# AC 2007-1821: HORSESHOE APPLICATIONS: A MATERIALS SELECTION PROJECT FOR FIRST-YEAR STUDENTS

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# Horseshoe Applications: A Materials Selection Project for First-year Students


## Abstract

Engineering Technology students typically take a one-semester introductory course in materials. Often taken in the first semester, the course covers basic materials topics, with lab exercises included to reinforce specific individual concepts. This paper describes a new lab exercise presented to the students as a material selection project. Focused on horseshoes, as used today in equine transportation, sport and recreational activities, the lab exercise includes student evaluation of application requirements, relevant material properties, and total product cost (product life cycle analysis). The exercise is structured to function as a unifying project, bringing together the students' understanding of mechanical and physical material properties, processing considerations, application requirements, and cost information. Because horseshoes are presently manufactured from iron-based alloys, aluminum alloys, and polymer materials, they present an opportunity for comparison of different materials used in a single application. Additionally, horseshoes have a long history of use spanning cultures and eras of technological change. This provides an opportunity for students to consider historical and regional differences in product requirements and resources, and the consequences of technological change on material choices and process feasibility.


## Introduction

The Horseshoes Material Selection Project was used for the first time in the Fall 2006 semester, for a group of 24 students in a first semester materials course. All of the students were male and the class was composed of both traditional and non-traditional (age >25 years) students. More than half of the students were employed full-time and taking courses part-time. The project was assigned in the 14$^{th}$ week of the semester, after the students had been exposed to all of the major course topics and laboratory experiments in mechanical and physical property measurement. The primary objective of the project was to give the students experience in selection of a material for a specific application. Students were allowed some freedom to develop and describe the details of their own fictional applications but were expected to work with existing materials and/or available products in defining an optimal material choice. Horseshoes were chosen as the application for this project because the application is relatively easy to explain and material properties are fundamental to the performance of the product.

## Project Assignment

The project was introduced by the instructor, who began with background information about the number of equines in the United States (9.2 million in 2005[1], the number in the student's state of residence, and the number in seven local counties (nearly 30,000). In 2002, the total statewide cost of equine hoof /farrier services was more than $20,000,000.[2] The instructor also provided a brief history of the development and use of horseshoes, including illustrations of equine hoof anatomy and presently available materials and products. Samples of steel and aluminum horseshoes were passed around the classroom for the students to inspect and compare. One of the samples was unused, and the other showed wear patterns characteristic for a "worn out" horseshoe. One of the horseshoes was also constructed from an aluminum alloy but included a

steel “wear plate” in the toe. The instructor displayed literature from horseshoe manufacturers and equine industry publications related to horseshoes and horseshoeing.
A written handout was provided to the students which defined the written project assignment, provided additional background information, and included links to web-based information on the history and applications of horseshoes, as well as supplier information.
Since this project was the first formal exercise in material selection for the semester, the instructor demonstrated the design and use of a selection matrix, which was also explained and described in the course textbook.[3] An example selection matrix was created, with material choices on a top, horizontal axis and selection criteria (material properties, processing considerations, cost etc) as a vertical axis. The selection matrix was presented as a way to organize information for objective decision-making, although it was pointed out that the (possibly subjective) choice of selection criteria and potential “weighting” of these criteria has a direct effect on the problem solution.

Students were required to submit a written project report which included the following:

1. A definition statement of their application, including the number of horses to be shod and the function of the horses (e.g. trail riding, dude ranch, racing, mounted police, etc.)
2. A table listing available materials and their properties (physical and mechanical).
3. A material selection matrix showing criteria for selection and scoring for each material.
4. A paragraph explaining how ratings and relative importance of criteria were determined.
5. Additional paragraph(s) discussing the results of the selection matrix, how sensitive the selection might be to changes in criteria or relative importance, discussion of material types or families which have properties unsuitable for the application.

Project report requirements were developed to encourage the students to gain practice in creating a material selection matrix and also to think about how significantly the results can be affected by input parameters and performance requirements. In other words, the students were expected to define a problem, create a solution using a specific decision-making technique, and then recognize the sensitivity of the solution to changes (or errors) in the input parameters. These expectations collectively require all six of the levels of thinking as define by B.S Bloom in his taxonomy[4]; knowledge, comprehension, application, analysis, synthesis, and evaluation.

**Student Reports and Assessment**

Out of a class of 24 students only 15 students completed this assignment. This poor participation was atypical for the course overall. Participation in the other nine laboratory exercises averaged 23 out of 24 students. There was no obvious explanation for the lack of effort, and no students asked for assistance or further clarification of the assignment. The reports that were submitted generally showed sincere attempt at completing the assignments. In addition to an evaluation of basic grammar and spelling, student reports were scored using the assessment points labeled A through J as shown in Table 1.  Student scores for these items are shown in the two columns on the right. The primary focus in evaluating the reports was to document the students’ ability to communicate effectively and to apply knowledge and problem-solving techniques to a material selection problem. This focus for evaluation is part of an overall departmental plan for documenting and continuously improving achievement on defined department-level program outcomes.

Items A through J were chosen to evaluate several levels of student thinking as described by Bloom, and were used collectively to determine students' ability to apply knowledge and problem-solving skills. Items A and B required only restatement or repetition of information, but the information included depended on a higher level synthesis or formulation of a coherent "problem" or application. Similarly, items D and F were relatively basic activities, requiring mainly reporting or describing rather than discovery or analysis. Most of the students performed well on items A, B, and D, demonstrating that they have mastered a basic understanding of problem or application statement and material properties. Only one student provided any documentation of material properties or cost, the remaining students merely gave qualitative statements like "harder", "better strength-to-weight ratio", or "less expensive".

All of the students created a material selection matrix, which was demonstration of utilization of a problem-solving technique, but item C assesses whether or not the student demonstrated the ability to adjust the selection matrix to accommodate criteria of differing importance to the selection (by creating "weightings" or "factors" to emphasize certain criteria more than others). Scoring of this item was either "0" or "2", since the student either used weighting or not. The mean score of 1.1 on this item indicates that only about half of the students chose to modify their matrices in this way. The evaluation rubric includes the assumption that modifying the selection matrix is necessary to demonstrate optimal mastery of the matrix as a problem-solving tool.

Item E was also scored at either "0" or "2" and was used to record whether or not the student considered a wide range of material options or simplified the problem by restricting the choices to closely-related materials. Again, the evaluation rubric was designed to reward students who included a range of material choices in their selection matrix.

Items G and H evaluate higher levels of thinking by examining whether or not the student was able to reflect on and appraise his own solution. As indicated by the mean scores, more than half of the students included discussion statements like "I was surprised at the answer" or "The result was what I expected". An even larger group included discussion of how their selection of criteria or weight affected the solution and how the solution might change under different application conditions. Items I and J are related, but the students demonstrated significantly more awareness of current material processing and availability and local manufacturing conditions than for historical or geographical differences. This is probably the result of emphasis during the semester of current materials and processes relevant to local and United States industry. Neither item I nor J is a core skill for the immediate material selection assignment directly, but can be considered important indicators for the ability of the student to revise his solution if technologies or other parameters change.

**Summary and Recommendations**

This first exercise in using horseshoes as a material selection project was useful in evaluating basic student abilities for recalling and explaining basic knowledge. Some of the student reports also revealed higher levels of thinking, including skills in analysis, synthesis, and evaluation. Unfortunately, not all of the students demonstrated capability in these aspects, and only 15 of the 24 students in the course submitted a report. This was a significantly lower percentage of participation than any of the other lab exercises during the semester (10 lab reports total). It is possible that the open-ended nature of this assignment discouraged some students from making an attempt. Perhaps the horseshoe application, with no electronics, moving parts, mechanisms, software, lights or other high-tech features was too mundane to capture the students' interest. It is also possible that the timing of the assignment, near the end of the semester, caught many students at a very busy point in the semester. The poor participation of the students and poor performance on assessment items F and J suggest that the students may benefit from more background information and more complete instructions to successfully complete the assignment. Specifically, the instructions should include directives to include materials from at least two types or families, to provide quantitative information with citations, and to include at least two references to information not provided in class. The assessment rubric should also be provided to the students when the assignment is explained so that they will have a clear understanding of the learning objectives and measurement criteria and can work more effectively towards these criteria.

Table 1 - Report Evaluation Rubric

The following list of items was used as a guide in evaluating the fifteen student reports received. The items were selected to identify specific learning objectives (see descriptions above). Each item was rated on a scale from 0 to 2, where 0 = Not Present, 1 = Some Evidence, and 2 = Clearly Evident. The mean scores for all fifteen student reports are shown in the column on the right.

| | | Mean Scores |
|---|---|---|
| | Description of Application | |
| A | Quantitative information provided | 1.5 |
| B | Important performance parameters explained | 1.8 |
| | Creation of Material Selection Matrix | |
| C | Criteria weighting related to Application Description | 1.1 |
| D | Both Mechanical and Physical properties included | 1.8 |
| E | Materials chosen from at least two types or families | 1.3 |
| F | Documentation/citation for properties and/or costs | 0.1 |
| | Discussion | |
| G | Reflective, comments on the decision-making process | 1.6 |
| H | Includes how selection would change with altered weightings of criteria | 1.7 |
| I | Includes awareness of reasons for material availability or process suitability | 1.5 |
| J | Includes regional, geographic, or historical considerations for material availability or cost | 0.7 |

Web resources for additional information on horseshoes

https://www.anvilbrand.com/store/catalog/ supplier catalog
http://www.ollov.com/ manufacturer of rubber horseshoes
http://www.horseshoes.com/ industry reference site
http://www.horseshoes.com/supplies/alphabet/equithane/ info sheets on adhesives
http://www.centaurforge.com/ supplier catalog (cont.)
http://inventors.about.com/library/inventors/blhorseshoe.htm info about the history of horseshoes
http://www.nchorsenews.com/GlueOnShoe.htm news article about glue-on shoes
http://en.wikipedia.org/wiki/Horseshoe Wikipedia
http://www.madehow.com/Volume-6/Horseshoe.html info about how horseshoes are made
http://www.horseshoes.com/advice/advcclms.htm info about horseshoeing
http://www.horseshoes.com/advice/invtshoe/winvhrs.htm info about the history of horseshoes
http://www.stcroixforge.com supplier of horseshoes
http://www.easywalkerhorseshoes.com supplier of polymer horseshoes
http://www.mustadinc.com supplier of nails and pads

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[1] American Horse Council Study, http://www.horsecouncil.org/statistics.htm
[2] Economic Impact of the Equine Industry to Indiana, Purdue Extension Publication ID-320-W. http://www.ces.purdue.edu/extmedia/ID/ID-320-W.pdf
[3] Materials and Processes in Manufacturing, E.P. DeGarmo, J.T. Black, and R.A.Kohser, 2003 John Wiley and Sons.
[4] Taxonomy of educational objectives, B. S. Bloom. 1984, Allyn and Bacon, Boston, MA