CONSOLIDATING MUD BRICK AT AL-HUMAYMA, JORDAN

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BACKGROUND

Archaeological site of al-Humayma

- Chief Nabataean, Roman, Byzantine and early Islamic centre in the Hisma, Jordan's southern desert.
- Major occupation from 1st to early 7th centuries AD.
- Excavation of Field E125 by Dr. M. Barbara Reeves of Queen's University (Canada).

Field E125

- Low mound approximately 30 metres in width at the centre of the site.
- Excavation uncovered late Roman mud brick walls.
- Walls identified as fortified house used by historic Abassid family in their revolt against the Umayyad dynasty in the mid-8th century AD.

Degradation of mud brick

- Rainfall leads to separation of clay particles that bind mud bricks.
- Although rainfall in the Hisma averages only 80 mm per year, torrential storms are common in the winter months.
- al-Humayma sits in a triangular catch basin and flooding occurs regularly in the winter. Accumulation of standing water has lead to deterioration of mud walls at Field E125.

Purpose of the research project

- To investigate the effectiveness of chemical consolidants to stabilize the mud brick architecture at al-Humayma.

A suitable consolidant will…

- Confer stability and durability with as little introduced material as possible.
- Increase resistance to water penetration and abrasion by wind-carried particles.
- Have a low viscosity to ensure thorough penetration.
- Leave pores and capillaries open and unaffected.
- Not change the original colour or gloss of the mud brick.
- Avoid the use of water as a carrier.
- Be reversible if possible.
- Be easy and safe to use.
- Be inexpensive. (Bultinck, 1969)

Consolidants previously tested

- The Getty Conservation Institute has tested the following in a number of mud brick preservation experiments:
  - Conservare H100 Consolidation Treatment (Prosoco Inc.)
  - Desmodur N-3390 (Bayer-Mobay Co.)
  - 5% Paraloid B-72 (Rohm and Haas) in toluene

Mud brick walls at Field E125, al-Humayma
(photo provided by Dr. M. B. Reeves)

EXPERIMENTAL

Removing clay from sand and silt

Separating sand and silt through gravimetric settling

Sample Preparation

- The content of sand, silt and clay from soil collected at Field E125 (26%, 55% and 19%, respectively) was compared to the contents of an actual mud brick from the site (69%, 14% and 17%, respectively).
- It was necessary for the contents of the soil to closely match the mud brick, so soil was separated through gravimetric settling.
- Component parts then recombined, with addition of non-reactive silica to raise sand content, in order to obtain ratio of approximately 70% sand, 15% silt and 15% clay.
- Soil was mixed with distilled water and poured into cylindrical moulds, measuring 1.5 cm in diametre and 3 cm in height, to make 33 small plugs.
- Plugs were baked at 50ºC (temperature similar to that found at the site) for 48 hours.

Consolidation

- 6 plugs remained untreated.
- 9 plugs were treated with H100 Consolidation Treatment, 9 with Desmodur N-3390 and 9 with 5% Paraloid B-72 in toluene.
- Plugs were soaked in consolidants for 5 minutes, then wrapped in aluminum foil and left to set over night.
- Treated plugs were then baked for 24 hours (until equilibrium mass was reached).

Plugs soaked in consolidant

Plugs wrapped in aluminum foil

Colour Measurements

- A visual examination of the plugs was performed following consolidation in order to identify colour change.

Compression Testing

- 3 of the untreated plugs and 3 of each type of treated plug were subjected to compression testing with an Instron Screw Driven Tensile Tester.
- Unit progressed at a rate of 0.1 seconds for 60 seconds.
- Measurements of load versus time were taken to determine how much stronger the plugs became with the addition of consolidants.

Accelerated Aging with Wet-Dry Cycling

- 3 of the untreated plugs and 3 of each of each type of treated plug were weighed to establish their dry weight.
- They were then soaked for 24 hours in distilled water, and weighed again to see how much water weight they had taken on. The plugs were then baked for approximately 24 hours, or until they reached an equilibrium mass. This two-step process was repeated nine more times.
- The testing was performed to see how well the consolidants would protect the plugs from disaggregation by means of water absorption.

Plugs treated with consolidants

RESULTS

Colour Change after Application of Consolidant and Baking

- 5% Paraloid B72: slight darkening.
- H100 Consolidation Treatment: little colour change.
- Desmodur N-3390: drastic darkening.

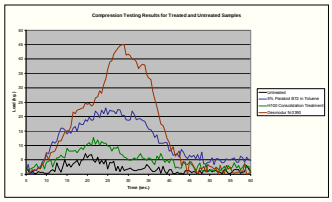
Untreated

5% Paraloid B72 in toluene

H100 Consolidation Treatment

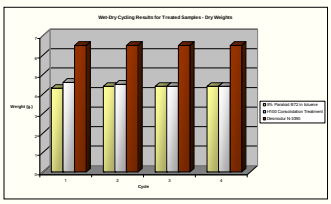
Desmodur N-3390

Compression Testing Results



- Untreated samples had little strength.
- H100 added only a small amount of compressive strength.
- 5% B72 made samples significantly stronger than H100.
- N-3390 provided the most strength.

Accelerated Aging with Wet-Dry Cycling



Untreated samples:

- disintegrated immediately with first immersion in distilled water.

Samples treated with H100 Consolidation Treatment:

- lost an average of 0.2 g of their starting weights because they became extremely soft following the second cycle, and lost small amounts of mud each time they were re-immersed in water.

Samples treated with 5% Paraloid B72 in toluene:

- retained an average of 0.1 g of water following four rounds of wet-dry cycling.
- samples remained relatively sturdy, but began to soften after the first soaking.

Samples treated with Desmodur N-3390:

- gained an average of 2 g more than B72 or H100 treated plugs following initial consolidation and baking.
- weight remained consistent and plugs retained strength.

CONCLUSIONS

- Samples treated with Desmodur N-3390 exhibited the most compressive strength and durability. This consolidant is extremely dense and viscous (it added 2 g to the dry weight of the plugs following initial application and baking), however, and caused a substantial darkening in colour, and is, therefore, not recommended for use. Despite reports by the Getty Conservation Institute that H100 Consolidation Treatment is an excellent stabilizer for mud brick, this study found that 5% Paraloid B72 in toluene was more effective in providing both compressive strength and durability to plugs made from the soil found at Field E125, although it did cause the plugs to darken slightly. Conclusive results can only be achieved, however, if these products can be tested on the walls at the site itself.

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