Creativity in the New Stone Age Part 1 - Structural Stone in Contemporary Structures

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Abstract

Stone has been used as a structural material for thousands of years and yet its use has declined in recent times. When paired with a modern approach to structural analysis, design and detailing, and a rigorous statistical analysis of material strengths, stone can realise its potential as a material fit for the 21st century.

Keywords: Stone, Beams, Columns, Slabs, Statistics, Analysis, FE Modelling, Prototype, Testing, Weibull

1 Introduction

When paired with a modern approach to structural analysis, design & detailing, and a rigorous statistical analysis of material strengths, stone can realise its potential as a material fit for the 21st century.

The aim of our research has been to develop new, practical and efficient ways to use stone as a standard primary structural component. Here, we propose a building system as a low energy alternative to more common steel and concrete frame structures. This research is in its early stages and this paper outlines our initial thoughts and investigations.

2 Properties of Stone

Stone has several advantages over concrete in that it is often of higher stiffness, compressive and tensile strength, it does not creep to the same extent and there is often no need for additional secondary finishes. This attribute, when combined with its higher mechanical properties can in some instances allow thinner and lighter structures. In some cases, the reduction in structural weight can lead to reductions in the size of supporting elements and foundations.

The use of stone as a structural material requires a clear understanding of the properties of the stone being proposed. Primarily the density, compressive and tensile strength, the level of material variability between different samples of the same batch, and between material strengths in each of the 3 bed plane orientations. To confirm the structural properties of the material, strict testing procedures exist. These require the testing of samples taken from the specific blocks of stone to be used in the construction

2.1 Reliability analysis

In the Eurocodes [1], the resistance of materials to failure are determined from their design value of strength (normally 'failure' stress) which is in turn derived from the characteristic strength value and dividing by an appropriate factor of safety (FoS). The characteristic value is the predicted lower 5th percentile failure value for the property with 75% confidence, meaning 5% of samples tested will fail at a strength lower than this value. The FoS is chosen to ensure the design value correlates to a predicted failure rate of 0.1%. Therefore, the more variation in the material, the larger the material FoS. For most building materials, this FoS is constant although it varies for masonry [2][3][4].

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