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Sewing, Adhesion, and Grain Direction in Book Conservation

INTRODUCTION: BOOK STRUCTURES

Book conservators do not look at bindings primarily by their age, provenance, or style, but by the extent of their damages in relation to usability (handling, digitizing, or exhibiting). It is therefore fundamental to classify the features of the book according to their durability for use.

The structure of a book is the way each component is connected to the whole—its skeleton—and affects how the binding functions. It determines the **motion** of the parts during regular use. Book terminology does not clearly communicate these relationships. Nonetheless, conservation requires a deep understanding of structural weaknesses and strengths towards the goal of extending book longevity.

The essence of *bookbinding* is the *binding*, understood as a link between parts. There are two main types of connections for the parts of a book and their contribution to the structure: how folios in a text block are attached together, and how the covers are attached to the text block. As for how folios are attached together in a text block, there are also two main types of connections, for they can only be **sewn** or **adhered**.¹ The materials and techniques used for these areas define how the book moves when handled and can advise against certain handling methods. For instance, tight-back bindings should not be pried open, as the strain on the spine can cause it to break.

Each component plays its role and should not be dismissed (e.g., fastenings, endbands, pastedowns, flaps, and corners) but considered according to their contribution to the structure (and the condition of the book). All in all very few elements are merely decorative: a glimpse on the archaeology of bookbinding shows the extent to which most components are devised to play a specific function. Evolution and improvement of some parts have only pushed others into the background, often involving alternative setbacks. In Szirmai's (1991) words, "*the history of craft bookbinding technique shows*

that improvements have seldom been achieved without concomitant drawbacks."

BOOK STRUCTURES AND CONSERVATION

Conservation should not intend to improve or correct an artifact, but only its condition. Although bindings are innately suitable for their context, conservation often aims to preserve them beyond their intended lifespan. As such, merely preserving each of the materials is commonly not enough for books, as a minimal manipulation is required to access their contents. Weak structures that do not allow for safe handling or involve hazards need to be fixed.

A study of structural weak points and strengths is valuable to set preservation policies and paramount when it comes to conservation. The original structure needs to be understood, the condition of the materials and their damages considered, and finally a conservation treatment that fulfils the book's present needs should be set, with regard to function and available resources.

STRUCTURAL PARAMETERS FOR BOOK DESCRIPTION

Conroy (1987) developed a comprehensive study of the most significant structural elements, which he grouped in linings, sewing supports, and joints. Lining refers to materials applied to the spine, building up layers that affect *tension* and *compression*.

These two terms provide very useful distinctions for structural purposes because they refer to movement and straining (damage) and enable a clear differentiation of the diverse layers gathered in a spine, which are not always that distinguishable—specifically those operating conjointly on a tight back.

The way linings, joints, and sewing supports are connected does explain the motion of a book, but not all books have sewing supports nor any sewing at all (e.g., board books and many albums), and neither are all spines lined. In early medieval long stitch bindings, for instance, the spine consists solely of an unsupported sewing, devoid of any other layers.²

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A structural classification according to types of links (namely sewn or adhered) can be applied to any kind of book, not precluding those that lack spine linings or sewing supports. A general description should not miss describing the main bonds (folio-to-folio and text block-to-covers) as their characteristics and interaction describe the movement of the book. Describing specifically any other damaged part on this basis is certainly most advisable. Ultimately, motion is the most common cause of damage. This can be derived from handling, but other factors involve the swelling and shrinking of connected materials overtime. Age and environment, for instance, also contribute to movement in the book, microscopic and silent, but which can result in the detachment or failure of attachment points.

On the other hand, the same structure can behave diversely according to the nature of each material. As Conroy (1987) points out, “tight-back bindings vary greatly in action according to how much the leather has been pared.” The pliability, thickness, condition, and other features of the bound materials need to be considered accordingly.

SEWING AND PASTING: FEATURING ENDURANCE TO USE

Sewing and adhesion—the primary types of unions between book components³—have unique effects on the behavior of book pliability. It is well known that adhesion stiffens and compacts whereas sewing confers flexibility.

Finding the right balance between sewing and adhering is the key to achieving an enduring and easily handled book, no matter how antagonistic these two concepts might often be. As noted by Clarkson (1975): “Since the 1500’s [...] bookbinders have thought less of the basic sewing structure and placed reliance more on adhesives [...]; having no understanding of the subtlety and nuance of sewing structures.”

Considering the ways in which books are found to be damaged, it can be ascertained that, in moveable book components, sewn attachments tend to endure better than adhered ones. Despite what one may assume, sewing—which requires creating a hole—weakens less than adhesion because it allows motion with no threat to flexibility, even when the conjoined parts behave diversely. Handling and relative humidity compel each material to swell or shrink as they would do on their own, with the only effect on the sewn system to become more or less taut. If tension is not enough to cause breakage, none of them is endangered. The strain is reverted when conditions revert to their initial state with eventual loosening due to repeated use or decay.

Conversely, the addition of glue stiffens materials. Glued materials are more prone to cracking when bent. Porous materials become more compact and less hygroscopic when glued. Strains arise when adhesive is applied only locally because of the dual behavior at the edge: the backed area stretches while

the neighboring zone curls. Thus, adjoining areas are subject to rip along the gap of different docility. Likewise, the edge suffers a major stress under relative humidity variations.

As opposed to sewn unions, the system does not go back to its initial state after releasing strain: either they endure or simply fail (detach, break, rip).

Adhesion strengthens when it comes to static areas (generally within the boards: corners, pastedowns, covers, etc.) but weakens areas that require movement (mainly folios, joints, and spine [fig. 1]; but also fastenings, guards [fig. 5], endbands, etc.).

The fundamental concept has since always been applied and underlies referral recommendations, such as Szirmai’s: “[The ‘quarter-joint’ structure’s] virtue lies in the adhesive-free zone along the joint, which has been recognized as an advantage”; or Clarkson’s (1975): “In conservation work one needs to use minimum or no adhesive in the spine and certainly not for any structural reasons,” to quote just two.

Endbands are a very simple example: sewn endbands are often found broken—but still extant—as opposed to the frequency with which pasted endbands are lost due to full detachment.

OTHER STRUCTURAL FEATURES (GRAIN DIRECTION AND DISPLAY)

Provided that bonds of the same type have a general similar behavior, two bonds of the same type can vary greatly depending on their intrinsic features. For instance, an adhered union between text block and covers shall behave quite differently if the endleaves are of parchment, rather than paper. Some materials enhance a structural grounding whereas others restrict it. For example, wooden boards are lighter but much harder than paper-based boards, being a superior protection against mechanical hazards (abrasion, hits, etc.). Given that the conservator’s choices fulfill historical and aesthetic appropriateness, it is worth noting that the same material embodies a stronger structural basis when strategically applied as well as prevents setbacks in the long run. As a case in point, text-block sheets are laid out with the grain parallel to the spine in order to ensure sufficient drape, devoid of strains by the sewing. It is by no mere chance that medieval wooden boards were also oriented with vertical grain direction, often reinforced with cross-grained butt joints to prevent cockling (Honey and Velios 2009).

Under the same principle, different areas of a part have specific demands. A pliable spine calls for more flexibility at the joints than in the center. A pared or thinned-down reinforcement shall be more flexible than a straight one because instead of a single sharp edge delimiting two areas of diverse flexibility, there shall be several neighboring zones of decreasing pliability. The difference for adjacent regions is therefore

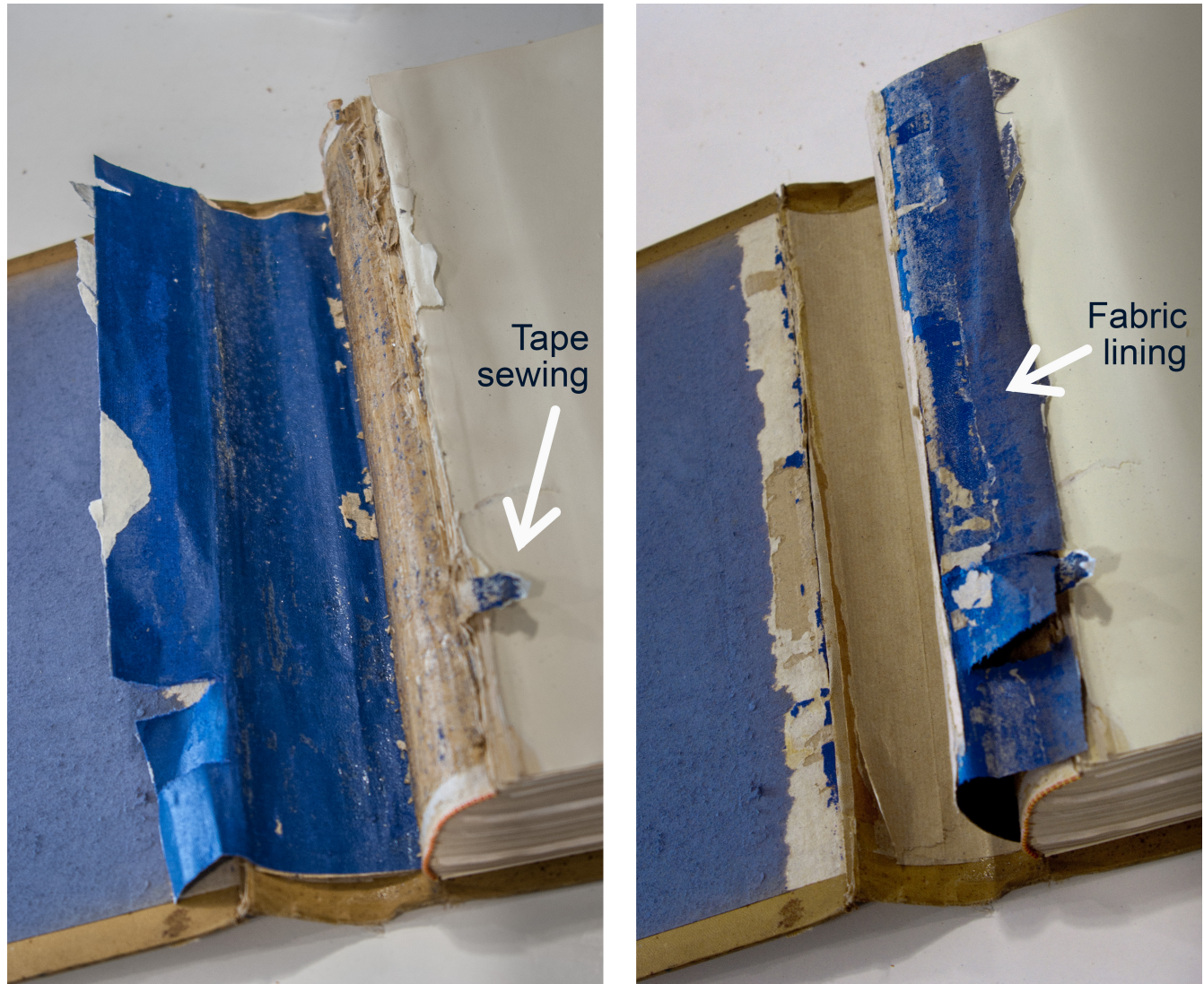


Fig. 1. Book sewn on tapes with adhered fabric spine lining. The original reinforcement devised by the bookbinder has not been enough to hold the heavy text block. The backed part on the movable area (spine) was detached, whereas the static stubs under the pastedowns remained adhered in place. The fabric stubs appear unstuck in the image just after being detached by the conservator in order to replace it with a mull. *El Mercurio* (c. 1930), from the Historical Archive of Barcelona.

much bigger in the first case. In other words, some distributed minor weak points present less threat than a single major one.

Elementary concepts arise when extrapolating this principle to primary attachments with much applicability in conservation. For the board-attachment connection, a union consisting of several hookings along the joint is more stable than one with a reduced number and performs better when evenly distributed. The same basic principle applies when hanging out the laundry by just one clothes peg (or two or more): the more pegs, the less strain and distortion. Pegs and working time are saved if clothes are simply folded at the middle, applying a similar even force all along the fold, but the lack of hooking has obvious risks (see figs. 5 and 7).

The practical effect of this tenet consists in securing the joining all-along (see figs. 4 and 6), rather than only locally (e.g., a damaged thong). Therefore bracing materials can be lighter, and strains are minimized on the attached parts while being very durable. If none of the bonds are sewn, bear in mind the gamble of using no clothes pegs!

Resuming the benefits of sewing vs. adhesion, a comparable superiority of fabric tissues over paper is to be expected. Concerning mechanical behavior, fabric is more flexible and tenacious than paper. A close up explains it: a tissue consists of woven *twisted* groups of threads (Steere 2022), whereas paper is composed of entangled (and sized, that is *adhered*) single fibers. In turn, papers offer a wide range of structural natures: rag paper lacks grain direction, therefore tears are not

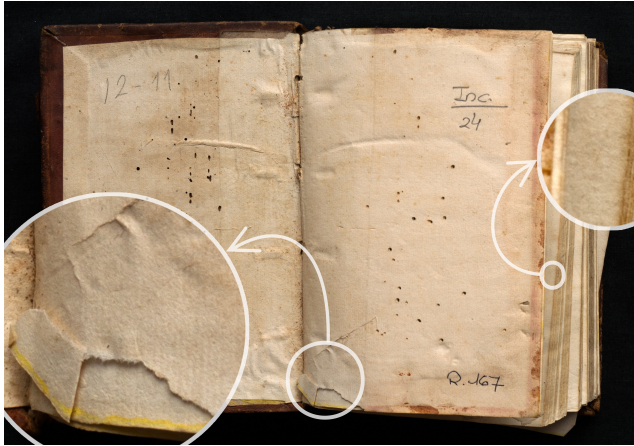


Fig. 2. Incunabula dated 1499 from the Public Library of Girona Carles Rahola (R. 167). The endpapers have horizontal grain direction (lower detail) whereas the text block folios have lengthwise grain (detail at right). The endpapers are less apt to tear apart along the joint since ripping is encouraged horizontally (bottom detail).

favored on a particular orientation. But machine-made and laid paper do tear easier along the grain. Moreover, the fiber length and compactness of paper also defines its performance (swelling, pliability, resistance to tear, and so on).

A personal observation of the author states that endpapers before the 17th century are sometimes found cross-grained while the text block has the *right* vertical grain (fig. 2). It is strongly encouraged to quantify and define the context in which this happens. Still lacking proper research, these findings seem too frequent to be the cumulative result of a slovenly crafting performance. It simply provides reasonable grounds for belief of an intended action. The goal would

be to lessen the risk of tears along the spine-fold derived from half the adhesion of endleaves (solely the pastedown). Strength on joints might have been prioritized to an easier and well-groomed completion. It appears unsound that experienced craftsmen did not foresee the singular swelling of half laid paper against the grain. The struggle with the wavy joint and a pastedown taller than the flyleaf might have been the compromise to prevent full detachment of flyleaves. Earlier and contemporary structures deliberately reinforced this weak point (Blaser 1994)—either using vellum stubs instead, or in multiple options of hooked stations. Therefore, endpapers depict not only a covering material, but a material integrating significant attachment points (thus, structure).

Be that as it may, it can't be neglected that grain direction makes paper very vulnerable to tearing when the ripping angle starts along the grain, but is most resistant to tearing perpendicular to the grain. Let's take advantage of this fact as a way to bestow structure to those elements that might require it, just like experienced bookbinders have been always doing.

DISPROPORTIONED BOOKS

Proportionality of bindings does not refer to unusual dimensions, but rather to the capacity of a structure to endure, protect their contents, and be handled. Disproportion means that some vulnerability shall make the book collapse even when their components are in good condition. For instance, a book can be disproportionate if the cover-to-text-block attachment is too weak to sustain it (or if the text block is too heavy, as shown in fig. 1), the edges much too high (as in fig. 3), or the spine much too stiff (as in fig. 8). Typically



Fig. 3. Disproportioned book from 1871 before (a) and after conservation (b). Left: Images taken from above the head of the book. After conservation (b) the book is able to stand without the text block falling apart from the spine whereas before (a) a weight was needed to hold the book upright (black piece on top). Association of Architects of Catalonia (CoAC).



Fig. 4. Sewn reinforcement over a mull. The sewing hooks the gatherings distributed all along the spine, not too close to each other. Note that the original spine lining has not been removed, only the loose areas.

disproportioned bindings are, for instance, heavy cased-in books whose endpapers are the only cover-to-text-block attachment point.

Most concerning structural damages involve detachment of the folios and/or covers. However, many other parts should be taken care of according to their relevance and function in a book: ties, clasps, endbands, spine, flap, and so on.

Depending on their proportions, bindings with the same type of structure can behave very differently in terms of durability. All features (size, weight, type of material) matter. When books have failed due to a disproportionate binding structure, merely fixing the damaged parts may be enough for exhibition purposes but may not be enough for more intensive use.

EXPERIMENTATION

In daily conservation, the above concepts can be applied in practical terms, as demonstrated in the following case studies. All of them consist of disproportioned bindings with major structural damages (board and folio detachment). They are not meant to be followed as step-by-step treatment formulas, not even in reference to precise products or materials, precisely because conservation treatments need to be tailored to the context and nature of each artifact. These case studies are not the result of a planned research project but selected from routine treatments in the conservation lab. There is still much room for research and improvement of analytical design.

Through these case studies, this article intends to highlight this underlying idea: the strength of the skeleton of a book is based on types of bonds and the structural complexion of their components. Each conservator should use familiar materials and techniques to achieve a more stable and enduring structure.

CASE STUDY #1: HEAVY BOOKS

Text blocks that are too heavy can weaken certain types of board attachments. A combination of factors that can lead to failure include excessively thick text blocks or those made of heavy paper (e.g. coated papers); sewing cords that are recessed, too narrow, or too frayed; and boards with excessive squares. If the original combination of components produces a weak binding structure, conservation will not succeed by merely repairing all the broken parts and reproducing the same structure. With a recessed sewing structure that was too weak to support its text block, case study 1 featured many of the components mentioned above to form a failing structure. The selected treatment demonstrates the superiority of sewn reinforcements over adhesive ones for areas of movement (fig. 3).

For the joint, the area of the book requiring the most motion, the chosen reinforcement material ought to be highly flexible and endowed with structural integrity. For example, woven fabric is preferable to non-woven (e.g. synthetic spunbond) materials, which have less grain direction. Similarly, non-woven materials are preferable to paper, which has a weaker bond between its fibers despite its good grain direction. A reinforcement material that is optimal for the repair of a part of a book can be detrimental to another part depending on its contribution to the structure of the binding. The type and length of composing fibers, thickness, compactness, and many other features of the material thus need to be considered accordingly.

Hollow-back spines are reasonably accessible to the conservator, specifically for books with detached boards. Furthermore, they tolerate the addition of a moderately thick layer over the spine while not protruding nor being visible after conservation. Thus, a mull is preferable for this particular case. Considering that the attachment requiring strengthening is that of the boards to the text block, the mull is oriented with more tenacious warp yarn across the spine (Steere 2022), strengthening the connection between boards and folios.

Next, the mesh is held on the text block. It is not recommended to remove or replace older spine linings whenever they are firmly stuck, for this might loosen the gatherings, distort the spine, and eventually involve breakage of some folios. The union of the mull onto the spine is unquestionably sewing (see fig. 1). It is more time consuming than pasting but will last longer. A random sewing collecting both the mull and the gatherings will suffice (fig. 4). The mull is intended to replace the role of the weakened thongs by relocating strains along the spine, thus the sewing is preferably held directly through the gatherings rather than just the thongs. The new sewing shall be well distributed in order to divide up the stress and the stitches not too close to each other so that the mull is not weakened by an excess of holes.

The mull can be previously held onto the spine with a light layer of methyl cellulose to facilitate sewing. This optional step is negligible in relation to reinforcement purposes but meant uniquely to ease the conservator's performance.

Ensuing the text block sewing, the stubs of the mull are to be held onto the covers. Unfortunately, a sewn hooking is ordinarily not a sensible option since it would require detaching along the joint both the endpapers and the binding's covering material. For most common materials (e.g. decorated papers, printed cloth), a haphazard outcome is to be expected. The board material usually employed for covers is then slotted along the joints' edge and the mull stubs inserted in a few centimeters.

The structure is then reinforced: joints and spine—the movable areas—are endowed with materials embodying the skeleton and rely mainly on sewn bonding. A heavy book can then stand on its own, proving it has a solid binding.

CASE STUDY #2: ALBUMS, BOOKS WITHOUT SEWING

In photographic albums, the contents are inserted after the book is bound, which needs to be flexible to endure handling and accommodate the photographs. Yet in many cases, such as the one shown in figure 5, the folios are simply adhered to each other through guarded fabric stubs. Adhesion does not ensure a pliable structure, therefore sooner or later the tipped-on pieces might tear apart or detach from each other, regardless of the type of material. The covers may also become disjoined due to the severe damage.

Treatment is similar to the previous example. The tears of the guards are mended in advance, in this case with Japanese paper thinner than the guards and cross-grained in relation to



Fig. 5. Album from the Photographic Archive of Barcelona, before conservation. The guards were detached and torn apart. Folios had been compiled devoid of any sewing but stuck together with folded guards. Albums require a flexible skeleton that adhesion cannot provide, despite employing an appropriate material such as fabric.

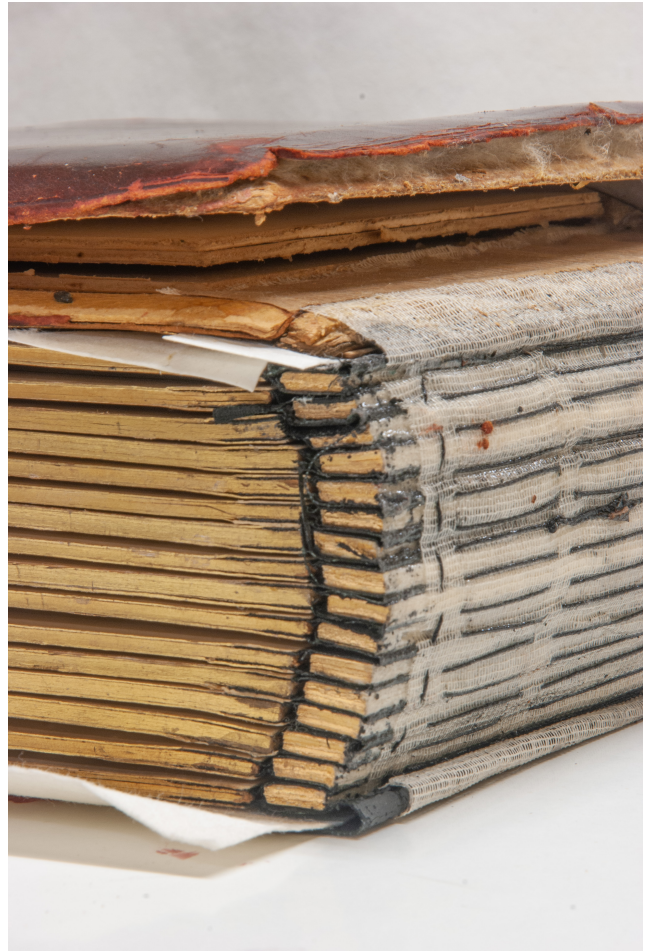


Fig. 6. Album from the Photographic Archive of Barcelona, after sewing the gatherings over a mull. The stubs of the mull are inserted inside the boards of the covers (on top), which have been split for this purpose. Black thread is used to match the color of the guards.

the spine-fold (regardless of the grain of the guards). In such a way resistance to tearing is minimized and the link exerted by the sewing is stronger. For a neater finishing, the innermost side of the gatherings (that visible from the spine-fold) is mended with a much thinner Japanese tissue whose grain is lengthwise to the fold. The contribution to structure of the visible mends is trivial, just preventing them from opening and ensuring a tidy and uncluttered fold. Since there was no sewing before conservation, the sewn reinforcement—again over a mull—needs to hook every gathering, preferably from head to tail (see fig. 6). The boards are reunited as in the previous example, inserting the mull stubs into the slotted boards.

As a result, the restored book is far more enduring (see fig. 7). The sewing restricts excessive stress towards the guards and prevents them from splitting apart. Thus, it is possible to repair the spine-folds with light, pliable, and not very visible mends (previously dyed for a better match).

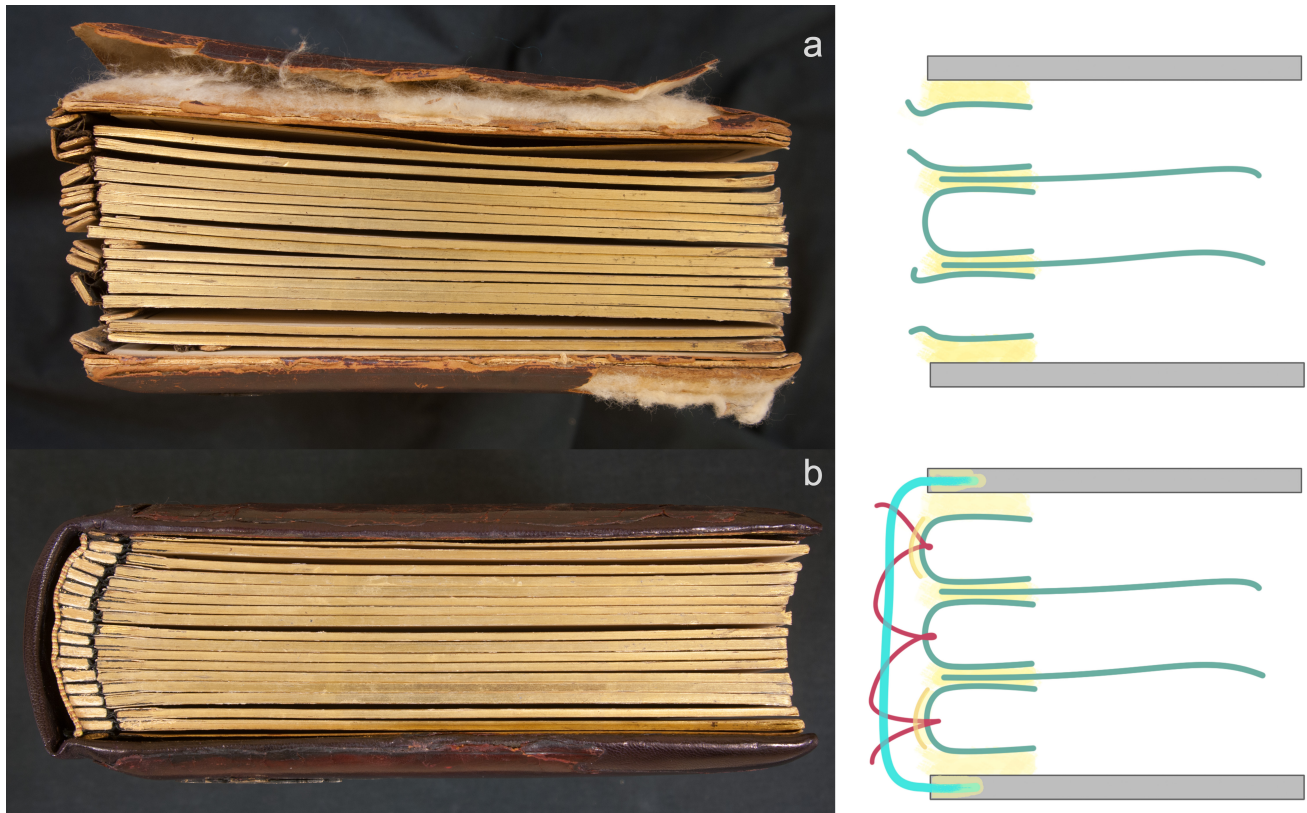


Fig. 7. Album from the Photographic Archive of Barcelona, before (a) and after conservation (b). Light adhered mends were applied on the guards, and an invisible sewn reinforcement (using black thread) supports the structure. Left: head edge before and after. Right: structure before and after. The mull, in blue, adhesive in yellow, thread in red, boards in gray, guards and folios in green.

CASE STUDY #3: SEWN UNSUPPORTED BOUND BOOKS

Sewn, unsupported books lack proper covers, the binding consisting merely of a printed paper adhered onto the spine. The link between the folios is often quite unsubstantial since they were commonly meant to be re-sewn and fittingly bound after acquisition. The sewing indeed lacks sewing supports and is often more localized in the center, leaving the head and tail unconstrained. The reason is a potential trimming of the uncut edges and also the temporary quality of a sewing intended to be rebound.

In a similar manner to the previous case study, both main structural connections are frail, but additionally the printed spine-support is often massively cracked (see fig. 8). Nonetheless, the tight-back spine does not tolerate many added layers, nor can the paper covers can be treated as a thick cardboard.

At worst, a possible solution is to turn the spine into a hollow-back, releasing stress in the printed spine (see fig. 9a) and strengthening the sewing. The wrapper is first detached from the spine and mended. Alternatively to the stronger reinforcements used in the previous case studies, a much lighter piece



Fig. 8. Sewn, unsupported book bound in drawn-on covers from ETSEIB, UPC (Superior Technical Engineering School of Barcelona, Polytechnic University of Catalonia). Massive cracking along the spine material, board detachment, and friability of the unsupported sewing.

of Japanese heat-set tissue is used. This is adhered onto a synthetic mesh (e.g., a Reemay, rather than thicker fabric layers; see fig. 9b). The paper tissue is displayed in contact with the spine with its grain direction across the joints and with the

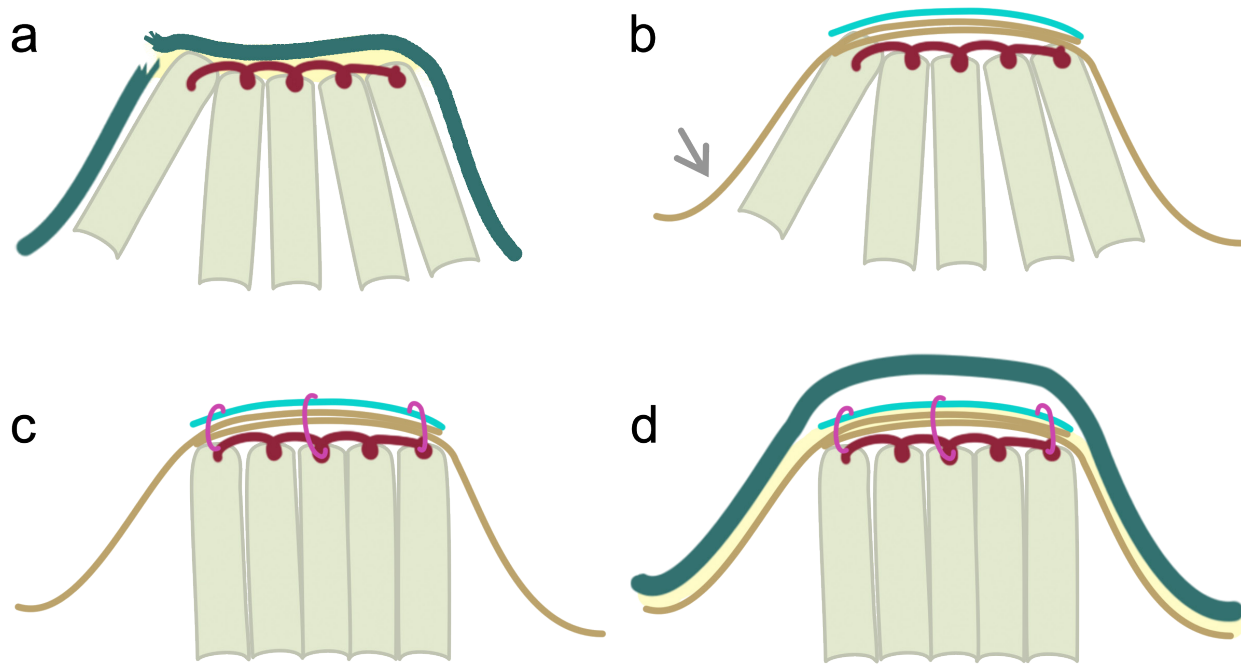


Fig. 9. Structure of same book as previous figure. a) Before treatment, the sewing is frail (in red) and the covers (green) are detached along the joints. Adhesion (pale yellow) applied on the tight-back. b) After removal of drawn-on covers two layers of hot-melt tissue (brown) are placed onto the spine, with the adhesive layer—pointed by the arrow—facing up. On top, a layer of synthetic mesh (blue), a Reemay. c) A secondary sewing (pink) gathers the text block and the Reemay, restricting minimally the motion between gatherings. d) The restored covers (green) are adhered (yellow) onto the hot-melt tissue (brown) remoistened it with ethanol. The spine of the drawn-on covers lack strains because it is adhesive free and does not compress. The text block is sewn. The covers and text block are linked along the joints by means of the cross-grained Japanese tissue, which is sewn both on the text block and the Reemay.

adhesive layer (indicated by the arrow in fig. 9b), facing the synthetic mesh. The paper is meant to be adhered lengthwise to the joints of the wrapper. It can be as large as the covers, thus preventing potential tears along the edge of the heat-set tissue and endowing a proper drape. If the covers are printed on both sides and readability is compromised by the tissue, a few centimeters along the joint will suffice. Afterwards, the text block is re-sewn over the paired materials (see fig. 9c). Again, it is suggested that it goes all along the spine, rather than being gathered at the center. Subsequently, the adhesive of the heat-set tissue is activated by spraying ethanol and immediately stuck to the inner side of the restored wrapper (fig. 9d). The use of ethanol (or heat) instead of water-based adhesives avoids fiber swelling and distortion of the printed wrapper.

As a result, the interconnection between the folios is tighter due to the complementary sewing, while the paper spine is free from stress as it is detached from the text block (fig. 10). The covers have an adhered directional link across the spine, under the sewing. The use of perpendicular grain direction on the reinforcement allows the use of thin layers that are barely noticeable and yet very effective. There can be several variations of the same idea, all of them tailored to each case.



Fig. 10. Same book as fig. 8, after conservation. The wrapper expands when opening the book, instead of compressing as it did before conservation and enhances the long-term preservation.

CONCLUSION

The book structure is the skeleton gathering the main parts of a book. Conservation needs to prioritize structural damages whenever handling is a requirement, specifically for

disproportioned books. The potential modification of the original structure might be necessary when their damages are severe.

Providing structure can be achieved primarily by selecting the right type of joining: unions that require movement endure more when they are sewn, whereas static areas are stronger when adhered.

Secondly, but also relevant, the choice of materials embodying the skeleton (i.e. grain direction) is also a remarkable structural provider. When strategically applied, they enable lighter but steadier reinforcements.

Movable areas should remain light, devoid of thick adhesive layers.

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Last, but not the least, I would like to thank Jaume Abril, for his loving support.

NOTES

1. Should magnetic ties (on pocket agendas) also be considered as a third type? Please do contact the author if there’s a relevant gap!
2. In later versions of this structure, two or more layers are sewn (not lined), and the sewing passes through the sections and the covers (and the spine supports, if any).
3. Rolls and concertina bindings appear to consist of a single folio being rolled or folded, but even these structures consist of some adhered or sewn components (Song 2009).

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