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# THE MECHANICAL AND SUPPORTING EFFECT OF STITCHES IN TEXTILE CONSERVATION

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# The Mechanical and Supporting Effect of Stitches in Textile Conservation

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## **ABSTRACT**

The purpose of this study was to investigate the mechanical and supporting effects of conservation stitches on textile objects. The aim was to better understand what impact different stitch patterns used in textile conservation have on the textiles after long-term storage and exhibition. The study focused on the conservation of silk.

A literature review established the most commonly used stitches, threads, and support fabrics for treatments of silk artefacts in Europe and North America. The research compared laid couching and brick couching. Two different lengths of stitch lines were also studied. In total, 46 textile specimens were prepared, of either standard or artefact silk. The specimens were degraded with a horizontal or vertical tear in order to compare the results depending on the different kinds of damage. Thereafter, they were conserved in a similar manner with slight variations to the above-mentioned variables. After treatment, the specimens were subjected to a fixed-load test. By hanging them from a whiteboard using magnets and weighting with 50 g each. The fixed-load test lasted for three weeks. The results were evaluated through measuring the elongation of the specimen and opening of the tear as well as visual evaluation of the stitching from photographs of the specimen.

Result showed that most damage was caused to the specimens with a horizontal tear sewn with 20/25 mm long stitch lines of laid couching, and that the specimens with a vertical tear were damaged the least, independent of stitch pattern used.

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# 1. Introduction

This thesis begins with a background of the subject leading on to the research questions and objectives as well as limitations. The following section brings up some previous research in the textile conservation field found in literature. The focus lies on sewing techniques and experiments on stitched specimens. The literature review underlies the experimental element of the study and is followed by an in-depth section describing the experimental stage. Specimens of silk fabric were conserved in order to investigate how stitches can result in damage to textiles. The results of the experiments are then summarised and presented through text, tables, and photographs, with an aim to point out changes in the textile specimens. The results are discussed and conclusions made based on the research questions. The thesis is finished with a summary in English followed by a summary in Swedish.

## 1.1. Background

Stitching is probably the most widely used treatment method in textile conservation. It is a versatile technique that can be adapted for several purposes, such as different kinds of damage, retouching, and mounting. During study to become a textile conservator, learning the basics of conservation stitches, it is taught that different materials or types of objects need different kinds of stitches, thread, and support fabric.

It is not common for stitching techniques used in textile conservation to be described in detail in literature and published case-studies (Nilsson 2015a; Sutherland 2016). There is rarely any information on stitch type, length of stitches, and spacing between stitch lines (Nilsson 2015a). Therefore, this knowledge is something that can only be learnt by hands-on experience, working with objects or discussing the matter with colleagues who have had more practice.<sup>1</sup> Lennard and Ewer (2010) suggest that the reason for lack of written documentation could be due to new research often focusing on treatments that are seen as unusual. There is though some information: according to Landi (1998), spacing should match the amount of support needed as well as the aesthetics of the textile. For structural needs and preventing further damage, she states that the laid stitch should extend into the strong fabric and that the holding stitches should go straight across the weave. For aesthetic reasons, she suggests that the holding stitches are also placed to form a brick pattern.

In recent years, there has been an increased interest to study the effect of stitching threads (Benson 2013), sewing methods (Nilsson 2015b) and stitch density (Sutherland 2016). Their work has added knowledge to what previously was an area in textile conservation that lacked experimental research, and establish a base for further studies to build on.

With increasing experience, a textile conservator will become more confident in selecting what type of stitching method to use; however, without research it is difficult to know what real effect it has on the textile in the long run. Therefore, more research is needed in the area to gain more knowledge about which consequences different methods could have on textile objects in the future, for making broader foundations of knowledge for treatments in the present as well as making interventions increasingly reversible for coming generations.

## 1.2. Textile conservation in Sweden

The textile conservation of today probably originates from the everyday mending and repair of worn clothes and other textiles. The textile conservation tradition in Sweden started in the late 19th century when the idea of certain textiles having cultural or historical values was born and an interest of preserving the Swedish cultural heritage came into existence (Nilsson 2015a). Mending by sewing has always been a method for supporting fragile textiles. It can be seen that some of the first textile conservators in Sweden were embroiderers (Ridderstedt 2000).

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<sup>1</sup> Which is not necessarily a bad thing since information is easier to take in from a first-hand source.

Agnes Branting (1862-1930) was one of the pioneers in Swedish textile conservation. She started her own atelier, together with two of her previous co-workers from Friends of Handicraft (Handarbetets vänner), Licism, in 1904.<sup>2</sup> Branting received her first conservation commission the same year. In 1908, she also founded the Pietas association together with Rudolf Cederström, Sigurd Wallin and Bernhard Salin. The purpose of Pietas was to treat textiles on museum terms, not restore, and that the treated textiles should be documented through text and photography. In the early years of the studio, textiles were mainly conserved through removal of sharp creases and folds and sewing them to a support fabric. After 1930, objects were also washed and later deconstruction of objects was accepted. During the 1950s the interest for chemical treatments was large. (Lundwall 2000; Ridderstedt 2000)

In 1903, Rudolf Cederström (1876-1944) succeeded his mentor, Carl Anton Ossbahr (1859-1925), as the head of the Royal Armoury in Stockholm. Ossbahr had taken the first steps towards conservation but his methods were unsuccessful and damaging. Cederström saw that Ossbahr's treatments for silk banners had caused deterioration and he travelled across Europe to study contemporary conservation in search for new methods. He experimented with new techniques and preferred to wait several years to see the results of treatments before implementing them. In the beginning of the 1920s, he had developed a new method for the conservation of painted banners, including water treatment and sandwiching between two layers of silk crepeline. This method continued to be used and was described in an article by Agnes Geijer in *Studies of Conservation* 1957. (Nilsson 2015a; Wallenborg & Andersson 2000)

In 1889 John Böttiger (1853-1936) received a commission from King Oscar II to make an inventory of all tapestries in Sweden. The inventory resulted in a work of four volumes, *Svenska statens samling af väfda tapeter* (The Swedish State Collection of Tapestries) published between 1895 and 1898. Many years later, in 1923 he also established a conservation studio at the Royal Collection at the Royal Castle in Stockholm for the tapestries at the Royal Palace, developing new methods for their conservation. (Almqvist et al. 2000; Fogelmarck 2011)

Agnes Geijer (1898-1989) was the niece of Agnes Branting. After Branting's death, Geijer took her place at Licism and Pietas, bringing with her new ideas. During the 1930s she 'discovered water', using it to moisten textiles, making them easier to work with (Estham 2011). In 1972, her book *Ur textilkonstens historia* (A History of Textile Art) was published. It was later also translated into English. The book was printed in its fourth Swedish edition in 2006 and has gained readers from outside the academic sphere (Nationalencyklopedin, Agnes Geijer).

The three-year conservation programme at the University of Gothenburg started in 1985. Before this, textile conservators had at least three years of handicraft training often complemented with studies in art history. After an apprenticeship with experienced colleagues, one was titled a conservator (Lundwall 2000). Presently the programme is being reorganised from a three-year bachelor with focus on a specific material group, into a three-year bachelor providing a wider base of knowledge in conservation. It will be possible to follow up with a master's programme with emphasis on the conservation of a chosen material.

### 1.3. Sewing in textile conservation

Sewing treatments have changed over time as new methods are discovered or old ones deemed damaging. Present sewn conservation treatments often have far fewer stitches, placed further apart, and sewn with a finer thread than used by colleagues in the early years of the profession.

As an example, the conservation of the curtains at Uppark house can be mentioned. Uppark house was built in the late 17<sup>th</sup> century in the village South Harting, England. During the 18<sup>th</sup> century it was fashionably furnished, and apart from the kitchen, which was changed in the late 19<sup>th</sup> or early 20<sup>th</sup> century, the interior was preserved by its different inhabitants until 1954 when it was handed over to

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<sup>2</sup> Licism worked originally with designing, producing, and renovating ecclesiastical textiles.

the National Trust. In 1989, a fire partly destroyed the house, however much of the furnishings were saved, including window curtains which were ripped down. The National Trust decided to restore the building and interior to the condition of the day before the fire. The curtains had been conserved in the 1930s and some of the previously treated areas had been damaged. Where this had happened, conservators chose to imitate the sewing technique of the old conservation treatment, using thicker thread and denser stitching than is used in modern textile conservation, thereby conserving the previous conservation treatment, with the goal to restore the condition to that the textile had before the fire. (Ponsonby 2015)

Another example of a historic conservation using stitches is found with the Star-Spangled Banner. It first came to the Smithsonian National Museum of American History as a loan in 1907, the loan later turned into a gift in 1912. The flag got its name from a poem which was written about it in 1814 when it was seen raised over Fort McHenry in Baltimore, USA, to signal the victory over British forces. The flag was made in 1813 when a large flag that could be seen from a long distance was ordered for the fort. In 1914, it was conserved with a patented method, developed for flag conservation. This method involved laying the flag on a piece of linen fabric, ironing it and stitching it with an interlocking network of stitches, covering the face of the flag. The Star-Spangled Banner was covered with about 1,7 million stitches all of which were removed during a re-conservation carried out between 1998 and 2007. A structural engineer estimated that about one in a hundred of the stitches in the previous treatment was necessary. The stitches had to be removed to separate the flag from the weakened support fabric and release it from the tension they caused. The stitches took ten months to remove and left markings all over the surface of the original textile. In 2014, a check of the condition of the flag was done to evaluate its new display case, it was then seen that the textile had relaxed from the previous stitched treatment. (Taylor et al. 2008; *American Artifacts: Star-Spangled Banner* 2014)

During the third quarter of the 20<sup>th</sup> century, costume conservation at the Swedish Royal Armoury was at its highest level, peaking in the 1960s. One of the many of costumes to be given extensive treatments was King Gustav III's wedding costume in silk with flat silver strips in the weft. Using brick couching the silver strips were stitched down two by two. The conservation of the coat took 990 hours to complete. (Nilsson 2015a)

#### 1.4. Research objectives and questions

The purpose of this study is to investigate how conservation stitches mechanically affect supported areas of a textile object. The aim is to better understand what impact different stitch patterns and stitches used in textile conservation have on textiles after long-term storage and exhibition.

Since stitching is so commonly used and can be used for several purposes on a large variety of textile objects, it is an important area to study. The fact that there has been little research, does also contribute to the urgency to find out more about its effects. Could stitches damage the textiles which they are meant to preserve and if so, how? Could different types of stitches or stitch patterns affect the textile or create damage in different ways? Do longer stitch lines give more support?

The focus of this thesis is to investigate whether different types of stitches cause more or less damage to textiles. The objective of this thesis focuses on studying the force an artefact experiences during hanging display or storage.

This leads to the following research questions:

- What are the different mechanical effects caused by laid couching or brick couching used to support a tear on a silk textile in a hanging position?
- How does the length of the stitch line mechanically affect the supported area of a silk textile in a hanging position?
- What is the difference in the mechanical effect of the stitches in the supported area depending on if the tear in the silk textile has a horizontal or vertical orientation?

## 1.5. Limitations

To limit the scope of this thesis, the study focuses on the conservation of silk using a support fabric attached with stitches. Silk was chosen due to the fact that it is a relatively sensitive fibre and degrades more quickly than other natural fibres, due to its sensitivity to light and acids (Boersma et al. 2007; Tímár-Balázsy & Eastop 1998).

The number of stitching techniques are limited to two. The most common and important stitch used in textile conservation is laid couching (Landi 1998; Nilsson 2015b); therefore, it is one of the stitches used. In Sweden, brick couching is also a common stitch (Nilsson 2015b) and is also tested. Other limitations were done while working with the specimens due to the time limit. Artificially aged silk was initially considered but was replaced by historic artefact silk. The number of artefact silk specimens were also limited due to time and material availability.

## 2. Literature review and previous research

### 2.1. Previous studies

A survey conducted by Nilsson (2005), sent to conservation workshops, showed that the second most important criterion for considering a conservation treatment successful is that it should give durable support, preventing the object from further damage. This survey also concluded that the most common treatment method for costumes is to insert a support fabric between the outer fabric and the lining. The support fabric is then secured by couching over the outer fabric but not through the lining. In Nilsson's study (2015b) standard silk fabric specimens, 200 mm x 120 mm in size, were aged and degraded in two ways. Rectangular specimens were given a horizontal tear and circular specimens were degraded by abrasion. Both types of specimens were treated in three different ways: laid couching, brick couching or crepeline covering. The stitch lines were by turn 20/25 mm long. After conservation, the specimens were subjected to accelerated wear and finally, the conservation sewing treatment was removed. Maximum force at break was determined in every step and every type of specimen. The tests showed that stitched treatments affected the silk specimens in various ways; the damaged specimens had very little relative strength, which increased four times to 20% of the unaged standard silk, after conservation. The first thread to break during tensile strength testing was most often the sewing thread in the weft direction in the upper part of the specimen, holding the support fabric. Analysis also showed that the brick couching increased the strength of the conserved specimens three times and laid couching four times. Nilsson's study also compared how much time the different types of treatment took to execute. This information was useful when designing a time plan for the experimental part of the study described in this paper.

To test the impact of different sewing threads Benson (2014) performed a fixed-load test. The test was chosen as a relatively realistic method for representing the force an object could be subjected to in a museum setting. Her test was inspired by an earlier study performed by Landi (1988) who added weight to a hanging silk which had previously been conserved using different threads and techniques. Landi's test was not described in such a way that it was possible to reproduce, but the only experimental study found, evaluating how the thread relates to the artefact. Benson, therefore, constructed a test based on the information given. In her test, Benson evaluated 35 mm wide, 190 mm long fabric specimens cut in half and conserved using laid couching with 40 mm long stitch lines, in this way the two halves were joined together again. The specimens were hung for two weeks with a 50 g weight fastened at the short side of the specimen. Benson found that polyester Tetex® thread was damaging to natural fibre textiles and recommends natural fibre thread for natural fibre textiles.<sup>3</sup> However, the stitching technique had more impact on damage type and severity than the chemical makeup of the stitching thread.

Sutherland (2016) carried out an investigation of different spacings of laid couching using cotton thread and fabric, measuring elongation and recovery from a fixed-load test, developed by Benson. Sutherland used a questionnaire, sent to textile conservators via e-mail and shared through the ConsDistList, as one of her methods to conclude the most common stitch spacing.<sup>4</sup> This showed that spacings used ranged between 2 mm – 10 mm. Sutherland increased the width of the specimens to 45 mm, with the same length of 190 mm. The length of the stitch lines was also increased to 45 mm. From Benson's previous conclusion that the duration of the test was of greater significance than the weight, Sutherland increased the time period to three weeks and decreased the weight to 30 g. Sutherland's specimens had the same kind of damage as Benson's, a tear through the middle without any intact material at either side. Both Benson and Sutherland also marked the stitch points prior to stitching using a template and a pencil or felt tip pen. Sutherland found that denser stitched areas were less elastic; this over-stitching restricts the movement of the conserved area, which in turn can cause

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<sup>3</sup> Tetex® is a semi-translucent polyester fabric, also known as Stabilitex®, of which a warp thread was drawn.

<sup>4</sup> The ConsDistList is an e-mail network for conservation professionals.

tension between areas and lead to further damage. In all specimens, the top stitch of every line of stitching caused distortion of the weft; this was greater on specimens with wider spaced lines.

Asai et al. (2008) describe how support methods for tapestries developed by Historic Royal Palaces in the United Kingdom were tested. The aim of the study was to develop a method to test, examine and document the effect of stitches and support fabric on tapestries. Specimens were damaged by abrasion, using a glass bristle brush to create a worn area in the centre, with only the warp remaining. They were conserved in different ways with varying amounts of stitching and tensile tested. The test showed that the specimens with the least space between stitch lines gave the least deformation to the specimens. A conclusion drawn from this study is that the experiment gives useful information even though the effects of conservation stitches are difficult to determine due to a large number of variables.

Ballard (1996) has studied the effect of relative humidity (RH) and temperature on the tensile strength of textile fibres. The results show that fibres such as silk, which become weaker when wetted, extends 10 % more in 100 % RH compared to 65 % RH. Additionally, the elastic recovery of the fibres decreases while stressed in a higher RH environment.

## 2.2. Stitching

The conservation stitches are meant to preserve the material but every time the needle passes through the fabric small holes are created. It can be seen in previous studies that some damage is done by the stitches, the needle holes become larger and the weave distorted (Benson 2013; Sutherland 2016). In their respective articles, Reeves (1986) and Himmelstein (1986) both bring up cases where stitches have caused damage to textiles. Reeves describes how previous stitched treatments of objects, which she had worked with, caused distortion, but could not be removed without risking large material loss. Jedrzejewska's (2011) article from 1981 also discusses problems with sewing treatments and brings up adhesive treatment as an alternative and presents arguments for and against both. One of the arguments against the needle is that sewing creates holes in the textile and might also cut the fibres.

Landi (1998) discusses support methods for textile objects. She considers laid couching to be one of the most important stitches in textile conservation and illustrates the technique amongst other used in textile conservation. Brick couching is not included in Landi's work, but shares similarities with darning, which is described as a technique used to fill holes or strengthen fabric. Brick couching is always worked into a support fabric and in one direction only. She suggests using a needle as thin as possible and to avoid securing the thread with knots since these could cause damage if pulled through the textile. Landi also shows a photograph of a textile that has suffered damage from a repair done with a strong thread, without support and long stitches, which upon attempted removal caused damage to the weak silk.

Lundwall (2003) discusses her views on stitching. She states that the sewing method should always relate to the condition of the textile, with an aim to sew as few stitches as possible. The preferred stitches are described as long and placed far apart, and that small, dense stitches could cause damage to the original fabric.

## 2.3. Reversibility and ethics

Sewing is viewed by many as the most reversible treatment and that might be true in most cases, but the damage it can cause must be taken into consideration. As Muñoz Viñas (2005) states, reversibility is a fuzzy concept which is not easy to define. Stitching is reversible in the sense that the thread is theoretically possible to remove, but the holes and marks that are made by it might not be, especially if the object cannot be treated in water, where there could be a risk of the original material falling apart.<sup>5</sup> Muñoz Viñas also mentions a possible risk, that the responsibility conservators feel towards an object could be lowered due to reversibility, if a treatment is reversible it does not matter if it is not perfect.

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<sup>5</sup> Which is exemplified by the previously mentioned cases written about by Landi, Himmelstein, and Reeves.



Therefore, it is important to remember that full reversibility is impossible to achieve. Notions such as removability or retreatability are more realistic and attainable; with these reversibility is not called for but can be an additional benefit.

According to Appelbaum (2007), reversibility is vital for the future of objects. An optimal treatment should be both easy to detect and to remove. This is important since future treatments will very likely be necessary and because values of objects change over time and may lead to a desire to treat objects in a different manner. She points out that for some, the unattainability of reversibility is a justification to ignore it. A treatment that is made as reversible as possible can only benefit the object and the conservator working with it. Reversibility can affect treatment choice in many ways. Appelbaum points out that reversibility is not about being able to put objects in a pre-treatment state. A treatment may be reversible in many ways and to varying degrees. She looks upon the core of reversibility as retreatability.

## 3. Experimental method

### 3.1. Test materials

Standard silk fabric has been used in this test with the intention to make the experiment as reproducible as possible and to allow it to be compared to both previous and future research. Material from a historic artefact was also used, since the time for this study did not allow for artificial ageing of standard silk. This was a way to also test weak and deteriorated silk.

#### 3.1.1. Standard silk

Standard silk fabric ISO 105-F06:2000 *Bombyx mori* was used for the fabric specimens. The fabric is a white, plain weave with 52 threads/cm in the warp and 37 wefts/cm. Both warp and weft are a single thread without twist. The weight of the fabric is 60 g / m<sup>2</sup>.

#### 3.1.2. Historic artefact in silk

A black silk satin shawl, probably from the first quarter of the 20th century, was used as the naturally aged silk specimen fabric. Measurements of the shawl are 95 cm wide including selvedge on both sides and 195 cm long excluding an 18 cm long fringe on each end. The shawl is printed with a floral ornament repeating five times on each end of the textile. The shawl belongs to the study collection of the Department of Conservation at the University of Gothenburg. It had several white stains, folds, and a few tears in the warp direction (Figure 1).



Figure 1. Overview of the black silk shawl. One half pictured. Photo: Marie Schön

The weave is a five-shaft satin with a 2-ply, S-twisted warp with 88 threads/cm and the weft is an unspun single thread with a density of 43 wefts/cm.

Examination of the fabric, using a scanning electron microscope with energy dispersive x-ray (SEM/EDX), revealed that both warp and weft was weighted with tin. (See Appendix 2 for spectrum.)

The practice of weighting silk probably originates from black dyeing of textiles. There is a London court regulation from 1606 limiting the maximum added weight per pound of silk, which could indicate the time when the technique began to be more commonly used.<sup>6</sup> Different types of tin

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<sup>6</sup> At that time fabric was sold by the kilo instead of by the meter; as is common today.

weighting methods were developed during the mid to late 19th century, this changed the silk industry in Europe and North America. The rapid deterioration process of how heavy weighted silks turned into dust, was described as early as 1897. Despite this many weighted silks have survived and are now part of museum collections. (Hacke 2008)

### 3.1.3. Conservation material

The conservation material consists of standard silk fabric ISO 105-F06:2000 *Bombyx mori*, which was used as support fabric for all specimens, it is the same material as used for the standard silk specimens.

For all stitching, a white, 90 denier, 2-ply, S-twisted silk thread was used. The specimens were stitched using a Milward beading needle number 15.

## 3.2. Specimen preparation

All specimens were cut and sewn by the author. The specimens were divided into two main groups, the standard silk specimens (S) and the artefact silk specimens (A).

A total of 46 specimens were cut, 29 specimens of standard silk and 17 specimens of artefact silk. The size of the specimens was 200 mm in the warp direction and 120 mm in the weft direction. Due to the limited material availability of both standard and artefact silk, no standard for cutting out the specimens was followed. While cutting out the specimens from the artefact silk, areas with tears were avoided since it would interfere with the test and not represent the whole fabric, stained areas were included as they were scattered evenly across the textile. The specimens were cut out of the middle section of the shawl, avoiding the printed areas.

Using a scalpel, 14 of the standard silk specimens were given a 40 mm horizontal slit in the centre of the piece to simulate a tear and 14 were given a 40 mm vertical slit. In the same way, eight of the artefact silk specimens were given horizontal slits and eight were given vertical slits. As support fabric, 40 pieces, 70 x 70 mm in size of standard silk were cut. The support fabric was centred and aligned under the damage prior to stitching.

For reference, five specimens of each material were used. One of each fabric type was left without a tear, one of each tear orientation was left without any stitching and one of each tear direction was given support fabric only. The different reference variations are explained in Table 1.

Table 1. Showing the different reference specimens and their code.

Specimen description	Standard silk references	Artefact silk references
w/o tear	S	A
w/ vertical tear	SV	AV
w/ horizontal tear	SH	AH
w/ vertical tear and support fabric	SVSF	AVSF
w/ horizontal tear and support fabric	SHSF	AHSF

Standard silk specimens were treated with laid couching or brick couching, the stitch lines were either 20/25 mm long or 30/35 mm long. Artefact silk specimens were also treated with laid couching or brick couching but only with the 20/25 mm long stitch lines. This limitation was made in order to complete the experiment within the timeframe and since the shorter stitch lines would reduce the number of needle insertions through the textile.

Laid couching, also termed self-couching, is sewn by first laying a long stitch in either warp or weft direction. Small holding stitches are then put perpendicular to the first stitch at equal distances along

its length. This makes up one row or stitch line and is repeated as necessary, depending on the size of the damage. (Landi 1998; Winslow Grimm 2002)

Invisible darning is sewn with parallel rows of small running stitches. The rows follow the warp or weft direction of the textile, depending of the damage. The stitches are placed in a regular pattern like brick-work. In Swedish often referred to just as running stitches, Nilsson refers to the technique as brick couching. (Winslow Grimm 2002; Nilsson 2015b)

The spacing between stitch lines was 5 mm, the holding stitches for the laid couching were spaced 5 mm apart. The running stitches were 1 mm on the face side and 4 mm long on the reverse. Finally, running stitches were sewn around the support fabric 4-6 mm from the edge, approximately 1 mm on the face side and 5 mm on the reverse. This was done in order to secure the support fabric in place.

For a schematic overview of all the specimens see Tables 2 and 3. In the tables, all three variables that differed between the specimens are given, i.e. the orientation of the tear, the type of stitch and the length of stitch lines. The standard and artefact silks are given in separate tables. For each type, excluding references, three specimens were sewn and numbered I-III. The table also gives the system to the naming of the specimens, e.g. the second artefact silk specimen in the group with a horizontal tear secured with brick couching will be called AHB2 II.

Table 2. Showing the different variables of standard silk specimens and their code.

Standard silk								
Specimen code	SHL2	SHB2	SVL2	SVB2	SHL3	SHB3	SVL3	SVB3
Tear	H	H	V	V	H	H	V	V
Stitch	L	B	L	B	L	B	L	B
Length of stitch lines	20/25	20/25	20/25	20/25	30/35	30/35	30/35	30/35

Table 3. Showing the different variables of artefact silk specimens and their code.

Artefact silk				
Specimen code	AHL2	AHB2	AVL2	AVB2
Tear	H	H	V	V
Stitch	L	B	L	B
Length of stitch lines	20/25	20/25	20/25	20/25

Key to letters	
Standard silk	S
Artefact silk	A
Horizontal	H
Vertical	V
Laid Couching	L
Brick couching	B

The decision was to follow a stitch line pattern most common in Sweden according to Nilsson (2015b), and was also illustrated by Landi (1998). All lines are centred over the tear and sewn with varying length, e.g. 20/25 mm. To keep the specimens as alike as possible, patterns have been followed for treating the damage. Figures 2 and 3 shows illustrations of two specimens and the patterns followed when sewing. The yellow square marks the support fabric on the reverse of the specimen and the arrow shows the warp direction. (For illustrations of the other specimens see Appendix 3).

All sewing threads were fastened with two backstitches into the support fabric. For specimens with a vertical tear, the stitching began at the bottom left and worked up. For specimens with a horizontal tear, stitching began at the bottom right and worked to the left. The starting thread was fastened in the same area on similar specimens but due to the different stitches using different amounts of thread it was not possible to use only one length of thread. Lengths of thread following the first have not all

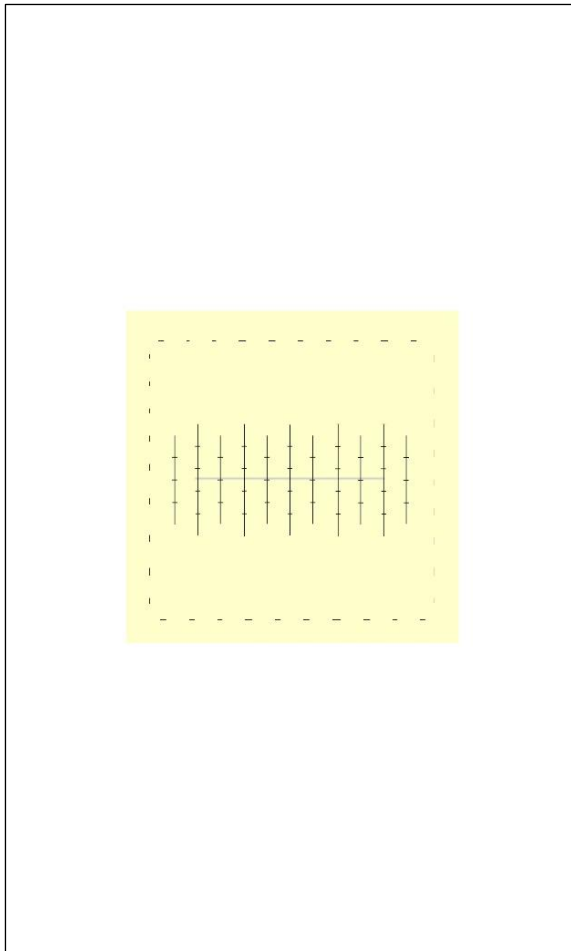


Figure 2. Specimen with horizontal tear secured with 20/25 mm lines of laid couching. Illustration: Marie Schön

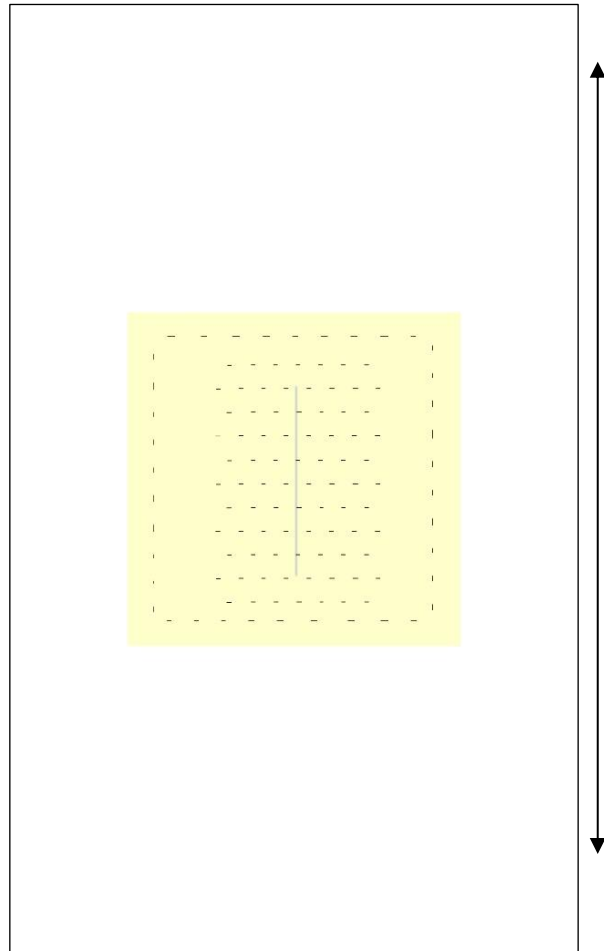


Figure 3. Specimen with vertical tear secured with 30/35 mm rows of brick couching. Illustration: Marie Schön

been fastened in the same place. The beginning point of stitch lines was measured out during sewing to keep with the pattern but the rest was mainly judged by eye. Once sewn, stitches were not pulled out, or reworked, as that is often not possible when working with real objects. This means that all stitches and stitch lines are not perfectly straight which is comparable to sewing treatments carried out in an everyday work situation.

### 3.3. Fixed-load test

Each specimen was hung on a magnetic whiteboard using five 6 mm in diameter neodymium magnets, with a thickness of 3 mm. The magnets were spaced evenly on a piece of plastic, approximately 0,5 mm thick, placed under the magnets to spread the force over a 10 x 70 mm area. Zip lock bags filled with 12 g of lead shot attached to a 70 mm wide bulldog clip with polyester sewing thread, formed a total weight of 50 g. The clips were fastened to the centre of the lower end of each specimen (Figure 4).

The experiment lasted for three weeks (3 April 2017 – 24 April 2017) with measurements taken during the process and photographs before and after. The ambient environment conditions were recorded during the time of the test. The temperature varied between 20.37 °C and 22.70 °C with a mean of 21.07 °C. The relative humidity (RH) varied between 15.90% and 44.31% with a mean of 30.81% (Figure 5). According to the standard ISO 139 the atmosphere in a textile laboratory should be fixed at 20 °C and 65% RH, tolerating a  $\pm 2$  °C fluctuation in temperature and a  $\pm 4$ % fluctuation of the RH (STA Branca Idealair 2016). The temperature was relatively even. During weekdays, it was somewhat fluctuating and exceeded the upper temperature limit a few times, by a maximum of 0.70 °C. The RH

had a significant fluctuation and was well below the standard. For a more detailed graph, see Appendix 4.



Figure 4. All specimens hanging on the whiteboard on the first day of the fixed-load test. Photo: Marie Schön

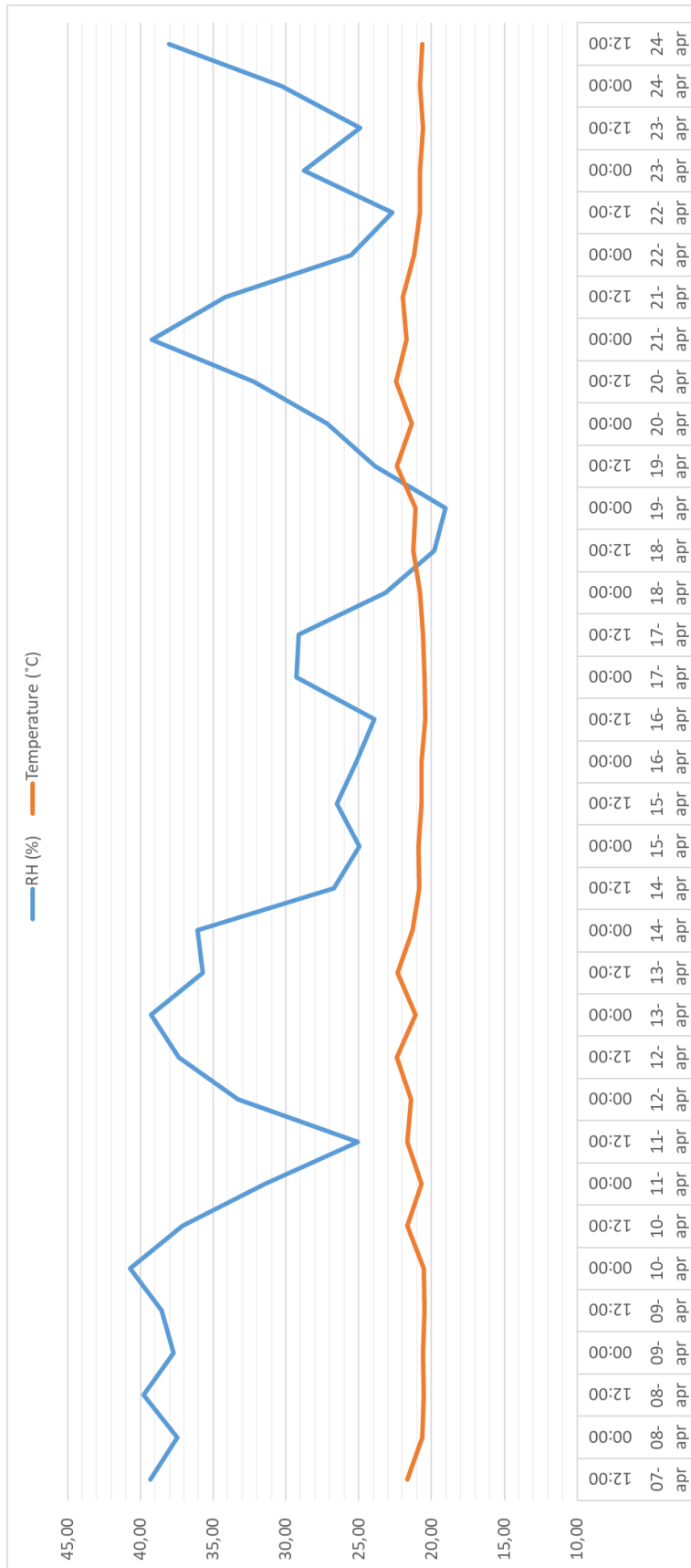


Figure 5. Graph showing temperature and RH in the room during the period the fixed-load test was carried out.

## 4. Evaluation methods

### 4.1. Extension

Prior to testing, measurements were taken from all specimens in order to detect changes in dimension. The total lengths and widths of both the specimens and the tear were measured using a ruler with mm units. All measurement was determined by eye with guidance of the ruler. During the test, measurements were taken of the tear; before hanging, after one week, after three weeks, and after hanging. Measurements of the total length and width of the samples were taken before and after hanging. Photographs of the hanging specimens were taken on day one and after three weeks.

### 4.2. Photography

Photographs of all specimens were taken before any testing began. A Nikon D3100 camera with an 18-55 mm DX lens was used for full view pictures, for close-up images, focusing on the supported area; a micro lens was attached to the camera. The photographs were taken to enable the identification of possible changes or damage to the weave structure.

Of select specimens, high magnification photographs of individual stitches were taken using a Nikon DS-Fi1 camera attached to a Zeiss stereomicroscope with a 32x magnification. High magnification photographs after the test were taken using a Nikon DS-Fi1 camera attached to a Nikon SMZ800 stereomicroscope at 30x magnification. The photographed stitches are the ones in the centre of the support; one of the stitch holding the support fabric at the top, three images of different points of the centre or top stitch line and one of the stitch holding the support fabric at the bottom. These images will show the effect of single stitches on the textile.



## 5. Results

### 5.1. Extension evaluation

No significant change in the dimensions of the specimens was possible to measure using the ruler immediately after the end of the test with the specimens lying flat. The specimens showing change were within 2 mm increase in length and 1 mm decrease in width. Measurements of the 21 out of 46 specimens showing change are given in Table 4.

*Table 4. Change in length and width of specimens, before and immediately after the fixed-load test. (Codes are explained in Tables 1-3.)*

Specimen code	Height (mm)	Width mm)
S	/	-1
SV	+1	-1
SHL2 I	+1	-1
SHL2 II	+1	/
SHL2 III	+1	/
SHB2 III	+1	-1
SVB2 I	+1	/
SHB3 I	+2	-1
SHB3 II	/	-1
SHB3 III	+1	-1
SVB3 I	+1	/
SVB3 II	+1	-1
SVB3 III	/	-1
AH	+2	/
AHL2 I	+1	-1
AHL2 III	/	-1
AHB2 I	+1	/
AVL2 II	/	-1
AVL2 III	/	-1
AVB2 I	/	-1
AVB2 II	/	-1

There was not a large difference in the measurement taken of the tear after one week compared to the measurements taken after three weeks. This could indicate that most change happened soon after the specimens were hung and loaded. During the test, the tear opening of the specimens with horizontal tear showed a change in the tear opening. None of the specimens' tear length changed either horizontally or vertically. Measurements of the tear opening for the 18 out of 46 specimens with a change are given in Table 5. All specimens in the table, except one, AVL2 III, have a horizontal tear. Out of the 14 sewn specimens with an opening, 10 were secured with laid couching. None of the sewn

specimens opened more than 1 mm. The standard silk reference specimen with horizontal tear and support fabric opened more than the reference with tear only.

*Table 5. Opening of the tear measured before the test and after three weeks, still hanging. (Codes are explained in Tables 1-3.)*

Specimen code	Before (mm)	Hanging (mm)
SH	0	0-1
SHSF	0-1	2
SHL2 I	0	1
SHL2 II	0-1	1
SHL2 III	0-1	1
SHB2 I	0	0-1
SHL3 I	0	0-1
SHL3 II	0	0-1
SHL3 III	0	0-1
SHB3 I	0	0-1
AH	0	3
AHSF	0	1-2
AHL2 I	0	0-1
AHL2 II	0	0-1
AHL2 III	0	0-1
AHB2 I	0	0-1
AHB2 II	0	0-1
AVL2 III	0	0-1

## 5.2. Photographic evaluation

Since there was no great change to the dimensions of the specimen, no overall photographs were taken after the test.

The results from the close-up photographs are presented here. The information is presented in photographs and text. The photographs, taken before and immediately after the test, with the specimens lying flat, demonstrate how the specimens responded to three weeks of loading with 50 g. Within their respective groups the three specimens all show similar results.

None of the specimens with a vertical tear showed any visible change in the close-up photographs after the fixed-load test.

The specimens showing most notable change was the SHL2 group. The tear had a visible opening (Figures 6 & 7) and some deformation in the weft is visible at the upper and lower ends of the laid stitching (Figures 8 & 9). There might be a bit more deformation close to the stitches which are less straight but it is difficult to determine. Some deformation was also visible before the test probably due to the thread being pulled too tight, this is consistent for all specimens with laid couching. For the SHL3 specimens, with longer laid couching stitch lines the tear opening is hardly noticeable. Moreover, the weft is not as deformed.

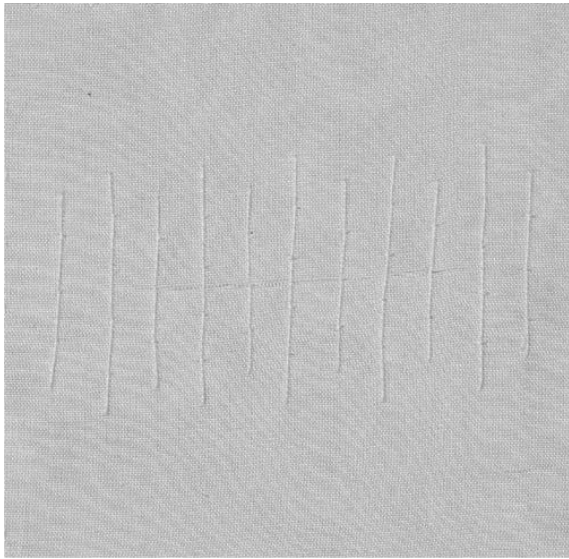


Figure 6. Close-up photograph of specimen SHL2 II, before the fixed-load test. Photo: Marie Schön

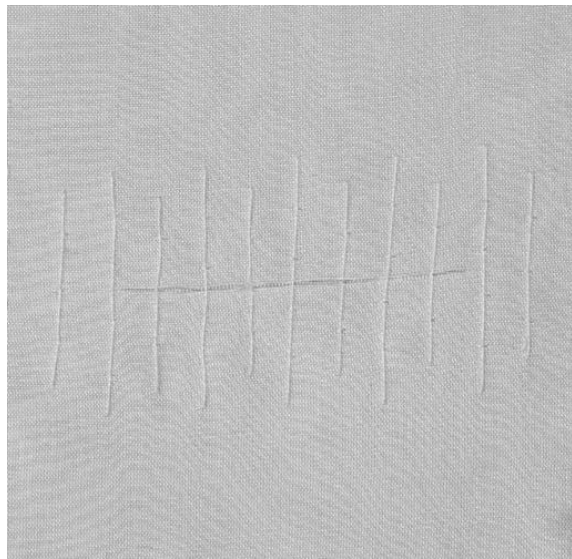


Figure 7. Close-up photograph of specimen SHL2 II, after the fixed-load test, visible opening of the tear. Photo: Marie Schön

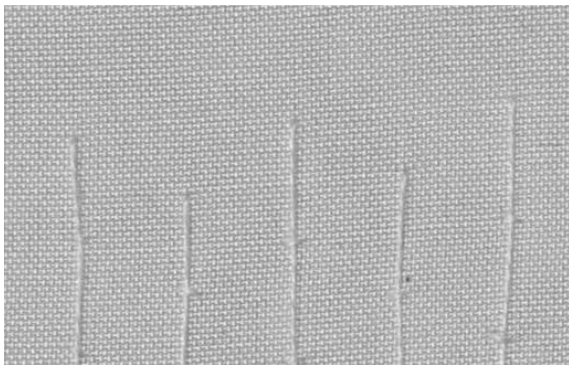


Figure 8. Detail of close-up photograph of specimen SHL2 II, before the fixed load test. Photo: Marie Schön

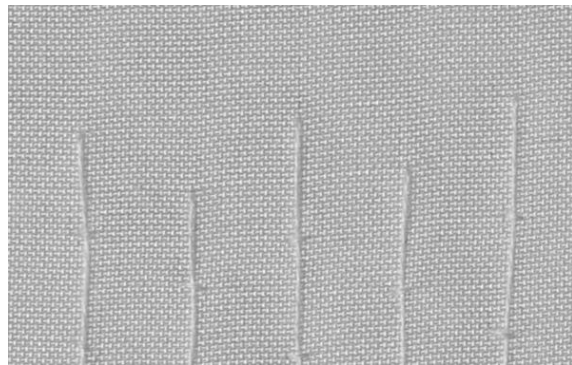


Figure 9. Detail of close-up photograph of specimen SHL2 II, after the fixed load test, some deformation of the weave visible. Photo: Marie Schön

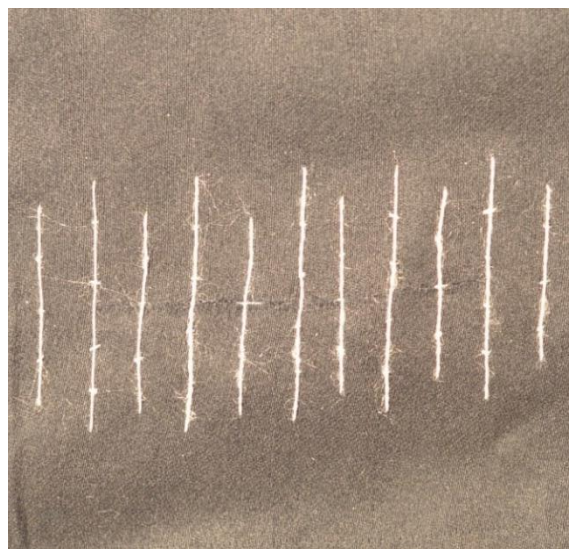


Figure 10. Close-up photograph of specimen AHL2 III, before the fixed-load test. Photo: Marie Schön

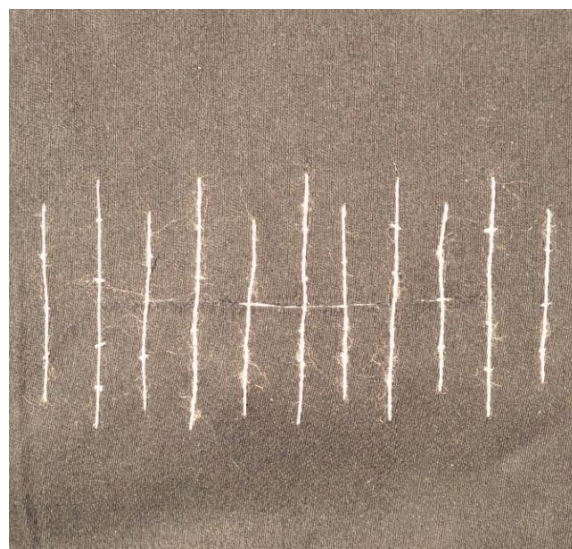


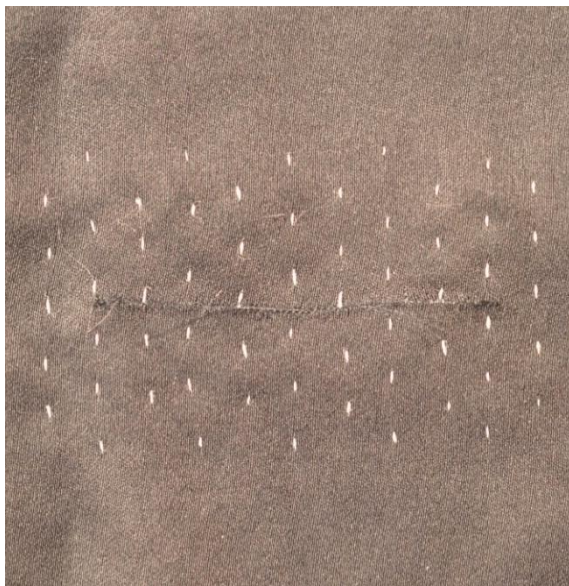
Figure 11. Close-up photograph of specimen AHL2 III, after the fixed-load test, visible opening of the tear. Photo: Marie Schön



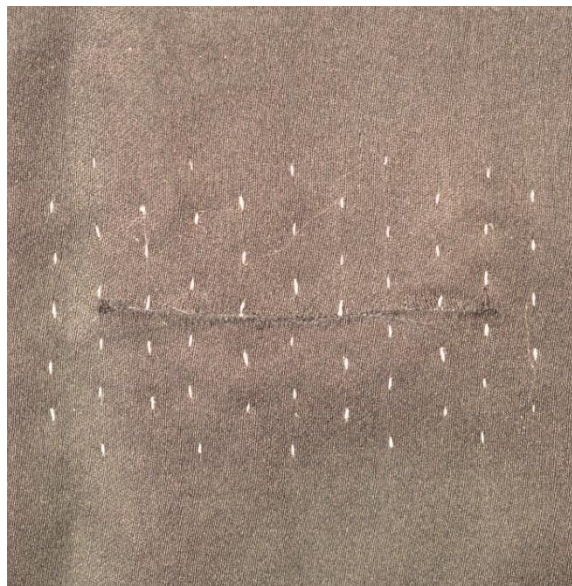
The artefact silk specimens with the same stitch pattern as SHL2, AHL2 also experienced a visible opening of the tears (Figures 10 & 11). The contrasting colour of the black artefact silk makes the opening more noticeable, but the tear opening does not seem to be wider than those for the SHL2 specimens. The satin weave made it difficult to see if any deformation of the weave occurred.

The other artefact silk specimen with horizontal tear but secured with brick couching, AHB2, experienced a much less noticeable opening of the tear (Figures 12 & 13).

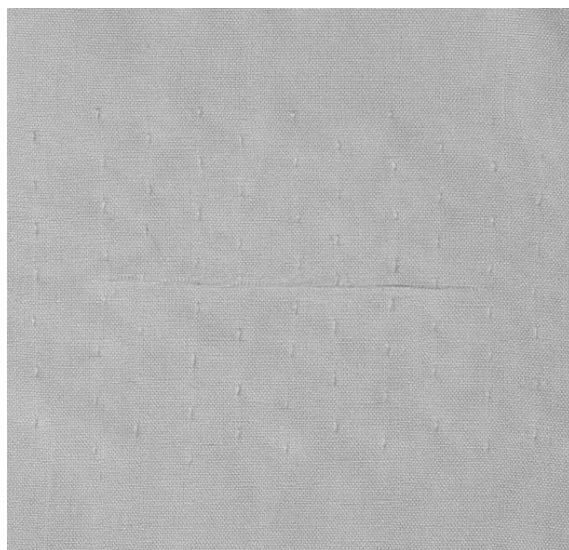
The specimens secured with brick couching all developed a puckered surface in the stitches area, probably due to the thread being pulled too tight. The threads probably need to be left loose, similar to what is illustrated by Landi (1998) as darning. The SHB2 and SHB3 groups both showed a slight opening of the tear. They showed no noticeable deformation of the weave, but it was difficult to determine due to the uneven surface and satin weave (Figures 14 & 15).



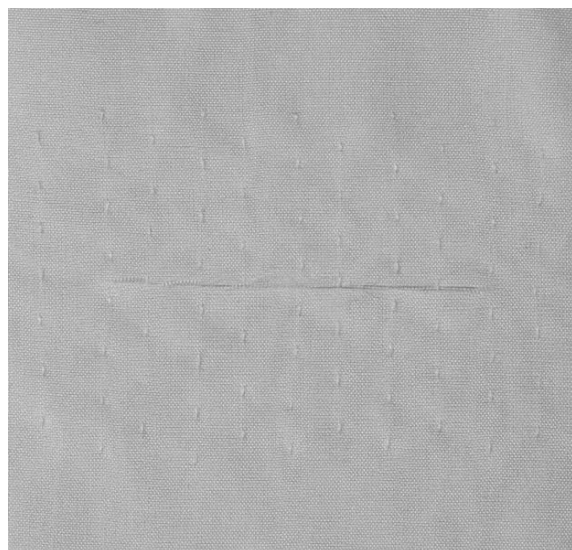
*Figure 12. Close-up photograph of specimen AHB2 I, before the fixed-load test. Photo: Marie Schön*



*Figure 13. Close-up photograph of specimen AHB2 I, after the fixed load test, only a slight change visible, Photo: Marie Schön*



*Figure 14. Close-up photograph of specimen SHB3 I, before the fixed-load test. Photo: Marie Schön*



*Figure 15. Close-up photograph of specimen SHB3 I, after the fixed-load test, a slight opening is visible. Photo: Marie Schön*

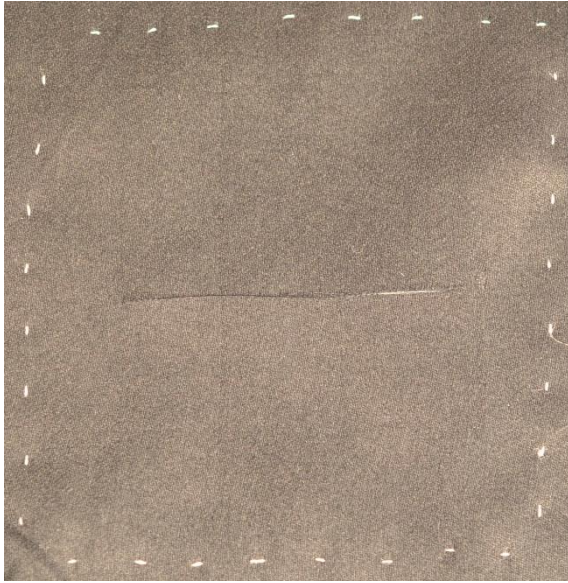


Figure 16. Close-up photograph of specimen AHSF, before the fixed-load test. Photo: Marie Schön

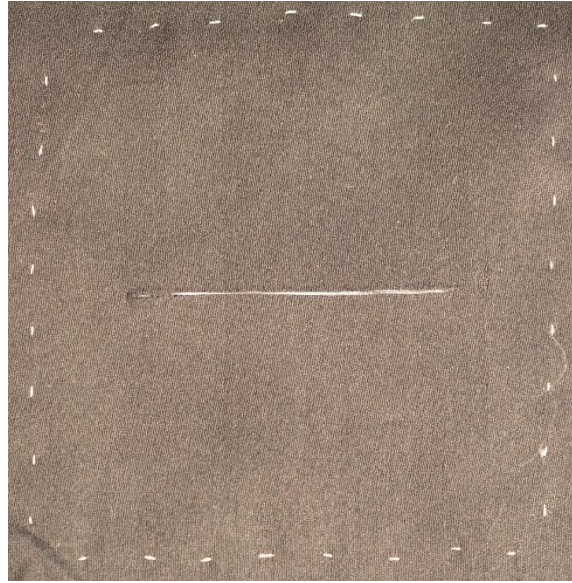


Figure 17. Close-up photograph of specimen AHSF, after the fixed-load test, an opening of the tear is visible. Photo: Marie Schön

The SV and SVSF reference specimens did not show any visible change to the tear, which is the same as for the artefact specimens AV and AVSF. The SH and SHSF both have visible openings as does the artefact specimens (Figures 16 & 17). The SHSF/AHSF opening is larger than the opening of the SH/AH. The AH seems to have opened more than the SH and is a bit frayed along the edges of the tear, this might be due to the tear not being totally aligned with the weft.

### 5.2.1. Stereomicroscope evaluation

Selected specimens were photographed with 30-32x magnification at five specific points along the centre of the secured area. These points were: the centre stitch holding the support fabric at the top and bottom, the upper and lower ends of the centre stitch line for horizontal tear specimens and the far left and right ends of the top stitch line for vertical tear specimens, the final photograph was taken at the centre of the respective stitch line. The high magnification photographs were taken three days after the end of the test and some distortion might have recovered. Also note that the before and after photographs were taken with the same camera but using different microscopes, hence the different magnification and quality of the images. The photographs were taken of all specimens numbered I in the respective groups.

A slight deformation of the weft is visible comparing the before and after loading of specimens in the SHL3 (Figures 18 & 19) and SHL2 groups, at the upper and lower ends of the laid thread. Some deformation can also be seen before the test, probably due to the thread being pulled too tight while sewing but seems to be worse with the artefact silk. The damage done by the stitches before the test was more visible in some of the specimens with a vertical tear. The distortion was greater in the artefact silk specimens, but only slightly visible in the standard silk specimens. It is also worth noting that this is more prominent at the left end of the stitch, which is the side which has the sharpest turns of the thread on the back of the specimen. In AVL2 I, a hole has formed at one end of the laid stitches where the thread turns, there is no major change in the size of the hole before and after the test (Figures 20 & 21).



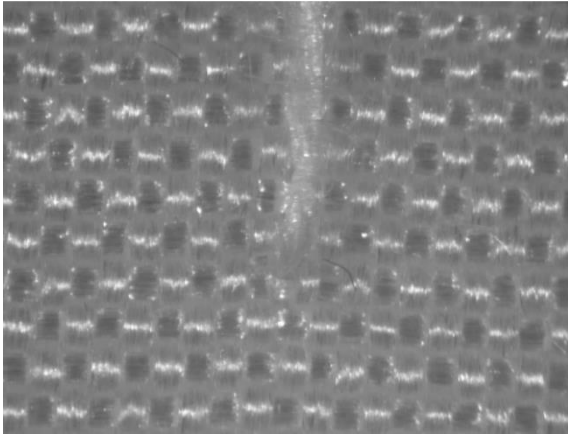


Figure 18. Stereomicroscope photograph of specimen SHL3 I at the lower end of the centre laid stitch, before the fixed-load test. Photo: Marie Schön

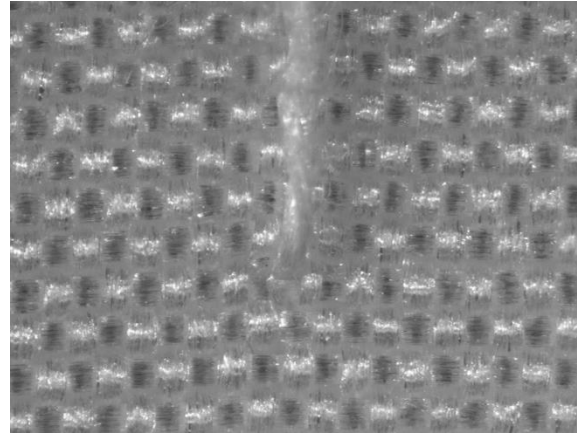


Figure 19. Stereomicroscope photograph of specimen SHL3 I at the lower end of the centre laid stitch, after the fixed-load test. The weft is slightly distorted at the end of the stitch. Photo: Marie Schön



Figure 20. Stereomicroscope photograph of specimen AVL2 I at the left end of the top laid stitch, before the fixed-load test. Distortion at the end of the stitch. Photo: Marie Schön

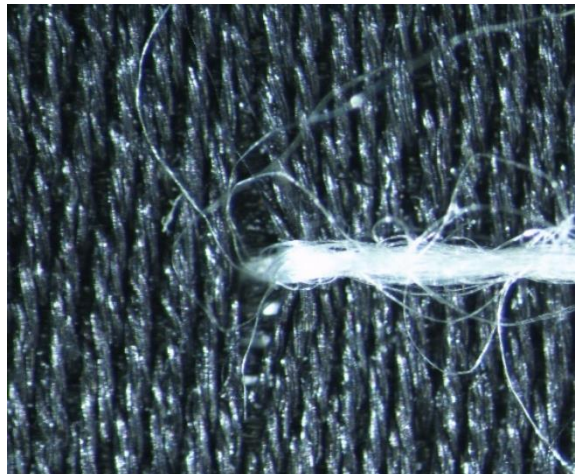


Figure 21. Stereomicroscope photograph of specimen AVL2 I at the left end of the top laid stitch, after the fixed-load test. Distortion at the end of the stitch. Photo: Marie Schön

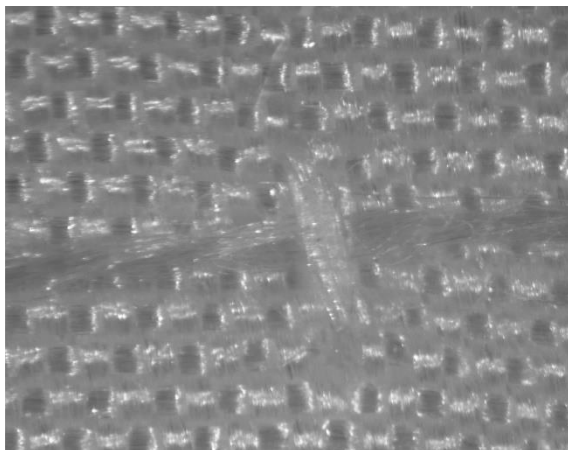


Figure 22. Stereomicroscope photograph of specimen SVL3 I at the centre holding stitch of the top laid stitch, before the fixed-load test. Distortion to both warp and weft by the holding stitch. Photo: Marie Schön

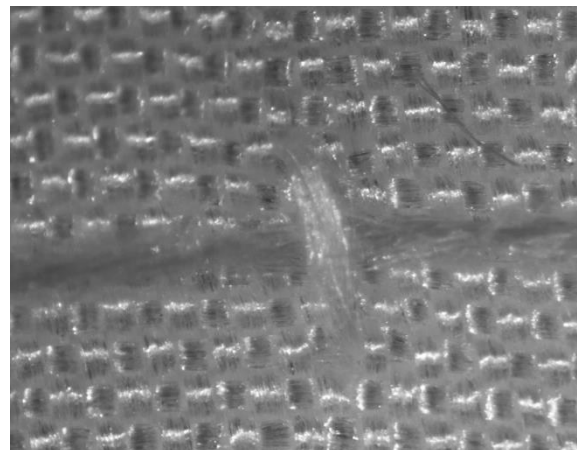


Figure 23. Stereomicroscope photograph of specimen SVL3 I at the centre holding stitch of the top laid stitch, after the fixed-load test. Distortion to both warp and weft by the holding stitch. Photo: Marie Schön



Figure 24. Stereomicroscope photograph of specimen AVSF at the centre bottom stitch holding the support fabric, before the fixed-load test. Photo: Marie Schön

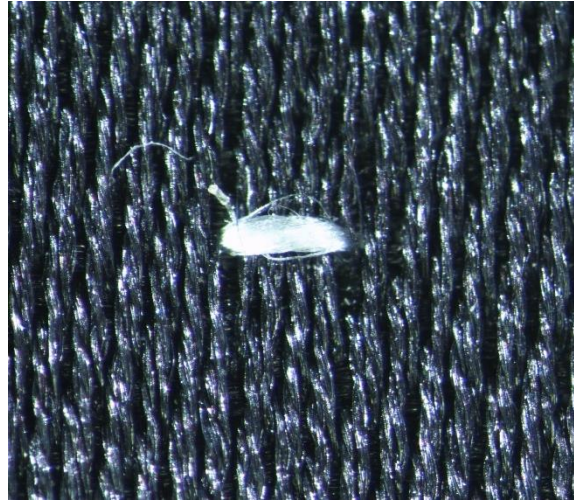


Figure 25. Stereomicroscope photograph of specimen AVSF at the centre bottom stitch holding the support fabric, after the fixed-load test. The stitch slightly gathers the warp. Photo: Marie Schön

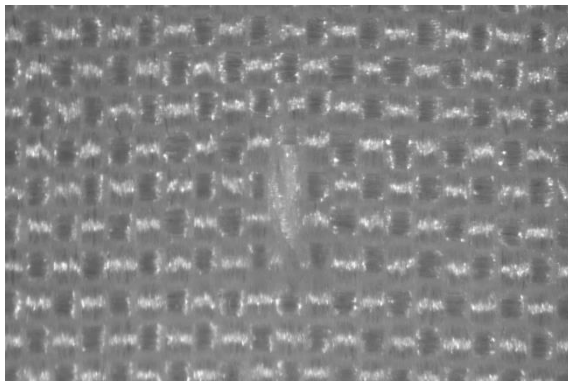


Figure 26. Stereomicroscope photograph of specimen SHB3 I at the bottom end of the centre stitch line of brick couching, before the fixed-load test. Photo: Marie Schön

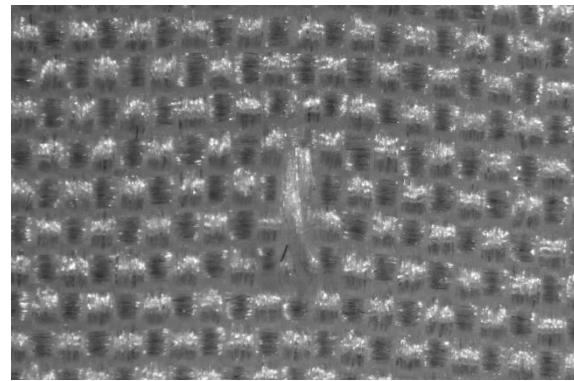


Figure 27. Stereomicroscope photograph of specimen SHB3 I at the bottom end of the centre stitch line of brick couching, after the fixed-load test. Deformation of the weft. Photo: Marie Schön

In addition to deformation at the laid stitch ends, the SVL3 I specimen also gives an example of some deformation to both warp and weft, the holding stitch is not straight and pulls the weft, this is visible both before and after loading (Figures 22 & 23). In the artefact silk specimens, a “gathering” of the warp threads was visible at some stitches in the weft direction. Examples of this are seen in specimen AVSF (Figures 24 & 25) at the centre of the bottom line of stitching holding the support fabric. A deformation of the weft at the top and bottom ends of the centre laid stitch was visible in specimen SHB3 I (Figures 26 & 27).

## 6. Discussion

The fixed-load test seems like a good method for simulating damage brought about by stitches while an object is in a hanging position. It would be interesting to compare the results with museum objects to evaluate the method.

The specimens used in this experiment are wider than used by Benson (2013) and Sutherland (2016) respectively, this probably gives a better representation of the damage due to vertical loading as there would normally be strong material surrounding a tear in an artefact. They could probably have been a bit narrower, since the impression was that the material on the sides of the bulldog clip was not affected by the load, and therefore not giving support to the weak area of the tear. A longer test period might be preferable to see more change in the specimens, as previously noted by both Benson and Sutherland. On the other hand, the experiment carried out in this study indicates that most change happens in the initial period of the fixed-load test. This indication could suggest a heavier weight to see more change in a shorter amount of time, resulting in a more accelerated test method.

Photographs in Benson's (2013, Figure 6.41 & Figure 6.43) thesis show a silk specimen supported with 6 mm spaced, 40 mm long rows of laid couching sewn with Tetex® or lace cotton thread.<sup>7</sup> Considering that the stitch lines are 5-10 mm longer than the longest used in this test the 0.81 mm/0.92 mm tear gap in Benson's tests is far larger than what looks like no noticeable gap for the SHL3 specimens in the present work. Benson did use 1 mm wider spacing between stitch lines and naturally aged silk from an historic artefact, but the present study did not show a great difference between opening of the tear of the SHL2 and AHL2 specimens. The greater resulting damage in Benson's specimen might also depend on the lack of material on either side of the damage. Less material was loaded with the same amount of weight but for a shorter time.

In the early stages of this thesis, it was considered important to use an aged textile for the specimens. Artificially aged standard silk was initially considered but due to time restrictions naturally aged fabric was chosen. The drawback of the artefact silk used in this study is the satin weave which made distortions to the weft impossible to evaluate. The weft is hidden by the warp on the face side and by the support fabric on the reverse. Therefore, it seems most important that the specimen fabric is of a plain weave where both warp and weft threads are clearly visible. The standard silk is a good example of such fabric and was well-suited to use for this experiment. Although the weave of the artefact silk made it more difficult to evaluate the specimens, the black colour made changes such as opening of the tear easier to spot. It could be an option for future research to use dyed support fabric in order to achieve the same effect, this would be better than dyed textile for the specimen, but the deteriorating effect of the dye might have to be considered.

A more accurate method for measurements would be desirable. At least for measuring the tear, using perhaps computer based digital analysis to measure the length and opening on photographs taken at different stages during the test, similar to methods used by Benson (2013) or Sutherland (2016), though not thoroughly explained in either of their respective theses. Out of the used evaluation methods, the close-up photographs, gave the most valuable information. Most of the distortion was visible on that scale and not as much when zoomed in on the stitches themselves. The stereomicroscope evaluation did not give as much information as the close-up photographs. Only a few of them showed visible change. The reason might be that only a selection of specimens were photographed and in specific areas. But also, as they were taken three days after the end of the test and some distortion might have recovered.

Unlike Benson and Sutherland, in the present investigation, no stitch markings were made prior to sewing. This was not done due to the risk of the markings affecting the fibres in any way, the previous

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<sup>7</sup> Tetex® thread refers to a warp thread drawn from polyester Tetex® fabric, also known as Stabilitex®. The lace cotton is numbered 185/2.



studies both lack a discussion about how the lead/ink might affect the fibres and therefore also the results. The method of not marking where to put the stitches does not seem to have affected the efficacy of the test as the specimens within the same group displayed the same type and amount of change.

The evaluation of the time required to execute the different treatments made by Nilsson (2015a) did turn out to be helpful. The mean time was close to the time it took to complete the treatment for one of the specimens, around one hour for the laid couching and a bit less for the brick couching. The first couple of specimens took longer to complete probably due to a learning process.

For future research, it would be interesting to study the optimal length for stitch lines and how the size of the damage or weight of the textile affects the result. It would also be interesting to investigate the relation between the length of the stitch line and the spacing of the stitch lines i.e. do more widely spaced stitch lines need to be longer to give the same support?

## 6.1. Conclusion

The results from this study indicate that more distortion is caused by laid couching than brick couching, especially if the length of the stitch lines is made too short. The specimens with the shorter stitch lines (20/25 mm) of laid couching in combination with the horizontal tear showed the most amount of distortion to the textile, such as opening of the tear and deformation of the weave. Another mechanical effect that can be caused by laid couching is when the laid stitch is pulled too tight which causes deformation of the weave and sometimes also a hole. This is not seen with the brick couching probably because the sewing thread does not need to make sharp turns in the fabric. The problem which can be caused by too tightly sewn stitches in brick couching is instead the puckering of the surface. The opening of the tear did not seem to change with the different length of stitch lines of the brick couching. The opening varied between specimens, some without and some with a slight opening of the tear.

Most distortion was seen in the specimens with a horizontal tear. The specimens with a vertical tear mainly displayed distortion of the warp created by tightly sewn stitches; no weave distortion was caused by the loading in the test as seen with the specimens with a horizontal tear. With time these types of distortion might cause further damage to the textile. It could therefore be concluded that vertical tears do not need as long stitch lines as horizontal tears regardless of what stitch is used; thus, minimizing the number of needle insertions. If a horizontal tear is conserved with laid couching, longer stitch lines should probably be used, but with brick couching they can be kept shorter.

## 7. Summary

Stitching is probably the most widely used treatment method in textile conservation. Still it is not common for stitching techniques to be described in detail in the literature and in published case-studies (Nilsson 2015a; Sutherland 2016). However, in recent years there has been an increasing interest to study the effect of stitching threads (Benson 2013), sewing methods (Nilsson 2015b) and stitch density (Sutherland 2016). Their work has added knowledge to an area of textile conservation that previously lacked experimental research, and established a base for further studies to build on. Still more research is needed in the area to gain more knowledge about which consequences different methods could have on textile objects in the future.

The purpose of this study was to investigate how conservation stitches mechanically affect supported areas of a textile object. The aim was to better understand what impact different stitch patterns and stitches used in textile conservation have on textiles after long-term storage and exhibition. To limit the scope of this thesis, the study focused on the conservation of silk using a support fabric attached with stitches. The number of stitching techniques was limited to two: laid couching and brick couching.

Standard silk fabric, ISO 105-F06:2000 *Bombyx mori*, has been used in this study with the intention to make it as reproducible as possible. Textile from a historic artefact was also used. The artefact silk was taken from a black shawl of tin weighted silk.

All 46 specimens were cut and sewn by the author. The size of the specimens was 200 mm in the warp direction and 120 mm in the weft direction. Half of the 28 standard silk specimens and 16 of the artefact silk specimens were given a 40 mm long horizontal tear and the other half a vertical tear, centred in the specimen. One of each was kept without tear for reference.

A 70x70 mm support fabric of standard silk was centred and aligned behind the damage. The conservation sewing was done using either 20/25 or 30/35 long stitch lines of either laid couching or brick couching. Reference specimens without stitching and with support fabric only were also prepared.

Each specimen was hung on a magnetic whiteboard using neodymium magnets. A piece of thick plastic was placed under the magnets to spread the force over a 10 x 70 mm area. Zip lock bags with lead shot attached to a 70 mm wide bulldog clip, formed a total load of 50 g. The clips were fastened to the lower short end of each specimen. The experiment lasted for three weeks. Measurements taken during the process and photographs before and after, were used to evaluate the results.

No significant change in the dimensions of the specimens was possible to measure using a ruler immediately after the end of the test. There was not a large difference in the measurement taken of the tear after one week compared to the measurements taken after three weeks. This could indicate that most change happened soon after the specimens were loaded.

In the photographic evaluation, the specimens showing most notable change were the specimens with a horizontal tear secured with 20/25 mm long stitch lines of laid couching. Some deformation could be seen before the test, probably due to the thread being pulled too tight while sewing, this effect seems to be worse with the artefact silk. The tear had a visible opening after loading and some distortion in the weft is visible at the upper and lower ends of the laid stitching. For the specimens with longer laid couching stitch lines the tear opening is hardly noticeable, the weft is also not as distorted.

The specimens secured with brick couching all showed a puckered surface in the stitched area, probably due to the thread being pulled too tight. They also showed a slight opening of the tear. There was no noticeable deformation of the weave, but it was difficult to determine due to the uneven surface.

The results from this study indicate that more damage is caused by laid couching than of brick couching, especially if the stitch lines are short. The opening of the tear did not seem to change with the different lengths of stitch lines of the brick couching.

Most damage was seen on the specimens with a horizontal tear. The specimens with a vertical tear mainly displayed damage created by the tightly sewn stitches. It could therefore be concluded that vertical tears do not need as long stitch lines as horizontal tears regardless of what stitch is used. If a horizontal tear is conserved with laid couching longer stitch lines should probably be used, about 30/35 mm in this case, but with brick couching they can be kept shorter.

## 8. Swedish summary – Sammanfattning

Sömnad är troligtvis den vanligaste metoden inom textilkonservering. Ändå är det ovanligt att den beskrivs ingående i litteratur eller fallstudier (Nilsson 2015a; Sutherland 2016). På senare år har dock intresset för att studera effekten av sytrådar (Benson 2013), sömnadsmetoder (Nilsson 2015b) och stygnstäthet (Sutherland 2016) ökat. Nämnda arbeten har tillfört kunskap till ett område som tidigare saknade forskning och har lagt en grund för fortsatt forskning att bygga på. Mer forskning inom området behövs fortfarande för att få ännu mer kunskap om vilka konsekvenser olika metoder skulle kunna ha på textila föremål i framtiden.

Syftet med den här studien var att undersöka hur konserveringsstygn mekaniskt påverkar säkrade områden av ett textilt föremål. Målet var att få en bättre förståelse för hur olika typer av stygnmönster och stygn som används inom textilkonservering påverkar textilerna efter hängande förvaring eller utställning. För att begränsa arbetets omfattning fokuserade studien på konservering av siden med hjälp av ett stödtyg som fästs med stygn. Antalet stygn typer begränsades till två, läggsöm och förstygn.

Standardsiden, ISO 105-F06:2000 *Bombyx mori*, användes i experimentet med målet att göra det så reproducerbart som möjligt. Tyg från ett historiskt föremål har också använts. Materialet togs från en svart sjal av förtyngt siden.

Alla 46 prover klipptes ut och syddes av författaren. Provernas storlek var 200 mm i varpriktning och 120 mm i inslagsriktning. Hälften av de 28 proverna av standardsiden och 16 proverna av historiskt siden gavs en 40 mm lång horisontell reva, den andra hälften gavs en vertikal reva, centrerat i mitten av provet. En av varje materialtyp behölls utan reva som referens.

En 70 x 70 mm stödtygsbit av standardsiden centrerades bakom revan och lades trådrikt. Konserveringssömnaden utfördes med antingen 20/25 mm eller 30/35 mm långa rader av antingen läggsöm eller förstygn. Dessutom förbereddes referensprover helt utan säkring och med endast stödtyg.

Varje prov hängdes på en magnetisk whiteboard med neodymiummagneter. En bit tjock plast placerades under magneterna för att sprida ut kraften över en 10 x 70 mm stor yta. Zip-påsar med blyhagel som fästes vid en 70 mm bred bulldogklämma, utgjorde en total vikt av 50 g. Klämmorna fästes i den nedre kortändan av varje prov. Experimentet varade i tre veckor. Mått tagna under processen och fotografier tagna före och efter användes för att utvärdera resultatet.

Ingen signifikant förändring av provernas yttermått kunde uppmätas med linjal direkt efter testets slut. Det fanns inte heller någon stor skillnad i revans mått efter att testet pågått en vecka jämfört med efter att ha pågått tre veckor. Detta kan indikera att mest förändring sker strax efter att proverna hängts upp.

I den fotografiska utvärderingen visade de prover med horisontell reva säkrat med 20/25 mm långa stygnrader av läggsöm störst förändring. En viss deformation finns även före testet, troligtvis på grund av att sytråden dragits åt för hårt, denna effekt var mer påtaglig hos det historiska sidenet. Revan hade en synlig öppning efter att ha blivit utsatt för tyngd och inslaget hade deformerats i de övre och undre områden där sömmen började och slutade. Prover med längre rader av läggsöm fanns ingen noterbar öppning av revan. Inslaget var heller inte lika deformerat.

Proverna som sytts med förstygn visade alla en bubblig yta i det säkrade området, troligtvis på grund av att tråden dragits åt för hårt. De visade också en ringa öppning av revan. Ingen noterbar deformation av väven, vilket dock var svårt att avgöra på grund av ytans ojämnheter.

Resultaten i studien indikerar att mer skada orsakas av läggsöm än av förstygn, särskilt om stygnraderna är korta. Revans öppning verkade inte förändras med de olika längderna på stygnraderna när förstygn användes.

Mest skada kunde ses på de prover med horisontell reva. Proverna med vertikal reva visade främst skador skapade av de hårt åtdraga stygnen. Därför kan slutsatsen dras att vertikala revor inte kräver lika långa stygnrader som horisontella revor oavsett vilket stygn som används. Om en horisontell reva konserveras med läggsöm bör längre stygnrader troligtvis användas, omkring 30/35 mm i detta fall, men med förstygn kan de hållas kortare.

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## Appendix 1. List of suppliers

Standard Silk ISO 105-F06:2000 *Bombyx mori*

Cromocol

Åsboholmsgatan 16

SE-504 51

Borås, Sweden

Tel.: +46 (0) 33-23 50 00

E-mail: [info@cromocol.se](mailto:info@cromocol.se)

Website: <https://www.cromocol.se/index.php>

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Spun silk 210/2, White

Pipers Silks

Chinnerys

Egremont Street

Glemsford, Suffolk

CO10 7SA, UK

Tel.: +44 (0) 1787 470323

E-mail: [sales@pipers-silks.com](mailto:sales@pipers-silks.com)

Website: <http://www.pipers-silks.com>

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Neodymium magnets, article no. M80

Formina

Södra Uddens väg 11

SE-475 36

Kalvsund, Sweden

Tel.: +46 (0) 31-96 24 68

E-mail: [info@formina.se](mailto:info@formina.se)

Website: <http://formina.se/>

Bulldog clips, article no. 11965

IN-EX FÄRG AB

Kungsgatan 22

SE-411 19

Göteborg, Sweden

Tel.: +46 (0) 31-711 88 16

E-mail: [info@in-exfarg.se](mailto:info@in-exfarg.se)

Website: <https://www.in-exfarg.se/>

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Lead shots (Blyhagel)

Dan Berg Elprojekt AB

Örelidsvägen 1

SE-517 71

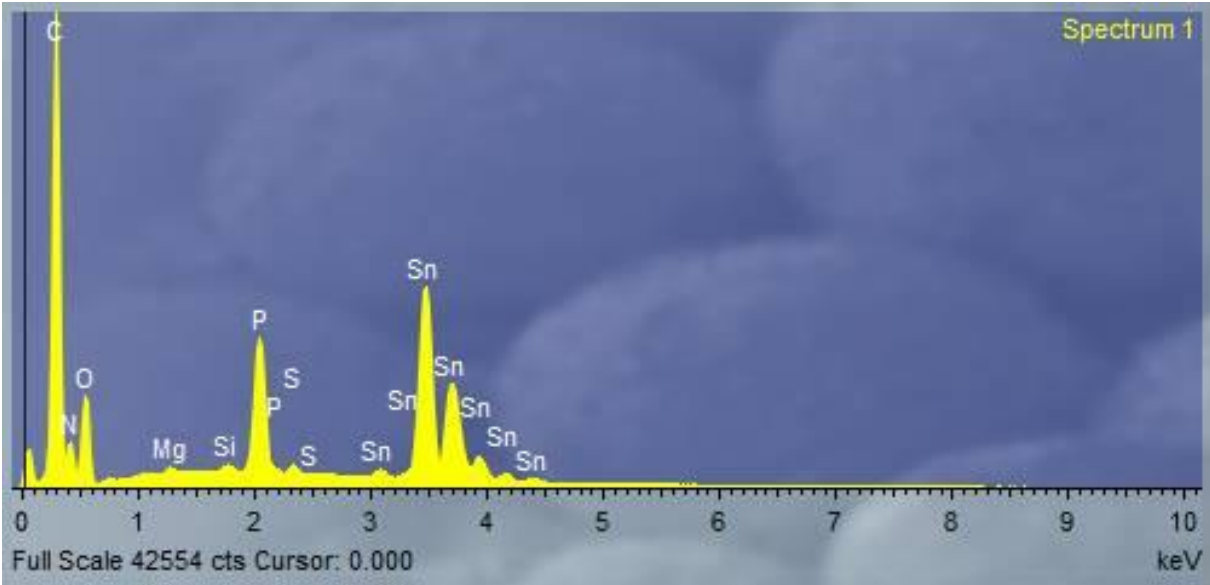
Olsfors, Sweden

Tel.: +46 (0) 33 299 000

E-mail: [dan.berg@danberg.se](mailto:dan.berg@danberg.se)

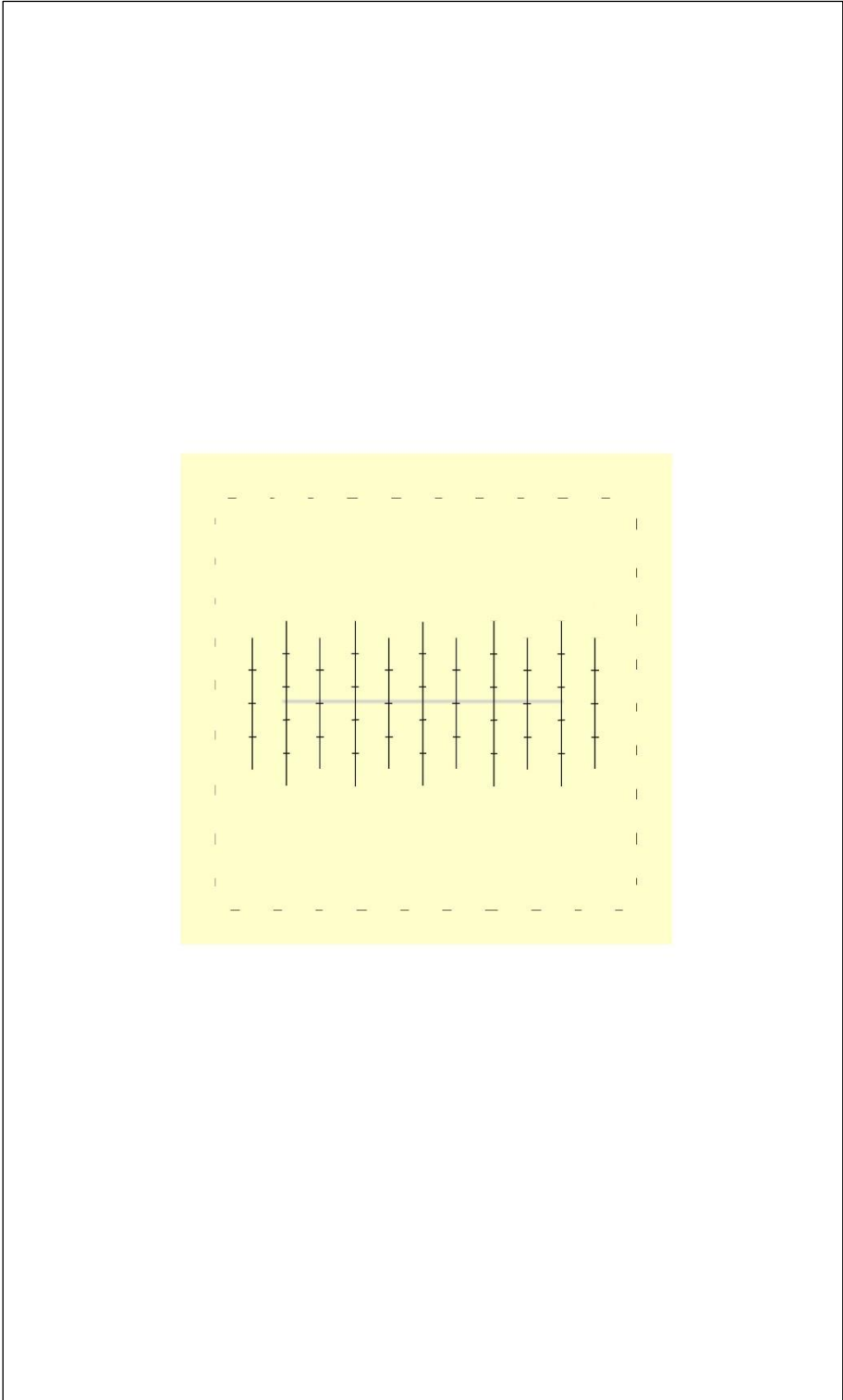
Website: <http://www.danberg.se/>

**Appendix 2. SEM/EDX spectrum of the artefact silk**

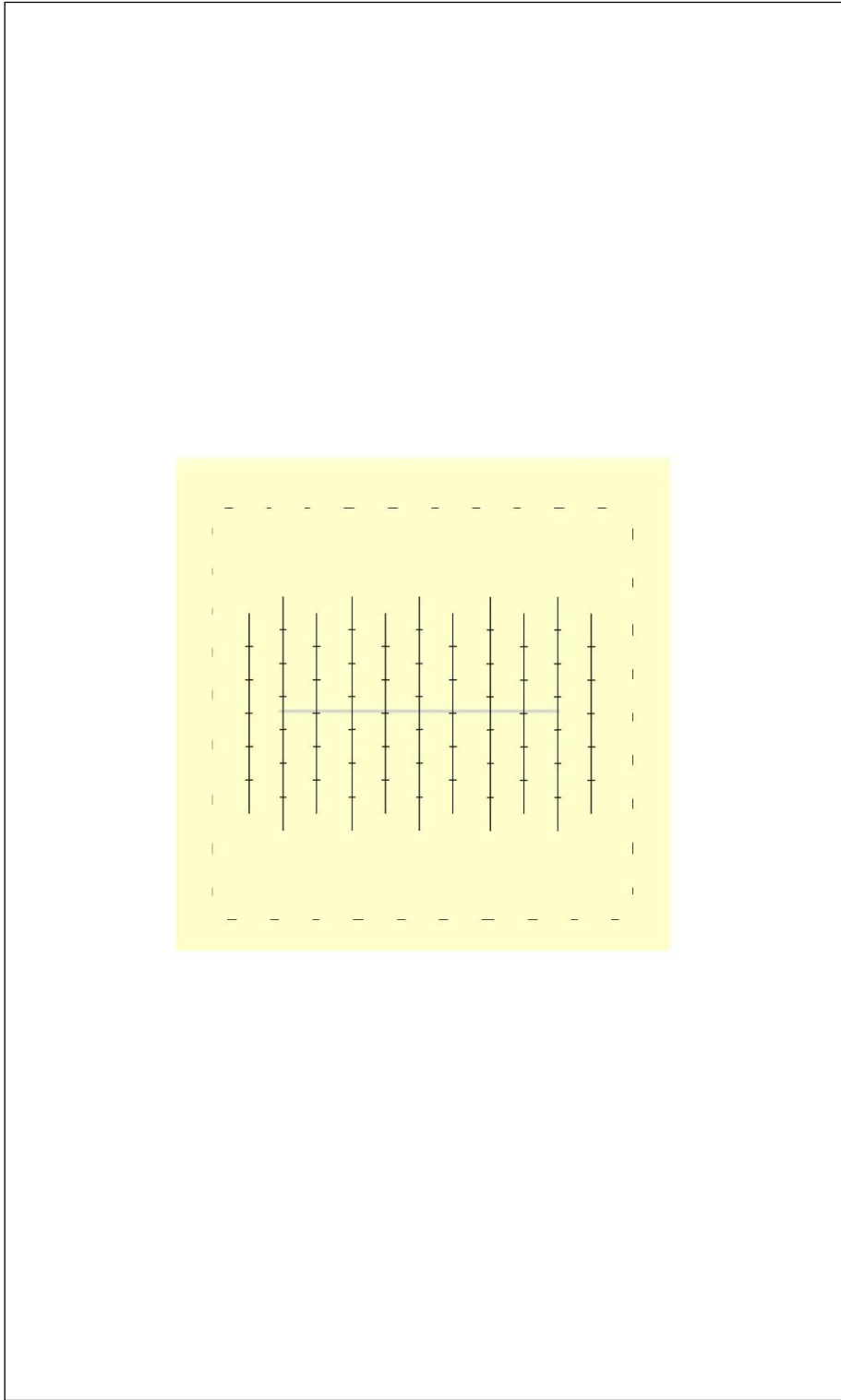


*Figure 28. SEM/EDX spectrum of the artefact silk, showing the presence of tin (Sn) in the textile.*

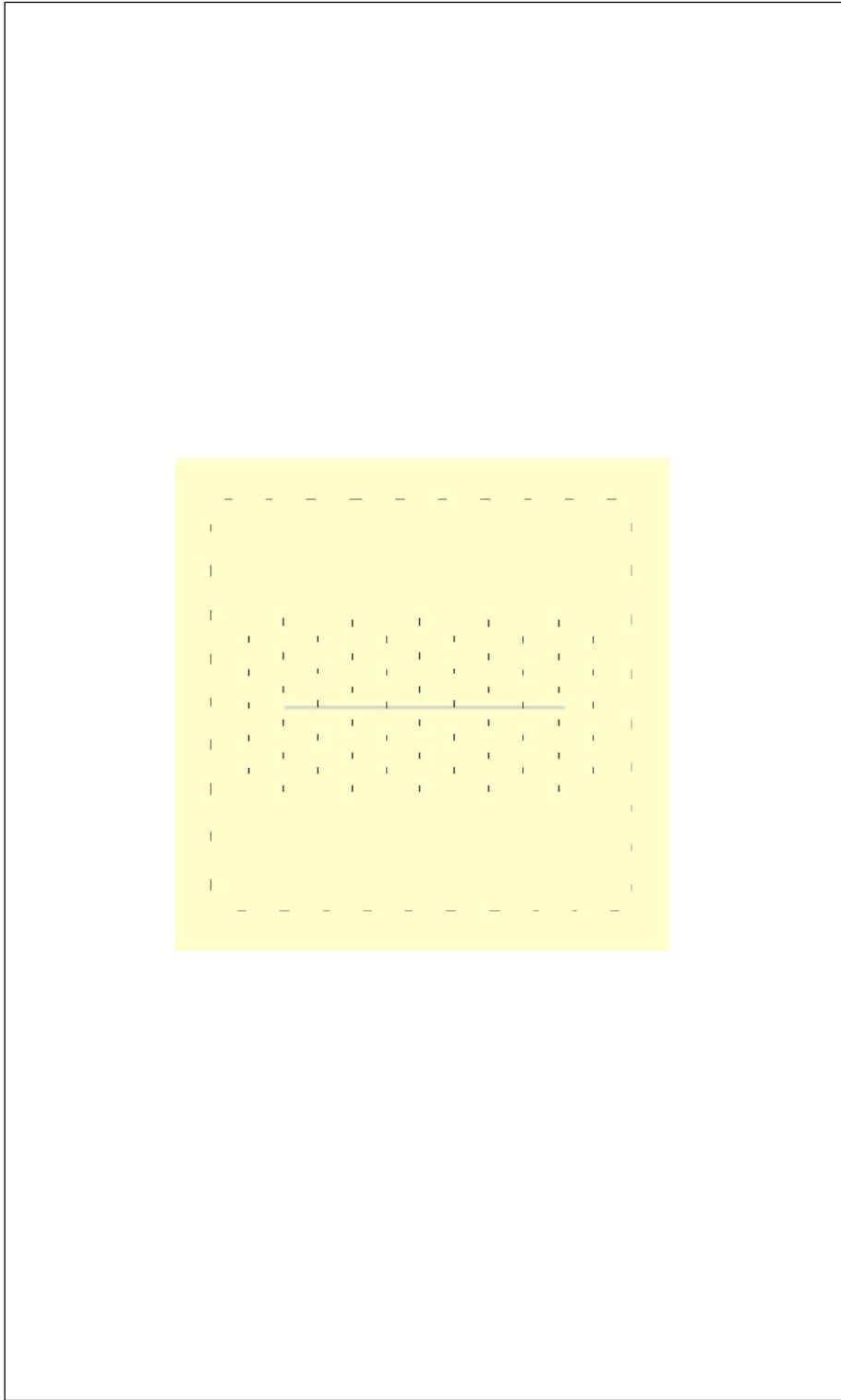
**Appendix 3. Illustrations of specimens**



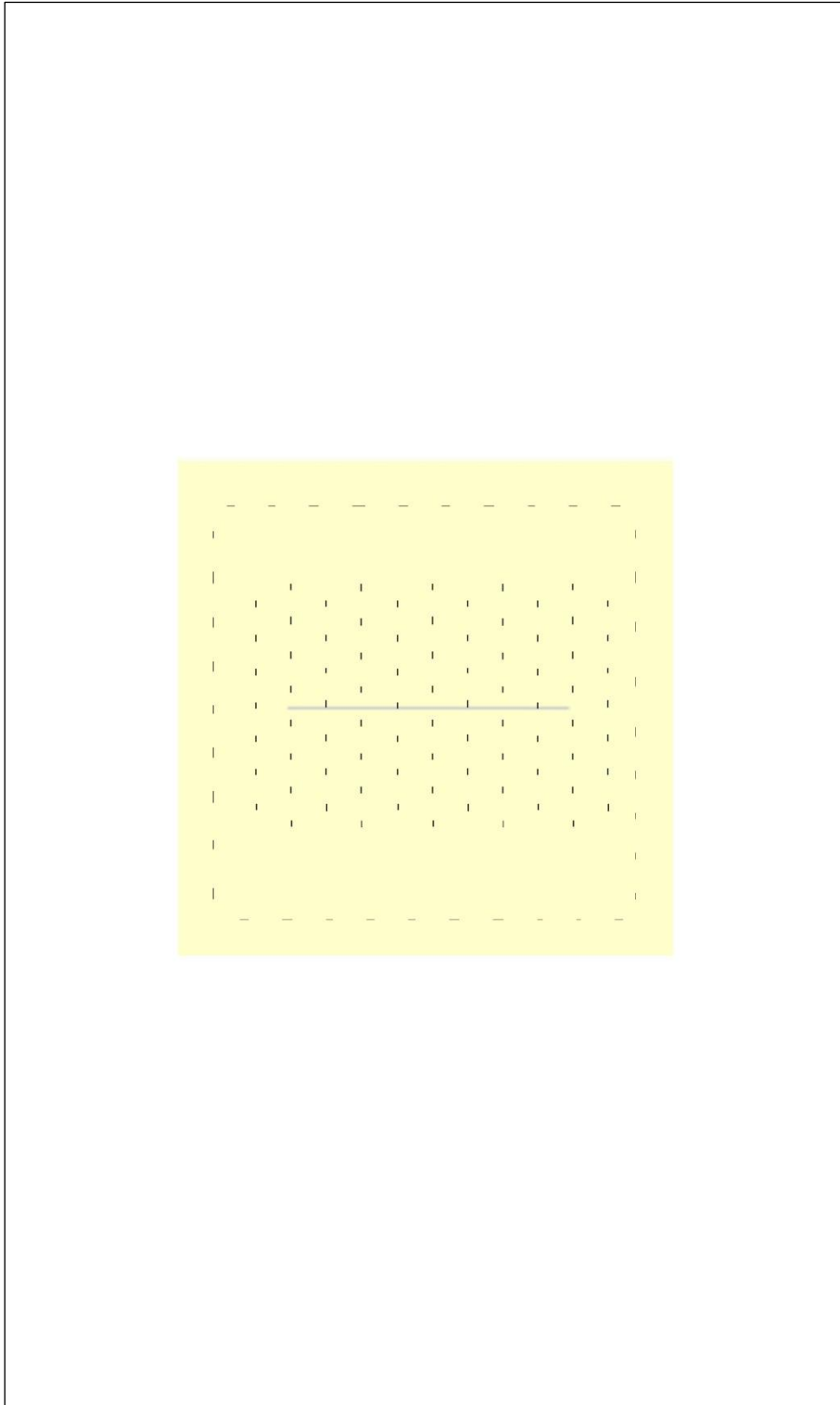
*Figure 29. Specimen with horizontal tear secured with 20/25 mm lines of laid couching.  
Illustration: Marie Schön*



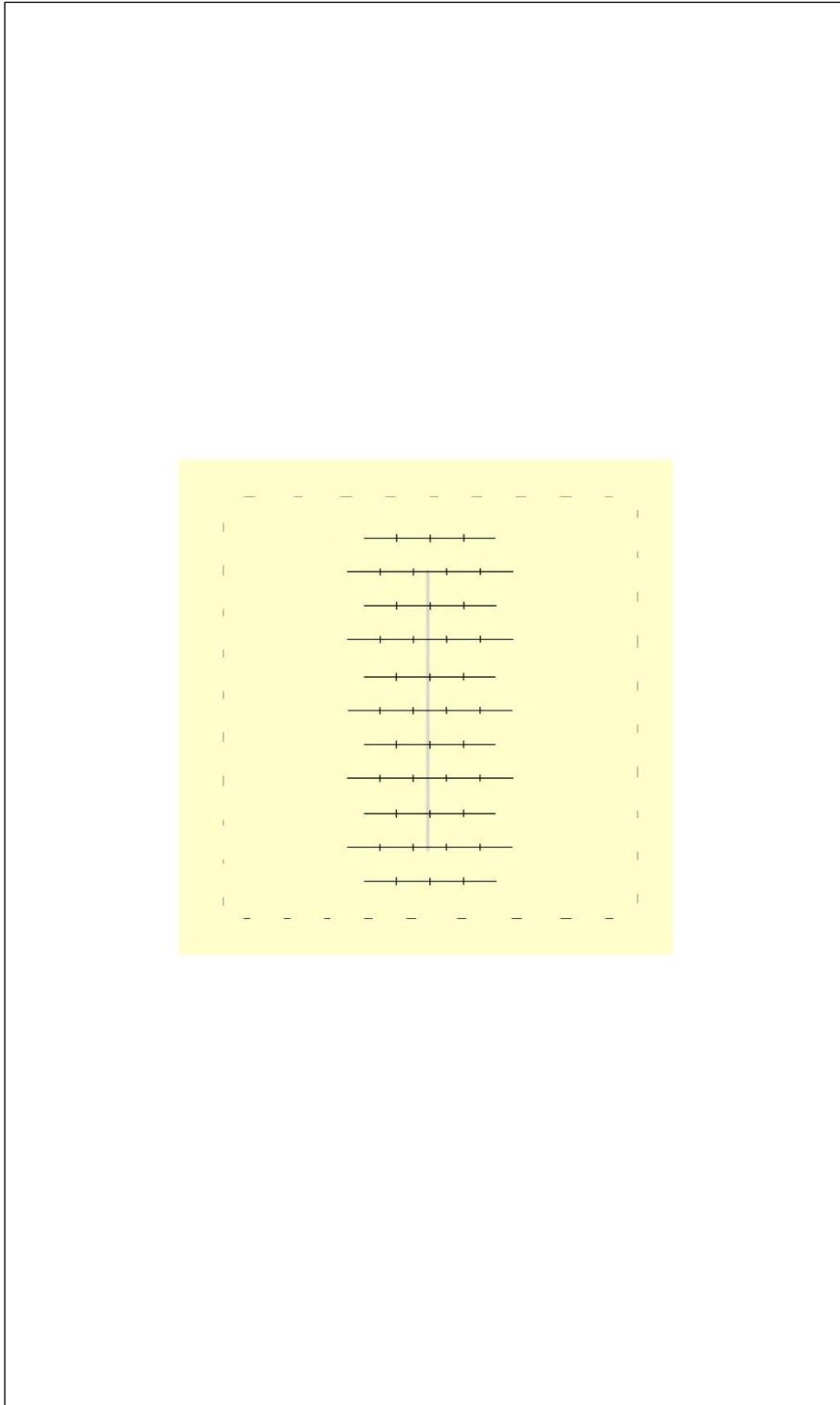
*Figure 30. Specimen with horizontal tear secured with 30/35 mm lines of laid couching.  
Illustration: Marie Schön*



*Figure 31. Specimen with horizontal tear secured with 20/25 mm lines of brick couching.  
Illustration: Marie Schön*

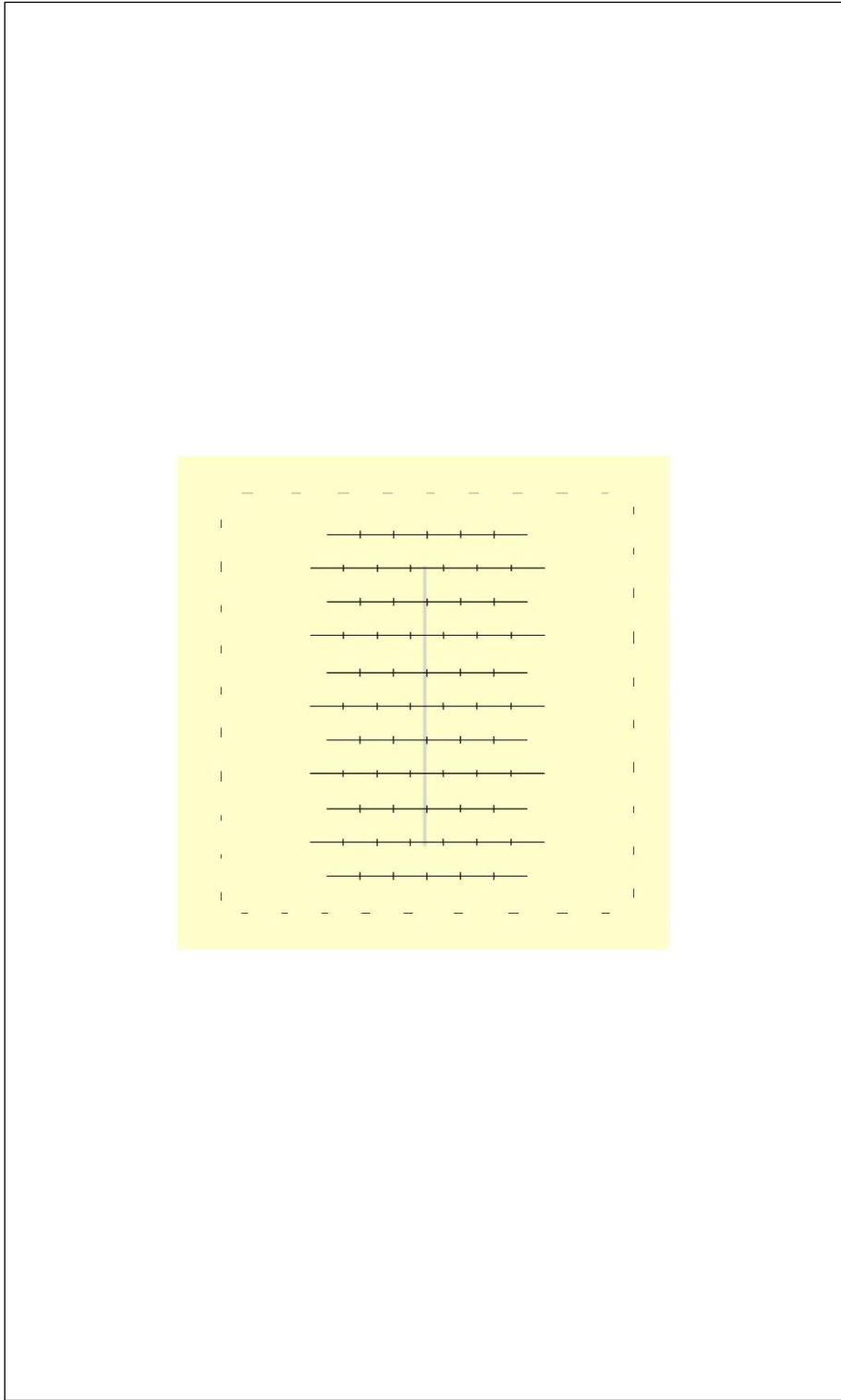


*Figure 32. Specimen with horizontal tear secured with 30/35 mm lines of brick couching.  
Illustration: Marie Schön*

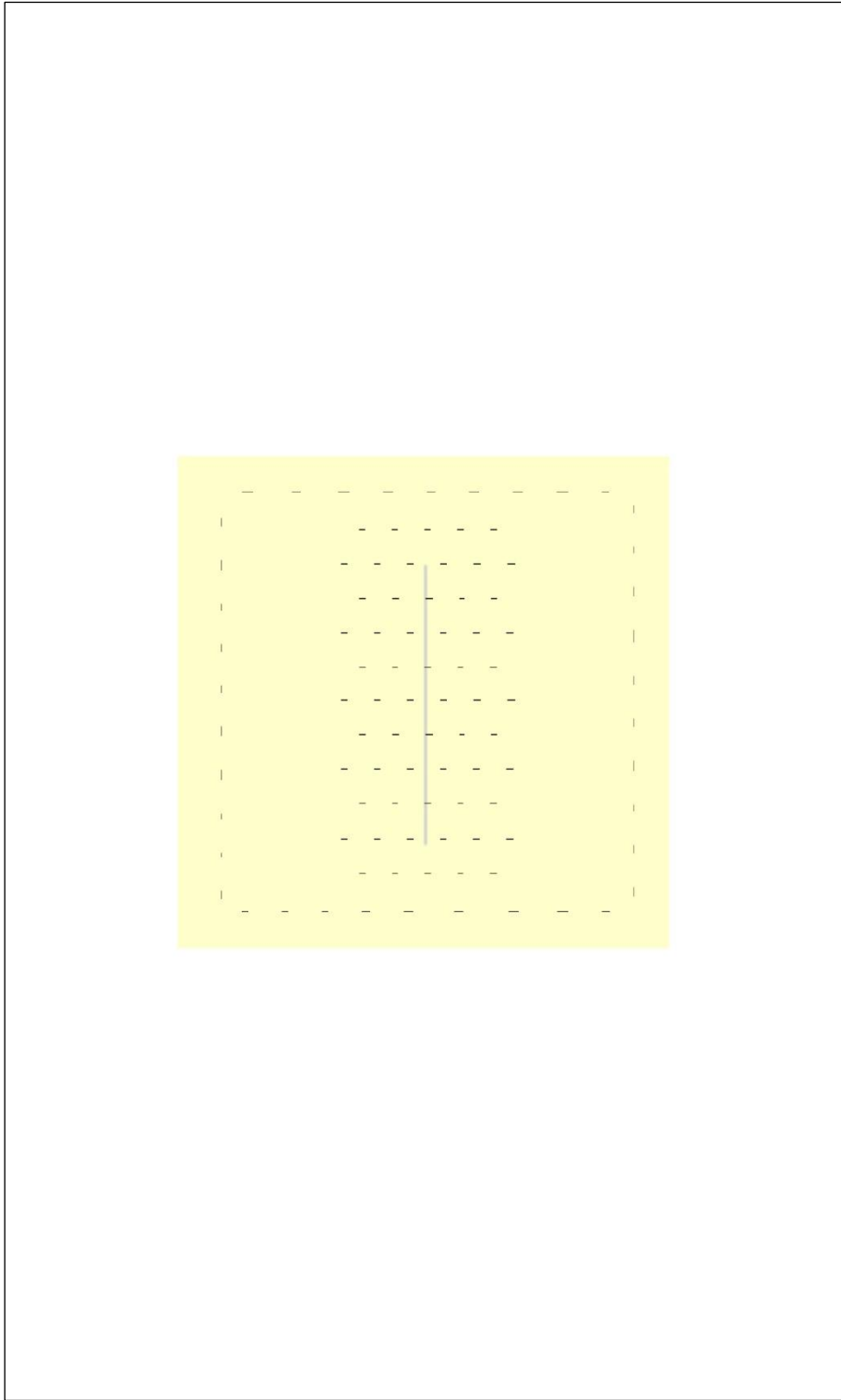


*Figure 33. Specimen with vertical tear secured with 20/25 mm lines of laid couching.  
Illustration: Marie Schön*

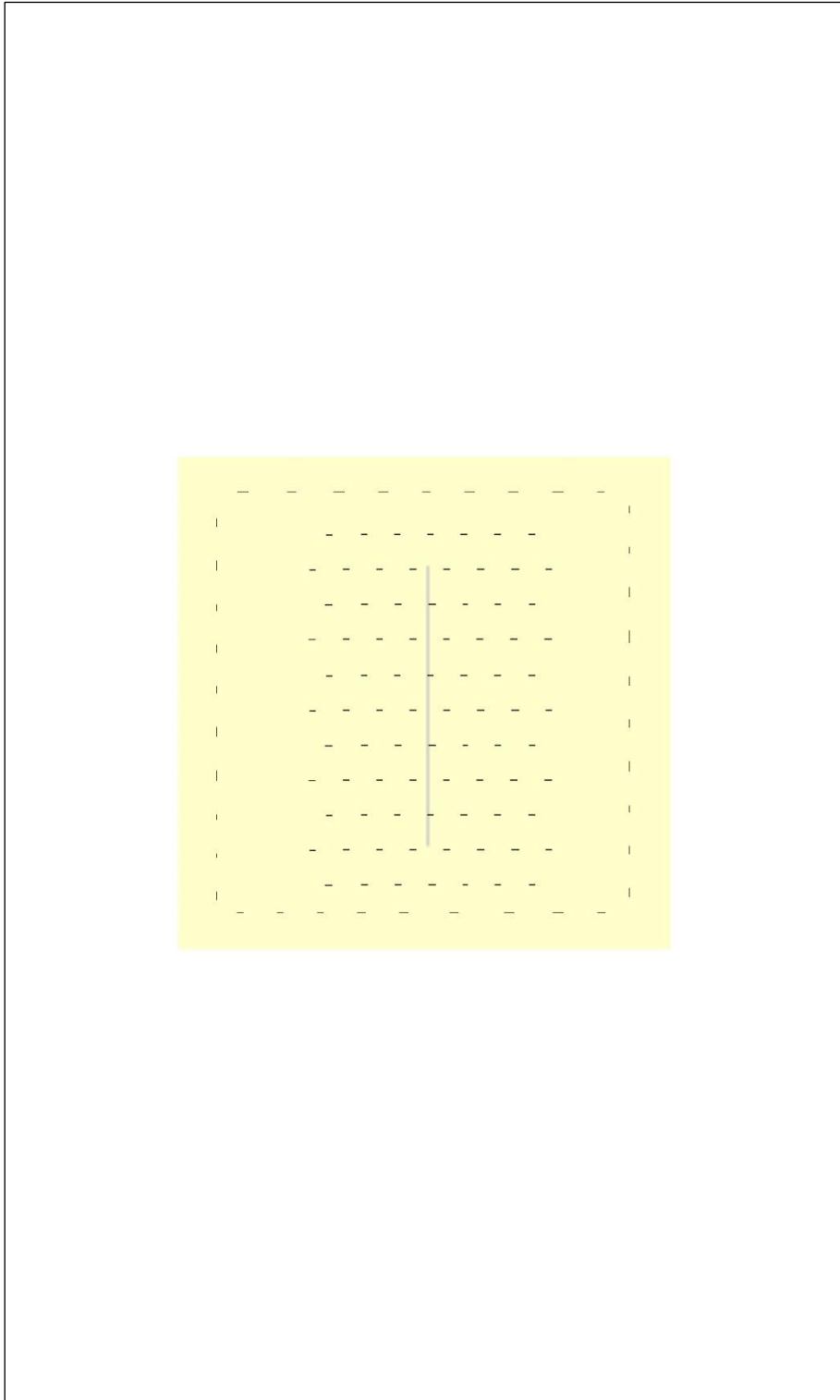




*Figure 34. Specimen with vertical tear secured with 30/35 mm lines of laid couching.  
Illustration: Marie Schön*



*Figure 35. Specimen with vertical tear secured with 20/25 mm lines of brick couching.  
Illustration: Marie Schön*



*Figure 36. Specimen with vertical tear secured with 30/35 mm lines of brick couching.  
Illustration: Marie Schön*

# Appendix 4. Temperature and relative humidity graph

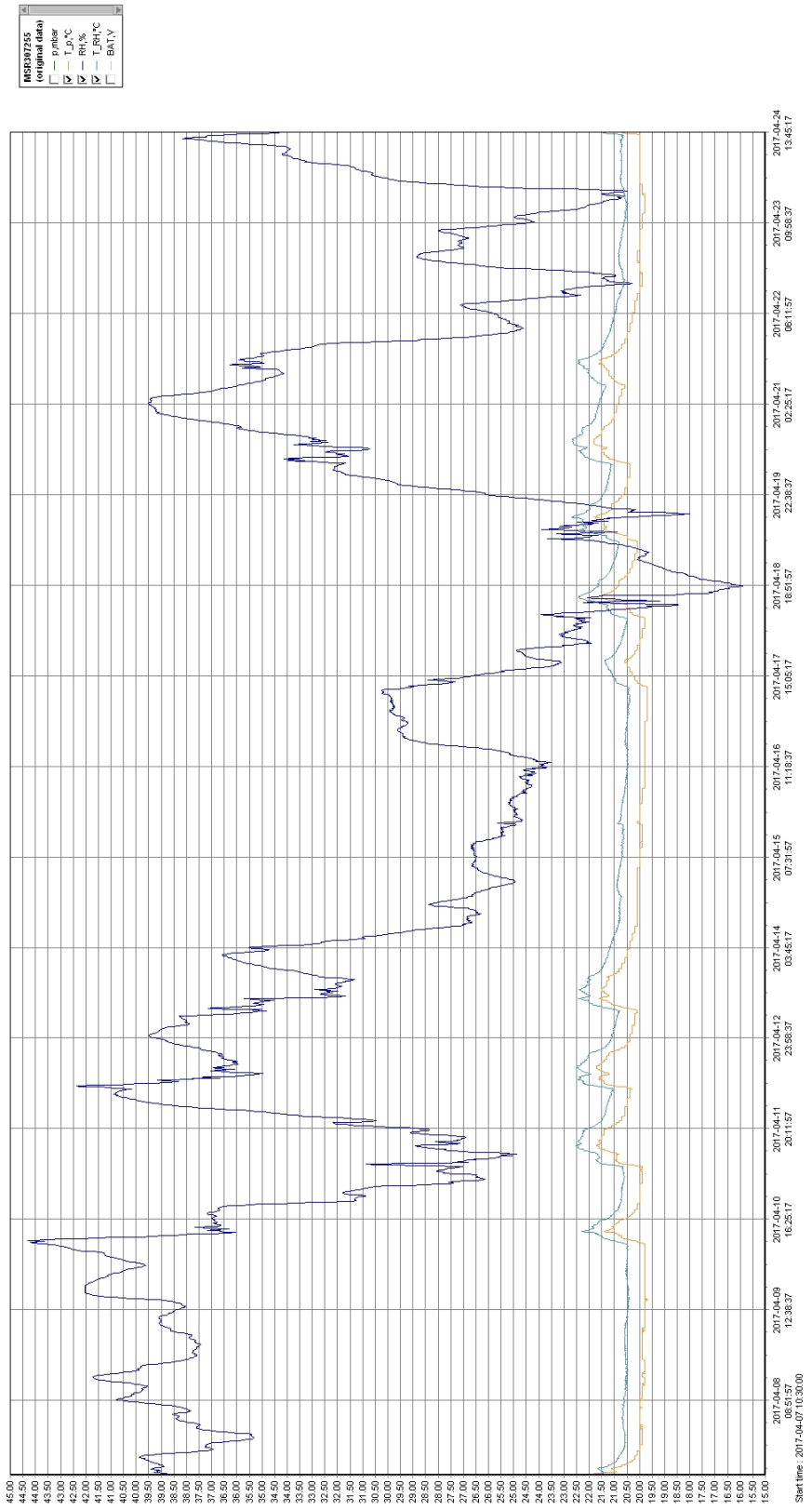


Figure 37. Graph showing temperature and humidity in the room for the fixed-load test. Blue line showing RH and turquoise line showing temperature

