An Innovative Shell Structure in Codogno (Italy) Evaluation of Structural and Seismic Performance

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ABSTRACT

An innovative semi-prefabricated building system was developed in Italy in the years '30 of XX cent. by a very active brick factory near Piacenza, RDB (from the initials of the first owners). The SAP system (the acronym means 'Senza Armatura Provvisoria', or 'without provisional centring') allowed to build curved surfaces prefabricating light elements with curved shape. After 2nd WW this technique was applied also for building the new structures covering wide spaces for the developing industry or for public leisure spaces, with prefabricated panels of the desired length. A particularly interesting application is in the BISAP (double-SAP) panel, that could be adapted for building large shells generated from ruled surfaces, such as the hyperbolic paraboloids joined together to form a pitched roof or an inverted umbrella. This shape of shells was used by many pioneers in structural architecture, such as Feliz Candela in Mexico or Pier L. Nervi in San Francisco, with very innovative use of reinforced concrete in thin layers or with some reticulated ribs.

In Codogno (LO), Italy, the BISAP panels were employed to cover a large sport hall, about 37 × 26 m wide, with no intermediate supports, resting (mainly) on the four corner pillars. Border pitch beams sustains at the top two crossed beams that separate (and support) the four hypar fields. The two rafter beams per side are connected at the base by prestressed tie beams, in order to minimize displacements and assure the preservation of the original shape. The prefabricated panels, disposed following the rules generating the hypar surface, form these four fields. Additional reinforcement is disposed orthogonally and at 45° to the rib direction in the concrete slab. Probably for lack of confidence with the structural solution adopted, additional slender pillars are disposed on the four sides between the main corner pillars, used also for windows support.

The first aim of the structural analysis performed in this study was to assess the static conditions of the roof under the loads assigned by the code for Serviceability Limit State, and then to evaluate seismic vulnerability at ULS of the whole sport hall, being a public space subjected to particular safety care. The FE code used (Straus7) allowed a very careful discretization of the orthotropic slab with the correct inclination and rotation of the ribs, giving a reliable forecast of the behaviour also in seismic conditions: dynamic analysis of the modal shapes give a satisfactory response of the shell, which maintains nearly unchanged his shape during free vibrations. The increase of the seismic safety of the structure can be then obtained simply increasing the stiffness of the four corner supports, where shear action is concentrated, adding ribs to the L-shaped sections to form a cross shaped one. In this way also the slenderness (and weakness) of additional intermediated pillars could be overcome.

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