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（都市イノベーション学府 Graduate School of Urban Innovation）

論 文 要 旨

Summary of Dissertation

令和　06　年　08　月　26　日

Date（YYYY-MM-DD）:

専　　攻 Department	Department of Civil Engineering
氏　　名 Name	Aqsa Jamil
論文題目 Title	Impact-loading-based modified Weibull stress evaluation for structural steel
和訳または英訳 Translation (J->E, or E->J)	(衝撃試験に基づく構造用鋼材の修正ワイブル応力評価)

During the extreme events of Northridge (1994) and Kobe (1995) earthquakes, catastrophic failure occurred in numerous steel structures due to brittle fractures initiated on the welded beam-column connections. The design philosophies, material development, techniques and practices of inspection etc. have been revolutionized after historic failures caused by brittle fractures. Throughout the passing years the failure criterion has been redefined with enhanced prediction techniques and analytical modelling by using the concept of Weibull probability. Application of modified Weibull stress (MWS) has been proposed to estimate such failures, however, the evaluation methodology requires difficult experimental procedures. The brittle (cleavage) fracture identification process based on MWS consists of two-parameters determination, i.e., shape and scale parameters. Therefore, to study the effect of brittle fracture during earthquakes in detail for various steel structures, there is a need to simplify the evaluation methodology of MWS and its material parameters. The present study focuses on the development of a simplified and economic MWS evaluation methodology based on Charpy impact approach. The Charpy impact test is a widely accepted method for the measurement of material's fracture toughness and facilitates the investigation on the temperature related ductile-brittle transition phenomena. To develop the impact-based MWS evaluation methodology, the MWS approach was applied to the impact problem by simulating the Charpy impact analytical model. To deal with strong non-linearity and reproduction of elasto-plastic deformation phenomena under impact, an explicit-dynamic analysis was performed employing penalty contact method. The fracture occurrence probability at different temperatures was evaluated based on MWS, while internal energy from the analysis was decided at 95% fracture probability. For the verification of applicability of the MWS-based analytical fracture estimation to high strain rate Charpy impact problem, the Charpy impact experiments were conducted, and the experimental absorbed energy was compared with analytical energy for two Japanese structural steels i.e., SM570Q and SM490YB. It was found that the analytical values and the experimental values are in good agreement in the low-temperature region where brittle fracture dominates provided the applicability of the analytical model based on the MWS calculations.

After the validation of Charpy impact analytical model in the brittle fracture region, an analytical parametric study was conducted implementing the MWS calculations for the constraint determination. The parametric analysis was conducted on a lower-temperature region for a body-centered cubic (BCC) structural steel SM570Q. The main purpose of this parametric study was to acquire the constraint or stress-triaxiality by changing the standardized notch geometry of Charpy impact specimen to develop an impact-based Weibull parameter assessment technique. Multiple analyses were conducted by varying the depth, angle, and root radius of the notch at different temperatures, and the impact of each parameter on the constraint level was also confirmed. The developed impact-based Weibull procedure was able to distinguish between the ductile-brittle transition behavior for all parameters involved in the constraint identification. The analytical results indicated that the impact energy decreased by deepening the notch depth (ND), decreasing the root radius (NRR) and the notch angle (NA), hence increasing the brittleness. From the comprehensive parametric study, experiments were performed on selected modified specimen's geometries using Charpy impact testing machine. To focus on the cleavage fracture mechanism, the experiments were performed in the low-temperature region of the DBTT, and the selected specimens covered a wide range of constraints for the brittle zone. The experimental absorbed energy at different constraint levels served as the basis for the determination of unique values of MWS parameters. The calibration of the MWS parameters was accomplished using the least-square method. The calibration of the MWS shape and scale parameters was accomplished from the experimental results conducted at -196 °C, while for threshold stress -80 °C results were used. Finally, an impact-based rationalized evaluation methodology was developed for the MWS approach.

4,000 字以内 Must not exceed 4,000 Japanese characters or 1,600 words.

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The English title of the dissertation should be written in sentence case, where only the first letter of the first word is capitalized. It should not exceed 250 characters in English (single-byte characters) and 125 characters in Japanese (double-byte characters). Special characters such as umlauts or accent marks are not permitted.