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2D Mechanical Representation of Superconducting Magnets: a Comparative Study of Plane Stress and Plane Strain Options.

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When approaching the mechanical design of a superconducting magnet, whenever possible the starting model is a 2D approximation. If rotational symmetry (solenoid-like winding) is present, the 2D representation is unique and contains no approximations. If, on the other hand, a bi-axial system is opted for, the 2D representation is not unique: the main options are plane stress, plane strain, or a combination of the two. If z is the direction normal to the 2D plane, the plane stress option defines a stress state in which no normal or shear stresses perpendicular to the xy plane can occur (σz=σxz=σyz=0). In the plane stress condition, deformation can occur in the thickness of the element, which will become thinner when stretched and thicker when compressed; it is generally used for objects with limited depth (thin objects). In contrast, plane strain refers to the fact that deformation can only occur in plane, which means that no out-of-plane deformation will occur (εz=εxz=εyz=0), while, due to the fixity of longitudinal motion, normal stress will be generated. The plane strain option is generally appropriate for structures of nearly infinite length, relative to their cross section, that exhibit negligible length changes under load. Superconducting magnets, such as racetracks or multipoles, do not fit neatly into any of the above options: they are far from thin but deform longitudinally under load. This work reports a comparative study of plane stress, plane strain and a combination of the two in the specific case study of a dipole magnet.

Primary authors: PAMPALONI, Alessandra (INFN); BERSANI, Andrea (INFN Genova (IT)); GAGNO, Andrea (INFN); CAIFFI, BARBARA (INFN); LEVI, Filippo (INFN); BRACCO, Michela (INFN); SALA, Nicola (INFN Genova); MUSENICH, Riccardo (INFN e Universita Genova (IT)); BURIOLI, Sergio (INFN e Universita Genova (IT)); FARINON, Stefania (INFN e Universita Genova (IT))

Presenter: SALA, Nicola (INFN Genova)

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