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Corrosion Evaluations of Masonry Clad Steel Frame Buildings (Pre-1950)

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ABSTRACT

When distress of a structure is evident, it is important to determine the nature of the degradation to select the best restoration strategy. This standard practice provides testing procedures and investigative techniques for the evaluation of masonry-clad steel frame buildings. The investigation and evaluation techniques described in this standard focus on degradation resulting from corrosion of the steel frame.

This standard provides the investigator, corrosion specialist, engineer, or owner a framework for evaluating the corrosion condition of a steel frame building beyond simple visual inspection and basic sounding techniques. Evaluation techniques that identify general and localized corrosion of masonry-clad steel frame buildings are provided.

This standard is intended for use by corrosion specialists, historic architects, structural engineers, and exterior building envelope consultants involved with evaluating corrosion of steel frame buildings and the subsequent effect on the masonry cladding. It also may be useful to owners of historic buildings whose service life may be affected by steel frame corrosion.

KEYWORDS

Historic building, masonry, steel frame corrosion, inspection, survey, TG 460

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Foreword

This NACE International standard practice provides testing procedures and investigative techniques for the evaluation of masonry clad steel frame buildings. The investigation and evaluation techniques described in this standard focus on degradation resulting from corrosion of the steel frame. When distress of a structure is evident, it is important to determine the nature of the degradation to select the best restoration strategy. Although this standard does not specifically address restoration options, additional information on repairs and corrosion mitigation techniques can be found in other NACE International and industry wide standard practices, test methods, and state-of-the-art reports, and other publications.[1-19]

This standard is intended for use by corrosion specialists, historic architects, structural engineers, and exterior building envelope consultants involved with evaluating corrosion of steel frame buildings and the subsequent affect to the masonry cladding. It also may be useful to owners of historic buildings whose service life may be affected by steel frame corrosion.

Note: The term structural engineer used throughout this document refers to a nationally or locally licensed/certificated design professional qualified and experienced in structural engineering

NACE Task Group (TG) 460, “Testing and Evaluation of Corrosion on Steel-Framed Buildings” prepared this standard. The TG is composed of users, consulting engineers, manufacturers, and other interested parties, and this standard represents a consensus of those members. This standard is not intended to be all encompassing. However, it provides information that allows the user to perform testing and evaluation of masonry clad steel frame buildings that are believed damaged from corrosion of the structural steel frame or ancillary steel. The buildings subject to this evaluation methodology were constructed between the 1880s and the 1940s. Note that the information gathered during this investigation may require subsequent investigation and evaluation by a qualified structural engineering personnel or equivalent locally or national licensed professional, or architect depending on the nature and extent of degradation.

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In NACE standards, the terms ***shall, must, should,*** and ***may*** are used in accordance with the definitions of these terms in the NACE Publications Style Manual. The terms ***shall*** and ***must*** are used to state a requirement, and are considered mandatory. The term ***should*** is used to state something good and is recommended, but is not considered mandatory. The term ***may*** is used to state something considered optional.

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Section 1: General

1.1 Inspecting and monitoring the condition of steel frame buildings involves the use of a number of evaluation techniques, ranging from simple visual inspections that identify rust staining, open joints, cracks, masonry spalling, and displacement to physical and chemical inspection methods, which use sounding mallets, ultrasonic testing, electrical resistance, chemical analyses, or electrochemical potential and corrosion rate measurements.[20,21] Various other Non-Destructive Evaluation (NDE) techniques can be added to the inspection to enhance the condition survey.

1.2 A number of relevant standards and overview technical papers that discuss issues germane to corrosion inspection of steel frame buildings are available. While the concepts in testing are similar, the results of the data collected from a steel frame building will differ dramatically from a concrete structure.[22-36] In 2000, a book related to corrosion in steel frame buildings[37] was published by Historic Scotland.[(1)]

1.3 The purpose of this standard is to provide the investigator, corrosion specialist, engineer, or owner a framework for evaluating the corrosion condition of a steel frame building beyond simple visual inspection and basic sounding techniques. Evaluation techniques that identify general and localized corrosion of masonry clad steel frame buildings are provided. Although this standard specifically addresses masonry clad steel frame buildings, many of the techniques also apply to reinforced concrete, pre-stressed and post-tensioned reinforcement. Commentary is included for screening corrosion control methods that might be considered as part of recommendations for restoration of the steel frame building being evaluated. However, it is beyond the scope of this standard to fully address all factors associated with the design, criteria, and implementation of such corrosion control measures.

Section 2: Definitions

Anchorage: Anchorages in a steel frame building are straps which secure the cladding stone to the infill or steel frame. Anchorage systems are unique to each individual building.

Appurtenances: Appurtenances include elements such as rods, j-hooks, shelf angles, outriggers, and other supporting steel elements within the framing system. Projecting building components, such as cornices, bay windows, balconies, and balconettes will have steel support systems.

Carbonation: Carbonation is a condition whereby the high pH of a mortar- or organophosphorus compound (OPC)-based electrolyte has undergone chemical changes and the calcium hydroxide within the mortar interacts with atmospheric carbon dioxide. The formation of carbonic acid lowers the pH to the point where steel can corrode. Carbonation is a slowly-occurring reaction which is based upon the diffusion coefficient of the cladding material and mortar.

Displacement: Shifting or outward movement of masonry units or damaged masonry from the plane of the structure.

Electrode Potential: The potential of an electrode in an electrolyte as measured against a reference electrode. The electrode potential does not include any resistance losses in potential in either the electrolyte or the external circuit. It represents the reversible work to move a unit of charge from the electrode surface through the electrolyte to the reference electrode.

General Corrosion: Also referred to as “uniform corrosion,” general corrosion proceeds more or less uniformly over an exposed surface without appreciable localization.

Linear Polarization Resistance (LPR) Measurement: The LPR measurement applies a small (20 mV) potential difference between the steel and a secondary electrode on the surface which results in a small current flow. This is then proportional to the inverse of the polarization resistance, and hence is directly proportional to the corrosion rate.

Masonry Cladding: A layer of real or simulated (terra cotta, cast stone) stone applied to a building or structure made of a material other than stone. Stone cladding in historic steel frame buildings is original to the structure unless replacement has occurred.

Masonry Infill: The material between the steel frame and cladding masonry. This is typically comprised of brick, but can also include concrete, anomalous construction materials, and masonry debris.

Oxide Jacking: The cracking or displacement of masonry on a building caused by the accumulation of corrosion product of the embedded steel placing tensile forces onto the masonry cover.

Pozzolan: A siliceous or silico-aluminous material that will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties.

[(1)] Historic Environment Scotland, formerly Historic Scotland, Longmore House, Salisbury Place, Edinburgh EH9 1SH, U.K.