How to Transport a 2,000 Year Old Mosaic

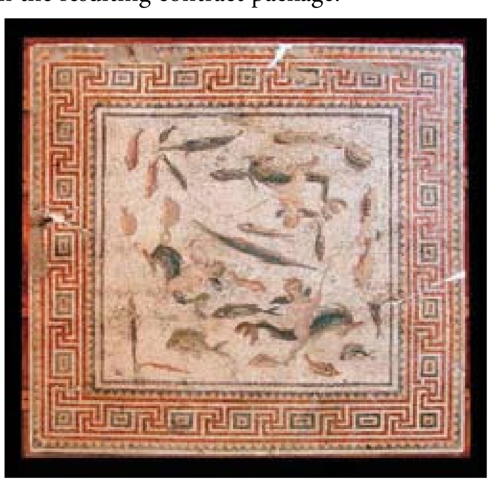
By Craig E. Barnes, P.E., SECB

Three large mosaic floor pieces, similar to terrazzo and measuring approximately 8- x 9-feet were acquired by the Museum of Fine Arts in Boston, Massachusetts. When acquired, the mosaics were part of an excavation from the Roman era, undertaken by the conservation department of Princeton University. This intricate mosaic was excavated at the site of ancient Antioch, in what is now southeastern Turkey. The city was a center of culture and learning and its people were known for their luxurious lifestyles. The mosaic once paved the courtyard of a third-century Roman house overlooking the Mediterranean. Its central panel shows three cupids each riding a dolphin and casting a fishing line into a sea teeming with marine life.

The mosaics consist of tesserae, which are small glass and marble chips measuring approximately ⅜-inch square and ¼-inch thick, set in mortar to form a walking surface. In 1930, the mosaics were backed with a reinforced concrete substrate approximately 3 inches thick. This was the available technology at the time for recovering, protecting and transporting art objects of this sort.

The objective of the Museum was to restore the tesserae and to provide a permanent backing to ensure long-term viewing possibilities. With the possibility that the mosaics could very well become a traveling part of the Museum's exhibits, and could thus end up anywhere in the world on display, CBI Consulting, Inc., was asked to develop an armature for protection, transportation and display for the restored object.

After disassembling, transporting and reassembling many exhibits for the Museum of Fine Arts (MFA), conservation engineer, Jean-Louis Lachevre, had adopted a philosophy that the armature needed to be self-contained, so that parts necessary for the complete armature could be stored within, and also would function as support during display. With those ground rules, the team began collaborating on the design. The first part of the process was to relate back, in sketch form, the conversations between Museum participants and CBI engineers. *Figure 1* is one of the sketches resulting from that process. Once concept agreement was reached, design and hard line drawings completed the first phase Contract Documents. *Figure 2* is one detail from the resulting contract package.



Panel overall. Photo courtesy of Mei-An-Tsu

Design Parameters

The conservation department of the Museum of Fine Arts has adopted the philosophy that most of the objects under Museum care have survived for thousands of years and, as

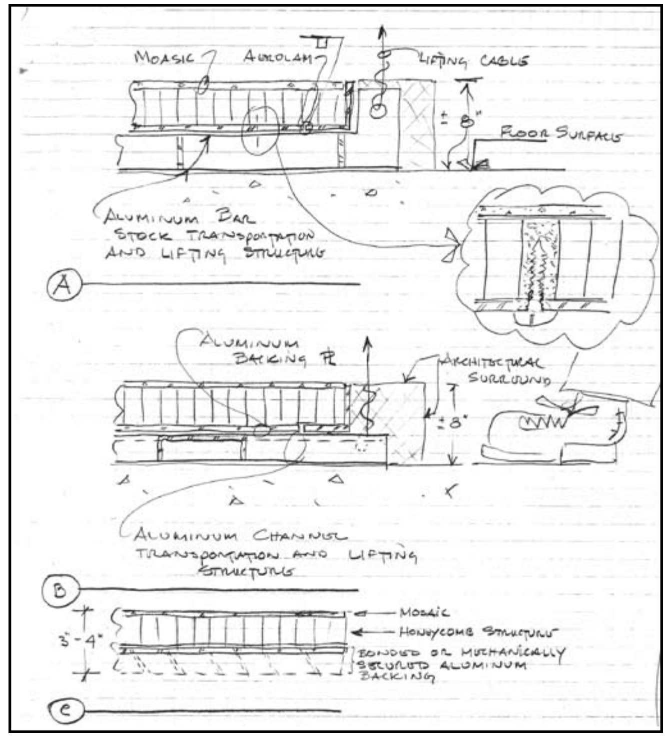
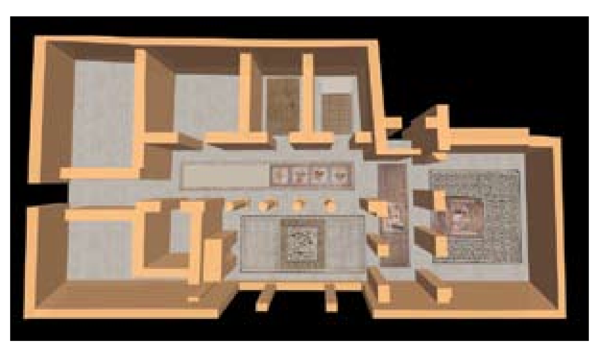


Figure 1: Planning Sketches

current custodians of those objects, every attempt must be made to ensure that they will survive for thousands of years to come. That philosophy was also required of the designers, not only regarding the immediacy of protecting the artwork, but also looking ahead for those thousands of years. As a traveling exhibit, it was necessary to look at possible seismic events which could occur in any venue where the exhibit may be on display. CBI has participated in providing armatures for museum objects to be displayed throughout the United States, Europe, Egypt and Japan. Geographically, these representative locations would expose the objects to almost any possible seismic intensity.

In addition to the lateral and vertical acceleration caused by seismic disturbances, transportation forces must also be considered and estimated. In the past, CBI performed a parametric study to determine the magnitude of cost differential when providing different degrees of stiffness to support systems. The parametric study consisted of subjecting a planar rectangular structure to unit loads applied in various locations, and documenting unitized distortions. Finite elements were used to model a structure with various properties. The objective was to provide, on a scaled basis, the effort needed to change the stiffness of the planar rectangular structure. A rectangular shape was chosen, as that is frequently the shape of the setting substrate for transportation of



Top View. Photo courtesy of Michelle Szwarc.

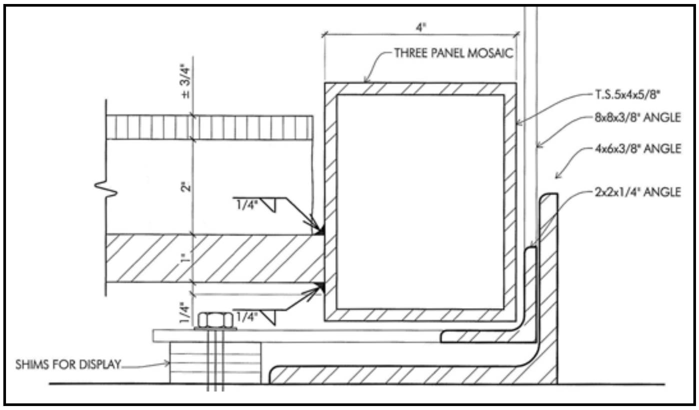


Figure 2: Contract Document Detail

friezes, plaques and mosaics. To provide real world comparisons, construction standard typical values such as L/180, L/240, L/360, L/400, L/600, and L/1200 were used. For the conservationist, this provided a deflection ratio that could be easily understood. These ratios, often seen in product literature, relate to elements such as drywall, plaster, brick masonry, and flat concrete that everyone either has in their home or, as conservationists, regularly work with. The deflection ratio utilized often depends on the degree of articulation (flexibility) of the material being supported. In the case of the three panel mosaic, L/600 was used as a reasonable compromise between a very flexible system and a system so stiff as to exceed a reasonable budget.

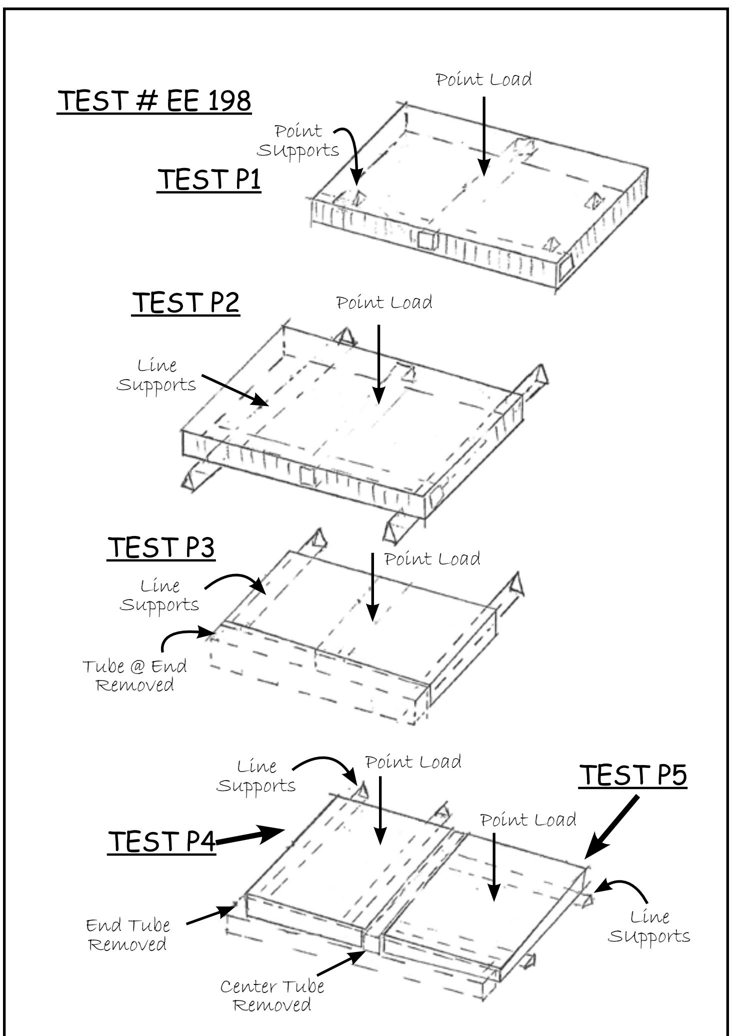


Figure 3: Load Test Set-Up

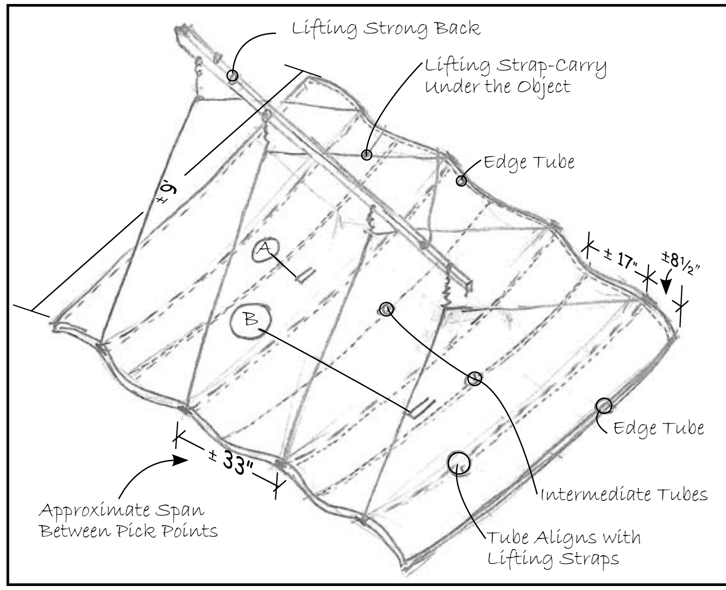


Figure 4: Isometric of Suspended Panel — Approximate Deflected Shape

Alternate Approach

The course of the project changed when the Museum, upon further review, determined that the three panels would in all likelihood be stabilized, restored, transported and set into a permanent display at the Museum of Fine Arts in Boston. In short, the complications of repeated shipping and handling would be substantially minimized. With this change in requirement, CBI and Arthur Beal (MFA's representative) undertook the task of researching a stiff backup substrate which would be lightweight and cost effective.

Past solutions used for a variety of relatively flat objects consisted of stiffened steel or aluminum plates utilizing channels, tees and angles. The mosaic project used honeycomb aluminum flat plate rectangles. Section properties of the honeycomb panels, determined by engineering approximation, were subjected to finite element evaluations. Real time samples were secured from a manufacturer for laboratory testing. Ultimately, the honeycomb panel was used in tandem with a second panel of the same shape and cross section. The need to marry two panels compositely, rather than using a single panel, was necessary to meet manufacturing constraints. A single panel consisted of two 1/32-inch thick aluminum sheets, bonded with epoxy to a typical honeycomb foil system resulting in a ¾-inch deep aluminum core. Sample sections were tested to determine accurate Young's Modulus values, following which load tests were run to confirm strength and deflection estimates. Tests were run on single thickness panels (*Figure 3*), as well as the two panel composite panels.

The system by which the panels would be handled was developed by Museum personnel and CBI Consulting Inc. The solution was a strong back and strap system suspended from a gantry as shown in *Figure 4*. The double composite panel was super stiffened to control deflection along the strap support line. The straps contributed no vertical support along their length, thus the finite element model considered only the cable reaction points. L/600 deflection ratio was utilized for the studies.

Figure 5: Bond Test

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Once satisfied that the composite honeycomb substrate had the desired properties, CBI worked with the Museum and the testing laboratory to determine the best way to secure the tesserae mosaic to the honeycombed panel. The need for proper securement was paramount. The object would, at some time in the transportation and setting process, be suspended in an inverted position. Due to the fragile nature of the tesserae, it could not be impacted by materials that would injure the tesserae themselves or cause displacement of the fragile tesserae pieces. Confined by those restraints, the solution was to develop a system of securement that would suspend the tesserae from the backside without any mechanical support. To make the object easier to handle and preserve, the MFA's conservation department planned on removing the concrete substrate that was part of the original (1930) transportation system. From a structural standpoint, this meant that it would not be possible to consider the aluminum honeycombed substrate and the tesserae as composite construction.

Figure 6: Deflection Test

A laboratory program was proposed to test a variety of conditions involving the bonding of the tesserae to the aluminum panel, and determining the composite nature of what was now the sandwiched aluminum panel necessary to create the deflection criteria desired. Belt and suspender testing was done, in order to guard against damaging or destroying a priceless art object. See *Figure 5* and *Figure 6* for a view of the testing program.

Detail View. Photo courtesy of Mei-An Tsu.

Although the structural engineer was not involved in the process of removing the concrete backup, you can perhaps imagine how complicated an issue that was. The removal process, using a traveling wet saw and involving very small increments of removal of the concrete and steel backup, took several months to accomplish and was noteworthy enough to be the subject of a separate paper by Mei-An Tsu of the MFA.

The three panels of mosaic are on permanent display at the Museum of Fine Arts in Boston, Massachusetts. The interested reader is invited to see this most remarkable undertaking in a video documentary prepared by Arthur Beal and run as part of the display.■

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