Ministry of Higher Education
and Scientific Research
AL-Muthanna University
College of Engineering
Department of Civil Engineering

Nonlinear Finite Element Analysis of Steel Columns Under Oblique Impact Loading

A thesis submitted to the council of the College of Engineering at Al- Muthanna University in partial fulfilment of the requirements of for the degree of Master of science (M.Sc.) in Civil Engineering

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2024 September 1446 Rabi al-Awwal

Summary

Impact loads are dynamic loads that are created when a structure is suddenly subjected to a load or when stress, strain, or deformation change quickly. This happens as a result of falling rocks, ships colliding, impact from moving items, machinery, etc. The stability of the structure may be significantly affected by this load.

This study aims to understand the dynamic behaviour of the steel column under the influence of an oblique impact load, including understanding the extent to which the steel column is affected by the inclined impact load at different angles, predicting the form of failure of the column under several effective angles.

Finite Element (FE) models were developed and then verified against an experimental results of steel columns subjected to lateral impact loading using the ABAQUS software. The comparison between the numerical outcomes and the experimental findings showed reasonable agreement in terms of displacement-time curve, impact force and mode of failure.

Later, these robust models were utilized to examine the influence of the oblique impact loading on the behaviour of IPE-section and hollow steel columns. In addition, several important parameters such as the angle degree, materials properties and impact location were also studied. The models were also used to study the parameters affecting the behaviour of the steel column under the influence of an inclined impact load, which include the impact energy, impact speed, impact location, the effect of impact hardness by changing the coefficient of friction, and the boundary condition of the column. If the material parameters are specified appropriately.

ABAQUS/Explicit was found to be a useful tool for simulating the behaviour of solid, hollow, rectangular and circular steel columns under oblique impact.

Parametric studies have confirmed that the I-section solid steel column is affected by the inclined impact load at angles of 15, 30 and 45 degrees around the x-axis, and the rest of the angles have an imperceptible effect, while the rectangular hollow steel column is affected by the impact load at angles of 45, 65 and 85 degrees around the z-axis, and the rest of the angles have an imperceptible effect. For the circular hollow steel column, it has been observed that when the inclined impact load at angles of 5, 10 and 15 degrees around the z-axis is applied, its effect is equivalent to the effect of the lateral impact load, which is a critical load for the column. It has been found that the most influential parameters on the models of the three types of columns (solid steel column, circular hollow steel column and rectangular hollow steel column) are the impact energy, i.e. the mass and the impact velocity. A clear effect on the failure mode and force-displacement curves of the columns was observed when the velocity and mass changed. The results of the impact of the hollow circular steel column showed that when it was subjected to an inclined impact load at an angle of 5, 10, 15 and at an impact speed of 10 m/s and 20 m/s, its impact exceeds the effect of the lateral impact load.

The present investigation furnished an all-encompassing understanding of the conduct of steel columns when exposed to an oblique impact load, along with the aspects influencing said behaviour.

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بكالوريوس هندسة مدنية 2020

بأشراف

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ربيع الاول 1446 ايلول 2024