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A Method of Style Convertible Footwear Construction by Replaceable Upper

Md. Farhan Absar Tahsin, Subol Halder, Md. Imrul Kayes Limon, Muhammad Naimul Hasan*
Department of Leather Engineering, Khulna University of Engineering & Technology,
Khulna-9203, BANGLADESH

ABSTRACT
The traditional footwear uses stitch or adhesive bond to fix the upper with the bottom part. But permanently fixation makes several problems in shoe maintenance. The objectives of this study were to develop a shoe construction method where style and aesthetic look of shoe can be easily changed and to provide better cleaning facilities inside of the shoe. In this study, one pair of derby and another pair of oxford shoe with removable upper were designed and developed. In this construction, strips of Velcro and snap buttons were used along the feather edge of the shoe to attach the upper and bottom firmly. The replacement of the upper was possible through this construction. Several tests like strength analysis, wear trial and material consumption were carried out to ensure good functionality, comfort and efficient material consumption of the developed footwear. The average breaking load of the join along the lasting edge of the shoe was found to be 106 N by ASTM D 1683 method that was higher than the value of the control sample. Material consumption of derby shoe upper was compared by 0^0 of Russ and Small method (RSM) where the developed construction method consumed almost 125cm^2 more leather compared to the conventional cemented method. But the material consumption reduces comparatively by using more replaceable uppers on the same bottom. 14 days with each day 30 minutes wear trial was also carried out and the wearer rate 1.67 in pain rating scale (1 to 10) which indicates that the wearer felt comfort by wearing these shoes. So, this construction method may be a solution for particular people who want to change their shoe style frequently and it may also solve several difficulties related to shoe maintenance.

Keywords: Style convertible shoe, Replaceable upper, Shoe construction, Material consumption, Wear trial

1. Introduction

Conventional shoes usually consist of two primary portions, the upper portion and the bottom portion. The upper portion of a shoe may contain a different number of parts that determines style, design, aesthetic look and bottom portions generally indicate the weight, comfort and construction method of the shoe [1]. Usually, the upper and bottom parts in most types of shoes are permanently attached together by cementing method or stitching. The cleaning dirt from inside of the shoe and eliminating the unpleasant smell of shoe become difficult due to permanent attachment. Similarly, the complete shoe may have to be thrown away if any major damage occurs to either the upper or bottom parts [2]. This can be avoided by developing a construction method of the shoe which may allow a user to remove and replace the bottom or upper by another one. This type of upper and bottom are interchangeable which may offer some extra facilities to the user. A removable upper may allow the user to replace the upper with an upper of a different color or style. In a different environment, this replacement system may also allow the wearer to wear a wide variety of a combination of different uppers and bottoms [3]. The upper can be easily removed from the sole which allows faster drying of sweat and easy removal of bad odor after long use. Thus a hygienic condition can be confirmed inside the shoe.

A removable sole provides facility to clean off adhered dirt and contaminants. Again, the used or damaged sole can be easily replaced by a new or good one. Many researches have been carried out to develop the design of footwear (sandal or shoe) with removable parts. Some of those were about the removable sole, insole, heel or upper. All those researches didn't have the same goal. Some researches focused on aesthetic appeal and style conversion while some other focused on comfort and safety. In these researches, various fastening systems had been used to attach the removable upper with soles such as loop and string, clips, bead and recess, and hooks or other means [4-6]. Each particular fastener has particular properties and utilities. Some of these were less comfortable and some were less user friendly. Moreover, some of these were not of enough strength and durability. Recently, several shoes with removable upper have been developed to use in a particular season as indoor footwear [7]. But this type of shoe can't be used regularly in professional or social functions. Even this type of shoe may not be suitable for all seasons.

The objectives of this study were to develop a shoe construction method where the uppers or bottoms can be easily replaced without affecting the strength and comfort along the lasting edge and to provide better cleaning facilities inside of the shoe.

2. Methodology

2.1 Designing of the shoes

A last of 41 size was selected for designing both oxford and derby shoes. Designs of the shoes were drawn on the masked last which is shown in Fig.1. Standard forms were developed by flattening the masking tape and several modifications were carried out to the standard formes for proper fitting and adjustment of the shoe upper to the last. Finally, all the sectional patterns were made for both oxford and derby shoes.

* Corresponding author. Tel.: +88-01717328716
E-mail addresses: limon@le.kuet.ac.bd

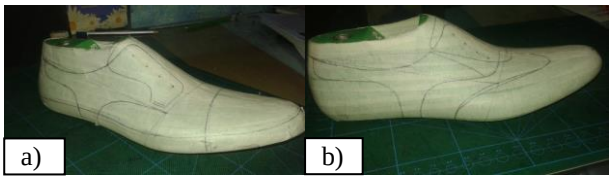

Fig.1 Design of the shoes a) Derby b) Oxford

2.2 Development of the shoes

At first, shoe upper parts were traced and cut by the developed patterns. The cut components were skived and stitched with adjacent parts to develop the complete uppers. When one pair of oxford shoe and another pair of derby shoe uppers were developed, the strips of Velcro hook were secured to the feather edge of the shoe uppers. Initially, the adhesive was used to join leather with Velcro hook and then the double row of stitches was done along the top and bottom edges of the Velcro hook. Several stud and post parts of snap buttons were fixed on the Velcro hook along feather edge according to the location which was predefined in the design stage that is represented in Fig.2(a).

Two strips were cut according to the shape of the pattern from the same leathers and those were used to join the upper feather edge and the bottom part of the shoes. The Velcro loop parts, socket and cap of the snap button were fixed along the top edge of the strips which is shown in Fig.2(b).

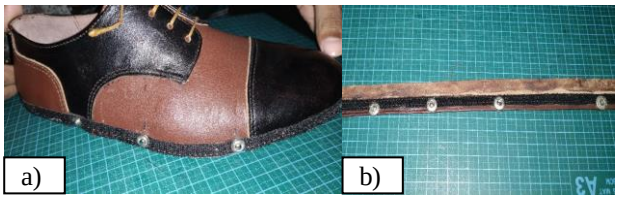

Fig.2 Attachment of fasteners with a) upper b) strip

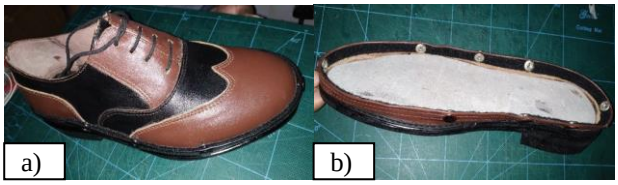

Fig.3 Developed construction method a) Complete shoe, b) Detached bottom

By joining the uppers with the strips with the help of Velcro and snap buttons the bottom edge was lasted with insole board by adhesive. Finally, sole, heel and welt were attached with the lasted insole. Fig.3(a) represents the complete shoe which was made by the new construction method and Fig.3(b) shows the replaceable shoe bottom. Two complete pair of shoes were developed in this construction method where upper of any pair of shoes was possible to replace easily with the upper of another pair of shoes.

2.3 Strength comparison

Proper strength is mandatory along the feather edge to make the shoes usable and long-lasting. To evaluate the strength of the shoe along lasting edge one control sample and two experimental samples were prepared.

The first sample was prepared by overlapping two cut pieces of leather by 12 mm. Centerline of the overlapping area was marked and a seam was given along the centerline whose schematic diagram is shown in Fig.4 and this sample was considered as the control sample. The control sample was prepared to measure the breaking load of the seam by using ASTM D 1683 (American Society for Testing and Materials) method. The applied load on the test specimen was perpendicular to the direction of the seam line. The sample was clamped in between the jaws. Jaw speed was 50 mm/min and it was gradually increased up to the breaking point of the specimen. Load at breaking the joint was noted.

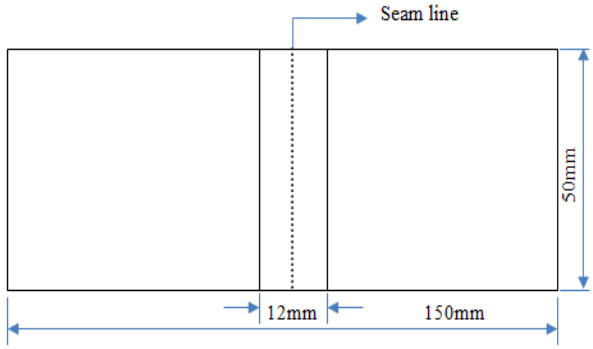

Fig.4 Schematic diagram of specimen for seam breaking load measurement

Two pieces of Velcro (hook and loop) were cut with the dimension of (12mm x 50mm) and hook portion of Velcro was attached with grain side of one leather piece and loop portion was attached with flesh side of another one at the marked region by two parallel sewing. After that, two cut pieces were attached by Velcro that is shown in Fig.5. Then the same methodology was followed for determining the load that was followed for control sample. Load at breaking the joint was noted.

Another experimental sample was prepared similar to the sample of Velcro breaking load measurement. Additionally, a point was marked at the center point of the marked region and a snap button was attached to the marked center point of both leather pieces. After that, two parts were joined by duel fastener (Velcro and snap button) that is shown in Fig.6. Then the breaking load was measured by the same methodology as followed for determining seam breaking load of control sample. Average breaking load for Velcro and snap button was measured from the values of Velcro breaking load and breaking load of Velcro including the snap button. Finally, the average value of the experimental samples was compared with the value of control sample.

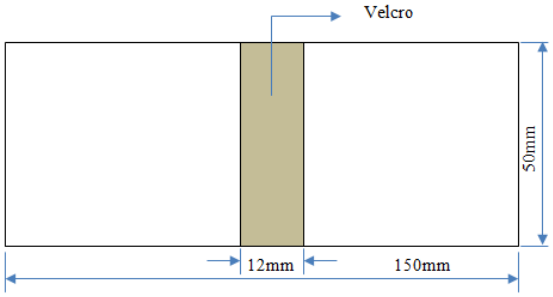

Fig.5 Schematic diagram of specimen for breaking load measurement of Velcro

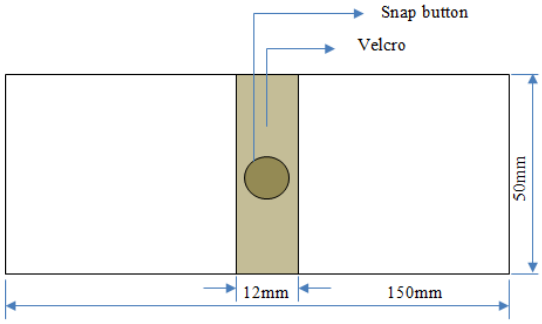

Fig.6 Schematic diagram of specimen for breaking load measurement of Velcro including snap button

2.4 Wear Trial

A male subject was selected for the wear trial of the shoes. Age of the subject was 23, weight 63 kg, height 167 cm and there was no injury to the subject's feet. The shoes were given to the subject to wear and the observation was done very carefully. The feedback from the subject was taken and recorded. Firstly, one pair of oxford shoe upper was assembled with the bottom part by Velcro and snap buttons. Then it was trialled for seven days with each day for 30 minutes. Then the oxford upper was interchanged with a pair of the derby upper and was trialled for seven days. Thus trial for two weeks was carried out one pair of shoe bottom. Then the bottom was replaced with the other pair of the bottom and was trialled for 14 days for two pairs of uppers respectively. Thus trial for four weeks was completed successfully.

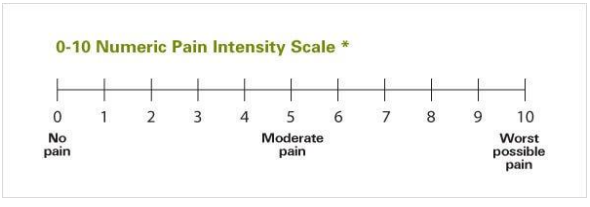

Fig.7 Pain rating scale [8]

The subject was asked to give a pain rating of the shoe every day after trial to determine the comfort level by wearing these shoes and the rating was recorded. The scale which was used to record the rate of pain of the subject's feet was shown in Fig.7.

2.5 Material consumption comparison

Material consumption of cemented derby shoe and the developed shoe was measured by 0^0 of Russ and Small Method (RSM) with the help of graph paper. Each part of the upper of two shoes was traced on graph paper according to the method and the consumption of per pair shoe was calculated. Fig.8 represents the nesting process of the Russ and Small 0^0 method for the only counter pattern. Then the difference of material consumption between the developed shoe and cemented derby shoe with lasting allowance was determined.

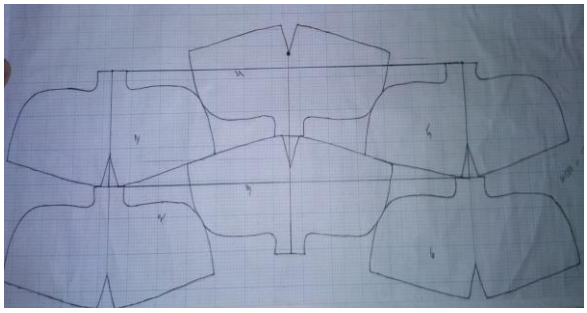

Fig.8 Consumption of counter pattern by Russ and Small 0^0 method

3. Results and discussion

3.1 Strength Comparison

The seam breaking load of the control sample was found to be 90N. The breaking load of only Velcro and Velcro including snap button were respectively 92N and 120N which were higher than the value of control sample that is shown in Fig.9. In the developed shoe construction method snap buttons were used at a specific interval along feather edge. An average value of Velcro and Velcro including snap button breaking load was determined to get the average breaking load along the feather edge. The value was 106N which determines that the strength along the feather edge for the developed shoes is sufficient to use and to make it durable.

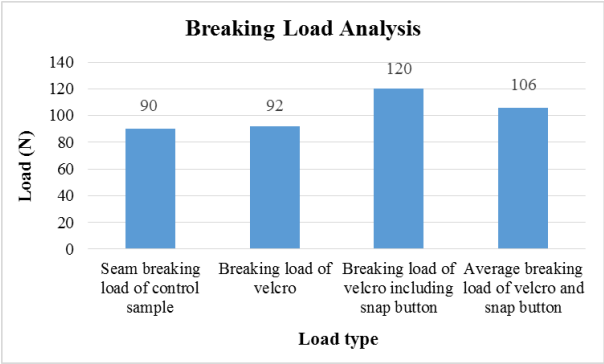

Fig.9 Breaking load analysis

3.2 Wear Trial

The wearer had given a rating of pain which was experienced by him during the daily trial session and a complete overview of rating is illustrated in Table 1. It

was noted that wearer felt less comfortable in the beginning but the comfort property of shoe improved day by day. The rating was taken every day and the ratings were averaged at the end of the week which was done for a total four weeks. Four average values were also averaged and finally, an overall rating was found to be 1.67. This rating is an agreement of shoe comfort with a previous study [9] where the comfort rating was 1.84 for shoes without any special inserts. So according to the comfort rating scale and previous study, it can be said that the developed shoes exhibited good comfort property to the feet of the wearer.

Table 1 Rating Given by Subject.

Day	Week 1	Week 2	Week 3	Week 4
1	3	3	3	2
2	3	2	3	1
3	3	1	2	1
4	2	1	2	1
5	2	1	2	1
6	1	1	1	1
7	1	1	1	1
Average Rating	2.14	1.42	2	1.14
Final Average Rating			1.67	

3.3 Material consumption comparison

Material consumption for each part of two pairs of shoes was measured and the total value of cemented shoe was found to be 1393.47cm^2 and for the developed shoe it was 1519.1cm^2 which is represented in Table 2. The consumption was higher in 125.63cm^2 in case of the developed shoes due to the strip required for the construction method and the strip consumption value was 481.96 cm^2. For one pair of shoes, the total consumption value is higher but when a user will use two or more replaceable upper on the same bottom the consumption value will be less in case of developed shoe than cemented shoe as the lasting allowance will not be required for any of the replaceable upper.

Table 2 Consumption comparison of Derby shoes.

Parts of shoe	Cemented derby shoe (cm^2)	Developed derby shoe (cm^2)
Vamp	588	443.76
Counter	308.2	231.66
Quarter	233.49	243.57
Toecap	263.78	118.15
Strip	0	481.96
Total	1393.47	1519.1

4. Conclusion

Two pair of shoes were developed in the study where the upper was easily replaceable from the bottom with another pair of upper. The strength along the feather edge was sufficient for the construction method that was determined through several tests. Wear trial for four weeks was carried out to justify wear ability and comfort property. The rating provided by the subject was satisfactory for wearing shoes. Similarly, in the case of material consumption, for one pair of the shoe, the consumption was higher but using two or more replaceable upper on the same bottom reduces the material consumption comparatively. Furthermore, the inside of the shoe can be cleaned and bad odor can be removed easily by removing the upper. The strip may also serve as mudguard and increase the aesthetic appeal of footwear. There are also several potential limitations of this study. The possibility of getting a more accurate result of wear trial would be higher if the number of subjects was more. The shoes were made manually and the results might be affected in case of large scale production. Further studies may be carried out by considering these limitations. Despite these limitations, this study provides the solution to the problems related to the maintenance of the inside of shoes and it may be helpful for the industry in developing shoes for the person who wants to alter the shoe style frequently.

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