A Novel Three-Element Column–Slab Connection System with Variable Centre of Rotation for Reinforced Concrete Structures

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This paper presents the concept and ongoing development of a column–slab connection system for reinforced concrete structures, based on a three-element mechanism with pinned joints. In conventional solutions, loads transferred from a slab to a column never pass precisely through the column axis, generating unavoidable eccentric loading. This eccentricity demands additional reinforcement steel and concrete volume beyond what purely axial assumptions would require, increasing both material consumption and construction cost.

The proposed system redistributes the support reaction along three distinct load paths: a vertically acting compressed element and two inclined tension members connected via pins. This arrangement creates a connection with a variable centre of rotation, enabling controlled force flow, reduction of bending moments, and optimisation of connection stiffness in response to varying load conditions.

The overall project encompasses four objectives: (1) formulation of mathematical models to determine optimal connection geometry, (2) design of numerical models (3) assessment of economic and environmental benefits.

The work presented here covers the research completed prior to the conference, which includes four stages. At first, a systematic literature review was conducted using Scopus, Web of Science, and Google Scholar, focusing on punching shear, unbalanced moment transfer, semi-rigid connections, and variable-centre-of-rotation concepts. A structured comparison of existing column–slab joint solutions was compiled, with identification of key research gaps. Second, a Python-based optimisation program was developed to systematically explore the parameter space and identify geometries that maximise load-bearing capacity while minimising material use. Fourth, a 2D finite element model was built in Autodesk Robot / ANSYS to validate the analytical algorithm. Bending moments and internal forces obtained from the FEM model were compared against Python program outputs, and a comparative analysis against reference cases — classical pinned and rigid connections — was performed to quantify moment and force reductions achieved by the proposed system.

The expected outcomes of the full project include design criteria for structural engineers (equations, geometric parameter ranges, and sample construction drawings), a validated experimental and numerical dataset for future research.

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