Article: What a relief! A practical, inexpensive approach to the conservation of a large XIX Dynasty sandstone stela
Author(s): Christina Krumrine and Lisa Kronthal
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1. Introduction

In October of 1993 the Brooklyn Museum reopened its West Wing Egyptian Galleries. Approximately 600 objects that had been in storage during the three year renovation were reinstalled into newly designed cases in state-of-the-art, climate controlled galleries. The enormous job of preparing these objects for reinstallation fell upon the Museum's conservation staff during a time of severe financial crisis for the Museum and its primary benefactor, the City of New York.

The Museum's economic woes resulted in staff shortages and in stringent budgets for the conservation department. These strictures were felt most severely during the treatment of several large stone objects in the collection. Faced with the task of reassembling these massive objects, the conservators needed to develop techniques that utilized basic materials readily available in the conservation lab and which required only minimal assistance from the Museum's already overburdened art handlers.

The authors pioneered such techniques during the treatment of a large Ptolemaic limestone sarcophagus lid that had broken into two heavy pieces. The technique was further refined during the treatment of a sandstone stela broken into five large fragments (fig. 1). Both objects were previously repaired using difficult to reverse materials and techniques. This paper will discuss the conservation treatment of the relief in detail and introduce new techniques for structural repair that are simple to carry out and easy to reverse.

2. Dowel and Sleeve Joins: A New Approach

Having carried out many structural repairs on large, heavy stone objects, the authors were familiar with commonly used doweling techniques, most of which employ stainless steel dowels in conjunction with structural adhesives such as polyesters or epoxies. They also knew how difficult and time consuming it can be to reverse this type of structural join.

Could one refine these commonly used techniques to develop a system that eliminated the need for difficult-to-reverse adhesives? Such a system was developed. Instead of adhesives, the system relies on gravity, absolutely parallel drill holes and extremely tight fitting sleeves for the stainless steel dowels.
3. Description

The stela (Fig. 1), which depicts Ramses II, measures approximately 1.7 m in height and 87.2 cm wide. Its depth ranges from 13 - 18.5 cm. and it weighs approximately 275 kilograms. The large monument comes from the Egyptian temple of Amarah West in Nubia and was acquired by The Brooklyn Museum in 1939 (The Brooklyn Museum Archives: 1939).

3.1. Previous Restoration

The relief was found in five fragments which were re-attached with plaster and cement soon after excavation. All the previous joins were slightly out of alignment. Figure 2 illustrates the location of the copper and brass dowels and staples used in the previous restoration.

Upon removal of excessive plaster fill on the back and sides of the relief, several of the notched copper and bronze dowels used in the previous restoration became visible. On the sides of the relief there were numerous copper and brass staples which were set into carved recesses with plaster and cement. The exposed dowels and staples were corroded, and the plaster and sandstone surrounding the dowel and staple sites exhibited hairline cracking and spalling.

Inpainting from previous repairs was unsightly and extended onto the original stone surfaces. For all of these reasons, it was decided that all structural and cosmetic repairs should be reversed and the fragments reattached using inert, structurally sound materials.

4. Reversing Previous Restoration

Previous plaster and cement fills on the face of the relief were mechanically removed with scalpels (Fig. 3). Overpaint on either side of the old fills was removed with acetone and cotton swabs without damaging any ancient pigmentation. All of this was done while the relief was vertical.

To address the old internal structural repairs, the stela had to be dismantled from its old wooden backboard and placed horizontally, face down, on a wooden work table. The table top was first prepared with several layers of Volara polyethylene padding followed by two layers of silicone Mylar. The silicone Mylar provided a slick surface on which the fragments could be maneuvered during dowel removal.

Using chisels, the plaster and cement were removed from the breaks on the back and the sides of the relief. The internal brass and copper pins at the horizontal breaks were easy to locate after all the plaster and cement “adhesive” had been removed from between the break edges. These notched dowels, still firmly held by the plaster in their holes, were removed by drilling through...
the metal with long drill bits. Eventually the metal split and the fragments could be separated (Fig. 4). Separation was easily accomplished by sliding the fragments on the layers of silicone Mylar previously placed on the table.

Once the dowels had been taken out, cement and plaster were removed from within the existing drill holes with chisels. All of the existing holes were approximately 8 - 10 centimeters in length and 4 centimeters in diameter with the exception of the three holes in the curved top fragment. These holes were extremely large and irregular and the brass dowels found in them were bent. This seemed to indicate that the previous restorers had tremendous difficulty aligning the dowel holes along this sharply angled, diagonal break.

5. Leveling and Aligning Individual Fragments

5.1. No-Muscle Method for Moving Large Stone Fragments

In order to move the heavy fragments of the stela, the conservators developed a new “pallet” system which eliminated the need for brute strength to move the five fragments ranging in weight from 15 to 100 kilograms.

Figures 5 and 6 illustrate the new pallet system used to maneuver the relief. First, the table was covered with a single sheet of silicone Mylar which was attached to the table by applying double sided tape to the uncoated side of the Mylar film. A template of each fragment was cut out of paper, trimming approximately 2 to 4 centimeters from the perimeter of each shape.

The slightly reduced template of each fragment was then traced onto a thin, rigid board of Masonite. The Masonite was cut to shape with a jigsaw. Each pallet was then covered with silicone Mylar on one side, and a thin sheet of Volara polyethylene padding on the other side. Both of these materials were attached to the Masonite with double-sided tape. The bottom, silicone Mylar-side of each pallet was placed on the prepared table. Each fragment was then lifted onto the padded side of its corresponding pallet, face up. The interface of the two silicone Mylar surfaces enables the conservators to glide each fragment across the table with minimal effort.

The back surface of the relief was very irregular and varied dramatically in thickness across its length. This meant that each fragment had to be leveled in relationship to the others, something that was not accomplished during the previous restorations. The pallets made proper alignment a simple task. Each palletized fragment was presented to its mate by sliding it on the table, then both fragments were leveled using pre-cut wooden shims. After all five fragments were leveled in relationship to each other, the shims were permanently adhered to the individual Masonite palettes with hot-glue. By adhering the shims to the palettes, there was never a need to re-level the fragments during the course of treatment.
6. Assembling the Fragments

6.1. Dowels

As described earlier, the relief fragments were not properly aligned during previous repairs. The pre-existing dowel holes were not parallel and they were generally too narrow and/or too short to accommodate dowels and sleeves of adequate length and diameter. The configuration of the breaks and the weight of the fragments called for a total of seven 3.5 cm diameter stainless steel dowels: three along the top diagonal break, two along the middle, horizontal break, and two at the bottom vertical break (Fig. 7).

All dowels were 25.5 centimeters in length except for those used at the bottom vertical break. Since all the weight of the upper fragments would rest on the bottom two fragments, longer 31.5 centimeter dowels were used at the vertical break for added strength.

6.2. Creating Absolutely Parallel Dowel Holes

Figures 8 and 9 illustrate a simple rig that was developed for obtaining absolutely parallel dowel alignment along break edges. The rig was constructed from a single, squared length of wood screwed to a wooden “L” shaped stand. The wood strip had to be long enough to accommodate two corner clamps which would hold the dowels in their parallel position and would span the distance between the dowel holes. One arm of each metal corner clamp was secured to each end of the wood strip so that the second, extended arm of each clamp was positioned perpendicular to the break edge. A stainless steel rod was then placed in the extended arm of each clamp. This system maintained a constant distance between the two parallel dowels.

As the rig was presented to the break edge, the two parallel dowels in the rig were simultaneously inserted into the pre-existing holes. Since the pre-existing holes were out of alignment - that is, not parallel - the rigged, parallel dowels would scrape against the interior surfaces of the holes. The holes therefore needed to be widened at the points where the dowels scraped. The hole interiors were drilled with a metal bur until they accepted the parallel, rigged dowels. The size of the existing dowel holes had to be lengthened to accommodate the new stainless steel dowels, and slightly widened to accept both the dowels and new internal sleeves. Since the new joining method was going to rely on the mechanics and rigidity of internal dowels and sleeves - and NOT on adhesive - these longer dowels were needed to ensure adequate strength at the joins.

Once one set of holes was aligned and lengthened along a break edge, the rigged dowels were re-introduced into the drilled holes and held in position temporarily with dental wax. The rig was then removed, leaving the dowels extending outward from the holes. The corresponding fragment was brought to meet the extended dowels and the break was slowly closed. Again, wherever the
dowels scraped, the holes needed to be widened. The two holes along the second break edge were widened and lengthened until all the holes were perfectly parallel and the fragments closed tightly with the two dowels in place.

6.3. Creating Tight-Fitting Epoxy Putty Sleeves

It is extremely difficult and expensive to buy stainless steel rods and matching sleeves that have little "play" between the two. Rods can be precision milled to fit snugly into stainless steel sleeves, but this can be very costly. Since the goal of the treatment was to eliminate structural adhesives and rely instead on gravity and the mechanical rigidity of a dowel and sleeve join, only minimal movement of the rod within the sleeve could be accepted. Customized, form-fitting epoxy putty sleeves proved to be an economical answer to these problems.

All holes were first lined with a 1/8" thick isolating layer made from a paste comprised of Acryloid B-72 bulked with fumed silica and cellulose powder. After drying, this lining was sanded until it had a very smooth, regular surface. This thick, smooth isolating layer was applied to ensure the reversibility of the epoxy putty sleeves. Saturating the isolating layer with acetone or ethanol will soften the lining material and allow an epoxy sleeve to be pulled out of the drill hole.

With the rigged dowels sitting in their corresponding holes along one of the break edges, Pliacre epoxy putty was carefully packed around the dowels in the hole. Before doing this, however, the surfaces of the dowels were coated with petroleum jelly and covered with a single layer of plastic wrap to prevent the epoxy putty from sticking to the dowels. This procedure can be seen in the foreground of Figure 9. When the epoxy set, two rigid, absolutely parallel, tight fitting epoxy sleeves had been created around each dowel. Figure 10 shows the stratigraphy of the dowel hole interiors.

To create matching sleeves on the corresponding break edge, the dowels were inserted into their new, hardened epoxy sleeves and their protruding ends were again isolated with petroleum jelly and a layer of plastic wrap. These extended dowels then served as a rig for the second set of sleeves. Soft epoxy putty was inserted into the holes along the opposite break edge, and, as the two fragments were closed together, the dowels pressed into the soft epoxy (Fig. 11). Once the epoxy hardened and the fragments were pulled apart, the plastic wrap and petroleum jelly were removed. The dowels were then reinserted into the sleeves on one break edge and the matching fragment was joined by sliding it onto the extending dowels.

The result is a purely mechanical joining system which eliminates the need for structural adhesives.
6.4. Complex Dowel Alignment on Sharply Angled Breaks

The simple rig in Fig. 8 had to be refined to accommodate three dowels along the top of the stela, which had a sharply angled diagonal break. This break edge was too long and angled to use a simple rig with one horizontal strip of wood. Instead, two individual rigs had to be “stepped”, one behind the other (Fig. 12). A simple corner clamp was secured to the outside edge of each rig’s horizontal wooden element, then the rigs were glued down to a Masonite pallet. The rigs were kept parallel to one another by placing a squared length of wood between the two and gluing it to the Masonite pallet as well.

Whenever more than one rig is used to align dowel holes, each rig MUST be glued to the same board. If not, when the rigs are moved during the processes of aligning the holes and making sleeves they will not remain parallel. If the dowel holes and their corresponding sleeves are not parallel, the joined fragments will not be properly aligned. The dowel holes along the sharply angled break were prepared the same way as the other holes, with an isolation layer and epoxy sleeve (Fig. 13).

6.5. Joining the Fragments

Before the relief was assembled, all its break edges were consolidated with a 30% solution of Acryloid B-72 in ethanol. During the transport of the relief into the gallery, we wanted to be certain that there would be no movement along the length of any of the dowels. For this reason, Acryloid B-72 bulked with fumed silica was used in some of the sleeves as a precautionary measure (Fig. 7). At the diagonal and horizontal breaks, the dowels were adhered in their sleeves along the lower break edges only. At the vertical break, both ends of the dowels were notched and adhered in their sleeves. This was done because any movement of the two fragments at the vertical break could potentially exert pressure on the dowels in the upper breaks.

Once again, it is gravity, the tight fitting sleeves and parallel dowels which enables the piece to stand without any structural adhesive. To reverse the joins, one need only lay the relief horizontally and pull the fragments apart. The Acryloid B-72 along the vertical break need only be softened with solvents.

7. Transporting and Mounting the Relief

Belt clamps were wrapped around the entire stela to secure it to its wooden platform. A second platform, constructed from wood and padded with thick polyethylene foam, was placed on top of the object. The two platforms, with the stela in between, were then strapped tightly together with the belt clamps and lowered with a forklift onto dollies.
The relief was rolled horizontally into the gallery and a forklift, in combination with manpower, lifted the object to a vertical position. The conservators and art handlers carefully slid the assembled relief onto its gallery platform using two sheets of silicone Mylar placed beneath the object. The Mylar was removed and the bottom edge was leveled with recessed wooden shims. Two, 3/4" wide brass clips were placed on either side of the relief and screwed to the backboard to prevent the relief from falling forward should anyone accidentally bump into the case.

8. A Better Acryloid B-72 Fill Material

A paste comprised of Acryloid B-72, fumed silica and cellulose powder was also used to fill losses along the cracks and on the sides of the relief where the staples had been removed (Fig. 14). This paste mixture has unique properties that make it particularly versatile. The combination of Acryloid B-72 and fumed silica or microballoons is not novel. When only these two materials are used, however, the mixture can be very sticky, stringy and difficult to apply. It shrinks no matter how viscous a solution of Acryloid B-72 is used, and the fill material remains soft and spongy for many days.

If cellulose powder is added to a mixture of Acryloid B-72 in acetone and fumed silica, however, all of the above problems are eliminated: the paste is very thick and cohesive, so one can grab a small amount out of the jar and place the material on the surface without pulling along strings of adhesive with the spatula. It does not shrink. It dries hard, not spongy, which makes carving, sanding and texturing an easy task. The dried fill material is strong yet light, and it can be easily re-softened, manipulated and shaped with the application of solvents or heat.

The paste is made by dampening 40 grams of cellulose powder with acetone, adding only enough solvent to wet the fibers, not make a liquid. Next, add 60 milliliters of 20% Acryloid B-72 in acetone and mix well with a spatula; then add 3 grams of fumed silica and mix well again. The viscosity of the prepared paste can be adjusted by adding more or less of the Acryloid B-72 solution. When working with the paste, be sure to stir the mixture every now and again to prevent the Acryloid B-72 solution from rising to the top of the container.

The fills on the front of the relief were textured with small metal files to simulate the texture of the original sandstone. All fills were then inpainted with Liquitex acrylic paints (Fig. 15).

9. Conclusion

The techniques developed by the conservators can be easily adapted to almost any kind of dowel repair. There are, however, certain problems that must be addressed, especially for extremely large stone objects.
**Krumrine and Kronthal**

During the treatment of the stela, the silicone Mylar on the table top and on the underside of the pallets frequently tore. The tearing was probably due to the fact that only the edges of the Mylar were adhered with double-sided tape. Had the Mylar sheets been adhered along their entire surface with an adhesive, the tearing would have been minimized.

For especially large objects, a frictionless surface other than silicone Mylar should be considered. Silicone Mylar is available in rolls of a maximum width of approximately 1 meter. The Mylar cannot be overlapped when preparing the table or the underside of the pallets. Any overlapping causes tears in the Mylar when the pallets are moved. Therefore, for fragments wider than one meter, it is not practical to use the Mylar. In the future, the conservators intend to further refine these techniques by exploring the use of Teflon and high-density polypropylene instead of Mylar.

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**Authors' Addresses**

Christina Krumrine, 41 Union Square West, #206, New York, NY 10003

Lisa Kronthal, American Museum of Natural History, Central Park West at 79th Street, NY 10024

**Reference**

The Brooklyn Museum Archives. 1939. Egyptian Department, The Brooklyn Museum, 200 Eastern Parkway, Brooklyn, NY, 11238, USA.
Sources of Materials

1. Acryloid B-72
   Conservation Materials Ltd.,
   1395 Greg St., Suite 110, P.O. Box 2884,
   Sparks, NV, 89431, USA
   telephone: (702)331-0582, 1-800-733-5283

2. Cab-O-Sil (fumed silica)
   Cabot Corporation,
   Cab-O-Sil Division,
   Rt. 36 West,
   Tuscola, IL, 61953-0188, USA
   telephone: (217)253-3370

3. Cellulose Powder CF-11
   Whatman Labsales,
   P.O. Box 1359,
   Hillsboro, OR, 97123-99892, USA
   telephone: 1-800-942-8626

4. Double-Coated Tape (3M #415)
   Light Impressions,
   439 Monroe Ave.,
   P.O. Box 940,
   Rochester, NY 14603-0940
   telephone: 1-800-828-6216

5. Hot-Melt Glue Sticks
   3M Center,
   St. Paul, MN 55144-1000, USA
   telephone: (612)733-1110

University Products, Inc.
517 Main Street,
P.O. Box 101,
Holyoke, MA 01041-0101

6. Liquitex Acrylic Paints
   Binney & Smith Inc.,
   Easton, PA, 18044-0431, USA
   also available at most art supply stores

7. Masonite
   available at most lumber yards.

8. Pliacre Epoxy Putty
   Philadelphia Resins,
   130 Commerce Drive,
   Montgomeryville, PA, 18936, USA
   telephone: (215)855-8450

9. Silicone-Coated Mylar
   Conservation Materials Ltd.,
   1395 Greg St., Suite 110, P.O. Box 2884,
   Sparks, NV, 89431, USA
   telephone: (702)331-0582, 1-800-723-5283

10. Stainless Steel Dowels
    Small Parts Inc.,
    13980 N.W. 58th Court, P.O. Box 4650,
    Miami Lakes, FL, 33014
    telephone: (305)557-8222

11. Volara (closed-cell polyethylene foam sheet)
    Foam-Tex Inc.,
    150 West 22nd Street,
    New York, NY, 10011-2421, USA
    telephone: (212)727-1780

University Products, Inc.
517 Main Street,
P.O. Box 101,
Holyoke, MA 01041-0101
Figure 1. XIXth dynasty stela of Ramesses II, front view, before treatment.

Figure 2. Diagram of stela, indicating location of old repairs.
Figure 3. Stela, during treatment, after removal of old fill materials.
Figure 4. Stela, during treatment. The top, curved fragment is removed revealing notched copper dowels and staples used in the previous repair.

Figure 5. Diagram of pallet system developed for moving heavy fragments.
Figure 6. Pallets used for moving large stone fragments. Pallet in foreground is upside down, exposing silicon mylar underside. Remaining pallets show Volara padding onto which fragments were placed.
Figure 7. Diagram of stela indicating location of new dowels and application of adhesive.

□ = application of B-72 + fumed silica between dowel and sleeve
Figure 8. Simple rig for creating parallel dowel holes.

Figure 9. Simple rig with dowels in corresponding holes.
Figure 10. Stratigraphy of dowel hole interiors.

Figure 11. Diagram showing process for creating companion, parallel dowel sleeve.
Figure 12. Modified rig for sharply angled break at top of stela.

Figure 13. Top break edge with parallel dowels in place.
Figure 14. Stela, during treatment, after filling losses.

Figure 15. Stela, after inpainting of fills.