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Multi-scale approach to the mechanical behaviour of epoxy impregnated Nb3Sn Dipole Coils for the 11T Dipole.

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The superconducting dipole magnets being developed at CERN for the HL-LHC project are equipped with coils manufactured from Nb₃Sn Rutherford cables, following the *Wind & React* fabrication technique. The brittleness of the multifilamentary structure of the Nb₃Sn within the cable strands exposes the coils to permanent performance degradation when subjected to excessive strain during assembly and operation. The coils have to be heavily pre-stressed to ensure the required mechanical stability of the cables under the Lorentz forces when the magnet is powered to maximum current under high field. Reaching the maximum acceptable stresses during assembly and operation without causing permanent damage requires refined knowledge of the mechanical behaviour of these epoxy impregnated Nb₃Sn coils. This paper will show a detailed analysis of the characterisation of cable stacks (10-stack) under compression using representative coil material in order to predict the behaviour of the Nb₃Sn coils. By means of standard mechanical measuring techniques and finite element analysis, the results from the 10-stack measurements are extrapolated to an actual and fully detailed coil cross section using 2D imaging techniques. The stress and strain distribution from the actual coil geometry are used to predict the stresses and strains at the strand level and the filaments within the strand. The model of the strand and filaments is based on a scanning electron microscope image of a strand of interest within the original coil in order to provide a realistic geometry and a better representation of the stresses and strains within the multi-filament structure. The results from this multi-scale approach has allowed for a better understanding of the stresses and strains that are observed at the strand and filament level by accounting for the global stresses and strains of the realistic coil geometry.

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