UNIVERSITY OF GOTHENBURG

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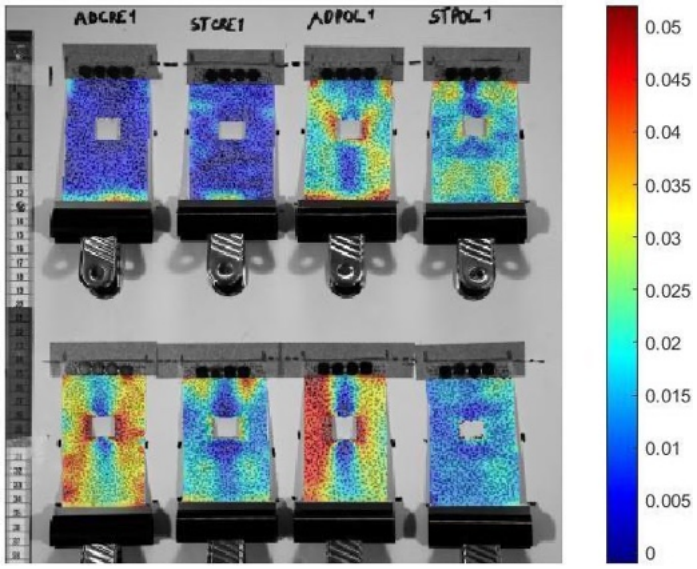
Evaluating Three Sheer Support Fabrics Attached with Laid-Couching or Adhesive on Double-Sided Textiles by 2D Digital Image Correlation



Gabriel Caracol

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UNIVERSITY OF GOTHENBURG
Department of Conservation
P.O. Box 130 SE-405 30 Gothenburg, Sweden

http://www.conservation.gu.se
Fax +46 31 7864703
Tel +46 31 7864700

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Author: Gabriel Caracol
Supervisors: Johanna Nilsson and Liv Friis

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ABSTRACT
This thesis focuses on the use of sheer mesh fabrics for structural support of holes in double-sided (and occasionally also semi-transparent) textiles. In textile conservation, it is usual to treat structural damages by attaching a newer layer of material to the backside of the object, typically of the same material. When it comes to double-sided textile objects, however, the application of this method would entail covering a part of the object that features significant aesthetic and/or functional attributes. So, this research sought out to find alternatives for this type of treatment using sheer support fabrics. A survey was sent out to understand what strategies are being currently implemented by professionals in these special cases. In addition, 3 different sheer fabrics, silk crepeline, polyester tulle and nylon net, combined with 2 distinct attachment methods; stitching and adhesive treatment were tested. To evaluate and compare each different combination, two tests were conducted. First, cotton mock-up samples with holes were treated with each method and put through a fixed-load test. The progression of the test was monitored using 2D Digital Image Correlation, a method that enabled the determination of the effect of each method on strain and displacement values. Additionally, each method was applied to a lace fragment in order to compare them visually and access their impact on the object. Results showed that choice of sheer fabric made a considerable difference on average strain values and distribution. It was also concluded that, for the most part, conservation stitching was successful in supporting the damaged area, showing lower strain values. Silk crepeline was the material showing the lowest strain and displacement values, having an even and consistent progression throughout the fixed-load test. On the other hand, besides experiencing adhesion failure on all tested samples, the nylon net mock-ups showed the most similar behaviour with the untreated control sample. When it comes to visual impact, more testing is needed to produce conclusive results.

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1. INTRODUCTION

1.1 Background

A common damage that textile conservators must deal with in their work is structural damage, meaning damage that has affected the textile´s structural integrity in some way, be it in the form of tears, holes, wear and tear, missing warp or weft threads, among others. In general, a way to treat these damages and give the object extra support is to add a layer or patch of a new fabric, either on the backside or in between layers. The choice of this new fabric can be a complex one, but conservators normally strive for a material that is compatible with the object, not only composition wise, but aesthetically as well. The addition of this new component, however, usually entails that parts of the object will be covered by this patch.

The starting point of the thesis was conceptualizing a way to adapt this general treatment to objects that shouldn't be covered on either side and did not have more than one layer. In this study, "double-sided objects" refers to objects that feature significant aesthetic and/or functional elements on both sides, meaning that treating them without compromising one side's integrity can be a challenge. Double sided embroideries, textile art installations, double weave textile art pieces, banners with designs on both faces are some of the examples of these objects.

Sheer light fabrics such as silk or polyester crepeline and nylon net are also commonly used in the field of textile conservation. They are typically employed as protective layers or overlays for very fragile or damaged objects due to their semi-transparent properties, which do not completely obstruct visualization. Even though there is a lack of published literature on the topic, these materials can also be used as support fabrics to support structural damage. In this case, these are normally attached to the object with adhesives, stitches or a combination of both. These fabrics could, therefore, be compatible for structural damage treatment for certain double-sided objects.

In relation to this, advances in textile conservation research have increasingly incorporated scientific methods to assess the mechanical behaviour of materials. One of these methods is two-dimensional Digital Image Correlation (2D DIC), a non-contact optical technique used to monitor strain and deformation. Initially developed in engineering fields, 2D DIC has been successfully applied in conservation research to study the mechanical responses of materials in a variety of situations, providing important insights into the impact of different techniques.

1.2 Previous research

As previously mentioned, the use of sheer fabrics as backing supports in textile conservation has received limited attention in literature. Nonetheless, a few studies have explored their general properties and applications.

An example is Fulkerson LaVallee's 2005 master's thesis, which examined the abrasiveness and other characteristics of various sheer overlay fabrics. Based on responses from a survey distributed to textile conservators, the author selected several fabrics for testing parameters such as elongation, coverability, weave structure, and abrasiveness. The outcomes were compiled into a comparative table which is useful.

Another research by Karsten & Kerr (2011) focused on the performance of sheer overlays in adhesive treatments. Their study evaluated six different adhesives, including Lascaux 360/498HV, applied over nylon net, silk crepeline, and polyester crepeline. By testing peel strength and analysing adhesive transfer with scanning electron microscopy (SEM), they addressed not only bond strength but also the removability of adhesive interventions.

When it comes to the topic of structural damage stabilization in textile conservation, there is a bigger amount of literature published, specifically related to the impact of different stitching techniques. Nilsson (2015) evaluated three methods of supporting damaged silk: silk patches secured with laid couching or brick couching, and silk crepeline overlays secured with running stitches. Their performance was evaluated through a series of tensile tests performed at different moments like before and after damage and treatment.

Schön (2017) expanded on this by investigating how stitching technique (laid vs. brick couching), stitch length, and spacing (20/25 mm and 30/35 mm) influence the mechanical behaviour of both modern and historical silk textiles with horizontal and vertical tears.

In another study, Sutherland and Lennard (2017) explored how the spacing of laid-thread couching (3 mm, 5 mm, 7 mm, and 9 mm) affects the stabilization of old cotton substrates with horizontal tears. Their research also incorporated digital image correlation for strain monitoring during fixed-load testing, which offered valuable insights into the impact stitching variables can have on strain.

The application of DIC in textile conservation has been further investigated in the work of Lennard, Costantini, and Harrison (2023), who employed the method to assess support stitching on wool rep fabrics and historic tapestry fragments. Additionally, a very significant three-year interdisciplinary research project (Lennard et al., 2011) demonstrated the effectiveness of 2D DIC for strain monitoring on large-scale tapestries. This project established practical guidelines and confirmed DIC's accuracy by cross-referencing it with optical fibre sensors and other strain measurement techniques.

Together, all these studies provide a valuable foundation for understanding the mechanical implications of sheer overlays and potential attachment methods, as well as affirming DIC as a reliable method for strain analysis in textile conservation.

1.3 Research questions

Due to having to adapt the more established conservation treatment for structural damage for double-sided textile objects, this thesis investigates the use of different sheer fabrics and attachment methods.

The following questions will be the basis for the research:

- What strategies are being employed to treat structural damage to double-sided textile objects?
- How does each combination of sheer support fabric and attachment method affect damage support as well view of the area it was applied to?
- How does each combination of sheer backing fabric and attachment method affect strain distribution and behaviour?

1.4 Purpose and aim

One of the objectives of the study is to investigate current strategies being used by textile conservators for treating structural damage in double-sided textile objects through a literature review and a targeted survey. On the other hand, through a practical experiment and analysis, another goal is to assess how different sheer support fabrics, as well as different attachment methods such as stitching and adhesives affect the aesthetic and structural integrity of these objects. The research will then seek to address the gap in research regarding this topic.

The aim of the thesis is to explore and compare the visual and mechanical impact of the different sheer support fabrics as well as two distinct methods of attachment. Besides that, it will help to make more informed decisions when double-sided textiles are being conserved in a way that both sides of the material require preservation and minimal aesthetic disruption.

1.5 Methodology

In order to answer the research questions, the study used a combination of qualitative and quantitative methods.

A literature review was conducted to gather existing knowledge on the treatment of double-sided textile objects. Besides that, it also included research on stitching and adhesive techniques, the use of sheer fabrics in textile conservation, and the application of 2D Digital Image Correlation (DIC) in heritage science, which also informed the design of the experimental phase.

A targeted survey was sent out to textile conservators to gather insights on the strategies currently used to stabilize double-sided textile objects. The survey aimed to identify commonly

faced challenges, treatment preferences, and the types of objects most frequently needing such interventions.

To evaluate the mechanical performance of different sheer support fabrics as well as stitching and adhesive techniques, cotton mock-up samples were prepared. These were put under a fixed-load test while being monitored using 2D Digital Image Correlation (DIC). This provided quantitative and qualitative data on the structural response of the samples under prolonged stress.

Finally, photo documentation was carried out before and after the fixed-load test to assess how each stabilization method responds to prolonged mechanical stress. This helped identify any visible changes such as deformation or damage resulting from strain. In addition to this, a separate visual comparison was done to examine the aesthetic impact of each method on a fragment of semi-transparent lace. This included assessing the visibility of the intervention and overall visual integration of the sheer overlay fabrics on the object.

1.6 Delimitations

Double-sided textiles can be composed of a wide range of textile fibres. To narrow the scope of the study cotton was selected due to its wide availability and bigger gap in research when it comes to conservation stitching research.

As support fabrics, three different sheer mesh fabrics were selected for the study, one made of silk (silk crepeline), one made of polyester (polyester tulle) and one made of nylon (nylon net).

In order to limit variables only one stitching technique and only one mixture of two adhesives were selected for the experiment as attachment methods of the support fabric. The number of replicas for each mock-up sample was limited to three.

Besides that, unpredictable fluctuations in relative humidity (RH) and temperature (T) in the room the experiment was conducted in could influence the results.

1.7 Ethical Discussion

In conservation, when it comes to any treatments, there are a set of ideas that professionals tend to abide by. Concepts like reversibility, minimal intervention, the use of compatible materials, among others, have long been topics of discussion in the conservation community, and is mentioned in official documents like the E.C.C.O Professional Guidelines II (ECCO, 2003) and the ICOM Code of Ethics for Museums (ICOM, 2017).

However, these concepts are not always easy to define and debates surrounding both their definition and validity have been common. Reversibility, for example, is defined by Muñoz Viñas as “(...) an ethical principle that mandates that it should be possible to take the object back to the state it was before treatment took place.” (2005, pp.185). Appelbaum adds that reversibility also implies that the treatment is discernible to conservators, to allow for its

detection and possible removal (Appelbaum 2007, p. 353). On the other hand, reversibility has also been described as unattainable (Muñoz Viñas, 2005, p. 186).

A shift in the definition of reversible, or rather, the preference for terms like “retreatablity” have emphasized the importance of a treatment to not hinder possible future treatments instead (Muñoz Viñas 2005, pp.187). Applebaum highlights how due to the shifting nature of object´s values with time, sometimes past treatments are reproached differently to reflect these changes (2007, p.353).

This is relevant to textile conservation because both stitching and adhesive treatments can be described as non-reversible to some extent. While it is possible to remove threads from a treatment, the holes left by the needle during the process remain as well as remnants of the adhesive, especially when it is a type that is prone to becoming insoluble with ageing (Geijer, 1981, p. 151). Besides that, by removing these treatments, there is also a risk of material loss in the form of fibres or more. If the concept of retreatable is applied instead, both methods could be applied in a way that makes their removal possible and allow for future treatments.

Minimum intervention is also a contested principle, as Muñoz Viñas states, when taken to its’ extreme it can mean that no intervention is done to objects at all (2005, p.188). When trying to apply this concept to textile conservation approaches such as stitching and adhesive treatments, it becomes even clearer how hard it is to define minimum intervention. Some could argue that adhesive treatments are more “invasive” since they have the potential to chemically alter the object (Geijer, 1981, p. 149). Besides that, even in lower concentrations, sometimes adhesive treatments require additional stitching around the edges to prevent adhesion failure or lifting, something that can be considered “too interventive” (Chamberlin and Garside, 2024, p.445). However, stitching treatments can also be carried out in a way that is considered not minimally invasive, depending on the area being treated and the amount of support needed. This demonstrates how limiting the choice of treatment to the one that is “altering the object the least” can end up working against the object´s favour, especially if factors like the object´s context and intended purpose are not taken into account (Applebaum, 2007, pp. 303 and 305)

A very important step in the decision-making process of conservation is considering all these above mentioned factors, like what type of values are connected to the object (Applebaum, 2007, p.115) as well as its´ intended use. Objects that are still in use will receive a very different approach than museum objects, where their value usually falls more into being a proper representation of their prior use or significance (Applebaum, 2007, p.117). This is also related to the conflict of stabilizing an object while making sure it’s integrity is not comprised.

Because of this, authenticity is another concept that is discussed in conservation, while not always being clear to define. While some consider the changes the objects have suffered through time to be a factor of their authenticity, others argue that these changes are in fact obscuring the original state of the subject (Lennard et al, 2024 p.75). However, it has also been discussed to what extent interventions to an object always imply a certain level of loss of integrity due to the removal or addition of material (Brooks et al., 1994 p.241). When it comes to double-sided textile objects, this is a relevant question, since most treatments would imply choosing a side to “sacrifice”, meaning that one or both of the sides will receive a treatment

that will alter its appearance. Several aspects, such as the ones mentioned above, will influence this choice.

Aesthetic integrity is a very subjective aspect in conservation. Applebaum argues for the use of the “six-inch, six-foot rule”. This rule implies that regular viewers of the object should not be able to discern treatments or damages while standing six feet (~ 1,8m) from it, while experts and more interested viewers will be able to identify these by standing six inches (~15cm) from it (Applebaum 2007, p.243). In a study investigating the attributes most valued by textile conservators to consider a treatment successful, Nilsson and Axelsson found that coherence and completeness were the most important, as well as the discreteness of the treatment (2015, p.200 and 205). But again, the effectiveness of a treatment and how it affects its aesthetic integrity will also greatly depend on its intended use. What could be considered a very undiscernible treatment in a museum exhibition context could for example be considered too visually disturbing if applied to objects in a collection intended for studying (Guidess, 2024, p.87).

All in all, while it may not be possible to determine a single "ideal" treatment for structural damage in double-sided textile objects due to the inherently subjective and case specific nature of conservation decisions, the considerations explored above are essential for guiding ethical and informed choices. This thesis aims to contribute to that dialogue by comparing stitching and adhesive treatments and examining how each approach impacts the object visually and affects its perceived integrity.

2. LITERATURE REVIEW

2.1 Treatments on double-sided textile objects

In the attempt to find examples of double-sided objects being treated and gather insight into the solutions being currently used in textile conservation, a literature review was done. The terms “double sided”, “back side”, “reverse face”, “double faced”, “double weave”, “exposed warp/weft” were searched in databases in combination with “textile conservation” and “textile restoration”. The result was a very limited number of relevant studies. The most relevant literature found was mainly connected to the conservation of silk banners that usually present this double-sided nature. Due to these limited results, terms like “lace”, “embroidery” and “open weave” were added to the search.

When it comes to research relating to double sided silk banners, an article discussing the retreatment approaches to a selected number of union banners by van Enckevort et al. (2024) was of interest. Besides the aspect of their larger size, the authors also refer to their double-sided nature and there are references to treatment approaches done with it in mind. This gets highlighted when describing a treatment of a banner that will be displayed in a way where both faces are equally as visible, hanging freely in the middle of a room. Most treatments and retreatments described in the article are some kind of adhesive treatment, generally casted onto a sheer overlay like silk crepeline and sometimes complemented by stitching. It is, of course, relevant to bring up the fact that fragile silk objects like these generally undergo similar treatments, whether they are double sided or not. Due to this, the double-sided nature of these examples is not always the driving force of the choice of adhesive sheer overlays, but more of an extra component to consider when doing the treatment and planning for exhibition.

On the other hand, a case study where both faces were integral to the object to the point where the treatment was designed around this aspect was the research into the conservation of Thangka paintings done by Cotte (2007). Thangka paintings are meant to be hung above altars in Himalayan temples and are usually framed by silk mountings that are stretched over rods. These very often contain important inscriptions on the back face that are integral to the object´s religious value (Cotte 2007, pp. 2-3). The article describes how, in past treatments, a cut-out has been made in the lining fabric to allow the visualization of these components. However, this method is inadequate in the case where stabilization needs to be done in these areas. So, the author sought out to explore alternatives from both textile and painting conservation fields. The method that was concluded to be the most effective was the application of an adhesive onto silk crepeline that would then be attached to the back of these objects through solvent reactivation and consistent pressure. The article also explored ways to adapt this method so it was more easily accessible to the communities that would treat these objects.

Lastly, the search moved on to lace conservation that could be useful due to their transparent and empty space characteristics. For conservation of structural damage in lace, there seems to be more alternatives being applied. The use of sheer overlays such as tulle and nets fastened with thread is common, either by being the main support, or as a way to hold components

together temporarily as more complex stitching treatments are undergoing. The use of adhesives is also sometimes reported (Fredriksson, 2021, pp.6-7).

2.2 Stitching in textile Conservation

Historically, stitching in textile conservation has been an intuitive practice, largely based on the conservator's experience (Lennard & Ewer 2010, p.144). A survey conducted by Sutherland and Lennard (2017) identified 13 variables that influence decisions regarding stitch spacing. This included size of the loss, specific aesthetic goals, and thread type, among others. The study highlighted that conservators often rely on their previous experience, a "gut feeling", when making these decisions (Sutherland & Lennard 2017. p.2). This highlights the value of further systematic research into conservation stitching to enhance understanding and support more informed decisions in textile conservation.

There have been discussions on the effects of different stitching techniques in textile conservation since the beginning of the practice. However, the evolution and changes in practice have been, once again, been mainly driven by empirical knowledge and professional communication rather than scientific studies. For example, Landi emphasized that one of the most crucial aspects of stitching in conservation is ensuring that stitches do not affect the textile's drape. Additionally, avoiding stitches that are too tight, or small helps prevent damage to the fabric (Nilsson, 2015, p.37). Sewing treatments have evolved as professionals exchanged insights and refined their techniques. Earlier conservation approaches used more stitches, placed closely together, often with thicker thread. Today, conservators favour fewer stitches, spaced further apart, and sewn with finer thread to minimize intervention and potential damage (Schön 2017, p.2).

Besides that, a 1981 article by Jedrzejewska presented a comparative analysis of stitching versus adhesive treatments in textile conservation. While it indicated the shift towards advocating for adhesive methods, it also reflected the prevailing preference for stitching at the time. Stitching was, and still is to some point, perceived as more natural to textiles, described as a gentle and controllable procedure that aligned with their materiality (Jedrzejewska 1981, p.148). However, the article also acknowledged concerns about the technique's reversibility, as the process inherently leaves holes in the fabric (Jedrzejewska 1981, p.149).

Adverse effects of stitching treatments on textiles have not been overlooked or under-documented. Naturally, discussions have included consideration of the negative impacts that inappropriate stitching can have on objects. There has been a longstanding preference for "invisible" stitching (Corah 1977, p.111) and concerns about weave distortions caused by overly tight stitches (Schön 2017, p.6). In some cases, these discussions have even led to recommendations for minimal intervention or opting for no stitching at all (Corah 1977, p.112).

Furthermore, back to the article by Jedrzejewska, adhesives were portrayed in a slightly harsher light. Descriptions of adhesive treatments as "brutal" and capable of permanently disfiguring objects (Jedrzejewska 1981, p.149) reflected widespread fears, which could be a reflection of

past adverse effects resulting from misguided applications of the method. These concerns were not unfounded as misuse of adhesives had historically led to alterations in key textile properties such as colour, pliability, and transparency (Jedrzejewska 1981, p.149). Despite this, the article contributed to an evolving discourse on the ethical implications of both techniques.

During the late 90´s and early 2000´s, there has been a surge of scientific research on adhesive treatments in textile conservation (Lennard & Ewer 2010, p.145). This growing body of work has contributed to the wider acceptance of adhesives in the field. This has been driven by the need to understand and mitigate past issues and by the prior resistance to exploring this method.

However, stitching in conservation has not received the same level of scientific interest. While some studies have emerged examining the effects of variables in conservation stitching—such as those by Nilsson (2015), Schön (2017), Sutherland and Lennard (2017) and Lennard et al. (2023).much remains unexplored, especially when compared to the extensive research on adhesives.

2.2.1 Techniques and Nomenclature

Besides the limited amount of research in this specific field, conservation stitching also faces challenges related to nomenclature and the lack of detailed documentation. Recently, there has been incentive for conservators to be more descriptive and include more comprehensive descriptions of stitching techniques in their reports and publications. However, even with these improvements, there is still a general scarcity of images and diagrams that could enhance the understanding of specific stitching methods. The absence of visual aids makes it difficult to accurately interpret how stitches are applied, leading to inconsistencies in practice and communication among conservators.

The terminology used for stitching has also evolved over time, with different sources sometimes referring to the same technique by different names. For example, while the *The Directory of Hand Stitches used in Textile Conservation re*mains a valuable reference (Lennard & Ewer 2010, p.141), many of the stitch names it lists can vary based on region or can no longer be referred to by that terminology. Additionally, language differences further complicate standardization, as some languages may have multiple terms for the same stitch while others may lack equivalent terminology altogether.

Regarding, more specifically, hole mending and stabilization, various methods have been employed, often determined on a case-by-case basis. The approach is, again, usually guided by the intuition and experience of textile conservators. While the importance of using a support fabric beneath fragile textiles is widely acknowledged (Lennard & Ewer 2010, p.144), ensuring a stable foundation before stitching, the techniques used to secure this support fabric can be, at times, inconsistently documented.

For instance, a 1996 *Textile Conservation Newsletter* article on repairing areas of loss in military uniforms provides some guidance but remains relatively broad in its description. It advises attaching patches "(...) along the edges of the loss area with couching, whip stitches, or other appropriate unobtrusive stitches."(Dancause 1996, p.12) highlighting a general approach rather than a precise method. It warns practitioners to avoid placing stitches too close to the raw edges, as this can increase the risk of fraying.

In the past few years, however, a more limited and specific number of stitches and techniques for support and hole stabilization have become widespread and recommended, appearing not only on research studies but also on manuals. These are laid-thread couching, brick couching and, in some cases, the running stitch.

Laid-thread couching has appeared in significant literature for quite some time and seems to be the current most widespread conservation stitch for stabilization. In Landi´s Textile Conservation Manual, it is referred to as "one of the most important stitches in conservation" (Landi 1997, p. 117). This technique is also mentioned as the one giving the flattest treatment, not adding too much extra material to the object. As described by Nilsson (Nilsson 2015b, p.3), it is a long straight stitch, laid in line with either the warp or weft of a fabric and then fastened in place with short perpendicular holding stitches, inserted at regular intervals. The intervals between these holding stitches can depend on aesthetic and structural reasons on a case-by case basis, but there seems to be a preference for staggering these from laid thread to laid thread (Landi 1997, p. 117).

In some publications (Corah 1977, p. 109; Winslow Grimm 2002, pp. 26 and 34), there is a distinction between "self-couching stitch" and "proper laid-thread couching". The former refers to using the same thread for the laid thread and the couching, only starting and stopping once, while the latter means the laid thread is done first, individually, while the horizontal smaller stitches (the couching) are added later, meaning these can be made with a different thread that better matches the textile. Corah (1977, p. 109) also mentions a technique that uses loose threads in the object as the laid thread, making the treatment consist of only adding the couched stitches.

In the literature, brick couching is mentioned less often than other stitching methods and can be referred to with different names, but it generally refers to a type of shorter stitch done at certain intervals in order to make a pattern similar to brick work (Nilsson 2015b, p.3). A similar stitch can be found in *The Directory of Hand Stitches Used in Textile Conservation* (2002, p.38) under the "Tabby stitch" name and it is usually more common in tapestry conservation going over one weft or warp thread at a time.

Lastly, the running stitch is a simple, straight stitch formed by passing the needle in and out of the fabric at regular intervals, creating evenly spaced, dashed lines. In conservation, it is most usually used either to secure a backing fabric in place prior to the more complex stabilization stitching or to secure a protective overlay on top of more damaged fragile objects (Nilsson 2015b, p.3)

2.2.2 Scientific Studies on Conservation Stitching

An important study on thread used for conservation stitching was Benson et al.´s 2014 research on different thread types, specifically applied on laid-thread couching. With the intent on looking further into the "like-with-like" mentality that is so widespread in conservation, the effects of natural and synthetic fibres were compared. In the end, the composition of the threads seemed to have little impact on the results, concluding that factors like whether the threads were stable or filament are more important on factors like elongation and recovery.

Although not focused on stitching techniques, Benson´s projects concluded that the different way stitching was conducted in the mock up samples was important to how these performed in the tensile and fixed load tests. Factors like thread alignment with the weave grain, stitch spacing, placement of the needle (between weave yarns or through them) and placement of start and finish stitches influenced the degree of damage seen on the samples (Benson et al., 2014).

As mentioned, Nilsson, based on a questionnaire, compared three methods on surrogates with wear and tear: damage secured to a backing fabric with either laid couching or brick couching and the covering of the damage with a silk crepeline layer secured with running stitches. To evaluate the effect of these methods, the surrogates were put through tensile testing of maximal force at break at different points such as before damage, after damage, after conservation and, finally, after removal of all stitches. This was done in order to not only evaluate the effect of the methods in comparison to their state prior to damage, but also their reversibility, or rather how it impacts the silk after removal. The samples were also put through accelerated wear tests after conservation.

Regarding the results, Nilsson concluded that, in general, conserved samples were successful in strengthening the silk post damage. Laid couching was considered the strongest one, giving samples with wear damages up to five times more strength than before conservation. However, it only restored the strength of the samples up to 27% compared to the undamaged ones. This was considered a good result by Nilsson, as the stitching would break before the damaged area is harmed further.

Brick couching, while not being as effective as laid couching, also presented satisfactory results, especially after the accelerated wear test, as it was not as affected, possibly due to not having as much of long and exposed stitches as the laid-thread couching.

Even though laid couching was the method giving the samples the strongest support, the silk crepeline overlay was considered by Nilsson being the most appropriate for treatments of more fragile silk due to the few amount of stitches necessary to protect the material and how it was the one affecting the samples the least negatively after stitch removal. Besides that, after the accelerated test, the crepeline overlay acted as a protective sacrificial layer, successfully protecting the silk.

A part of Nilsson´s project was testing different orientation and placement of supporting stitching on silk and wool samples and subsequently putting these through abrasion tests by the Martindale method (SS-EN ISO 12947-2:1999). These were then evaluated using data from tensile tests. The results were that the direction of the long stitch in the laid couching technique made a difference, such as the long stitch being in the warp direction resulting in stronger samples for the silk surrogates. Besides that, in the wool samples, the ones with couching over the whole area resulted in stronger support than those with couching only over part of the area.

Another relevant study is Schön´s bachelor´s thesis (Schön, 2017). The study investigates the mechanical effects of different stitching techniques in textile conservation, specifically comparing laid couching and brick couching. Besides comparing these two different stitches, Schön also investigated different stitches lengths and spacing, comparing 20/25mm and 30/35mm measurements between stitches. This was done through the assembly of mock up samples with tears. These were put through a fixed-load test and the before and after appearance, as well as elongation were documented. The conclusions were that, in this experiment, laid thread couching stitches caused more distortion to the silk substrate, especially when done with shorter stitches and in the horizontal tears, which translated into samples with tear openings and weave deformations post fixed-load test. However, it was also concluded that, on either stitch technique, tight stitches were detrimental to the samples, observed by the formation of holes in some of the laid-thread samples and a puckered surface in some of the brick couching samples. On the other hand, longer laid-thread stitches gave good results, where the weft wasn't disturbed and tear opening wasn't noticeable. Due to the experiment's results, Schön recommends that horizontal tears should either be conserved with longer laid thread stitching or shorter brick couching.

A study going more in-depth about stitch spacing regarding laid thread couching was done by Sutherland and Lennard (2017). The distances investigated were 3mm, 5mm, 7mm and 9mm on old cotton substrates with horizontal tears. The research also employed the method of measuring the samples at different crucial moments during and after a fixed-load test. Additionally, samples with the 5 mm and 9 mm were investigated further by employing a 2D DIC strain monitoring system during the fixed-load test. The experiment allowed to conclude that, the wider the stitching done, the bigger the extension observed in the mock-up samples, meaning that areas with denser stitching were more constricted and less elastic. This can be problematic due to different tensions in different areas of an object, which can lead to different interactions with the environment, leading to the aggravation of the damage. Lastly, the samples with 5 mm spaces of stitching rows, which was also the most used distance used according to a survey conducted, gave quite good results, showing the most similar behaviour to the control mock-up samples.

Lennard has been involved in other projects using digital image correlation to track strain in relation to textile conservation and exhibition methods. One of these projects (Lennard et al., 2023) investigated the comparison of laid-thread and brick couching with different distances such as16 mm, 8 mm and 4 mm in tapestries. In order to do so, both wool rep and historic tapestry fragments were used in this project. The study reached a similar conclusion as

discussed before, that even though closer stitching translates into lower strain, it also means the area is less flexible. So, it was also found that there was higher strain in the brick couching samples, meaning it was slightly less restrictive, not preventing as much extension as the laid couching. Finally, it was found that the three different spacing tested did not have that much impact in causing or preventing strain, as both the 4 mm and 16 mm samples had similar values of strain.

Besides that, it was found that patch supports can work well if the tapestry has damage in a more discrete area, while full support showed good results in supporting the whole tapestry, even if stitching was not done through all the damaged areas. Similarly to one of Nilsson´s conclusions, stitching that passed through the areas of damage successfully prevented higher levels of extension and strain, while not completely preventing the damages from opening.

In summary, the existing research on conservation stitching techniques have presented key findings, especially regarding laid and brick couching. Nilsson found laid couching to be the strongest method, restoring silk's strength significantly, while the silk crepeline method was the most reversible. Maria Schön's work reinforced the idea that tight stitches cause fabric distortion, while longer laid-thread stitches were more effective, especially for horizontal tears. Sutherland and Lennard's studies further supported the idea that wider stitch spacing (e.g., 5 mm and 9 mm) offers more flexibility while still reducing strain, whereas tighter stitches (3 mm) restrict fabric movement, potentially worsening damage. Lennard's 2023 study also reinforced these conclusions, highlighting the importance of wider stitches for better flexibility without compromising support in tapestries. Overall, these studies emphasize the importance of choosing the right stitch length and spacing to balance support and flexibility while minimizing further damage to textiles.

2.3 Adhesives in Textile Conservation

Despite their somewhat controversial perception in the textile conservation field, adhesive treatments have a recorded history of use that dates back for a long time. For example, starch or modified starch have been used to consolidate very fragile textiles, just as thermoplastic adhesives (Timar-Balazsy & Eastop 1998, p.306). No matter the technique or adhesive used, this type of treatment seems to have been used in its majority as an alternative for when conservation stitching is considered to be too damaging for a fragile object (Hillyer 2024, p.305), an approach that can still be documented today.

On the other hand, as mentioned, past adhesive treatments haven't always been beneficial for the objects, something that greatly contributed to the hesitance surrounding their widespread use and recommendation. Numerous accounts of adhesive treatments eventually permanently altering some of textile´s key characteristics like their colour, flexibility or even accelerating their own aging have been recorded (Timar-Balazsy & Eastop 1998, p. 306; Jedrzejewska 1981, p.149). Some adhesives used in treatments have been known to become stiffer or insoluble, yellowing and embedded with dirt (Timar-Balazsy & Eastop 1998, p. 305-306).

The type of adhesive used has not always been the reason behind these failed treatments, however. Factors like application technique play an important role in the success and longevity of the treatment. For example, aside from the altering of the textile´s characteristics, a lot of objects have needed to be retreated years later due to adhesive bond failure, even when using chemically and physically stable thermoplastic adhesives. This was an especially common phenomenon following the 90's, after a more widespread acceptance and incorporation of adhesive treatments into more institutions, as described by Hillyer (2024, p.311). Aspects like the lack of complementary stitching, the overstretching of support fabrics prior to adhesive casting (mainly on nylon net) leading to eventual distortions and the use of excessive temperature in reactivations have been behind adhesive bond failure (Hillyer 2024, p.311).

Debates surrounding what constitutes a good adhesive treatment have also evolved with time. Already in 1967 Lodewijks described the need for adhesive treatments to have good resistance to aging poorly, as well as having good flexibility and being able to be removed or soluble after application. This was later complemented by Blums in 1983, who highlighted these characteristics but added the need for resistance to yellowing and the release of damaging components that could negatively affect the object or fade its dyes (Timar-Balazsy & Eastop 1998, p.306). The combination of several failed treatments with the general unfamiliarity with the technique and science behind it by most of the textile conservator community made it so that perceptions on it were very polarized (Lennard & Ewer 2010, p.145). However, the evolution of knowledge in the field and the publication of numerous scientific research, mainly about thermoplastic adhesives, led to a more widespread acceptance of the method (Lennard & Ewer 2010, p.145).

According to Hilyer (2024), in the past 20 years there has been a decrease not only of adhesive treatment research, but also adhesive treatments themselves. This is explained as reflection of the evolution of the perception of this technique as currently being less controversial due to establishing good practices and proper techniques (Hillyer 2024, p.311).

2.3.1 Adhesive Treatment Procedures

As described in the Textile Conservator's Manual and other scientific publications (Medina & Rogerson 2006, p.26), the main adhesive treatment application method generally implies the casting of an adhesive film either on its own or over a base fabric, generally a sheer overlay such as silk crepeline. Techniques on how to proceed with this can vary, but it is recommended that it is done over a non-stick surface, leading to the formation of a smooth film that can easily be released post drying. Landi claims that using thin gauge Melinex® as the support surface will lead to a flat smooth film, while teflon-coated glass cloth can create a more broken film (Landi 1997, p.121). Besides that, factors such as making sure there are no air bubbles are also relevant to good adhesive film formation. The casting can be done with a brush or paint roller and starting from the centre outwards can lead to a more even film (Landi 1997, p.121).

After letting the film dry and off-gas, it is placed on the intended area and reactivated, in order to promote adhesion to the textile. There are several ways to reactivate an adhesive, and it of course depends on the properties of the adhesive itself. The most common techniques are heat reactivation, which has been used since the 1950's, and solvent reactivation, appearing around the beginning of the 1990's (Medina & Rogerson 2006, p.26). According to Medina and Rogerson: "In this case, the adhesive, cast onto the fabric, is reactivated through the application of an organic solvent, which acts as a plasticizer on the polymer chain of the adhesive, moving it from a glass to an elastic state. As the solvent evaporates the adhesive solidifies, forming a high number of secondary bonds between the molecules of the adhesive and the molecules of the textile fibres." (Medina & Rogerson 2006, p.26).

All in all, the numerous different factors involved in the adhesive film making and reactivation process can make it so that conservators can utilize these to cater and adapt the object being conserved.

2.3.2 Lascaux 303HV:498HV

Lascaux 303HV is currently being used in replacement of the no longer produced 360HV due to their similar characteristics. By combining these two adhesives with different glass transition temperatures (Tg) it makes it possible to adapt characteristics like adhesion strength and film tackiness depending on proportion and concentration. The glass transition temperature is the temperature at which a polymer goes from its glassy to elastic state, meaning flexibility increases as well as stickiness (Timar-Balazsy & Eastop 1998, p. 403). Lascaux´s 303HV Tg is around 28ºC while 498HV is 6ºC, meaning that the bigger the proportion of 303HV in the solution (Timar-Balazsy & Eastop 1998, p. 407), the more sticky the adhesive will be prior to activation.

Besides adhesive proportion in the solution, other factors influence adhesive strength and longevity. A study by Karsten & Down (2005) compared the influence of concentration, reactivation time, pressure and solvent on the peel strength of Lascaux 360:498 films on silk substrates. The research also investigated the differences between heat and solvent reactivation. Among the conclusions was the fact that the combination of different variables could give similar results. For example, different solvents used to reactivate the adhesive could produce similar peel strengths by adjusting other variables like reactivation time and amount of pressure. Besides that, by comparing continuous films with films only coating the fabrics yarns, it was concluded that continuous films produced stronger bonds, up to eight times. Acetone was also the solvent producing the strongest bonds and in the fastest time frame and minimal pressure, while industrial methylated spirit (IMS) and heat lead to similar results. Lastly, it was discovered that increasing reactivation time was successful in increasing peel strength in all variations.

Similarly, Medina and Rogerson (2006) investigated the impact of adhesive concentration and reactivation techniques on aspects like peel strength, appearance, flexibility and removability.

A mixture of 1:2 (360:498 HV) Lascaux was tested on silk substrate, casted over silk crepeline. Contrary to the research mentioned before, heat reactivation was found to be the one producing the strongest bonds. However, the solvent reactivation technique used differed from the Karsten et al (2005) study, as they applied acetone and IMS with either a brush over the adhesive film or via cold poultice. It was found that solvent reactivation led to more uniform adhesive distribution in comparison with heat, as well as a less shiny appearance. When it comes to effects of different solvents, IMS-reactivated samples generally exhibited stronger adhesion than those treated with acetone, which the authors justified with the higher evaporation rate of the ladder, limiting the time for the adhesive bonds to develop. Removability tests showed that acetone, on both application techniques left more adhesive residue on the textile than IMS or heat reactivation.

The choice of solvent for a treatment isn't solely based on the performance of the resulting film, however. Certain solvents can have negative impacts on the objects, such as acetone, that can swell cellulose triacetate fibres and dissolve cellulose acetate, while alcohols may extract bound water from the structural proteins of wool. These uncertainties can sometimes limit the usability of a certain solvent (Medina & Rogerson 2006, p.31).

However, a study by Krejčí et al. (2021) provided new insights into this issue. In their research, the effects of solvents on protein-based textiles like natural silk and cellulose-based textiles like cotton were tested. Measurements of individual thread strength showed no significant negative impact from the tested solvents on either protein or cellulose fabrics (Krejčí et al. 2021, p.16). This finding suggests that, under controlled conditions, solvent-based adhesive reactivation or removal may not necessarily compromise textile integrity.

2.4 Support Fabrics in Textile Conservation

Landi describes the main objective of a support treatment as the ability to restore the object´s strength to a point where it could handle certain conditions of storage and display (1997, p.85). So, being aware of the kind of handling the object will be subjected to is key to understanding the amount of extra support it will need.

When it comes to the use of fabrics for additional support in textile conservation, most literature found is older and seems to be in agreement with each other, describing similar ideas and guidelines to follow. These ideas range from the use similar fabrics to the ones in the object to be conserved, composition wise and structure wise (Lennard & Ewer 2010, p.194) to how the fabric chosen should be sturdy enough to add strength but still remain pliant enough to not alter its drape too significantly (Flury-Lemberg 1998, p.169). All in all, there seems to be a general consideration to how the addition of this extra component might affect the object.

Ballard discussed how different textile fibres and yarn/fabric construction can alter the reinforcement characteristics of support fabrics (1995, p.1). The difference between natural and synthetic fabrics is also pointed out and how synthetic backing fabrics are generally not as affected by environmental changes such as relative humidity (Ballard 1995, p.1).

So, there has been a growing acceptance into using synthetic support fabrics due to aspects like this. They are described by Landi (1997, p.180) as being more appropriate to use in cases where adhesives are involved in the treatment or if the object will be exposed to light. The argument for a “like-with-like” mentality applied to support fabrics can be opposed by the knowledge that older textiles that have been subjected to degradation will react differently to environmental changes than a newer fabric added for support, even if these have similar structures and the same composition. Both Ballard (1995, p.1) and Landi (1997, p.179) discuss this, the former defending that the support fabric should therefore be stronger and less stretchy than the object it's supporting.

Regarding more specific scientific research into the performance of different support fabrics, the literature seems to be more limited, mainly focusing on tapestry conservation such as the research project by Hofenk et al. (1998) investigating the different performances of cotton and linen support fabrics. Another relevant study is one by Simpson where differently structured cotton fabrics were tested for abrasiveness, where it was found that satin weave fabrics removed more fibres by friction than plain weaved ones (1991, p.182).

When using fabrics for added support to an object, it usually means that one of the faces of it will be covered for the sake of this type of treatment, unless it is done in an object with several layers where the fabric can be slipped in between. This means that most of the ideas and discussed aspects cannot be fully applied to double sided objects. However, even when discussing regular cases, there have been concerns with obscuring part of the object, with Flury-Lemberg mentioning that support fabrics should be as transparent as possible, to allow the visualization and analysis of the backside (Nilsson 2015a, p.38).

On the other hand, literature on the use of sheer fabrics such as meshes as support fabrics is lacking, probably due to the fact that these materials are mainly used as protective layers and overlays in textile conservation (Fulkerson LaVallee 2005, p.1). The main concern surrounding these materials has been the potential of their structures to become imprinted on the object or their abrasiveness (Corah 1977, p.112). Aspects like low yarn count, open structure and mono-filament yarn have been found to be the reason certain tulle and mesh fabrics tend to be more abrasive (Fulkerson LaVallee 2005, p.17).

One relevant study is the investigation into the abrasiveness of different sheer overlay fabrics done by LaValle in 2005. The author chose several sheer fabrics based on a survey sent to textile conservators and tested them for aspects like elongation, coverability, fabric structure, abrasiveness, among others. After all the testing, knitted fabrics like nylon net were found to be more abrasive compared to woven ones like silk crepeline. Woven fabrics were also found to be the ones with the least stretch and growth under tension. Nonetheless, criteria like monofilament vs multifilament, type of filament yarn and type of knit structure did not seem to have an impact on abrasiveness. The most abrasive fabric tested was nylon net, while polyester georgette was the least abrasive, however, these also represent the fabric with the least cover and most cover respectively.

Another study that investigated the performance of different sheer overlays, particularly applied to adhesive treatments was done by Karsten & Kerr (2011). For the research, 6 different adhesives, among them Lascaux 360/498HV, casted over either nylon net, silk crepeline or polyester crepeline, were tested for peel strength. The article also discussed aspects like the film casting process, especially how different adhesives tended to fill the interstices of the fabric´s structure. Lascaux was documented as one of the adhesives that seemed to fill these interstices the most, even in more diluted solutions. Still regarding the Lascaux specimens, those prepared with silk crepeline were weaker than corresponding polyester crepeline, which diverged from the majority of adhesives tested, where nylon net specimens were the weakest. However, when tested for adhesive transfer, the nylon net showed the most amount of adhesive residue post peeling. This was explained by the fewer existence of points for mechanical interlocking for the adhesive because of the bigger size of the interstices as well as its composition of monofilament yarns.

2.5 2D Digital Image Correlation Applied in Textile Conservation

According to Constantini et al., Digital Image Correlation can be defined as "(...) a contactless optical technique that measures displacement and strain. This is done by taking successive images of the objects over time under various loading conditions and then analysing them through specific correlation-based algorithms." (2020, p.3). There are two types of DIC, 2-dimentional DIC, which analyses planar distortions by using one camera, and 3-dimentional DIC which also analyses out-of-plane distortions and is tracked with a pair of synchronized cameras (Lennard et al., 2023, p.3).

The algorithms used to track strain, and displacement may vary depending on the software being used, however, they generally divide the images into subsets, which are groups of pixels (Lennard et al., 2021, p.3). The position of these is then compared from the reference image to the images taken afterwards, to identify changes occurring in them. In order to do this, the software needs to be able to identify some kind of pattern in these subsets. This is normally done by applying a speckle pattern to the surface being tracked. This is essential to the success and accuracy of the tracking. Aspects like speckle size, randomness, isotropy and high grayscale contrast (Costantini et al., 2020, p.3) are important because each subset needs to have a considerable unique pattern in order for the software to distinguish them and do the correlation accurately. The appropriate size for a subset can be hard to establish (see Figure 1), since bigger sizes can lead to the loss of information and smaller sizes can lead to lower randomness which, in turn, affects the correlation (Lennard et al., 2021, p.3). According to Lovaas: "We need speckles that are at least 5 pixels in size with at least a 5 (around 1 mm) pixel spacing in order to resolve the speckles in the images." (2020). In a research project that employed DIC, a speckle pattern of dots with around 1mm was applied to the wool rep samples with a marker (Costantini et al., 2020, p.8). The research focused on the relation between relative humidity related creep and strain and the mechanical deterioration of tapestries (Costantini et al., 2020).

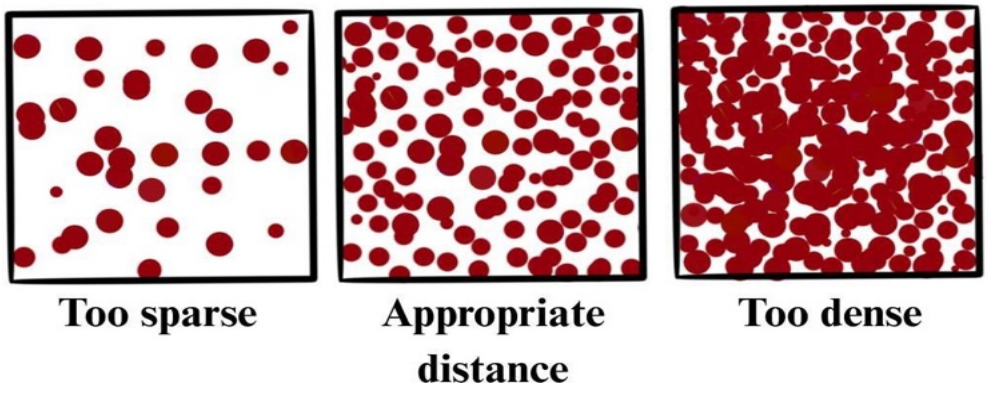

Figure 1. Examples of speckle patterns and tips for appropriate densities.

There have been some disadvantages documented for the use of this technique, however. Concerns with its accuracy have been discussed due to its dependency on the quality of the imaging system used as well as being less accurate than interferometric techniques (Pan et al., 2009). Similar concerns were lifted in Lennard et al.´s 2021 research project, where 2D DIC was deemed not appropriate to track strain in tapestries with undulating surfaces, as the software is not able to detect the out of place deformations. For cases like this, 3D DIC was advised (Lennard et al., 2021, p.3).

Nevertheless, DIC, both 2D and 3D have been used in textile conservation research and have proved to be a useful tool to measure and track strain and displacement. One of the first instances of using this method on textile research was on a 3 year-long project at the University of Southampton, which focused on investigating the strain behaviour of different areas of a tapestry (Lennard et al., 2011). Aside from using optical fibre sensors and other strain measuring techniques to validate the data generated by the DIC, the research also sought out to set some parameters regarding aspects like choice of cell size and camera settings. In the end of this collaboration between conservators and engineers, DIC was proven to be an accurate tool for strain analysis, even making it possible to detect strain not visible to the naked eye and generating intuitive strain maps for easy problem-area detection.

Another recent study highlighting the potential of this tool for textile conservation, specifically applied to tapestries was Lennard et al.´s 2023 research. It focused on using DIC to evaluate the performance of different tapestry stitching support techniques. Among the conclusions was that there is a correlation between damage and high displacement and strain values. Besides that, it was found that while overall global strain was more related to relative humidity values, specific local strain was more influenced by duration of hanging (Lennard et al., 2023, p.7). This study was another instance of highlighting the potential of DIC as it can allow to track historic tapestries without the application of a speckle pattern but instead by setting up the software to track patterns in the object itself.

3. MATERIALS AND METHODS

3.1 Sheer Support Fabrics

This project will focus on three different sheer fabrics: silk crepeline, nylon net and polyester net used as support to structural damage in cotton mock-up samples.

The silk crepeline used was from CTS Conservation and is an undyed, unprimed and 100% silk plain-weave fabric with a density of 10g/m2. The polyester tulle was a 100% polyester "invisible illusion tulle" from MacCulloch & Wallis Ltd. Lastly, the nylon net was the #N8000 from Dukeries Textiles and Fancy Goods Ltd, UK. It has 20 denier and is monofilament net.

Silk crepeline was selected due to its common use in textile conservation. Some of the advantages of this material is the fact it has no additives and is very light (Cotte 2007, p. 6), making it compatible with silk objects, which usually are in most need of added support or a protective layer. Besides this, it's easily dyeable which makes it a great overlay option, being easy to conceal and not very visually disturbing (LaVallee 2005, p.6). On the other hand, as it is considerably harder to manipulate and work with, as well as usually being more expensive, it is not always the best option. As silk is susceptible to photodegradation, silk crepeline is also not advisable to be used on objects that will come in direct contact with light. Concerns about compatibility can also be raised if silk crepeline is used on non-silk objects, especially when wet treatments are involved.

Nylon net is more commonly used in conservation as a cover for textiles while they are being wet washed, to avoid the extensive loss of fibres (Landi 1997, p.145). Its dyeability, transparency and workability make it an option for support of certain textiles. However, attention should also be taken to characteristics like its abrasiveness. lower strength (Fulkerson LaVallee 2005, p.91) and problems with long term ageing and degradation especially associated with light (Lennard & Ewer 2010, p. 195).

Lastly, the polyester tulle was chosen as an attempt to start to explore potential replacements for Tetex®/Stabiltex® as this material is no longer in production. Tetex® (also marketed as Stabiltex®) is a monofilament polyester plain weave fabric, similar to crepeline in density and structure. According to the literature review, there is a noticeable gap in research on finding suitable alternatives for this material. This can be an issue because, without a reliable and tested polyester netting material available for conservation, conservators are often forced to use less compatible or appropriate materials for specific treatments, resorting to saving leftover Tetex® in their institutions for limited use. As the chosen fabric for this study isn´t woven like Tetex®, it is more an attempt to find a sheer polyester option. Having a polyester option for sheer support fabrics is advantageous due to this material being more durable and resistant to environmental changes and chemical attacks (Fulkerson LaVallee 2005, p.12). A disadvantage of this material is its poor dyeability, limiting its uses to objects compatible with the available colours produced by the manufacturer.

3.1.1 Fabric Structure Analysis

Microscopic pictures of the sheer fabrics themselves were taken to evaluate their inherent structure. These were captured with the Dino-Lite Premier Digital Microscope in the model AM7013MZT with a magnification of 50x (see Figures 2-4).

According to the information provided by the manufacturers as well as the analysis of the Dino-Lite digital microscope pictures information about the tested fabric´s structure was gathered. The silk crepeline is the only woven fabric with an open plain weave, while the polyester tulle and the nylon net are both knitted meshes. The polyester tulle is a warp-knitted with a diamond shape and the nylon net is also warp-knitted with a hexagonal shape. When it comes to yarn characteristics of the fabrics, it was not possible to collect information about the polyester tulle. However, both the silk crepeline and the nylon net are both made with multi-filament yarn.

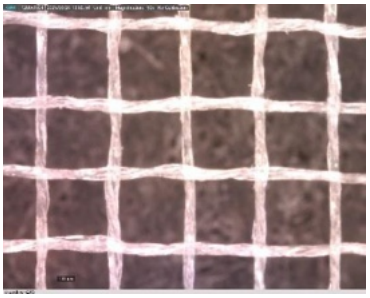

Figure 2. Silk Crepeline

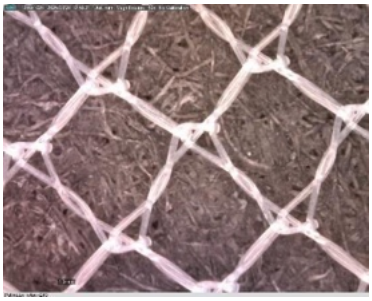

Figure 3. Polyester tulle

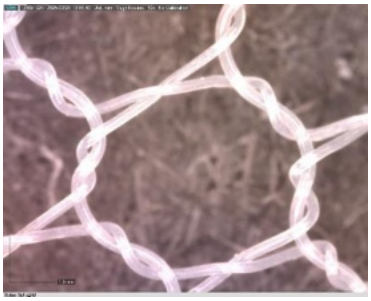

Figure 4. Nylon Net

3.2 Lascaux 303:498 Adhesive and Laid-Thread Couching

When it comes to the adhesive, the hydroxypropyl cellulose adhesive, Klucel G and the butyl methacrylate's Lascaux 303HV and 498HV were considered, not only because of their widespread use in textile conservation, but also because of the author´s previous experience with both. Even with Klucel G´s popularity due to its´ water soluble and matte appearance characteristics (Hillyer 2024, p.312), it ended up being discarded due to reports of weak adhesive bond and over ease in removing (Krejčí et al. 2021, p.10; Medina & Rogerson 2006, p.26), which aligned with previous experiences the author had with the adhesive. So, a combination of Lascaux 303HV and 498HV which is an acid free thermoplastic acrylic adhesive was selected.

A 15% solution of Lascaux, prepared in a 1:2 ratio of Lascaux 303 to Lascaux 498, was selected for the experiment. This formulation was chosen based on initial testing, which indicated that it provided adequate strength and compatibility across all sheer support fabrics used. The selected ratio produced an adhesive that was sufficiently tacky to remain in place during activation while maintaining flexibility and ease of application.

Regarding the stitching technique selected to attach the support fabrics to the samples, based on the literature review and reported positive results, laid-thread couching with 5mm spacing was selected.

3.3 Experimental design and analyses

In order to answer the research questions, different methods were employed. To understand what strategies are being used to treat structural damage to double-sided textile objects, a survey was sent out to textile conservation professionals. To answer the remaining questions about how different combinations of sheer support fabrics and attachment methods affect visibility, damage support and strain behaviour, practical experiments were conducted. A fixed-load test was done for the duration of one week (approximately 167 hours) on mock-up cotton samples made with the selected sheer support fabrics and 2 distinct attachment methods, conservation stitching and an adhesive treatment. This test was tracked with 2D digital image correlation and was repeated 3 times.

The experiment was conducted with the expectation of comparing the different backing fabrics as well as different combinations with the two attachment methods with each other. These samples were also compared to a control sample meant to represent a more generally applied conservation treatment, a cotton backing patch attached with stitching. The comparison was made in regard to strain and displacement distribution as well their average values after 167 hours of constant stress. This data was obtained through the 2D DIC software used, Ncorr. Besides that, the samples were also compared when it comes to the appearance of any new damages or deformation post fixed-load testing, something that was assessed through visual analysis and Dino Lite images.

To further analyse the impact of the different support methods tested on the visual component of an object, additional tests were made on an old semi-transparent lace curtain fragment to compare each of them visually. This component was also included to allow for an easier visualization of how these methods could be applied to real objects.

3.4 Experimental Design

The experimental design was set up with the independent and dependent variables in mind. The main independent variable was the different sheer support fabrics used as patches for the damage stabilizing treatment.

As the choice of support fabric is only one factor that can affect the success of a damage-stabilizing treatment, another independent variable was introduced: the attachment method. To limit the possible variables, only one type of stitching was used (laid-thread couching) and one concentration ratio of the chosen adhesives, see Table 1 for the independent variables and sample names.

One factor of importance was the type of damage being treated between the possible structural damages that can appear in textile objects. One type of damage was selected, a square hole, in order to be as reproducible as possible.

Table 1. Variables, replicas and naming of the samples.

Support fabric	Attachment method	Replica	Sample name
Silk Crepeline	Laid-thread couching with 5mm spacing	1	STCRE1
		2	STCRE2
		3	STCRE3
	15% Lascaux 303:498 (1:2)	1	ADCRE1
		2	ADCRE2
		3	ADCRE3
Polyester Tulle	Laid-thread couching with 5mm spacing	1	STPOL1
		2	STPOL2
		3	STPOL3
	15% Lascaux 303:498 (1:2)	1	ADPOL1
		2	ADPOL2
		3	ADPOL3
Nylon Net	Laid-thread couching with 5mm spacing	1	STNYL1
		2	STNYL2
		3	STNYL3
	15% Lascaux 303:498 (1:2)	1	ADNYL1
		2	ADNYL2
		3	ADNYL3

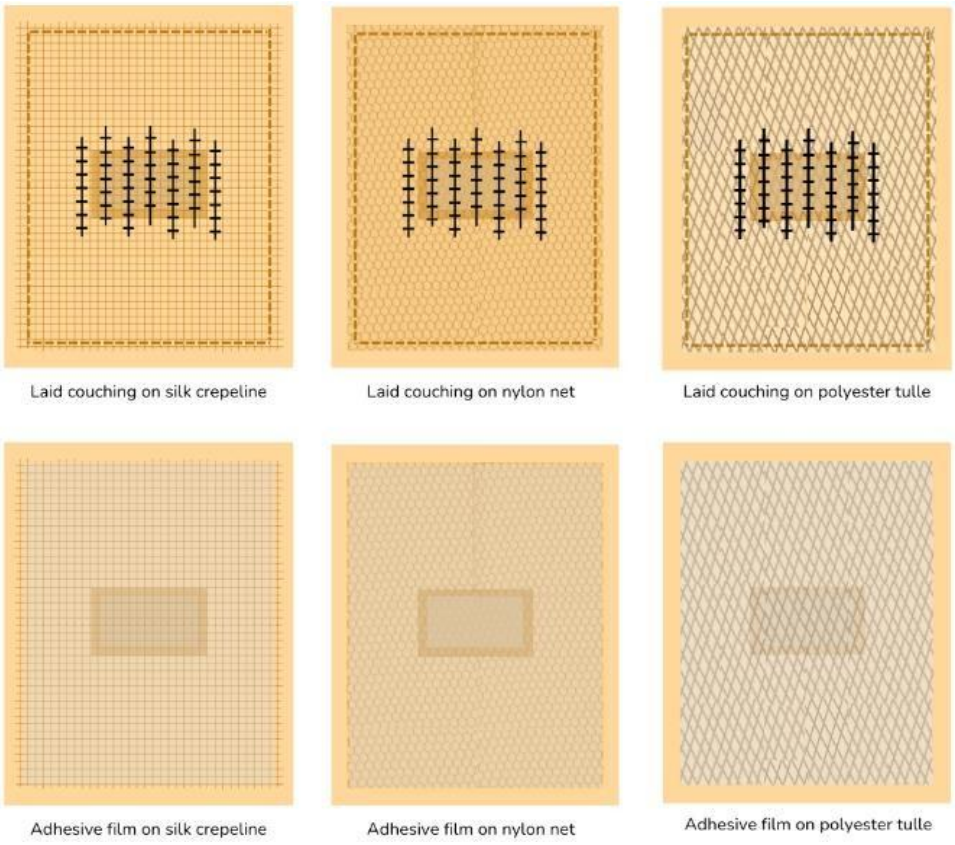

Figure 5. Diagrams of the mock-up samples

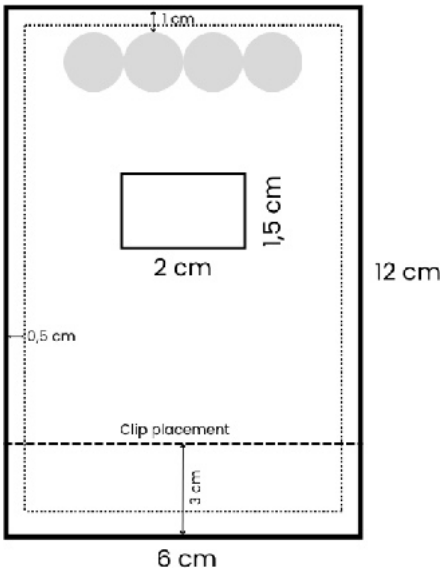

Figure 6. Measurements of the mock-up samples

The mock-up samples were made by the author in a standardised way according to the diagram shown in figure 5 and 6.

An important factor that could influence the experiment was fluctuations in RH and T in the room it was being conducted. The experiment was carried out in a laboratory in the university with relatively stable RH and T values, however, unpredictable times the doors would be open or different colleagues being in the same room could influence these values. On the other hand, since all the different independent variables were being tested simultaneously, these fluctuations affected all of the samples simultaneously still allowing for a reliable comparison across the same replica samples.

3.5 Survey

In order to better understand the issue of conserving double-sided textile objects and gain insight into the practices currently being used by textile conservators a survey was sent out to the Textile Working Group from the International Council of Museums - Committee for Conservation (ICOM-CC) and the Swedish Association for Textile Conservation (Svenska föreningen för textilkonservering, SFT). Between the 2 groups, the survey reached around 340 people.

The survey had 10 questions regarding which types of damages are most common on double-sided textile objects, experiences with them, treatments performed and asked for suggestions on how to treat hypothetical objects. The survey was available online from middle of February to middle of April 2025. A full transcript of the survey can be found in Appendix 1, as well as a link to a video made to clarify the definition and examples of double-sided textile objects.

3.6 Fabric cover calculation

Based on the research done by LaVallee (2005), the percentage of coverability was also calculated for each support fabric. By visually analysing the area covered by the netting versus the open space of the fabric, the percentage of coverage can be calculated. This test will offer insight into how much the netting actually covers the object and possibly correlate to how each mesh fabric affects the object visually.

The microscope pictures of the same sized area of the fabrics were edited in software *Procreate* to generate a duo-toned black and white images. These images were then processed in the *Image Color Extract* website by *Cool PHP Tools*[1] which indicates the percentage of each colour present.

3.7 Oddy Testing

Due to the lack of information on possible additives or treatments used on the polyester tulle fabric from the manufacturer, a 4 g sample of the material was sent out to the Swedish National Heritage Board (*Riksantikvarieämbetet*) for Oddy-testing. The test used copper, silver and lead coupons and the material was tested for 28 days at a 60º C temperature. At the Swedish National Heritage Board, the British Museum procedure for Oddy testing (AIC 2024) is conducted.

3.8 Fixed-Load Test with 2D Digital Image Correlation

A fixed-load test with 2D Digital Image Correlation was selected as a method to evaluate the different combinations of support fabrics and attachment methods mechanically. The design of this experiment was made inspired by the practical experiments conducted in Schön´s bachelor´s thesis (2017) and the research project by Lennard et al. (2023).

A fixed-load test is a mechanical assessment method used to evaluate a material or treatment's ability to withstand constant tension or stress over a defined period of time. In conservation contexts, this type of testing helps to simulate the strain that objects experience due to their own weight during extended display or storage. In this study, the fixed load test was employed to assess the performance of the different treatments and sheer support fabrics under long-term exhibition conditions. Although actual exhibition periods can last for months or years, this test was designed with an exaggerated weight and a shorter time frame to accelerate the observation of potential deformation or failure. Each sample was subjected to constant stress for a total of 167 hours (approximately one week). A fixed load of 120 g (~1,18 N) was applied to each specimen. This weight was suspended from the specimens by being attached to office clips with magnets (see Figure 7).

Eight specimens were tested simultaneously, and the experiment was repeated three times. Each specimen was secured to a vertical whiteboard using four magnets near their top edge. To further prevent slippage, adhesive tape was also applied along the top of each sample (see Figure 7).

[1] [1] https://www.coolphptools.com/color_extract#demo

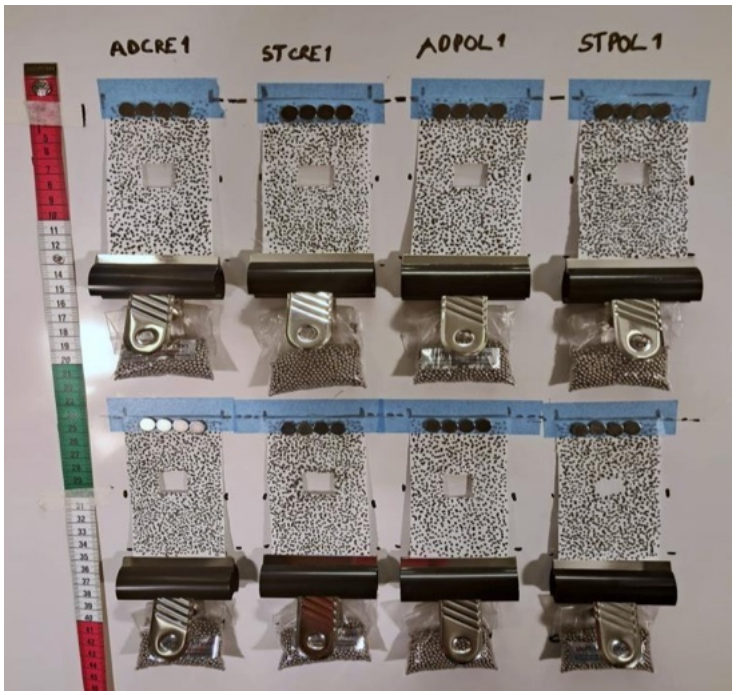

Figure 7. Mock-up samples attached to the whiteboard during fixed-load testing.

Digital Image Correlation (DIC) is an optical technique that uses digital images captured consecutively from a single camera to measure strain and displacement. A software then breaks each image into sections which are groups of pixels, tracking how these move relative to their initial positions. The key to this process is the presence of a distinguishable surface pattern, typically a speckle pattern applied to the specimen, which allows the software to track the motion. For this experiment, a permanent black marker was used to make dots on the samples to act out as the speckle pattern. This method has been used successfully in other textile conservation based 2D DIC studies (Lennard et al., 2023).

Figure 8. Speckling of the cotton substrate with permanent black marker.

Figure 9. Sample with complete speckling.

A Sony Alpha 7II DSLR camera was set up on a stable tripod 1,5 m in front of the board where the samples were subjected to the fixed load test. It was used to take periodic pictures to track

the progress of the speckle pattern and be processed by the 2D DIC software. Throughout the week, 11 pictures were captured, one before the weights were placed on the samples and one after 1 minute of the weights being placed. The remaining pictures were taken after the following hours: 5 hours, 10 hours, 24 hours, 30 hours, 48 hours, 72 hours, 96 hours, 100 hours and 167 hours. Due to laboratory accessibility constraints, it was not possible to capture images during the weekend, which explains the bigger gap in time between the two last pictures. In order to get more even lighting on the whole surface of the whiteboard, two halogen lamp spotlights were used, placed at an approximately 45º angle at around 0,5 m.

For the processing of the images on the 2D DIC software, the first picture was used as the reference picture and the region of interest (ROI) was manually drawn in *Microsoft Paint* and uploaded to the program. A calibration to convert pixels into millimetres was done during the formatting of the displacements, by drawing a line with a known distance of 60 mm. The different parameters used to process the data are described in Table 2.

Table 2. Parameters used for photo processing during 2D DIC analysis.

2D DIC PARAMETERS	
Subset radius	30
Subset spacing	10
Number of threads	1
Number of regions	8
Number of seeds per region	1
Strain radius	5

In general, the DIC technique provides two main types of data: quantitative and qualitative. Quantitatively, it can measure strain and displacement values. Qualitatively, it generates local strain and displacement maps, offering a visual representation of how the specimen behaves under the weights, also allowing for the identification of problem areas. Strain is a mechanics concept that indicates relative deformation in relation to a reference position. It is a dimensionless unit, but the higher the value, the higher tensile strain it indicates. As it indicates relative deformation, it's related to displacement, which indicates measurable deformation.

For this study, the Matlab based software, Ncorr, was used to process the 2D DIC data. It was selected due to it being open-source and having intuitive set-up. Besides that, it was corroborated by a study that compared its´ results with Strain Gauge, a conventional method to measure strain (Ali et al., 2016). It was found to be a high reliability method with a relatively lower cost than most strain measuring methods (Ali et al., 2016). This paper, along with the Ncorr´s user manual found on its´ official website were the main resources used to operate the software.

It gives two distinct sets of data pertaining to strain or displacement. One of them is a diagram showing the strain or displacement data through a colour gradient going from blue to red, blue indicating the lowest and red the highest value. This allows for a visualization of where the tension or displacement is distributed through the samples.

For these plots, the higher the number and, consequently the darker the red colour shown, the higher the tension or deformation in millimetres being represented in the diagram. Since the experiment consisted in fixed load testing, only the vertical strain (Eyy strain plot) and displacement (V-displacement) will be analysed and discussed.

This software does not provide average strain and displacement quantative data, instead providing the values of each point in the monitored areas. It is also possible to extract this data and manually calculate the average strain and displacement in a software like Microsoft Excel. This was done to calculate the average strain and displacement of each sample after 167 hours of fixed load testing.

Aside from average final strain calculations, with the intent of analysing the progression of average strain throughout different points of the fixed load test, calculations of the average strain from each individual picture were made. These were then plotted together in a line graph for better visualization. Due to time constrains, this was only done for the first batch of samples tested in the experiment.

3.9 Dino-Lite documentation

To complement the fixed load test with 2D DIC, photographs were taken before and after the test, in order to track any damages or structural changes in the samples. These images allowed for the close examination of any surface deformations, fibre damage, or alterations to the weave structure. These photos were taken both with a smartphone camera and a Dino-Lite Premier Digital Microscope in the model AM7013MZT with a magnification of 6.8. For the Dino-Lite pictures, specific points were chosen for the documentation, according to the diagram below.

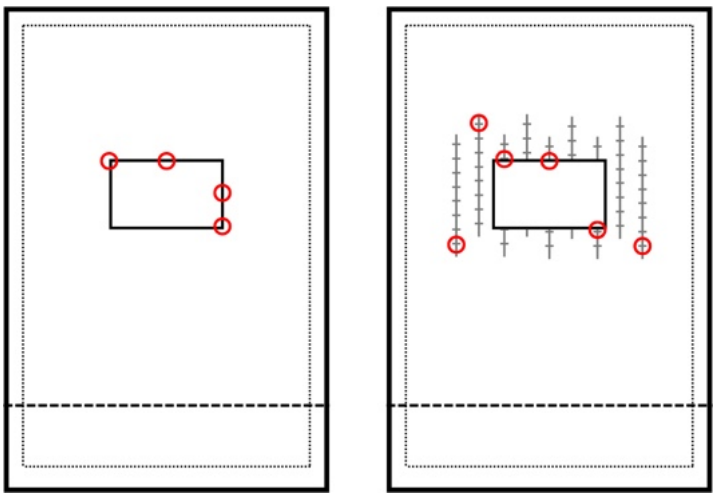

Figure 10. Diagram with the areas documented with the Dino-Lite Digital Microscope, illustrating adhesive samples on the left and stitched samples on the right.

To make sure the after pictures reflected actual permanent damage, these were captured a week after taking each batch of samples out of the fixed-load test.

3.10 Visual Comparison of real object samples

For the visual comparison of the lace samples before and after pictures were taken in the department´s photography studio using a Sony Alpha 7II DSLR camera. Two spotlights were used on level 6 with a diffusing box. These spotlights were placed at an approximately 45º angle at around 0,5 m from the table the fragment was placed.

In order to make conclusions about the visual impact each technique had on the lace a subjective visual comparison was made not only between the before and after pictures of the same area but also between the different areas themselves. Based on Nilsson´s research (Nilsson & Östen, 2015), visual aspects like coherence and discernibleness were considered in this comparison.

3.11 Specimen preparation

3.11.1 Cotton Substrates

Plain-weave, unbleached cotton fabric was selected as the primary substrate. It was acquired from Textilhuset Swelogent in January 2025 and has a density of 155g/m2.

The fabric was washed in a 0.3% solution of Orvus WA paste to remove any sizing or surface contaminants. After air-drying, the cotton was ironed to remove creases and subsequently cut into rectangular specimens measuring 12 × 6 cm. A controlled, reproducible area of structural damage was simulated by cutting a rectangular hole measuring 2 × 1.5 cm in the centre of each cotton specimen using a scalpel. It is recognized that this type of damage is not usually naturally occurring in textile objects, however it was selected due to its easier reproducibility.

3.11.2 Sheer Support Fabrics

All selected sheer support fabrics were similarly washed with a 0.3% solution of Orvus WA paste and ironed before use. They were cut into pieces measuring 11 × 5 cm before being attached to the substrate.

For silk crepeline, the warp direction was identified by locating the selvedge edge. The pieces were cut with the warp aligned vertically, as the warp threads in the structure are less elastic than the weft, which would prevent stretching during the test. This configuration matched the cotton fabric, which was also cut with the warp aligned vertically.

In the case of polyester tulle, which has a knitted diamond-shaped open structure, the fabric does not have a traditional warp and weft. However, the long axis of the diamond shape, which typically corresponds with the roll length, was aligned vertically to act as a functional warp.

For nylon net, which features a hexagonal mesh structure, the warp threads are on the diagonal sides of the hexagons. Ideally, aligning the warp direction with the main stress direction would require cutting the fabric on the bias. Due to time constraints and practical limitations, this was not done. Instead, the roll length was used as the functional warp.

3.11.3 Adhesive samples

Adhesive samples were prepared by first creating adhesive films on the sheer support fabrics. Before application, the sheer fabrics were lightly humidified using a damp towel to promote adhesion to a polyethylene plastic film, which was secured to the worktable with tape. The humidified sheer fabrics were arranged as desired, taped onto the plastic sheet, and then coated with the adhesive using a small paint roller. To approximate the same thickness of film on every support fabric, the same amount of adhesive was applied on all of them, 2,5ml. Besides that, each piece was rolled twice to ensure even application and then left to off gas for 48 hours.

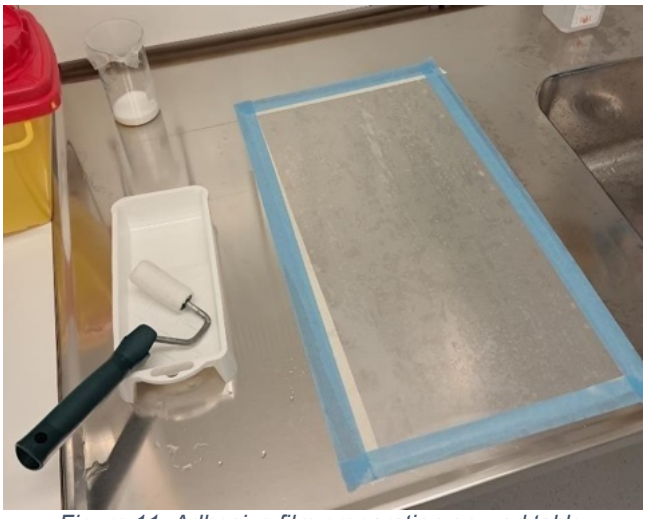

Figure 11. Adhesive film preparation on worktable

To activate the adhesive and adhere the sheer fabric to the cotton substrate, a solvent vapor reactivation system was employed. A piece of blotting paper dampened with a solution of 95 parts ethanol, 4 parts methanol, and 1 part water was placed on top of the adhesive-coated sheer fabric positioned over the cotton specimen. This solution was opted for as it is a substitute for industrial methylated spirits (IMS), a solvent that was recommended in literature (Karsten & Down, 2005; Medina & Rogerson, 2006).

This paper was then covered with a sheet of Melinex® and a glass plate with 360 g of weights for three minutes, a time frame that has also been mentioned in literature (Karsten & Down, 2005). After this initial activation period, the blotting paper and Melinex® were removed, and the glass plate with the weights was left in place for an additional 10 minutes to ensure proper adhesion.

Figure 12. Adhesive activation

3.11.4 Stitched samples

Stitched samples were prepared using polyester Mara 120 thread in a light grey colour. A custom template was used to mark the beginning and end of each long stitch, ensuring a consistent spacing of 5 mm. Shorter, horizontal stitches were checked routinely to maintain approximately 5 mm spacing, however minor variations occurred to better reflect conditions found in actual conservation practice.

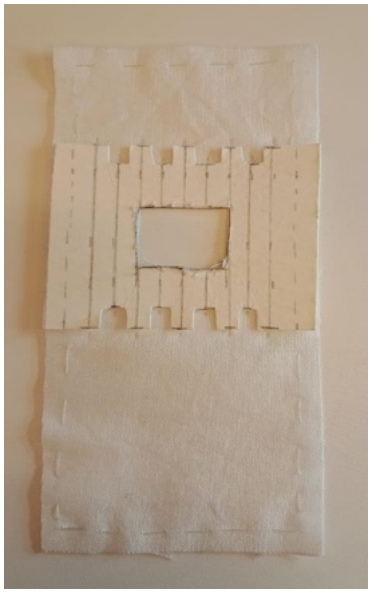

Figure 13.Template for stitched samples

Figure 14. Stitched nylon net sample, prior to speckling

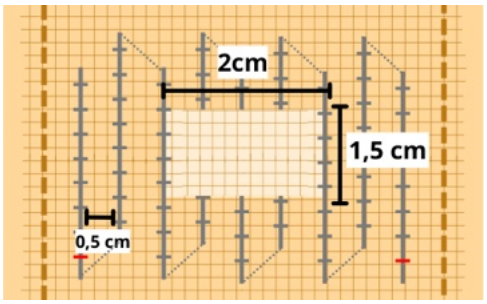

Figure 15. Stitching samples guideline/standard, start and stop points marked in red

Stitching was performed around the hole and no stitches were placed directly over the cut-out and the exposed sheer support fabric in order to avoid excessive visibility of the stitching or the risk of fabric distortion during fixed load testing. All start and stop points, done as backstitches, were made in the same location across all samples to ensure consistency.

3.11.5 Control Specimens

Two types of control specimens were prepared. Specimens with the cut-out damage but no intervention, were used to assess the mechanical performance of the damaged substrate. Besides that, specimens treated with a traditional cotton support patch applied on the back and secured with laid-thread couching were also made. The stitching on this sample was done in the same way as the other stitched samples in the experiment.

3.11.6 Lace fragment tests

A semi-transparent cellulose-based lace fragment from a curtain belonging to the Conservation Department´s collection was used to perform additional visual comparison.

Since the fragment was considerably yellowed, and there was not enough time to dye each support fabric to a suitable matching colour, the lace was instead bleached with a 0,25% solution of calcium hypochlorite. The fragment was left submerged in the solution for 15 minutes, rinsed three times and then left to dry on the worktable for 24 h.

By bringing the object to a closer colour of the support fabrics, these would be less discernible and blend in with the object more, something that is often sought out for in conservation treatments.

Figure 16. Lace fragment, before bleaching

Figure 17. Lace fragment, after bleaching

The fragment was divided into 6 sections where both square holes and smaller circular holes were made using a scalpel. Since this material wasn´t going to be put through any type of mechanical testing, merely a subjective visual comparison, the production of these damages was not as standardized as the cotton samples. These were made in similar areas across the fragment and were kept to an approximate similar size.

Three of these areas were treated with each of the support fabrics prepared with an adhesive film of 15% Lascaux 303:498 (in a proportion of 1:2). These were prepared and activated in the same way as the cotton mock-up samples.

The remaining areas were treated with each of the support fabrics and laid thread couching with 5 mm spacing. The stitching was done with beige silk thread. Since the size of the holes differed from the cotton mock-up samples, the stitching was adapted to their size and shapes.

4. RESULTS

4.1 Survey

The survey received a total of 14 answers. Due to time constraints, it was not possible to resend the survey to other conservators' groups in order to get more replies. A full transcript of all the obtained answers can be found in the Appendix 2.

The respondents consisted of 7 museum conservators, 6 free-lance or private conservators and 1 student. Most of them had more than 10 years of experience on the field (9 answers) and the remaining had either less than 5 years or between 5 to 10 years. Most of the respondents have dealt with double sided objects, with the majority mentioning flags/banners and 4 mentioning embroideries.

Table 3. Information regarding the respondents of the survey

Employment situation	Respondents	Experience	Respondents	Experience w/ double-sided textiles	Respondents
Museum conservators	7	**Less than 5 years**	4	**Yes**	10
Free-lance/self employed	6	**5 to 10 years**	1	**No**	4
Student	1	**More than 10 years**	9		

When asked about the main challenges involved in dealing with these types of objects, the respondents mentioned the need to adapt the support fabric normally used in order to maintain visibility on both sides of the object. Some have also mentioned the difficulty in choosing which side to add this support fabric to, even when using sheer overlays, due to the inevitably of altering its appearance. Factors like uncertainty of where to place hanging systems and of how to deal with incomplete parts were also brought up.

Regarding the most common types of structural damages seen in these objects, all respondents mentioned holes, followed by wear and tear and loss of warp/weft threads. One respondent added “inappropriate or disfiguring past treatments” as a typical type of structural damage.

The types of treatments to structural damages done to these objects by the respondents ranged from using sheer fabrics such as silk crepeline on one or both sides attached by stitching or adhesive; using an adhesive soaked patch or threads to infill or give additional support; or even a regular treatment, using an opaque backing fabric supported by laid-thread stitching. As for the type of stitching used, the respondents were not very descriptive, but there was a mention of a staggered type of stitch, potentially brick couching. On the other hand, the mention of encasing the object between 2 layers of some kind of sheer fabric (sandwiching) was a popular response. When mentioning adhesive treatments, all respondents, with the exception of one,

recommended some kind of supplementation with stitching, to ensure the adhesive patches would stay in place.

On the hypothetical treatment question, the results were similar, with a preference to stitching as a way to attach sheer support fabrics. When it comes to the types of materials mentioned, silk crepeline had four mentions, nylon net had two and all other respondents mentioned an unspecified type of netting or tulle. One respondent also mentioned Japanese paper as a possibility for support material. Sandwiching the object was, once again, a common response, being mentioned four times. Lastly, some respondents also recommended the use of a smaller, close to size of the loss patch to complement the sheer support fabric and act as an infill.

4.2 Fabric Cover Calculation

The ratio of open space to yarn was calculated and the percentage of covered area is presented in the table 4. The area corresponds to 49,6 mm ^{2}.

Table 4. Percentage of yarn of each support fabric in an area of 49,6mm ^{2}.

Sheer support fabric	Percentage of yarn
Silk crepeline	37,3%
Polyester Tulle	26,7%
Nylon Net	25,7%

4.3 Oddy Testing

The Oddy-Test from the polyester tulle sent to the Swedish National Heritage Board indicated that the material is suitable for long-term conservation use, as it passed on all three coupons used.

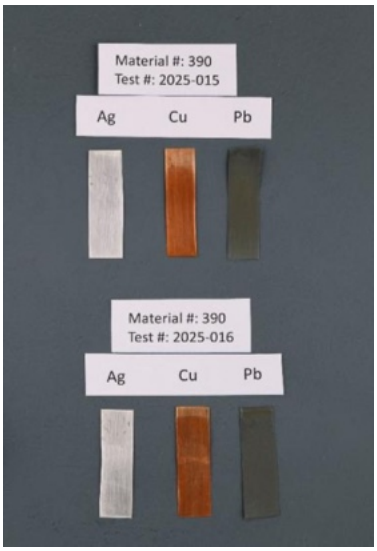

Figure 70. Oddy test results of polyester tulle sample. Photo taken by Elyse Canosa.

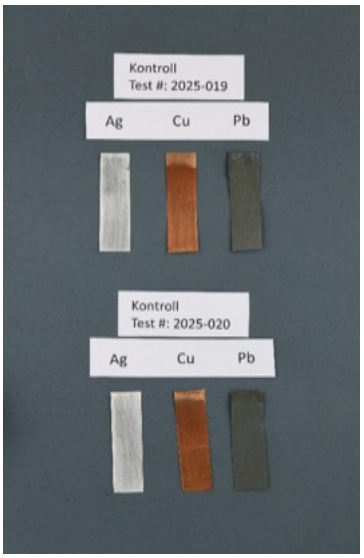

Figure 71. Oddy test results of control. Photo taken by Elyse Canosa.

4.4 Fixed-Load Test with 2D Digital Image Correlation

By analysing the Eyy strain plots of all batches, it's possible to conclude that the untreated control sample had areas with one of the highest values of strain, mainly concentrated on the sides and around the vertical edges of the hole (Figure 18-20). This is followed by the adhesive nylon net samples, with the highest tension located in the same areas. The adhesive polyester tulle samples, however, show a high-tension area going from the top corners of the sample to the top corners of the hole, something that is not as accentuated in other specimens (Figure 19-20).

When it comes to the adhesive and stitched silk crepeline samples, these presented not only the lowest tension but also the most uniform distribution of strain, only showing higher strain areas around the edges or corners of the samples. Both of the attachment methods also showed very similar strain maps, unlike the other support fabric samples where clear distinctions could be seen depending on attachment method employed. For the polyester tulle and nylon net samples, the adhesive samples showed areas with more accentuated tension compared to their stitched counterparts.

In general, all the repeats of the experiment produced comparable results, with the exception of some deviations. For example, in the second batch of samples the adhesive crepeline sample presented two areas with higher tension near the top and bottom edge (Figure 19). Besides this, even though the distribution of tension was similar in repeat samples, the level varied slightly. This was more prominent with the adhesive nylon net samples and the untreated control sample, where in the third batch (Figure 20) presented considerably darker red areas.

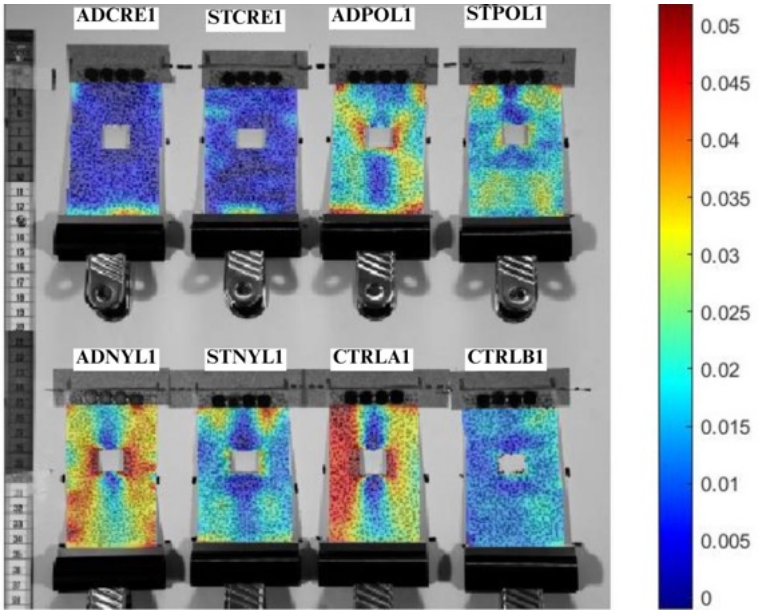

Figure 18. Eyy strain plot of first batch of samples after 167 hours of fixed load testing.

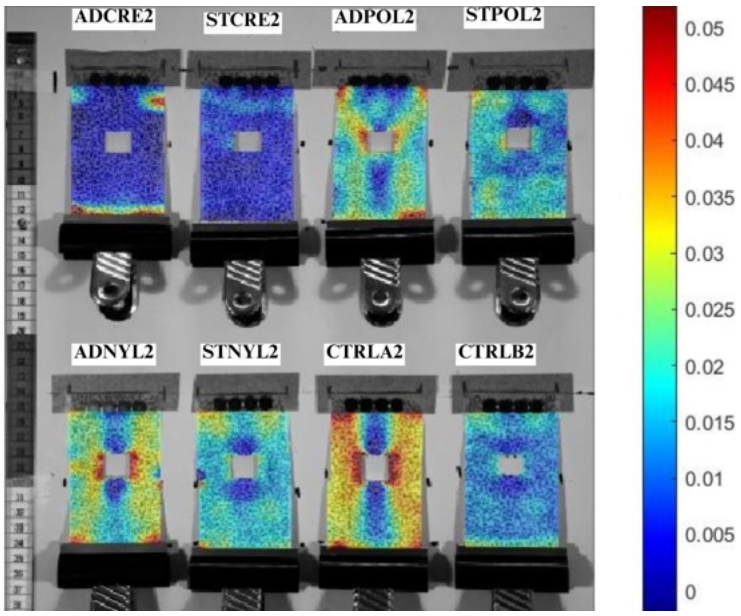

Figure 19. Eyy strain plot of second batch of samples after 167 hours of fixed load testing.

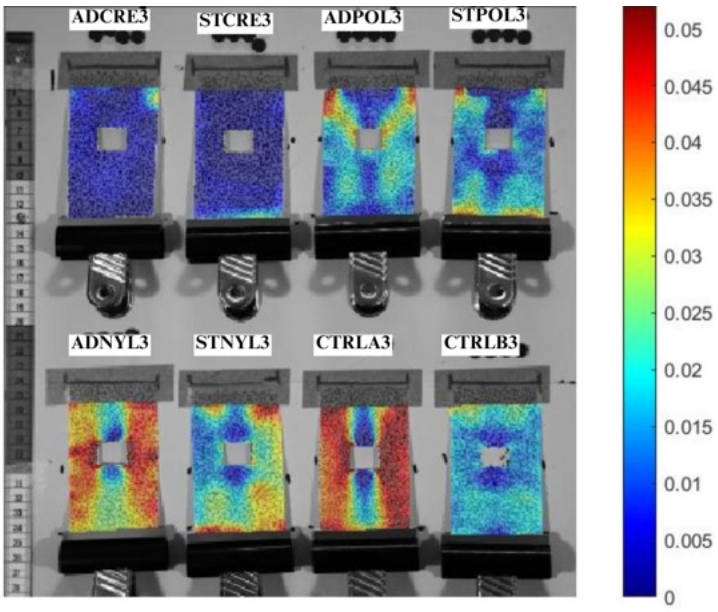

Figure 20. Eyy strain plot of third batch of samples after 167 hours of fixed load testing.

Moving on to the final average strain, the adhesive nylon net sample was the one that presented the highest values, with the exception of the second batch where the untreated control sample was the highest. The adhesive silk crepeline samples were the ones with the lowest average strain, being followed by the stitched silk crepeline samples and the stitched cotton control samples across all batches of the experiment.

For both the polyester tulle and nylon net specimens, the adhesive samples showed higher average tension in comparison with their stitched counterparts. When it comes to the silk crepeline samples, their values were very close, but the stitched samples showed slightly higher average strain. The difference between the adhesive and stitched samples in the silk crepeline reaches around 0.001 ε, for the polyester tulle it reaches 0.002 ε and for the nylon net it reaches around 0.0136 ε.

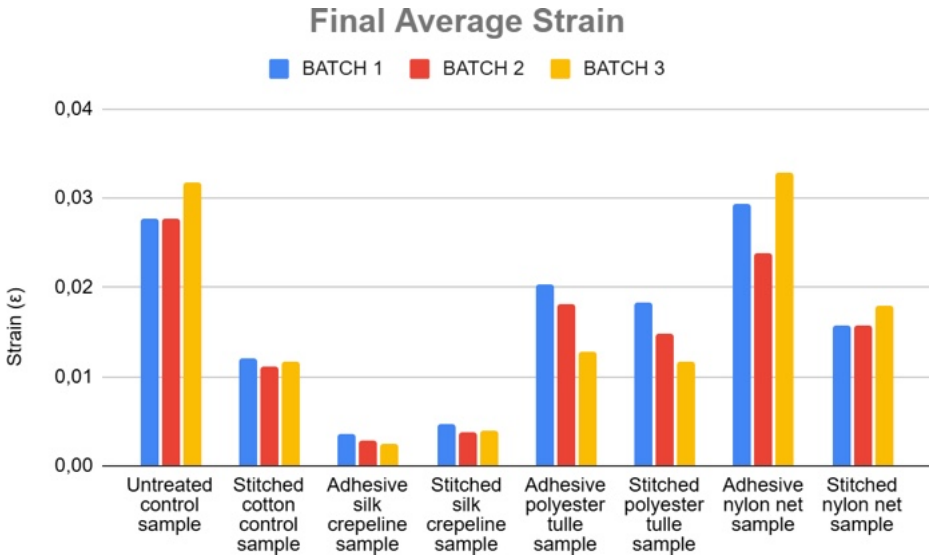

Figure 21. Final average strain (ε) of samples after 167 hours of fixed load testing.

Table 5. Average strain on samples after 167 hours of fixed load testing.

Final Average Strain			
Sample	**BATCH 1**	**BATCH 2**	**BATCH 3**
Untreated control sample	0,0277	0,0277	0,0317
Stitched cotton control sample	0,012	0,0112	0,0117
Adhesive silk crepeline sample	0,0036	0,0028	0,0025
Stitched silk crepeline sample	0,0046	0,0038	0,004
Adhesive polyester tulle sample	0,0204	0,0181	0,0128
Stitched polyester tulle sample	0,0184	0,0149	0,0116
Adhesive nylon net sample	0,0294	0,0239	0,0329
Stitched nylon net sample	0,0158	0,0158	0,0179

When it comes to displacement, the adhesive nylon net sample and the untreated control sample show the areas with the most displacement in all the samples and across all batches. Besides that, the most amount of displacement is concentrated on the lower section of all the samples. The silk crepeline samples, both adhesive and stitched show the lowest amount of displacement.

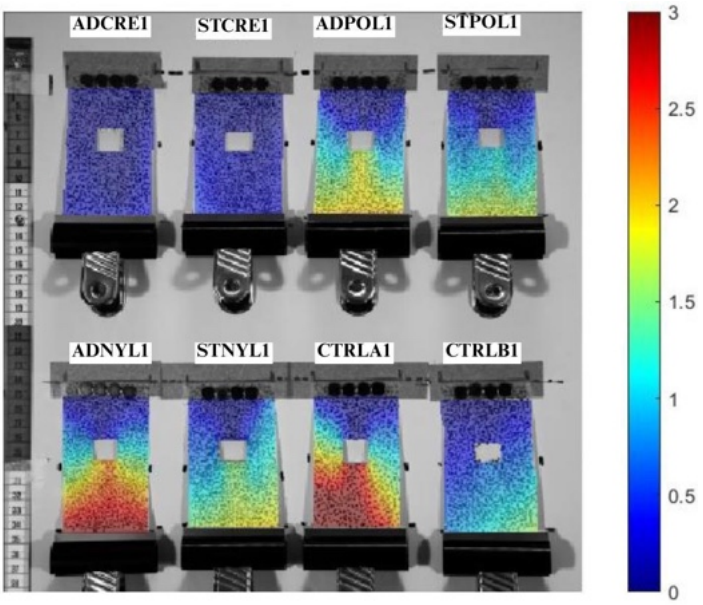

Figure 22. Vertical displacement plot of first batch of samples after 167 hours of fixed load testing (gradient in mm)

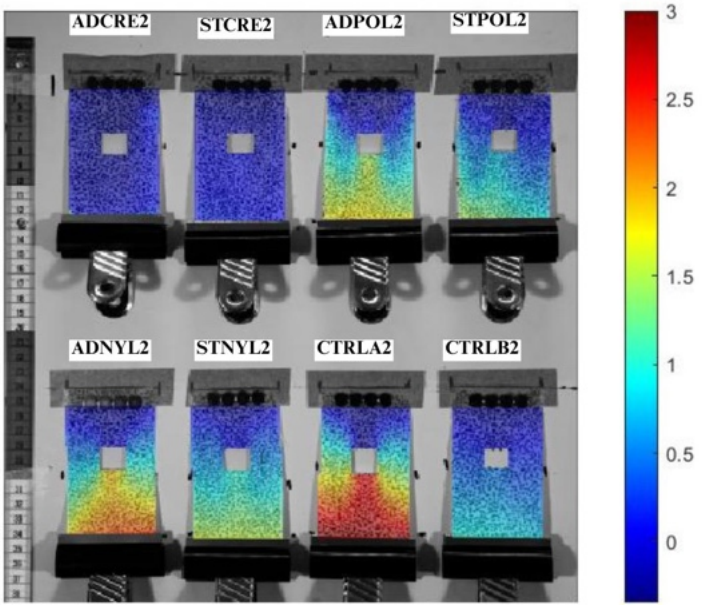

Figure 23. Vertical displacemen

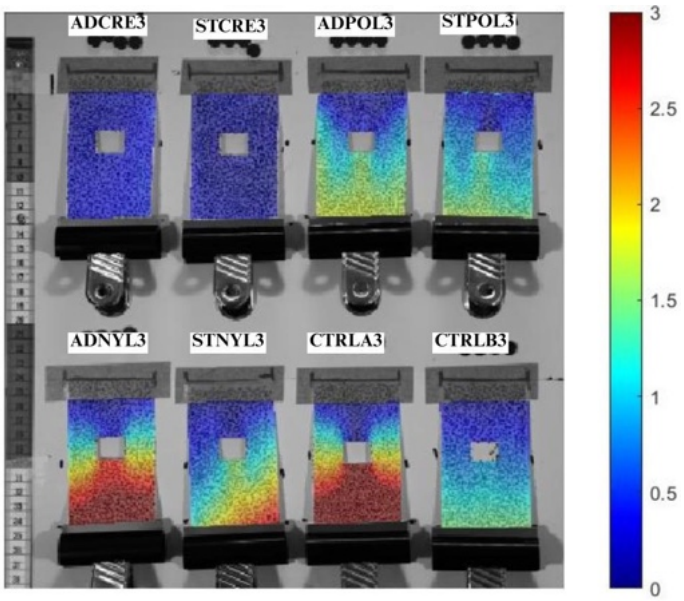

Figure 24. Vertical displacement plot of third batch of samples after 167 hours of fixed load testing (gradient in mm)

Regarding the average displacement, all the samples showed higher standard deviation values comparatively to the strain average. Besides this, no samples reached or surpassed an average of 2 mm of displacement.

The highest displacement average was shown by the untreated control samples, with the exception of the third batch of the experiment, where the adhesive nylon sample was the highest. The untreated control is followed by the adhesive nylon net samples and the adhesive polyester tulle samples for highest displacement average. When it comes to lowest displacement average, the adhesive silk crepeline sample showed the least displacement, followed by the stitched silk crepeline and stitched cotton control samples.

Comparatively between samples with the same support fabric, the ones with adhesive presented higher levels of displacement than their stitched counterparts, except for the silk crepeline samples, where the opposite can be observed.

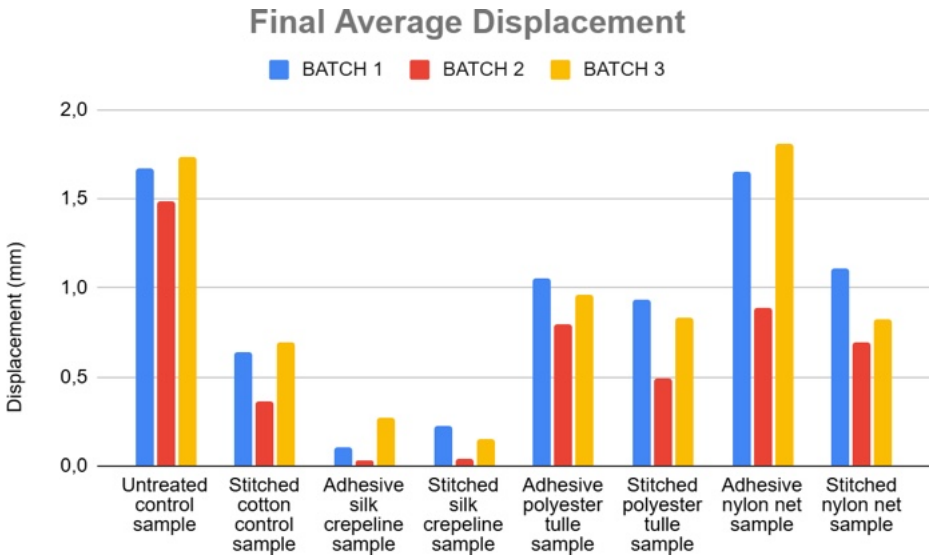

Figure 25. Final average displacement (mm) of samples after 167 hours of fixed load testing.

Table 6. Average displacement on samples after 167 hours of fixed load testing

	Final Average Displacement (mm)		
Sample	**BATCH 1**	**BATCH 2**	**BATCH 3**
Untreated control sample	1,6713	1,48375	1,7313
Stitched cotton control sample	0,636	0,3666	0,6976
Adhesive silk crepeline sample	0,105	0,031	0,2704
Stitched silk crepeline sample	0,22675	0,0441	0,1506
Adhesive polyester tulle sample	1,0574	0,80045	0,9595
Stitched polyester tulle sample	0,93585	0,4968	0,8369
Adhesive nylon net sample	1,6498	0,8925	1,80605
Stitched nylon net sample	1,1129	0,6978	0,8257

Regarding the progression of average strain values throughout the fixed-load test, the crepeline samples showed the most even progression of average strain. The line formed by their values is the one with the least leaps in strain. Besides that, both samples also showed the biggest similarity between them in terms of progression, with only a slight difference in strain values, where the stitched sample showed higher values. The adhesive crepeline samples showed the least strain, and the biggest leap it experienced was from 10 to 24 hours under the fixed-load test, where it increased 0.0005 (see Figure 26).

After the crepeline samples, the stitched nylon and adhesive polyester tulle samples also had a more even progression. Similarly to the crepeline samples, they also experienced the biggest leap after 24 hours and, after that, increased slightly until the 100-hour mark, not showing bigger leaps than 0.0011 and 0.0021 respectively.

When comparing the tested samples to the cotton backing control sample, the adhesive polyester tulle samples had a very similar progression. Both of these samples experienced a very stable first 24h hours, where their average strain remained the same. After 24 hours, these samples had a bigger leap in strain that kept increasing slightly until the 100-hour mark.

On the other hand, the adhesive nylon net mock-up behaved similarly progression wise to the untreated control sample, with both experiencing the greatest leaps in average strain.

Generally, all the tested samples had a decrease in average strain between 100 and 167 hours under the fixed-load test. The untreated control sample experienced the biggest decrease, followed by the adhesive nylon sample.

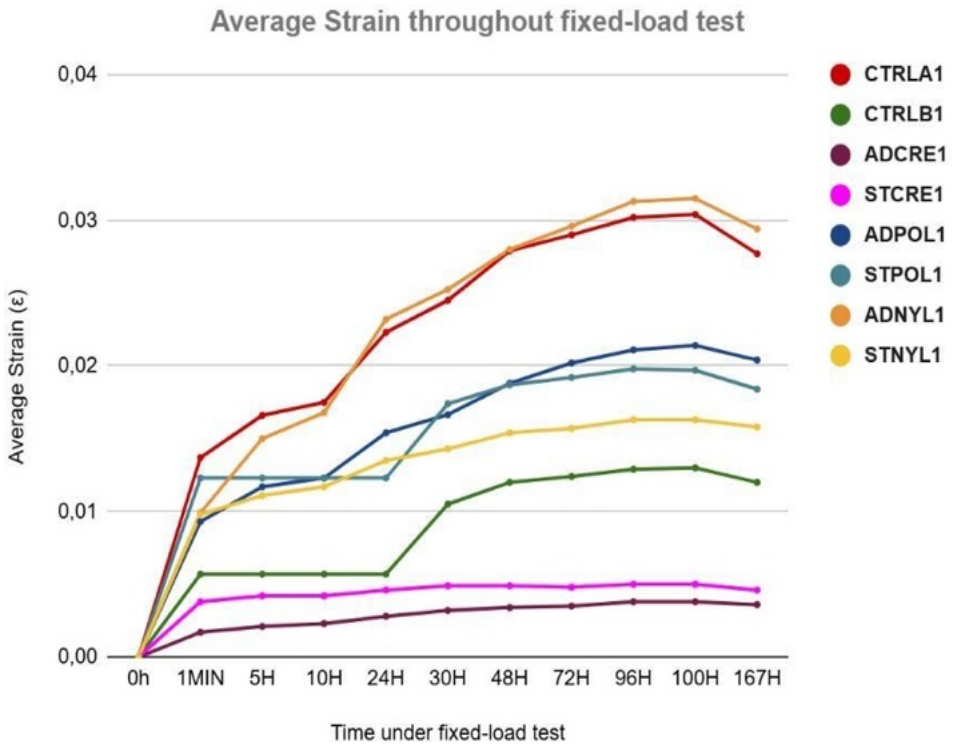

Figure 26. Average strain (ε) of first batch of samples at different points in fixed-load test

Table 7. Average strain (ε) of first batch of samples at different points in fixed-load test

Time	SAMPLE							
	CTRLA1	CTRLB1	ADCRE1	STCRE1	ADPOL1	STPOL1	ADNYL1	STNYL1
0h	0	0	0	0	0	0	0	0
1MIN	0,0137	0,0057	0,0017	0,0038	0,0093	0,0123	0,0099	0,0098
5H	0,0166	0,0057	0,0021	0,0042	0,0117	0,0123	0,015	0,0111
10H	0,0175	0,0057	0,0023	0,0042	0,0123	0,0123	0,0168	0,0117
24H	0,0223	0,0057	0,0028	0,0046	0,0154	0,0123	0,0232	0,0135
30H	0,0245	0,0105	0,0032	0,0049	0,01665	0,0174	0,02525	0,0143
48H	0,0279	0,012	0,0034	0,0049	0,0188	0,0187	0,028	0,0154
72H	0,029	0,0124	0,0035	0,0048	0,0202	0,0192	0,0296	0,0157
96H	0,0302	0,0129	0,0038	0,005	0,0211	0,0198	0,0313	0,0163
100H	0,0304	0,013	0,0038	0,005	0,0214	0,0197	0,0315	0,0163
167H	0,0277	0,012	0,0036	0,0046	0,0204	0,0184	0,0294	0,0158

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4.5 Dino-Lite Pictures of Mock-up Samples

After analysing the Dino-Lite pictures from before and after the fixed-load tests of the samples it was possible to conclude that the samples made with silk crepeline did not experience that many changes or the appearance of new damages after the test. These samples did not demonstrate considerable differences, aside from some loose yarns surrounding the hole becoming slightly looser afterwards, both on one of the adhesive samples (Figure 27-28) and two of the stitched ones (Figure 29-30).

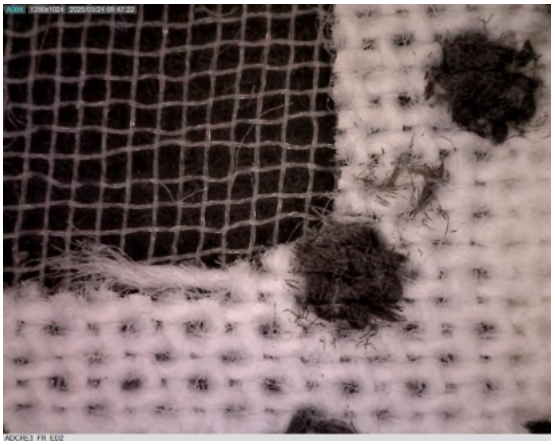

Figure 27. Bottom right corner of hole on adhesive silk crepeline sample, before fixed load test

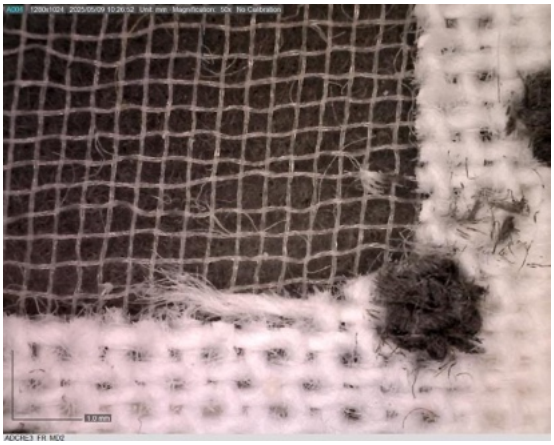

Figure 28. Bottom right corner of hole on adhesive silk crepeline sample, after fixed load test

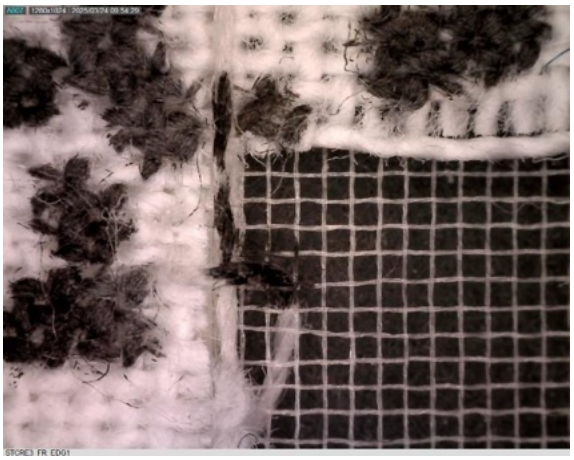

Figure 29. Upper left corner of hole on stitched silk crepeline sample, before fixed load test

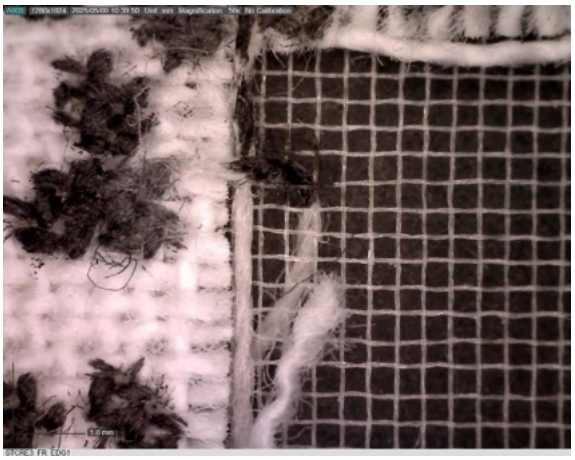

Figure 30. Upper left corner of hole on stitched silk crepeline sample, after fixed load test

When it comes to the remaining adhesive samples, made with nylon net and polyester tulle, most of them experienced adhesion failure, either on all the edges of the hole or some of them (see Figure 31). The adhesive polyester samples experienced less adhesion failure, only two samples demonstrating it and only on the lower edge of the hole. On the other hand, the adhesive nylon net samples all showed adhesion failure on almost every edge. Even when adhesion failure was observed however, most of the time, loose cut yarns around the hole that had been glued down on the support fabric remained glued down (Figure 33-36).

Another change observed in these adhesive samples was the slight deformation of the support fabric, consequently making the whole sample deform, specifically their edges. This was seen on the one adhesive polyester tulle sample that did not have adhesive failure and all of the adhesive nylon net samples (Figure 32).

Figure 31. Adhesion failure in the adhesive nylon net sample (batch 3) after 100hr on the fixed-load test

Figure 32. Deformation in the adhesive nylon net sample (batch 3) after 167hr on the fixed-load test

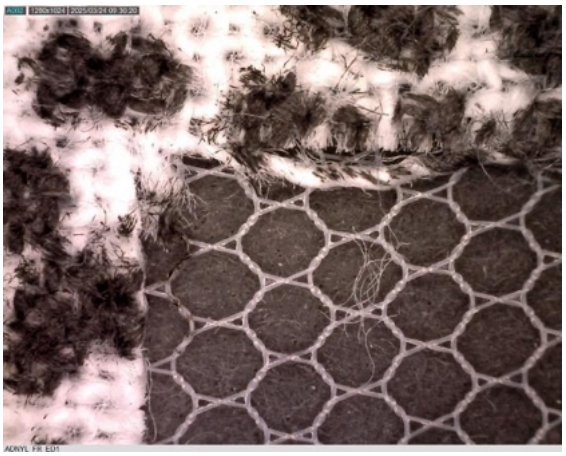

Figure 33. Upper left corner of adhesive nylon net sample (batch 3), before fixed-load test, adhesion failure

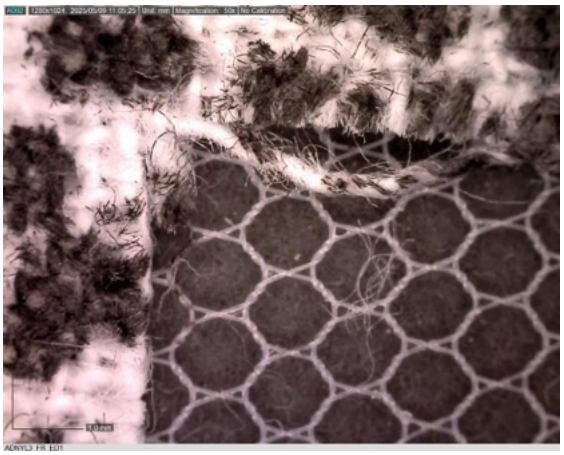

Figure 34. Upper left corner of adhesive nylon net sample (batch 3), after fixed-load test, adhesion failure

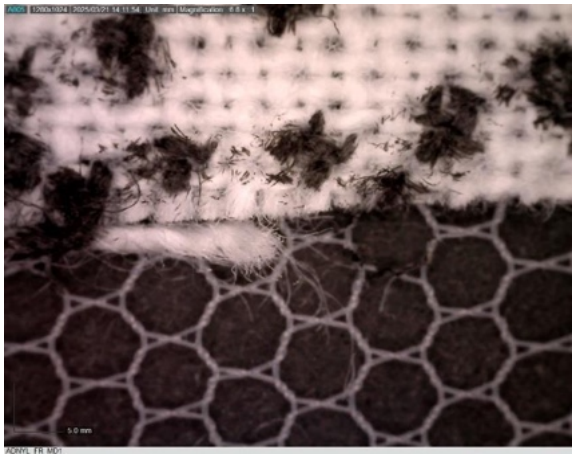

Figure 35. Upper edge of adhesive nylon net sample (batch 1), before fixed-load test

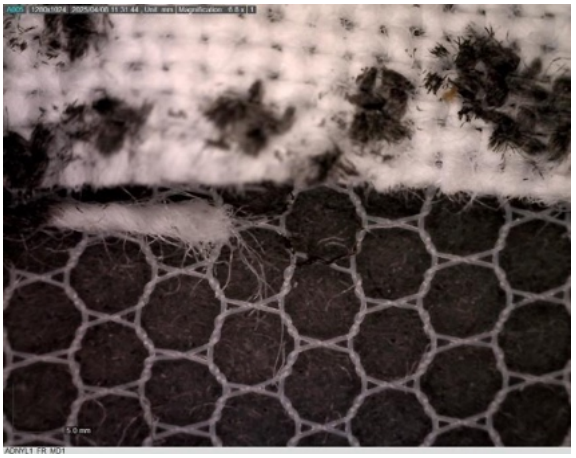

Figure 36. Upper edge of adhesive nylon net sample (batch 1), after fixed-load test, adhesion failure

Regarding their stitched samples counterparts, these experienced less changes. For the polyester tulle samples, only the one from the second batch had small damages like a stitching hole slightly increasing in size post hanging and one of the backstitches getting loose (Figure 37-39).

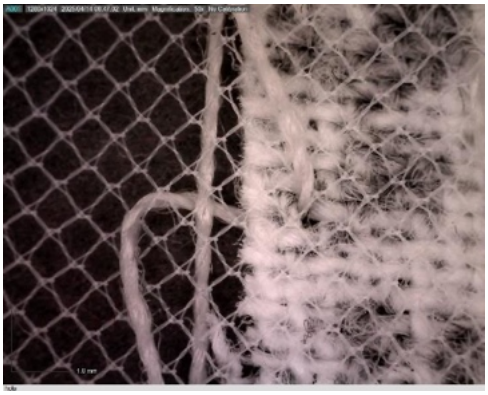

Figure 37. Stitch needle hole of stitched polyester tulle sample (batch 2), after fixed-load test, bigger needle hole

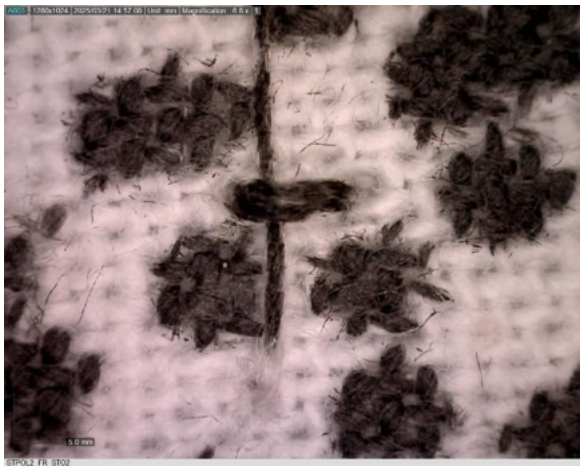

Figure 38. Backstitch of stitched polyester tulle sample (batch 2), before fixed-load test

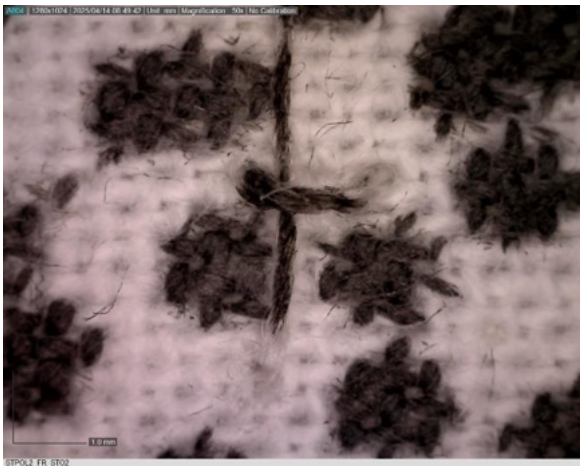

Figure 39. Backstitch of stitched polyester tulle sample (batch 2), after fixed-load test, looser backstitch

Lastly, in general, some stitches became tighter after the test, which was visible in two stitched crepeline samples and two stitched polyester tulle samples (Figure 40-41). However, this did not cause any observable damage to these samples.

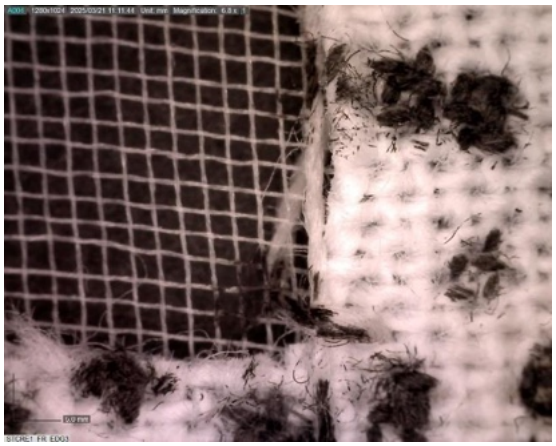

Figure 40. Bottom right corner of hole on stitched silk crepeline sample (batch 1), before fixed load test

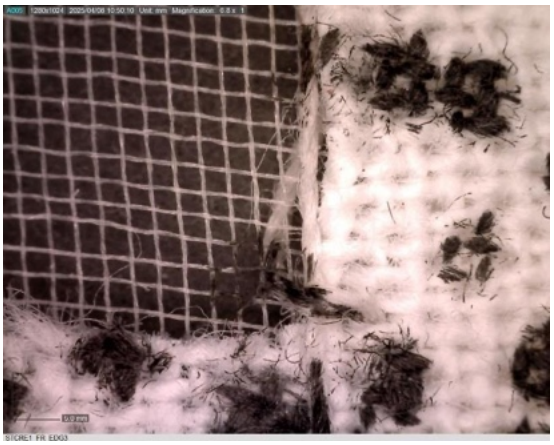

Figure 41. Bottom right corner of hole on stitched silk crepeline sample (batch 1), after fixed load test

4.6 Tests on the Lace Fragment

Pictures were taken of the lace fragment before and after applying the different hole stabilizing techniques. Pictures focusing on 3 different techniques at a time but also each of them individually were taken of both sides of the fragment.

Figure 42. Lace fragment section before conservation, front side

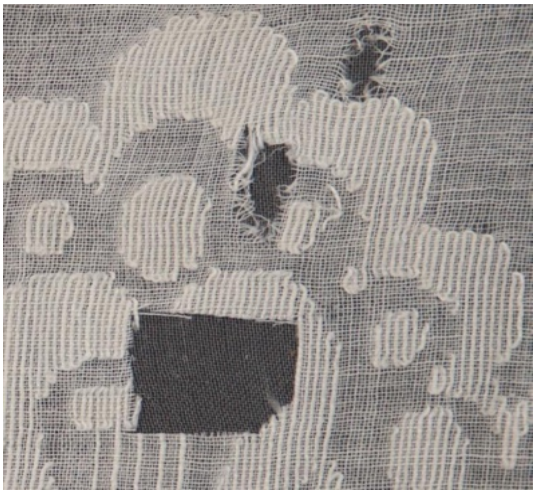

Figure 43. Lace fragment section after conservation, adhesive silk crepeline, front side

Figure 44. Lace fragment section before conservation, front side

Figure 45. Lace fragment section after conservation, adhesive polyester tulle, front side

Figure 46. Lace fragment section before conservation, front side

Figure 47. Lace fragment section after conservation, adhesive nylon net, front side

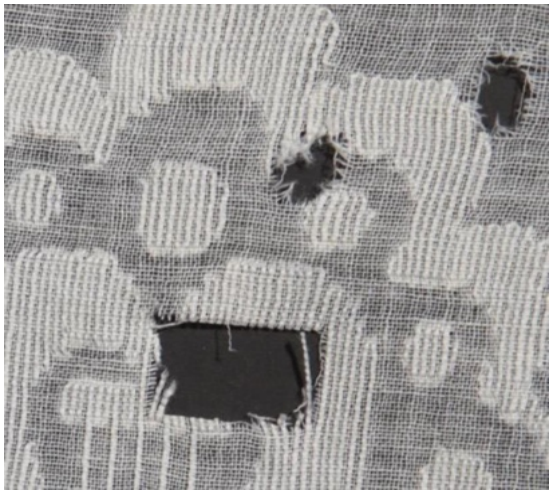

Figure 48. Lace fragment section before conservation, front side

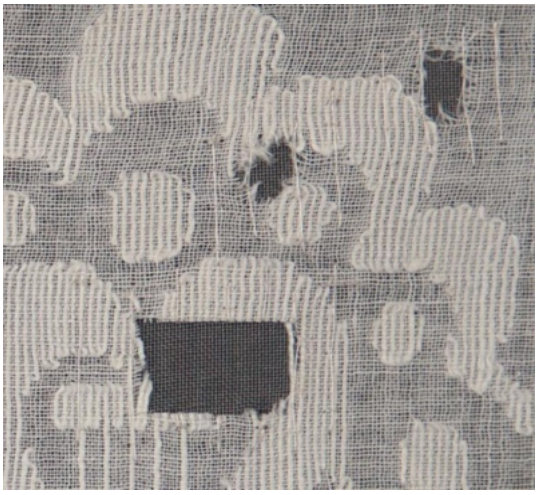

Figure 49. Lace fragment section after conservation, stitched silk crepeline, front side

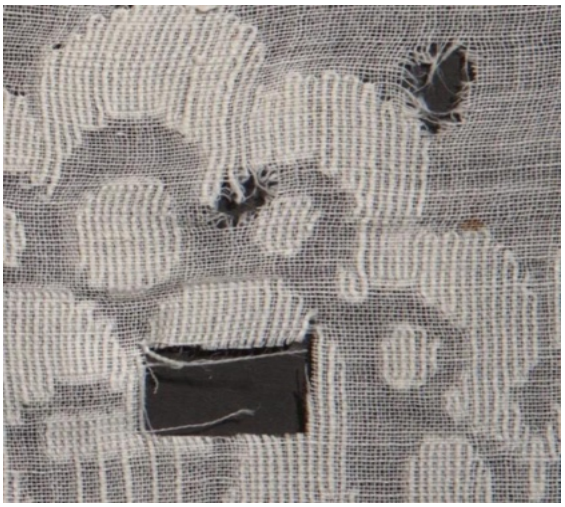

Figure 50. Lace fragment section before conservation, front side

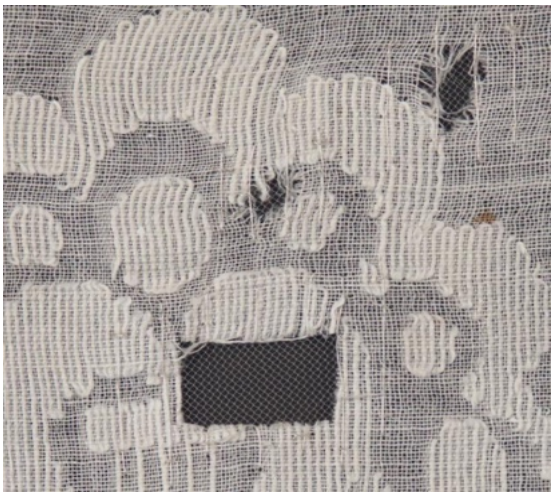

Figure 51. Lace fragment section after conservation, stitched polyester tulle, front side

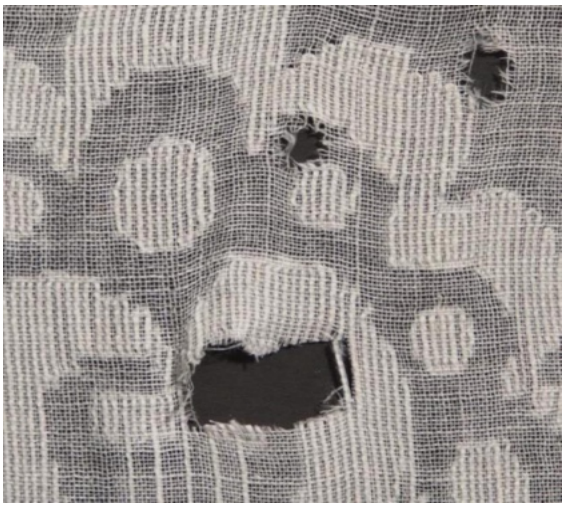

Figure 52. Lace fragment section before conservation, front side

Figure 53. Lace fragment section after conservation, stitched nylon net, front side

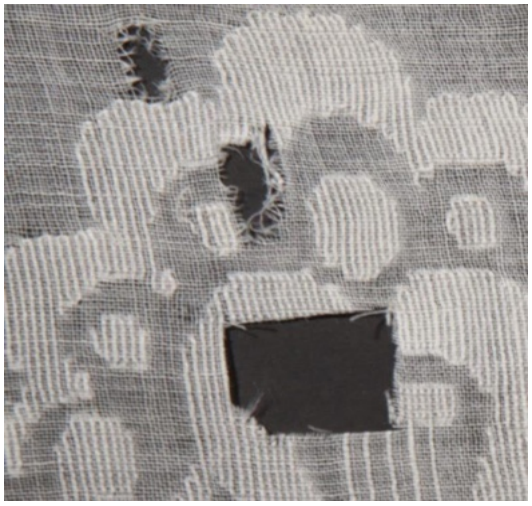

Figure 54. Lace fragment section before conservation, back side

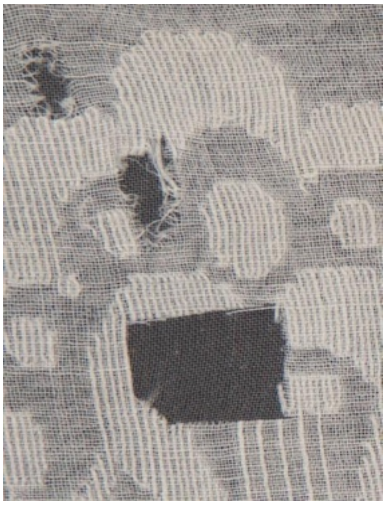

Figure 55. Lace fragment section after conservation, adhesive silk crepeline, back side

Figure 56. Lace fragment section before conservation, back side

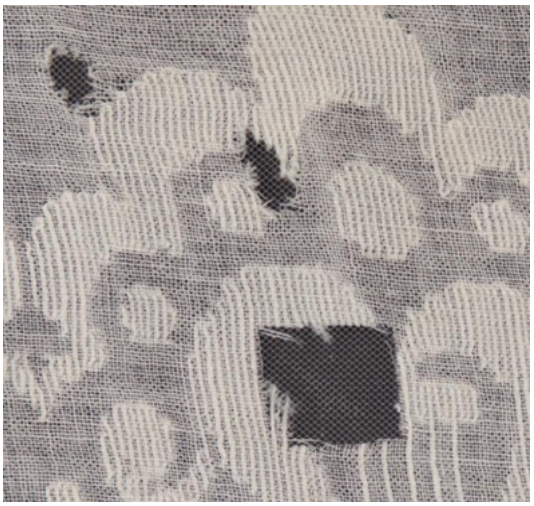

Figure 57. Lace fragment section after conservation, adhesive polyester tulle, back side

Figure 58. Lace fragment section before conservation, back side

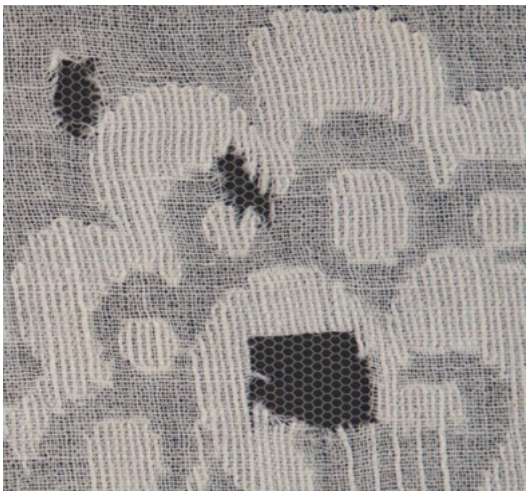

Figure 59. Lace fragment section after conservation, adhesive nylon net, back side

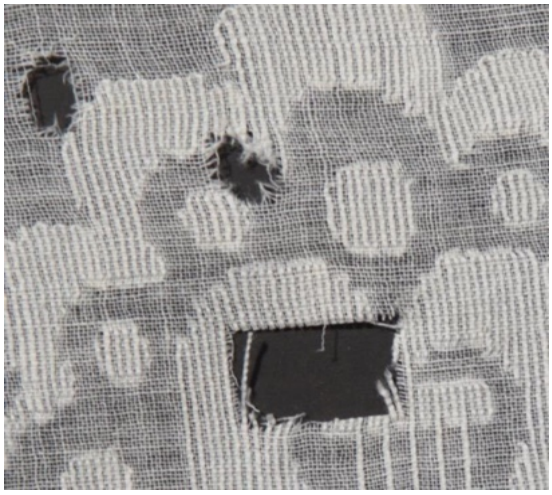

Figure 60. Lace fragment section before conservation, back side

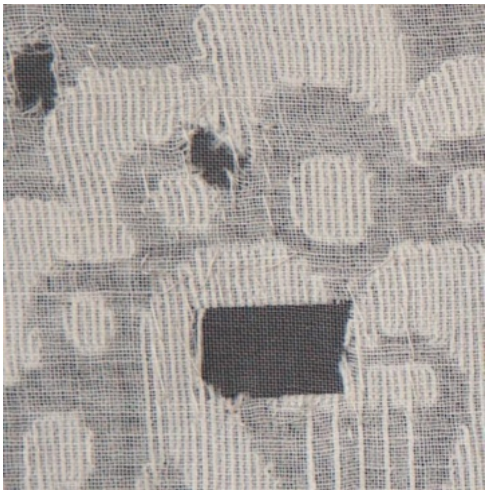

Figure 61. Lace fragment section after conservation, stitched silk crepeline, back side

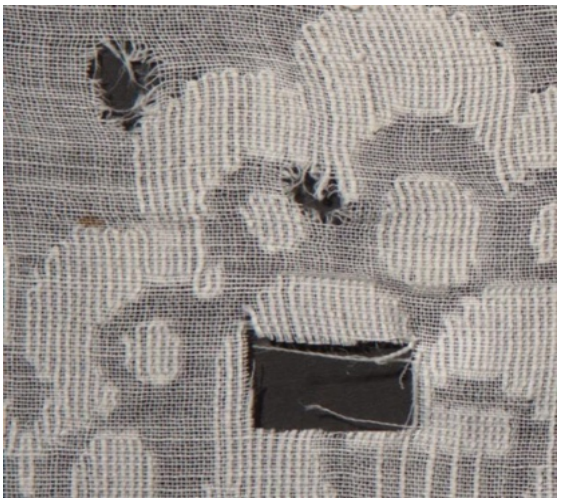

Figure 62. Lace fragment section before conservation, back side

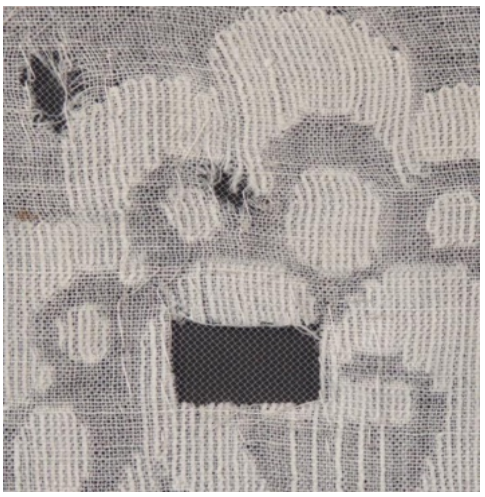

Figure 63. Lace fragment section after conservation, stitched polyester tulle, back side

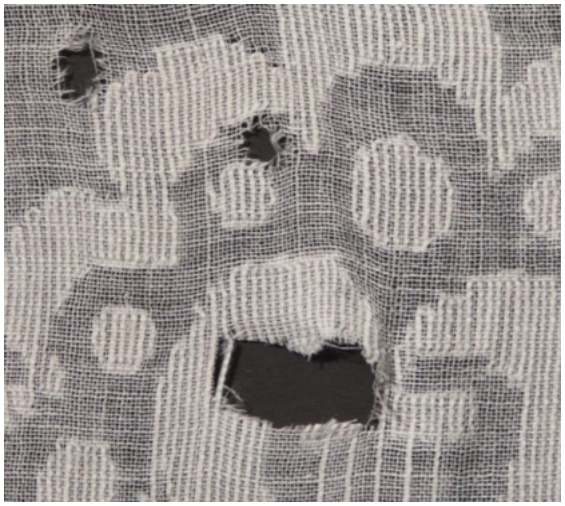

Figure 64. Lace fragment section before conservation, back side

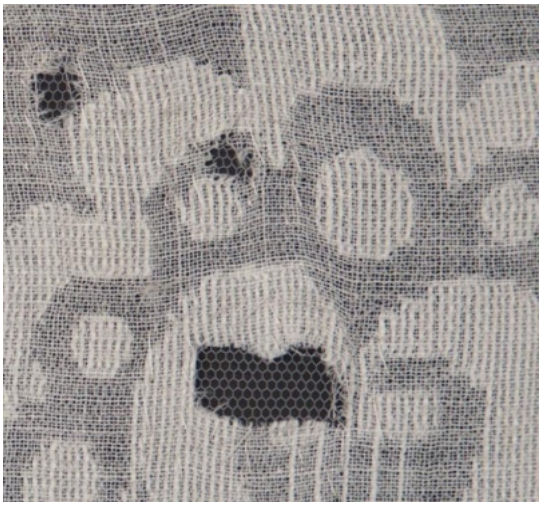

Figure 65. Lace fragment section after conservation, stitched nylon net, back side

In general, by analysing the different areas of the fragment from a certain distance, approximately 50 cm (see Appendix 8), all the techniques seem to blend in with the textile. From this distance, all the additions made for the sake of the treatment, like the support fabric and stitching are not noticeable at a first glance and don't distract from the rest of the object.

Depending on the angle of the light hitting the fragment, the stitching can be more or less discrete from a distance of 50 cm. This is due to how shiny the silk threads are. Besides this, the stitches which are easier to spot are the start and stop points, made as backstitches.

Another aspect of the treatments that could be more discernible from this distance, perhaps to more trained eyes or for those interested in conservation, is the slight colour change that occurs in areas with and without the support fabrics. The areas of the holes themselves of course also allow for a visualization of the support fabrics structure.

When it comes to how each fabric affects the backside visually, they all produce a distinct effect due to their different structures (see Figures 54-65). Even though they are all very sheer and could be difficult to notice if not pointed out, there are subtle changes. The silk crepeline gives the lace a slightly hazy or blurry effect, making it harder to clearly see the weave pattern of the textile in those areas. The polyester tulle and nylon net, due to their knitted structures, tend to cross the negative spaces of the textile weave more often, producing a kind of overlapped nets appearance. Between these two, however, the author considers the nylon net to be more discernible.

Moving on to a more close-up inspection of these areas, the stitching remains discreet on the front face. On the backside, they are slightly more visible, mainly due to the stiches going from the last short horizontal to the next long vertical stitch (see Figures 60-65).

5. DISCUSSION

5.1 Fabric structure and cover analysis

When it comes to the effect the different fabrics can have on the substrate due to their structures, it´s most likely that the nylon net and polyester tulle will be more abrasive. This is because both meshes have a knitted structure, that according to LaValle's research (LaVallee, 2005), tends to be more abrasive.

Also according to LaValle (2005), warp knitted meshes have special characteristics when it comes to elastic recovery due to the knitted loops changing shape under tension. This means that the nylon net is more likely to return to its original shape after being stretched, which can also explain the reports of it shrinking and deforming objects when used for adhesive treatments (Hillyer, 2024). Something similar to this was observed on the samples used for the fixed-load test (Figure 32). On the other hand, the polyester tulle is also warp knitted, so it could be expected that it would have similar characteristics in elastic recovery. However, this deformation was only observed on one of these samples.

Regarding the coverability of the support fabrics used, silk crepeline is the one covering the most amount of area due to its weaved structure. The knitted meshes have lower coverability, nylon net having the lowest percentage due to its open structure. However, this characteristic does not directly translate to discernability, since besides being a subjective factor, this will also depend on a combination of other factors, like the object the meshes will be applied to.

5.2 Fixed-Load Test with 2D Digital Image Correlation and Dino Lite Pictures

In order to draw conclusions regarding how each different treatment method performed in comparison to a more established hole stabilization treatment like the use of a cotton support fabric, the results from the fixed-load test tracked with 2D DIC and the before and after Dino Lite pictures will be discussed. Besides this, how each different sheer support fabric performed as well as a comparison between the use of adhesives and stitching will also be included.

Firstly, the strain distribution diverged considerably between each sample. This points to the impact that choice of support fabric combined with attachment method can have on hole stabilizing treatments in regard to their strain behaviours. In general, samples of the same support fabric showed bigger similarities in strain values and distribution than samples of the same attachment method, indicating that this aspect had a bigger impact on the performance of the treatment.

When it comes to displacement distribution, however, it is more generally similar across all samples, the highest values being concentrated at the bottom of the specimen, coming from where the office clips where attached. This outcome was expected, as the samples would stretch more closer to where they are being pulled down. This distribution also explains the difference in standard deviations from the average strain and displacement calculations. As the highest

displacement values are mostly concentrated on the bottom, it makes the displacement distribution highly uneven across the whole area, unlike the some of the strain distributions that show smoother transitions in values.

Something that did not align with initial expectations was the fact that the silk crepeline samples presented not only more evenly distributed strain but also the lowest average of final strain and displacement. Initially, it was thought the stitched cotton control sample would be the one showing these values, as the support fabric and substrate would behave the most similarly. These low values and even distribution could possibly be due to silk crepeline´s simple, open weave structure and lower flexibility and stretch (LaVallee, 2005), giving the surrogates support and preventing them from stretching too much. Besides that, the fact the silk crepeline was the fabric with the highest cover rate, means it has more points of connection to the cotton substrate. This correlates to previous studies (Karsten & Kerr, 2011) where silk crepeline showed to be the strongest support fabric in adhesive treatments due to the higher amount of adhesive found in its interstices, meaning the areas in the structure with open space.

The silk crepeline samples were the most similar to each other, only having a difference of 0,001 in strain values between its´ adhesive and stitched samples. This points to the lower impact of attachment method when using silk crepeline.

Regarding the progression of average strain during the 167 hours of fixed-load test, the silk crepeline samples showed, once again, promising results. As both samples showed a pretty consistent and even increase in average strain with time, unlike the high peaks that the cotton backing control sample displayed, it could be argued that this method is preferable. This is because having a consistent average strain throughout time, in combination with even strain distribution throughout the whole area, is a desirable characteristic for a support/stabilizing treatment.

As was expected, the untreated control sample showed one of the highest strain and displacement values out of all the samples. Besides that, by analysing the strain maps, it's possible to see that it also showed the areas with the greatest strain. This means that even if the untreated control sample didn't always have the highest average strain values out of all the samples, these areas had the highest strain detected in all the samples of the same batch. This aligns with expectations since the lack of support around the damage will cause higher levels of tension around that area. It is also important to consider the phenomenon of pseudo-strain in areas near the hole, where the DIC algorithm can misinterpret the opening of damages as high values of strain (Costantini et al., 2020, p.9).

On the other hand, the adhesive nylon net samples had the highest average strain out of all the samples, and the distribution of the highest values was in similar areas as the untreated samples. It also demonstrated a similar progression of strain values throughout fixed-load test, by having several big peaks, which could correlate to when adhesion failure was experienced. The more elastic and open structure of this fabric could explain these results. However, by comparing the strain maps and average strain it can be concluded that the adhesive nylon net specimens demonstrated a slightly more even distribution of strain comparatively to the untreated samples.

The nylon net and polyester tulle adhesive samples shared similarities, with higher strain areas around the vertical edges of the hole and side edges. The adhesion failure experienced by some of the polyester tulle and all the nylon net samples also relates to the higher levels of average strain and displacement that these samples showed in comparison with their stitched counterparts. It seems like the stitching was successful in supporting the damaged area, preventing the tension from concentrating too intensely on those spots. This result aligns with the recommendation from several sources that some adhesive treatments should be supplemented by some additional stitching (Hillyer, 2024).

When discussing the stitched samples, it´s also relevant to consider lower strain areas don´t always correlate to beneficial treatments. In previous studies (Lennard et al., 2023), the presence of lower strain areas on too closely spaced stitched areas was interpreted as detrimental due to different areas in the object potentially responding to shifts in RH differently. However, stitching in this experiment was still considered beneficial, since it resulted in more even strain distributions around the hole compared to their adhesive treatment counterparts.

Regarding the adhesion failure, it is important to keep in mind the possibility that the nylon net could have been overstretched during the adhesive film preparation, even with the precautions taken to prevent this. It is hypothesised that this could have led to inappropriate behaviour during the test, as previously documented (Hillyer, 2024), with the potential to impact adhesion properties due to the introduction of additional tension from the fabric structure returning to its original, unstretched state. Besides that, as mentioned earlier, the fact that the nylon net was not cut or attached in the warp direction could have also affected its´ stretching characteristics. These factors could have contributed to the deformation observed in the nylon net adhesive samples and one adhesive polyester tulle sample (Figure 31-36).

The way in which the stitching is done is also very relevant to how it will affect the samples. Most of the stitching was made with the idea of avoiding overpulling in mind, however on points where this did occur, a bigger hole was created after hanging (Figure 37). This correlates to previous studies on conversation stitching (Benson et al., 2014; Schön, 2017).

On the other hand, the stitched polyester tulle sample behaving very similarly to the cotton backing control sample when it comes to average strain progression was unexpected. Since the two support fabrics have very different structures, one being a diamond shaped knitted mesh and the other a plain-weave fabric, the fact that they both displayed no changes in average strain until having a high peak at 24 hours was not predicted. In the future, it would be interesting to process the data from the rest of the sample batches, to confirm if this behaviour would remain. It is also important to point out that these two samples were aligned vertically in the board during the fixed-load test, and the closest to the right spotlight. The heat radiating from this device while taking the photograph could have influenced these samples more than the rest.

Another unpredicted result was the similarities in strain progression of the stitched nylon net and adhesive polyester tulle mock-ups since these differ not only in support fabric but also in

attachment method. However, both of these displayed an even progression in strain compared to the adhesive nylon net and untreated control sample, showing they were more successful at providing the cotton substrate even support throughout the week.

In general, all the samples had their second biggest peak in strain after the 24-hour mark, something that is consistent with their corresponding Eyy strain maps, especially for the nylon net samples (see Figures 66-67). This could indicate that after a day of fixed-load testing, the strain levels stabilize slightly.

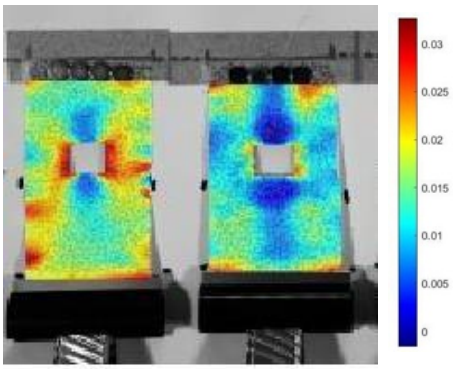

Figure 66. Eyy strain map of the adhesive and stitched nylon net samples of first batch of samples after 10 hours of fixed-load testing

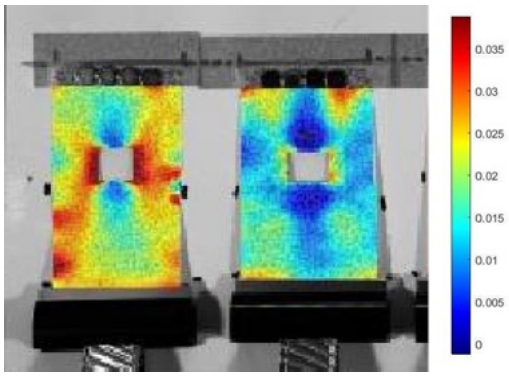

Figure 67. Eyy strain map of the adhesive and stitched nylon net samples of first batch of samples after 24 hours of fixed-load testing

Besides this peak, the fact all samples displayed a decrease in average strain between the 100 and 167 hours could point to another stabilization in the substrate. After the initial extension, the cotton samples might have undergone a strain-relaxation phase due to internal structures in the fibres stabilising (Ballard 2011, p.191). On the other hand, fluctuations in the temperature and relative humidity values could also have affected this progression. In the future, it would be interesting to remake the fixed load-test with the possibility of having more pictures in between these two points, to more accurately track this strain progression.

5.3 Visual assessment of lace fragments

After a subjective assessment of the different hole stabilising techniques applied to a lace fragment from the Conservation Department these were the conclusions made.

Even though the new components added for the sake of the treatment, like the sheer support fabrics and thread for the stitched examples are not that easily discernible from 50cm distance, the fact nothing is used to cover the hole brings more attention to this damage. Because of this, this approach to treat the holes does make them more discernible in comparison. Some could argue that this is not desirable in a treatment, since the damages can take the attention away from the value of the object.

Besides that, the sheer support fabrics themselves also become visible in the hole areas. Depending on the fabric this fact can be more or less visually disturbing. In the author's perception, nylon net is the fabric that becomes the most visually disruptive in these areas, due

to its' more open structure. The silk crepeline seems to be the one blending in the most in these hole areas, which could be due to its similar weave structure to the object itself.

However, aside from these areas, all the support fabrics seem to be discreet and not change the appearance of the object in a disruptive manner. The small colour change present at the edge of when the support fabric starts could also be mitigated by dying the material with a more desirable colour.

These conclusions also showcase that the sheer fabric's cover percentage don't directly correlate with their visibility or how much they affect an object visually. Aside from this aspect being subjective, how each support fabric affects an object visually will also depend on the object's structure and appearance.

Regarding the comparison between the adhesive and stitching techniques, at the 50 cm distance in the front side the stitching is only visible when light hits it a specific way, as mentioned. This will of course depend greatly on the thread used. Since in this test silk threads were used, it was expected they would be less discernible, thanks to their very fine nature. In some smaller areas around the running stich used to attach the fabric patches on the stitched examples it is also possible to point out some of the stitching. Aside from that, another interesting aspect of the stitched examples was that the stitching on the nylon net was slightly easier to see, as it overlapped with its´ more open structure.

All in all, it is possible to conclude that all support fabrics and stitching are discreet in the areas they cover the object. Due to their different structures, some are more easily discernible compared to others. On the other hand, this treatment approach leads more attention to the damage area, since no patch was used to cover the holes, which still remains visible and shows the support fabric structure if observing closely. Perhaps a way to mitigate this aspect would be to add a small patch of a similar structured material to the object on the hole area.

5.4 Current Practices and Recommendations

By interpreting the answers of the survey, it possible to gather some insight into conservators' possible thought processes and similar lines of action when dealing with double-sided textile objects. However, due to the limited number of responses to the survey it is recognized that its' results cannot be representative of a substantial enough group of professionals.

Out of the 10 professionals that had dealt with these types of objects before, the answers regarding treatment recommendations or past treatments were very diverse, showcasing a wide range of possibilities. These diverse responses made it possible to deduce that there does not seem to exist a set principle or rule to how these types of objects should be treated in case of structural damage. As it is for most conservation treatments, conservators reasoning aligns more with a case-by-case basis. On the other hand, the numerous mentions of sheer support fabrics like silk crepeline show an interest and preference for these materials as a way to not fully compromise visibility.

Besides this, several individuals also pointed to the suggestion of combining both adhesive and conservation stitching attachment methods for patches, something that aligns with one of the conclusions of the practical experiment. By supplementing the adhesive treatment with punctual stitching on areas like patch edges or surrounding areas of loss, adhesion failure can be prevented as well as areas of higher strain values.

Another point that was mentioned several times was placing a layer of sheer support fabric on both sides of the damage, “sandwhisching”. This can indicate that these professionals consider this option to provide higher support and protection to the damaged area. It could be interesting to conduct an experiment comparing the use of one or two layers of sheer support fabric to confirm this hypothesis.

When it comes to recommendations of the use of either a patch or full support, the respondents did not imply a preference for one or the other. This could be due once again to the case-by-case nature of conservation. However, according to research already discussed (Lennard 2023 and Nilsson 2016), a recommendation would be to use full supports on objects with a higher number of damages, as it has shown to help avoid areas of higher strain.

Some professionals mentioned the use of a cut to size of loss patch to compliment the sheer support fabric treatment, in order to better conceal the losses. This could potentially contribute to making the damages less discernible, something that was noted in the lace tests of the experiment. However, care and extra precautions should be taken when attaching this patch, as there would be higher risk of fraying due to its smaller size and potentially unusual shape.

Lastly, the several different challenges listed shows that these professionals consider double-sided textile objects something that requires extra thought and has more components to consider when preparing for treatment. Making sure visibility of either side wasn´t compromised was mentioned several times, aligning with the one of the intentions of this research project.

6. CONCLUSIONS

This thesis set out to investigate the current strategies used to treat structural damage in double-sided textile objects and to evaluate how combinations of sheer support fabrics and attachment methods influence both the visual and structural outcomes of conservation treatments.

The survey results revealed that while no single treatment is universally applied to double-sided textiles, there is a clear preference among the respondents for using sheer mesh fabrics, attached to the object through stitching, adhesives, or a combination of both. Ethical concerns such as authenticity and minimal intervention were also frequently mentioned in the responses, underlining the complexity and subjectivity of treatment decisions in these cases.

Through the practical experiment using 2D DIC, findings demonstrated that the type of support fabric had a more significant influence on strain behaviour than the method of attachment. Even though the strain and displacement values produced don´t have a precise error associated with them, the results of the experiment still allowed for a comparative analysis of the different materials and techniques tested.

Of all materials tested, silk crepeline offered the most favourable structural performance, showing low, homogenous distribution and even progression of strain values throughout the fixed-load test. These samples even showed lower strain and displacement values than the stitched cotton backing controls. In contrast, nylon net most often displayed the highest strain and behaved similarly to untreated control samples, suggesting its inadequacy as a supportive material for structural damages.

Among the attachment methods, adhesive treatments generally resulted in higher strain values than stitching, especially around the damaged area. This suggests that the stitching done to their counterparts' samples was successful in reducing localized strain. This can indicate that a combined method may be more effective in some scenarios.

No significant mechanical or visual deterioration was observed in stitched samples before and after the fixed load test. In contrast, adhesive-only samples showed signs of failure, particularly in those backed with nylon net and polyester tulle, suggesting reduced long-term stability under stress for these combinations.

Through a visual comparison of tests done on a semi-transparent fragment, it was possible to conclude that, while the elements added for the sake of the treatment may not be necessarily discernible at a certain distance, the approach of not covering the damage has the potential to actually bring more attention to it.

Overall, this research highlights the importance of material choice in treatments, showing that aspects like support fabric can have a greater impact on strain behaviours than attachment method. The findings contribute to a deeper understanding of how different sheer support fabrics perform and can aid in informed decision-making when treating structurally compromised, double-sided textile objects.

6.1 Further Research

While the current findings provide insights into the mechanical behaviour of different combinations of sheer support fabrics and attachment methods, additional investigation could be beneficial to clarify some of the observations made.

One area for further research relates to the appearance of deformations in the adhesive samples. This was observed in several adhesive samples, especially the nylon net ones, but the cause could not be definitively determined. Future studies could investigate whether these distortions derive from the inherent structure of the support fabric or from problems during the adhesive film preparation, such as uneven tension or the omission of bias cutting.

There is also a notable gap in research on adhesive treatments using sheer fabrics other than silk crepeline. More comparative studies are needed to evaluate the performance of other alternatives, for when silk crepeline can´t be used due to incompatibility or resource issues. This would help determine whether other materials are unsuitable for adhesive-based treatments or whether they just lack sufficient testing to be confidently recommended.

Another point of interest concerns the strain behaviour of the stitched polyester tulle sample, which unexpectedly showed a very similar strain progression to the stitched cotton control sample. Repeating the test and examining the reproducibility of this result would help determine whether this similarity was an anomaly or a replicable phenomenon.

Lastly, as this thesis has shown that support fabric structure significantly influences treatment performance, further exploration into optimal orientation strategies, especially for mesh-based materials like nylon net and polyester tulle, could lead to improved guidelines for their use in conservation contexts. Additionally, further and more conclusive research into the visual impact of different sheer support fabrics could further help professionals when implementing these in a treatment.

Continued research into these areas would not only contribute to finding alternatives for the structural treatment of double-sided textile objects but also to the body of knowledge in textile conservation overall.

7. SUMMARY

With the intention of investigating stabilizing treatments that could potentially be applied to textile objects with a double-sided nature, this project was developed. In order to conceptualize treatments that respect an object's integrity and authenticity, factors like how the treatment may impact these need to be considered. Because of this, a usual stabilizing treatment in textile conservation, like the application of a patch on the backside of the structural damage, will not always be appropriate. For objects with aesthetic and/or functional aspects on both faces, visualization of both of these might be essential.

After an initial literature review, it was found that there currently isn't a standardized way of dealing with these kinds of objects, or even general advice or factors to consider that were published. This thesis sought out to investigate if there are strategies currently employed to treat structural damage in double-sided textile objects and compare between certain methods. The study combined a survey sent to textile conservators, a literature review, and experimental testing to evaluate the visual and mechanical effects of different combinations of sheer support fabrics and attachment methods.

In order to achieve the aim and objective, the following research questions were formulated:

- What strategies are being employed to treat structural damage to double-sided textile objects?
- How does each combination of sheer support fabric and attachment method affect damage support as well view of the area it was applied to?
- How does each combination of sheer backing fabric and attachment method affect strain distribution and baheviour?

The survey was sent out to textile conservators belonging to both the Textile Working Group of ICOM-CC and *Svenska föreningen för textilkonservering*. It revealed that while treatments vary, there is a preference for sheer mesh fabrics, most often attached with stitching, adhesive, or a combination of both. Additional suggestions included cut-to-size patches for visual integration. Overall, responses highlighted the complex decision-making necessary, especially regarding the balance between structural stability and preserving the visibility of both sides.

The literature review revealed a scarcity of published case studies on double-sided textile objects conservation, with only two examples found. These describe silk banners and a Thangka painting and both employed some kind of variation of the adhesive treatment casted onto silk crepeline, sometimes with complementary stitching. Besides that, the literature review also revealed that research into stitching techniques remains limited, with practice largely shaped by empirical knowledge. Recent studies, however, have shown that wider stitch spacing and laid-thread couching offer improved flexibility and reduced strain compared to tighter stitches, which can cause distortion. Adhesive treatments, once met with mistrust due to past adverse effects, have gained wider acceptance through scientific research demonstrating their

effectiveness, particularly with thermoplastic adhesives and solvent reactivation methods. Lastly, the literature review allowed for the development of the practical experiment, by compiling information on 2D Digital Image Correlation. This method has proven to be a valuable tool in textile conservation research, enabling the accurate measurement and mapping of strain. Studies, particularly on historic tapestries, have shown its effectiveness in detecting damage-prone areas and even assessing the performance of support techniques.

In order to answer the research questions about the comparison between different hole-stabilizing methods, a practical experiment with cotton mock-up samples was conducted. Three different support fabrics, silk crepeline, nylon net and polyester tulle, were combined with two attachment methods, laid-tread couching and adhesive treatment with a thermoplastic adhesive. These were put through a fixed-load test for 167 hours, while being tracked by 2D DIC, which produced strain and displacement data. Visual changes were also documented before and after testing by photo documentation.

Results showed that fabric choice had a greater impact on strain behaviour than attachment method. Silk crepeline exhibited the most uniform and low strain progression, outperforming even the stitched cotton control sample, while nylon net performed poorly, showing the highest strain values and behaviour similar to untreated samples. The adhesive attachment method generally resulted in higher strain values than stitching. Besides that, all nylon net adhesive samples experienced adhesive failure or caused textile deformation.

Aside the adhesion failure, no considerable mechanical or visual adverse effects were observed in the samples post fixed-load test, especially in the samples with the stitched attachment method.

On top of the practical experiment, additional tests were done to a cotton semi-transparent lace fragment in order to reflect on the visual impact of each method tested. Even though this was a subjective evaluation, it was possible to conclude that all the methods tested have the potential to bring more attention to the damage they are intended to support. Because of this, it is recommended that alternatives like the use of a small patch, like it was mentioned in some survey replies, are considered.

In conclusion, this project highlighted the importance of choice of materials when conceptualizing a structural damage stabilizing treatment, as well as the need to adapt these for specific objects and their integrity. While silk crepeline emerged as the most mechanically effective support fabric when it comes to strain and displacement, it will not always be the most appropriate support fabric to apply. So, this work provided a foundation for further exploration into alternative sheer fabrics as well as techniques that can balance structural stability with the visibility requirements of double-sided textiles.

8. REFERENCES

American Institute for Conservation (AIC). (2024). **Oddy Testing Protocols. British Museum Protocols.** *Conservation-Wiki.com; American Institute for Conservation.* Available at: https://www.conservation-wiki.com/wiki/Oddy_Test_Protocols#British_Museum_Protocols

Ali, M. B., A. F. Ab Ghani, S. Dhar Malingam, and J. Mahmud. (2016) **Digital Image Correlation (DIC) Technique in Measuring Strain Using Opensource Platform Ncorr**. *Journal of Advanced Research in Applied Mechanics* 26, n. 1, 10–21.

Appelbaum, B. (2007) **Conservation Treatment Methodology.** Oxford: Butterworth-Heinemann.

Ballard, M. W. (2011) **Hanging Out: Strength, Elongation, and Relative Humidity: Some Physical Properties of Textile Fibers**. In Brooks, M. & Eastop, D. (Eds.), *Changing Views of Textile Conservation*, 189–93. Getty Publications.

Ballard, M. W. (1995) **How backings work: The effect of textile properties on appearance.** In *Lining and Backing: The Support of Paintings, Paper and Textiles, The UKIC Conference*, 7–8. UKIC, 1995.

Benson, S., Lennard, S. and Margaret J. S. (2014) **'Like-with-like': A comparison of natural and synthetic stitching threads used in textile conservation.** In ICOM Committee for Conservation 17th Triennial Meeting Melbourne Australia 19-23 September 2014. Pulido & Nunes; ICOM Committee for Conservation.

Bing, P., Qian, K., Xie, H. and Asundi, A. (2009) **Two-Dimensional Digital Image Correlation for in-Plane Displacement and Strain Measurement: A Review**. *Measurement Science and Technology* 20(6) (April 2009): 062001. https://doi.org/10.1088/0957-0233/20/6/062001.

Brooks, M. M., Clark, C., Eastop, D., and Petschek, C. (1994) **Restoration and conservation. issues for conservators: a textile conservation perspective**, 99:103–14. British Museum Occasional Papers.

Chamberlin, R. and Garside, P. (2024) **The analysis and stitch support treatment of a suspected tin-weighted silk child's dress.** In Lennard, F., Ewer, P. & Mina, L. (Eds.) *Textile Conservation: Advances in Practice*, 442–50. 2nd Edition. Routledge.

Corah, G. (1977) **Textile Conservation: Deterioration of Materials.** Master Thesis, Rochester Institute of Techology.

Costantini, R., Lennard, R., Alsayednoor, J. and Harrison, P. (2020) **Investigating Mechanical Damage Mechanisms of Tapestries Displayed at Different Angles Using 2D DIC**. *The European Physical Journal Plus* 135(6) (22th July 2020): 515. https://doi.org/10.1140/epjp/s13360-020-00520-7.

Cotte, S. (2007) **An Evaluation of the Role of Semi-Transparent Relining in the Conservation of Thangka Paintings**. *Studies in Conservation* 52(1) (March 2007): 2–12. https://doi.org/10.1179/sic.2007.52.1.2.

Dancause, R. (1996) **On holy ground: Methods for the repair of areas of loss on historic military uniforms.** *TCN: Textile conservation newsletter*.

Enckevort, J., Rumsey, K. and Gillions, B. (2024) **The treatment and retreatment of trade union banners: (Re)building a specialism in the conservation of large painted textiles based on their living history.** In Lennard, F., Ewer, P. & Mina, L. (Eds.) *Textile Conservation: Advances in Practice,* 202-11. 2nd Edition. Routledge

European Confederation of Conservator-Restorers'Organisations (2003). **Professional Guidelines (II): Code of Ethics.** *Brüssel*, 2-4.

Flury-Lemberg, M. (1998) **Conservation with Needle and Thread**. In Brooks, M. & Eastop, D. (Eds.), *Changing Views of Textile Conservation*, 168-74. Getty Publications.

Fredriksson, A. (2021) **Conservation of Lace. To Conserve and Support Guipure Lace.** Bachelor Thesis, University of Gothenburg. https://gupea.ub.gu.se/handle/2077/69190.

Guidess, G. (2024) **To Reveal and not Obscure, Balancing conservation and visual access.** In Lennard, F., Ewer, P. & Mina, L. (Eds.) *Textile Conservation: Advances in Practice,* 80-89. 2nd Edition. Routledge

Hillyer, L. (2024) **Progress in adhesive techniques–the conservation of two Coptic tunics at the Victoria and Albert Museum**. In Lennard, F., Ewer, P. & Mina, L. (Eds.) *Textile Conservation: Advances in Practice,* 305-13. 2nd Edition. Routledge

Hofenk de Graaff, J. H., Boersma, J. & Roelofs, W. H. (1998) **Tapestry Conservation: Support Methods and Fabrics for Tapestries. Part III. Scientific Research" Linen versus Cotton"**. Instituut Collectie Nederland. https://doi.org/10.13140/RG.2.1.4775.9122

International Council of Museums. (2017). ***ICOM Code of Ethics for Museums***.

Jedrzejewska, H. (1981) **Problems in the Conservation of Textiles: Needle versus Adhesive**. In *Changing views of textile conservation*. Getty Publications.

Karsten, I. F. and J. Down. (2005) **The effect of adhesive concentration, reactivation time, and pressure on the peel strength of heat and solvent-reactivated Lascaux 360/498 HV bonds to silk**. In ICOM Committee for Conservation 14th Triennial Meeting, The Hague, 12-16 September 2005, 927-35. James & James/Earthscan.

Karsten, I. F., and Kerr, N. (2011) **Peel strength of silk and nylon textiles adhered to sheer support fabrics**. In *Proceedings of Symposium 2011: Adhesives and Consolidants for Conservation: Research and Applications*, 17–21.

Krejčí, J., Drábková, K., Bureš Víchová, J. and Škrdlantová, M. (2021) **Reversibility of Adhesive Techniques Applied on Historical Textiles**. *The European Physical Journal Plus* 136(6) (7th of June 2021): 642. https://doi.org/10.1140/epjp/s13360-021-01597-4.

Landi, S. (1997) ***Textile Conservator's Manual***. Oxford, UNITED KINGDOM: Taylor & Francis Group.

LaVallee, F. (2005) ***The Abrasiveness of Sheer Overlay Fabrics Used in Textile Conservation.*** Master Thesis, University of Rhode Island. https://doi.org/10.23860/thesis-fulkerson-lavallee-donna-2005.

Lennard, F., Constantini, R. and Harrison, P. (2021) **Investigating Tapestry Conservation and Display with Digital Image Correlation**. In *Spring Forum of the Icon Textile Group*, *Conservation: Out in the Open - The Challenges of Displaying & Conserving Textiles on Open Display*, pp.122-132. The Institute of Conservation.

Lennard, F., Eastop, D., Dulieu-Barton, J., Chambers, A., Khennouf, D., Ye, C. and Williams, H. (2011) **Strain monitoring of tapestries: results of a three-year research project**. In *ICOM Committee for Conservation 16th Triennial Meeting Lisbon Portugal,* 19-23 September 2011. Critério Artes Gráficas, Lda.; ICOM Committee for Conservation.

Lennard, F., Costantini, R. and Harrison, P. (2023) **Investigating Stitched Support Techniques for Tapestry Using Digital Image Correlation.** *Studies in Conservation* 68(5) (4th of July 2023): 558–74. https://doi.org/10.1080/00393630.2022.2083414.

Lennard, F. and Ewer, P. (2010) **Remedial Conservation**. In Lennard, F. & Ewer, P. (Eds.) *Textile Conservation: Advances in Practice*. Oxford: Butterworth-Heinemann. Taylor & Francis Group.

Lennard, F., Ewer, P. and Mina, L. (2024) **Treatment ethics and decision-making**. In Lennard, F., Ewer, P. & Mina, L. (Eds.) *Textile Conservation: Advances in Practice,* 71-79. 2nd Edition. Routledge

LePage, W. **A practical guide to DIC**. Digitalimagecorrelation.org. *DIC Fundamentals* (blog), https://digitalimagecorrelation.org/#patterning.

Lovaas, N. (2020) **Subset, Step Size and Strain Filter Selection**. Correlated Solutions, Inc. https://correlated.kayako.com/article/44-subset-step-size-and-strain-filter-selection.

Medina, C., and Rogerson, C. (2006) **Solvent Reactivation of Adhesives in Textile Conservation: Survey and Comparison with Heat Reactivation.** In *Conservar Património* 3–4, 25–38. https://doi.org/10.14568/cp3-4_3.

Muñoz Viñas, S. (2005) **Contemporary Theory of Conservation.** London: Routledge. https://doi.org/10.4324/9780080476834.

Nilsson, J. and Axelsson Ö. (2015) **Attributes of Aesthetic Quality Used by Textile Conservators in Evaluating Conservation Interventions on Museum Costumes**. *Perceptual and Motor Skills* 121(1), 199–218.

Nilsson, J. (2015a). Ageing and Conservation of Silk – Evaluation of Three Support Methods Using Artificially Aged Silk. PhD Thesis, University of Gothenburg. https://gupea.ub.gu.se/handle/2077/40524

Nilsson, J. (2015b). **Evaluation of stitched support methods for the remedial conservation of historical silk costumes.** *E-conservation Journal*, 1–20.

Schön, M. (2017) **The Mechanical and Supporting Effect of Stitches in Textile Conservation**. Bachelor Thesis, University of Gothenburg. https://gupea.ub.gu.se/handle/2077/52723.

Simpson, L. P. (1991) **Abrasiveness of Certain Backing Fabrics for Supporting Historic Textiles.** *Journal of the American Institute for Conservation* 30(2), 179–85. https://doi.org/10.2307/3179529.

Sutherland, S. and Lennard, F. (2017) **"Each to their own"? An investigation into the spacing of laid-thread couching as used in textile conservation**. In *Newsletter of the ICOM Committee for Conservation, Working Group of Textiles*.

Timar-Balazsy, A. and Eastop, D. (1998) ***Chemical Principles of Textile Conservation*.** Oxford, UNITED KINGDOM: Taylor & Francis Group. http://ebookcentral.proquest.com/lib/gu/detail.action?docID=1024588.

Winslow Grimm, M. (2002) ***The Directory of Hand Stitches Used in Textile Conservation.*** 2nd ed. Washington D.C.: Textile Speciality Group, American Institute for Conservation.

9. LIST OF ILLUSTRATIONS

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10.3 List of tables

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Appendix 1: Survey

Full transcript of the survey

Treatment Solutions for Double-sided Textile objects

This survey is part of a Textile Conservation thesis at the University of Gothenburg exploring damage-stabilizing treatments for double-sided textile objects. In this study, "double-sided objects" refers to objects that feature significant aesthetic and/or functional elements on both sides. Treating these objects without compromising one side's integrity can be a challenge in conservation.

Double sided embroideries, textile art installations, double weave textile art pieces, banners with designs on both faces are some of the examples of these objects. Textile objects with an element of transparency to them are also relevant to the study, as this aspect needs to be considered before a stabilizing treatment.

The purpose of this survey is to gather insights on these objects, focusing on which categories most frequently require conservation treatment, what types of damage are most common, and the methods being used to stabilize them. Therefore, the survey is to be answered exclusively by practicing textile conservators.

For clarifications and examples see https://youtu.be/tj8mzsm6xgE

For more information about personal data processing see at the University of Gothenburg check https://www.gu.se/en/about-the-website/processing-personal-data

For more information or questions contact Gabriel Caracol at gusbrietoev@student.gu.se

1. What type of institution do you work at?

2. How many years have you been practicing textile conservation?

- Less than 5 years
- 5 to 10 years
- More than 10 years

3. Have you worked with double-sided textile objects in your conservation practice? (Please still send in the survey if your answer is no)

4. If yes, what types of double-sided objects have you worked on? (e.g., flags, embroidered textiles, textile installations, etc.)

5. Have you encountered any specific challenges when working with these objects? Describe them.

6. What types of structural damage have you observed in these objects?

- Wear and tear

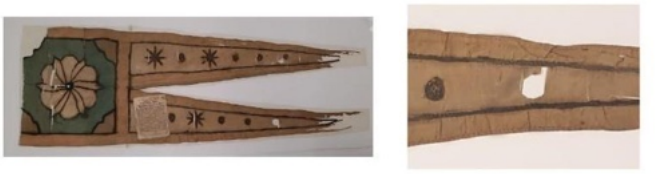
- Holes
- Broken warp/weft threads
- Loss of warp/weft threads
- Other (please specify)

7. Have you treated double-sided textile objects with structural damages, such as the ones mentioned in the previous question?

- Yes
- No

8. If you have experience treating structural damage in double-sided textile objects, could you describe the specific methods or treatments you've used? Please provide details on techniques such as patching, type of stitching, adhesive treatments, or any other methods you've found effective.

9. Look at the pictures below



"Transparent" by Lars Johansson and Gunilla Lagerbielke, National Museum Collection. Photo: Gabriel Caracol, National Museum©

"Transparent" by Lars Johansson and Gunilla Lagerbielke, National Museum Collection. Photo: Gabriel Caracol, National Museum©

9. If the objects in the pictures were to be displayed in a way that showcases both sides (e.g., hanging vertically in the center of a room or in a transparent display case visible from both sides), **how would you stabilize or treat a hole in such an object? Please describe your preferred method** (e.g., using a patch and laid couching, adhesive treatment using a sheer fabric, or other techniques).

10. If you are open to a follow-up interview, please leave your contact information below.

Appendix 2: Survey answers

Table 8. Information regarding the respondents of the survey, questions 1-3

Employment situation	Respondents	Experience	Respondents	Experience w/ double-sided textiles	Respondents
Museum conservators	7	**Less than 5 years**	4	**Yes**	10
Free-lance/self employed	6	**5 to 10 years**	1	**No**	4
Student	1	**More than 10 years**	9		

Table 9. Answers to question 4.

If yes, what types of double-sided objects have you worked on? (e.g., flags, embroidered textiles, textile installations, etc.)
flag, banner, tapestry
From the archaeological textiles therefore the technical information was essential on both sides.
Painting (oil on a aide and tempera on the other) on satin Silk, 17th century
One embroiedered curtain, one huge loincloth
Banners, embroidered textiles, lace
Flags, sporting pennants, banners
contemporary art, flags, shawls, embroideries
double-sided flags/banners, embroidered textiles, open warp tapestry, modern textile artworks
Fanor, broderade textilier och fodrade textilier
fanor, standar, fönsterskärmar,

Table 10. Answers to question 5.

Have you encountered any specific challenges when working with these objects? Describe them.
yes, the problem of where to place hanging systems and how to deal with very fragile or incomplete parts.
It was necessary to adapt the choice of consolidation support, we tested different transparent/semi-transparent textile. Despite this choice of transparent fabrics it was necessary to make a choice of the face on which we will apply it. Because even if the support is transparent it still alters the perception of the chosen face.
Necessity of a solid consolidation treatment because of the big dimension of the textile and its degradation
The difficulty in choosing which side to restore/sew the hanging system
Not being able to use traditional methods which include the addition of a support patch on the reverse of the textile without severely diminishing the visibility of one side of the textile
Deciding the correct course of treatment, whether it is necessary to completely cover up the reverse in order to preserve the textile for longer
most challenges come with display requests, for example to display a shawl draped over a mannequin and show parts of both sides, any support needs to allow both sides to be visible.
support systems often require a different approach to normal textiles that can have the backface covered and mounting is a larger discussion in how it should and can be displayed best.
Inget som inte har gått att lösa. Ska nu ta fram en fana som är dubbelsidig med ett applicerat broderi i intarsia, där skador är finns. Måste lossa sömmar fast jag helst skulle vilja låta bli.
Det finns inget att fästa lagningar i. Alla tillkomna delar syns från antingen det ena eller det andra hållet.

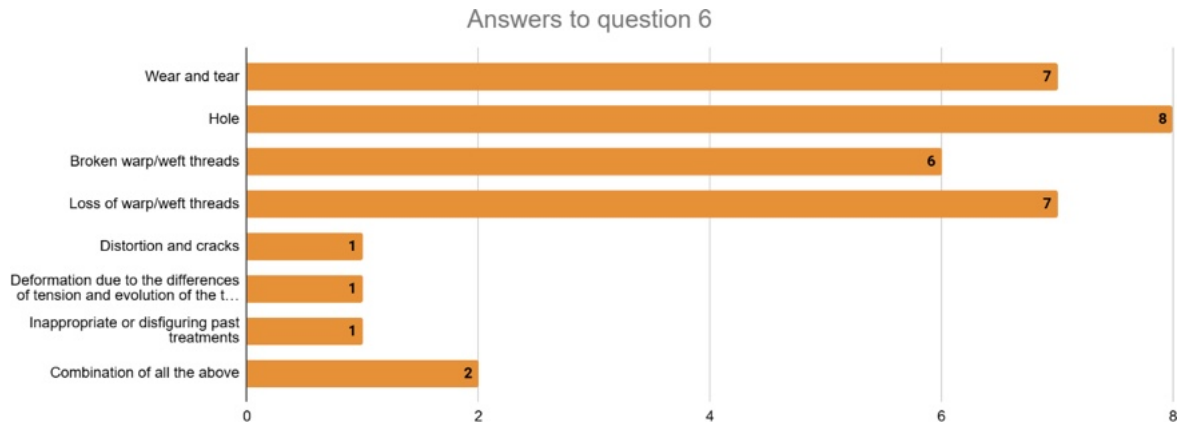


Figure 68. Answers to question 6.

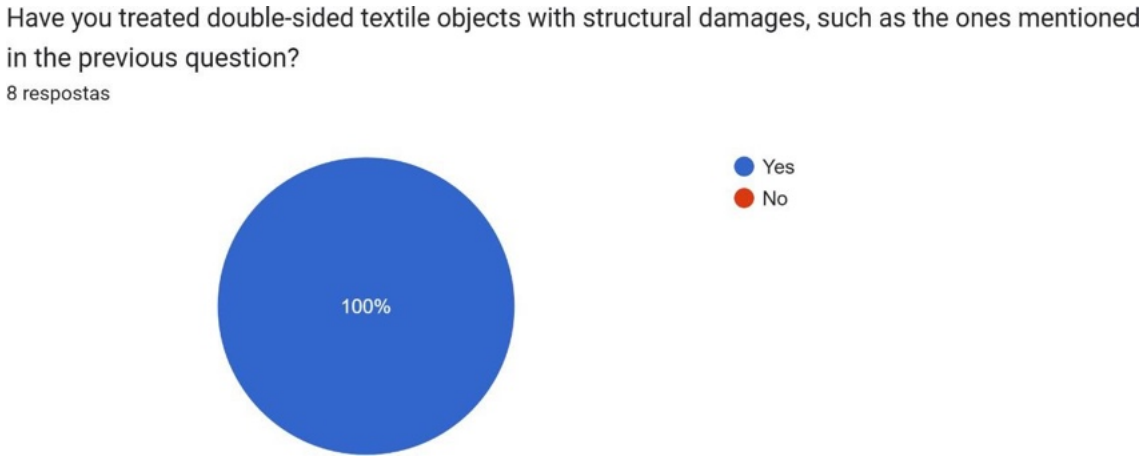


Figure 69. Answers to question 7.

Table 11. Answers to question 7.

If you have experience treating structural damage in double-sided textile objects, could you describe the specific methods or treatments you've used? Please provide details on techniques such as patching, type of stitching, adhesive treatments, or any other methods you've found effective.
several techniques combined: for example, inlay gap-filling, held in place by sewn crepeline (or tulle) or adhesive film
I used a silk crepe dyed to the color of the background of the work (clear dominance). I proceeded to a complete dubbing, the set was maintained by fixing lines arranged in staggered. At the niveua of the hole, gap and tear area of similar but smaller line was set up. The lines are made with a curved needle and silk organza thread.
We did some tests of consolidation with Beva. The idea for the tear was to use pre-glued strings, prepared with beva, that we then reactivated in the tear, and doing so on both side. Beva was quite shiny but it was solid. For the holes, it was the same idea with a consolidation piece, attached by beva pre-glued strings. For the visual, something in the direction of the tear was ideal. For the solidity, I guess it could be tested better but it worked on both side on another textile, depending if the state of the textile is really bad, something perpendicular to the tear would be better.
I did a "classic" conservation treatment, by sewing the holes on a support with couching stiches ; the museum choosed which side to present for these two objets, so we had a visible side and a non visible side (against the wall). There were finally treated like one-sided textiles

For a gauze like object which had many losses and became quite brittle, the textile was sandwiched between a layer of crepeline and a layer of tule. These layers subtly provided some camouflage for the losses and made the gauze look like a unity again. The sandwich was stitched along the edges and where the losses were located. This way, stitching through the original material could be greatly limited.
Sandwiching between layers of net with stitched support, duplicate stitch on a knitted shawl.
for banners and flags I have mostly used adhesive treatments. The most successful was a self-prepared Beva that was cast onto silk crepeline and applied onto the banner on one side using the bias to avoid the moire effect. I have also used different mixtures of Lascaux applied to silk crepeline, which often requires extra support at the edges with stitching to prevent the adhesive for peeling or failing over time. I have also used a polyester-like crepeline for the adhesive treatment on more modern banners or when the banner was to be used again (not in a museum setting) Nylon net stitched through the damage, most likely on both sides to create a 'sandwich' that provides more support. Though the same technique could be used with crepeline.
Sytt in mellan silkes Crepeline under och över objektet. Sytt runt skador med små förstygn, ibland redsömmar med tunt silkestråd. Ibland kombinerat med infärgat stödtyg. Skulle vilja använda presure mounting mer.
Mest osynligt är nog dubbelsidig Beva/laminering. Laminering används endast i de fall materialet tillåter det. Svårt om det är glest och grovt tyg. Att sy är ofta väldigt känsligt och syns för mycket. Svårt att fästa tråden i material som inte finns eller som är väldigt skört.

Table 12. Answers to question 8.

If the objects in the pictures were to be displayed in a way that showcases both sides (e.g., hanging vertically in the center of a room or in a transparent display case visible from both sides), how would you stabilize or treat a hole in such an object? Please describe your preferred method (e.g., using a patch and laid couching, adhesive treatment using a sheer fabric, or other techniques).
This depends on the location of the gap, the condition of the fibers around the hole, the thickness of the textile and the suspension system
I think I will use a transparent fabric maintained by sewing.
For the first, depends of the condition of the objet : if it's still stable, maybe an adhesive treatment with a sheer fabric (or japanese paper ?), but couching stiches on a sheer fabric are no excluded despite the problem of double sides ; or maybe if the objet is very crumbly, sewing the entire triangle between two layers of crepeline, and had a patch with the same color and weave just in the hole. For the second one, probably a nylon net (on one side, or two layers with the textile inside ?)
Depending on the stability of the object. In case of loss during handling, sandwiching the object between two layers of crepeline or tule or a combination, either connected with stitches or adhesive. For smaller losses the application of a support patch with adhesive, possibly combined with laid-couching.
Either adhesive treatment with silk crepeline or fine netting and couching
Sandwiching between layers of net, stitched support, no adhesive.
A sandwich of nylon net for the second picture (likely the support stiches will need to go over the hole to prevent it from stretch as net is not structurally stable enough. For the flag, I would likely consider an adhesive treatment with dyed crepeline. However, since the hole is very large, I would try a heavier silk that matches the flag best, cut exactly to the shape of the hole to act as an infill. This would then be covered with the adhesive treated silk crepeline (ideally on one side, but potentially it may need both). As the different silk fabrics have different textures it might be necessary to put the crepeline on the bias. If health and safety as well as the space allowed it, I would use a self-prepared Beva in white spirits applied to the silk crepeline. Note, the health and safety is quite a high risk when using so much white spirits and no one else can be in the locatation under the time and during the drying time (normally over night).

Appendix 3: Material List

Cotton	Alltyg, Artikelnummer:10011	In "Oblekt" available at https://www.textilhuset.se/sv/1543/10011/alltyg
Silk Crepeline	Lyon Voile Crepeline, 10g/m2 from CTS Conservation	Available at https://ctsconservation.com/en/papers-cloths-textiles/6422-lyon-voile-crepeline-10-gm-5-m-x-140-cm-wide-7-m.html
Nylon Net	#N8000 from Dukeries Textiles and Fancy Goods Ltd, UK	
Polyester Tulle	Invisible Illusion Tulle, MacCulloch & Wallis Ltd	In "White" available at https://www.macculloch-wallis.co.uk/p/4074I/sheer-fabrics/mw/invisible-illusion-tulle
Lascaux 303	Acrylic Heat Set Adhesive	Available at https://www.preservationequipment.com/Catalogue/Conservation-Materials/Adhesives/Lascaux-303-HV-Acrylic-Adhesive
Lascaux 498	Acrylic Adhesive	Available at https://www.preservationequipment.com/Catalogue/Conservation-Materials/Adhesives/Lascaux-498-HV-Acrylic-Adhesive

Appendix 4: Oddy Test Results

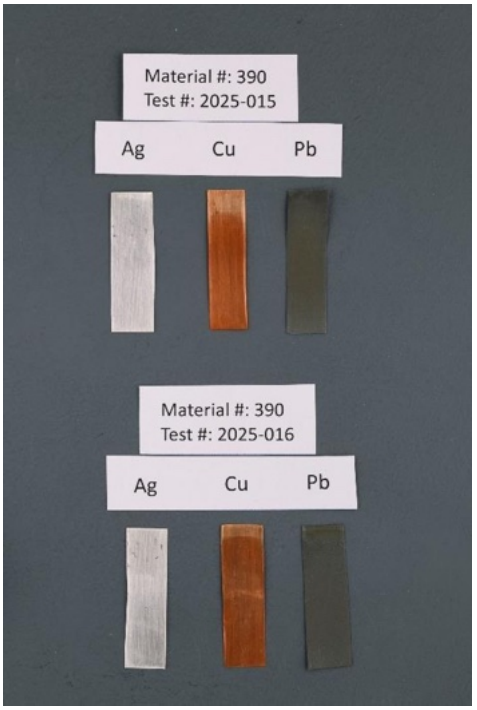


Figure 70. Oddy test results of polyester tulle sample. Photo taken by Elyse Canosa, Swedish National Heritage Board.

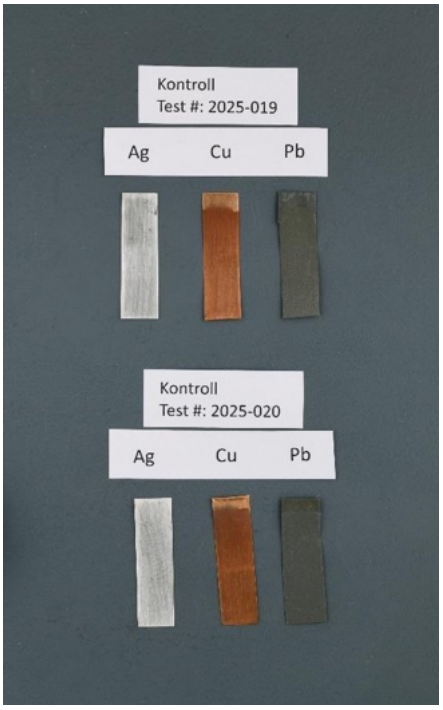


Figure 71. Oddy test results of control. Photo taken by Elyse Canosa, Swedish National Heritage Board.

Appendix 5: 2D Digital Image Correlation data

Table 13. Final strain average and standard deviation for the samples after 167 hours of fixed load testing

Sample	Final Average Strain					
	BATCH 1		BATCH 2		BATCH 3	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Untreated control sample	0,0277	0,0119	0,0277	0,0080	0,0317	0,0130
Stitched cotton control sample	0,012	0,0033	0,0112	0,0017	0,0117	0,0032
Adhesive silk crepeline sample	0,0036	0,0055	0,0028	0,0045	0,0025	0,0039
Stitched silk crepeline sample	0,0046	0,0041	0,0038	0,0026	0,004	0,0052
Adhesive polyester tulle sample	0,0204	0,0080	0,0181	0,0046	0,0128	0,0075
Stitched polyester tulle sample	0,0184	0,0058	0,0149	0,0029	0,0116	0,0108
Adhesive nylon net sample	0,0294	0,0069	0,0239	0,0053	0,0329	0,0087
Stitched nylon net sample	0,0158	0,0075	0,0158	0,0023	0,0179	0,0078

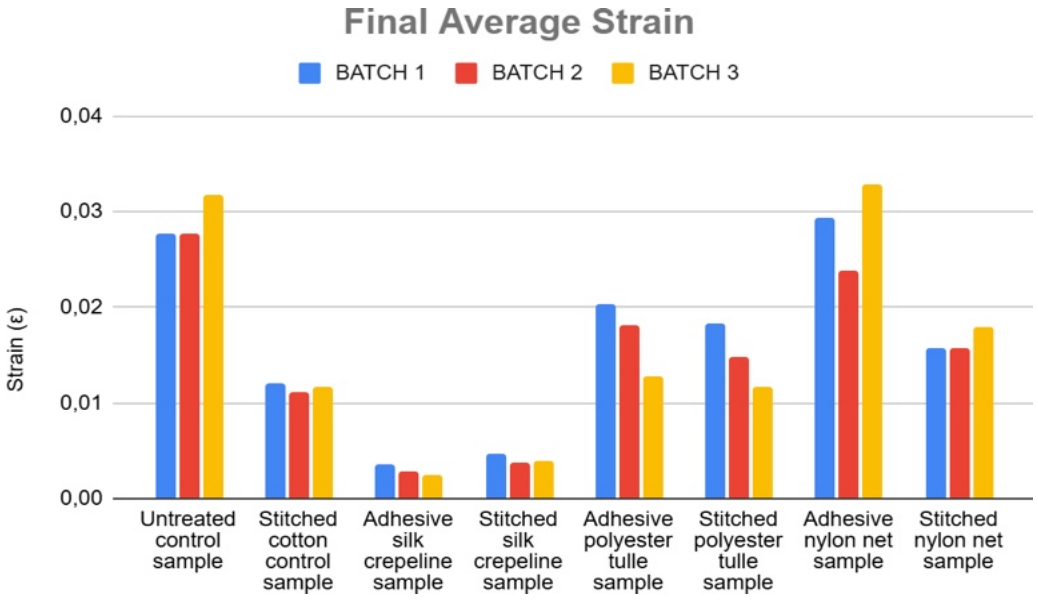


Figure 70. Final average strain (ε) of samples after 167 hours of fixed load testing

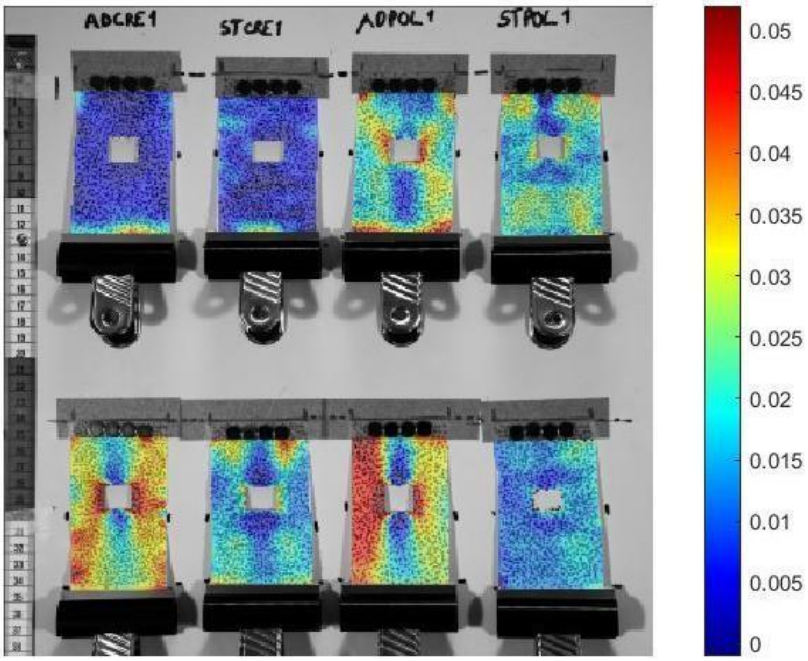


Figure 71. Eyy strain plot of first batch of samples after 167 hours of fixed load testing

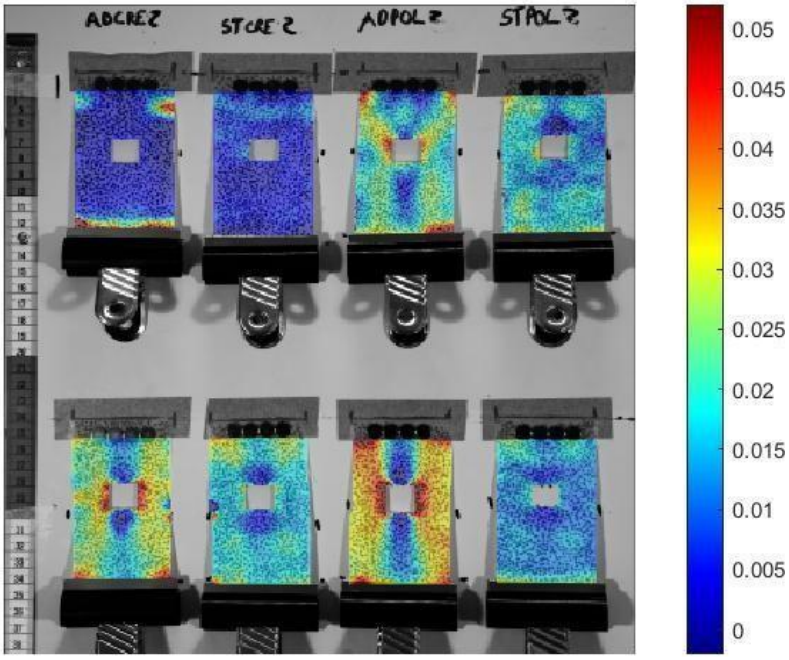


Figure 72. Eyy strain plot of second batch of samples after 167 hours of fixed load testing

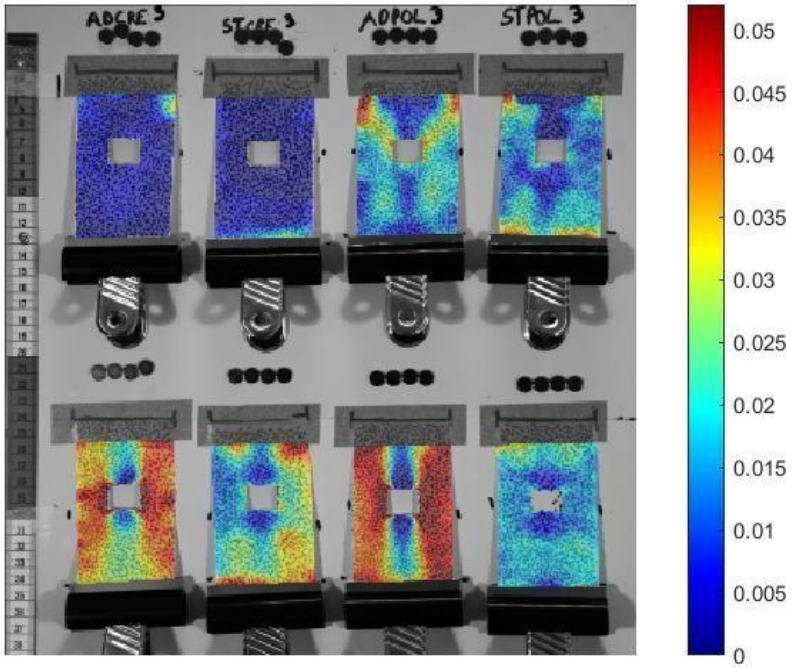


Figure 73. Eyy strain plot of third batch of samples after 167 hours of fixed load testing

Table 14. Final displacement average and standard deviation for the samples after 167 hours of fixed load testing

Sample	Final Displacement					
	BATCH 1		BATCH 2		BATCH 3	
	Average (mm)	Standard Deviation	Average (mm)	Standard Deviation	Average (mm)	Standard Deviation
Untreated control sample	1,6713	1,1158	1,48375	0,9861	1,7313	1,0472
Stitched cotton control sample	0,636	0,3955	0,3666	0,2993	0,6976	0,3253
Adhesive silk crepeline sample	0,105	0,1114	0,031	0,1202	0,2704	0,1042
Stitched silk crepeline sample	0,22675	0,1415	0,0441	0,1215	0,1506	0,0405
Adhesive polyester tulle sample	1,0574	0,6521	0,80045	0,5978	0,9595	0,4522
Stitched polyester tulle sample	0,93585	0,5214	0,4968	0,4091	0,8369	0,378
Adhesive nylon net sample	1,6498	0,9838	0,8925	0,7058	1,80605	1,1133
Stitched nylon net sample	1,1129	0,5575	0,6978	0,4676	0,8257	0,6031

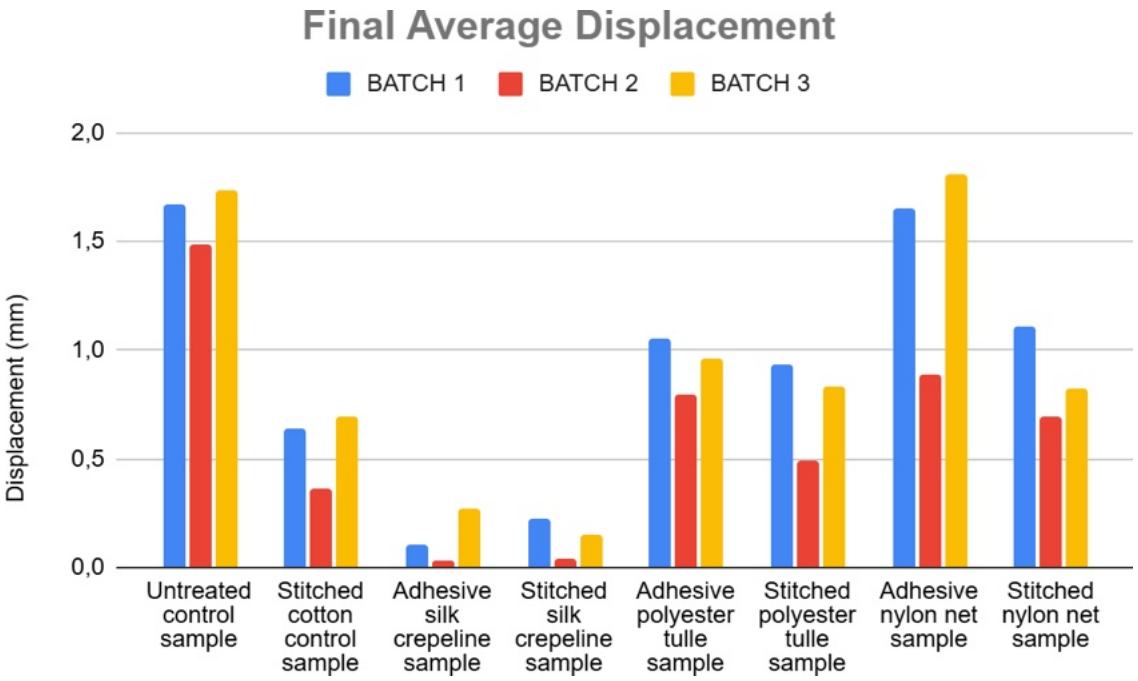


Figure 74. Final average displacement (mm) of samples after 167 hours of fixed load testing

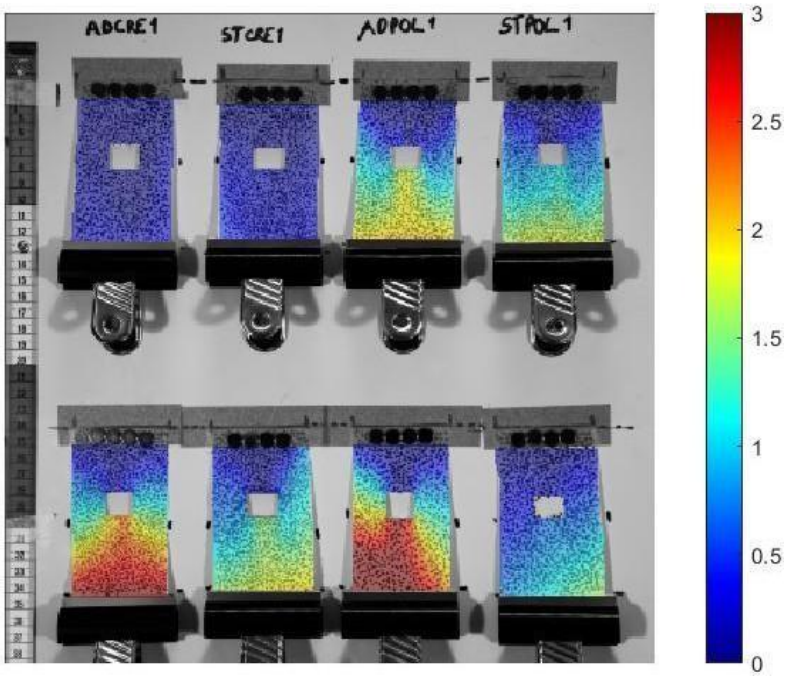


Figure 75. Vertical displacement plot of first batch of samples after 167 hours of fixed load testing (gradient in mm)

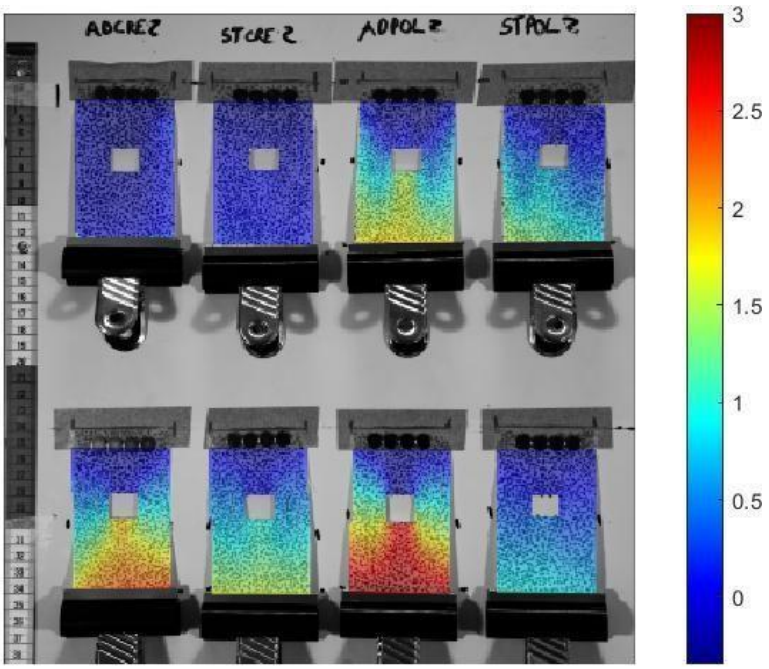


Figure 76. Vertical displacement plot of second batch of samples after 167 hours of fixed load testing (gradient in mm

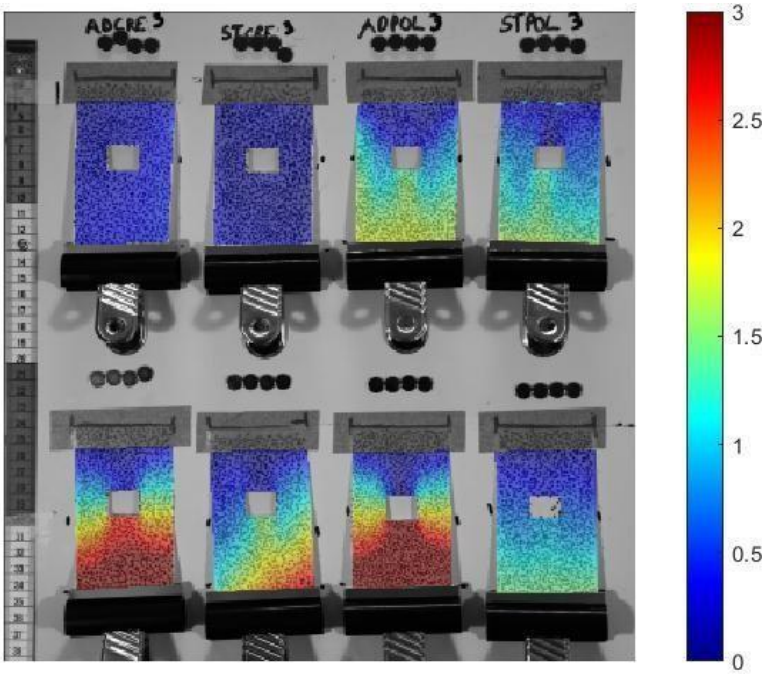


Figure 77. Vertical displacement plot of third batch of samples after 167 hours of fixed load testing (gradient in mm)

Table 7. Average strain (ε) of first batch of samples at different points in fixed-load test

	SAMPLE							
Time	CTRLA1	CTRLB1	ADCRE1	STCRE1	ADPOL1	STPOL1	ADNYL1	STNYL1
0h	0	0	0	0	0	0	0	0
1MIN	0,0137	0,0057	0,0017	0,0038	0,0093	0,0123	0,0099	0,0098
5H	0,0166	0,0057	0,0021	0,0042	0,0117	0,0123	0,015	0,0111
10H	0,0175	0,0057	0,0023	0,0042	0,0123	0,0123	0,0168	0,0117
24H	0,0223	0,0057	0,0028	0,0046	0,0154	0,0123	0,0232	0,0135
30H	0,0245	0,0105	0,0032	0,0049	0,01665	0,0174	0,02525	0,0143
48H	0,0279	0,012	0,0034	0,0049	0,0188	0,0187	0,028	0,0154
72H	0,029	0,0124	0,0035	0,0048	0,0202	0,0192	0,0296	0,0157
96H	0,0302	0,0129	0,0038	0,005	0,0211	0,0198	0,0313	0,0163
100H	0,0304	0,013	0,0038	0,005	0,0214	0,0197	0,0315	0,0163
167H	0,0277	0,012	0,0036	0,0046	0,0204	0,0184	0,0294	0,0158

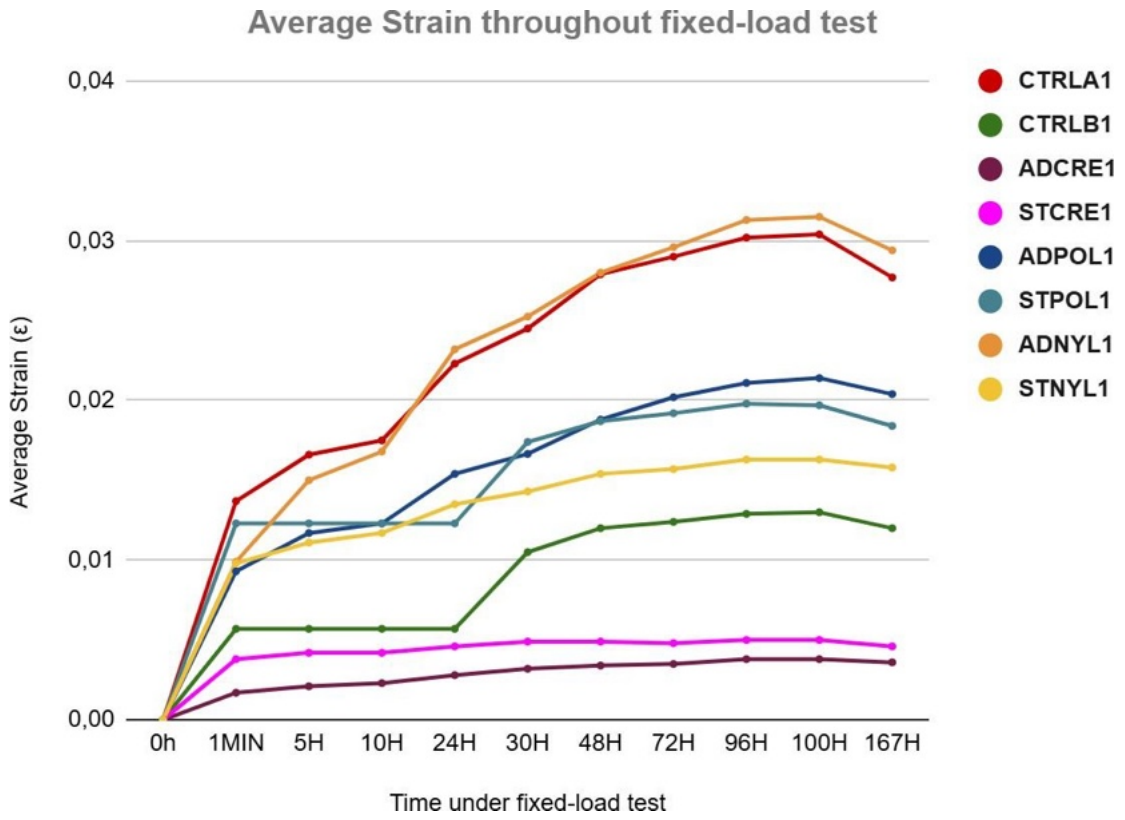


Figure 78. Average strain (ε) of first batch of samples at different points in fixed-load test

Appendix 6: Before and after fixed-load test pictures

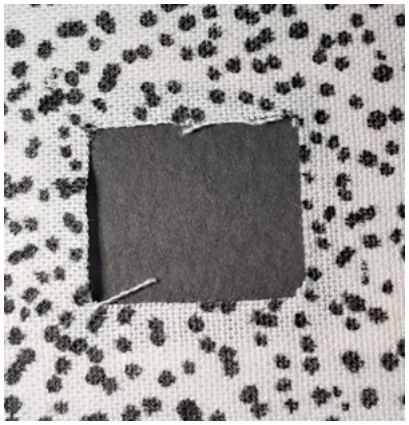


Figure 79. Untreated control sample before fixed-load test, front face

Figure 80. Untreated control sample after fixed-load test, front face

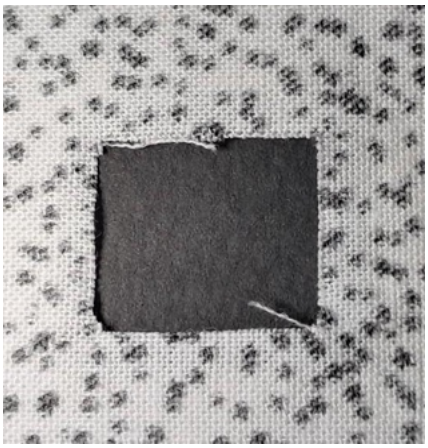


Figure 81. Untreated control sample before fixed-load test, back face

Figure 82. Untreated control sample after fixed-load test, back face

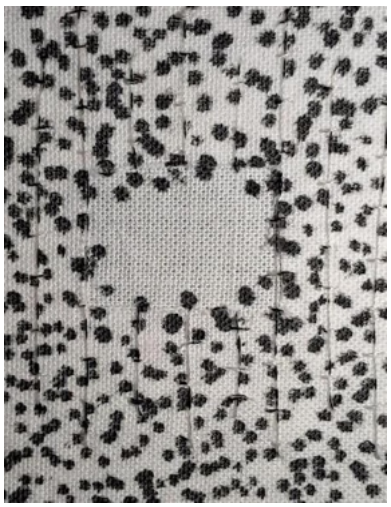


Figure 83. Cotton support stitched sample before fixed-load test, front face

Figure 84. Cotton support stitched sample after fixed-load test, front face

Figure 85. Cotton support stitched sample before fixed-load test, back face

Figure 86. Cotton support stitched sample after fixed-load test, back face

Figure 87. Silk crepeline adhesive sample before fixed-load test, front face

Figure 88. Silk crepeline adhesive sample after fixed-load test, front face

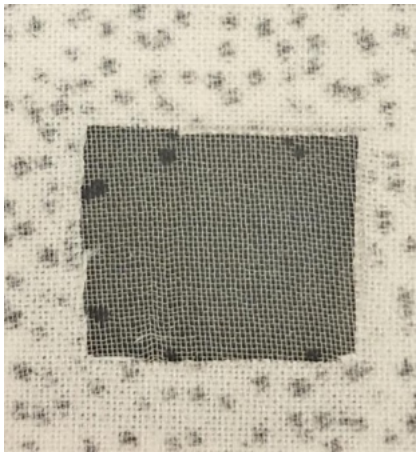


Figure 89. Silk crepeline adhesive sample before fixed-load test, back face

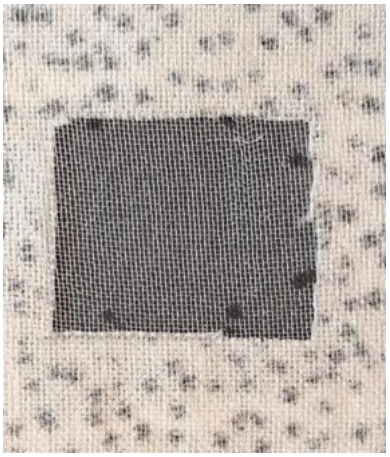


Figure 90. Silk crepeline adhesive sample after fixed-load test, back face

Figure 91. Polyester tulle adhesive sample before fixed-load test, front face

Figure 92. Polyester tulle adhesive sample after fixed-load test, front face

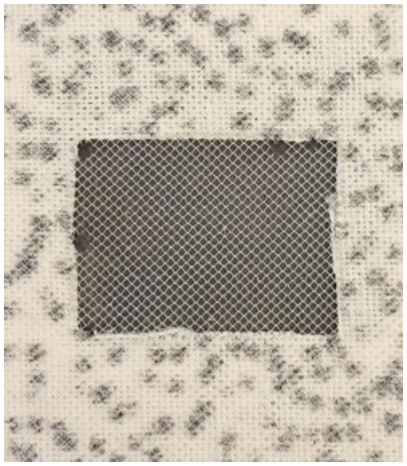


Figure 93. Polyester tulle adhesive sample before fixed-load test, back face

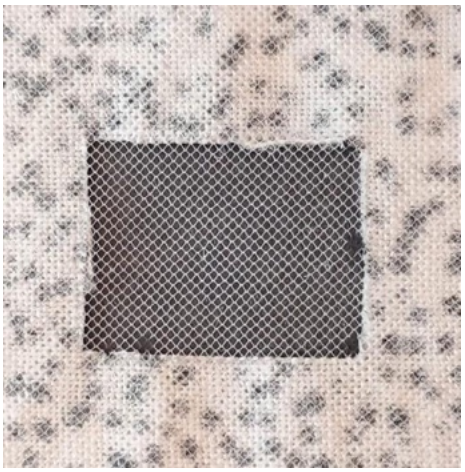


Figure 94. Polyester tulle adhesive sample after fixed-load test, back face

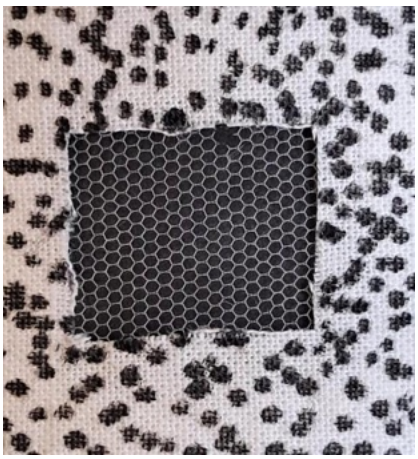


Figure 95. Nylon net adhesive sample before fixed-load test, front face

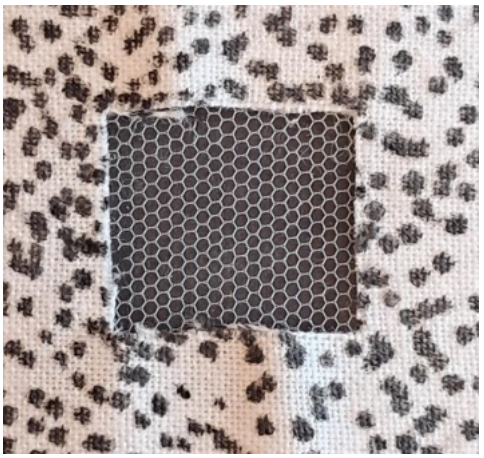


Figure 96. Nylon net adhesive sample after fixed-load test, front face

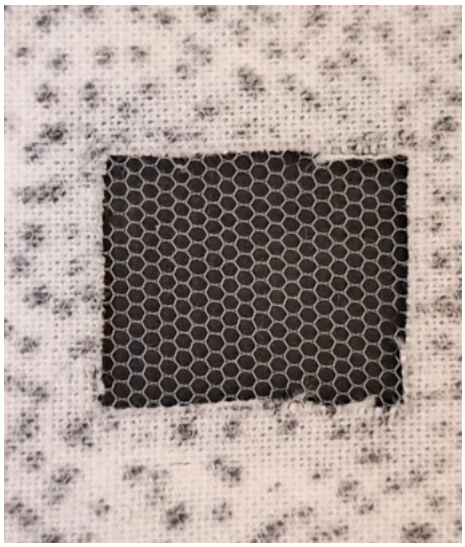


Figure 97. Nylon net adhesive sample before fixed-load test, back face

Figure 98. Nylon net adhesive sample after fixed-load test, back face

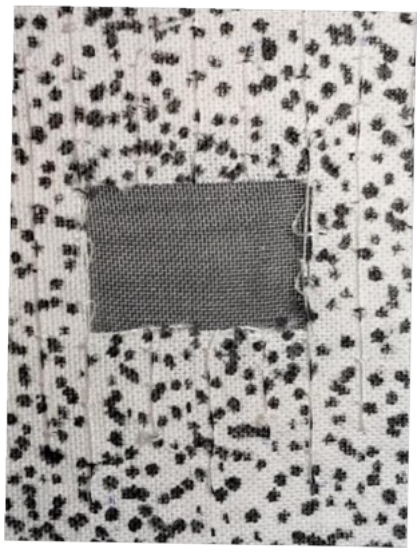


Figure 99. Silk crepeline stitched sample before fixed-load test, front face

Figure 100. Silk crepeline stitched sample after fixed-load test, front face

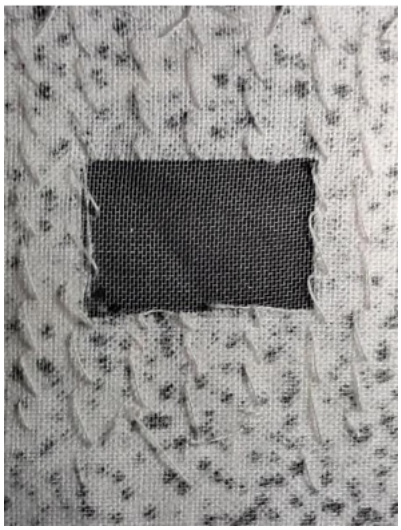


Figure 101. Silk crepeline stitched sample before fixed-load test, back face

Figure 102. Silk crepeline stitched sample before fixed-load test, back face

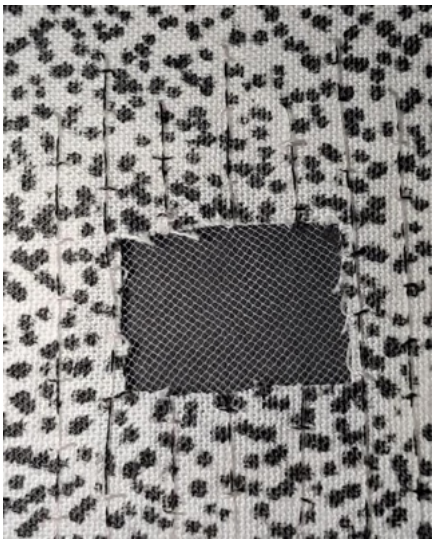


Figure 103. Polyester tulle stitched sample before fixed-load test, front face

Figure 104. Polyester tulle stitched sample after fixed-load test, front face

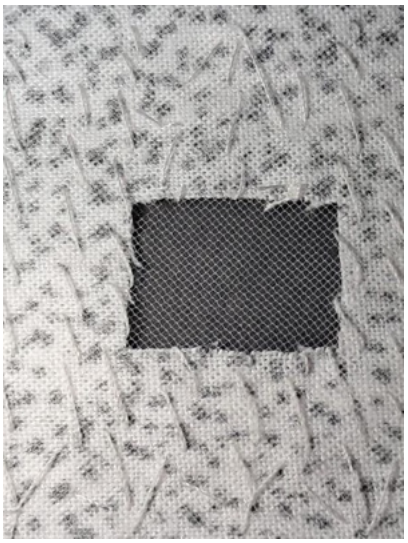


Figure 105. Polyester tulle stitched sample before fixed-load test, back face

Figure 106. Polyester tulle stitched sample after fixed-load test, back face

Figure 107. Nylon net stitched sample before fixed-load test, front face

Figure 108. Nylon net stitched sample after fixed-load test, front face

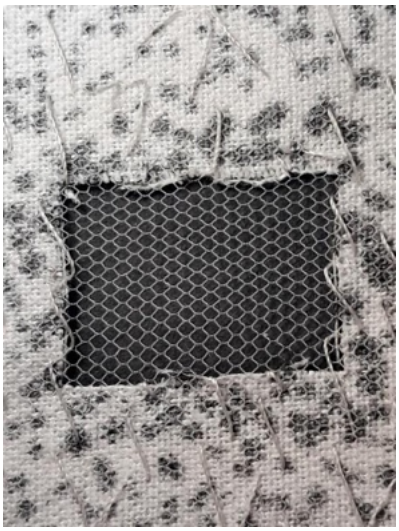


Figure 109. Nylon net stitched sample before fixed-load test, back face

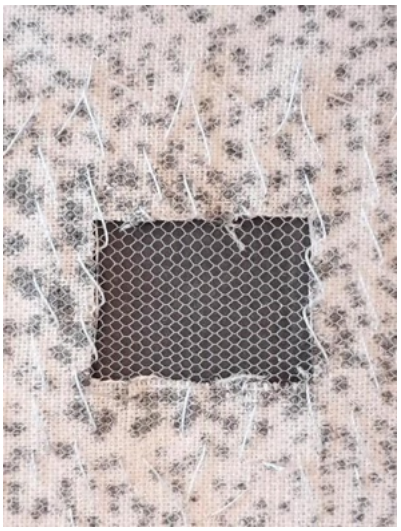


Figure 110. Nylon net stitched sample after fixed-load test, back face

Appendix 7: Dino-Lite Microscope Pictures

ADCRE1

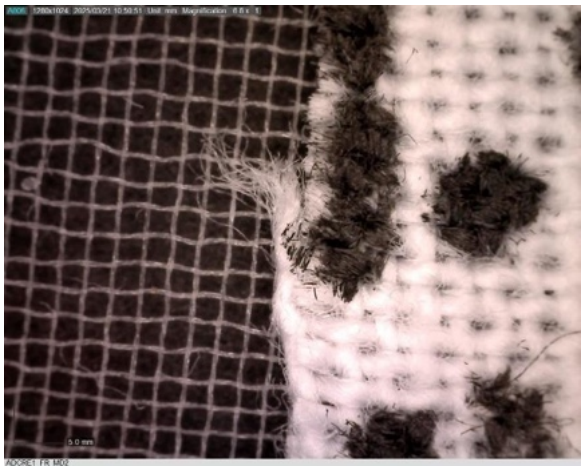


Figure 111. Point in adhesive silk crepeline sample, front side, before fixed-load test

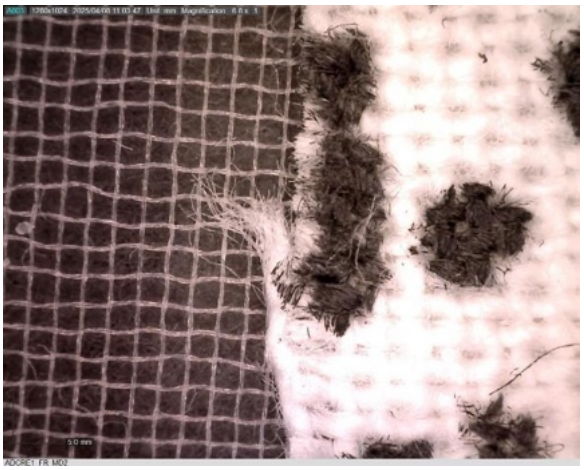


Figure 112. Point in adhesive silk crepeline sample, front side, after fixed-load test

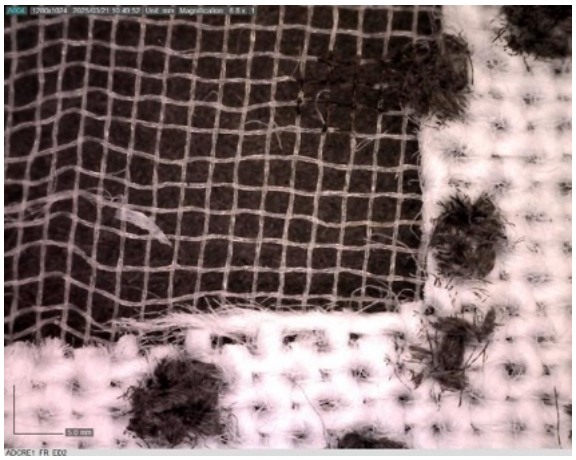


Figure 113. Point in adhesive silk crepeline sample, front side, before fixed-load test

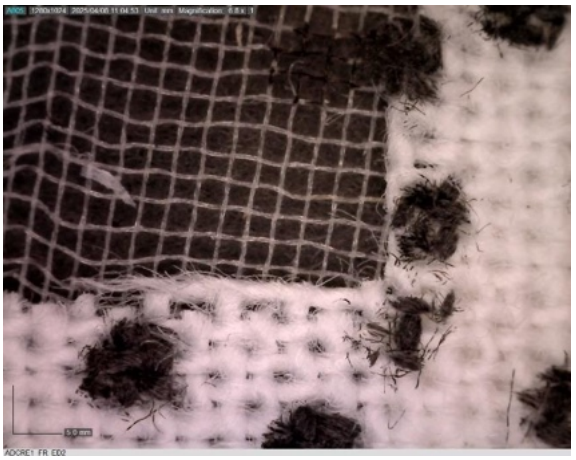


Figure 114. Point in adhesive silk crepeline sample, front side, after fixed-load test

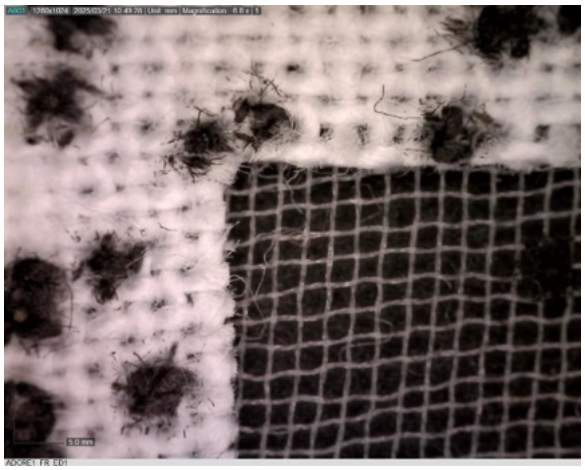


Figure 115. Point in adhesive silk crepeline sample, front side, before fixed-load test

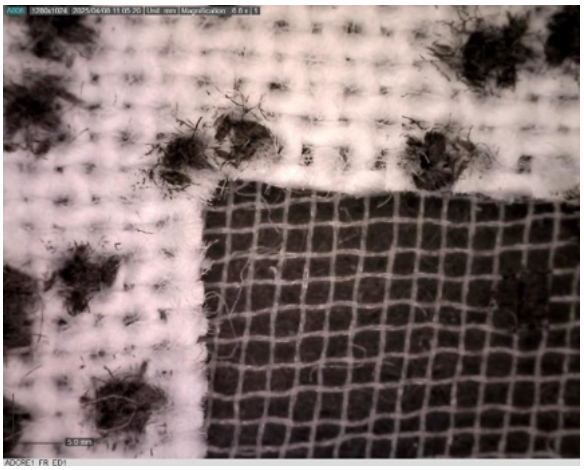


Figure 116. Point in adhesive silk crepeline sample, front side, after fixed-load test

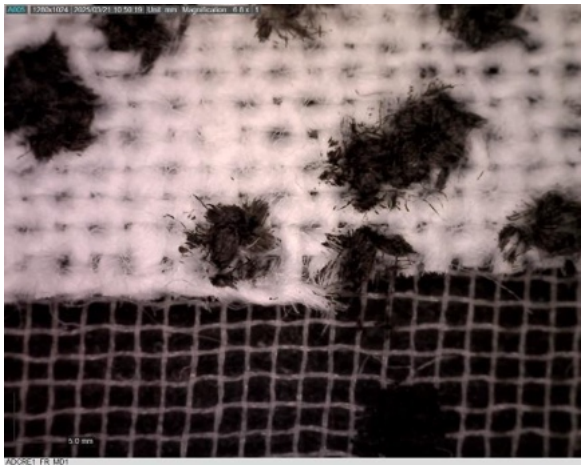


Figure 117. Point in adhesive silk crepeline sample, front side, before fixed-load test

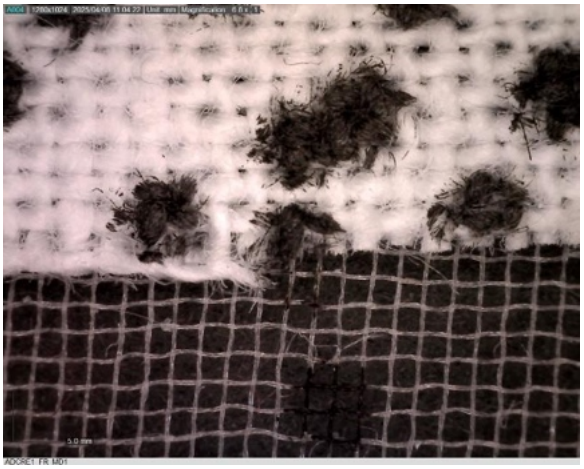


Figure 118. Point in adhesive silk crepeline sample, front side, after fixed-load test

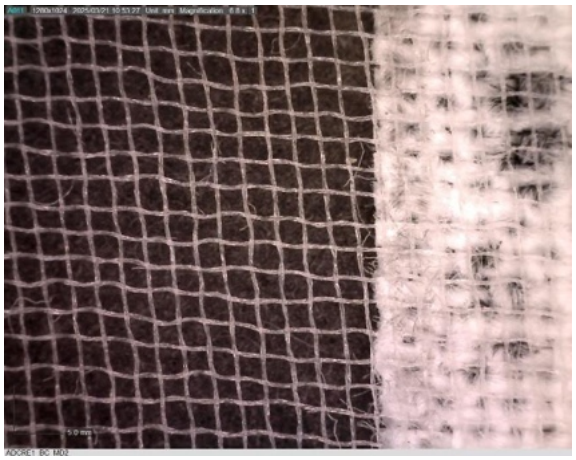


Figure 119. Point in adhesive silk crepeline sample, back side, before fixed-load test

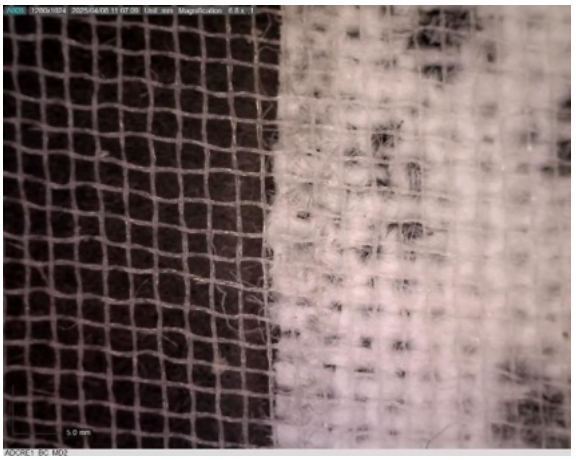


Figure 120. Point in adhesive silk crepeline sample, back side, after fixed-load test

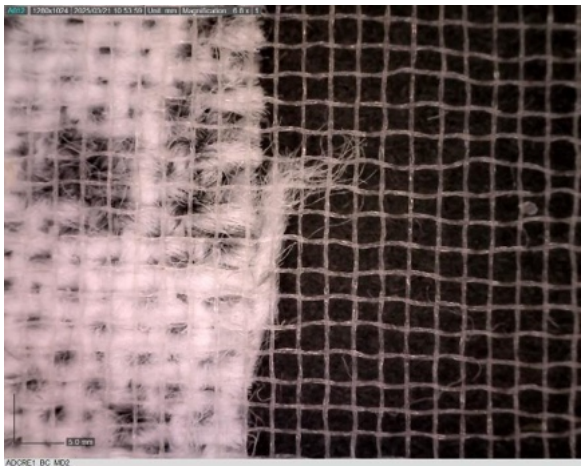


Figure 121. Point in adhesive silk crepeline sample, back side, before fixed-load test

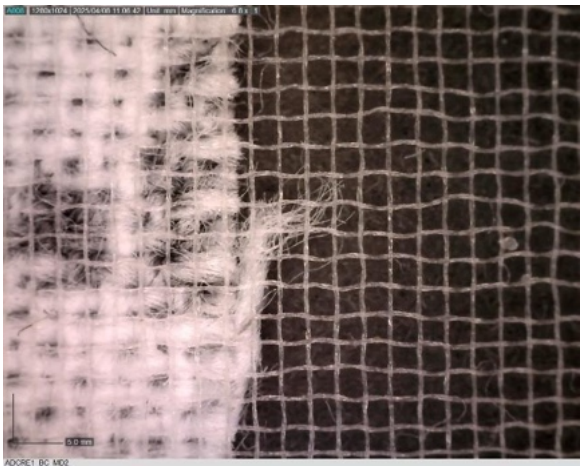


Figure 122. Point in adhesive silk crepeline sample, back side, after fixed-load test

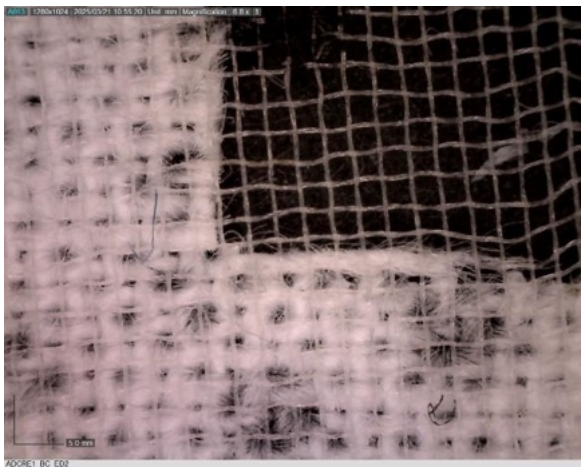


Figure 123. Point in adhesive silk crepeline sample, back side, before fixed-load test

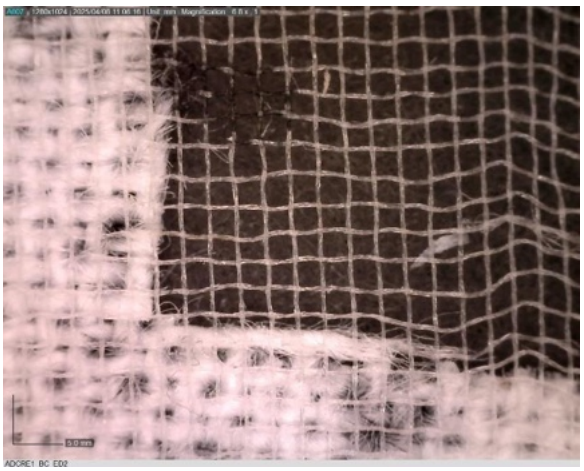


Figure 124. Point in adhesive silk crepeline sample, back side, after fixed-load test

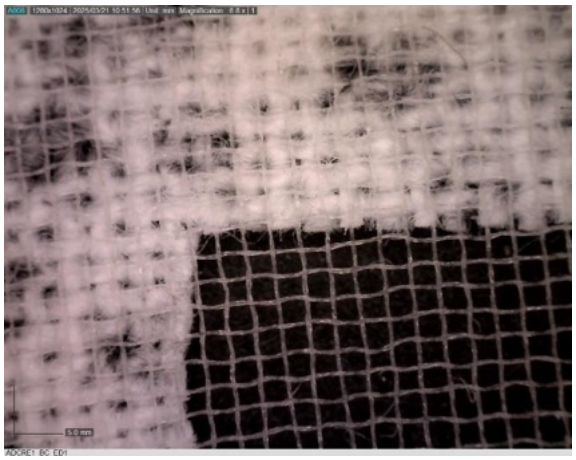


Figure 125. Point in adhesive silk crepeline sample, back side, before fixed-load test

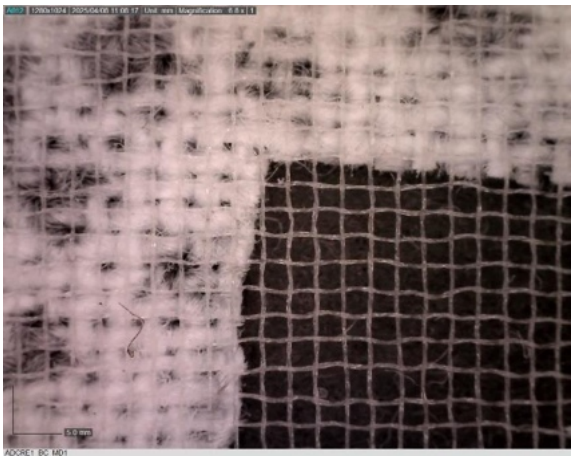


Figure 126. Point in adhesive silk crepeline sample, back side, after fixed-load test

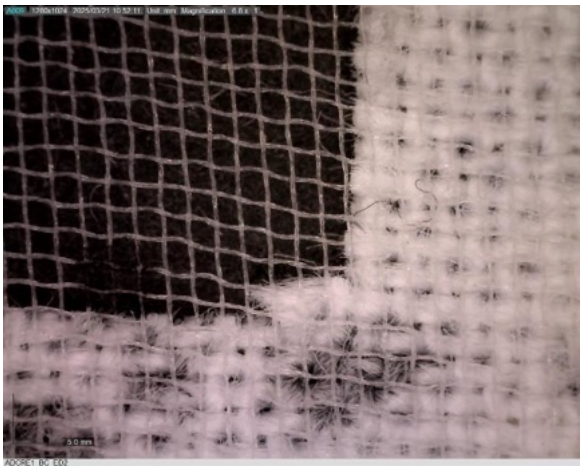


Figure 127. Point in adhesive silk crepeline sample, back side, before fixed-load test

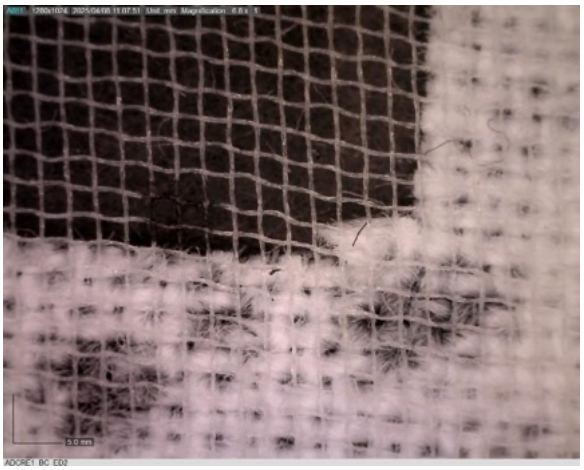


Figure 128. Point in adhesive silk crepeline sample, back side, after fixed-load test

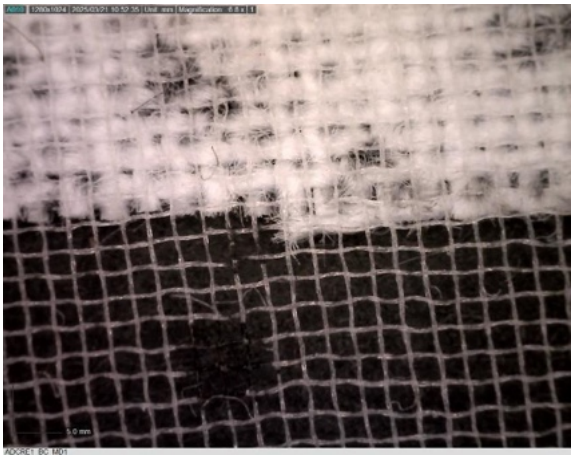


Figure 129. Point in adhesive silk crepeline sample, back side, before fixed-load test

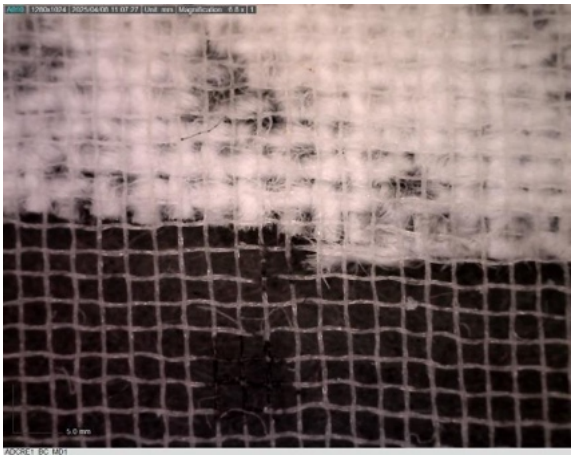


Figure 130. Point in adhesive silk crepeline sample, back side, after fixed-load test

ADPOL1

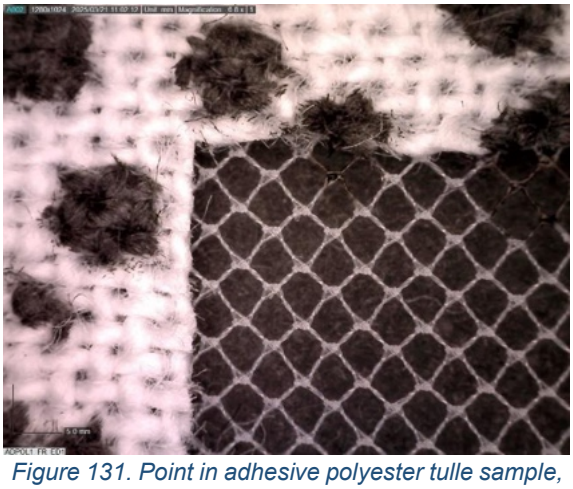


Figure 131. Point in adhesive polyester tulle sample, front side, before fixed-load test

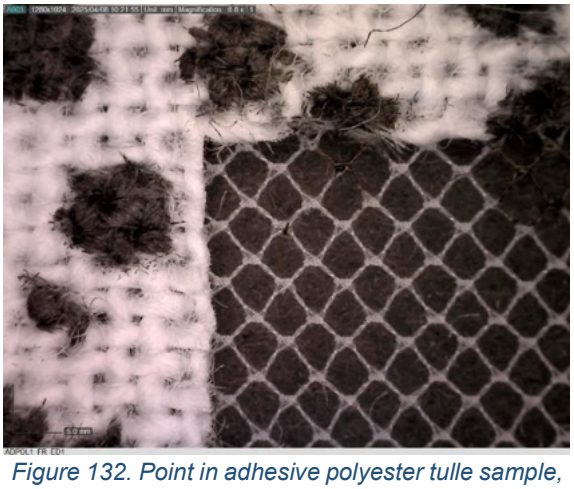


Figure 132. Point in adhesive polyester tulle sample, front side, after fixed-load test

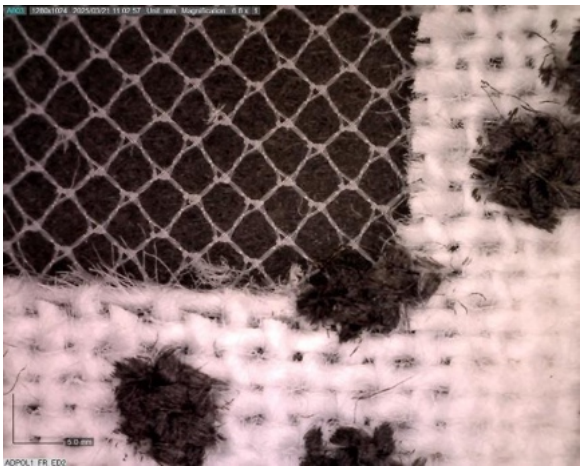


Figure 133. Point in adhesive polyester tulle sample, front side, before fixed-load test

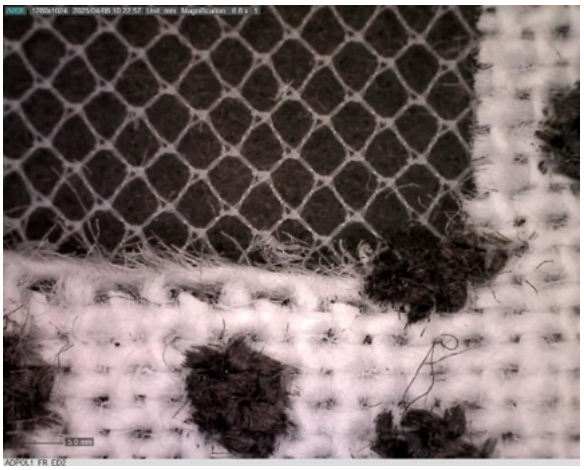


Figure 134. Point in adhesive polyester tulle sample, front side, after fixed-load test

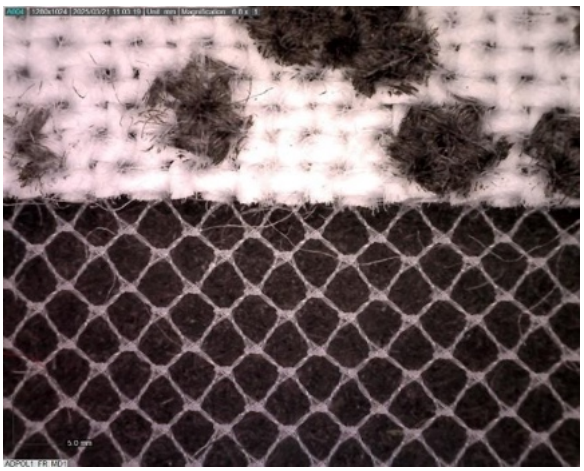


Figure 135. Point in adhesive polyester tulle sample, front side, before fixed-load test

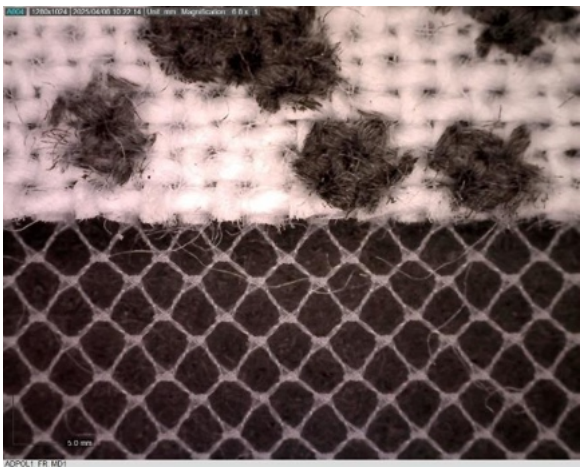


Figure 136. Point in adhesive polyester tulle sample, front side, after fixed-load test

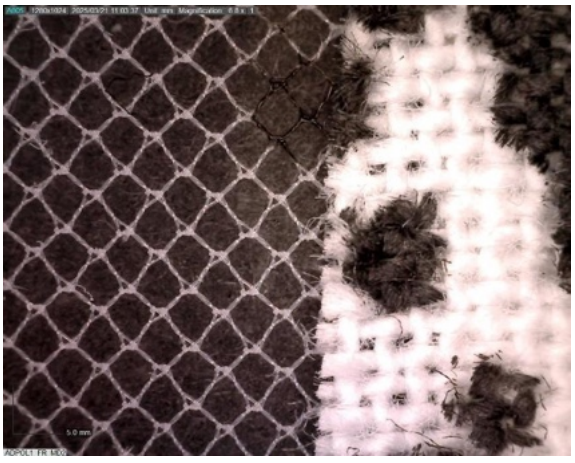


Figure 137. Point in adhesive polyester tulle sample, front side, before fixed-load test

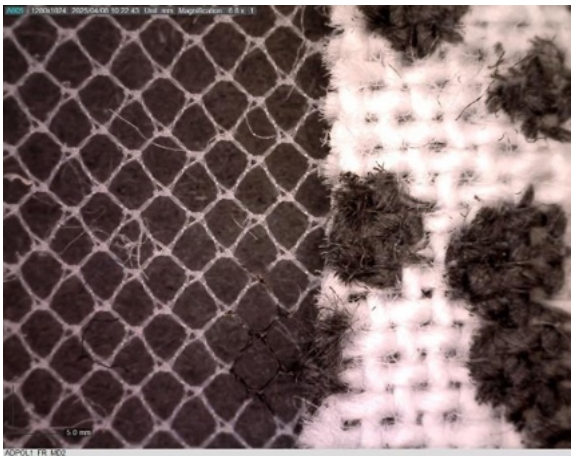


Figure 138. Point in adhesive polyester tulle sample, front side, after fixed-load test

Figure 139. Point in adhesive polyester tulle sample, back side, before fixed-load test

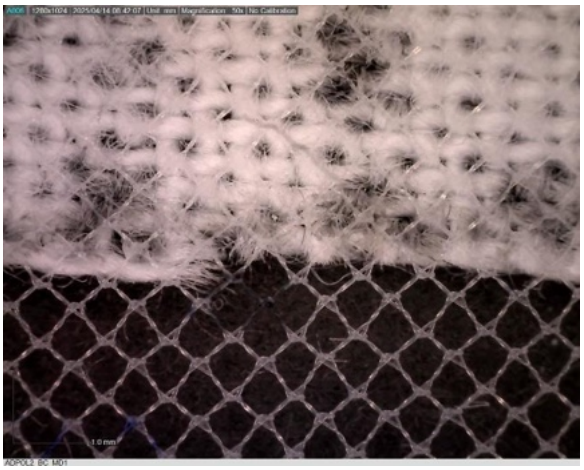


Figure 140. Point in adhesive polyester tulle sample, back side, after fixed-load test

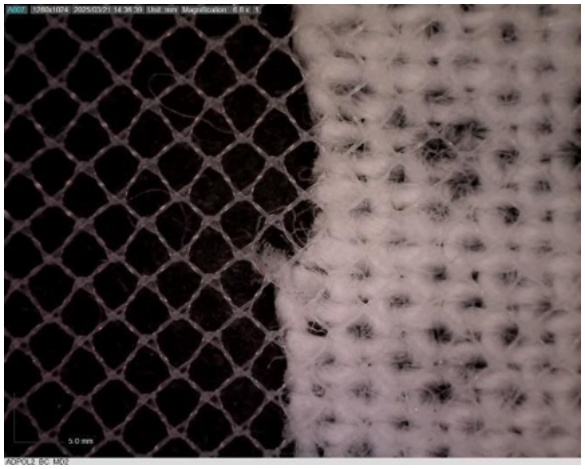


Figure 141. Point in adhesive polyester tulle sample, back side, before fixed-load test

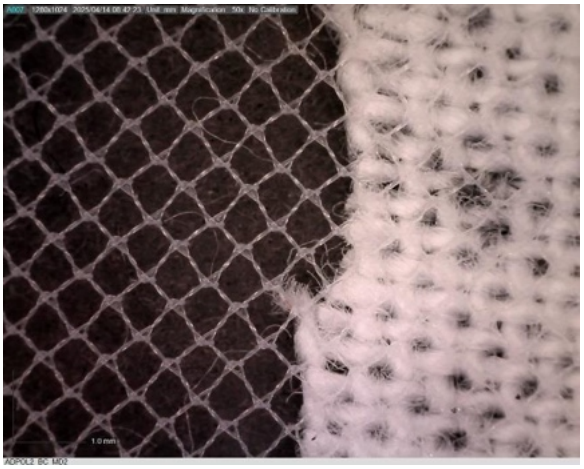


Figure 142. Point in adhesive polyester tulle sample, back side, after fixed-load test

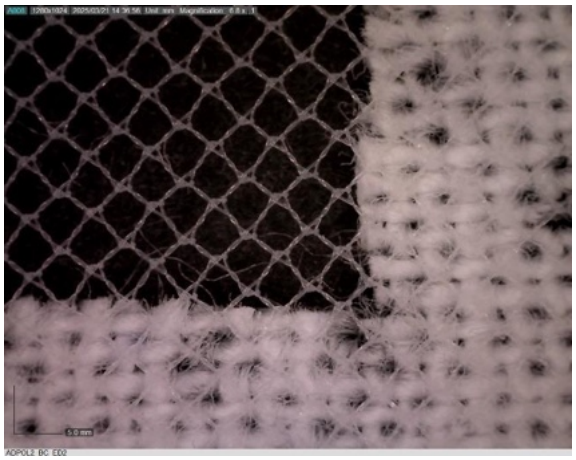


Figure 143. Point in adhesive polyester tulle sample, back side, before fixed-load test

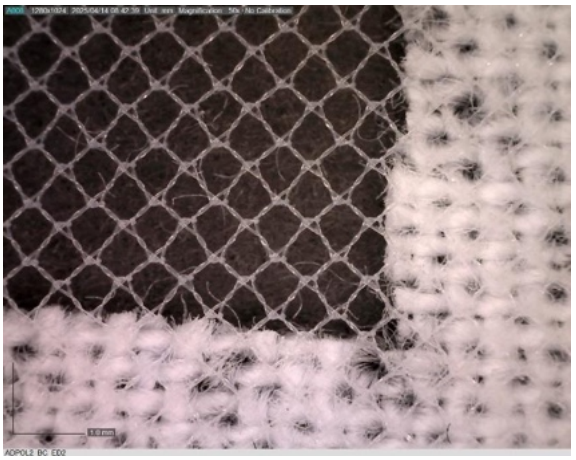


Figure 144. Point in adhesive polyester tulle sample, back side, after fixed-load test

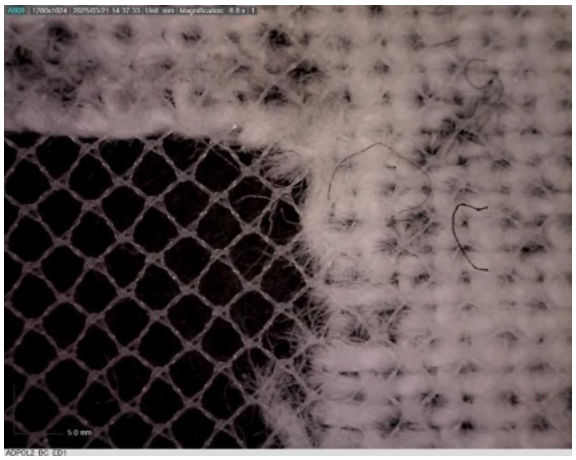


Figure 145. Point in adhesive polyester tulle sample, back side, before fixed-load test

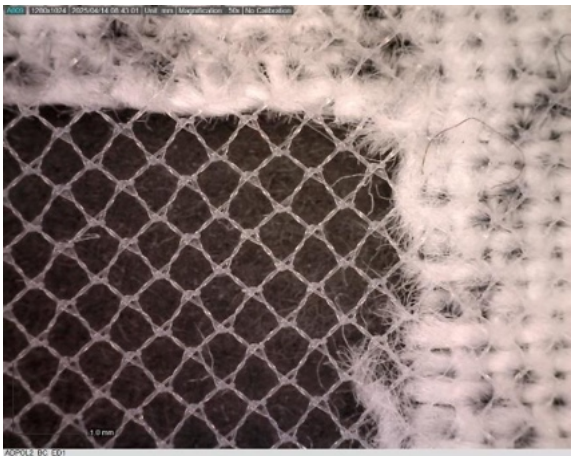


Figure 146. Point in adhesive polyester tulle sample, back side, after fixed-load test

ADNYL1

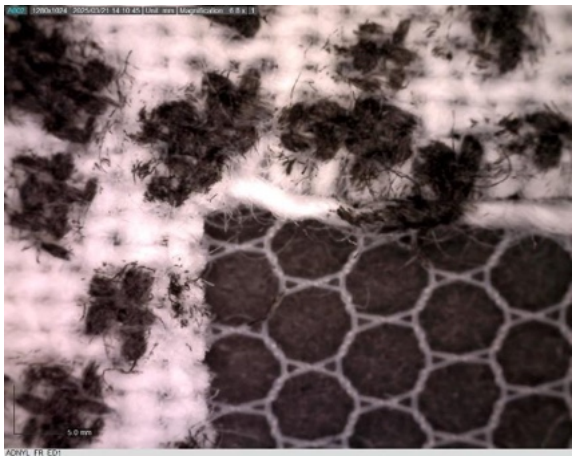


Figure 147. Point in adhesive nylon net sample, front side, before fixed-load test

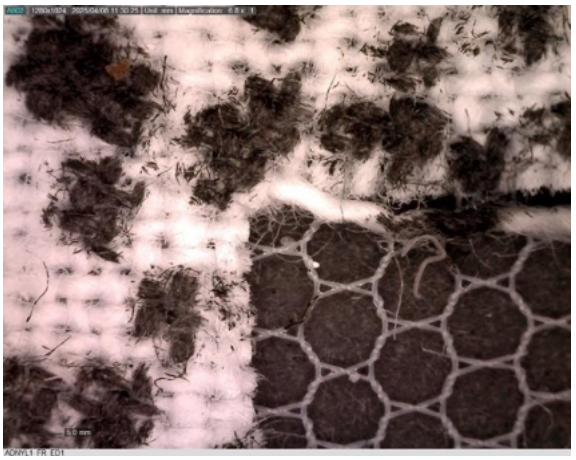


Figure 148. Point in adhesive nylon net sample, front side, after fixed-load test

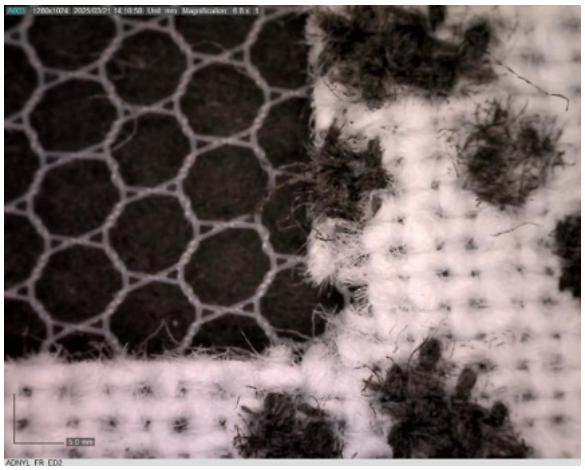


Figure 149. Point in adhesive nylon net sample, front side, before fixed-load test

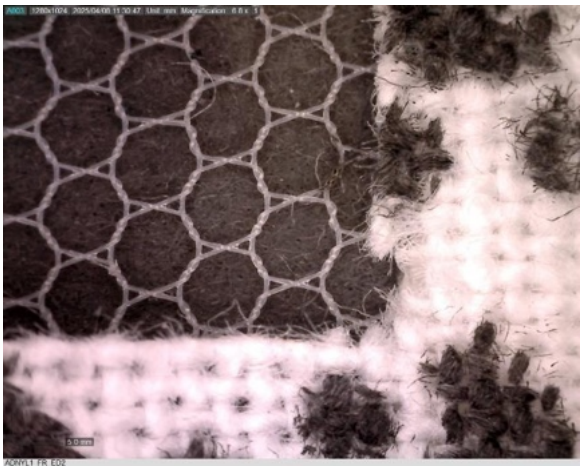


Figure 150Point in adhesive nylon net sample, front side, after fixed-load test

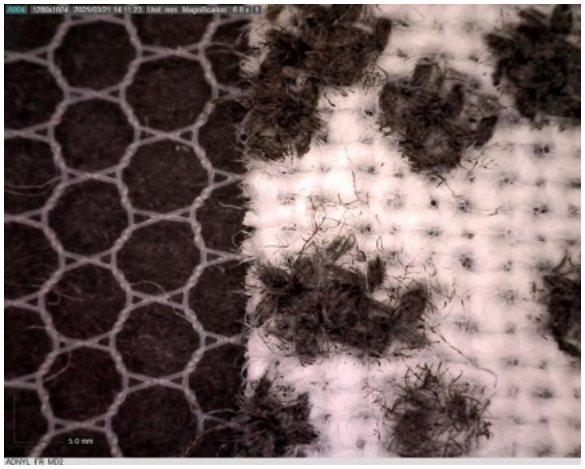


Figure 151. Point in adhesive nylon net sample, front side, before fixed-load test

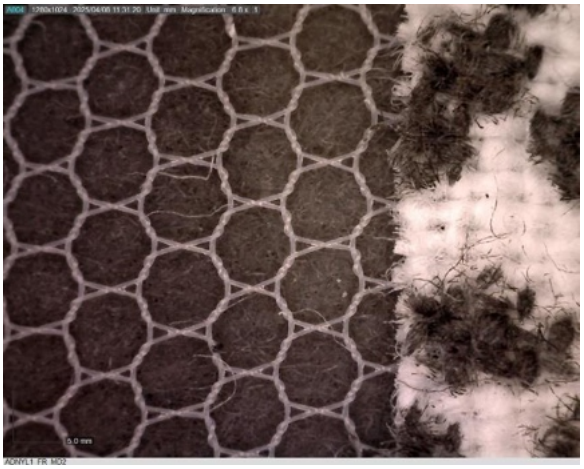


Figure 152. Point in adhesive nylon net sample, front side, after fixed-load test

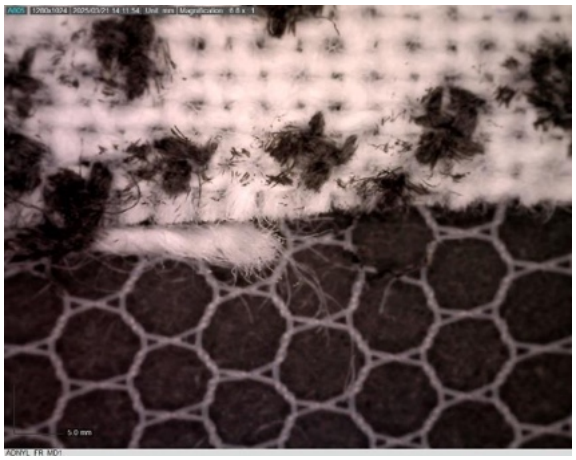


Figure 153. Point in adhesive nylon net sample, front side, before fixed-load test

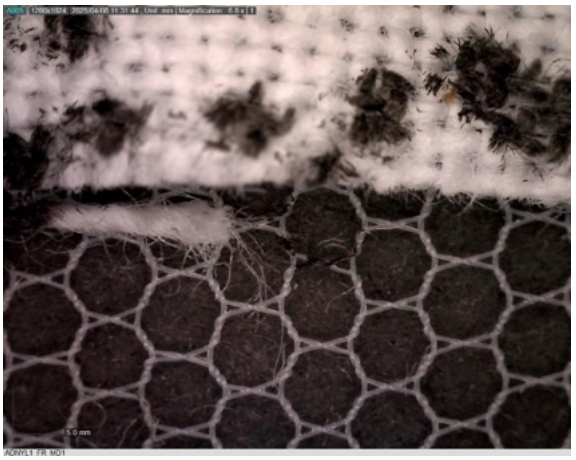


Figure 154. Point in adhesive nylon net sample, front side, after fixed-load test

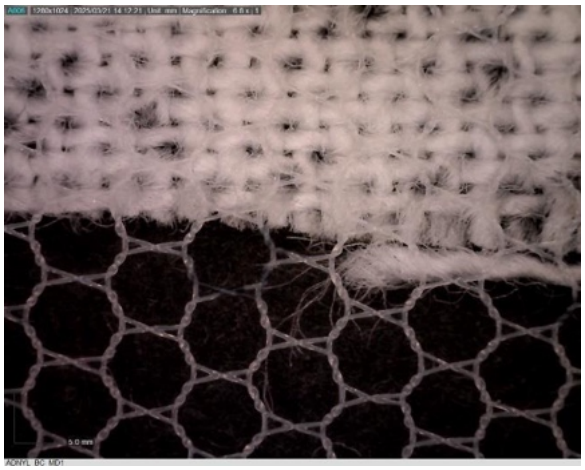


Figure 155. Point in adhesive nylon net sample, back side, before fixed-load test

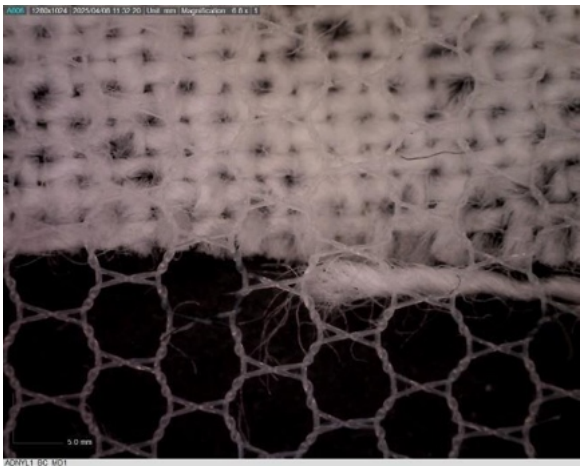


Figure 156. Point in adhesive nylon net sample, back side, after fixed-load test

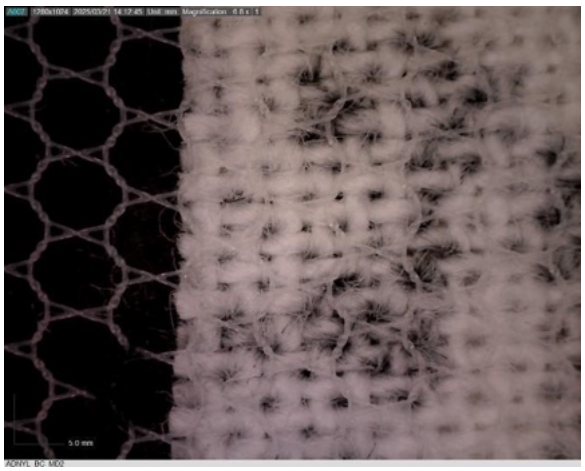


Figure 157. Point in adhesive nylon net sample, back side, before fixed-load test

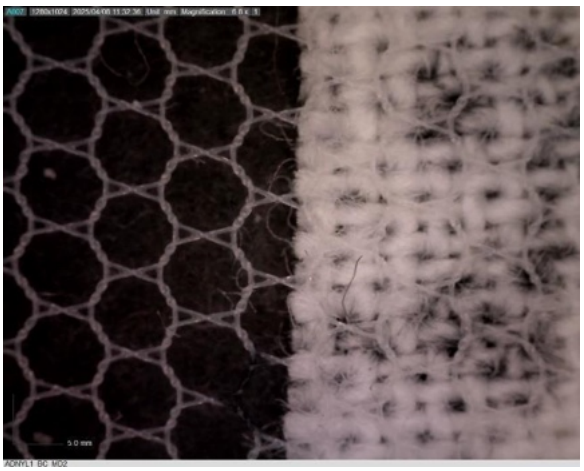


Figure 158. Point in adhesive nylon net sample, back side, after fixed-load test

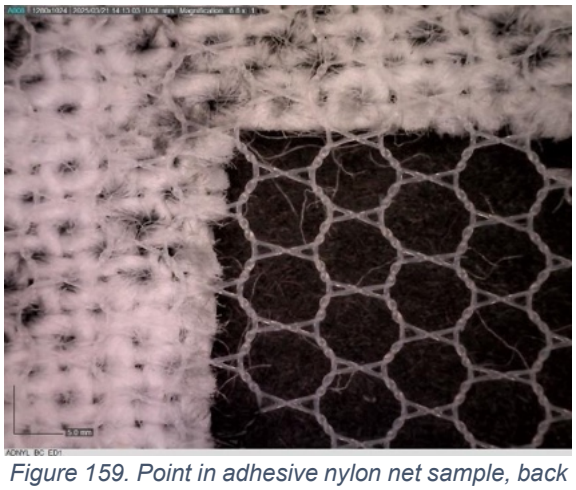


Figure 159. Point in adhesive nylon net sample, back side, before fixed-load test

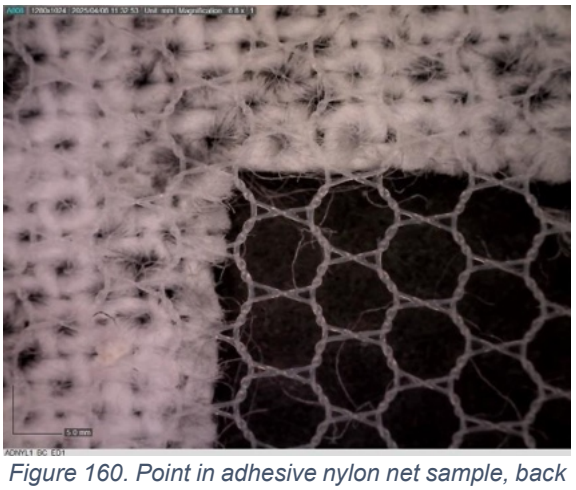


Figure 160. Point in adhesive nylon net sample, back side, after fixed-load test

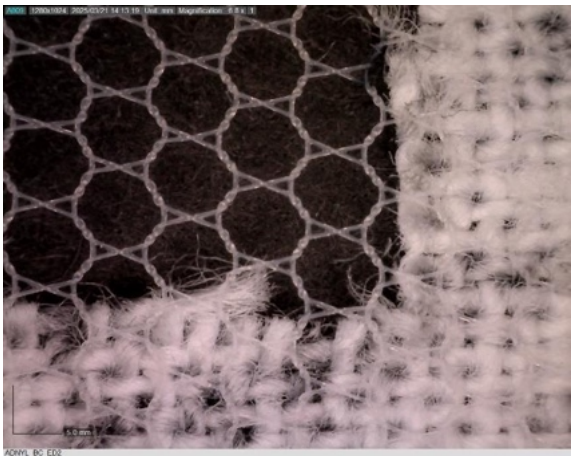


Figure 161. Point in adhesive nylon net sample, back side, after fixed-load test

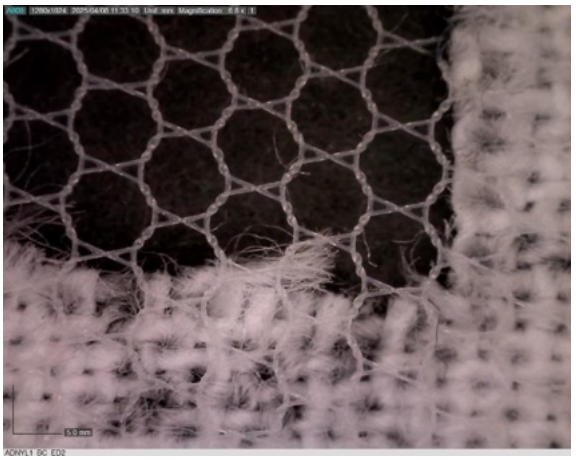


Figure 162. Point in adhesive nylon net sample, back side, after fixed-load test

STCRE1

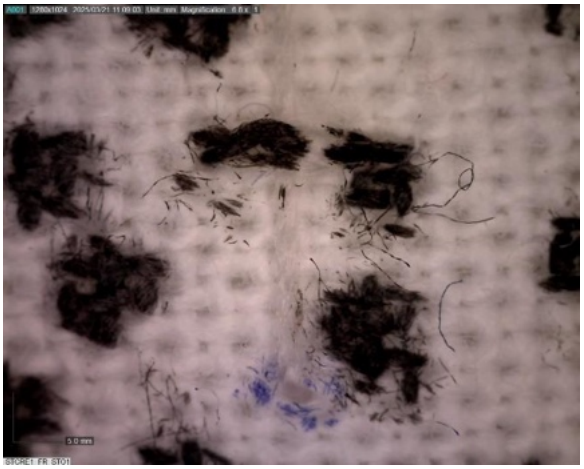


Figure 163. Point in stitched silk crepeline sample, front side, before fixed-load test

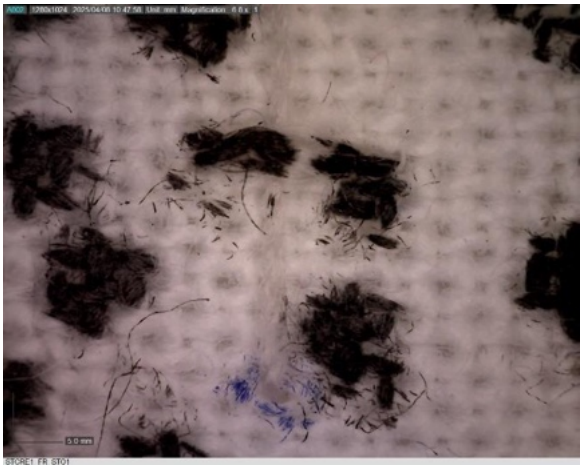


Figure 164. Point in stitched silk crepeline sample, front side, after fixed-load test

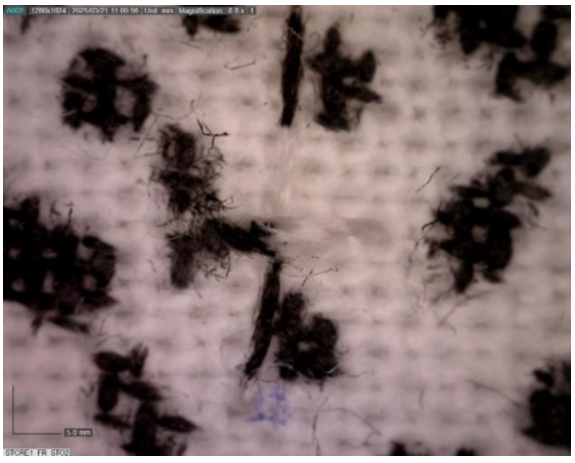


Figure 165. Point in stitched silk crepeline sample, front side, before fixed-load test

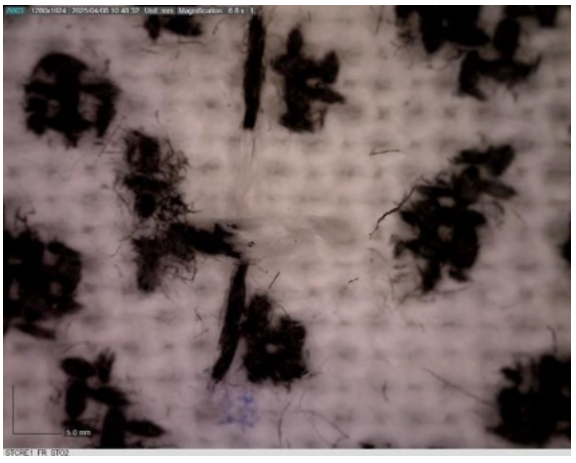


Figure 166. Point in stitched silk crepeline sample, front side, after fixed-load test

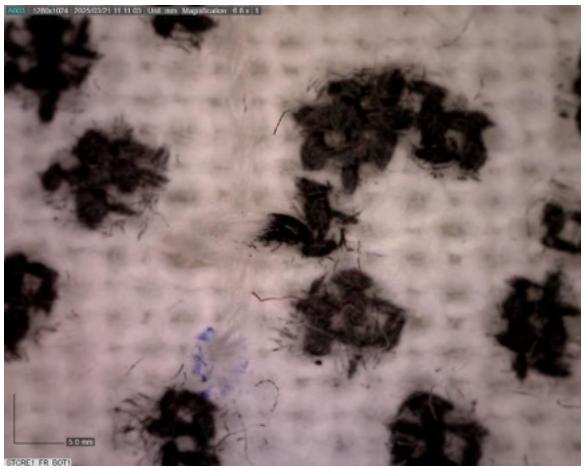


Figure 167. Point in stitched silk crepeline sample, front side, before fixed-load test

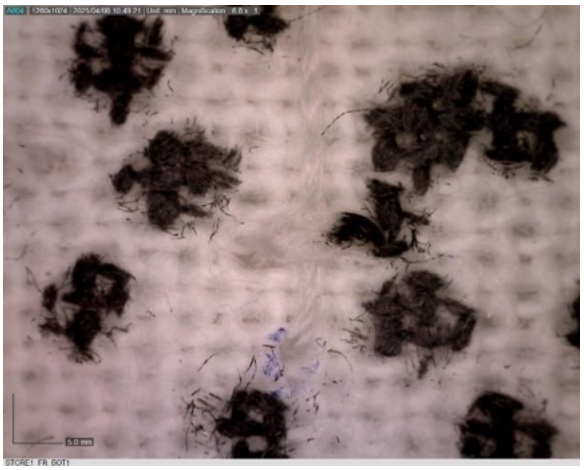


Figure 168. Point in stitched silk crepeline sample, front side, after fixed-load test

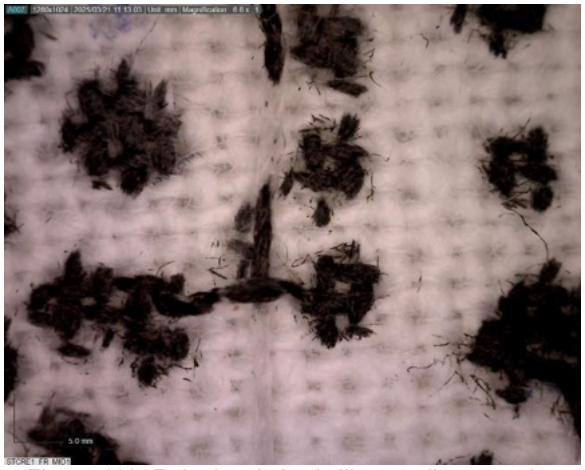


Figure 169. Point in stitched silk crepeline sample, front side, before fixed-load test

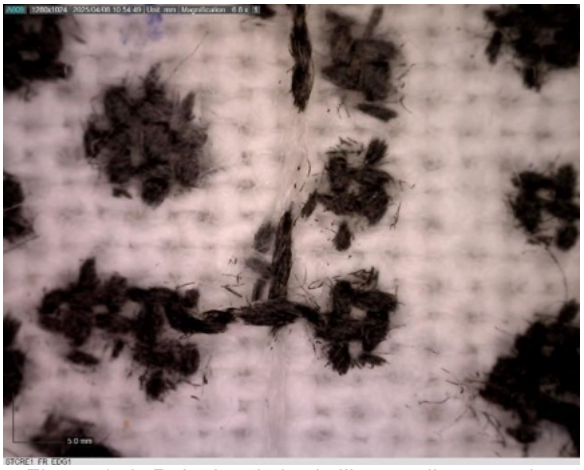


Figure 170. Point in stitched silk crepeline sample, front side, after fixed-load test

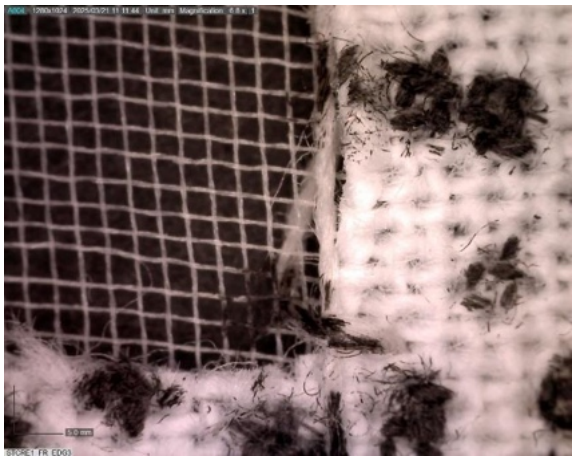


Figure 171. Point in stitched silk crepeline sample, front side, before fixed-load test

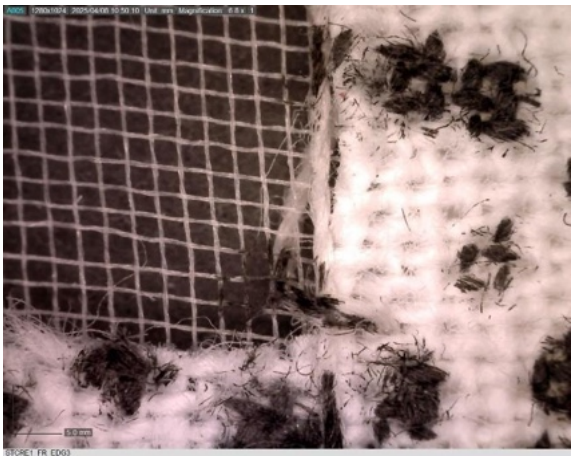


Figure 172. Point in stitched silk crepeline sample, front side, after fixed-load test

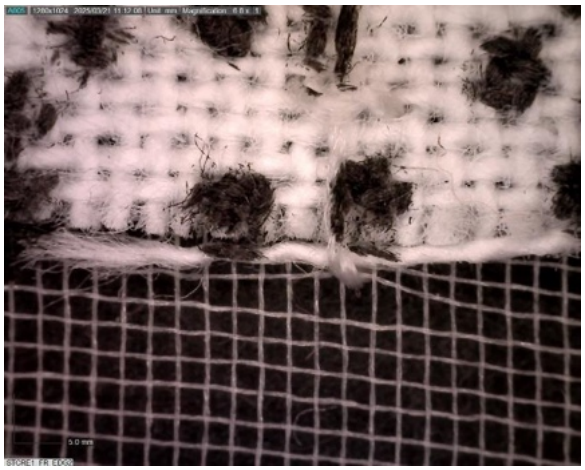


Figure 173. Point in stitched silk crepeline sample, front side, before fixed-load test

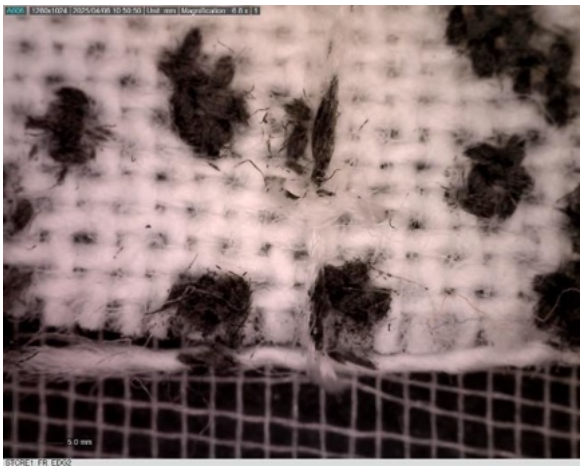


Figure 174. Point in stitched silk crepeline sample, front side, after fixed-load test

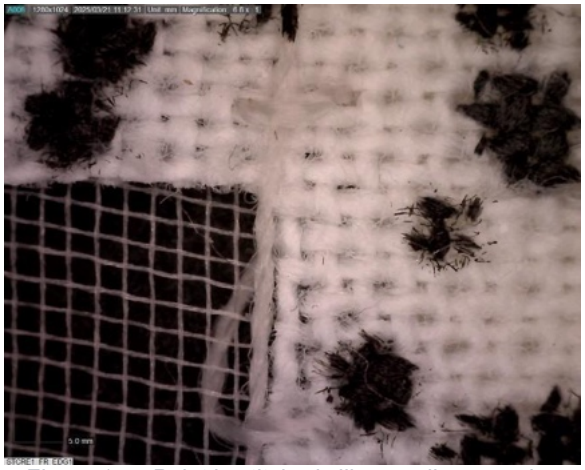


Figure 175. Point in stitched silk crepeline sample, front side, before fixed-load test

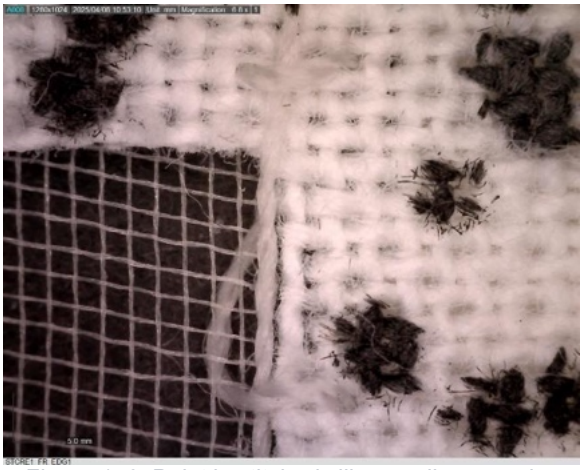


Figure 176. Point in stitched silk crepeline sample, front side, after fixed-load test

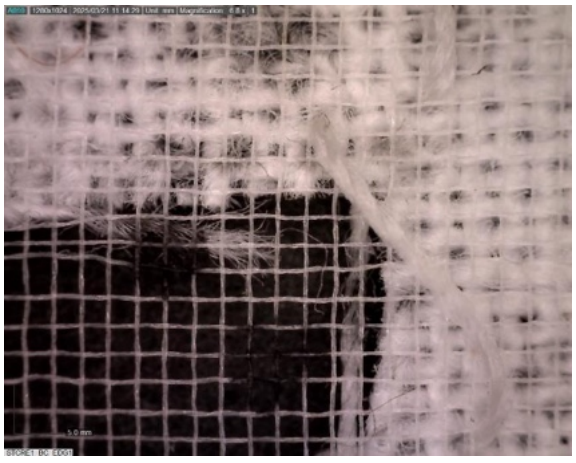


Figure 177. Point in stitched silk crepeline sample, back side, before fixed-load test

Figure 178. Point in stitched silk crepeline sample, back side, after fixed-load test

Figure 179. Point in stitched silk crepeline sample, back side, before fixed-load test

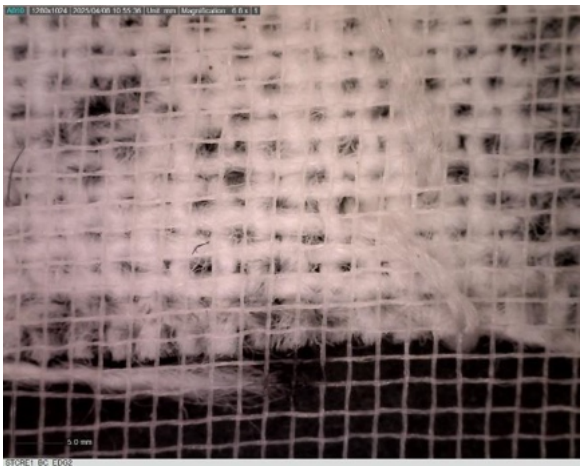


Figure 180. Point in stitched silk crepeline sample, back side, after fixed-load test

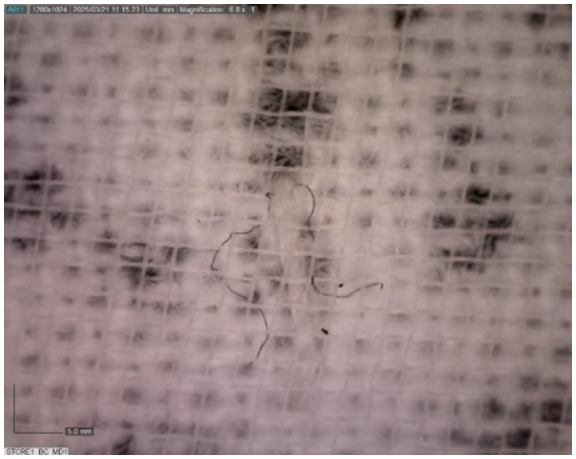


Figure 181. Point in stitched silk crepeline sample, back side, before fixed-load test

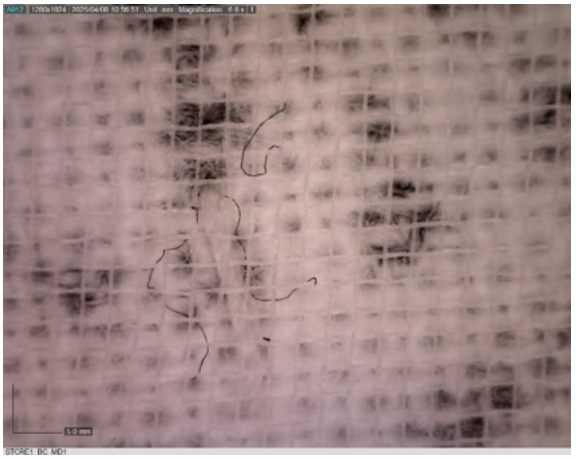


Figure 182. Point in stitched silk crepeline sample, back side, after fixed-load test

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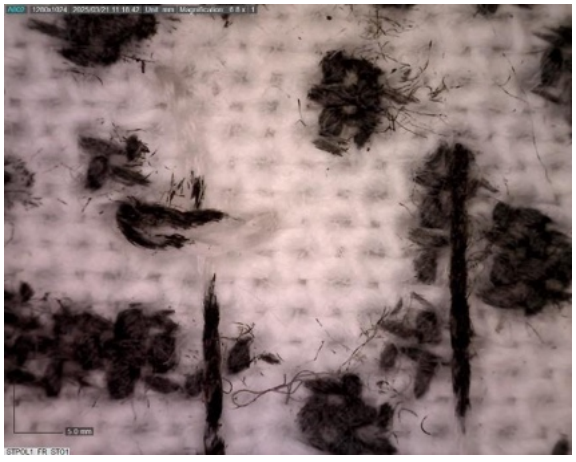

Figure 183. Point in stitched polyester tulle sample, front side, before fixed-load test

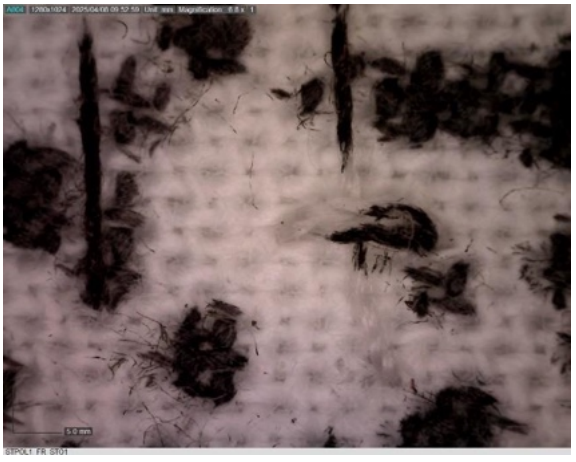

Figure 184. Point in stitched polyester tulle sample, front side, after fixed-load test

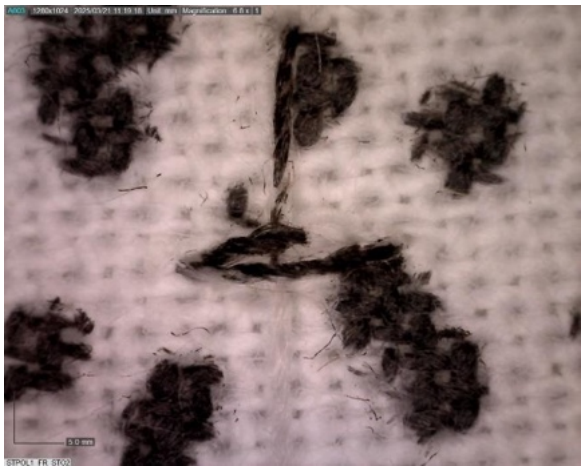

Figure 185. Point in stitched polyester tulle sample, front side, before fixed-load test

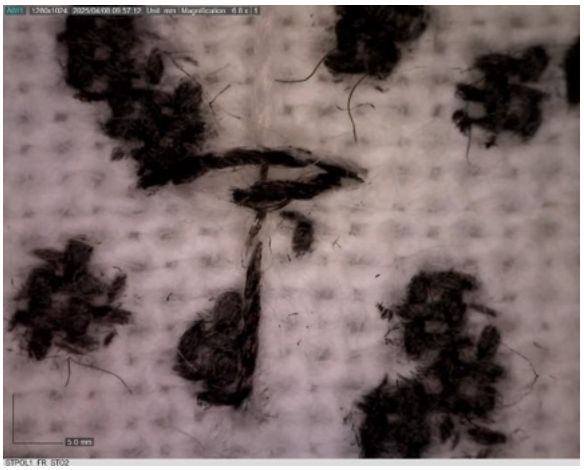

Figure 186. Point in stitched polyester tulle sample, front side, after fixed-load test

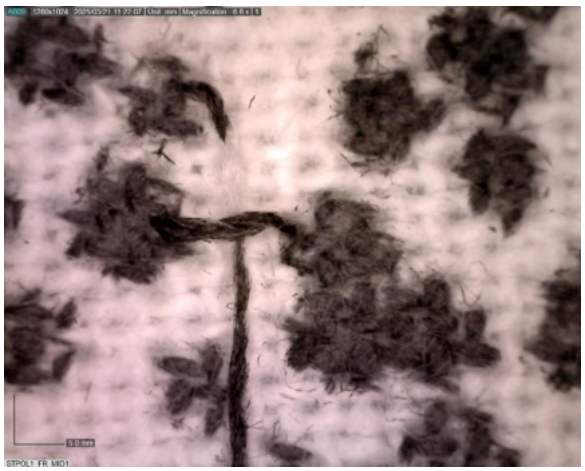

Figure 187. Point in stitched polyester tulle sample, front side, before fixed-load test

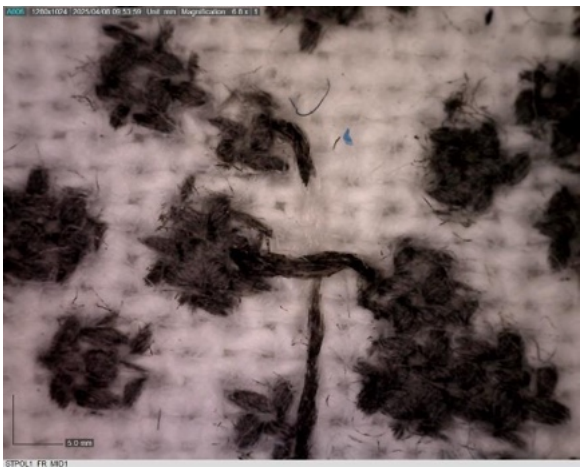

Figure 188. Point in stitched polyester tulle sample, front side, after fixed-load test

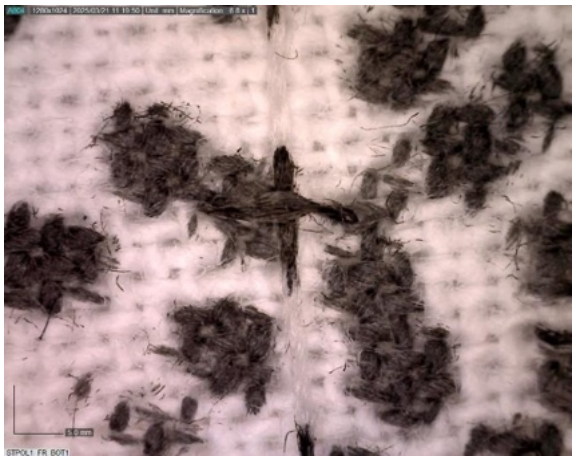

Figure 189. Point in stitched polyester tulle sample, front side, before fixed-load test

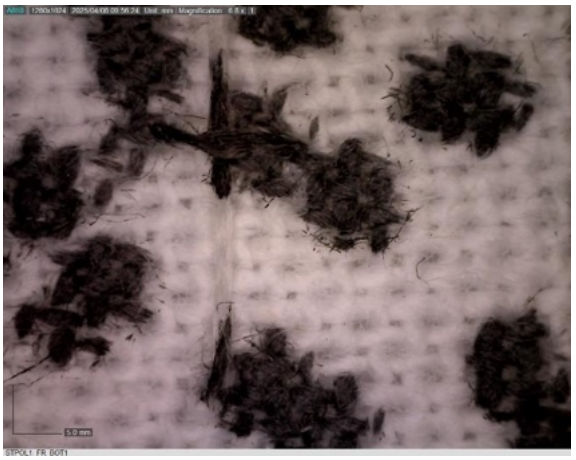

Figure 190. Point in stitched polyester tulle sample, front side, after fixed-load test

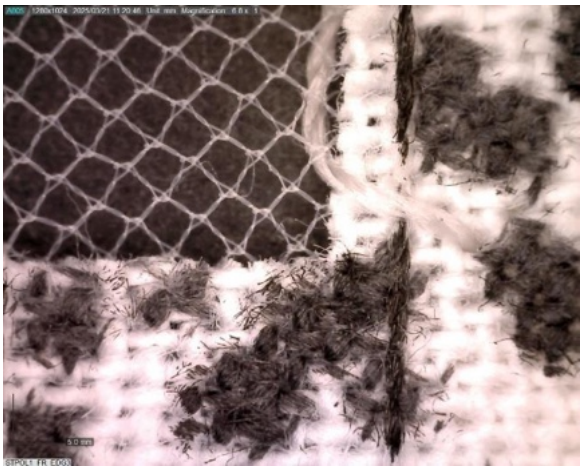

Figure 191. Point in stitched polyester tulle sample, front side, before fixed-load test

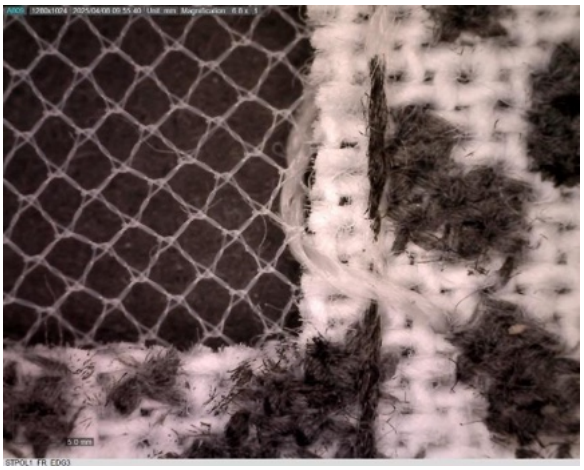

Figure 192. Point in stitched polyester tulle sample, front side, after fixed-load test

Figure 193. Point in stitched polyester tulle sample, front side, before fixed-load test

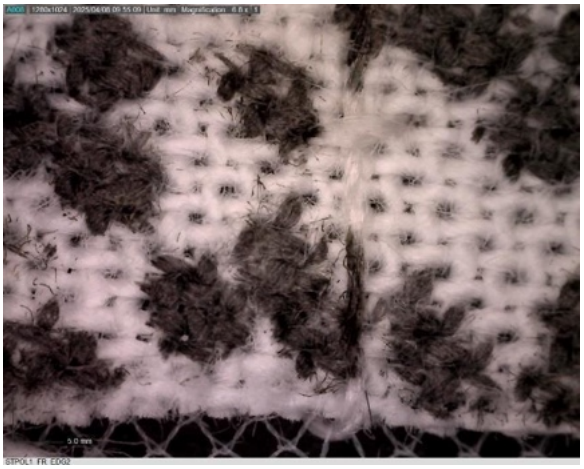

Figure 194. Point in stitched polyester tulle sample, front side, after fixed-load test

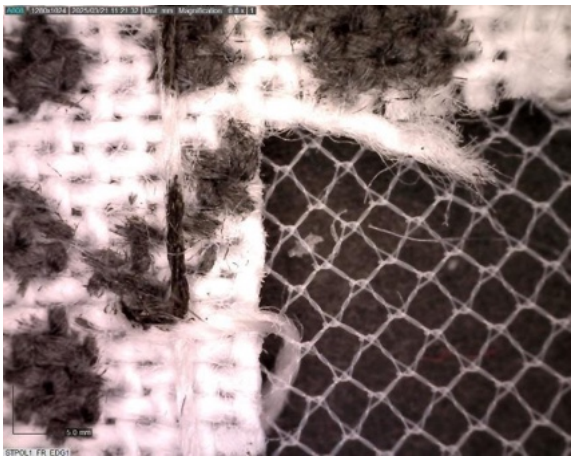

Figure 195. Point in stitched polyester tulle sample, front side, before fixed-load test

Figure 196. Point in stitched polyester tulle sample, front side, after fixed-load test

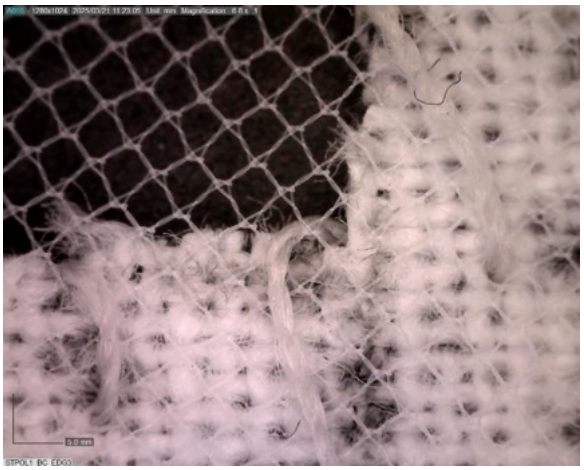

Figure 197. Point in stitched polyester tulle sample, back side, before fixed-load test

Figure 198. Point in stitched polyester tulle sample, back side, after fixed-load test

Figure 199. Point in stitched polyester tulle sample, back side, before fixed-load test

Figure 200. Point in stitched polyester tulle sample, back side, after fixed-load test

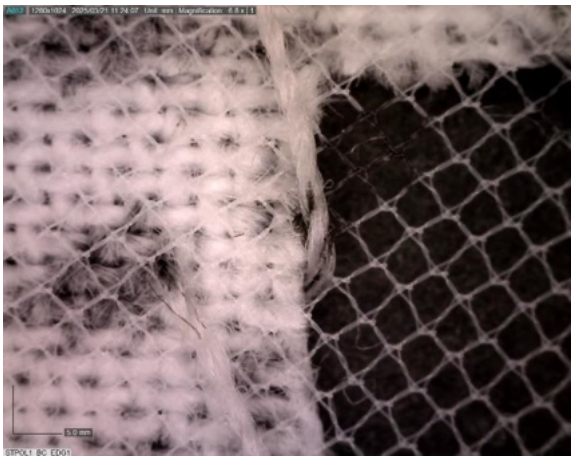

Figure 201. Point in stitched polyester tulle sample, back side, before fixed-load test

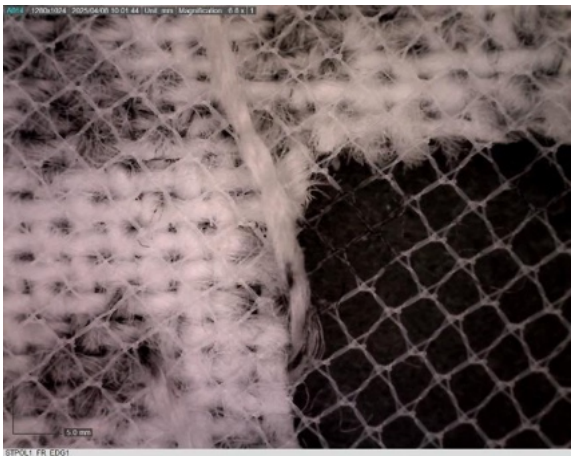

Figure 202. Point in stitched polyester tulle sample, back side, after fixed-load test

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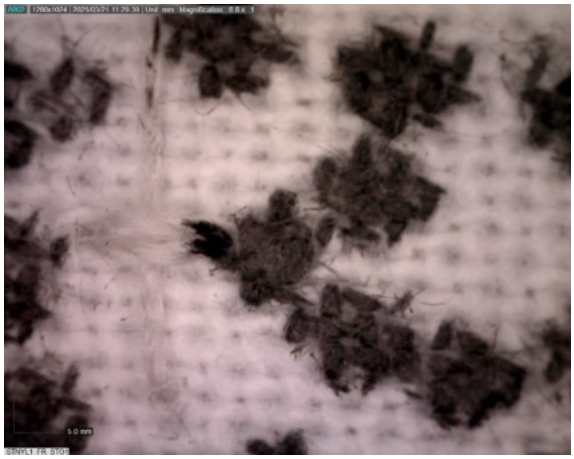

Figure 203 . Point in stitched nylon net sample, front side, before fixed-load test

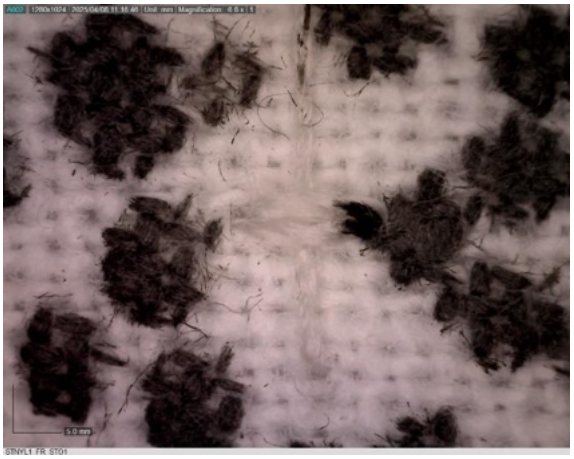

Figure 204. Point in stitched nylon net sample, front side, after fixed-load test

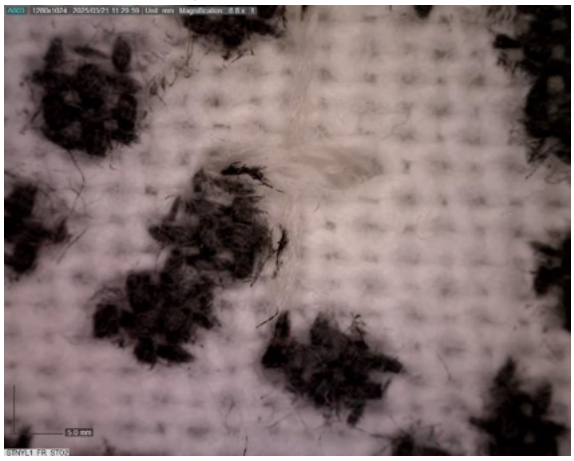

Figure 205. Point in stitched nylon net sample, front side, before fixed-load test

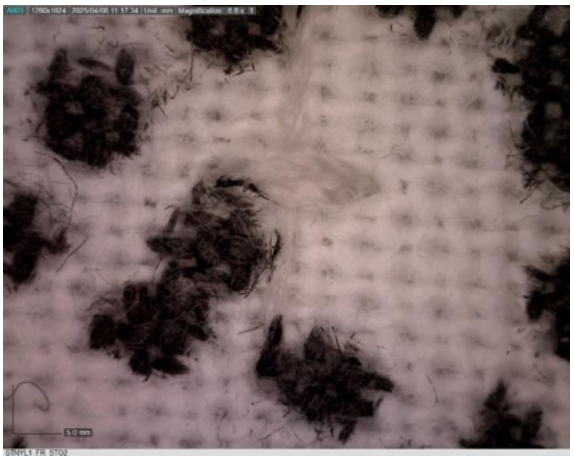

Figure 206. Point in stitched nylon net sample, front side, after fixed-load test

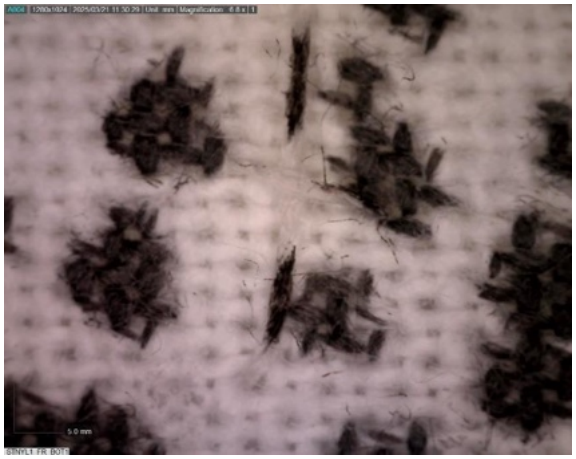

Figure 207. Point in stitched nylon net sample, front side, before fixed-load test

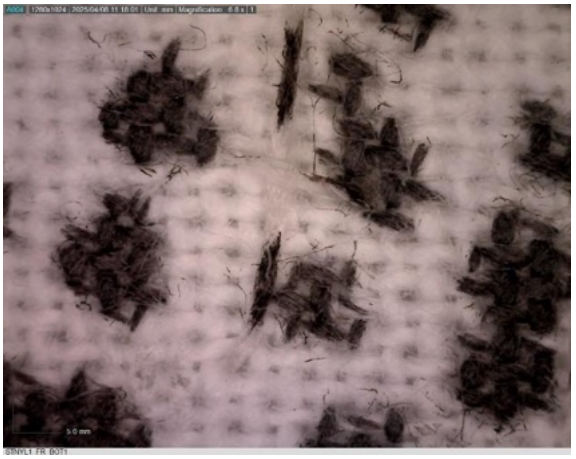

Figure 208. Point in stitched nylon net sample, front side, after fixed-load test

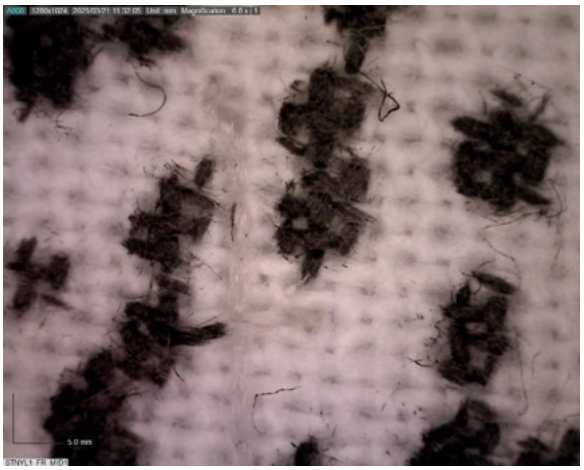

Figure 209. Point in stitched nylon net sample, front side, before fixed-load test

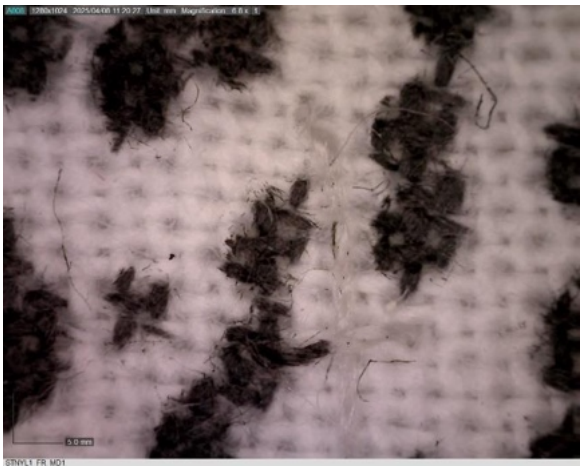

Figure 210. Point in stitched nylon net sample, front side, after fixed-load test

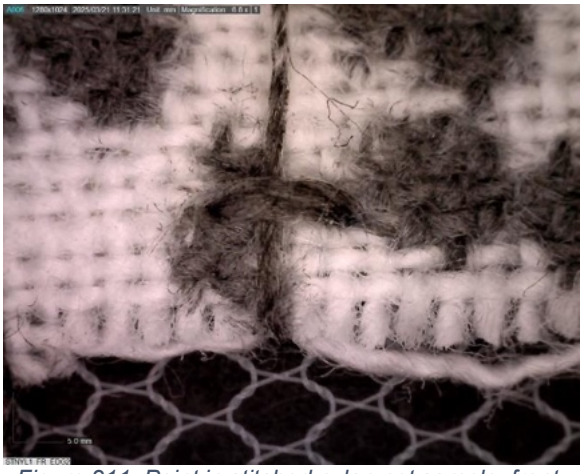

Figure 211. Point in stitched nylon net sample, front side, before fixed-load test

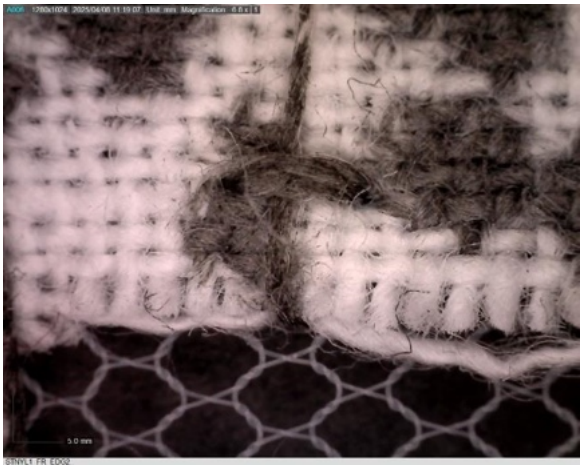

Figure 212. Point in stitched nylon net sample, front side, after fixed-load test

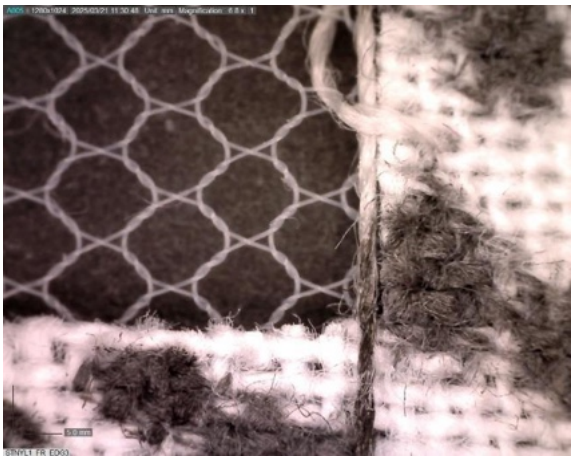

Figure 213. Point in stitched nylon net sample, front side, before fixed-load test

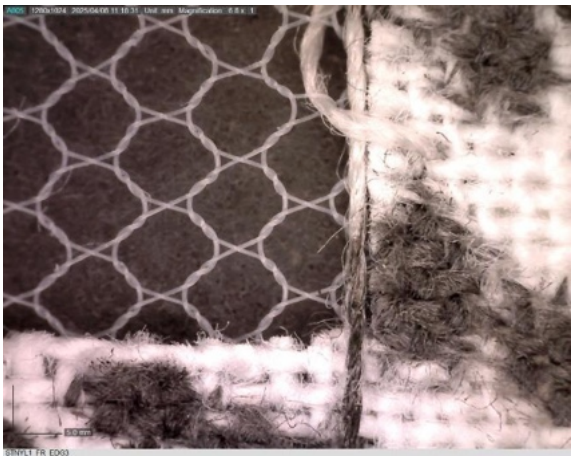

Figure 214. Point in stitched nylon net sample, front side, after fixed-load test

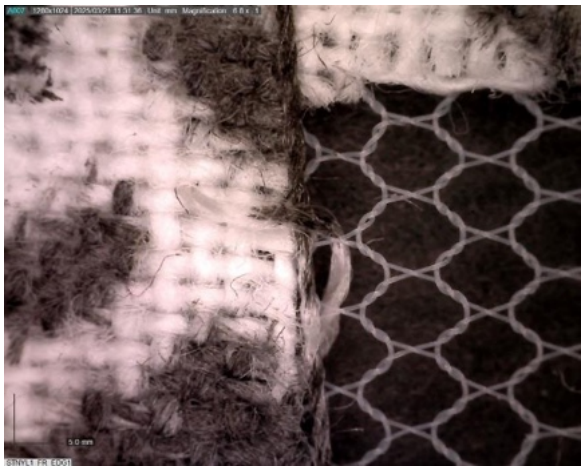

Figure 215. Point in stitched nylon net sample, front side, before fixed-load test

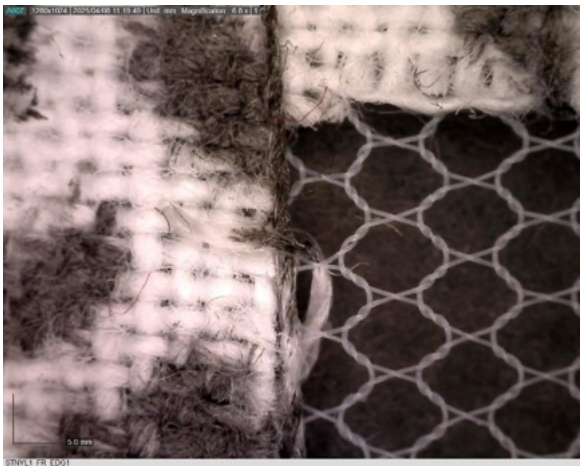

Figure 216. Point in stitched nylon net sample, front side, after fixed-load test

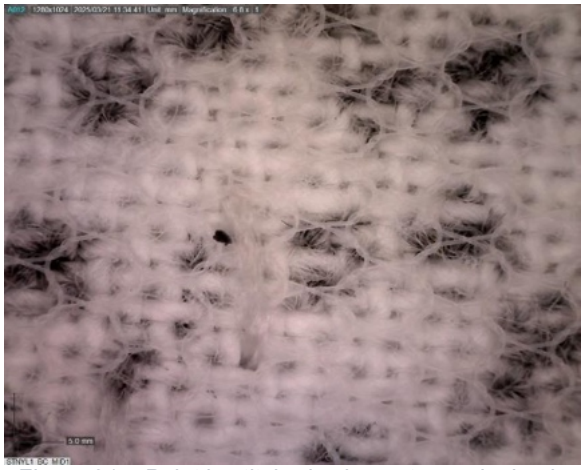

Figure 217. Point in stitched nylon net sample, back side, before fixed-load test

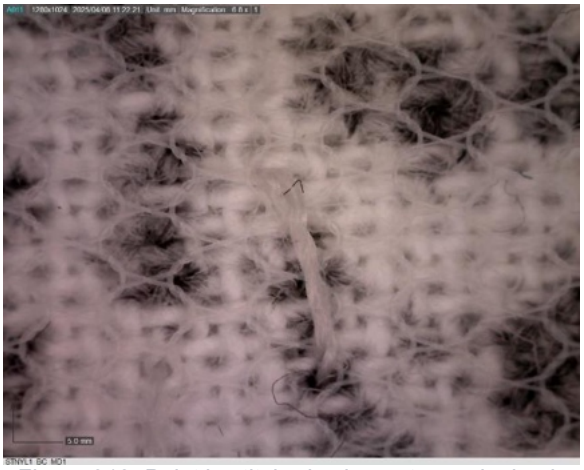

Figure 218. Point in stitched nylon net sample, back side, after fixed-load test

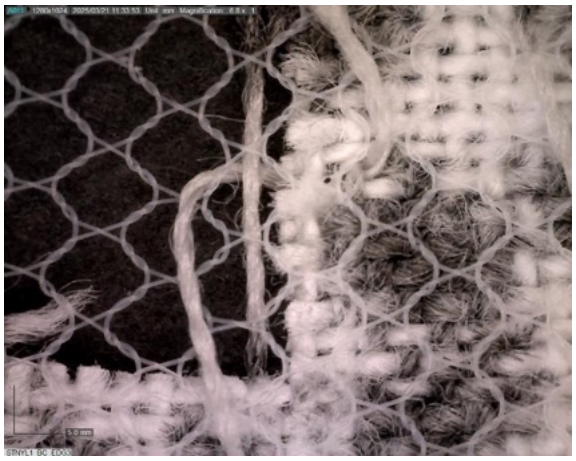

Figure 219. Point in stitched nylon net sample, back side, before fixed-load test

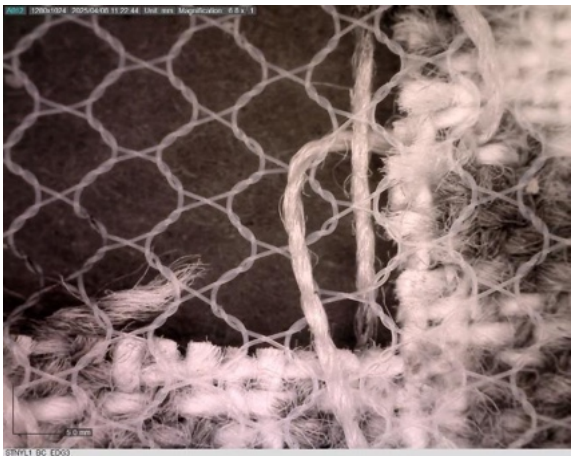

Figure 220. Point in stitched nylon net sample, back side, after fixed-load test

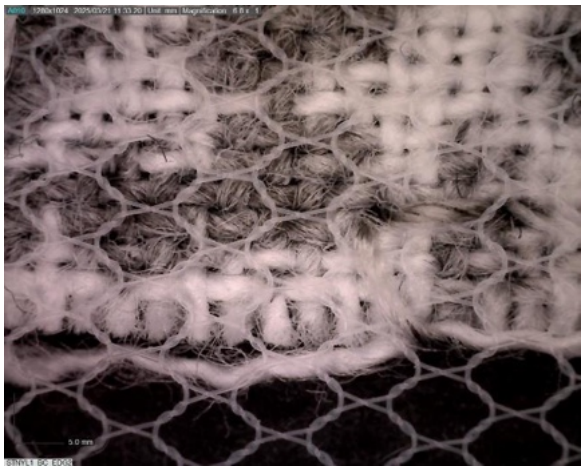

Figure 221. Point in stitched nylon net sample, back side, before fixed-load test

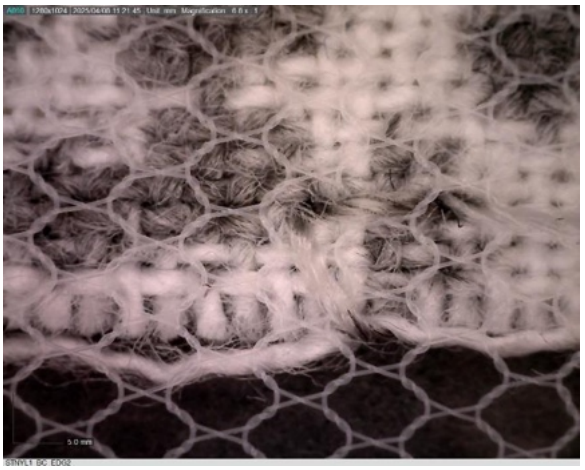

Figure 222. Point in stitched nylon net sample, back side, after fixed-load test

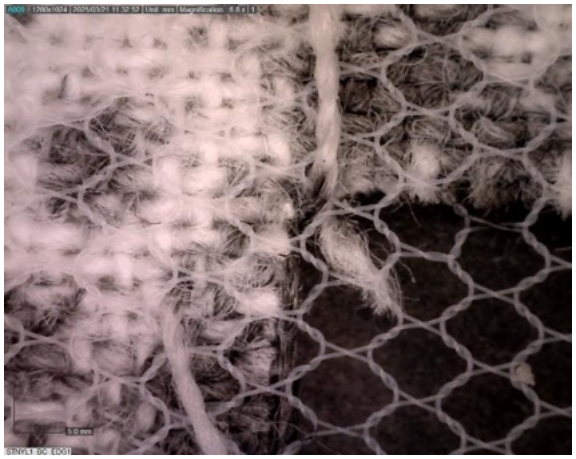

Figure 223. Point in stitched nylon net sample, back side, before fixed-load test

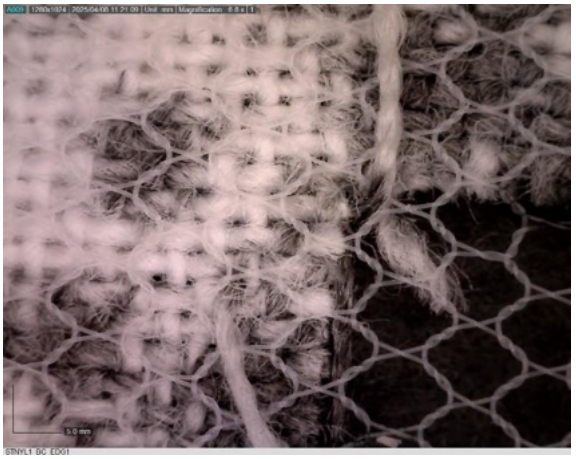

Figure 224. Point in stitched nylon net sample, back side, after fixed-load test

Appendix 8: Lace fragment conservation

Figure 225. Lace fragment before conservation, front face

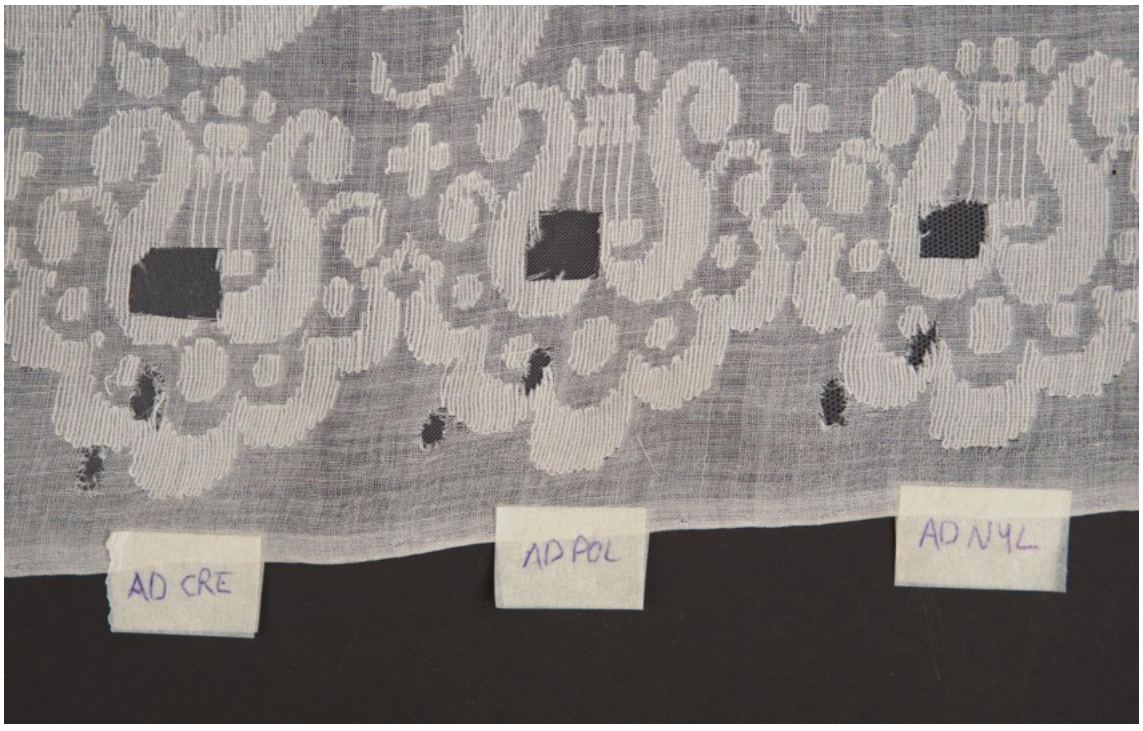

Figure 226. Lace fragment after conservation: adhesive silk crepeline, adhesive polyester tulle and adhesive nylon net from left to right, front face

Figure 227. Lace fragment before conservation methods, front face

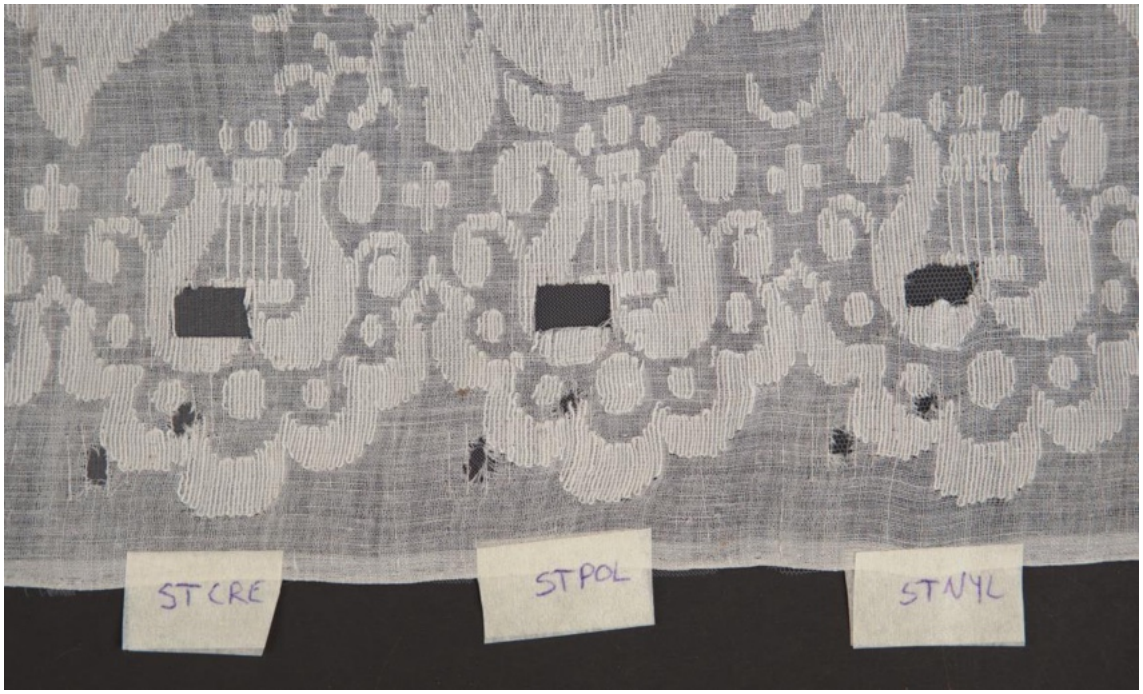

Figure 228. Lace fragment after conservation methods: stitched silk crepeline, stitched polyester tulle and stitched