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Stability Assessment of Historic Plaster Ceilings on Wood Lath

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1 Introduction

Plaster (often lime plaster, reinforced with animal hair) installed on wood lath secured to wood framing was a common ceiling system for hundreds of years in the Americas, and for thousands of years in Europe. Despite having a relatively good record of stability, some ceilings of this type have collapsed. Given their overhead position, often above large groups of people, when cracks or localized areas of displacement or damage occur in these ceilings, the question often arises as to whether the ceiling is stable and safe.

Failures of these historic plaster ceilings in the US typically fall into one of two broad categories: 1) failure of plaster keys, or 2) tensile failure or “pull-out” of the nailed connections of the overlying wood framing. While failure of the plaster keys can lead to localized failure of the plaster, it is relatively self-arresting and does not tend to lead to progressive or widespread collapse of the entire ceiling. The adequacy of the plaster keying through the lath, as originally constructed, depends on how well-keyed (mechanically interlocked) it is with the topside of the wood lath to which it is applied. In any installation, the best keys tend to occur at more vertical portions of the ceiling installation, where the wet plaster keys sagged down and over the backside of the wood lath during the original installation. In the more horizontal portions of a plaster ceiling, where gravity does not aid in the formation of keys, good keying was achieved when the workers forced sufficient plaster through the gaps in the lath with sufficient hand pressure on the trowel. In our experience reviewing the performance of the ceilings a century or more after their original installation, good keys are quite reliable and even marginal keys may perform quite well long-term. Because procedures for stability assessment of historic plaster ceilings on wood lath are not well quantified in building codes or technical literature, this article proposes best practices for assessing these ceilings.

By contrast, failure of the overlying structural wood framing and/or its connections can potentially lead to progressive collapse of the entire plaster ceiling. Indications of this failure mode are often visible at the topside plaster framing and include gross withdrawal (“pull-out”) of nailed wood-wood connections (often smooth shank nails), or gross displacement of wood members or connections.

When an individual connection pulls out, the loads and stresses tend to redistribute to the adjacent connections, potentially causing them to become overstressed and more likely to pull out, which can cause a “domino effect” leading to progressive collapse of the entire plaster ceiling. As such, this failure mode presents a far more significant risk to life safety than the more common (and generally self-arresting) failure mode of inadequate plaster keying. Standard structural engineering procedures and calculations can be used to evaluate the safety and stability of the supporting wood framing and connections.

In the US, lack of clear guidelines or standards on how to evaluate historic plaster ceilings and relatively little technical literature on the topic has been a hindrance to their proper evaluation of life safety/stability. Further, current literature does not clearly define the condition of plaster keys (*e.g.*

"good", "fair", "poor"), and instead requires the professional to make these judgements in the field, often based on visual observations alone. While most professionals agree that the percentages of damaged plaster keys are an approximate indicator of the overall condition of the plaster (Stewart. R, 2013), the pattern and/or percentage of plaster damage that distinguishes an area from "good" from "fair" from "poor" varies widely among practitioners. Additionally, visual and tactile review of the plaster keys is highly subjective and, thus, inconsistent within the industry.

To improve consistency in the stability assessment of historic plaster ceilings, condition assessment of these ceilings should include an initial hands-on visual assessment of both the topside and underside of the ceiling, taking into account the performance history of the plaster and documenting the percentage and pattern of damaged plaster keys, where present. In all cases, the visual assessment is an initial tool for evaluation, to be refined and compared to appropriate (project-specific) criteria. This refinement requires calculation of the project-specific factor of safety, review of other plaster ceilings of similar construction and condition, and identification of deterioration mechanisms that are suspected to have contibuted to deterioration or damage. In some cases, visual assessment and synthesis is supplemented with destructive pull-test testing to quantify the severity of damage, and/or vibration monitoring to evaluate vibration levels from known sources that may pose a risk of damage.

Where existing plaster conditions suggest vibrations of the plaster are contributing to plaster damage, vibration monitoring may be prudent. The main objectives of vibration monitoring are to establish a baseline vibration threshold for damage that is conservative enough to ensure that plaster damage is highly unlikely to occur when vibration levels do not exceed this limit, to identify vibrations sources that coincide with vibration levels above that conservative threshold, and to quantify the regularity at which activities associated with high vibration levels occur. However, there are various factors that make it difficult to directly apply currently available vibration assessment guidelines in evaluating the stability of historic plaster ceilings. Thus, we advise practitioners establish limiting criteria based on one of the following approaches: 1) set initial vibrations thresholds at the most conservative vibration criteria commonly referenced in currently available literature for historic and/or sensitive materials (*i.e.* 0.06 in./sec. for continuous vibrations), or 2) conduct vibration monitoring to establish a higher, but still conservative project-specific limit for plaster vibrations. In situations where ambient (typical) vibrations exceed vibration the most conservative criteria cited in currently available literature, the latter approach is most appropriate. Accurate identification of vibrations sources that are potentially contributing to plaster damage informs repair recommendations and aids development of vibration dampening strategies, where appropriate.

This article aims to unify stability assessment procedures for historic plaster ceilings, acknowledging that current common condition assessment procedures are not project-specific, typically conservative and, thus, preliminary in nature. Further, current common methods for plaster stability assessment are highly subjective because there are no current US standards for non-destructive testing and evaluation of plaster. Thus, a comprehensive and project-specific plaster stability assessment needs to include not only documenting the original and current condition of the plaster and wood framing through visual survey and calibration of visual observations with intermittent tactile assessment and empirical comparisons, but also development of appropriate evaluation criteria through post-processing, review of past performance (project specific and similar construction), calculation of the project-specific factor of safety, and in-situ testing and/or monitoring (where prudent).

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