indoor ranges and the use of shorter distances in the instruction of beginning and inexperienced archery students.

CHAPTER I

INTRODUCTION

Background of the Study

Archery is found on many university campuses in both the instructional and intramural areas. Archery, as an extra-campus recreational activity, is a growing indoor sport. This is evidenced by many new commercial indoor ranges and a growing list of professional level indoor tournaments. The development of the Professional Archer's Association's Indoor Round, in the mid 1960's, stimulated the current trend toward year-round indoor shooting. There is little evidence that this indoor shooting trend is weakening.

During the late 1960's and early 1970's, archery equipment, available to the public, advanced rapidly in both design and sophistication. This period of rapid technological growth is highlighted by the production and acceptance of the compound bow, which multiplied arrow velocities without adding draw weight. During the same period, the traditional finger release method gave way to a series of new release devices. This combination of superior bows and sophisticated release devices has resulted in increased arrow accuracy and velocity.

With the advent of higher arrow velocities and tighter arrow groups from all distances, the risk of backstop pass-throughs has substantially increased. Greater backstop pass-through ratios have resulted in greater potential arrow damage and subsequent repair costs as well as greater risk of property damage and personal injury.

In the public sector, traditional backstops were improved or replaced with more suitable designs. Such changes in public shooting ranges were made with relative ease since they tended to be permanent. Also, the tendency on commercial ranges is toward the construction of backstops rather than their purchase. These two factors separate the private indoor range from those normally found on university campuses.

Since university facilities tend to be multipurpose, heavy permanent backstops are unacceptable. The problem is also compounded by the absence of commercially produced backstops that are both portable and effective in stopping arrows shot from modern equipment. The interaction of these circumstances has lead to the use, in many instances, of inadequate backstops of traditional grass-twist design resulting in unnecessary arrow damage, repair costs, and potential liability.

This study should provide a vehicle for solving some of the problems resulting from the use of traditional grass-twist backstops at the decreased distances experienced in indoor archery activities. This study should also result in substantial savings for the university while enhancing the instructional and recreational benefits for student participants.

Purpose of the Study

The purpose of this study is to compare an archery backstop of corrugated cardboard design to a backstop of traditional grass-twist design. The study will emphasize differences in arrow pass-through levels tested over several distances and using bows of several weights, arrow-stopping potential, and storage. It is also the purpose of this study to present a tested alternative to traditional grass-twist backstops on indoor ranges showing that the alternative backstop will produce superior results at substantially reduced costs and liability risk.

Rationale for the Study

Archery equipment has undergone several technological advances which have increased both arrow velocities and accuracy. Archery backstops, of the type commercially produced and subsequently purchased for university indoor use, have remained relatively unchanged. This combination of factors has resulted in the need to study alternative backstop designs which would be more compatible with the modern archer equipment now in use on university campuses. Several sources agree that archery is a growing recreational activity.[1] Archery is on the increase as a university activity as evidenced by an increasing number of varsity men and women archery teams and an increasing number of recreation departments including archery facilities in their planning.[2] Since participation in all forms of shooting has increased from 1.7 million in 1946 to over 8 million in the mid 1970's, it is assumed that archery-related activities will continue at the same levels or increase.

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[1]Niemeyer states that the total number of archers rose from 1.7 million in 1946 to over 4.7 million in 1960 (Roy K. Niemeyer, Beginning Archery [Belmont, Calif,: Wadsworth Publishing, 1962-67-69], p. 5), while Honda, Lammers and Newson project in excess of 8 million archery participants in the United States in the mid 1970's (Shig Honda, Marjory E. Lammers and Ralph W. Newson, Archery [Boston: Allyn and Bacon, Inc., 1969 75], p. 1). Also, the U. S. Fish and Wildlife Service reported an increase of bow-hunting participants in 1975 numbering close to 3 million (U. S. Department of the Interior, 1975 National Survey of Hunting, Fishing and Wildlife-Associated Recreation [Washington, D. C.: Government Printing Office, 1977], p. 46).

[2]Jean A. Barrett, Archery (Pacific Palisades, Calif.: Goodyear Publishing Co., 1969), p. 4.

Archery is considered to be both an outdoor and an indoor activity;[3] and since many universities provide multi-use facilities for indoor archery activities, it becomes imperative that archery backstops provide maximum arrow-stopping effectiveness. Ineffective archery backstops used in crowded and limited quarters can increase the possibility of arrow damage, property damage, and personal injury.

Archery equipment has increased in both accuracy and cast potential.[4] Introduction of the compound bow, as well as recurved bows of improved design, had resulted in increased arrow velocities.[5] Because of flatter trajectories and increased arrow velocities, it can be expected that arrow groups will be tighter and will penetrate the backstop to a greater depth. These factors alone increase the chances for arrow pass-through if backstop effectiveness remains unchanged.

Many universities depend upon backstops that are commercially produced and available through archery supply companies. A survey of several equipment catalogs failed to show a commercially produced backstop of the corrugated cardboard design, or other design, that indicated more effectiveness than the traditional grass-twist type.[6] Backstops available, other than those of traditional grass-twist design, were either too small

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[3]Lorraine Pszczola, Archery (Philadelphia: W. B. Saunders Co., 1976), p. 61.

[4]Ibid., p. 6

[5]Jennings Compound Bow, Inc., 1977 Equipment Catalog (Valencia, Calif., Jennings Compound Bow, Inc., 1977), pp. 8-9.

[6]Equipment catalogs used in the survey included: (Bear Archery, Educators Equipment [Grayling, Mich.: Bear Archery, 1978], p. 8), (Kittredge Bow Hut, Archer's Bible [Mammoth Lakes, Calif.: Kittredge Bow Hut, 1975], pp. 74-75), (Robin Hood Archery, Inc., It All Started with Robin Hood [Montclair, N. J.: Robin Hood Archery, Inc., 1975], p. 149) and (Things from Bell, Inc., Wholesale Prices, 1979 [Homer N.Y.: Things from Bell, Inc., 1979], p. 43).

or were designed for limited use. From these facts, it is logical to assume that high use of traditional grass-twist backstops must occur on indoor ranges on campuses that depend upon equipment catalogs of companies who seem to be the most frequent suppliers of backstops.

Traditional grass-twist backstops are designed for use with outdoor archery rounds of forty yards or more.[7] Since most indoor archery rounds would necessarily be shot at much reduced distances due to lack of space and since it can be expected that arrows shot from closer distances will strike the target at higher velocities and in tighter groups, it can be assumed that the backstop will experience shorter life expectancy, arrow-stopping effectiveness and increased arrow penetrations.

Inasmuch as universities offer beginning instruction in archery, it is assumed that many students have not achieved a high degree of accuracy. Consequently, a greater ratio of target misses can be expected. Traditional grass-twist backstops have a surface area of some 12.5 square feet. Backstops of corrugated cardboard design can easily double the square footage of arrow-stopping surface. It can be assumed that this increased surface would reduce the number of arrows missing the backstop.

Based upon these facts, it seems reasonable to conclude that:

1. Present levels of archery activity on university campuses will remain the same or increase

2. Archery activities on university campuses take place on indoor ranges and in multi-use facilities

3. Archery equipment in use today is more accurate and arrows achieve increasingly higher velocities

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[7] Pszczcola, Archery, p. 61.

4. Many universities are using backstops of traditional grass-twist design which are becoming increasingly ineffective in stopping arrows shot from modern equipment at shorter distances

5. In many cases, indoor archery rounds are shot using backstops that we designed for use at longer distances (due in part to commercial availability)

6. Technological advances in archery equipment have tended to reduce the effective life of the traditional grass-twist backstop

7. Archers, especially beginners, tend to miss traditional-sized grass-twist backstops more than those backstops of increased surface area

8. Arrows missing or passing through the backstop can increase the possibility for property damage and personal injury

9. Arrow pass-throughs and excessive arrow penetration can cause excessive arrow damage and subsequently higher repair costs

In view of the fact-supported assumptions described in items one through nine, it is hypothesized that if an alternative backstop of a new design could be produced, such a backstop could be tested by direct comparison for superiority in several essential performance areas.

Justification for the Study

In recent years, a backstop utilizing corrugated cardboard as the arrow-stopping agent has been used with archery classes at Western Kentucky University. It would seem, from simple observation, that this new design is superior to the backstops of traditional grass-twist design in several respects. However, prior to this study a formal testing had not been attempted comparing the aforementioned designs. Neither had studies been conducted comparing such factors as:

1. arrow pass-through levels and subsequent arrow repair costs

2. arrow penetration levels tested over several distances and using several bow weights

3. arrow-stopping potential with beginning and inexperienced archers

4. storage

A pilot study indicated that the backstop of the new corrugated cardboard design might prove superior in the four areas aforementioned. In such case, adoption of the new design backstop could result in both increased instructional benefits and reduced equipment repair costs at a time when there are increasing pressures on the university budget. It would seem that there is a need for studies of alternative methods, materials, and equipment such as the new backstop design tested in this study which promise superior performance at reduced cost.

Review of Literature

Information needed in the completion of this study ranged beyond the standard archery book, which tends to stress historical and instructional facts and procedures. Since the purposes of the study are comparisons of a technical nature and/or deal with information that is found in other than traditional sources, it was necessary to draw information from materials not normally thought of as research reference sources.

Basic sources of information on the technical aspects of modern archery equipment and the resulting relationship to archery equipment of a more traditional type is rarely found in other than manufacturer catalogs. Likewise, the most abundant source of information on the availability of commercially produced equipment is in supplier catalogs. Specifications and technical data on compound vs working recurved bows are usually available in the data sheets that accompany new equipment or in promotional literature circulated by manufacturers of compound bows. Sources of the aforementioned type were used in developing this study.

Also conducted was a survey of available university catalogs which supported the researcher's experience that many universities offer archery instruction or use archery-related activities in their intramural or intercollegiate sports programs. Although exact figures are not possible from this type of source, some necessary generalizations are possible to confirm.

Other sources of information used in the process of this study included archery texts and instructional manuals, government publications of both national and state origin, hunter safety education materials and a training supplement under the copyright of the author of this study.

A search of the literature showed no statistics on penetration levels, pass-through levels or effective life characteristics of the traditional grass-twist backstop. Several texts, however, showed this backstop associated with archery rounds of shorter distances than the normal forty- to sixty-yard range of the American Round usually associated with this type backstop.[8]

A review of equipment catalogs used by Western Kentucky University for equipment acquisition showed two types of backstops for sale. The first of these is constructed of polyurethane foam and is advertised as a lightweight backstop.[9] The traditional grass-twist backstop advertised in the same catalog was said to be, "regulation tough, fibrous . . . ."[10]

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[8]Niemeyer, Beginning Archery, pp. 34-36, and Pszczola, Archery, p. 82.

[9]Snitz Manufacturing Company, 1978-79 Fall and Winter Physical Education and Athletic Team Catalog (East Troy, Wis.: Snitz Manufacturing Company, 1978), p. 42.

[10]Ibid., p. 42.

Bear Archery Equipment Catalog (1978)[11] shows the traditional grass-twist backstop being used in indoor facilities where distances of forty yards or greater would be unusual. Things from Bell Catalog[12] shows much the same situation. Indoor rounds are discussed in the Kentucky Hunter Safety Education Training Supplement.[13] In this source the indoor backstop recommended is of corrugated cardboard design although the backstop pictured is of permanent rather than portable design.

Equipment catalogs seemed to be the best source of current information on bow weights, efficiency, and cast. Two such catalogs were used in the preparation of this study. The Jennings Equipment Catalog (1977)[14] was used as a source of information about the compound bow while the Bear Archery Equipment Catalog (1978)[15] was used in similar connection with bows of traditional design.

Primary sources for the difinition of terms used in this study were Archery Training Supplement[16] and Archery.[17]

Definition of Terms

Arrow--a projectile shot from a bow (aluminum arrows were used in this study

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[11] Bear Archery Equipment Catalog (1978), p. 8

[12] Things from Bell Catalog (1979), p. 43.

[13] Chuck Crume, Archery Training Supplement (Frankfort, KY,: Department of Fish and Wildlife Resources, 1977), p. 32.

[14] Jennings Equipment Catalog (1977), pp. 8-9.

[15] Bear Archery Equipment Supplement (1978), p. 11.

[16] Crume, Archery Training Supplement, pp. 49-51.

[17] Pszczola, Archery, pp. 101-104.

Butt--an archery backstop

Backstop--a device used for stopping arrows

Cast--the distance an arrow is projected from a bow

Compound bow--a bow that utilizes mechanical advantage through the incorporation of pullies, cables, excentric cams or other devices which tend to increase arrow velocities while decreasing hold weight

Draw--the length an arrow is pulled (usually measured from the bow string to the arrow rest when the bow is at full draw)

Feather--a feather cut in a specific design and attached to an arrow to stabilize the flight from bow to target

Fletching--stabilizing attachments to an arrow made from feathers, plastic, or other material

Limb--the flexible sections of a bow

Nock--the attachment to an arrow into which the string is placed

Pass-through--the pentration of a backstop by an arrow to a depth where arrow damage (to the fletching) can be expected to occur or total penetration and exit from the rear of the backstop

Re-curve--a bow design that adds cast to the bow by placing a working curve in the limb

Release--the act of releasing the bow string

Release (mechanical)--a device for drawing and releasing the string of a bow other than the use of the fingers

Vane--a type of fletching made of plastic material

Weight (draw)--the number of pounds of pull necessary to draw a bow a given distance (usually twenty-eight inches)

CHAPTER II

METHODS AND PROCEDURES

Pilot Study

Prior to 1975, backstops of traditional grass-twist design were used in conjunction with indoor archery classes at Western Kentucky University. These backstops were of the type typically used in the shooting of the American Round.[18] Indoors, however, archers using these backstops seldom shot beyond thirty yards. This short distance shooting seemed to decrease the useful life of the backstop and allowed an unusually damage to the arrow fletching.

In the fall of 1975, a prototype backstop constructed of corrugated cardboard was produced and placed on the archery range in substitution for one of the backstops of grass-twist design. This backstop was used over a two-year span with two backstops of grass-twist design. The results were interesting.

Over a period of four semesters and two summer terms a total of nine archery classes used the range. Additional use of the range included two summer all-sports camps and a hunter safety education class. The range was also used for evening practice and intramural activities.

Approximately 44,000 arrows were shot at the three backstops over a two-year period.[19] At this figure, somewhere over 13,360 arrows were

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[18]The American Round is an outdoor archery round shot by the National Archers' Association at distances of 40, 50, and 60 yards.

[19]This estimate could be as much as 10,000 arrows low.

shot at each backstop. At the end of this period, six grass-twist backstops had been expended and retired because of their inability to stop arrows. This results in an estimated life expectancy of some 4,500 arrows for the grass-twist backstops.

At the end of the same two-year period, the corrugated cardboard backstop was still in use. Although it had absorbed over 13,600 arrows and showed considerable shallow surface damage, average arrow penetration was well within safety limits.[20] This level of effectiveness was recorded after approximately three times the use that caused the traditional grass-twist backstop to be discarded.

The results of this rather informal pilot study seemed to support the conclusion that a backstop of corrugated cardboard design in several desirable areas. The pilot study also indicated that adoption of a backstop of the new corrugated cardboard design might result in substantial savings in both material and repair costs. Due to the decreased number of pass-throughs, there also seemed to be an increased safety factor.

Characteristics Tested

A number of desirable characteristics for archery backstops were listed. These included the following:

1. arrow-stopping potential
2. cost of backstop
3. life expectancy of the backstop
4. arrow penetration levels

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[20] Average arrow penetration, when shot from a 30 pound bow from a distance of 20 yards, was less than 19 inches. This depth is still 5 inches short of feather damage and 24 inches short of pass-through.

5. arrow damage sustained in excessive penetration and pass-through

6. arrow repair costs for damage sustained in excessive penetration and pass-throughs

7. surface area and resulting arrow-stopping potential

8. storage

These eight characteristics were combined and fused into four characteristics which were used in comparing the traditional grass-twist backstop to one of corrugated cardboard design. The four summary characteristics selected for testing were:

1. arrow pass-through levels and subsequent arrow repair costs

2. arrow penetration levels, tested over several distances and using several bow weights

3. arrow-stopping potential with beginning and inexperienced archers

4. storage

Arrow Pass-through Levels and Subsequent Arrow Repair Costs

This characteristic was tested by shooting four thousand arrows into a grass-twist backstop and four thousand arrows into a corrugated cardboard backstop and counting the number of pass-throughs.[21] Arrows were blocked in increments of five hundred. The number of pass-throughs for each increment were multiplied by a cost of repair figure.[22] The number

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[21] An arrow was considered a pass-through when the fletching penetrated into the backstop or the arrow exited the backstop.

[22] The pass-throughs cost of repair figure was obtained by causing twelve arrows to pass through a grass-twist backstop until all arrows had sustained damage to at least one feather. It was determined that one pass-through in two will cause feather damage on a new grass-twist backstop and one pass-through in four will cause feather damage at the four thousand arrow level. These two figures were average indicating a one in three pass-through feather damage level. Repair costs were calculated by determining the number of feathers that could be replaced

of pass-throughs and subsequent project arrow repair costs were placed in a table indicating results of the test on each type backstop.

Since normal shooting distances at Western Kentucky University range from 10 to 30 yards and since bows used in those classes range from 20 to 35 pounds of draw weight, an attempt was made to average these conditions for the test. The distance selected for shooting was 20 yards; and since 27 pound draw weight bows were not available, 30 pound draw weight bows were used for the test.

Two archers of approximately the same size, weight, and shooting skill level were selected to conduct the test. Each shot new 1716, XX-75, aluminum target arrows 28 inches long.

A new grass-twist backstop was randomly selected for the test from those stored for range use, while a new corrugated cardboard backstop was constructed for the test. The new corrugated cardboard backstop was essentially the same as the one used in the pilot study with the exception that threaded rods were used as cardboard compressors replacing the turnbuckles used on the pilot model.

Arrow Penetration Levels, Tested Over Several Distances and Using Several Bow Weights

This characteristic was tested by shooting 10 arrows from distances of 10 yards, 15 yards, 20 yards, 25 yards, and 30 yards using bows of 20

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in one hour. This figure was multiplied by a labor-per-hour figure. The product was divided by the number of feathers replaced in one hour. To this figure was added the cost of one feather. This figure was divided by a damage pass-through factor of one in three. The result is the arrow repair cost per pass-through. (Six feathers per hour @ $3 per hour = $.50 per feather + $.05 feather cost = $.55 per feather replaced. This $.55 divided by a pass-through damage factor of one in three, or $.55 divided by 3 = $.183 per pass-through.

pounds, 30 pounds, and 35 pounds draw weight and a compound bow of 40 pounds breakover weight into a grass-twist backstop and a corrugated cardboard backstop. Penetration levels for each combination of bow weight and distance were averaged and placed in a table for each backstop type.

A new grass-twist backstop was randomly selected for the test from those stored for range use. The corrugated cardboard backstop was the one previously used. The archers conducting the first test also conducted this test.

Bows and arrows used in this test were randomly selected from those found in the equipment room and normally used with archery classes.

Arrow-Stopping Potential with Beginning and Inexperienced Archers

This characteristic was tested using fifteen archers during their first week of instruction. Each of the archers used in the test indicated that they had little or no experience in archery.

Each archer was asked to shoot five arrows at a grass-twist backstop and five arrows at a corrugated cardboard backstop from distances of 10 yards, 20 yards, and 30 yards. The test was replicated the second day. The total number of hits and misses for each distance and for each backstop was tabulated each day. The number of hits and misses for the two days was averaged. A percentage of misses for each distance and for each backstop was calculated and placed in a table. Percentages were noted as first day, second day, and average.

Storage

This characteristic was determined by calculating the area needed to store each of the two backstops. Both square feet and cubic feet were calculated. The grass-twist backstop may be stored in two sections as a single unit. Square feet of area was calculated by multiplying the length and width of floor space necessary to hold each backstop. Cubic feet was calculated by multiplying the square foot area figure by the height necessary to hold the backstop. In the case of the grass-twist backstop, cubic feet of storage was also calculated a second time, since this backstop can also be stored in two sections.

Analysis of Data

In most cases substantial differences occurred in the data representing the two backstops. After investigation of several references on the reporting of test data and consultation with two members of the Western Kentucky University faculty who teach statistics at the graduate level, it was concluded that the data might be reported in table form and analyzed by direct comparison without the use of methods to determine significant differences. The substantial differences in the data were apparent from simple review of the tables.

Cost Analysis

Where cost of materials are mentioned, current equipment catalogs and price lists were used. In some cases where there were differences in prices of the same item, the lowest price was used. Labor costs, where mentioned, were figured at three dollars an hour, which was intended as a minimum figure. All figures and estimates used in this study were calculated to produce the lowest differences possible. Any upward variation in the cost figures used here can be expected to produce greater differences. In all tests where cost figures were used as estimates, very conservative estimates were projected.

CHAPTER II

REPORTING OF TEST DATA

Pilot Study

Results of the pilot study indicated that substantial differences could be expected in several test areas when comparing backstops of traditional grass-twist design to one of corrugated cardboard design. Based upon information gained through the pilot study, it was concluded that four characteristics could be used for comparing the aforementioned backstops. The characteristics indicated for comparison were:

1. arrow pass-through levels and subsequent arrow repair costs

2. arrow penetration levels, tested over several distances and using several bow weights

3. arrow-stopping potential with beginning and inexperienced archers

4. storage

Arrow Pass-through Levels and Subsequent Arrow Repair Costs

Four thousand arrows were shot into a traditional grass-twist backstop, and 4,000 arrows were shot into a corrugated cardboard backstop using 30 pound bows at distances of 20 yards. The number of pass-throughs were counted and recorded for each backstop type in increments of 500 arrows. Results for the traditional grass-twist backstop showed only 1 pass-through in the first 500 arrows, 2 pass-throughs in the second 500, 4 pass-throughs in the third 500, 11 pass-throughs in the fourth 500, 28 pass-throughs in the fifth 500, 59 pass-throughs in the sixth 500, 78 pass-throughs in the seventh 500, and 165 pass-throughs in the eight 500 arrows. (See table 1.)

Results for the corrugated cardboard backstop showed no pass-throughs at any point from one to four thousand arrows. At four thousand arrows, the corrugated cardboard backstop showed only minor surface damage and was allowing approximately eleven inches of arrow penetration, while the grass-twist backstop was allowing approximately one third of all arrows to penetrate to a point of arrow damage possibility.

When the pass-throughs at each increment were multiplied by the arrow repair cost figure of .183 cents, the cost of shooting each 500 arrow increment increased from a low of 18.3 cents for the first 500 arrows to a high of $30.20 for the last 500 arrows. The total of all increments is $63.37. Add to this the cost of the backstop (about $40)[23] and it can be seen that the total cost of shooting 4,000 arrows into a grass-twist backstop would be about $103 or approximately 2.3 cents an arrow. Since the cost of constructing a corrugated cardboard backstop is about $40 and there are no pass-throughs, the approximate cost per arrow on this type backstop would be about 1 cent per arrow. However, when this figure is expanded to the 13,000 level of the pilot study, the per arrow cost drops to .3 cents per arrow. It is not known at this time at what arrow level pass-throughs start to occur on the corrugated cardboard backstop.

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[23]Things from Bell Catalog (1979), p. 43.

TABLE 1

NUMBER OF ARROW PASS-THROUGHS AND RESULTING ARROW REPAIR COST AT 500 ARROW INCREMENTS USING A TRADITIONAL GRASS-TWIST BACKSTOP

Increments of 500 Arrows	Number of Pass-Throughs	Arrow Repair Cost at .183 Cents Per Arrow
0- 500	1	$ .18
501-1000	2	.37
1001-1500	4	.73
1501-2000	11	2.01
2001-2500	28	5.11
2501-3000	59	10.50
3001-3500	78	14.27
3501-4000	165	30.20

NOTE: Number of pass-throughs was based on the use of XX-75 aluminum arrows shot from a 30 pound draw weight, recurved, laminated, composite bow selected from those used in archery classes and shot from a distance of 20 yards using 28 inches of arrow draw length. Because arrow repair cost figures are given to the nearest cent, it is not always possible to derive exact totals by adding component parts.

Arrow Penetration Levels, Tested Over Several Distances and Using Several Bow Weights

This characteristic was tested by shooting 10 arrows from distances of 10 yards, 15 yards, 20 yards, 25 yards, and 30 yards using bows with draw weights of 20 pounds, 30 pounds, 35 pounds, and a compound bow of 40 pounds breakover weight. Each was used at each distance with the traditional grass-twist backstop and the corrugated cardboard backstop. When the penetration levels were measured and averaged, the results shown in table 2 were obtained.

Tests of this characteristic indicated that grass-twist backstops would allow pass-throughs when heavier bow weights were used at short distances. Backstops of corrugated cardboard, however, allowed a maximum of nineteen inches of arrow penetration when heavy bow weights were used at short distances. This figure is still five inches short of possible arrow fletching damage.

TABLE 2

INCHES OF ARROW PENETRATION INTO BACKSTOPS OF TRADITIONAL GRASS-TWIST DESIGN AND CORRUGATED CARDBOARD DESIGN WHEN SHOT FROM BOWS OF SEVERAL DRAW WEIGHTS AND FROM SEVERAL DISTANCES

Bow Type or Draw Weights (in Pounds)	Distance from Backstop (in yards)				
	10	15	20	25	30
Backstop of Traditional Grass-Twist Design					
20	15.0	12.5	8.5	6.5	5.0
30	20.0	14.5	11.0	9.0	7.0
35	PT*	17.0	15.0	12.0	9.0
(Compound) 40	PT*	PT*	PT*	20.0	17.0
Backstop of Corrugated Cardboard Design					
20	9.0	7.5	6.5	6.0	5.0
30	13.0	10.0	8.0	6.5	5.0
35	16.0	12.0	9.0	7.0	5.0
(Compound) 40	19.0	17.5	15.5	12.5	9.0

*PT indicates pass-through level or a penetration depth of twenty-four inches or greater.

Arrow-Stopping Potential with Beginning and Inexperienced Archers

This characteristic was tested using fifteen archers with little or no previous archery experience. Each archer shot arrows at a grass-twist backstop and then at a corrugated cardboard backstop from distances of 10 yards, 20 yards, and 30 yards. The test was replicated a second day. Hits and misses were recorded, averaged, and a percentage of misses for each distance and backstop type was obtained and recorded in table 3.

TABLE 3

PERCENTAGE OF ARROWS MISSING TRADITIONAL GRASS-TWIST DESIGN BACKSTOPS AND CORRUGATED CARDBOARD DESIGN BACKSTOPS WHEN SHOT BY INEXPERIENCED ARCHERS

Distance to Target (yds.)	Percentage of Misses								
	1st Day			2nd Day			Average		
	H*	M**	%***	H	M	%	H	M	%
	Backstop of Traditional Grass-Twist Design								
10	35.0	10.0	22.2	36.0	9.0	20.0	71.0	19.0	21.1
20	21.0	24.0	53.3	22.0	23.0	51.1	43.0	47.0	52.2
30	9.0	36.0	80.0	17.0	28.0	62.2	26.0	64.0	71.1
	Backstop of Corrugated Cardboard Design								
10	43.0	2.0	4.4	45.0	0.0	0.0	48.0	2.0	2.2
20	33.0	12.0	26.6	36.0	9.0	20.0	69.0	21.0	23.3
30	23.0	22.0	48.8	31.0	14.0	31.1	54.0	36.0	39.9

*(H) Indicates arrows hitting the backstop
** (M) Indicates arrows missing the backstop
*** (%) Indicates the percentage of misses

For the grass-twist backstop, the averaged percentage of misses from 10 yards was 21.1 percent compared to 2.2 percent for the backstop of corrugated cardboard design. At 20 yards the percentages were 52.2 for the grass-twist backstop and 23.3 for the corrugated cardboard backstop. At 30 yards, the percentages reached 71.1 percent for the grass-twist backstop and 39.9 percent for the backstop of corrugated cardboard design. Results for this characteristic indicated a high percentage of misses from longer distances no matter which backstop was used, although the misses were substantially higher when the grass-twist backstop was used.

Storage

This characteristic was tested by calculating the square footage and cubic footage necessary to store each of the two backstop types. The results were placed in table 4.

TABLE 4

AREA NEEDED TO STORE BACKSTOPS OF TRADITIONAL GRASS-TWIST DESIGN AND BACKSTOPS OF CORRUGATED CARDBOARD DESIGN

Backstop Type	Storage Space Needed	
	Cubic feet	Square feet
Corrugated cardboard	24.0	6.0
Traditional grass-twist	30.0	7.5

Note: Backstops of traditional grass-twist design can be stored in 18.0 cubic feet of space if stored in two sections.

Storage area necessary for the grass-twist backstop indicated an area of 7½ square feet and 30 cubic feet when stored in one section. If stored in two sections, the necessary storage area was reduced to 18 cubic feet. The corrugated cardboard backstop required 24 cubic feet of three-dimensional storage space and 6 square feet of floor space. This type backstop is constructed in one piece and cannot be divided into sections as can the grass-twist backstop.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations made from this study are based upon the data collected in the testing of four selected characteristics. The characteristics selected for comparing a backstop of traditional grass-twist design to a backstop of corrugated cardboard design were:

1. arrow pass-through levels and subsequent arrow repair costs

2. arrow penetration levels, tested over several distances and using several bow weights

3. arrow-stopping potential with beginning and inexperienced archers

4. storage

Characteristics one, two, and three indicated the backstop of corrugated cardboard design to be substantially superior to the backstop of traditional grass-twist design. The fourth characteristic, storage, seemed about equally supportive of both designs.

Arrow Pass-through Levels and Subsequent Arrow Repair Costs

It is concluded that the cost of shooting 4,000 arrows into a grass-twist backstop is approximately 2.5 cents an arrow compared with somewhere less than .3 cents per arrow when using a backstop of corrugated cardboard design. This figure is calculated on only a 13,000 arrow level of life expectancy for the corrugated cardboard backstop. All indications are that the life expectancy of this type backstop will exceed the 13,000 arrow mark, some three times per side or a total in excess of 100,000 arrows. In any case, the data collected supports the conclusion that the corrugated cardboard backstop is substantially superior to the grass-twist backstop in arrow-stopping ability and arrow repair cost considerations.

It is recommended that additional tests be made with the corrugated cardboard backstop to determine the life expectancy and subsequent arrow repair costs at the point of the backstop's maximum effective life.

Arrow Penetration Levels, Tested Over Several Distances and Using Several Bow Weights

It is concluded that the data related to this characteristic indicates arrow penetration levels become critical at about 30 yards with bows of greater than 30 pounds draw weight, when using a grass-twist backstop. The data also indicates that compound type bows at distances of 40 yards and under tended to pass through this type backstop.

A backstop of corrugated cardboard, however, was found to be effective in stopping all arrows from all bows at all distances tested with a maximum arrow penetration of 19 inches, 5 inches short of pass-through.

It is recommended that the grass-twist backstop be used with bows of less than 30 pounds of draw weight and at distances of over 20 yards if used on indoor ranges. It is also recommended that grass-twist backstops not be used in connection with compound type bows on indoor ranges or at distances of less than 40 yards.

The use of a backstop of corrugated cardboard design is recommended for indoor archery ranges from all distances and for bow weights of up to 45 pounds. The corrugated cardboard backstop is also recommended for use with the compound type bow of up to 45 pounds of breakover weight.

Arrow-Stopping Potential with Beginning and Inexperienced Archers

It is concluded that data related to this characteristic indicated beginning and inexperienced archers tended to miss the traditional grass-twist backstop about twice as often as they missed the corrugated cardboard backstop. The exception to this tendency occurred at the ten-yard range where some 21 percent misses were recorded for the grass-twist backstop and 2 percent were recorded for the corrugated cardboard backstop.

It is recommended that the corrugated cardboard backstop be used in the instruction of beginning and inexperienced archers. It is also recommended that early instruction of beginning archers be held to maximum distances of fifteen yards to avoid excessive target misses and resulting arrow damage, repair costs, and danger of property damage and personal injury.

Storage

It is concluded that data related to this characteristic indicated little difference in the areas necessary to store the two backstop types. The largest factor seemed to be that the grass-twist backstop could be stored in two sections while the corrugated cardboard backstop was constructed as a single unit.

No recommendations are made with regard to the finding of this study regarding this characteristic.

General Recommendations

Based on the data collected as a result of this study, it is generally recommended that the corrugated cardboard backstop be adopted for use on indoor archery ranges. It is also recommended that backstops of traditional grass-twist design be used on indoor ranges at distances of at least forty yards as they were designed.

In the event that traditional grass-twist backstops are used at distances of less than forty yards, it is recommended that they be retired at the three to four thousand arrow level to reduce pass-throughs, resulting arrow damage, and chance of property damage and personal injury.

Since any pass-through or target miss can result in property damage and/or personal injury and the data presented in this study supports the view that higher levels of both occur with the grass-twist backstop, it is recommended that the grass-twist backstop be replaced with one of corrugated cardboard design.

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