A design stress-strain curve for prestressing strands

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Section 8 of AS 5100.5:2017 mandates the use of equilibrium and strain compatibility considerations to calculate the ultimate limit state (ULS) moment capacity for prestressed concrete sections. However, the standard does not provide a design stress-strain curve for prestressing strands. Rather, equation 8.1.7(1) is provided to estimate the stress in bonded tendons at ULS but with a condition placed on the effective prestress for its validity. In practice, many designs may not meet this requirement rendering the use of this equation invalid. Furthermore, the derivation of Equation 8.1.7(1) has been based on sections with a single layer of prestressing and its application for sections with more distributed prestressing is unclear. Nonetheless, AS 5100.5:2017 together with AS/NZS 4672.1-2007 provide strength and elongation limits that prestressing strands need to comply to. It has been typical design practice to use a 'model' stress-strain curve for strands, based on the afore-mentioned compliance limits, although there has been no consistency as to the form of these curves across industry. As such, the same prestressing can result in different moment capacities depending on the form of the curve. To provide a consistent basis for calculating the ULS moment capacity of prestressed beams of its bridge stock, Main Roads WA has recently mandated the use of 'design' stress-strain curves for strands. This paper discusses these which are based on the breaking and proof strengths as per AS/NZS 4672.1-2007 and an adopted failure strain of 5%. The proposed curves are also compared to stress-strain formulations found in several international design standards and widely cited publications. The sensitivity of the ULS moment capacity to the form of the stress-strain curve as well as the adopted failure strain is quantified using several as-constructed Teeroff beams. Comparison of the proposed formulations is also made to stress-strain test data provided by industry.