



**DEPARTMENT OF THE ARMY**  
**OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY**  
**INSTALLATIONS, ENERGY AND ENVIRONMENT**  
**110 ARMY PENTAGON**  
**WASHINGTON DC 20310-0110**

1 June 2021

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MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Cost / Benefit Analysis Methodology for Building Materials Used in Historic Army Housing

1. References:

- a. National Historic Preservation Act (NHPA) Title 54, U.S. Code 300101, et seq.
- b. Army Directive (AD) 2020-10, 25 Aug 2020, subject: Use of Imitative Substitute Building Materials in Historic Housing
- c. Department of the Army Inspector General (DAIG) Report ID-1903, Special Interest Item Assessment of the Residential Communities Initiative (RCI), 14 February – 22 March 2019.

2. This memorandum provides a cost / benefit analysis methodology for building materials used in historic Army housing. The cost / benefit analysis methodology is designed to support a determination of the appropriate building materials to use in projects that maintain and improve historic Army housing. The methodology is applicable to all historic Army housing, including pre-1919 housing.

3. The cost / benefit analysis addresses the three categories of building materials, as defined in AD 2020-10, used in historic Army housing: imitative substitute building materials, historic building materials, and in-kind building materials. Since cost is one of several factors to consider in determining what building materials to use in historic housing projects, this methodology includes both a quantitative cost / benefit analysis procedure for the initial costs and the lifecycle costs of the building materials, and a qualitative analysis procedure for other associated and relevant factors such as health and safety, and cultural and public use values. With proper planning, the use of any of the three categories of building materials will ensure that the significant historic and architectural characteristics of historic housing are maintained.

4. In its 2019 Report ID-1903, the DAIG identified historic housing as costly to maintain and operate, and specifically identified the high costs of specialized building materials required such as custom windows and custom roofing, and the specialized craftsmen required to install and maintain these materials as cost drivers. The DAIG also identified the health and safety concerns associated with lead-based paint and other hazards found in historic housing. The DAIG recommended cost / benefit analysis to address historic housing issues.

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5. AD 2020-10 requires the consideration of imitative substitute building materials in the maintenance, repair, rehabilitation, and renovation of Army-owned and privatized historic Army housing. As AD 2020-10 is implemented by Army Commands and installations through the NHPA Section 106 compliance process, installations with privatized or Army-owned historic housing may be asked to provide a cost / benefit analysis of building materials. The enclosed cost / benefit analysis methodology is provided for Army Command and installation-level implementation. This cost / benefit analysis was submitted by the Army to the Advisory Council on Historic Preservation to support a prior NHPA compliance action.

6. Inquiries regarding this memorandum may be directed to the undersigned at [david.b.guldenzopf.civ@mail.mil](mailto:david.b.guldenzopf.civ@mail.mil).

Enclosure

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## ENCLOSURE

### **Cost / Benefit Analysis Methodology for Building Materials Used in Historic Army Housing**

#### **1.0. Introduction, Overview and Considerations**

##### **1.1. Introduction**

The cost / benefit analysis methodology presented herein provides an approach for the quantitative and qualitative assessment of key factors associated with the various building materials used on historic Army housing. The methodology includes a quantitative analysis procedure for the initial and lifecycle costs of various building materials, and a qualitative analysis procedure for other associated and relevant factors. The presentation of the methodology is then followed by its application to analyze actual data from rehabilitated historic windows, in-kind wood windows, and vinyl windows used on historic Army housing. The methodology is also applied to analyze actual data for in-kind natural stone slate roofing and synthetic slate roofing used on historic Army housing. The cost / benefit analysis methodology presented here may be applied to other building materials used on historic housing.

All cost data used in the example analyses of windows and roofing are actual cost estimates and expenditures on historic Army housing dating from 1919-1940, from two installations in the eastern United States. All costs are expressed in current dollar values, and the dollar values are rounded for ease of calculation and understanding. All costs were incurred within the last 6 years.

The terms and definitions of the three categories of building materials used herein are in accordance with AD 2020-10: *Imitative substitute building materials* are modern, industry standard, natural, composite, and synthetic materials that simulate the appearance of and substitute for more costly historic building materials and in-kind building materials. *Historic building materials* are building materials that are 50 years old and older. *In-kind building materials* are new building materials that are identical to historic building materials in all possible respects, including their composition, design, color, texture, and other physical and visual properties. As stated in AD 2020-10, with proper planning, the use of any of these three building materials ensures that the significant historic and architectural characteristics of historic housing are maintained.

##### **1.2. Overview and Considerations: Cost / Benefit Analysis Methodology and Application to Windows and Roofing**

The quantitative analysis includes the initial total costs for each type of building material, and compares the initial total costs of the building materials with their total benefit in terms of the years of expected service, i.e., their lifecycle. That comparison is expressed as a ratio, the dollar cost/unit : number of years of service.

The costs used in the quantitative analysis are the actual costs per unit for each building material. The costs per window for rehabilitated historic windows are the costs associated with their rehabilitation which includes window removal, dip stripping in solvent to remove paint (typically lead-based paint), chemical rinsing, drying, repair, re-painting, and re-installation. The costs for in-kind windows include the purchase costs and installation of new in-kind windows and the removal and disposal of old windows. The costs for vinyl windows include their purchase cost and installation, and removal and disposal of old windows. The costs used for in-kind natural stone slate roofing and synthetic slate roofing are the costs per square foot for each material, installed.

The historic preservation field's knowledge base regarding the long-term performance of historic building materials, in-kind materials, and imitative substitute materials is underdeveloped. An estimate of the years of service or "service-life" for historic building materials, in-kind building materials, and imitative substitute materials is required due to the lack of systematically collected, quantifiable, lifecycle data regarding the longevity of these materials. Estimated years of service used in this analysis for historic building materials are based on best available information. Estimated years of service for in-kind building materials and imitative substitute building materials are based on the manufacturer's material replacement warranty period. The warranties provide for replacement of the building materials if they fail due to manufacturing defect prior to the end of the warranty period. This analysis assumes that in-kind materials and imitative substitute materials are properly installed and maintained in order to ensure the manufacturer's warranty period on the materials.

The service-life estimates used in this analysis for windows are: rehabilitated historic windows = 100 year service-life, wood in-kind windows = 20 year service-life/manufacturer's warranty, and vinyl windows = 40 year service-life/manufacturer's warranty. The 100 year service-life for rehabilitated historic windows assumes that a rehabilitated historic window will have a service-life of 100 years before it requires a second rehabilitation or replacement.

The service-life estimates used for roofing are: in-kind natural stone slate roofing = 125 year service-life, and synthetic slate roofing = 50 year service-life/manufacturer's warranty. The lifecycle of natural stone slate roofing is usually assumed to be from 75 years to 150+ years before the roof will require significant restoration or replacement. The estimated average service-life of 125 years used in this analysis is based on the type of stone used historically, and the type of stone that is currently available which varies in hardness or quality from slate that was available historically.

Historic building materials, in-kind building materials, and imitative substitute building materials service-life may all be greater or less than the estimates used for the purpose of this analysis. The lack of systematically collected and quantifiable data regarding the long-term performance of historic building materials, in-kind materials, and imitative substitute materials is a long-standing issue in the historic preservation field, and necessitates estimation of those values. The Army is currently collecting lifecycle building materials performance data over a 35 year period to address this long-standing historic preservation issue.

The qualitative factors addressed in this analysis include the health risk of lead-based paint exposure (windows only), the maintenance and repair considerations for the various building materials, and the cultural and public use values. Cultural and public use values relate to the value of maintaining the integrity of historic properties to the maximum extent possible in consideration of the potential for public visitation and the resulting economic benefit to the surrounding community from enhanced tourism associated with the historic properties. Also, for the purposes of this analysis, the energy efficiency factor is held as equivalent among the various building materials.

## **2.0. Application of Cost / Benefit Analysis Methodology: Rehabilitated Historic Windows, In-kind Windows, and Vinyl Windows**

### **2.1. Quantitative Factor Analysis**

The Army rehabilitated all historic windows on 43 historic housing units using the dip stripping method. Each historic window was carefully removed and the windows were then sent to a specialist who dipped the windows in solvent to chemically remove the paint layers. The stripped windows were then chemically rinsed, allowed to dry, repaired, repainted, and re-installed at the housing unit. The cost to rehabilitate the historic windows was \$2,500 per window. There is no warranty period provided for the rehabilitated historic windows.

The Army installed in-kind wood replacement windows on 127 historic housing units. The in-kind wood windows are identical to the historic windows that they replaced to the greatest extent possible including all aspects of their composition, design, and other visual properties. The in-kind wood windows are true divided light windows where the multiple panes of glass in each window are individually separated by muntins, as opposed to simulated divided light windows that have one pane of glass with removable muntins or grille attached to the glass. The in-kind wood windows cost \$1,500 each installed (including removal and disposal of the existing window), and have a 20 year manufacturer's replacement warranty.

The Army installed vinyl replacement windows on 202 historic housing units. The vinyl windows are made from a synthetic building material and simulate the appearance of the historic windows. The vinyl replacement windows are the same double hung window type as the historic windows; have the same overall dimensions including height, width, and depth as the historic windows; and are the same color as the historic windows. The vinyl replacement windows cost \$500 each installed (including removal and disposal of the existing window), and have a 40 year manufacture's replacement warranty.

Historic rehabilitated windows cost \$2,500 per window with a service-life estimate of 100 years. \$2,500 per rehabilitated historic window : 100 years of service = 25:1 cost / benefit ratio. Wood in-kind replacement windows cost \$1,500/window, with a service-life estimate of 20 years. \$1,500 per in-kind window : 20 years = 75:1 cost / benefit ratio. Vinyl replacement windows cost \$500 per window with a service-life estimate of 40 years. \$500 per vinyl window : 40 years of service = 12.5:1 cost / benefit ratio. The cost to service-life ratio indicates that the

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vinyl window costs \$12.50 for each year of service, rehabilitated historic windows cost \$25 for each year of service, and in-kind wood windows cost \$75 for each year of service.

Rehabilitated historic windows cost \$2,500 for an estimated 100 years of service. Factoring replacement of vinyl windows at their 40 year warranty period, the cost to obtain 100 years of service from vinyl windows is \$1,250 per vinyl window ( $\$500/\text{vinyl window} \times 2.5 \text{ 40 year replacements} = \$1,250$  for 100 years of service). Vinyl windows require one-half the cost of historic rehabilitated windows to obtain the same 100 year period of service.

Factoring replacement of in-kind windows costing \$1,500 each at their 20 year warranty period, the cost to obtain 100 years of service from in-kind windows is \$7,500 per window ( $\$1,500/\text{in-kind window} \times 5 \text{ 20 year replacements} = \$7,500$  for 100 years of service). In-kind wood windows cost six times more than vinyl windows to obtain the same 100 years of service. The inferior quality of the wood available for use in manufacturing modern in-kind wood windows is an industry-identified issue. As indicated by the manufacturer's warranty periods, the imitative substitute vinyl windows are more durable and are more cost effective than the in-kind windows.

## 2.2. Qualitative Factor Analysis

**Health and Safety Risk:** The health risk to children from lead-based paint exposure is a significant qualitative factor. Vinyl replacement windows and in-kind replacement windows entirely eliminate the lead exposure risk. With historic rehabilitated windows, the lead exposure risk to children is lowered but not eliminated. The dip stripping process for historic window rehabilitation allows lead to enter the wood grain itself, and that lead can re-appear as lead dust with window use, wear, and weathering.

**Maintenance and Repair:** Vinyl windows require minor maintenance, and the repair cost due to glass breakage is low for standard replacement glass. Vinyl is susceptible to expansion due to extreme heat. In-kind wood windows require periodic maintenance including repainting and are highly susceptible to rot and insect infestation. Glass breakage repair costs on in-kind windows are high due to the custom glass required. Historic rehabilitated windows require continuous maintenance and painting to maintain a low lead risk. Drafts and dust infiltration may also be an issue. Glass breakage repair costs on historic rehabilitated windows are high due to the custom glass required.

**Cultural and Public Use Value:** The vinyl windows that were used in the historic Army housing are imitative substitute building materials that were selected to simulate the original historic building material. The similar appearance, style, and dimensions of the vinyl windows relative to the original historic windows maintains the overall historic appearance and character of the historic housing, but vinyl windows do not fully maintain historic integrity since the historic windows are not retained. In-kind windows are designed to be indistinguishable from the historic windows that they replace to the greatest extent possible, but do not fully maintain historic integrity since they also replace the historic windows. Rehabilitated historic windows

reuse historic building materials, and fully maintain the historic integrity of the military housing to the maximum extent possible. Because general public access to Army installations is restricted, and access to military family housing areas on Army installations is further restricted to resident's only, public visitation of Army family housing areas is low. There is not a significant public use value associated with maintaining military housing historic integrity to the maximum extent possible since visitation by the general public is generally not allowed. There is a low related economic benefit to the surrounding community associated with maintaining historic military housing integrity to the maximum extent since there is no general public access to military housing for tourism purposes.

### **2.3. Windows Cost / Benefit Analysis Summary**

Based on the factors applied and the results of this analysis, vinyl windows present a greater overall lifecycle cost / benefit value than rehabilitated historic windows or in-kind windows. Vinyl windows also have a significantly lower initial cost than in-kind windows or rehabilitated historic windows. In terms of their lifecycle, for one-half the cost of historic rehabilitated windows and in-kind windows, vinyl windows deliver the same 100 year period of service as historic rehabilitated windows. Vinyl windows have lower anticipated maintenance and repair costs than in-kind or historic windows. Vinyl windows and in-kind windows both eliminate the lead poisoning hazard. Rehabilitated historic windows only reduce the lead exposure risk and do not eliminate the lead poisoning hazard.

The initial cost of in-kind windows is three times higher than vinyl windows, and the in-kind windows are less durable with a 20 year warranty as compared to the 40 year vinyl window warranty. In-kind windows have a higher anticipated maintenance and repair cost. Rehabilitated historic windows cost five times the initial cost of vinyl windows, and in the long-term cost twice as much as vinyl windows for the same 100 year service period. Rehabilitated historic windows do not eliminate the lead poisoning hazard, have no warranty, have a higher anticipated maintenance and repair cost, and fully maintain historic integrity. The cultural and public use values associated with maintaining historic integrity is low since military housing has restricted public access.

### **3.0. Application of Cost / Benefit Analysis Methodology: In-kind Natural Stone Slate Roofing and Synthetic Slate Roofing**

#### **3.1. Quantitative Factor Analysis**

The Army installed synthetic slate roofing materials on 76 historic housing units. The synthetic slate roofing was installed on new additions to existing historic housing that has natural stone slate roofing. The cost estimate received for in-kind natural stone slate roofing on the additions was \$50 per square foot, installed. The cost for synthetic slate roofing was \$10 per square foot, installed, with a 50 year materials replacement warranty. The synthetic slate is a composite imitative substitute material that simulates the historic natural stone slate roof appearance. Synthetic slate simulates the overall design of natural stone slate shingles in its

dimensions including height, width and depth; and the color and texture imitates weathered slate roof materials.

Synthetic slate costs \$10/sqft with a service-life estimate of 50 years = 1:5 cost / benefit. In-kind natural stone slate costs \$50/sqft with a service-life estimate of 125 years = 1:2.5 cost / benefit. Synthetic slate costs \$1 for each 5 years of service. Natural stone slate costs \$1 for each 2.5 years of service. Factoring replacement of synthetic slate every 50 years per its warranty period, the cost to obtain 125 years of service from synthetic slate is \$25 per square foot, one-half the cost of natural stone slate for the same 125 year period of performance.

### **3.2. Qualitative Factor Analysis**

**Maintenance and Repair:** Natural stone slate entails higher cost for materials and specialized craftsmen are required for repairs to slipped and broken slates, and for flashing replacement. The flashing materials used with natural stone slate typically do not last as long as the slate itself and require replacement more frequently, as often as every 20 years. Flashing replacement on natural stone slate roofs is costly since it requires specialized craftsmen to carefully remove the natural stone slate roofing materials without breakage, and the reinstallation of the natural stone slates in the areas where the flashing is replaced. The cost to repair and replace damaged synthetic slates is low, replacement materials are low cost and readily available, and no specialized craftsmen are required for repairs, to include flashing replacement.

**Cultural and Public Use Value:** Synthetic slate is not a historic building material so does not fully maintain historic integrity. As an imitative substitute material however, it conveys the overall historic appearance of a historic slate roof building, it simulates the overall design of natural stone slate shingles in its dimensions, color, and texture. Use of natural stone slate fully maintains the historic integrity of the housing to the maximum extent possible. Because general public access to Army installations is restricted, and access to military family housing areas on Army installations is further restricted to resident's only, public visitation of Army family housing areas is low. There is not a significant public use value associated with maintaining military housing historic integrity to the maximum extent possible since visitation by the general public is not usually allowed. There is a low related economic benefit to the surrounding community associated with maintaining historic military housing integrity to the maximum extent since there is no general public access to military housing for tourism purposes.

### **3.3. Roofing Materials Cost / Benefit Summary**

Synthetic slate has a 50 year replacement warranty, has lower initial cost and lower anticipated maintenance and repair costs, does not fully maintain historic integrity, but maintains the overall historic appearance by means of its shape, color, and texture that simulates natural stone slate. In-kind natural stone slate has a significantly higher initial cost and higher anticipated maintenance and repair costs for materials and specialized craftsmen. Natural stone slate fully maintains historic integrity however, there is a low cultural and public use value associated with maintaining historic housing integrity to maximum extent. For one-half the cost



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of natural stone slate, synthetic slate delivers the same overall appearance and 125 year period of performance.

#### **4.0. Synopsis: Cost / Benefit Analyses of Building Materials Used In Historic Army Housing**

In summary, the results of the application of this cost / benefit analysis methodology for Army historic housing building materials indicates that, in consideration of lifecycle, quantitative, and qualitative factors, the imitative substitute building materials analyzed deliver a superior short-term and long-term lifecycle cost / benefit solution than rehabilitate historic building materials or in-kind building materials.

Due to the initial lower costs of the imitative substitute building materials, their use in historic Army housing resulted in an immediate project cost savings when compared to both the rehabilitated historic building materials and in-kind building materials. Imitative substitute building materials lowered the direct project costs and resulted in an immediate financial benefit for the project when compared to more costly historic building materials or in-kind building materials.

The long-term, lifecycle analysis of both windows and roofing indicates that, for one-half the cost of the rehabilitated historic building materials and in-kind building materials, the imitative substitute building materials will deliver the same 100 year and 125 year service-life, respectively. The qualitative analysis indicates that imitative substitute building materials eliminate lead-based paint hazard in windows, have lower expected long-term maintenance and repair requirements and, due to the restricted access to military family housing areas on Army installations, the cultural and public use value and economic benefit to the surrounding community associated with maintaining historic building integrity to the maximum extent possible is low.

Based on the application of cost / benefit analysis to Army historic housing building materials and its results, the imitative substitute building materials analyzed provide a better overall, long-term value for the management of historic housing, while ensuring that the historic and architectural characteristics of historic housing are maintained.