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Design and Development of Specialised Footwear for Male Hajj Pilgrims

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ABSTRACT

Hajj is the fifth pillar of Islam and is obligatory at least once in a lifetime for Muslims who are physically and financially able to perform it. During the Hajj season, pilgrims undertake extensive walking and repeatedly enter and leave crowded religious spaces, making footwear selection and management an important practical concern. Previous observations indicate that first time pilgrims may experience confusion, loss, or inadvertent exchange of footwear, particularly when entering AL Haram Mosque. This study identifies design criteria for footwear specifically intended for male Hajj pilgrims in accordance with the requirements of ihram and examines how pilgrims manage their footwear when entering the mosque. A mixed methods approach was employed, with qualitative and quantitative data collected from Malaysian male pilgrims in Johor and Selangor who had performed Hajj between 2011 and 2017. Semi structured interviews were used to capture participants' experiences, while pilot testing, face validation, concept development, and usability testing supported the design process. The findings indicate that sandals are the most suitable footwear type, and that portability, ergonomics, durability, adjustability, and ease of storage are important design considerations. The study proposes a compact sandal concept that can be secured and carried into the mosque, thereby reducing the risk of footwear loss and supporting pilgrims during peak periods. The findings provide a practical reference for footwear designers, Tabung Haji, and Hajj travel operators.

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1 INTRODUCTION

Footwear design for Hajj should be treated as a user environment system rather than as a conventional fashion product. Hajj is a physically demanding mass gathering in which pilgrims repeatedly walk between ritual sites and negotiate dense, hot, and unfamiliar environments. Gatrad and Sheikh (2005) identified extensive mobility and crowd related demands as important practical health considerations during the pilgrimage. More recent evidence also demonstrates a substantial burden of musculoskeletal pain and injury during Hajj, particularly in the lower limbs (Alshehri et al., 2021; Alghamdi et al., 2024). These conditions place functional requirements including fit, comfort, stability, protection, and ease of use at the centre of footwear design.

Foot health is especially relevant because repetitive walking, heat exposure, crowd density, and preexisting health conditions can increase the likelihood of discomfort and injury. Clinical observations among Hajj pilgrims have documented blisters, erythema, and other foot injuries (Alfelali et al., 2014), while Sridhar et al. (2015) reported a substantial incidence of foot ailments among pilgrims seeking podiatric care. Recent evidence from Umrah similarly shows that foot problems remain common and that preventive practices are not consistently adopted (Alsaleh et al., 2025). Current Saudi health

guidance therefore continues to emphasise comfortable footwear, foot inspection, hygiene, and avoidance of barefoot walking as practical measures to reduce walking related injuries (Ministry of Health, Saudi Arabia, 2026).

For male pilgrims, the problem is not limited to walking performance. Footwear must also accommodate repeated transitions between movement, ritual activities, and mosque entry, where footwear may need to be removed and managed quickly in crowded settings. The present study further operates within an ihram specific design brief that favours an open sandal configuration for male users. Rather than undertaking a comparative jurisprudential analysis, this paper treats the religious requirement as a contextual design constraint and focuses on its implications for product form, usability, portability, and user comfort.

The broader footwear literature provides useful evidence for translating these contextual constraints into product requirements. Incorrectly fitted footwear is associated with foot pain and foot disorders, and mismatch between footwear dimensions and users' feet is widespread (Buldt & Menz, 2018). Studies of supportive footwear further indicate that stability, secure fixation, comfort, fit, and ease of putting footwear on and taking it off are important to both functional performance and user acceptance (Menz et al., 2017; Azhar et al., 2023; Kim & Hegazy, 2024). These findings are consistent with user centred product design approaches in which anthropometric characteristics and users' real task environments inform design decisions (Chen et al., 2026).

However, the relevant bodies of literature remain fragmented. Hajj health studies primarily document injury and physical burden, while general footwear studies focus on fit, comfort, balance, or clinical populations. Comparatively little design research integrates these concerns with the operational requirement to remove, retain, carry, and rapidly rewear personal footwear in the Al Haram context. The design opportunity is therefore not simply to produce another sandal, but to reconcile prolonged walking, user variability, ritual constraints, portability, and footwear management within one coherent product system.

Accordingly, this study frames male Hajj footwear as a context specific user centred design problem. The investigation uses the experiences of previous Malaysian male pilgrims to identify the most relevant functional and usability criteria, translate them into concept directions, and evaluate the practicality of proposed footwear features. This approach positions users lived experience as evidence for design decision making rather than treating comfort, portability, and footwear management as secondary product attributes.

The study therefore aims (1) to identify the type and design criteria of footwear suitable for male Hajj pilgrims, (2) to examine how male pilgrims manage their footwear when entering Al Haram Mosque, and (3) to translate the resulting requirements into a footwear concept that supports walking, rapid removal, secure carriage, and reuse during the Hajj journey.

2 LITERATURE REVIEW

The literature relevant to male Hajj footwear spans mass gathering health, foot health risk, footwear ergonomics, user acceptance, and context specific footwear management. These evidence streams need to be considered together because the design problem is not adequately explained by any single domain. Accordingly, this review links evidence on the physical demands of pilgrimage and lower limb injury with evidence on footwear fit, stability, comfort, adjustability, and the practical requirements for rapid removal, secure carriage, and rewearing in crowded sacred spaces.

The review is organised around five linked themes. First, the Hajj environment establishes the mobility and health burden. Second, footwear research identifies the design characteristics associated with fit, comfort, stability, and acceptance. Third, clinical footwear studies demonstrate why adjustability is important for users whose foot dimensions or symptoms vary. Fourth, the Hajj context

introduces operational requirements for removal, carriage, and rapid reuse. Finally, these strands are integrated into a specific research gap and set of design requirements.

2.1 Hajj Mobility, Environmental Exposure and Foot Health Risk

Hajj places unusual cumulative demands on the lower limbs because pilgrims perform repeated walking and standing activities within a dense mass gathering environment. Gatrad and Sheikh (2005) described the pilgrimage as physically demanding and requiring careful health preparation. In a large cross-sectional study, Alshehri et al. (2021) reported a high prevalence of musculoskeletal pain among pilgrims, with the ankle and foot among commonly affected sites. Alghamdi et al. (2024) likewise identified musculoskeletal injuries during the 2023 Hajj season, reinforcing the need to treat mobility and lower limb protection as central design concerns rather than peripheral comfort issues.

Foot specific evidence strengthens this requirement. Alfelali et al. (2014) observed clinically relevant foot injuries among Hajj pilgrims, including blisters and erythema, and emphasised the importance of appropriately fitting protective footwear. Sridhar et al. (2015) similarly documented foot ailments during Hajj, showing that foot problems can become clinically significant during the pilgrimage. In a more recent Umrah study, Alsaleh et al. (2025) reported a substantial prevalence of foot diseases and injuries, with sprains and strains among the most common problems.

These findings imply that a Hajj sandal should not be evaluated solely by visual form or compliance with a ritual dress brief. It must function as a protective interface between the user and the walking environment. Current Saudi Ministry of Health advice remains consistent with this interpretation, recommending comfortable footwear, regular foot inspection, proper hygiene, and avoidance of barefoot walking to reduce injury risk during Hajj (Ministry of Health, Saudi Arabia, 2026). From a design perspective, therefore, comfort, fit, traction, protection, and moisture management are safety related requirements with direct implications for continued mobility.

2.2 Footwear Fit, Comfort, Stability and User Acceptance

Footwear fit is one of the strongest recurring themes in the wider evidence base. Buldt and Menz (2018), in a systematic search and narrative review, found that incorrect footwear fit was common and associated with foot pain and several foot disorders. Their synthesis indicates that footwear dimensions must accommodate both foot length and width, which is particularly important in products intended for extended walking and diverse users.

Safety and comfort also depend on how the footwear is fixed to the foot and how the sole interacts with the walking surface. Kim and Hegazy (2024) reviewed footwear design features relevant to fall prevention and highlighted the importance of fit, fixation, sole characteristics, and slip resistance. Experimental work by Azhar et al. (2023) found that users' perceptions of stability, comfort, aesthetics, and ease of putting footwear on and taking it off shaped preference even when objective balance performance did not differ substantially between footwear conditions. This distinction is important: technical performance alone does not guarantee adoption if the product is inconvenient or uncomfortable.

A similar pattern was reported by Menz et al. (2017), whose prototype footwear demonstrated selected balance benefits but required further development to improve comfort, appearance, fit, and ease of use. Within design research, Chen et al. (2026) likewise argue for user specific and anthropometrically informed design decisions to reduce ergonomic risk. Although their application concerned customised kitchen environments, the underlying principle is directly transferable to footwear: product dimensions and interaction features should respond to users' bodily characteristics, tasks, and contexts of use rather than relying only on standardised assumptions.

2.3 Foot Morphology, Health Conditions and the Need for Adjustability

Adjustability becomes particularly important when foot dimensions or comfort requirements change. Rome et al. (2011) found that people with gout often used footwear with poor characteristics and that footwear choice was influenced by comfort, fit, and disease related limitations. Their findings indicate that users with painful or swollen feet may have difficulty tolerating fixed footwear dimensions. Frecklington et al. (2019) expanded this issue qualitatively, identifying comfort as a priority among people with gout and showing that flares, tophi, and differing environmental contexts constrain footwear choice. For Hajj oriented product development, these findings do not imply that all pilgrims have gout; rather, they demonstrate a broader design principle: a fixed upper can become unsuitable when foot volume, sensitivity, or comfort needs vary. An adjustable upper or fastening system can therefore increase accommodation across users and across changing physical conditions during prolonged activity.

2.4 Ritual and Operational Constraints for Footwear Management

The Hajj footwear problem also has an operational dimension. Pilgrims repeatedly transition between walking and prayer related spaces, and footwear may need to be removed, stored, carried, and reworn under time and crowd pressure. The study context therefore requires more than a comfortable sandal: the pair should remain easy to identify, remain together during carriage, avoid contaminating personal belongings, and be compact enough not to create an additional burden.

This operational requirement introduces a design tension. A sandal that is highly structured may improve support but become bulky to carry, whereas a very flexible sandal may be easier to pack but offer insufficient fixation or stability. The design task is therefore to balance portability with secure foot retention, durability, comfort, and rapid donning and doffing. This trade off supports an integrated product architecture in which the same upper or fastening components can contribute both to wearing the sandal and to securing the pair when it is carried.

2.5 Research Gap and Design Requirements

Taken together, the literature reveals a clear but under integrated design space. Hajj and Umrah studies document lower limb pain, foot injuries, and the consequences of prolonged walking (Alfelali et al., 2014; Sridhar et al., 2015; Alshehri et al., 2021; Alghamdi et al., 2024; Alsaleh et al., 2025). Footwear research establishes the importance of correct fit, fixation, stability, comfort, adjustability, and ease of use (Rome et al., 2011; Menz et al., 2017; Buldt & Menz, 2018; Frecklington et al., 2019; Azhar et al., 2023; Kim & Hegazy, 2024). However, these evidence streams rarely converge on the specific task of designing a portable male Hajj sandal that also supports footwear management at Al Haram Mosque.

The research gap is therefore defined as the absence of an integrated, user centred footwear design response that combines (a) walking related foot protection and comfort, (b) accommodation of user variability through adjustable fit, (c) ease of removal and rewearing, (d) compact and secure pair retention during mosque entry, and (e) the study's male ihram design constraint. These requirements provide a stronger theoretical basis for the subsequent interviews, concept generation, prototype development, and usability evaluation.

Table 1 converts the literature into an explicit design rationale. The resulting criteria are not treated as predetermined product specifications; instead, they establish sensitising design requirements that are examined against the experiences of the study participants in the subsequent mixed methods investigation.

Table 1 Literature synthesis and design implications for male Hajj footwear

Theme	Evidence base	Design implication
Foot health risk during pilgrimage	Hajj/Umrah studies document blisters, erythema, sprains/strains and substantial musculoskeletal or foot complaints under prolonged walking and crowd exposure (Alfelali et al., 2014; Sridhar et al., 2015; Alshehri et al., 2021; Alghamdi et al., 2024; Alsaleh et al., 2025).	Prioritise fit, protection, comfort and secure footing for prolonged walking.
Fit and dimensional accommodation	Incorrectly fitted footwear is common and is associated with foot pain and foot disorders (Buldt & Menz, 2018).	Provide adequate length/width accommodation and avoid a restrictive forefoot.
Stability and secure fixation	Footwear features such as fit, fixation and sole properties influence safety and perceived stability (Azhar et al., 2023; Kim & Hegazy, 2024).	Use secure but simple fixation and a stable, slip resistant sole configuration.
Comfort and user acceptance	Functional benefit does not ensure adoption; comfort, fit, aesthetics and ease of donning/doffing influence user acceptance (Menz et al., 2017; Chen et al., 2026).	Treat comfort and ease of use as core performance requirements.
Variable foot condition	Gout related flares and foot changes can restrict footwear fit and reduce activity participation (Rome et al., 2011; Frecklington et al., 2019).	Incorporate an adjustable upper or fastening system to accommodate variation.
Hajj specific operational use	Pilgrimage involves extensive mobility, while current health guidance continues to emphasise comfortable footwear and avoidance of barefoot walking (Gatrad & Sheikh, 2005; Ministry of Health, Saudi Arabia, 2026).	Support rapid removal, compact carriage, pair retention and easy rewearing

(Source: Authors' synthesis, 2026)

3 METHOD

This study employed a mixed methods design to investigate the requirements for footwear specifically intended for male Hajj pilgrims. The method covered research design, participant selection, data collection, interview procedures, concept development, usability testing, and data analysis. The overall process is illustrated in Figure 1.

Stage 1 involved a review of literature related to footwear, Hajj activities, religious requirements, and issues experienced by male pilgrims. Existing footwear designs and user behaviour in Mecca were also reviewed to identify the research gap and establish the basis for participant selection and method development. A pilot test was subsequently proposed to assess reliability and to support validation of the data collection process. The findings from Stage 1 informed concept generation and the development of footwear design criteria. Usability feedback was then used to refine the concept towards a final prototype intended to support the secure storage and carrying of sandals when entering Al Haram Mosque.

The study used qualitative and quantitative components within a mixed methods approach, drawing on the methodological principles described by Creswell and Plano Clark (2007). The methodology was weighted towards qualitative evidence (70%) to capture pilgrims' experiences and contextual requirements, with a smaller quantitative component (30%) used to support structured comparison and concept evaluation.

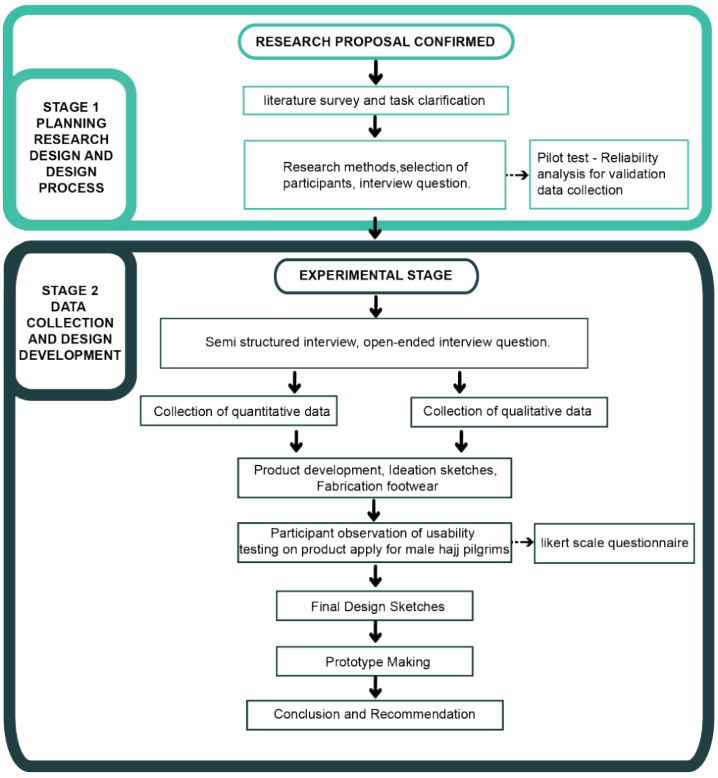


Figure 1 Research design and study process

The mixed methods approach was selected because the research questions addressed both user experience and design requirements. Attention was given to previous male pilgrims' experiences in Mecca, the activities and environmental conditions that affect footwear selection, and the ways pilgrims keep their footwear when entering mosque areas. The requirements of ihram for male pilgrims were also considered throughout the design process. Interview transcripts and open-ended responses were organised together with relevant literature to support interpretation of the findings.

Participants were Malaysian male pilgrims from Johor and Selangor who had performed Hajj during the six-year period from 2011 to 2017. The study focused on their previous experiences in Mecca to develop a clearer understanding of Hajj activities, footwear related issues, and practical requirements that might not be fully captured through literature alone.

Participants were recruited in Johor and Selangor based on their availability and willingness to share their knowledge and experience. Data were collected through direct personal interviews with male Hajj pilgrims. The interviews also allowed the researcher to clarify responses and compare recurring issues across participants. A semi structured format was used to encourage participants to respond naturally and to describe their experiences in greater depth.

The interview questions were developed from the research questions. Participant responses were recorded in written form by transferring oral information into text so that important details were not omitted. The findings were subsequently organised into graphical and visual presentations to support clear communication of the data.

A pilot test involving five male Hajj pilgrims was proposed to examine the reliability of the usability testing questions and the measurement scale. In addition, face validity was conducted with three male Hajj pilgrims to ensure that the interview questions were understandable and could be answered within the allocated time.

Male Hajj pilgrims were selected because the study specifically addressed footwear for men and the requirements governing male attire during ihram. Semi structured interviews provided a basis for

clarifying the problem while allowing participants to share their own knowledge and experiences. Participant information was treated as confidential and used only for the purposes of the study.

The interview questions were directly linked to the research questions. Preliminary research was used to define the research objectives, identify key terms, and refine the research questions before the interview instrument was prepared. This process helped maintain alignment between the research problem, the questions posed to participants, and the information required for design development.

The interview component involved 30 respondents from Johor and Selangor who had performed Hajj between 2011 and 2017. Formal permission for data collection was supported by a university research letter. The responses were reviewed and evaluated in relation to the research questions and subsequently used to inform the design development process.

4 RESULTS AND FINDINGS

Qualitative and quantitative data were organised to support analysis of the footwear requirements identified by participants. Interview responses were transcribed from oral to written form and managed together with the questionnaire data. Microsoft Excel was used to organise and tabulate the findings. This process helped narrow the scope of the study and identify criteria relevant to the design of specific footwear for male Hajj pilgrims.

The interview instrument comprised three main sections. The first consisted of open-ended questions addressing participants' perceptions and experiences, including the type of footwear considered suitable for male Hajj pilgrims and the way footwear is managed when entering Al Haram Mosque. The findings were then used to support the identification of design requirements.

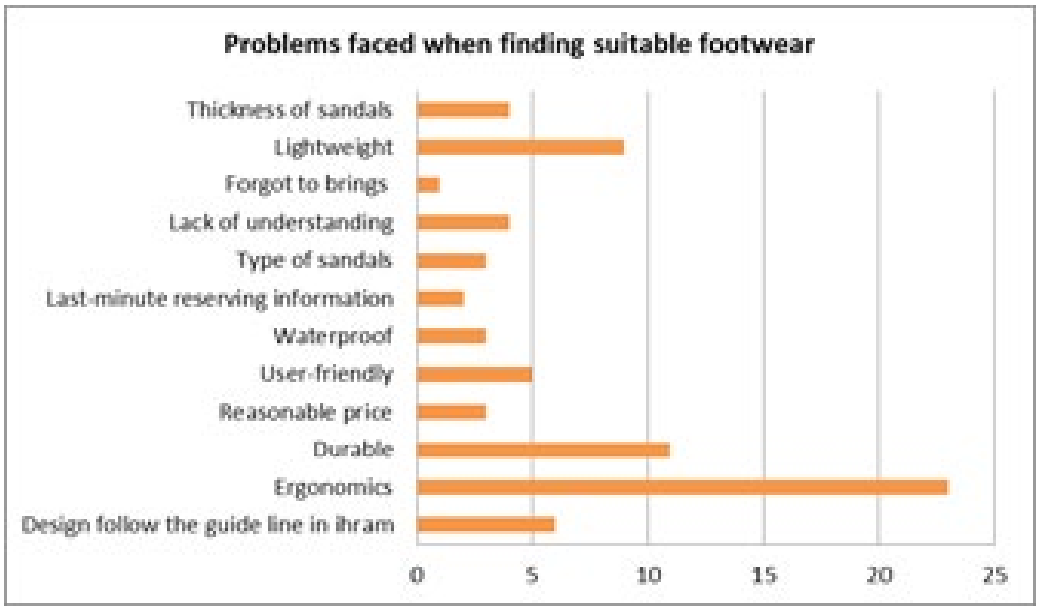


Figure 2 Frequently encountered problems when finding suitable footwear

Figure 2 summarises footwear related problems identified by respondents. The strongest emphasis is associated with ergonomic suitability, followed by durability and lightweight characteristics, while additional concerns include sandal thickness, forgetting to bring footwear, limited understanding, sandal type, lastminute information, waterproofing, user friendliness, reasonable price, and compliance with the guideline for ihram. Beyond these footwear characteristics, interview responses also indicated that pilgrims routinely manage several personal items when travelling to the mosque, particularly identity documents and footwear bags. Participants explained that identification items are kept with them throughout the Hajj season, while shoe bags are commonly used to carry sandals into prayer areas because pilgrims are concerned about losing footwear left on racks or in storage areas. Smartphones

and prayer mats were also carried depending on the situation and individual needs.

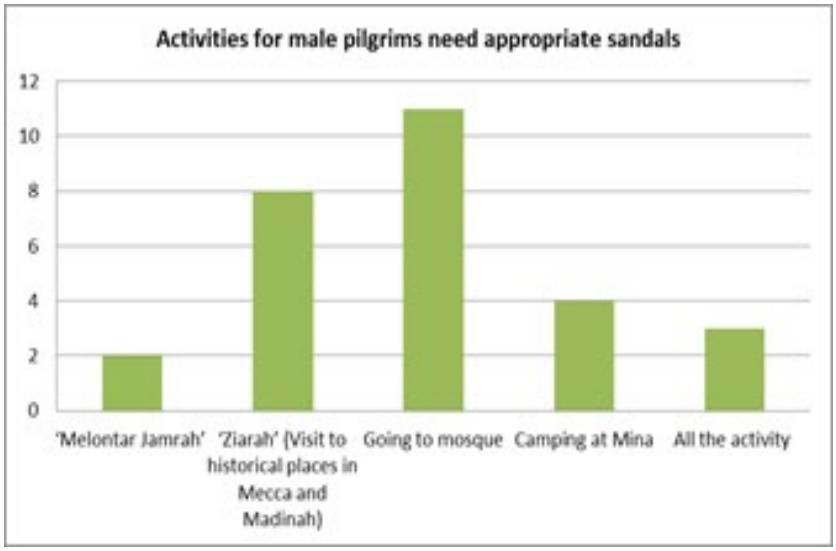


Figure 3 Activities for which male pilgrims require appropriate sandals

Figure 3 shows the activities for which respondents considered appropriate sandals necessary. Going to the mosque was the most frequently identified activity, followed by *ziarah* or visits to historical and religious sites. Respondents explained that mosque visits occur repeatedly throughout the day and therefore place continuous demands on footwear. Ziarah similarly involves walking and repeated entry into prayer spaces. Camping in Mina and other Hajj activities also require footwear that can be worn across different conditions. Participants noted that closed shoes can complicate wudhu and that, in Mina, pilgrims may rely on the same sandals for a wider range of daily activities, with an additional pair carried as an emergency option.

4.1 Design Development, Fabrication and Product Testing

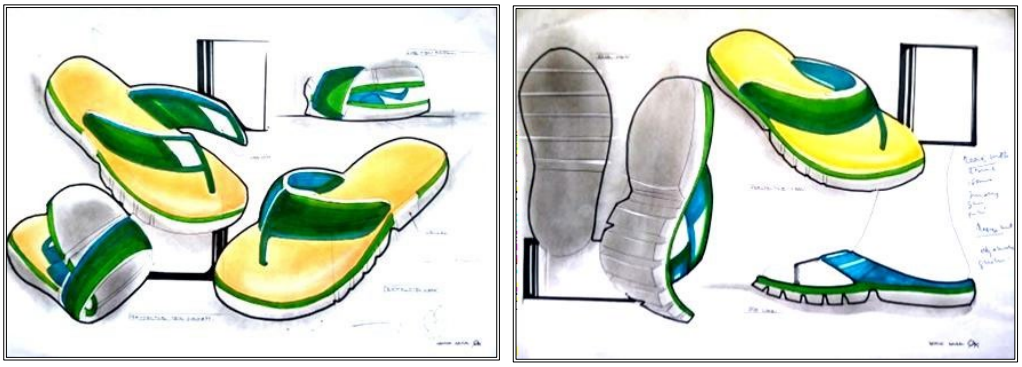


Figure 4 Concept generation 1

The findings indicated that sandals are the most suitable footwear type for male Hajj pilgrims. A portable sandal concept was therefore developed to facilitate footwear management when entering mosque areas during peak periods. The initial concept was explored through ideation sketches based on the form and structure of conventional sandals.

The first concept allows the sandal to be folded into a more compact form for storage and carrying. The upper was designed with asymmetrical lengths so that the two sections overlap and can be secured using Velcro. A single structure between the insole and upper reinforces the sandal and joins the components near the toe area.

The upper was designed with a fixed connection to the main structure according to the footwear mould, while material use was minimised in relation to the intended function. Velcro was positioned on

the upper to allow the two sections to overlap and lock. Additional fastening at the side of the midsole supports compact folding, while air spaces in the outsole are intended to improve flexibility and allow the sandal to adapt to uneven surfaces.

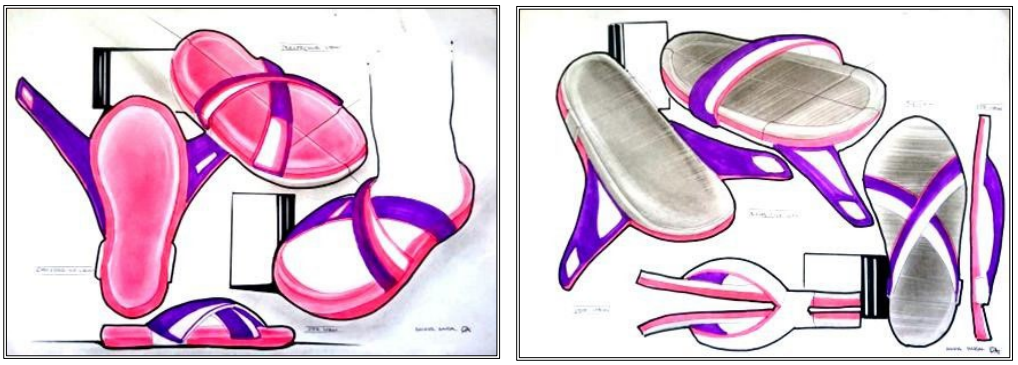


Figure 5 Concept generation 2

The second design direction was developed from specific issues identified in the interviews. Rather than fixing the upper to one configuration, the concept uses an open and adjustable arrangement that allows users to modify fit according to their comfort requirements.

Interview findings indicated that some male pilgrims experience foot related conditions such as gout. During a flareup, changes in foot size may make standard sandals feel tight and uncomfortable, which can make walking more difficult. This finding highlighted the need for adjustability in the upper section of the footwear.

The proposed concept therefore incorporates an adjustable upper that can be modified according to user preference. For storage and carrying, the two outsole surfaces can be brought together and the upper straps used as a locking system to secure the pair of sandals.

4.1.1 Usability Testing

Think aloud protocols were selected because they are widely used in usability testing to capture users' immediate responses while interacting with a product. Two common approaches are Concurrent Think Aloud (CTA) and Retrospective Think Aloud (RTA). In CTA, participants verbalise their thoughts while completing a task, although the evaluator may need to remind them to continue speaking. The emphasis is placed on what is occurring during the interaction rather than on requiring participants to explain every reason behind an action.

RTA differs by asking participants to complete the task without verbalising their thoughts while the interaction is recorded. After task completion, participants review the recording and comment retrospectively on their experience. This approach can provide additional insight into users' reasoning, intentions, and strategies. The two approaches were considered in relation to the practical evaluation of the proposed footwear concepts.

Two respondents representing the target user group participated in the usability test. Two potential concepts were evaluated to identify user preference and the practicality of the proposed design features. The questionnaire results are summarised in Figure 6.

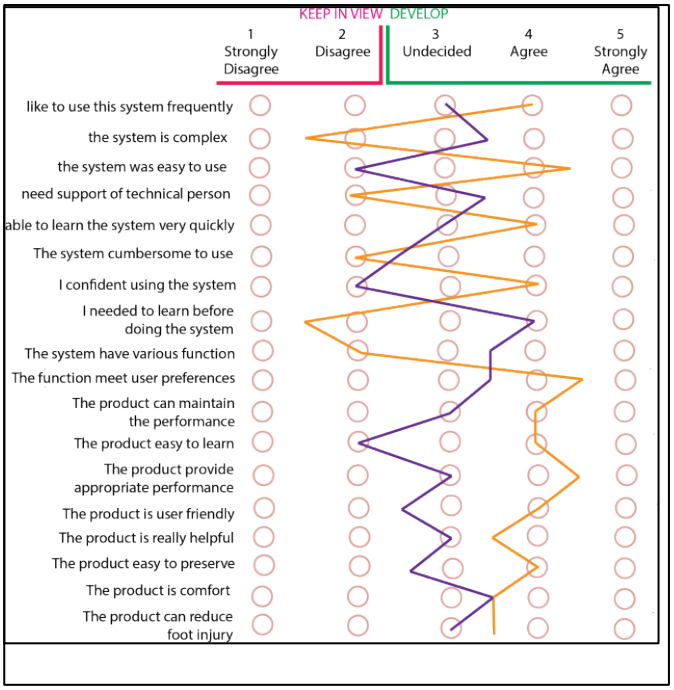


Figure 6 System analysis from the questionnaire survey

5 DISCUSSION

5.1 Product Analysis in Relation to Design Factors

From a usability perspective, the design emphasises ergonomics and material suitability. Polyvinyl chloride (PVC) fabric was proposed for the upper and as a laminate for the insole because the sandals are expected to encounter water and dust during Hajj activities. The material was selected for its water resistance and flexibility, characteristics considered appropriate for the intended use environment.

From an aesthetic perspective, the proposed colour scheme combines dark blue and light brown. The two-colour combination differentiates the product from conventional Hajj footwear. Light brown was selected to create a neutral appearance and to make visible dirt or impurities easier to notice, while dark blue was used to communicate a more masculine visual character consistent with the product's intended male user group.

From a technical and functional perspective, the design addresses the problem of keeping sandals secure when entering mosque areas, especially during peak periods. Simple fastening features are intended to make the product easy to understand and quick to operate. The adjustable and compact configuration also supports use by pilgrims across different ages and varying foot conditions, contributing to a more user-friendly footwear solution.

CONCLUSIONS

This study explored the experiences of male Hajj pilgrims to identify requirements for sandals suitable for use during the Hajj season. The findings indicate that footwear management at Al Haram Mosque is influenced not only by the sandals themselves, but also by the unique circulation and prayer environment surrounding the centrally located Ka'bah. Because pilgrims approach and face the Ka'bah from surrounding areas, movement through mosque entrances and exits can differ from that of conventional mosque layouts.

Participants reported that they may enter Al Haram Mosque through the entrance nearest to their accommodation and place sandals on a shoe rack. During crowded periods, however, circulation control may prevent them from returning through the same entrance, requiring additional movement to retrieve

footwear. This increases the practical burden of leaving sandals at a fixed storage point.

The large number of pilgrims also contributes to footwear displacement and confusion. Sandals may fall from racks when many pairs are stored together, after which cleaning staff may collect and relocate them. Identifying a particular pair can then become difficult because of similarities in colour, size, and brand.

Pilgrims are therefore commonly advised to carry an additional bag for their sandals. Based on the analysis of existing footwear and the user findings, this study proposes an incremental design solution in which male Hajj sandals can be compacted, secured as a pair, and carried more efficiently into mosque areas. The proposed concept integrates practical storage with ergonomic, material, aesthetic, and ihram related design considerations.

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AUTHOR CONTRIBUTIONS

All authors played equal roles in this research.

CONFLICT OF INTEREST

No conflict of interest was involved.

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