Dealing with a cradled panel painting

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1. Introduction

Historical approach to the panel panting structural conservation was following: a panel painting must be flat. Nineteenth century restorers did not take under consideration the fact that dimensional changes of a wooden panel are natural process and there is nothing wrong with the phenomena when the panel painting is getting convex until it does not cause significant damages in a paint layer. Therefore, numerous of panel paintings, were brutally thinned and flatten by means of a strong, rigid auxiliary support mounted onto the back of the panel.

These system, called cradles and being kind of a stiff heavy grid consists of vertical and horizontal battens caused frequently inconceivable damages to the panting structure. Nowadays, more restrained approach to the panel structural conservation is taken and cradlings are not applied anymore. However, problem with great amount of deteriorated panel paintings have been under heavy cradle for decades is current and important issue in the 20th and 21st centuries discussion about the panel painting conservation-restoration.

The following paper takes a closer look on disadvantages of using traditional cradling and problems that the system causes, as well as considers several attempts that have been undertaken to improve it basing on literature research. To understand problem better three test panels with various types of auxiliary panel constructions were prepared and analyzed. Obtained knowledge allowed to carry out the conservation of a 17th century Flemish panel panting with blocked cradling.

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2. Different approaches to a warped panel painting

2.1. Why does a wooden panel warp?

Dimensional changes and warping of a wooden panel in response to fluctuations of relative humidity is its characteristic feature arising from anisotropic and hydroscopic nature of wood. A single board exhibits different percentage of swelling and shrinkage as well as various deformations depending on numerous factors such as: a plane of the board (tangential or radial), its thickness, the area in the tree trunk the board was cut off, wood species, wood abnormalities and failures, amount and gradients of moisture content, mechanical stress, etc. Figure 1 shows how the single board shrinks and warps within drying process\(^1\).

![Figure 1. Seasoning distortion and four principal ways of board warping (KOS Nico, VAN DUIN Paul, *The conservation of panel paintings and related objects*, The Getty Foundation, 2014, p.34.)](image)

In case of a panel painting differences in distortion and warping are even larger because of one-sided moisture barrier produced by the ground and the paint film as well as the fact, that the panel painting is often restrained in its cross-grain direction with a tightly fitting frame or/and an auxiliary support attached to the reverse. Uneven moisture exchange between front of the panel being relatively unaffected by humidity changes and uncoated back easily responding to these fluctuations, results in panel curvature that is convex to the paint layer. Additionally, the wood at the back may undergo compression set, which is a plastic deformation caused by blocked panel expansion and contraction. As a result, wood cells compress and deform, creating irreversible curvature. At the worst, accumulated tension leads to splitting of the panel structure, loosing joins and detaching paint and ground layers from the support\(^2\).

2.2. Historical approach – cradling

Swelling, shrinkage and warping in response to changes in moisture contents, is therefore a typical phenomena for the panel paintings. On the other hand, it may

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cause damages of the painting and decreases aesthetic values of the image. In early
panel conservation treatment, it was the most important goal to maintain the panel flat.
It was achieved but moisturizing and/or thinning the panel, making the wood more
rapidly responsive to atmospheric variation. To keep the panel straightened the cradles
were applied while the panel was loaded. The principle of cradling dates back to at
least 1770, when Rubens's _La Kermesse_, in the Louvre, was cradled by L. Hacqui³.

Cradling is a type of secondary support applied onto the back of the panel,
consists of vertical and horizontal wooden perpendicular battens creating kind of a grid.
Those members that run along grain direction are permanently fixed to the panel,
glued, nailed or screwed. Sometimes they are attached in that way to reinforce joins,
damages, and splits. Glued members have slots into which sliding crossbars are
inserted. Sliding battens hold the panel in a flat plane and provide rigidity for the
complete structure, while allowing cross-grain expansion and contraction⁴. In extreme
cases and until the end of eighteenth century, both battens, vertical and horizontal,
were fixed to the panel restraining all movement⁵.

This system enables merely minimal warping of the panel and only before battens
are blocked, preventing further movement and increasing inner tension. Many
cradlings have locked up because of inadequate clearance, poor construction or
excessive use of glue in assembly. Additionally, the system causes unequal
distribution of tension in panel's structure. The exposed area of the panel not covered
with the cradles are free to warp, whereas overlying areas of the panel are more stable,
more rigid, stronger and less hygroscopic than the unsupported area. Therefore,
greater stress and tension transition occur close to glued members (Figure 2a), what
results in splits along glued cradles (Figure 2b), "washboard effect" (Figure 2c) and
blistering and flaking of the ground and the paint film⁶.

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2.3. Current approach

In the mid-twentieth century drawbacks of the rigid cradles to the natural flexibility of panels began to be better understood. It was finally clear that these restrainers, although holding panels in place, do not hinder their need to expand and contract. It became obvious that materials that are used for battens must be stable and unaffected by environmental fluctuations. Additionally, fixed or glued areas should be limited, since they introduce extra tension, especially in case of hide glue which is hygroscopic and reacts to moisture contents fluctuations as well.

Due to wide variations in the structure and behaviour of wood, it is difficult to predict the response of the panel painting, particularly to conservation treatments. Therefore, the modern approach to the panel structural conservation have become less invasive, and today the rule is to allow the panel for the cross-grain movement and the out-of-plane deformation as well as to manipulate the original surface as little as possible. At the same time, the goal is still to exert a certain amount of restraint to keep the panel from the dangerous deformation. Nowadays more flexible systems consists of smaller members in more suitable and lighter shapes and materials are used. Previous cradled panel are treated differently (modified or removed) depending on the painting and the cradling condition.

In addition, as the deformation of wooden panels largely depends on ambient humidity, more attentions is paid to the preventive conservation. Issues of climate control, appropriate framing and storage are crucial in providing stability and restraining the panel painting from deterioration. In museums, where air conditioning systems enable the control of humidity and temperature within set parameters (20°C and 55% RH for easel paintings) and professional care is guaranteed, a danger arising from panel dimensional changes and warping is reduced. However, many artworks are housed in historic buildings, churches and private home with no climate control and even increased temperature and relative humidity fluctuations due to central heating and venting. Therefore, destination, future ambient humidity, type of framing, possibility of transporting must be taken under consideration within design of auxiliary panel supports.

2.3.1. Italian crossbars systems in the 20th century

The most common construction employing in Italy since early 1950 is the system consists of wooden trapezoidal crossbars and pegs. Two rows of glued pegs create a dovetail track for a sliding crossbar. All elements must be carefully plain and sand.

To prevent from excessive friction two side edges of bars and the face of pegs are coated with hot paraffin and then polished. Distribution of pegs should be regular, creating as equal rows as possible. However, irregularities and failures of the panel often cause that spaces must be fitted individually. Pegs can be attached by means of hide glue, PVAc glue which is more elastic or Araldite®, when the uneven surface of the panel must be compensate by resin\(^\text{12}\). Crossbars and pegs of the early 1950s were much heavier and wider, and sometimes even screwed onto panel, locally blocking the movement. Over time, they have become narrower, lighter and thus, more flexible\(^\text{13}\).

The system allows for swelling and shrinkage of the panel, while imposing some amount of restraint. It was investigated to followed traditional preferences for stiff constraints but attempting to improve damaging character of the overly rigid cradling. Using an engineering formula, crossbars were modified. It is known that doubling the thickness of a beam enhances its stiffness eight times. To reduce material and make battens smaller in width keeping the same tension, the height of battens should be increased. Thus, trapezoidal shape of battens was obtained which also allows their easier attachment with small pegs. Small faces of pegs minimalize friction against the bars and therefore do not block them. Additionally, if any tension in the panel increase, they rather delaminate than cause that the panel splits\(^\text{14}\).

This cross-grain batten support is applied only to the panel that had previously been thinned or cradling. It would not be used when the panel retained its original surface since the support is noticeable aesthetic intrusion. Besides the system with wooden bars and pegs, there are different variation of this type of construction\(^\text{15}\).

Besides wooden pegs, various metal screws and bolts can be used as a less invasive crossbars attachment. Application of springs has become more and more common as well. Adding some form of spring action to the construction of crossbars facilitates panel warping. The spring can be inserted into slots cut out in crossbars, in small blocks that hold bars, or into a strainer that is constructed around the panel. Easier and more effective solution is mounting the panel into its frame with steel springs\(^\text{16}\).

Instead of wooden crossbars, metal “T” section bars may be applied and hold by small wooden cleats. Aluminium, as very flexible material is usually used. Bars stiffness is varied by thickness of bar tongue and numerous of fixed point. Attachment may be done with glue or the system of screws and springs that adjust to the panel curvature. Blocks may be shaped differently and made of the same type of wood as the panel or of balsa wood that has very low density and therefore greater stability. Another type of construction applies mahogany crossbars with U-shaped metallic bands inserted into both sides. Wooden cleats that are glued to the panel have

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\(^{13}\) Ibid., p. 310.
\(^{15}\) Ibid., pp. 351-352.
\(^{16}\) Ibid., p. 311.
attached Teflon or brass rollers which slide within the metal track and ensure free movement of the crossbars\textsuperscript{17}.

There are also numerous other examples of various use of crossbars system in history of the structural conservation of panels. Differences arise from history of conservation in distinct countries, individual problems of each panel, and perceiving ethical issues\textsuperscript{18}. Many of panel paintings that were treated with crossbars systems have not displayed any further damages. However, the implementation of the construction always carries a risk. Restraint that a crossbar should put upon a panel has always been difficult to judge or predict. Excessive restraint may block movement and facilitates split formation, while too little restraint can allow for too high level of deformation\textsuperscript{19}. Therefore, investigation of more flexible, dynamic and safe auxiliary panel support should be one of the most important issue within a future development in the structural panel conservation. Solutions offered by Bobak and Marchand seem to be a milestone in that field. These systems are characterized in next section.

### 2.3.2. Flexible auxiliary supports

The goal of flexible systems is to allow for movement in all directions of the panel instead of eliminating warping and to provide minimal of restraint and physical attachment to the original\textsuperscript{20}. The most disruptive thing about this construction is totally new shape and low thickness of the cross-grain battens.

The uniform rectangular-section batten has greater straightening effect on the surface toward the outer edges. To avoid the problem, the battens should be made gradually weaker toward the ends. This can be obtained by reducing the thickness or the width of the battens. As the second solution is easier to produce because of flat section, the tapered battens are used in this system. The lattices are made of Sitka spruce - light, strong timber with desirable high value of Young’s modulus (providing proper flexibility), that can be obtained in large, straight-grained, knot-free sections\textsuperscript{21}.

Number, thickness and width of battens may be simply calculated with using adequate formulas to prevent the panel from excessive load. However, in case of an old and fragile panels it is always more problematic to predict the resistance to bending that the weak panel will withstand before it fails. Therefore, considerable skills and experience is required in distribution of particular members of the system. Battens are linked together with thin, flat timber strips and kept in contact with the panel thanks to another narrow wooden lattices usually attached to the panel with small balsa blocks\textsuperscript{22}.

\textsuperscript{19} Ibid., p. 55.
\textsuperscript{22} Ibid., pp. 388-392.
The system can be reinforced with flexible back springs consists of thin horizontal wooden battens attached perpendicularly to the central bar, joined with the frame. The construction presses gently against the panel and encourages return movement of the panel equally. Endings of the battens that contact with the panel are equipped with balsa-foam-balsa pads, allowing them to adjust to changes in the curvature. The construction may be covered with a backboard which together with the central bar take the springs pressure and acts as an environmental barrier. If the panel is self-supporting the back springs can be also employed as an independent, unattached secondary support²³.

The construction of these auxiliary supports can be modified to suit the structural condition of each panel. Easily may be fitted into a panel tray or an adapted display frames. Additionally, in contrast to traditional cradles, the system can be quickly disassembled. All these advantages combined with great flexibility of the system and its aesthetic values result in frequent and effective employing in recent years²⁴.

3. Test panels with various auxiliary panel supports

3.1. The goal

For better understanding relations between dimensional changes and warping of panel paintings, arising from uneven transition of moisture in its inner structure, and ambient humidity and temperature, as well as consequences of restraining the panel movement with a rigid secondary support, three test panel with various auxiliary systems were made. Comparison between traditional cradling, modified crossbars construction and flexible system, and analysis of their influence on the panel painting were the main goal of the test.

For first two systems similar oak panels (approximately 290 x 310 x 8 mm) were employed. They consisted of three nearly quarter sawn planks, attached with tongue-groove joints. Both underwent compression shrinkage as a result of restraining cross-grain expansion by means of clamps while the panel had been moisturizing. Then, both were sized one-sidedly with hide glue and covered with gesso and paint layers. During these actions convex warping of the panels appeared and had kept until the equilibrium moisture content with ambient air was reestablished. In consequence of these interventions the situation similar to that occurring in case of historic panel paintings inserted into tight frames and exposed to humidity fluctuations, has performed. Next step was application of cradling. The third panel was prepared differently and is described below.

3.2. Traditional cradling

3.2.1. Making

As it was mentioned in theoretical section, the cradling consists of glued members ran along grain direction of the panel and sliding crossbars. To prepared glued members, four cross-grain slots, for four sliding crossbars to be inserted, were cut out into an oak board, that then was cut into narrower battens. The oak board had length a few millimeters shorter that the panel. Four slots (27 mm wide and 7 mm deep) were distributed regularly with similar spaces and cut out by means of a router. From the board four battens (28.3 cm long, 1.5 cm high and 1.5 cm wide) and one batten a bit narrower (1.1 cm wide) were obtained. Subsequently, battens were planed and sanded (Figure 3a). Bottom plane of the battens were scratched to enhance gluing (Figure 3b).

Pine crossbars were prepared at identical width and thickens as the slots in glued members to prevent them from falling out. End-grain faces were plain as well. To decrease friction crossbars were sanded, polished and covered with paraffine (Figure 3c) melted with a hot airflow (Figure 3d).

Figure 3. Preparation of battens; vertical member after plaining and sanding (a), fixed areas should be rough to enhance gluing (b); polished crossbars are covered with paraffine (c), which is then melted with a heater (d) (Photos: Paulina Węgrzyn, December 2017)

The panel was clamped to a bench and all battens were distributed on the reverse. The surface of the panel was sanded, and areas of battens attachment were scratched slightly. Then, the vertical members were glued with 50% hide glue (Figure 4a). It was crucial to glue the members in one line ensuring proper insertion of the crossbars (Figure 4b).

Figure 6c shows the final appearance of the cradling in form of a symmetric grid consists of five glued members and four crossbars. Two members were glued near to the edges, next two onto joins to reinforce them, and the last narrower one was fixed in the middle. Here, the tension between the panel and the crossbars is smaller than toward the edges, therefore width of the central batten may be reduced. For fixed members the same timber as for the panel was employed, but for crossbar more flexible pine wood was chosen.
3.2.2. Analysis

The cradling was prepared in a way as it was made from the beginning of the conservation treatment until almost the mid-twenty century. Although, this construction seems to be lighter than many examples we are familiar with, the battens create strong grid acting as tough straightening factor.

The panel, one month after covering with ground and paint layer in stable environmental condition (around 21°C and 50% RH) exhibited curvature being a result of slight convex warping and deformation arising from grow-rings arrangement. After cradling, the panel kept in the same ambient conditions became straighter. Next, the panel was left for one night on a heater in a room with very low relative humidity. After that it warped subtly returning to its previous curvature. The maximum amplitude of curvature measured 3 mm. However, this time, one small crack appeared next to a join. Moreover, previous quite loose crossbars became much harder to move. It testifies that the pressure that crossbars put against warping panel, while it is blocking with rigid cradles, is significant.

Additionally, areas cover with cradles are more than twice as thick as a panel. It causes uneven exchange of moisture between exposed and overlaid parts. After long-term humidity fluctuations, tension accumulated along perimeter of the cradles will surely impact a deformation and even splits in these areas of the panel.

Figure 4. Views of the cradled panel; without sliding crossbars (a), with sliding crossbars (b), overall view (c) (Photos: Paulina Węgrzyn, December 2017)
3.3. The system with trapezoidal battens and pegs

3.3.1. Making

The system consists of cross-grain trapezoidal battens held by small wooden pegs attached along panel grain direction. All elements were cut mechanically at the small angle in oak timber (Figure 5). Small pegs were approximately 2 x 1.3 x 1.3 cm. Battens were 1.6 cm wide and 1.5 thick. Length of the crossbars measures 29 cm, 2 cm shorter than width of the panel, as the panel may shrink around 5%.

![Figure 5. Trapezoidal crossbars and lozenge-section pegs for the system (Photo: Paulina Węgrzyn, November 2017)](image)

Every surface of the bars was sanded and polished. Crossbars end-grain edges being in contact with the panel were round off. It prevents battens from stuck in the panel if it starts to warp. To reduce friction melted paraffine was applied onto both sides of the crossbars and faces of the pegs. The panel was fixed to the working bench with clamps. All members were then adjusted, locked and the pegs were glued with 50% hide glue. Each row of pegs was distributed differently to investigate its impact on panel structure. Figure 6 shows the panel with the system.

![Figure 6. Overall view of the system with various distribution of wooden pegs (Photo: Paulina Węgrzyn, November 2017)](image)
3.3.2. Analysis

This time, shape of the crossbars as well as used timber were different. Therefore, at first sight these sliding battens seems weaker that those applied for the cradling. However, their doubled thickness and use of oak, that is stronger and less flexible wood than pine, cause that tension against the panel produced by this type of crossbars is comparable to tension put by rectangular cradles.

In this system tension given by crossbars can be modified by number of pegs that attach the crossbars to the panel surface. To understand better differences in relation between numbers of blocks and level of tension that they implicate together with crossbars, three different arrangement of pegs were employed. The greater amount of pegs is applied the firmer they fix the crossbars and decrease their flexibility. Additionally, the greater the number of blocks, the less tension each had to bear individually, therefore in case of extended warping they will not be easily delaminated. In some system this fact may be an advantage, however Figure 6 shows that here, application of numerous pegs (the first row) results in splits along a join.

![Figure 7. Splits caused by excessive number of block](Photo: Paulina Węgrzyn, November 2017)

The first and the second row of the pegs are too heavy for that panel. Moreover, overgenerous use of glue makes attachment highly fixed and blemishes panel appearance. The third solution seems to be the best one. This arrangement of blocks holds the crossbar solidly, allowing for its greater flexibility, and reinforces the joins. Any splits have not been observed.

3.4. Flexible auxiliary support

3.4.1. Making

Third construction was simplified variation of Marchant’s system. One central oak bar with three slots (50 mm wide and 2.8 mm deep) for three battens was prepared. It intended to be not glued to the panel but joined with a frame surrounding the panel, therefore length of the central bar was extended than length of the panel. Width of the bar measured 4.7 cm, thickness 1.5 cm. Three thin spindle-shaped battens, 35.4 cm...
long and 5 cm wide (in the widest point), were glued to the bar in central spots. Their thickness had to be identical as the slots to ensure precise adherence with the panel surface. They were cut mechanically in ash timber being strong but flexible wood species.

The panel was a single pine board cut radially from the central tree stem. It underwent compression shrinkage, however was not coated with paint layer. The panel measured 35.7 x 33.6 x 1 cm. It was warped convex slightly. Deflection measured 1.9 mm.

3.4.2. Analysis

The construction is a dynamic system that adjust to three-dimensional changes of the panel, while stabilizing its structure, weakened within centuries of damaging factors activity. Thin spindle-shaped battens provide flexibility that allows panel to swell, shrink and warp considerably. Lack of glued members eliminates tension between panel and glue, and panel and glued batten in response to humidity fluctuations, which is often reason of panel cracking.

Shape of the battens provide equal forces spreading. Their tension against the panel can be modified by number of battens, by their width, thickness or by use flexible pads attached to the ends of battens. Appropriate tension may be calculated quite precisely or estimate empirically by gradual loading of the central bar. Metal clamps, lead weights or a dynamometer can be employed for that purpose. If applied load is properly fitted, a risk of panel failures or its overscale curvature changes are minimal, even when climate conditions are unstable. Moreover, reversibility, lightness and aesthetic values are significant advantages of the construction.
3.5. Conclusion

The primary goal in the restoring of panel paintings is to renew the functionality of the structural support and to improve stability (with resulting benefits for ground and paint layers). As every intervention to the wooden support may cause dangerous and difficult to control tension and deformations, employed methods must feature of minimal invasiveness.

Prepared test panels let to understand better damaging character of traditional cradles and rigid crossbars system as well as to analyze a huge shift in an approach to the panel painting structural conservation. First two constructions do not fulfil their function as safe and stable auxiliary support. Their great stiffness impact on deterioration of panel structure, ground and paint layer. Therefore, the system including these types of crossbars should not be put into conservation practice.

New system proposed by Marchant and Bobak is a dynamic one. It allows the panel to swell, shrink and warp freely while supporting fragile panel by pushing it against. That tension can be calculated, therefore, there is little danger that the construction will be too strong and make panel split. However, look on the conservation practice should always be critical and many-sided. Despite of numerous advantages of the system, further researches on its improving or finding new solutions should be carry on.

4. The structural conservation of a cradled panel painting

4.1. Object of the treatment

The aim of this section is description of structural conservation treatments of the 17th century oil painting on wooden cradled panel by Jan Thomas van Ieperen, a Flemish Baroque painter active in Antwerp and in Vienna. He is known for numerous portraits of Austrian rulers and pastoral, religious and mythologic scenes painted in the after-Rubens-style.

The painting depicts goddess Diana in the forest in company of several women and surrounded by hunting dogs and game. The nude lying goddess is identified by the crescent moon in her hair and bow and quiver at her said.

The painting is pained in oil technique on white ground, probably consists of chalk, hide glue, perhaps oil as well. The panel consists of two oak planks, glued horizontally with butt join with two dowels (one is missed). Perpendicular growth rings visible on end-grain surface signify quarter sawing. Parallel regular saw marks indicate that planks were sawn in a sawmill. Panel measures 50.9 cm wide and 34.3 cm high. It thickness is varied from 8.9 mm to 10 mm.

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*Photo 9.* The front side of the painting (Photo: Paulina Węgrzyn, December 2017)

*Photo 10.* The back side of the painting (Photo: Paulina Węgrzyn, December 2017)
Probably in the 19th century the panel was partially thinned and rigid pine cradles were applied. The purpose was to keep the painting flat when it started to warp. The cradling consists of four glued members attached horizontally along grain direction and five sliding battens, which in result of accumulated dirt had blocked and have not been movable anymore.

Areas of cradling members attachment were carved out. This is interesting infrequent example of the cradles application. Usually panel is thinned and planed evenly over the whole surface. Perhaps, the purpose was to reduce overall thickness of the cradled panel without removal of too much original substance. Glued members measure 50.9 cm long; 2 cm thick but thickness decrease toward edges, width varies from 3 to 3.3 cm. Sliding battens are 34.4 cm long, 3.5 cm wide, 1 cm thick. Used timber has very bad quality, includes resin spillages and a few knots which distinct arrangement of growth rings introducing irregularity and extra tension within wood structure. The cradling is poorly finished and fixed with an overgenerous amount of hide glue that leaked onto sliding crossbars tracks.

General condition of the oil painting would be good if the cradles had not been applied. The ground and the paint film are cohesive despite of network of craquelures, a few lacunae appeared along edges. Unfortunately, there are five serious cracks across the panel, ground and painting layer. Splits were caused by heavy and rigid cradles which have blocked three-dimensional movement of the panel, as a response to fluctuations of relative humidity. Moreover, the panel was probably restrained by the frame from its four edges. All these factors applied great tension onto the panel and common the “washboard effect” has performed. Cracks in the panel structure go along edges of glued members. Figure 11 shows their extent. Additionally, because of accumulated dirt, aging of wooden material and stains of glue sliding battens are blocked. It may cause further deterioration of the panel painting.

![Figure 11. Graphic documentation of cracks on the painting surface](Graphic: Paulina Węgrzyn, December 2017)
4.2. Literature research

The main goal of structural conservation of panel painting is to give the panel ample room to move while at the same time exerting a certain amount of restraint to keep them from deforming. In the treatment of a previous cradled panel, intervention is necessary when: the original crossbars have been lost (causing warpage), the panel has previously been thinned, splits have caused loss of color or panels have cracked apart26.

Type and extent of treatment depend on scale of damages caused by a cradling. Some thinned and cradled panels, even when “washboard effect” occurred, exhibit stable condition and no sign of further deterioration. In that case to restore function of the cradles, following intervention may be undertaken: removing and sanding the sliding battens to achieve a looser fit; reducing the thickness of the battens to increase their flexibility; application self-adhesive Teflon PTFE tape onto the sliding crossbars to reduce friction; construction of shaped slips for the frame that follow the panel profile, employing new frame with space for some change in panel curvature; stabilization of panel by means of as microclimate boxes, glazing, and backboards; climate control of ambient environment27.

However, when mentioned treatment do not enhance panel condition or cradles hinder structural conservation and restoration of aesthetic values of the painting, decision on cradling removal may be taken. It is risky process that can bring unpredictable changes in the panel curvature, therefore special care, patience and experience are required. Firstly, the removal of the sliding battens is performed, and it often triggers an immediate increase in curvature. Secondly, glued members are remove to a veneer thickness. This action rather does not alter curvature, only use of different mediums for removal of wood residue and animal glue may result in some slight distortion28.

To increase safety of the intervention panel may be humidified for several days in 65-70% RH and special bed following the panel curvature may be prepared. It is important to determine in advance a way that battens will be removed to avoid increase the stress locally while reducing it in another area. During process as well as after removal, movement of the panel and any traces of further deterioration must be monitored. It can take some days for the panel to reach an initial equilibrium. After cradle removal, rejoining, and consolidation of any damaged areas, the panel may be self-supporting or demand application of more flexible secondary support or other solution responding for certain problem29.

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27 Ibid., pp. 373-37.
28 Ibid., pp. 373-374.
29 Ibid.
4.3. Conservation design

The main goal of the conservation of the 17th century painting by Jan van Ieperen is to prevent it from further deterioration. The most damaging factor is rigid, heavy and poorly done cradling with blocked sliding battens that completely restrain the panel from reaction to changing humidity and cause great tension within panel structure. Therefore, some interventions must be undertaken to reduce harmful character of the cradling. A few solutions may be implemented.

The first idea was to remove the battens one by one, clean, sand them and place back into cradling slots. First attempt was performed with use of clamping bars. Figure 12 shows the way of removal of the first batten. The removed batten could be then sanded and placed back, and the treatment could be repeated with other battens. However, this action caused that part of tension realised, panel boards dislocated slightly and as a result small piece of ground with the paint film felt off from the edge. It emerged that this method is not entire safe for the painting. Moreover, it still had not solved the problem of too heavy cradling. We cannot be sure, whether the cracks are result of the cradling or only blocked battens. It is possible, that restoring of battens movements would be enough and stop further deterioration. However, total removal of the cradling was considered afterwards. Arguments for that treatment are following.

![Figure 12. Removal of first sliding batten by means of clamping bars](Photo: Paulina Węgrzyn, December 2017)

It is difficult to measure the tension that the cradling put on the panel. However, we can estimate that cradles include too many and too thick elements as for that small painting. It is obvious that cradling has damaged the panel structure, what result in ground and painting layer deterioration. Additionally, cracks cause that the painting surface is uneven and deformed, and individual panel parts may dislocate slightly. Therefore, all cracks should be rejoined. Most of them are covered with the cradles what would restrict rejoining. The panel also shows good condition and proper
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thickness that provide resilience and self-supporting properties. Against the cradling removal can stand its historical value. Cradles are example of the nineteenth-century approach to the structural panel conservation. However, necessity of their preservation is decreased by bad quality and appearance of the cradling.

Taking to the consideration above arguments the decision about cradling removal was taken. The ideal situation is to remove the cradling safely with respect to all elements and preserve them as a witness of a historical intervention. This would require the interests of the owner to storage the cradling with the painting. In this case it is not considered. Additionally, safe removal of the cradling, both for the painting and for the cradles, is impossible. Battens are placed in the grooves what hinder the access to the bottom of the glued members. Removing them by transforming hardly accessible glue to a gel in nearly impracticable. Therefore, this ideal situation is impossible to perform. Cradles must be removed mechanically by cutting them off piece by piece. Instead, decent photographic documentation of the cradling must be performed.

The removal process is described below. During the treatment, proper measurement and photographic documentation has been doing to control dimensional changes of the panel and appearing damages such as splits separation. After cradling removal, it may be considered to fill in all gaps with balsa wood or oak with similar properties and in compatible grain direction. In this case, it was decided to leave the back of the panel in exiting condition. However, further observation is required. Within a few next years nothing bad would happen, however after tens of years uneven level of the wood substance and unequal moisture exchange may likely result in deformation of the painting surface.

After treatment, general condition of the painting was good. All cracks were rejoined and panel was able to handle his own weight. Therefore, any auxiliary support and construction to improve the panel stability did not have to be applied. Attachment of the central bar, connected with frame that put little tension against the panel (similar to that employed in third test panel) was consider. However, in case of small size of painting, common spring retaining clips attached to the frame in the middle of painting height may fulfil similar function as a central bar. Two another weaker clips may be added on both sides of the central clip. Restraining of the upper and bottom edges of the painting should be avoided, as these parts warp the most. Probably application of the unattached secondary support together with proper frame is the most sophisticated solution, however in this case framing clips in their simplicity and quick use are effective method as well.

4.4. Implementation

The first step in the conservation practice was photographic documentation of the painting and analysis of its condition based on precise measurement. Documentation was continued during cradling removal. Having information about progressive dimensional changes and any appeared damages ensures safer and more controlled intervention.
The cradling removal must be carried out in possible safest way. For that, the painting was clamped and stabilized on a working table. Firstly, the sliding battens were removed. The method with clamping bars failed, therefore, the pieces of glued members that held the battens in grooves were simply cut out releasing the crossbars (Figure 13). To release tension gradually, sliding battens should be remove symmetrically, starting from outer. Azebiki Deluxe Saw 90, a type of Japanese saw with very sharp and fine teeth for cutting across and along grain was employed.

![Figure 13. Mechanical removal of the cradling - releasing sliding battens (Photo: Paulina Węgrzyn, December 2017)](image)

Ungluing the glued members by transforming glue to a gel was impossible. Jemmying the single block with a hot spatula to soften glue failed. The access was too little. Therefore, cutting battens into pieces and further removing with one-hand Yarri-Kanna carving tool was applied (Figure 15). Special care was taken within the process, because the level of the battens was lower than level of surrounding original panel. Despite pine in not too hard wood, the action was tough. Areas with knots were the most troublesome, because of higher density of wood.

![Figure 14. Mechanical removal of the glued members (Photos: Paulina Węgrzyn, December 2017)](image)

During cradles removal the panel was exposed on dangerous movement. Therefore, rejoining the cracks was crucial for safety of further intervention. PVAc glue
Holzleim Express by UHU® dissolved in water was injected into splits. Next, the panel was clamped, loaded and left for one day.

During the treatment, changing the curvature and the painting condition was controlled and noted. A few phases of changes in the panel curvature were observed. Only after a few minutes since the panel was released from sliding battens the curvature changed. Gradually, the panel was transforming from the “washboarding” deformation to the cup distortion. This common situation is described by Bobak\textsuperscript{30} and shown at Figure 16. Panel profile rose 2.8 mm after removing sliding battens, and next 1 mm after glued members removal. Some splits became wider, so had to be rejoined once again afterwards. Besides, no more damages appeared, the panel condition was stable, so treatment could be proceeded.

The most part of the cradles was already removed. However, wood residues and glue crust still left. Mechanical removal was hard to carry out safely. Using water to dissolve glue was eliminated as well. Therefore, method with a gel application was employed. Laponite RD by Kremer Pigmente dissolved in water was used for that purpose. Water retained in thick structure of gel acts on the surface that gel is in contact, but does not penetrate material. Therefore, it is very effective and safe cleaning method, especially in wooden objects treatment. Gel softened glue, that was then easily removed from the panel surface with a spatula. Other solution substituted the aqueous method is use of a spatula warmed up with a heater to soften. However, it is not so effectives and more time-consuming.

*Figure 17. Removing glue and wood residues with a gel (Photo: Paulina Węgrzyn, December 2017)*

Figure 18 shows the result of cradling removal treatment. Further intervention has not been carried by the author of the paper. However, all mention decision was implemented. Subsequently, the ground and the paint film was consolidated and retouched.

*Figure 18. The back of the panel painting after cradling removal (Photo: Paulina Węgrzyn, December 2018)*
5. Conclusion

The paper summarizes several approaches to the structural conservation of panel paintings. Mentioned examples are only small part of historic and current using method, however presented literature research and done test panels allow for better understanding the problem and considering different solutions. Conclusion of that investigation were already mentioned (chapter 3.)

Obtained knowledge and experience were then implemented in the cradled panel painting treatment. Analysis of the relationship between the panel, the cradling and ambient environment as well as critical discussion about possible methods and technique that may be employed for that individual case result in deliberate, careful and effective intervention.
Bibliography


