

Appendix F: Sources of Conservation Treatment Trial Products and Equipment

Materials and Products

Repointing and Mortar Repairs

SAND

Copán River sand: Collected directly from the river, south of the main Acropolis of Copán.

Chamelecón River sand: Obtained from INDECO Plantel, Chamelecón Sector, El Palmar. The sand extraction area is just outside San Pedro Sula, at the start of the road to Copán.

INDECO Office
25–24 Ave., 9 Calle N.O.
San Pedro Sula, Honduras
Tel.: 555-4700; fax: 552-6945

STONE POWDER

Green volcanic tuff powder: Obtained locally in Copán Ruinas, crushed by hand.

Yellow volcanic tuff powder: From bag of already crushed stone found at the Centro Regional de Investigaciones Arqueológicas (CRIA) (exact provenance unknown).

LIME

Llanatillos quicklime: From the village of Llanatillos, in the hills north of Copán Valley.

Chiquilas lime: From different vendors in Chiquilas, a village an hour away from Copán Ruinas, on the road to San Pedro Sula. Quicklime is available from a number of vendors, and two major commercial brands of hydrated lime can be found—Honducal and 5 Estrellas (also known as Super Estrellas).

POZZOLANIC ADDITIVES

MetaStar Metakaolin 501: Commercial product obtained in the United Kingdom from Imerys Minerals Ltd.

Imerys Minerals Ltd.
John Keay House, St Austell
Cornwall PL25 4DJ, UK
Tel.: 01726 74482; fax: 01726 625019

San Salvador tierra blanca (a volcanic tephra with a high content of pumice): From Joya de Cerén, El Salvador.

Guatemala pumice: Found locally in Copán Ruinas (exact origin unknown).

Copán clay tile: Found locally in Copán Ruinas.

MATERIALS TESTED FOR POZZOLANICITY BUT NOT POZZOLANIC

Llanatillos tierra blanca: From the village of Llanatillos, in the hills north of the Copán Valley.

Copán tierra blanca: From Barrio San Pedrito, Copán Ruinas.

Jacaleapa tierra blanca: From the town of Jacaleapa, southwest of Tegucigalpa.

Quimistán clay brick: Wood-fired brick from Ladrillo Rafon brickmaker, in the village of Quimistán, halfway between the towns of San Pedro Sula and La Entrada.

Copán clay brick: From Copán Ruinas.

Florida clay brick: Wood-fired brick from the village of Florida, just before the town of La Entrada, on the road between Copán Ruinas and La Entrada.

Los Planes clay brick: From the village of Los Planes, on the hills above the village of Santa Rita, just east of Copán Ruinas.

PIGMENTS

All pigments were obtained in the United States from Kremer Pigment Conservation Supplies Inc. The following pigments were used during the treatment trials:

κ44200 Chrome Oxide Opaque
κ40650 Raw Umber, Greenish Dark, Germany
κ40200 French Yellow Ochre Avana, Greenish

Kremer Pigment Conservation Supplies Inc.
228 Elizabeth Street
New York, NY 10012, USA
Tel.: 800 995-5501 or 212 219-2394; fax: 212 219-2395
<http://www.kremer-pigmente.de/englisch/homee.htm>

In western Honduras, some pigments were found at Comercial Larach and ACE/Fermosa hardware stores. Additional pigments should be available in Mexico:

Comercial Larach (yellow and red ochre pigments from Germany).

Las Acacias, 4 Ave., 15 y 14 Calle S.O.
San Pedro Sula, Honduras
Tel.: 552-9500

ACE/Fermosa (pigments including green chrome oxide and yellow ochre)

In Multiplaza Mall, Ave. Junior, and 3 Ave. y 4 Calle Barrio Borondillas
San Pedro Sula, Honduras
Tel.: 558-1470

Surface Stabilization

GENERAL CLEANING

Triton XL-80N: Nonionic surfactant manufactured by Dow Chemical Co., available in the United States from Conservation Support Systems.

Conservation Support Systems
924 West Pedregosa Street
Santa Barbara, CA 93101, USA
Tel.: 805 682-9845 or 800 482-6299;
fax: 805 682-2064/69
<http://www.silcom.com/~css/>

REDUCTION/REMOVAL OF PREVIOUS TREATMENTS

Acetone and distilled water: Available in Honduras in pharmacies and hardware stores.

Toluene and other common solvents: Available in San Pedro Sula, Honduras, from Transmerquim and Honduchem companies.

Grupo Transmerquim, S.A. de C.V.
Apartado Postal 2091
San Pedro Sula, Honduras

Tel.: 556-7781, 556-8770, 556-8403; fax: 556-8809;
fax ventas: 556-7590
Contact: Ing. Juan Manuel Torres, jmtorres@hn2.com

Honduchem
27 Calle N.E.
Colonia Calpules Autopista hacia La Lima
San Pedro Sula, Honduras
Tel.: 559-2043/44/45/46/47; fax: 559-2042

POULTICE MEDIA

Cellulose powder: Whatman Cellulose Powder CF11 medium fibers, manufactured by Whatman Inc., available in the United States from Markson LabSales or Fisher Scientific International Inc.

Markson LabSales
661 Route 23 South
Wayne, New Jersey 07470, USA
Tel.: 800 528-5114; fax: 800 858-2243
E-mail: CustService@markson.com
<http://www.markson.com>

Fisher Scientific International Inc.
Liberty Lane
Hampton, NH 03842, USA
General customer service tel.: 800 766-7000;
fax 800 926-1166
<http://www.fishersci.com>

Attapulgitte clay: Obtained in the United States from Conservation Support Systems.

Conservation Support Systems
924 West Pedregosa Street
Santa Barbara, CA 93101, USA
Tel.: 805 682-9845 or 800 482-6299;
fax: 805 682-2064/69
<http://www.silcom.com/~css/>

STABILIZATION OF FLAKING AND DETACHED SURFACES

Paraloid B-72 (also called Acryloid B-72): Acrylic resin manufactured by Rohm and Haas, Philadelphia, available in Honduras from Mexico; available in the United States from Talas.

Talas
568 Broadway
New York, NY 10012, USA
Tel.: 212 219-0770; fax: 212 219-0735
<http://www.talas-nyc.com/>

Rhoplex AC-35 (also called Primal AC-35): Aqueous acrylic emulsion manufactured by Rohm and Haas, Philadelphia, available in Honduras from Mexico; available in the United States from Conservation Support Systems.

Conservation Support Systems
924 West Pedregosa Street
Santa Barbara, CA 93101, USA

Tel.: 805 682-9843 or 800 482-6299;
fax: 805 682-2064/69
<http://www.silcom.com/~css/>

SURFACE CONSOLIDATION

Colloidal silica products: Ludox HS-40 and Syton X-50 are manufactured by DuPont, Wilmington, Del., and available in the United States from their nanomaterials branch.

DuPont Air Products NanoMaterials LLC
DuPont Nanomaterials, tel.: 800 356-7632
Pennsylvania facility that produces Syton,
tel.: 800 243-2143, x3636
Sales representative: Mac Anderson:
760 889-2407 (cell); 936 760-0426 (work)
<http://www.nanoslurry.com>

Specialized Tools and Equipment

Fine Sieves

Plastic six-sieve stack set (sieve sizes are 4.0 mm [#5], 2.0 mm [#10], 500 µm [#35], 250 µm [#60], 125 µm [#120], 63 µm [#230]) manufactured by Hubbard Scientific; also available in the United States from Forestry Suppliers.

Hubbard Scientific
401 W. Hickory Street
P.O. Box 2121
Fort Collins, CO 80522, USA
Tel.: 970 484-7445 or 800 289-9299; fax: 970 484-1198
<http://www.shnta.com/about.aspx>

Forestry Suppliers Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39284-8397, USA
Tel.: 601 354-3565; fax: 601 292-016
Sales: 800 647-5368
Tech support: 800 430-5566
Customer service: 800 752-8460
<http://www.forestry-suppliers.com/>

Synthetic Foam “Critical” Swabs

Available in the United States from VWR and ITW Texwipe.

VWR Corporate Headquarters
1310 Goshen Parkway
West Chester, PA 19380, USA
Tel.: 610 431-1700; orders: 800 932-5000;
fax: 610 431-9174
<http://www.vwr.com>

ITW Texwipe
300B Route 17 South
Mahwah, NJ 07430, USA
Tel.: 800 TEXWIPE; fax: 201 684-1801
E-mail: info@texwipe.com
<http://www.texwipe.com>

Small Metal Spatulas

Hand-forged Casselli spatulas, available in the United States from Talas. Fine edging spatulas were not found in Honduras, but they could be forged by a local blacksmith.

Talas
568 Broadway
New York, NY 10012, USA
Tel.: 212 219-0770; fax 212 219-0735
<http://www.talas-nyc.com>

Small Stone Chisels

Tiranti chisels available in the United Kingdom from Alec Tiranti Ltd.; Rebit chisels available in North America from Micon Products Ltd. Small stone chisels were not found in Honduras, but they could be forged by a local blacksmith.

Alec Tiranti Ltd.
70 High Street
Theale, Reading
Berkshire, RG7 5AR, UK
Tel.: 0118 930-2775; fax: 0118 932-3487
E-mail: enquiries@tiranti.co.uk
<http://www.tiranti.co.uk/>

Micon Products Ltd.
1325 Cartwright Street, Granville Island
Vancouver BC, Canada V6H 3R7
Tel.: 866 685-1285 or 604 683-1285; fax: 604 683-1597
<http://www.miconproducts.com/index.html>

Other Conservation Tools

All basic conservation tools and equipment—such as scalpels, scalpel blades, brushes, cotton swabs, syringes, needles, surgical gloves, dental picks, and rubber mortar mixing bowls—can be found in San Pedro Sula, Honduras, in large pharmacies, such as Super Farmacia Siman, and in large dental supply shops, such as Depósito Dental Moderno.

Super Farmacia Siman
6a Ave., 5a Calle, S.O. No. 32
Apartado Postal 116
San Pedro Sula, Honduras
Tel.: 553-0321, 553-1265, 552-2675

Depósito Dental Moderno
Edificio Alexandria
5 Calle, 7 y 8 Ave. S.O.
Apartado Postal 883
San Pedro Sula, Honduras
Tel.: 550-2165, 550-1380, 550-4620; fax: 550-4549

Appendix G:

Design Concepts for a New Protective Shelter for the Hieroglyphic Stairway

These notes, submitted by conservation architect Gionata Rizzi, describe his study to propose designs for a protective shelter for the Hieroglyphic Stairway in Copán. Together with the drawings in Figures G.1 to G.6, they form an *avant-projet*, a preliminary phase of design meant to explore and propose ideas to protect the original fabric of the steps and to preserve the glyphs.

The ideas suggested are based on two visits by Rizzi as consultant to the site, as well as on information provided by the GCI about scientific analyses carried out over the past years. These design concepts should not be regarded as proposals ready for implementation but, rather, as a base for further discussion with conservators, scientists, and archaeologists.

Ideal Parameters for a New Shelter

Based on the knowledge derived from the assessment of current conditions of the Hieroglyphic Stairway (**Fig. G.1**), a series of ideal parameters has been identified for developing the design of a permanent shelter:

- It should protect the Stairway from rainfall.
- It should protect the Stairway from direct sunlight.
- It should limit the temperature of the stone and, in any case, should prevent rapid thermal changes.
- It should not provide locations for birds to nest and to perch.
- It should prevent accumulation of wind-blown leaves.
- It should have a limited physical impact on the archaeological fabric.
- It should be resistant to local climatic conditions.
- It should be easy to maintain and replace.
- It should maintain an acceptable degree of luminosity.
- It should provide sufficient air exchange for the comfort of visitors.
- It should include a system to allow work to be carried out while minimizing direct contact to the stone.
- It should incorporate safety measures for the people who need to work on the steps.
- It should consider the aesthetic impact on the site and the surrounding landscape.

The First Attempts

The first attempts to give the above parameters an architectural shape (**Fig. G.2**) were generated from the idea that different approaches need to be explored before we focus on the few hypotheses that appear to be better solutions. The common denominator of these attempts is the goal of creating a structure that, although modern in design, can visually fit into the site. Given the impossibility of its being neutral, the shelter should at least be elegant.

The Velarium

This design involves a movable shelter, a canopy, that can be pulled up and down in response to the weather, exactly as the Romans did with the velarium above the amphitheaters. This approach has the great advantage of leaving the Stairway virtually unchanged when there is no rain. A movable canvas, however, provides no protection against solar radiation and fails to act as a microclimate stabilizer.

The Replica

This is a shelter that reproduces the geometry and the shape of the Stairway, an “architectural mold” raised from the original to act as a roof. This hypothesis would certainly allow good protection of the glyphs without obliterating the image of the pyramid. On the other hand, no matter what material the replica is made of, it would be a massive structure, requiring too much support from the pyramid itself. The risk of collapse due to earthquake or hurricane and the damage that such a heavy structure could cause to the original steps are also substantial disadvantages of this solution.

The Zeppelin

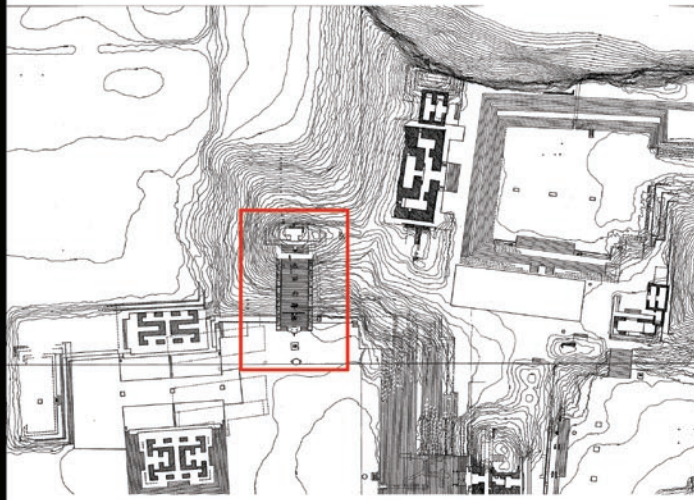
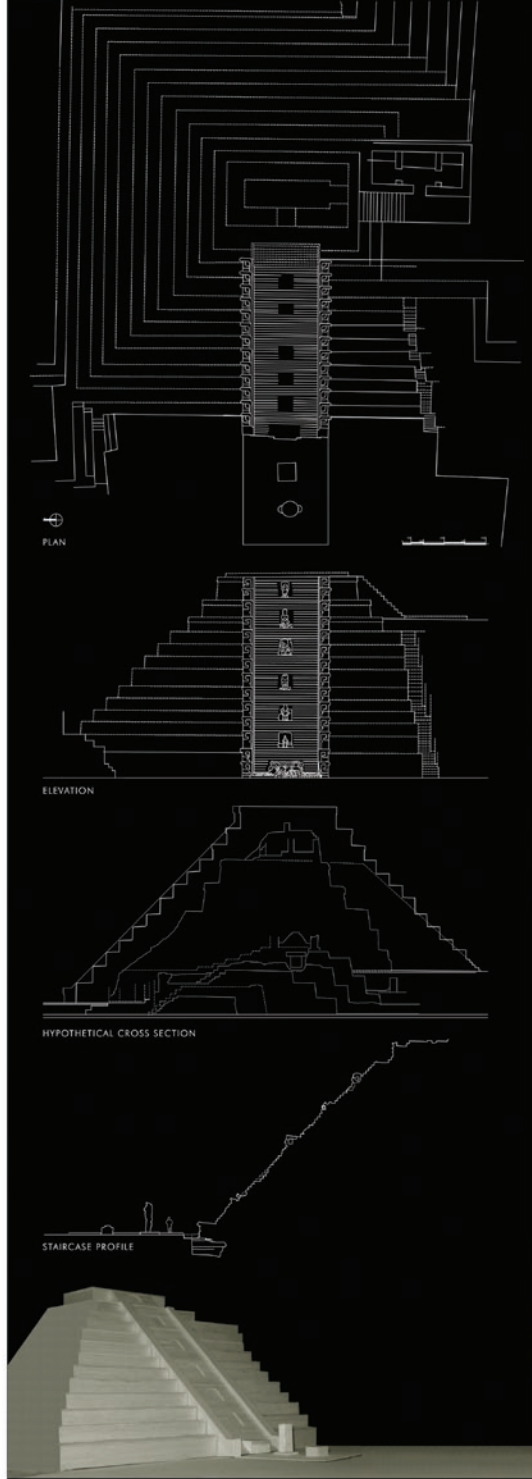
The possibility of building a suspended shelter in the form of a “flying mattress,” requiring no support except retaining cables, has been discussed with a French engineer specializing in zeppelins and balloons; technically feasible (the only question

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HIEROGLYPHIC STAIRWAY COPÁN STUDY FOR A PROTECTIVE SHELTER 01

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CONSERVATION INSTITUTE

GIONATA RIZZI with
MARZIA ALLONI DANIELA GARBETTA NATHAN FASH ARCHITECTS
GIANNI VERCELLI ENGINEER



The hieroglyphic stairway is one of the most important monuments in Copán. The glyphs, carved in a relatively weak volcanic stone, are seriously deteriorated. Scientific analysis has indicated that, in order to prevent further decay, it is essential to keep it away from water. The existing tarpaulin has proved useful to protect it from down-pours but it needs to be replaced with a more permanent structure. The new shelter ought to minimise the changes of temperature to which the stone is subjected and to prevent dry/wet cycles to occur; to do so it must protect the stair both from the sun and from the rain without inducing a "stack effect" that could result from the overheated air underneath. In addition to this, and possibly more difficult, the new shelter should create a suitable microclimate for the preservation of the stone but should not entirely prevent the perception of the stairway: it is crucial that its visual impact is appropriate for the site.



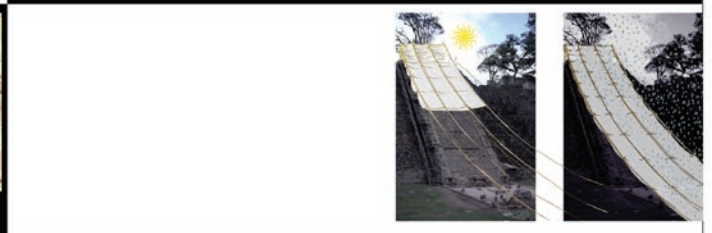
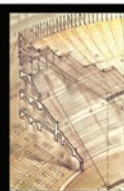
Figure G.1

HIEROGLYPHIC STAIRWAY COPÁN STUDY FOR A PROTECTIVE SHELTER 02

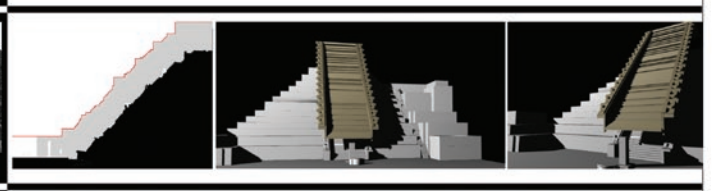
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GIANNI VERCELLI ENGINEER

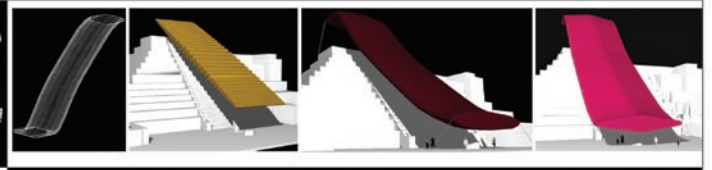
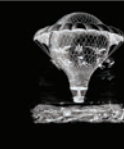
VELARIUM
A movable shelter in the form of a canvas that can be pulled up and down is not enough protection against solar radiation.



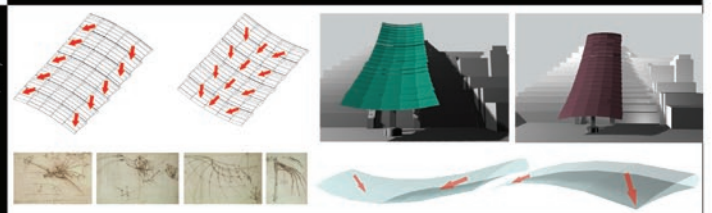
REPLICA
A shelter that reproduces the shape of the stairway would be too massive a structure and it would call for extensive support on the pyramid itself.



ZEPPELIN
An helium inflated shelter is a structure of high technological content and it would require continuous maintenance.



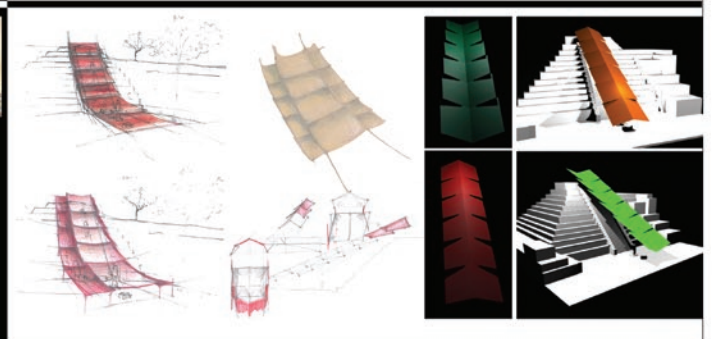
WINGS_1
Overlapping roofs made of hi-tech fabric stretched over a lightweight frame may be unstable in windy conditions.



WINGS_2
Overlapping rigid blades can be attached to suspended cables to form a "brise-soleil" through which air can circulate.



SAILS
The sails of a clipper need wind not to slack; a tensile structure needs to be three-dimensional to be stable.



FEATHERS
Fish-scales, armadillo's skin, feathers: nature has the prototypes of tiles or shingles roof. The shelter can be made of small elements recalling the "arte plumaria" of meso-america.

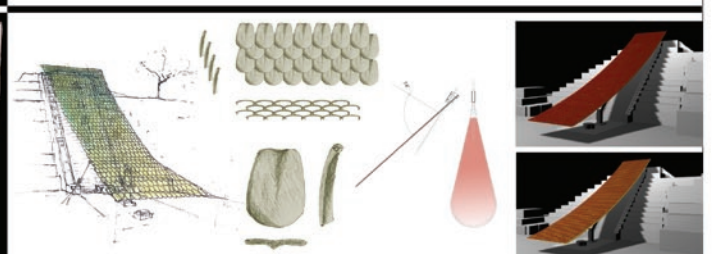


Figure G.2

being the number of cables necessary to stabilize it in the wind), this hypothesis attempts to deprive the shelter of architectural character and to make it (not just metaphorically) as light as possible. A helium-inflated structure, however, has high technological demands and requires constant control and gas refill; realistically, these types of maintenance are unlikely to be available in Copán.

The Wings 1

Overlapping roofs made of high-tech fabric stretched over a lightweight frame could be associated both with a concave and a convex shape. Visually this solution would recall the wings of a gigantic bat, an animal often portrayed in Copán sculpture. The major disadvantage is instability in windy conditions.

The Wings 2

Overlapping rigid blades built as airplane wings can be fixed to suspended cables to form a sort of *brise soleil*. Visually evocative of the shell of a lobster, it would be much more stable than the wings made of stretched fabric, but it would also be heavier. Its major disadvantage is that, under such a “carapace,” the Stairway would no longer be perceived from the site.

The Sails

A tensile structure with a system of flat sails, like those on a clipper ship, would protect the Stairway from rain and yet would allow sections of it to be seen. But to prevent slacking, the sails of a clipper need a steady wind, and a tensile structure needs to be three-dimensional for it not to flutter. The problem is that a stable, three-dimensional sail is visually obstructive.

The Feathers

Fish scales, armadillos’ skin, feathers: nature provides us with prototypes for a shelter conceived as a system of small elements, light and easy to replace. This hypothesis would translate into a somewhat deconstructed shelter recalling the plumary art of Mesoamerica. The design’s greatest drawback is the lack of precedents and the difficulty of dealing with a new building type.

The Four Proposals

The ideas described above led to four proposals, all with different characteristics, different technological contents, different aesthetic results, and specific advantages and disadvantages.

They all have the lightweight structure in common (all the shelters rest on suspended cables), as well as durability. It is possible that they all could be erected with minimal contact to the stone. Given the difficulty of building a suspended shelter parallel to the Stairway, all proposals but one are conceived to allow for air circulation, in order to prevent a “stack effect” and the consequent overheating of the air underneath.

In all proposals an attempt has been made to avoid completely blocking the view of the Stairway and to make the shelter not invisible (an impossibility) but harmonious with the site. For better three-dimensional control of the solutions proposed, a wooden model of the pyramid has been used, along with computerized models.

The schemes developed so far focus on the alternative types of shelter and do not address, in a specific way, other aspects. In all proposals, for instance, it is assumed that visitors will walk on a wooden stairway adjacent to the balustrade; there might possibly be two sets of stairs, one on each side of the Stairway—one for going up, the other for coming down.

Soil drainage at the bottom of the Stairway is obviously crucial and needs to be designed in response to the calculated water runoff; this issue is not dealt with here, since it must be addressed with consideration of the area as part of the drainage of the entire site. Protection from water and light at the top of the pyramid is also a very important issue that can only be addressed on site.

From the structural point of view, the bearing elements of all the proposed solutions consist of cables stretched from the base to the top of the pyramid. At the base of the pyramid is the anchorage point for the cables, which must be of sufficient weight to guarantee wind stability; at the top, there is the support over which, at the apex of the catenary, the cables bend toward a second anchorage point, similar to the one at the base. For a shelter 15 meters wide and 40 meters long, supported by two cables and subjected to the winds reported by the climatic study, this design may require four anchorage plinths, each about 15 m³ of concrete (approximately 5 × 3 × 1.6 m), as well as two slightly smaller foundations for the supports at the apex. These dimensions can be sensibly reduced if the action of the wind is equalized all along the catenary by transverse cables. Furthermore, the plinths at the top of the pyramid can be replaced by “root-poles” of adequate diameter and length.

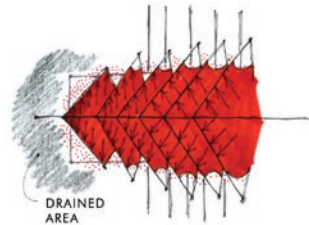
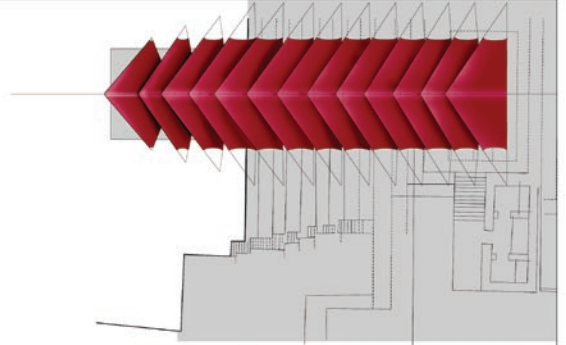
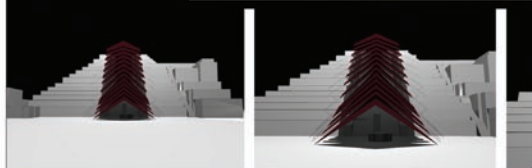
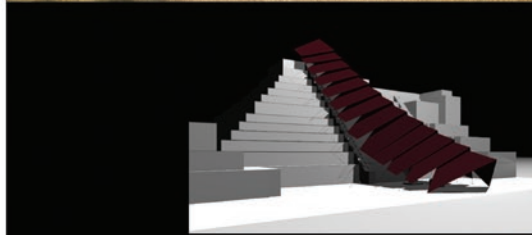
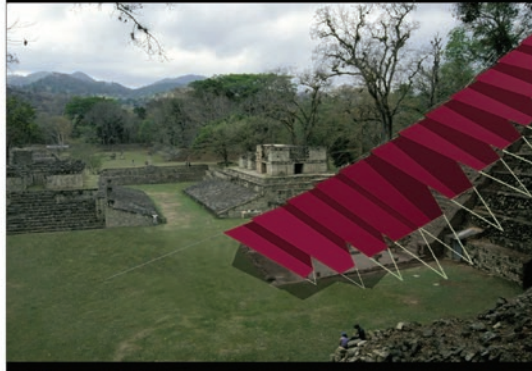
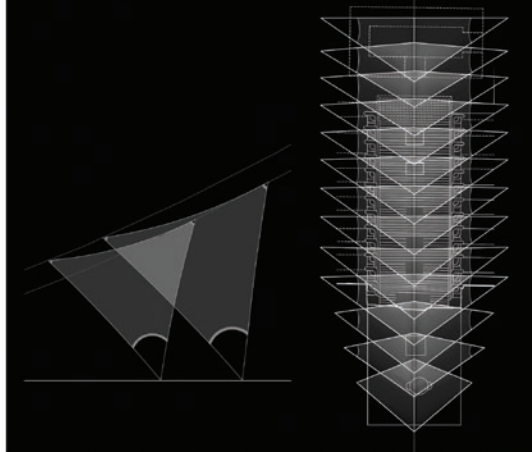
Once the cables are tensioned, all types of shelter can be erected with minimal intervention on the steps; the same is true for maintenance and replacement. In the first two cases, the sheltering elements can be pulled along the cables themselves; in the other two, the elements function directly on top of a structural net.

Cascading Sails

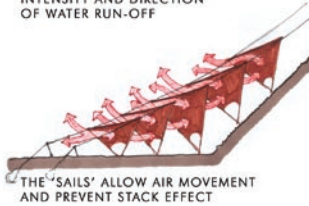
Picking up where the current tarpaulin shelter has left off, this proposal (**Fig. G.3**) seeks to improve appearance and resolve existing issues of conservation, while maintaining a similar material set and structural system. The evolving design departed from the minimalist idea of simply reusing the existing covering while allowing it to breathe both visually and physically. Like the existing cover, the tensile structure is kind to the unsculpted portion of the temple, as it requires minimal anchoring points. The design also guarantees an equivalent degree of protection against sun and rain, while allowing a freedom of choice in canvas color. To make the system stable, the “clipper sails” have been replaced by rhomboid sheets

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GIANNI VERCELLI ENGINEER



INTENSITY AND DIRECTION
OF WATER RUN-OFF



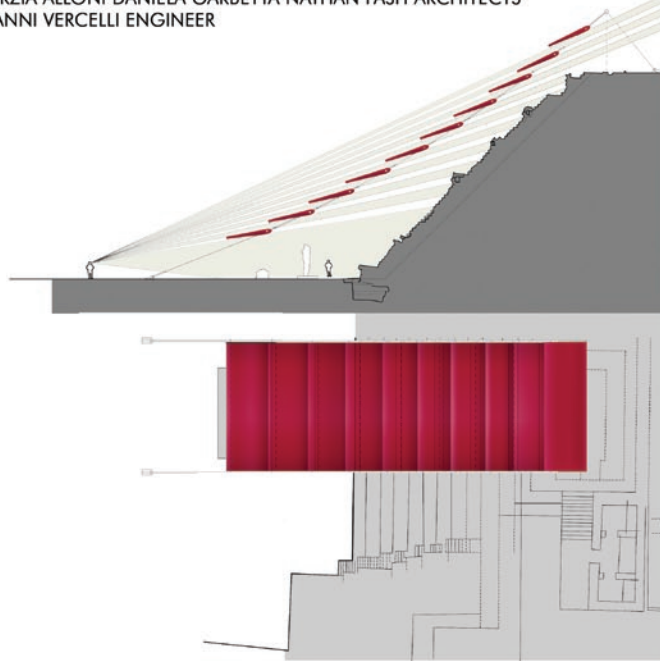
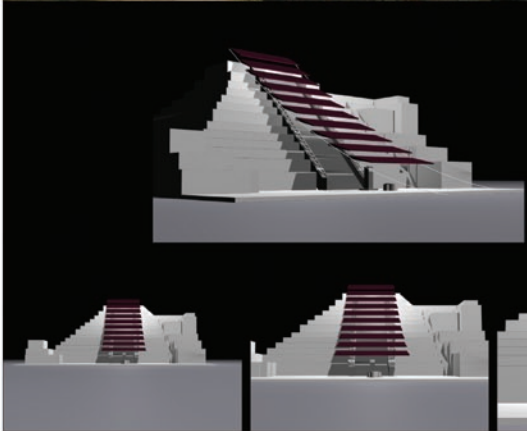
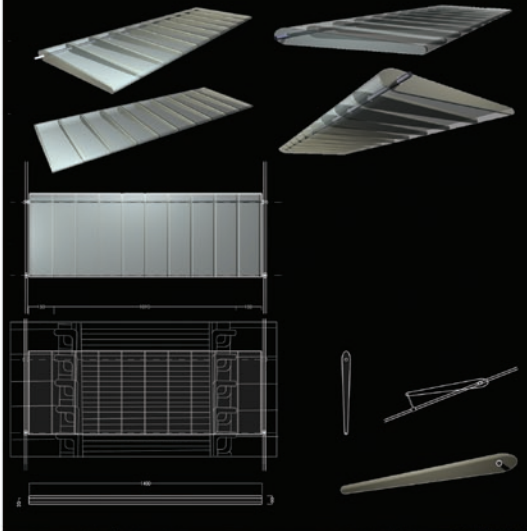
THE 'SAILS' ALLOW AIR MOVEMENT
AND PREVENT STACK EFFECT

SAILS the simplest hypothesis: an improvement of the existing tarpaulin. It consists of a series of overlapping sails, bent in the middle to ensure wind stability. Two central cables running parallel from top to bottom allow the sails to be stretched one above the other with some space in between. The discontinuity of the shelter makes it possible for air to move in and out and thus prevents the "stack effect" from occurring. Water run-off takes place mainly at the bottom where the soil must be drained, but also on the sides that ought to be protected at floor level. Sails can be made of the same fabric as that of tensile structures (polyester, kevlar or dakron) the durability of which exceeds 25 years and that can be treated against biological growth.

Figure G.3

THE GETTY CONSERVATION INSTITUTE

GIONATA RIZZI with MARZIA ALLONI DANIELA GARBETTA NATHAN FASH ARCHITECTS GIANNI VERCELLI ENGINEER



INTENSITY AND DIRECTION OF WATER RUN-OFF



AIR CIRCULATION PREVENTS STACK EFFECT

WINGS two suspended cables running parallel on the sides of the hieroglyphic stairway support ten lightweight blades as in a gigantic "venetian blind". The overlapping of the blades guarantees rain protection whereas the space between them allows air circulation and therefore prevents the "stack effect" from occurring. The blades slope at an angle which corresponds to the viewpoint of a person standing some 30 meters from the base of the pyramid so that, from this given position, they present minimum visual hindrance and allow the stair to be seen through the shelter. All water run-off takes place at the bottom in an area in front of the pyramid where the soil must be drained. The blades are built with the same technology of an aircraft's or glider's wings, with a rigid inner structure and aluminium or fabric skin.

Figure G.4

folded symmetrically along a central axis. In order to allow air circulation, as well as angular adjustment of each sail, two central cables were introduced, one above the other. Each sail is fixed along this central axis between the two cables and anchored to the ground at its two outer points. Each sail must be of a different size to accommodate the changing pitch of the cables. The final design presented herein utilizes this modulation to evoke a nearly organic form, reminiscent of many shells from the animal kingdom. Its repeating terraces also recall the form of the step pyramid seen in Copán and throughout the Maya world.

From the point of view of conservation, this type of shelter seems to offer good protection at the sides, both from wind-driven rain and wind-blown leaves (it obviously reduces the view of the Stairway from the sides), and seems to allow good air circulation. The fabric can be treated with a long-term biocide to discourage vegetal growth, and the color can be selected to obtain the desired level of luminosity. Thanks to the synthetic fabrics used today, tensile structures of this type have a life span of over thirty years.

Water runoff collects both at the bottom of the stair and at its sides, which need to be protected with a “stepping gutter,” possibly made of copper. Structurally quite simple, this system of sails can be pulled up, as on a yacht, with a winch installed at the top of the pyramid.

Wing Series

Much like the Cascading Sails design, the Wing Series presents itself as an array of repeating horizontal rigid members that span the width of the Hieroglyphic Stairway (**Fig. G.4**). Stepping boldly down the slope of the temple, it resembles the familiar Maya pyramid. Furthermore, the continuous sloped surface of each wing establishes an even greater contextual parallel with the neighboring Copán Ballcourt.

This system suggests a monumental venetian blind, with its lightweight winglike rigid members hanging from two parallel outer cables. The pitch and the overlapping of the blades guarantee rain protection, while the space between them allows for air circulation.

Each wing is built with the same technology used for airplanes or gliders; the surface can be either metal (possibly copper) or resin-coated synthetic cloth; the color choice is open. Each wing is rotated along the horizontal axis between the two points of attachment (a vertical adjusting device fixes it at the desired angle), and this adds a unique and powerful visual component to the design by making the Stairway visible from a given distance: in fact, the blades slope at an angle that corresponds to the viewpoint of a person standing about 50 meters from the base of the pyramid; from this vantage point, only the thickness of the wings would be a visual hindrance. This design would provide the visitor with an otherwise unattainable view of the Stairway “through” the shelter.

From the point of view of conservation, this type of shelter offers good protection from rainfall and solar radiation, but it is slightly less effective than the Cascading Sails design in protecting the sides from wind-driven rain and wind-blown

leaves. The materials have good durability (the metal skin option is more reliable but also heavier). Luminosity may be a problem, since the wings are completely opaque, but the amount of light passing through the wings and from the sides should be sufficient. Water runoff collects only at the bottom of the Stairway, and it needs to be properly drained.

Structurally this shelter calls for two parallel cables, one on each side, to support the wings. The sheltering elements are constructed like the wings of an airplane, except that they are supported at both ends. Fixing points to the cables are at the back, where the thicker section accommodates the transverse bearing element. During the assembly phase, each wing is set on the cables and, pulled up by a rope, it slides on two pulleys until it reaches its position. In order to guarantee the lateral stability of the shelter, the system will be braced by lateral cables anchoring the main cables.

Feather Skin

This proposal takes its formal inspiration from Mesoamerican plenary art and from the scarlet macaws, or *guacamayas*, resident in Copán (**Fig. G.5**). The protective weather shield, which appears continuous from a distance, is in fact a suspended array of adjacent but individual high-tech modules—the “feathers”—made as modern kites of Kevlar fabric stretched over a fiberglass framework. All of the feathers are identical in geometry and construction, simple in form, lightweight, and easily replaced. They are mounted on a group of steel cables running parallel from the top to the bottom of the pyramid. When the viewer looks down at the shelter, the central portion appears concave. The geometry and layout of the feathers allow rain to drain laterally as well as down the length of the cover, and there is no chance of penetration between the individual units. With a limitless palette of colors, the shelter becomes a blank canvas, or a matrix of pixels, to be experimented with creatively. The numerous subdivisions deconstruct the whole, rendering the surface nearly immaterial. It is a breathable skin of feathers that rustle gently in the wind.

From the point of view of conservation, this type of shelter can provide good protection against rain and sun, although the sides are rather open. The fabric that the feathers are made of can be treated with long-term biocide to discourage vegetal growth, and the color can be selected to obtain the desired level of luminosity. Air circulation takes place throughout the shelter, so that the air is not overheated. This factor contributes to the comfort of the visitors.

Water runoff collects both at the bottom of the stair and at its sides, which need to be protected with a “stepping gutter,” possibly made of copper.

Structurally this type of shelter calls for a series of longitudinal cables crossed by transverse ones. Together they provide the grid on which the “flexible tiles” can be fixed. The feathers are fastened from the stem at two adjacent cables, so as to provide stability and the proper pitch. Feathers are mounted one by one on the metal net after it is tensioned.

continued on p. 144

HIEROGLYPHIC STAIRWAY COPÁN STUDY FOR A PROTECTIVE SHELTER 05

THE GETTY
CONSERVATION INSTITUTE

GIONATA RIZZI with
MARZIA ALLONI DANIELA GARBETTA NATHAN FASH ARCHITECTS
GIANNI VERCELLI ENGINEER

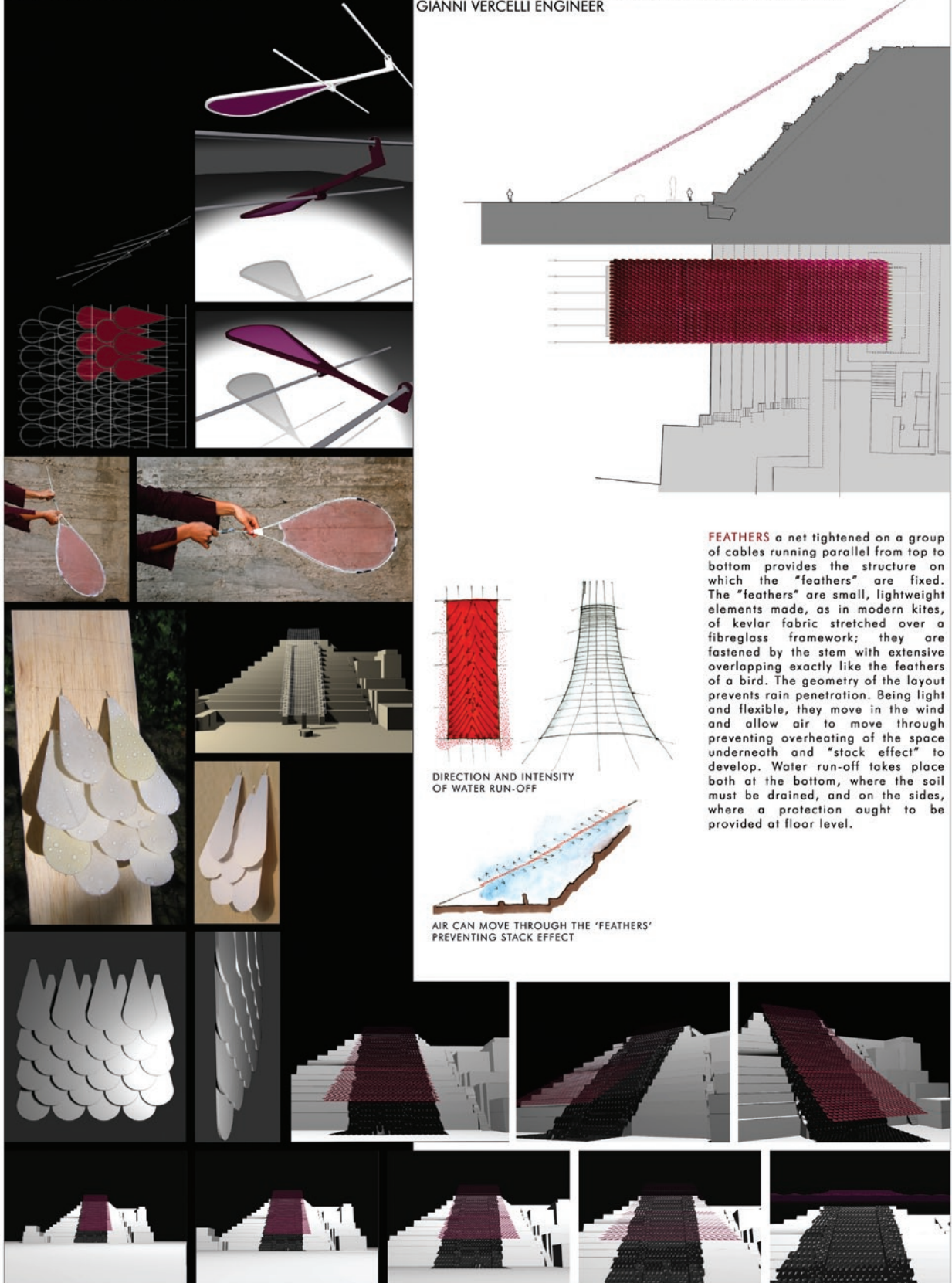
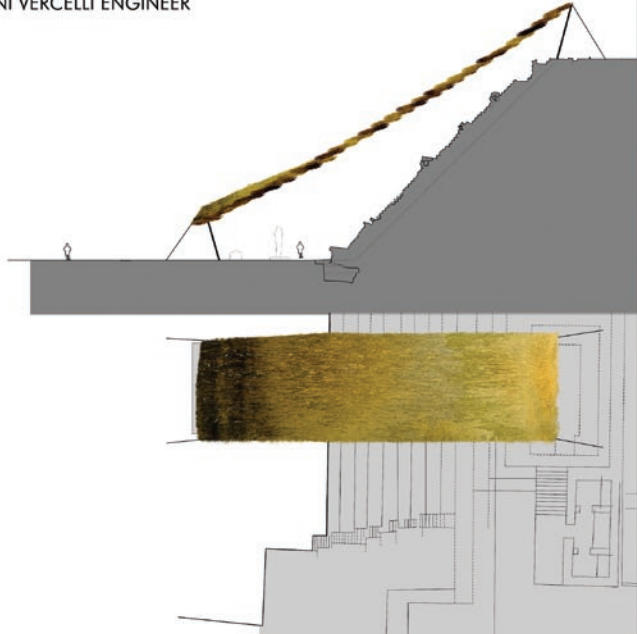
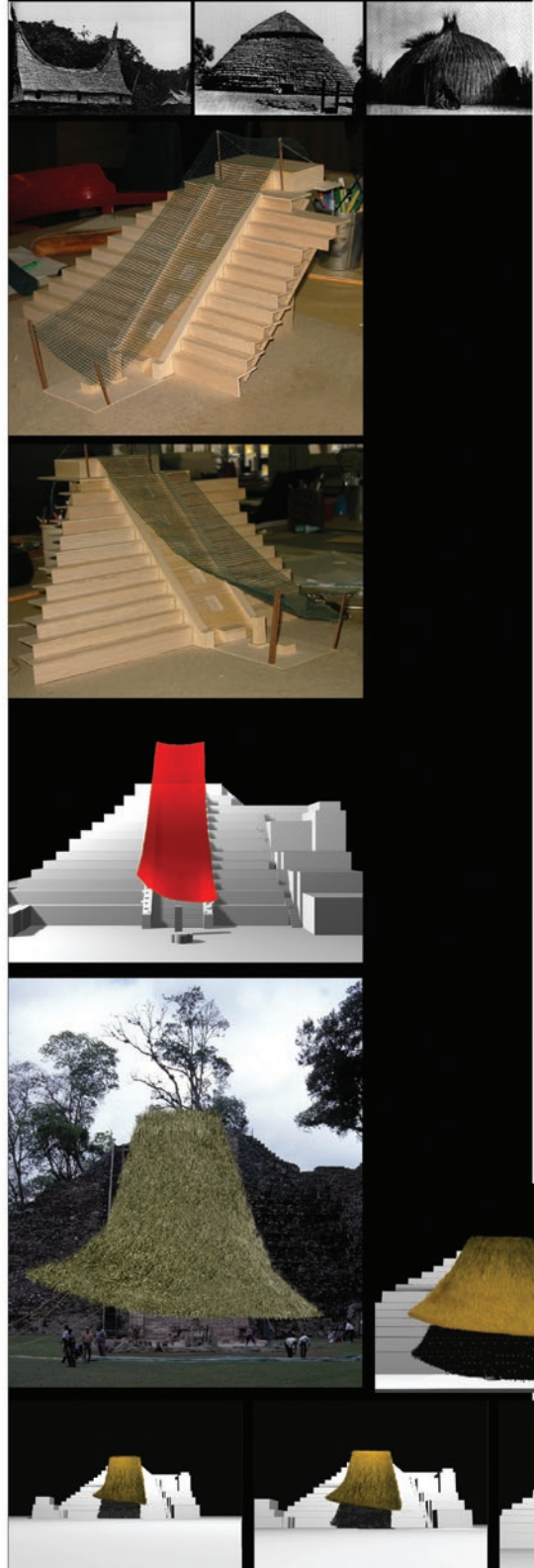


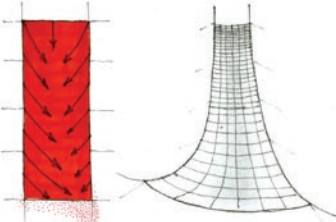
Figure G.5

THE GETTY
CONSERVATION INSTITUTE

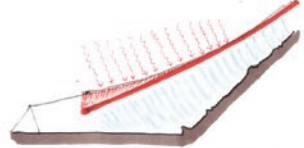
GIONATA RIZZI with
MARZIA ALLONI DANIELA GARBETTA NATHAN FASH ARCHITECTS
GIANNI VERCELLI ENGINEER



STRAW a net tightened on a group of cables running parallel from top to bottom provides the structure on which a traditional thatch is built. The shelter is a combination of modern and traditional technology that could largely be implemented with local resources. It will not be very durable but easy to repair and bound to receive adequate maintenance. The bottom north corner of the shelter is raised to improve the perception of the stair for visitors coming from the ball court. The thatch does not allow air circulation but provides good thermal insulation. Water run-off takes place mostly at the bottom south corner where the soil must be drained.



DIRECTION AND INTENSITY OF WATER RUN-OFF



STRAW ALLOWS NO AIR CIRCULATION BUT PROVIDES GOOD INSULATION

Figure G.6

Straw Blanket

The choice to utilize straw as the primary sheltering material ties this design to local building practices passed down from antiquity to the present day. Unlike the common thatch roof still in use in this part of the world, however, the straw blanket is affixed to a technologically sophisticated net and suspended in the air as a tensile structure (**Fig. G.6**). The thatch blanket envisioned in this proposal is of the same kind that is crafted today by the townspeople of Copán. Engaging the construction practices and materials native to the region adds a valuable element of local involvement, local pride, and local economy. As a natural organic material, the straw can age gracefully and be easily replaced by the use of local skills, labor, and materials. The required thickness of the thatch makes the blanket very visible, but its presence and purpose are very familiar in this context. The design suggests the unusual and intriguing image of a straw landslide, terminating at ground level with a lobe that is lifted like the corner of a blanket, visually revealing the sheltered artifact and inviting the incoming flow of visitors.

From the point of view of conservation, the straw blanket can certainly offer good protection from rain and sun, although the sides are somewhat open. It does not allow for air circulation, but it provides the best thermal insulation, so that overheating of the space below is unlikely to be an issue. Illumination may be a small problem, but light intensity should not differ much from the Wing Series. Straw, if properly fixed and properly maintained, lasts over twenty years, and it is very easy to repair.

Water runoff, which collects only at the bottom of the stair, needs to be appropriately drained.

Structurally, this shelter is similar to the Feather Skin, since it has a series of longitudinal cables supporting a metal net to which the straw is tied. The straw is fixed manually from the top, after the suspended structure is tensioned.

The weakness of this proposal lies in the fire risk—particularly from arson—inherent in the straw blanket. It is possible, however, to fireproof thatch by treating it with a solution of sulfate of ammonia, carbonate of ammonia, boric acid, and alum. This is best done by dipping the thatch before it is fixed to the net. However, the treatment must be repeated periodically.

Conclusions

Certain aspects remained unexplored at this stage. It is very difficult, for instance, to make cost estimates for structures that are so unconventional that they have no precedents; only for the Cascading Sails was it possible to price the sails themselves (€55,000, or about us\$70,000). However, it was not possible to price the cable system, for which local costs will need to be investigated.

A movable platform to allow operators to work on the Stairway without physically walking on it can certainly be devised as an addition to the cable system; however, the mechanism involved, the weight of the platform itself, and the damage it could cause in case of collapse suggest that allowing

workers to occasionally walk on the steps with the proper shoes represents a more acceptable risk. With regard to the safety of the operators, the best answer seems to be the use of harnesses.

Finally, preventing people from accessing the Stairway is an issue that can hardly be dealt with by a shelter that is meant to be, visually, as permeable as possible.

Appendix H: Photographic Monitoring Protocol for the Hieroglyphic Stairway

Photography offers one way to monitor the condition of the Hieroglyphic Stairway in the future. By regularly photographing selected areas of the Stairway under identical conditions and then by comparing photographs, changes in condition can be detected and the rate of deterioration monitored. This practice will help in the formulation of informed conservation decisions and enable the site's caretakers to take remedial actions as appropriate.

A number of stone blocks, called control blocks, have been chosen to be photographed at regular intervals. They were selected from various locations over the entire Stairway and are representative of the different types of conditions occurring on the monument. Many of them are among the blocks most likely to deteriorate in the near future, and therefore, they will provide an early indication of potential problems affecting the entire Stairway.

Protocol

To produce similar photographs through time, a photographic monitoring protocol based on nonstereoscopic photography, using 35 mm digital and analog cameras, was established. The protocol considers the many variables available when taking photographs, and it reduces these to a set of unique instructions. These instructions must be followed strictly for photography to be a successful monitoring tool. The protocol involves specifications in the following areas (see **Table H.1**):

- Location
- Distance (scale)
- Lens focal length
- Overlap between images
- Coverage
- Scale bar and reference
- Film or sensor type
- Film and sensor sensitivity
- Illumination type
- Illumination direction
- Exposure speed
- Aperture

Table H.1 Parameters for the photographic monitoring protocol.

Location	Center of each glyph.
Distance (scale)	1 m distance (\pm 2–3 cm) ensures the 20% minimum overlap.
Lens focal length	Film camera: 35 mm. Digital camera: 28 mm.
Scale bar and reference	Scale bar, block number, and date within the field of view. Scale bars should remain in the same position for each block, if feasible.
Film or sensor type	Film camera: Kodak T-Max monochrome. Digital camera: $\frac{2}{3}$ digital array color (23 mm \times 15 mm).
Film and sensor sensitivity	100 ISO for film and digital.
Illumination type	Single flash.
Illumination direction	Overhead, 1 m above camera. General shot: 0.65 m distance away from the stone (ca. 60° from horizontal). Raking light: 0.35 m distance away from the stone (ca. 70° from horizontal).
Exposure speed	$\frac{1}{60}$ second (flash synchronization mode).
Aperture	f/22 for most (f/20–f/25 for some). All photographs within the same block are taken with the same aperture. All photographs are bracketed with the nearest available apertures.

Location

One photograph should be taken for each glyph of a control block, directly perpendicular to the glyph's center. It is the simplest method, as opposed to taking photographs at a set interval apart.

Individual glyphs often span two blocks, and sometimes only a very small portion of a glyph belongs to a given block, and it can generally be captured on the photograph of the glyph next to it. Taking this fact into consideration, it was determined that forty-two photographs should be taken for the protocol.

Distance (Scale)

The distance chosen between the camera and the stone block is 1 meter, and it is equivalent to the width of approximately three

steps. The camera position only needs to be precise to 2–3 cm. Note that the distance is measured from the block to the camera back, where the film or digital sensor is located, not from the block to the camera lens.

Lens Focal Length

The analog camera uses a 35 mm lens for the protocol. This is a wide angle lens, but not so wide as to introduce distortions. The digital camera uses a 28 mm lens. A wider angle is used for the digital camera than for the analog camera because the two-thirds array (25 mm × 15 mm) of the digital camera doesn't cover the full area of 36 mm × 24 mm of a film camera. This has the effect of turning a wide angle into a normal angle, and a normal angle into a short telephoto lens. A 28 mm lens on a two-thirds array digital camera is equivalent to about a 44 mm lens in terms of the angle of view.

Overlap between Images

By photographing every glyph centrally, the overlap between images is 40% to 50%, which fulfills the 20% minimum overlap requirements. Therefore, detail lost at the edges of any photograph because of the relief in the glyphs will be picked up on the adjacent photograph.

Coverage

The coverage at 1 meter is approximately 1.0 m wide × 0.65 m high with the 35 mm lens on the film camera, and 0.8 m wide × 0.5 m high with the 28 mm lens on the digital camera.

Scale Bar and Reference

All protocol photography should have a scale bar and reference information (block number and date) within the field of view. If there is more than one photograph taken per control block, the scale bar should remain in the same position in all the images of the block, if this is feasible. If a 1-meter scale bar is used, the only exception is block 2, because of its length of approximately 1.9 m, for which the scale bar will have to be moved.

Film or Sensor Type

The film used in the analog camera is black-and-white Kodak T-Max, which can be processed at CRIA. The digital sensor of the recommended digital camera (Canon EOS 300D/Digital Rebel) is a two-thirds (25 mm × 15 mm) 6-megapixel array.

Film and Sensor Sensitivity

The speed or sensitivity of the film is 100 iso. The default setting of 100 iso is used in the digital camera.

Illumination Type

For simplicity, and to reduce the amount of equipment in the field, it was decided to use flash directly, without reflector, and off camera.

Illumination Direction

It was decided for the protocol photography that the relief in the glyphs should be accentuated by using one illumination from above, to be more consistent from block to block. As a number of control blocks are located up against the balustrades or the Seated Figures, any sideways illumination would have to be varied from left to right, and although this wouldn't be a problem to remember, illuminating from above is more consistent. Lighting from above also removes hot spots of illumination at the sides of the photograph.

All photographs are taken with the flash placed 1 meter above the camera. It was decided that the relief in the glyphs should be accentuated by flash—but not by so much that all detail in the recesses of the glyphs would be lost. The position of the flash at a distance of approximately two steps away from the glyph (around 0.6–0.7 m) and 1 m above the camera corresponds to an angle of approximately 60°–55° between the horizontal and the flash and gives a good balance between accentuation of the relief and the amount of shadows.

For certain blocks, in addition to the previous direction of illumination at 60°, a more raking light could be employed to highlight surface relief and bring out more subtle surface variation if required, but this would be at the expense of detail within the recesses of the block. For this purpose, a good position for the flash is one step away from the glyph (approximately 0.35 m) and 1 m above the camera, which corresponds to around 70° from horizontal. Any photograph at this angle should be considered only as a supplement to the photography at 60° and not as a replacement, as it would otherwise invalidate any consistency in the protocol for future comparisons.

Exposure Speed

For consistency of illumination among the control blocks and over time, flash should be used for all photography. Thus, exposure speed is always in flash synchronization mode at $\frac{1}{60}$ second.

Aperture

For a quality image and improved depth of field, small apertures are generally used. The aperture is determined by the camera according to the amount of light available, as the exposure speed synchronized with the flash is always the same. Experimentation shows that under the Stairway tarpaulin, apertures are generally f/16 and f/22, due to the slight variations in reflectivity of the block surfaces. The list of control blocks in **Table H.2** gives the recommended aperture for each block. Where there is more than one photograph per control block (e.g., five photos [glyphs] for control block 2), all those within a block are taken at the same aperture.

All exposures are bracketed—i.e., for each photograph, two additional photographs are taken using one aperture above and one aperture below the optimum aperture. For example, if the optimum aperture is f/22 and one-third stops are available on the camera chosen (this is the case with the recommended

Table H.2 Protocol photographs for each of the Stairway control blocks.

<i>Step</i>	<i>Block</i>	<i>Glyph(s) to be photographed</i>	<i>Number of photos to be taken</i>	<i>Recommended aperture (f-stop)</i>
1	2	FGHIJ	5	22
11	71	F	1	22
12	83	DE	2	25
12	86	IJK	3	22
23	203	P	1	22
23	204	Q	1	22
36	342	H	1	20
36	343	IJ	2	20
41	375	A	1	22
41	376	BC	2	22
43	409	PQ	2	22
43	410	RS	2	22
45	422	MN	2	22
50	462	ABC	3	22
52	483	HI	2	22
58	549	LM	2	20
59	551	ABC	3	22
61	575	M	1	20
61	576	N	1	20
61	578	QR	2	22
63	592	F	1	25
63	594	H	1	20
63	595	I	1	20



Figure H.1 Example of protocol imagery with scale bar and block number (date is missing).



Figures H.2a and b Examples of the two individual full-frame images to be taken for block 376, step 41, to obtain full coverage of the block; (a) shows glyph B, and (b) shows glyph C.

digital camera), then two more photographs should be taken at f/20 and at f/25. The analog camera recommended has half-stop intervals.

It should also be understood that any small variation in the angle or position of the flash will have an effect on the exposure. As the flash is handheld off camera, some variation will be inevitable, which is another compelling reason to bracket the exposures.

Figure H.1 is an example of a protocol photograph. All protocol photography should have a scale bar, block number, and the date of photography placed above the block.

Table H.2 presents a summary of the protocol photographs to be taken for each of the control blocks. As one can see, some of the longer blocks require several individual protocol photographs in order for full coverage of the block to be achieved.

Figures H.2a and b show two individual full-frame images that need to be taken to obtain full coverage of block 376. Note the overlap and the straddling of glyph B across the blocks.

The following photographic equipment was furnished to ИИАН for future photographic monitoring of control blocks of the hieroglyphic stairway:

Digital camera

Body: Canon EOS 350D/Digital Rebel XT 8 mp
Lens: Canon 28 mm f1.8 EF USM

Analog camera

Body: Canon EOS Rebel K2
Lens: Canon 35 mm f1.8 EF USM

Flashgun

Canon Speedlite 550 DFX

Tripod and tripod head

Manfrotto 3021 PRO and Manfrotto 329RC4

Figures H.3 through H.25 present all of the control blocks, each in a single image, to help in recognition of the blocks when the protocol photographs are taken on the Stairway. White crosses indicate the approximate centers of each individual photograph. Where there are several photographs (and glyphs) per block, the images have been mosaicked for convenience of presentation. Some of the composite images are made up of the cropped images of those glyphs that are only partly on the relevant block. For example, on block 578 the left-hand cross on glyph Q is at the extreme left edge, as the center of the glyph corresponds approximately to the left edge of the block. The mosaics are not geometrically correct (especially for block 2) and were created with the Canon software (Zoom-Viewer EX) accompanying the digital camera.

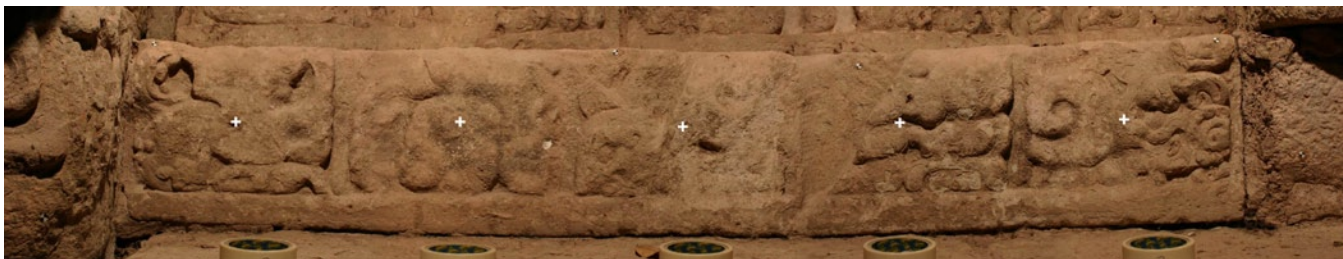


Figure H.5 Step 1, block 2, glyphs F–J.



Figure H.4 Step 11, block 71, glyph F.



Figure H.5 Step 12, block 85, glyphs D, E.



Figure H.6 Step 12, block 86, glyphs I-K.



Figure H.7 Step 23, block 203, glyph P.



Figure H.8 Step 23, block 204, glyph Q.



Figure H.9 Step 56, block 542, glyph H.



Figure H.10 Step 56, block 543, glyphs I, J.



Figure H.11 Step 41, block 375, glyph A.



Figure H.12 Step 41, block 376, glyphs B, C.



Figure H.13 Step 45, block 409, glyphs P, Q.



Figure H.14 Step 43, block 410, glyphs R, S.



Figure H.15 Step 45, block 422, glyphs M, N.



Figure H.16 Step 50, block 462, glyphs A-C.



Figure H.17 Step 52, block 483, glyphs H, I.



Figure H.18 Step 58, block 549, glyphs L, M.



Figure H.19 Step 59, block 551, glyphs A-C.



Figure H.20 Step 61, block 575, glyph M.



Figure H.21 Step 61, block 576, glyph N.



Figure H.22 Step 61, block 578, glyphs Q, R.



Figure H.23 Step 63, block 592, glyph F.



Figure H.24 Step 63, block 594, glyph H.



Figure H.25 Step 63, block 595, glyph I.

