UNIVERSITI TEKNOLOGI MARA

AN ENERGY-BASED ALTERNATE LOAD PATH (ALP) METHOD FOR PROGRESSIVE COLLAPSE ASSESSMENT OF A DOUBLE-SPAN STEEL BEAM USING THE PLASTIC HINGE ENERGY DISSIPATION MODEL

NUR EZZARYN BIN ASNAWI SUBKI

MSc

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Nur Ezzaryn Bin Asnawi Subki
Student I.D. No.	:	2016318875
Programme	:	Master of Science (Civil Engineering) – EC750
Faculty	:	Civil Engineering
Thesis Title	:	An energy-based Alternate Load Path (ALP) method for progressive collapse assessment of a double-span steel beam using the Plastic Hinge Energy Dissipation model
Signature of Student	:	……………………………………………..
Date	:	March 2021

ABSTRACT

This research develops a new energy-based Alternate Load Path (ALP) method that provides a quick progressive collapse assessment for a double-span steel beam in accordance with the design philosophy and requirements given in the Eurocode standards. An empirical model called the Plastic Hinge Energy Dissipation model is introduced, which can easily estimate the strain energy capacity of a double-span steel beam. A new acceptance criterion that represents actual structural resistance against collapse has also been proposed. The proposed energy-based method is expected to overcome the two issues that render the practicality and reliability of the current established energy-based methods due to the implementation of the Eurocode standards. The two issues are increase in analytical burden and unreliable acceptance criteria. The ultimate goal of this research is to develop and verify the empirical model and the proposed acceptance criterion, which later will constitute to a new energy-based ALP method. The research is executed into four major phases. The first phase involves critical review on past researches regarding the progressive collapse design approach. A comprehensive parametric study is conducted using the ABAQUS software in the second phase. The parametric study has revealed that the tensile catenary action affects the moment resistance, structural ductility and the final failure mechanism of a double-span beam under a monotonic pushdown force. The study also shows that the tensile catenary action is less dominant for beams with high bending stiffness due to delayed plastic hinge formation that hinders the mobilisation of the tensile catenary action. In the third phase, the empirical model is derived using the data set collected from the parametric study. The verification process has shown that the empirical model able to predict the strain energy capacity of a double-span beam consistently with tolerable error. However, the empirical model tends to underestimates the strain energy capacity for beams with high bending stiffness as this model only considers the strain energy induced by the flexural action. The final phase of this research is the verification of the proposed acceptance criterion. The proposed acceptance criterion able to quantify the resistance of a double-span steel beam under an instantaneous loss of column accurately with the percentage error of 5.4%. With both of the empirical model and the proposed acceptance criterion have been verified, a new energy-based ALP method is established. This new energy-based method is expected to benefit the Malaysian construction industry, which is currently enforcing the Eurocode standards as the codes of practice.

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