Consideration to the Uniformity and Effects of the Fabric in the Shroud of Turin.

by

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Technical Design

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This is an interim report requested by Pam Moon, a researcher on the Shroud of Turin.

Using photographic images found on the Oxford University website, this report examines the uniformity and effects within a small sample taken from the Shroud of Turin.

Permission has been given by Professor Ramsey at Oxford University to use these images for this report.

https://archdams.arch.ox.ac.uk/?c=1203&k=1bcdc90a8b

Summary

This analysis of the Turin Shroud fabric sample has been approached independent of any outside influences or research. I have used the images of the fabric sample at the above website as a source of information to be considered and documented as I see it. With no preconceived ideas, my interpretation of the Shroud sample is drawn from my expertise in the design of linen fabric and the technical application of the woven architecture. The ideal analysis could only be done on the actual fabric sample.

The report gives consideration to:

- The uniformity in construction of the fabric through analysis of the weave.
- The weave as a contributing factor in understanding the marks on the Shroud.
- The significance in the staining and the corresponding irregularities in the sample.

The report directs further research in the understanding of the fabric's influence on the image and the aesthetics of the Shroud of Turin.

Contents

Glossary of Technical Terms

End: A warp thread.

Interlacement: When one warp thread crosses over a weft thread or visa versa.

Pick: A weft thread.

Stitch on the bias of the fabric: a stitch at 45 degrees to the warp and weft threads

Warp: The threads (ends) running along the length (of the fabric) on the loom. The warp threads are interlaced with weft (picks) to form the woven fabric.

Warp density: The number of warp threads in 1 cm.

Warp faced: A larger percentage of the warp is exposed to the surface of the fabric.

Weft: The threads (picks) that interlace the warp threads at right angles to produce the woven fabric.

Weft density: The number of weft threads in 1 cm.

Weft faced: A larger percentage of the weft is exposed to the surface of the fabric.

Weave: Woven fabrics made with interlacing warp and weft threads.

Tension: Tightness.

Weave architecture: The type of weave construction ie 3,1 twill

Introduction

This interim report is on an analysis based solely on photographs taken of a small sample of the Shroud of Turin found on the Oxford University website.
https://archdams.arch.ox.ac.uk/?c=1203&k=1bcdc90a8b

The aim is to consider the fabric sample's uniformity and effects.

Due to the way that the fabric is skewed, its orientation and the uncertainty of the unit measurement that has been applied to the images, this interim report is a superficial analysis and cannot be assumed as accurate.

Analysis

The images in this report present as variations of the following

- 3,1 herringbone twill, warp face side of the Shroud sample.
- 3,1 herringbone twill, weft face side of the Shroud sample.
- Two plain weave, control samples.

(To help the reader source the image on the Oxford University website, the original website image reference is also quoted.)

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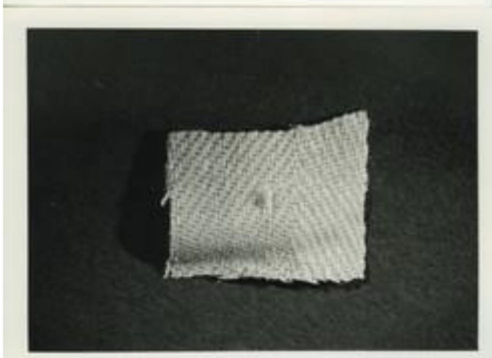

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Fig. 1: Shows the detail of the warp face side of the 3,1 herringbone twill sample taken from the Shroud of Turin. (Original website image ref p2575_8)
Fig. 2: Also shows the warp face of the 3.1 herringbone twill. (Original website image ref: p2575_8)

The 3,1 herringbone weave of the Turin Shroud is not a complex construction (Fig 1 and 2). A contributory unit repeat presents itself as a 3,1 twill. However the complete weave unit of the herringbone is not included within the sample. Therefore it is not possible to assess the uniformity of the entire herringbone weave structure. As a result, some of the findings will be based on the 3,1 twill unit.

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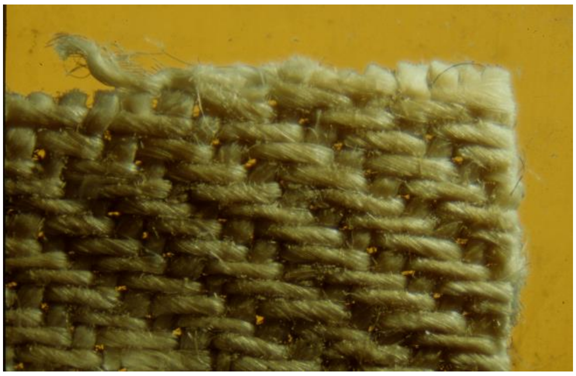

Fig 3: Detail of the shroud weave located at the edge of the sample. (Original website image ref: 4.17)

Figures 3 and 4 show a location at the edge of the cut Shroud sample, there is a definite change in the proportions of the weave repeat. Due to the collapse of the yarns at the cut edge, the tension of the fabric construction slackens. This has an influence on the stability of the fabric at this point and transfers its effects to the conformity of the weave as illustrated below.

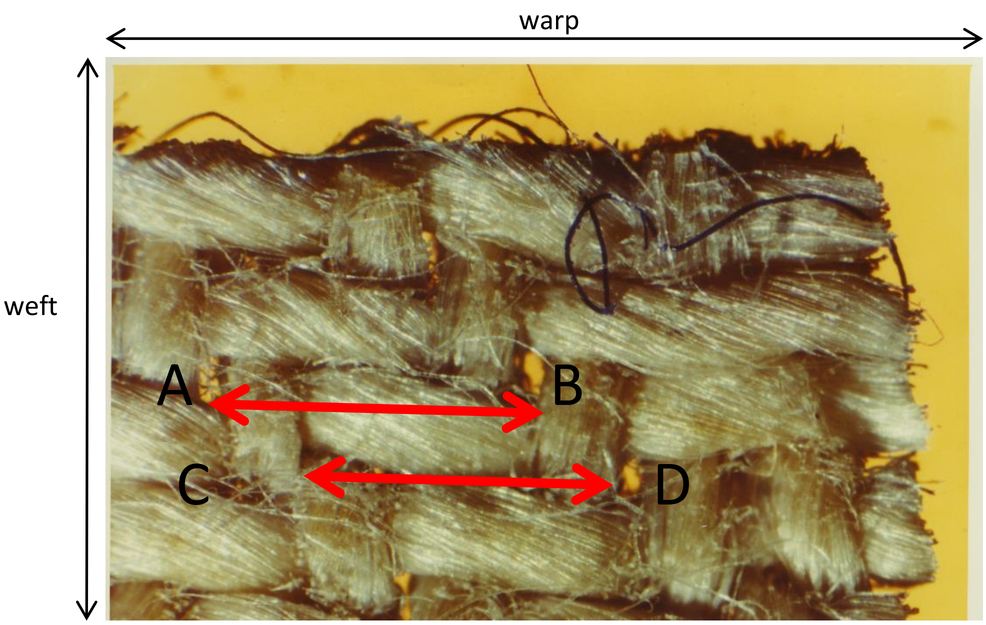

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Fig 4: Warp faced Shroud sample showing a close up view of the effects of the weave collapsing at the cut edge. (Original website image ref: 2575_2)

In Figure 4, the interlacement of the weave between areas A and B show the effects of the weave collapsing at the cut edge. This has an impact on the tension of the fabric and has a noticeable shift or movement in the interlacement of the weave. There is a noticeable gap between the designated areas A and B. Area A is tighter than that of area B. Subsequently, areas C and D are effected in the same way. Within the localised area, this movement of structure will have inevitably distorted any original markings or stains on the cloth.

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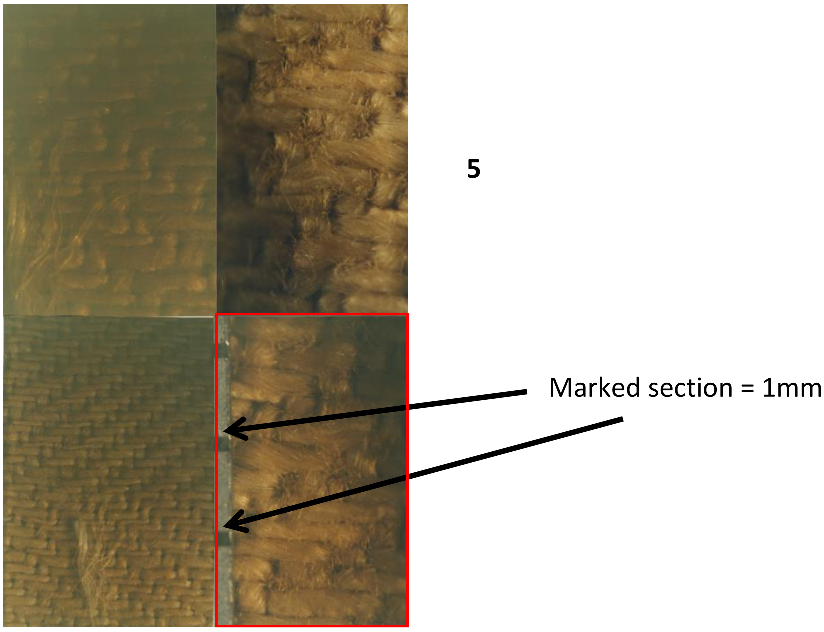

Fig. 5: This image illustrates detailed sections of the warp faced side of the Shroud's 3,1 herringbone twill. Within the red highlighted area, the marked section is assumed to measure 1mm. (Original website image ref: p2575_5)

In Figure 5, the image illustrates detailed sections of the Shroud's 3,1 herringbone twill. Based on the assumption that each marked section is 1mm. Four warp yarns (which is the repeat of the 3,1 twill) measure 1mm. Resulting in 40 warp yarns in 1 cm. Using the same marked section, 3 weft yarns measure 1mm. Resulting in 30 weft threads in 1 cm. Within 1cm^2 there are approximately 70 warp and weft yarns. This warp and weft density gives a high quality of fabric that would conform to the detailed marking on the Turin Shroud.

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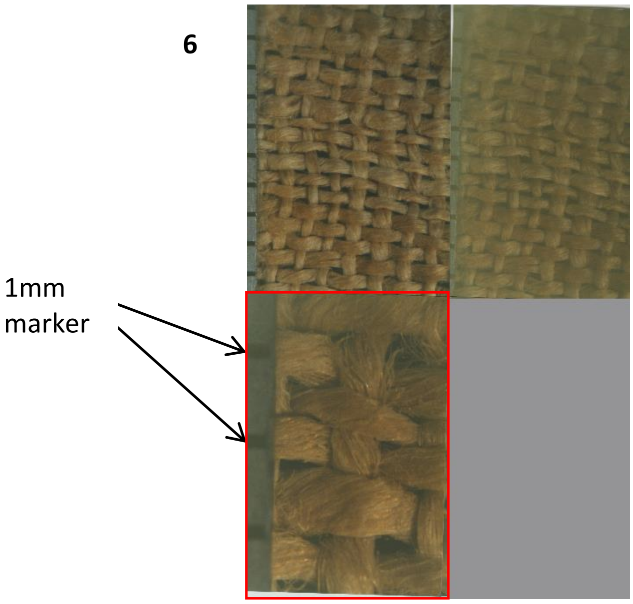

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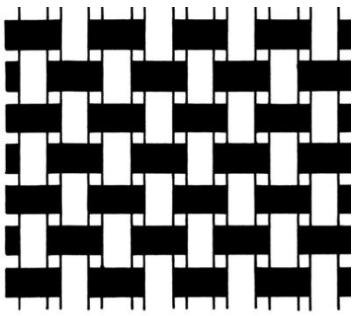

Fig. 6: Detailed sections of a control sample with a unit measure of 1mm. Within the red highlighted, the markers are assumed to be 1mm. (Original website image ref: p2574_9)
Fig 7: An illustration of a plain weave construction with optimum interlacement.

In comparison to the Turin Shroud fabric sample, the control sample (Fig. 6), is a different weave. It is a basic plain weave construction with optimum interlacement (Fig. 7). Using the markers as 1mm, there are 20 warp and 15 weft yarns per cm (Fig. 6). Resulting in 35 yarns per 1cm^2. This is half of density of the 3,1 herringbone in the Shroud sample (Fig. 5).

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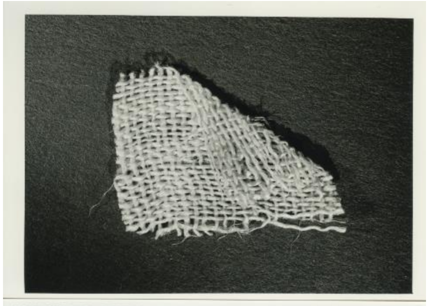

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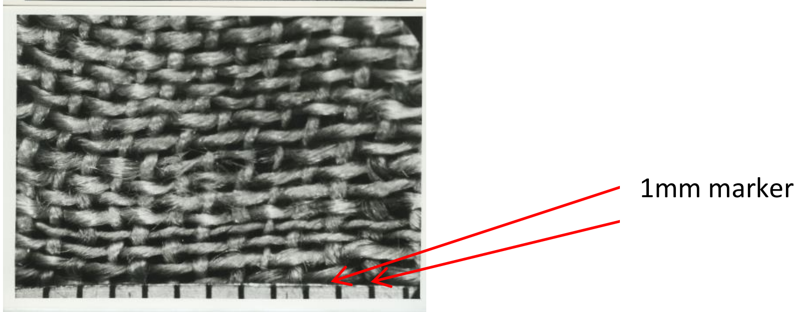

Fig. 8: A control sample with a plain weave construction. (Original website image ref: p2576_5)
Fig 9: A close up view of same control sample with assumed 1mm marker. (Original website image ref: p2576_5)

Above are the images of another control sample (Fig: 8 and 9). This control sample has the same plain weave construction as the control fabric illustrated in Figure 6. However, the warp density is 20 yarns per cm but the weft density has only 10 yarns per cm. Resulting in 30 yarns per 1cm². With such a low weft density the fabric will be unstable.

The plain weave fabric in both control samples could not retain the same amount of surface detail that marked the fine herringbone weave of the Shroud (Fig. 6 and 9).

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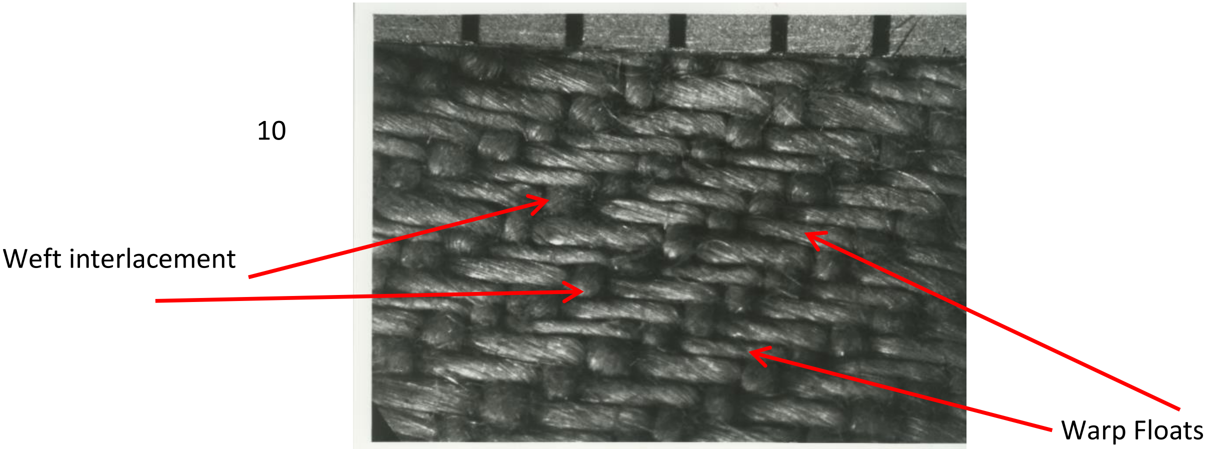

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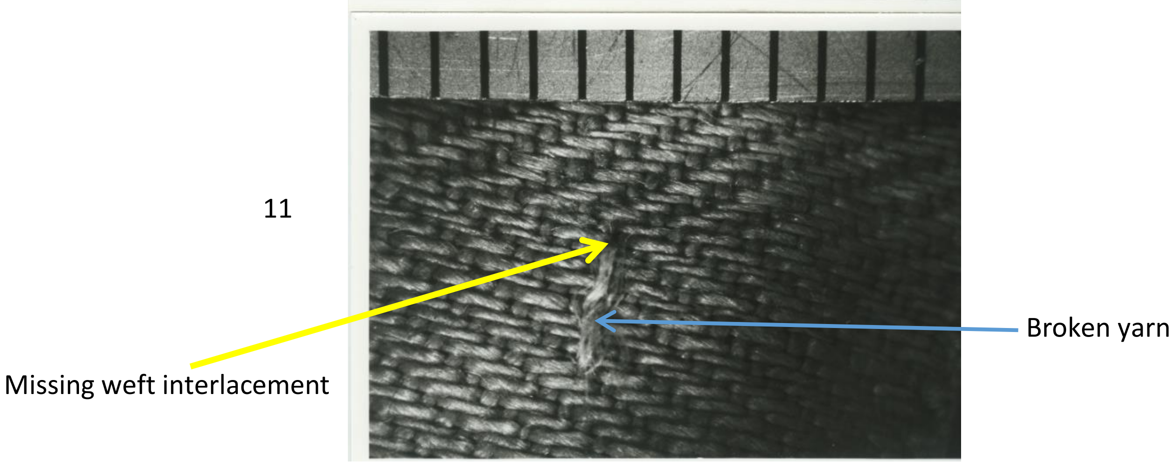

Fig 10: Showing a close up view of the warp faced side of the Shroud samples 3,1 herringbone twill. The red arrows indicate the warp floats and the weft interlacement. (Original website image ref: 2575_6)
Fig 11: Shows an area closer to the point of the twill on the warp faced side of the Shroud sample. The yellow arrow indicates the missing weft interlacement. The blue arrows shows the broken yarn. (Original website image ref: 2575_6)

Figure 11 shows an area closer to the point of the herringbone. This region reveals that the weave is more uniform and the tension appears to be less effected by the collapsing yarns at the cut edge. The warp yarn thickness is irregular. This is a trait of linen yarn that reveals natural variations within its fibres. In Figure 10, the repeat is constant.

The dominant warp float of the 3,1 herringbone covers 3 weft yarns. This 3,1 migration is fairly uniform throughout the sample (Fig. 10 and 11) but varies in length due to irregularities within the tension of the fabric. This is explained in more detail later (Fig 15).

From what is visible in Figure 11, the broken thread suggests that it may be a weft yarn. Notice the weft interlacement is missing. The effects of the break on the weave may lie under the protruding yarn and will have caused some defect on the reverse side of the fabric. Within this sample of the Shroud, the exposed broken yarn could reveal other clues to the fabric's composition.

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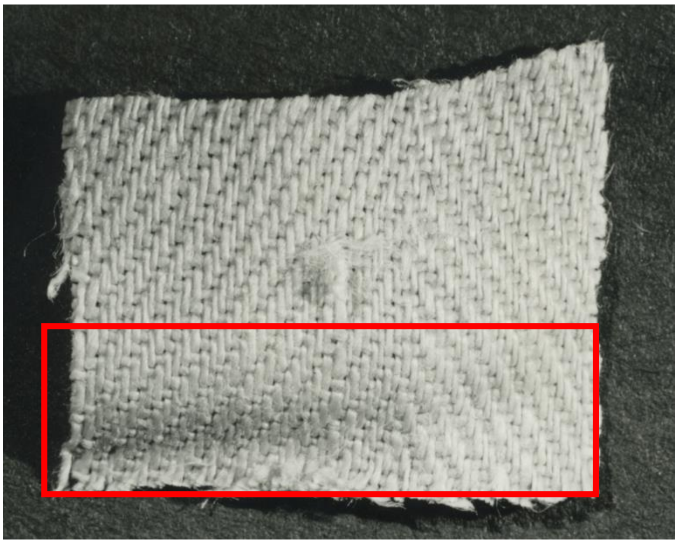

Fig. 12: The warp face side of the Shroud sample. The marked red area isolates a stain that corresponds with the stain on the weft faced side. (Original website image ref: p2575_8)

Figure 12 shows a marked isolated area. I had initially dismissed this area as a shadow casting over a raised part of the cloth. However, the reverse sample that is the weft faced side suggests otherwise (Fig. 13). The marked area of the above (Fig. 12) corresponds with the stains on the reversed side as shown below in image (Fig. 13). The weft faced side of the fabric below also shows many inconsistences in the fabric. Some of these inconsistences on the weft faced side can be a result of hand weaving.

13

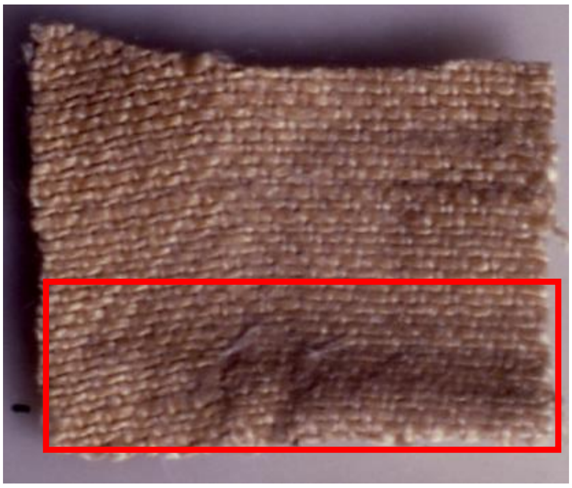

Fig 13: Weft face side of the Shroud sample Rotated 90° to the right showing many inconsistences. The red highlights the corresponding stain as seen in Fig: 14. (Original website image ref: p2575)

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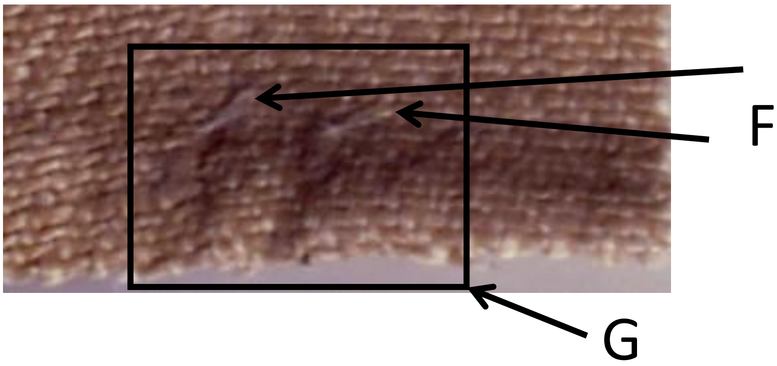

Fig 14: An enlarged area showing defects within marked area. This is the weft faced side of the Shroud sample. (Original website image ref: p2575)

Figure 14 shows an enlarged section of the weft faced side of the Shroud sample. This area seems to have some type of abrasion or pulled and cut threads indicated by F. Or they could be a type of stitch on the bias of the fabric. Within the area shown by G, two similar marks take the form of a repeat. Also within location G, there is a parity in the distortion of the weave structure. Area G shows a repeat of the same distorted effect. Looking at the staining on the full sample, shown in Figure 13, there is a formation of dark linear rectangular shapes. These shapes coupled with the idea of possible stitches in the bias direction may direct research into the effects of mends or reweaving on the sample. The idea of linear shapes is looked at in more detail later (Fig 18).

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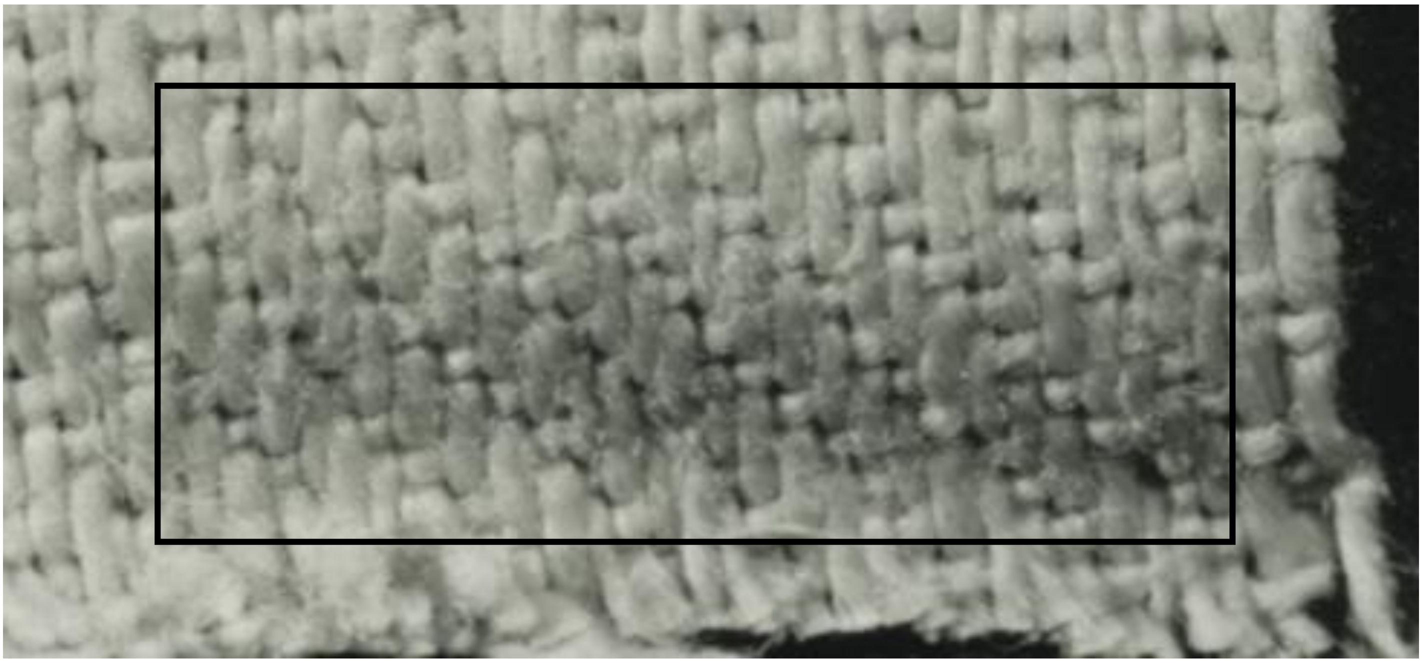

Fig. 15: Warp face Shroud sample flipped on the x axis. The highlighted area shows the extreme contrast in the tension and distortion of the weave. (Original website image ref: p2575_8)

Figure 15 illustrates the warp faced Shroud fabric flipped on the x axis. This gives a comparison of the same area and same orientation of weave as in Figure 13. The marked location in Figure 15 highlights the extreme contrast in the tension and distortion in the weave. Where the staining is most concentrated, the tension is noticeably tighter in the warp. This is not in keeping with the other areas of tension along the cut edge (Fig. 4). At this side of the fabric (Fig 15), the warp yarns seem to be more effected by the staining than the interlacing weft yarns. However, the stain has more concentration and impact on the reverse weft face side, as seen in Figure 13.

The yarns effected by the soiled area appear to be flattened (Fig15). This could suggest that some pressure has been applied at this point on the front warp face side, forcing more of the substance into the warp yarns. The element of heat within the substance, and/or the atmosphere may have caused the warp yarns to shrink and distort.

16

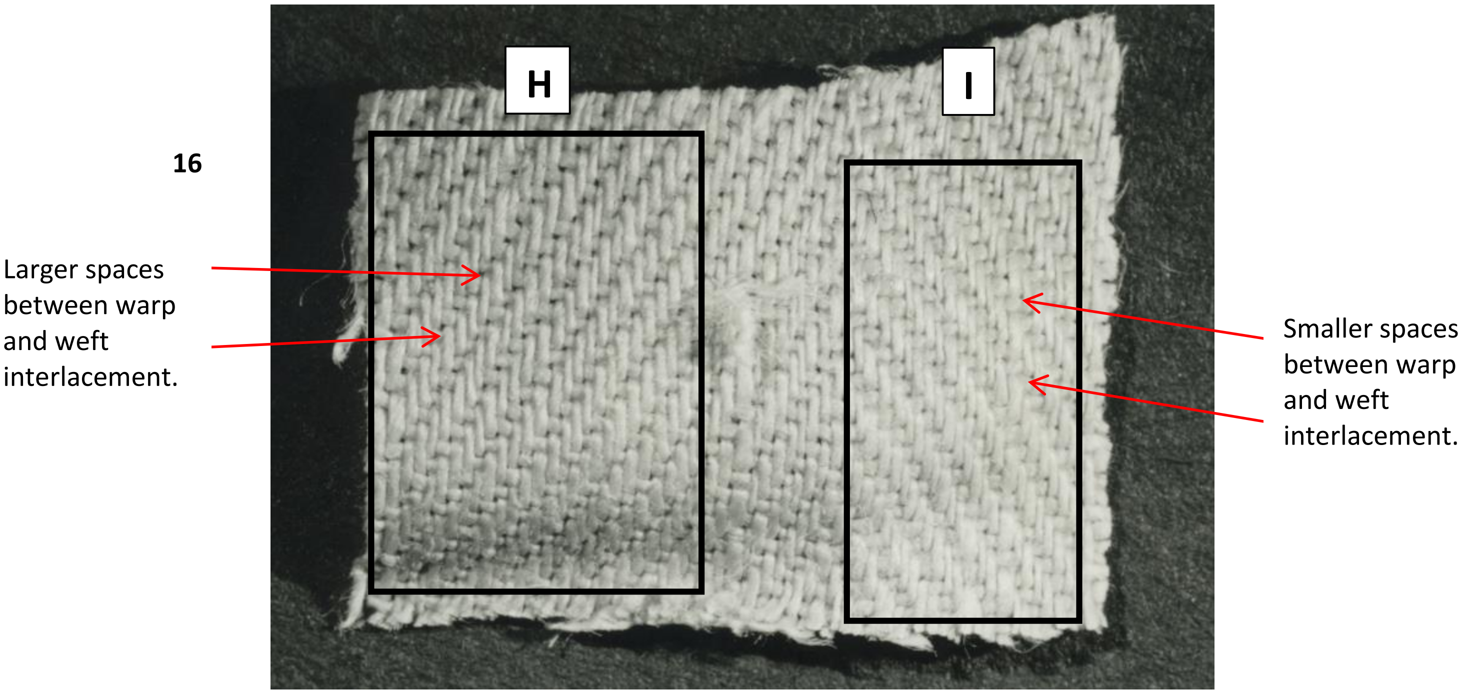

Fig. 16: Warp faced sample of the Shroud with marked areas to highlight the difference in the spaces between each warp and weft interlacement. . (Original website image ref: p2575_8)

In Figure 16, the warp repeat size within the 3, 1 twill is fairly uniform. It is apparent that spaces between each warp and weft interlacement are noticeably different. Location H has larger spaces than location I. Relative uniformity of the warp density (ends per cm) between the two sections rules out different warp sets. (Different number of warp yarns per cm). Area I may have been exposed to more moisture causing the cellulose fibres to swell. The two areas could contain different fibres with different characteristics.

17

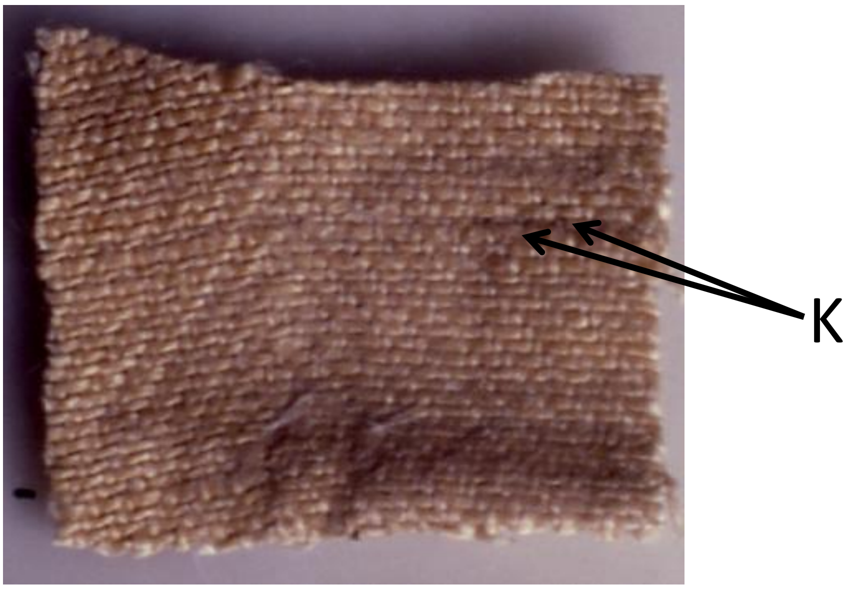

Fig. 17: Weft faced side of Shroud sample highlighting a defined line accentuated by contrasting weft yarns, marked K. (Original website image ref: p2575)

Located in Figure 17, there is a defined line marked K. This line is accentuated by the use of a noticeably thick weft yarn and much thinner weft yarn in consecutive picks. The line is more distinctive to the right of the sample. It sits on the area that is marked by the linear staining (Fig. 18). During the weaving process the weft yarn could have been beaten up tighter at this point. The distortion on the reverse weft face side seems to have little impact on the same corresponding area of the front warp face side. There is no visual evidence of the stain penetrating through the fabric (Fig. 16).

The marked locations in the image below (Fig. 18), could indicate that certain characteristics within the weave attract or drain the substance in the direction of a reservoir. Resulting in the stain becoming more concentrated with this reservoir. In Figure 19 the direction of the stain within the fabric is seems to be influenced by the weave structure. To confirm these theories, testing would need to be done on fabric constructed to mimic the same imperfections.

What characteristics could influence the direction of the stain?

- Disruption of uniformity in the weave structure caused by mistakes during hand weaving.
- Irregularity within the warp and/or weft density.
- Contrasting fine and thick threads used in consecutive picks causing a reservoir.

Fig. 18: Weft faced side of Shroud sample with dashed lines to show a patch work of linear staining. (Original website image ref: p2575)

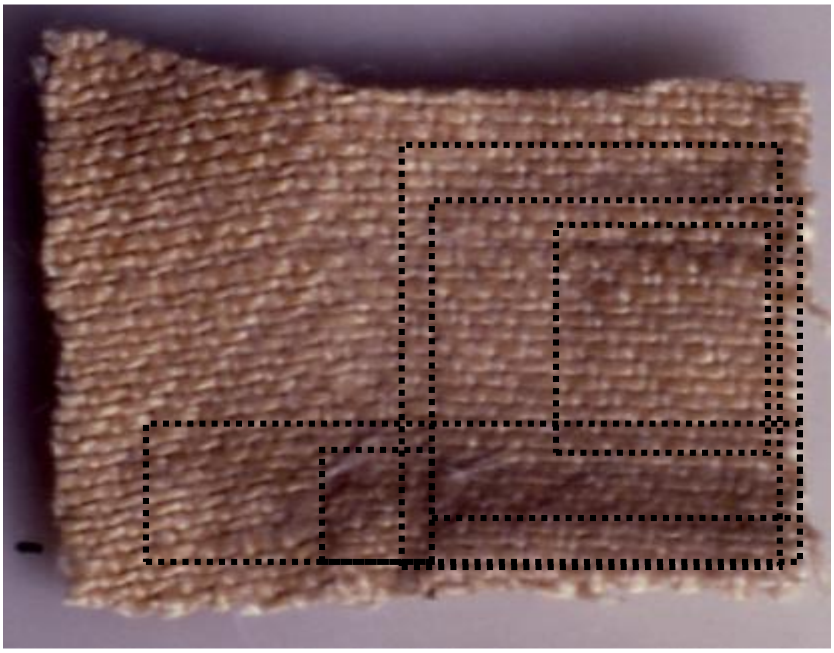

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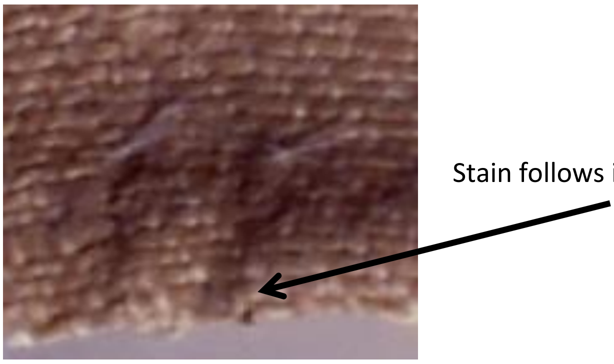
Fig 19: Close up of weft faced side of Shroud sample revealing staining possibly influenced by the path of the weave. (Original website image ref: p2575)

19



Stain follows in the path of the weave.

Below the arrows and line show a selection of various imperfections on the reverse weft faced side (Fig 20). The red markers indicate possible stitches along the bias direction of the fabric. The blue markers show what looks like a break in the weave pattern. The yellow line illustrates the interrupted migration of a weft yarn.

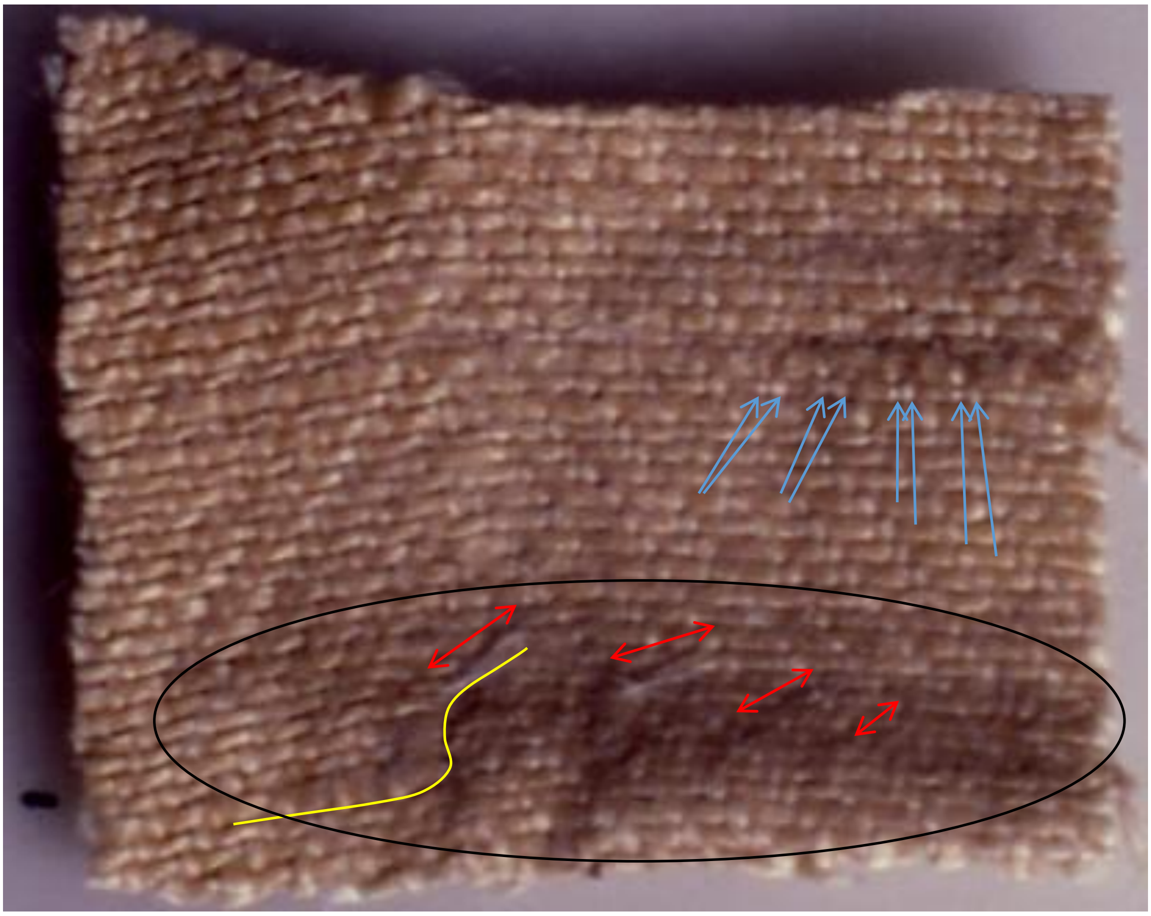


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Fig. 20: Weft face side of Shroud sample with indicators to show a selection of imperfections. (Original website image ref: p2575)

There are noticeable buckling effects within the Shroud fabric sample (Fig. 20 and 21). The above and below images show the weft face (Fig. 20) and warp face (Fig 21) of the sample. The two images highlight in black a corresponding buckled area. Since linen is prone to creasing, these effects cannot be overlooked. A crease could be formed during movement of the fabric but other elements such as staining, moisture, the distortion in the weave or variation of tension could contribute. Abrasion within a localised area could also influence the shaping and forming of a buckle or crease. It is interesting that the possible stitches on the bias direction of the fabric are located in this area. See red markers (Fig. 20).

Fig. 21: Warp faced side of Shroud sample showing highlighted buckled area. . (Original website image ref: p2575_8)

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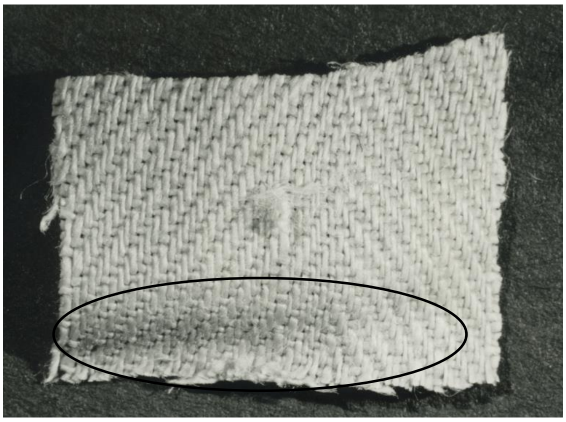

The Black Thread

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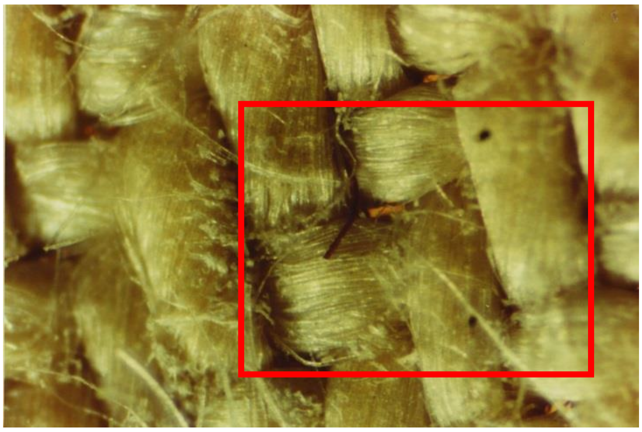

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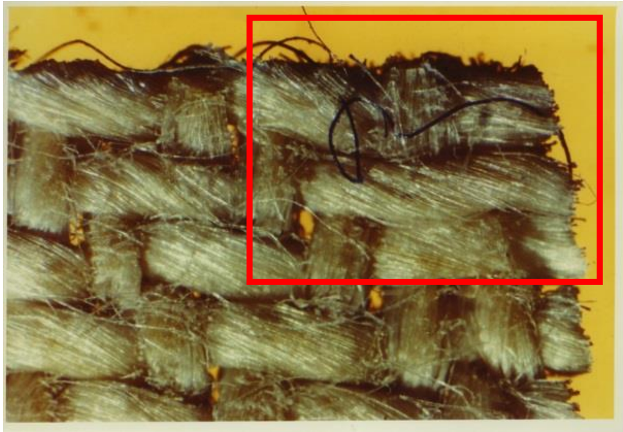

Fig. 22 and 23: The Shroud sample showing a black fibre within the marked area. (Original website image ref: p2575_9 and p2575_2 consecutively)

Figure 22 and 23 show a black fibre. At first, I wondered if this could be a hair. Within the location mark on Figure 22, the projecting fibre and the two black marks could be linked. In Figure 23 the same type of black fibre is intertwined with the fabric's fibres. When enlarged (Fig. 24) the black fibre appears to be a tightly twisted thread. Possibly a byssus thread (or sea silk) used in ancient times. Since it doesn't seem to be woven into the fabric, its function could have been for stitching. This may lead again to signs of repairs within the shroud fabric. Whatever its use, the black thread appears in the images to be an integral part of the sample.

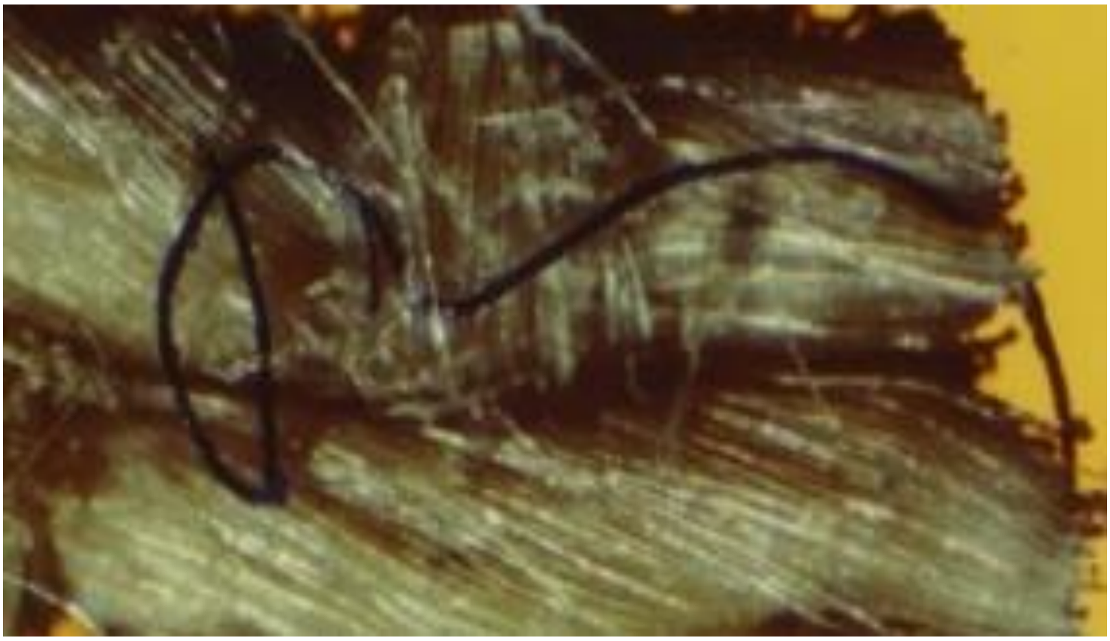

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Figure 23.1: Showing twist of black thread within the Shroud sample. (Original website image ref: p2575_2)

Comparison with Control Samples

Control sample 1

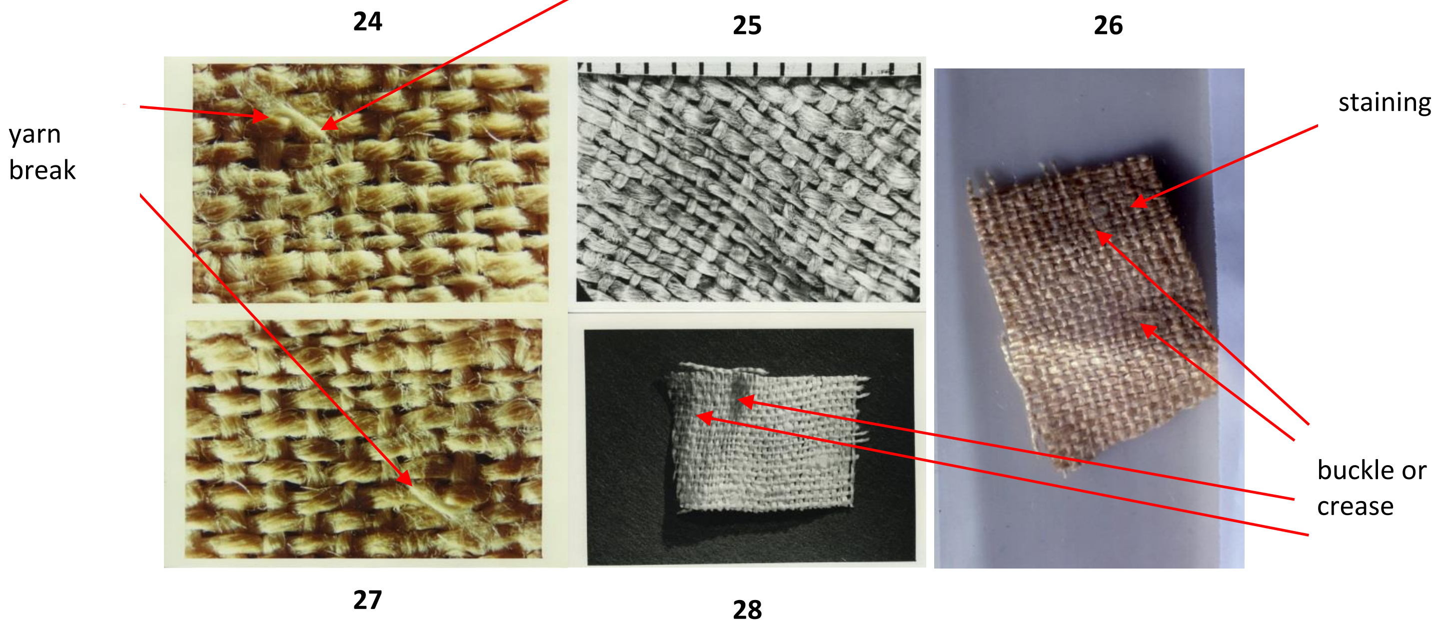

Fig. 24, 25, 26, 27 and 28 are images of the same control sample constructed using plain weave. (From left to right the original website image ref p2574_1, p2574_5 and p2574 consecutively.)

Control sample 2

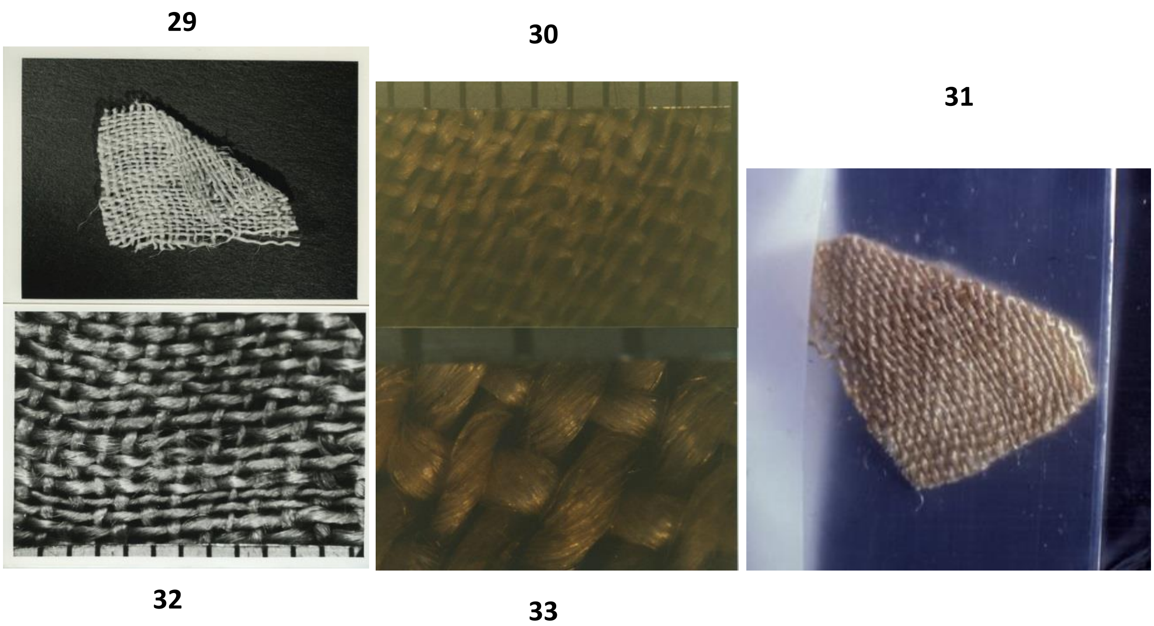

Fig. 29, 30, 31, 32 and 33 are images of the same control sample also constructed using plain weave. (From left to right the original website image ref p2576_5, p2576_3 and p2576 consecutively.)

This part of the report is a concise comparison between the 3,1 herringbone twill Shroud fabric sample with the two plain weave control samples. Since, the warp and weft densities and the weave types are the foundation of any fabric, these areas have already been compared (Fig. 5, 6, 8 and 9).

Tension

Control sample 1 and 2 show a lot of inconsistences within tension (Fig. 27 and 32). A contributing factor is that both controls have much lower densities than the Shroud sample (Fig. 5). In particular, control sample 2 has the most distortion due it having the lowest density.

Stains

The stains on the control samples (Fig. 26 and 31) are not in keeping with the linear shapes found in the Shroud sample (Fig. 18). Within the stained areas of the control samples there seems to be less abrasion, faults and less contrasting distortion of tension (Fig. 15) as found in the Shroud sample (Fig. 20).

Faults

Figures 24 and 27 show the same yarn break in Control 1. This is similar to the break in the Shroud sample (Fig. 11). It is difficult to see the break in interlacement of the weave in the control sample. This may lie underneath the broken yarn (Fig. 24). The break in Control 1 is much shorter in length than the break in the Shroud sample (Fig. 11).

Buckle

Control 1 shows buckling (Fig. 26 and 28). Subtle staining seems to be present around the location of the buckle. But is not as intense as in the Shroud sample (Fig. 20 and 21).

Yarn Imperfections

The yarn imperfections are obvious and are similar to the irregularities of variation in thickness found in the Shroud sample.

Weave Irregularities

The interlacement of the plain weave structure in the control samples appears to be more uniform that the Shroud sample. The plain weave structure is easier to hand weave and therefore is less likely to contain mistakes.

Black Thread

No black thread is obvious in the control samples.

Stitches

No stitch like forms are obvious in the control samples.

Conclusion

The Weave as a Contributing Factor in Understanding the Marks on the Shroud.

The performance of the 3,1 herringbone twill could be a contributing factor in understanding the marks on the Shroud of Turin. The uniformity of the fabric's architecture and composition could be key to the accuracy of the marking on the Shroud. Any faults within the fabric's construction itself will distort the image. Human error such as irregularities in warp and weft tensioning, variation within warp and weft densities are a contributing factor in the inconsistences of hand weaving.

The Significance in the Staining and the Corresponding Irregularities in the Tension and in the Weave.

In the Shroud sample, the weave within the areas of staining has been effected in terms of tension, density and distortion of yarns. The staining takes on a patchwork of linear contours. A specific area of very saturated staining on the reverse weft face side corresponds with the marking on the front warp faced side. It can be seen in some areas how the stain is influenced by weave structure. However, the overall arrangement of linear stains don't follow a natural course (Fig: 18). The staining in the control samples take on a more natural form and are less saturated (Fig. 24 to 31).

This opens up areas for further research.

- Has the stain influenced the fabric structure to distort?
- Can the imperfections of the weave have directed the stain to form the linear shapes? (ie the reservoir idea)
- The influence and effects of buckled areas.

The mentioned area of the Shroud sample with corresponding staining and buckle on the front and back of the fabric has extreme distortion (Fig: 20 and 21). Shrinkage is possible but the distortion within this area is so localised and acute that interference of a different kind such as mending maybe worth considering (Fig 20).

It is interesting that the possible stitches on the more bias direction of the fabric are located in the same buckled area (Fig 14 and Fig 20). Could the distortion caused by the buckle and the staining have weakened the fabric so much that it needed mending or supported by stitches? Similar stitch like forms are not obvious in the control samples (Fig. 24 to 31).

Importance and Influence of Fabrics Warp and Weft Density and the Benefits of Using a 3,1 Herringbone Twill

The weave determines the overall effect of the fabric and could be an important factor in the success of the image on the Shroud of Turin. The high warp and weft density of the Shroud sample (Fig. 5), lends itself to taking on detail both within the construction of the weave pattern and any print effect that would be applied to it. The high density warp float within the 3,1 herringbone twill pattern creates a significant surface area of fibre to be exposed to other elements (Fig. 10)). In contrast, the control fabrics (Fig. 6, 8 and 9) have a much lower warp and weft density and maximum interlacement with shorter floats. This configuration would not allow the same detail to be marked on the cloth.

Reason for the Superior Side of the Cloth to be in Contact with the Body.

Consideration to the coinciding front and back of the weave, in my opinion, is important in understanding the aesthetics of the Shroud fabric. The underside or the reverse weft faced side of the cloth has more prominent weft floats (Fig10). Because there are less weft floats than warp yarns, less detail can be exposed on the weft faced side of the cloth. Therefore, the superior side of cloth to use against the body would have been the warp face side. Any mends will be more visible on the weft face (reverse) side.

Regarding the Effects of Yarn Imperfection.

Although the variations of thickness within the yarn are considered to be characteristic of linen, the **effects** of this type of yarn imperfection within the Shroud fabric still needs to remain exposed.

The Implication of the Black Thread.

The black thread in the Shroud sample is intermingled with the fibres (Fig. 22, 23 and 24). Two dots similar in appearance look like binding or stitching (Fig. 22). The function of the black thread is not obvious in the sample but may have been a contributing factor in the stabilising of the fabric or used in mending. The presence of a black thread is not obvious in the control samples (Fig. 24 to 31).

The Relevance of Drape in Relation to the Behaviour of the Weave.

The behaviour of the weave structure most certainly has an influence on the way that the fabric drapes. The previously illustrated plain weave fabrics, used as control samples (Fig. 6, 8 and 9), would not have contoured the body as intimately or embraced its detail as effectively as the drape of the Shroud's 3,1 herringbone twill.

Mending

Yarns break during weaving. The success in identifying these breaks and fixing depends on the skill of the hand weaver. However, there are signs in the Shroud sample that direct the notion of mending or reweaving of the actual woven fabric. Many of the following considerations are not evident in the control samples.

- The stitch like forms on the more bias direction of the fabric (Fig. 20). These forms are not apparent in the control samples.

- Consideration to the black thread and its function (Fig. 22, 23 and 24). The suggestion that the thread could have been used to reinforce the fabric. No such thread is obvious in the control samples.

- There is disruption in the weave pattern located at one side of a pick. This disruption sits along a contour of linear staining (Fig 20 indicated by the blue markers). It is unusual that the whole pick is not effected in the same way.

- The difference in two sections of the sample that have a noticeable change in the size of spacing between the interlacement (Fig 16). This could suggest the use of different yarns.

- At the location of a heavy stain and buckle, there is an extreme contrast in the tension and distortion of the weave noticeably on the warp face side (Fig 15). A contributing factor could be the manipulation of mending.

- A patchwork of staining in the form of rectangular linear shapes (Fig 18) that does not conform to the staining on the control samples.

Further Research.

- Further areas of suggested research activity within this report would benefit from testing the effects and performance of a replica woven fabric exposed to the same elements as the Shroud.

- Images of cross sections would be useful in understanding the uniformity of the weave and its influence on the markings.

- Working out where the sample was positioned on the shroud before it was removed. This could help in understanding the staining and the structural imperfections in relation to the rest of the Shroud fabric.

- All of the considerations and suggestions in this analysis should be compared against the actual Shroud fabric sample and control samples.

Hidden Secrets

From the sample it is clear that the fabric of the Shroud is not uniform. How the weave structure behaves is a fundamental component in the Shroud's aesthetics. The intricacies of the fabric structure within such a small piece of fabric reveal many possible stories. Locked within its fabric's architecture and composition, the Shroud of Turin could reveal many hidden secrets.

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