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STRESS CONCENTRATIONS OF DIAGONAL TRUSS MEMBER – MAIN GIRDER JOINTS: AN EXPERIMENTAL STUDY

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Most failures of structural components are found at locations with high stress concentrations such as joints (bolted and riveted connections) in steel bridges. Stress concentration factors are used for designing structural joints, for strength assessments and fatigue life evaluations of existing joints. There are theories developed for estimating stress concentration factors for common connection geometries; however, when the connection geometry of a joint is complicated, experimental studies, mathematical modeling and finite element modeling (using computer programmes) are required. Accordingly, the present work is about the variation of stress concentrations at a diagonal truss member – main girder connection (with six bolts) of a steel truss bridge when changing the number of active bolts.

A finite element model of the isolated diagonal truss member with six holes (diameter 16 mm) was used in the analysis. The contacting interface of the surfaces of the holes and bolts (bolt – hole interface) were modeled with springs (stiffness 10^5 N/mm^2 for compression) assigned along the radial direction of the holes. Fine mesh of thin shell elements were used near the holes and a total of 1407 shell elements with 1528 nodes were employed to model the 150 mm wide, 16 mm thick T sectioned steel member. The length of the member was limited to 600 mm where the tensile stresses (applied nominal stress) became uniform (*Saint-Venant's Principle*). Photoelasticity testing was used to validate the finite element model.

Photoelasticity is one of the experimental methods used for determining stress concentrations of complicated geometries. In the present work, two photoelastic models, one a rectangular plate with a single bolt hole, the other a down scaled model of the diagonal truss member with six holes (both prepared using photoelastic plastic) were used. A range of stresses were then applied on the models to obtain the fringe values. Principal stress differences obtained from these photoelastic models were then compared with that of the finite element models to validate the proposed bolt – hole interfaces of the finite element models.

A large variation of the stress concentration factors of the joint was observed (from 4.6 when all 6 bolts are active to 16.6 when only 2 particular adjacent bolts are active) highlighting the importance of the subject. The observation reveals the perilous condition of existing bridge structures with loose joints due to corrosion, excessive deformations, fretting and construction faults. The stress concentration factors proposed in this work could be helpful for Engineers while the technique used to model the bolt – hole interface may be employed in the finite element models of similar joints without further validations.

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