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Type(English)	Outline

A Study on Performance Evaluation of Box Column Connections
with Internal Diaphragms in Steel Frames

by

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Abstract

This dissertation focuses on the performance evaluation of box column connections with internal diaphragms in steel frames. For a box moment frame, the performance of the connections can be improved by using continuity plates, known as internal diaphragms. The study aims to propose a comprehensive and alternative design approach for the internal diaphragm and to evaluate the performance of the internal diaphragm connections between plates and box columns, and wide flange (WF) beam and box columns. Thereafter, the study is further expanded to a prediction of stress due to shear lag and its design parameters for the internal diaphragm connections between box beams and box columns (T-joints) with beam under a point and uniformly distributed loads.

Initially, a theoretical study was carried out to predict the strength and load-deformation characteristics of plate-to-box column connections with internal diaphragms, which then were validated by numerical and experimental investigations, respectively. The numerical and experimental studies on the plate-to-box column connections considered the effects of diaphragm hole diameter and thickness, plate-to-column width and column width-to-thickness ratios, and concrete on the strength of the connections. With the designed diaphragms, the numerical performance of WF-beam-to-box column connections with and

without concrete filling was then evaluated under gravity and cyclic loadings, aiming to ensure the prequalification requirements. Furthermore, the study was carried out to predict of shear lag stress in the box T-joints. The occurrence of shear lag phenomenon in the box T-joint generates stress concentration localized at both web-flange junctions of the beam, which leads to cracking or failure in the weld region of the joint. To prevent such critical issue, peak stress at the weld region is required to be checked during the preliminary design stage. The shear lag stresses evaluated using least-work solution in which the longitudinal displacements of the beam flange and web were presumed. The evaluation process considered particularly the effects of column flange flexibility, depth of the beam web, and their relations on the stress distribution. The stress equations were analytically obtained with a complicated form. Therefore, a simplified method was proposed to facilitate the calculation procedure. The simplified method used a stress modification factor β_s from a parametric study, which represents the shear lag in the beam web. Further empirically simplified method for the evaluation of shear lag stress (peak stress) was developed in order to serve for the preliminary design.

The results are presented and discussed as finding that the designed internal diaphragms were the key elements to enhance the performance of the connections. The diaphragm parameters, plate-to-column width and column width-to-thickness ratios, and concrete significantly affect the strength of the connections. Concrete was able to improve the performance of the plate-to-box column connections by 30% strength increase compared with the connections without concrete filling. More importantly, the performance of the WF-beam-to-box column connections with the designed internal diaphragms alternatively agreed with the seismic prequalification requirement. For the stress evaluation in the box T-joints, the results showed that the simplified method was valid for predicting the shear lag stress in the box T-joints analytically, as well compared with finite element method (FEM) and test results. The results are further summarized, discussed, and clarified that the internal diaphragm also played a significant role in reducing the stress concentration at both edges of the beam flange in the box T-joint.

Keywords : Box Column Connections; Column Flange Flexibility; Finite Element Method; Internal Diaphragms; Least-Work Solution; Load-Deformation Relations; Shear Lag; Steel Frames

Dissertation Outline

This dissertation is arranged into seven chapters and one appendix. The contents for each chapter and appendix can be seen in Fig. 1 and the details are summarized as follows.

Chapter 1 describes the introduction of the dissertation, which contains the research overview, purpose and objectives, frameworks and scope of the study, and organization of the dissertation.

Chapter 2 presents the review of the related studies. The relevant and existing studies on the steel box column connections with internal diaphragm have been addressed. The relevant information, such as existing design and evaluation approaches were also included.

Chapter 3 provides the performance evaluation of the plate-to-box column connections, in which static behavior, such as strength, load-deformation relations, and mechanism of the connection was discussed using theoretical and numerical approaches.

Chapter 4 comprises of testing of plate-to-box column connections with internal diaphragms. The study discussed the confirmation of the static behavior considering the parametric effects, such as plate-to-column width and column width-to-thickness ratios, and concrete filling on the strength of the connections.

Chapter 5 presents the numerical performance evaluation of the WF-beam-to-box column connections using the designed diaphragms as proposed earlier in Chapter 3.

Chapter 6 discusses the theoretical and numerical evaluations of stress distribution due to shear lag in the box T-joints with beam subjected to a point and uniformly distributed loads. Using a method so-called “Least-work solution”, the normal stress due to shear lag can be predicted and further simplified by considering the effects of column flange flexibility and depth of beam web.

Chapter 7 concludes the results and main findings of this study, and provides recommendations and further studies.

Appendix A provides an evaluation of shear stress in the box T-joints using least-work solution method.

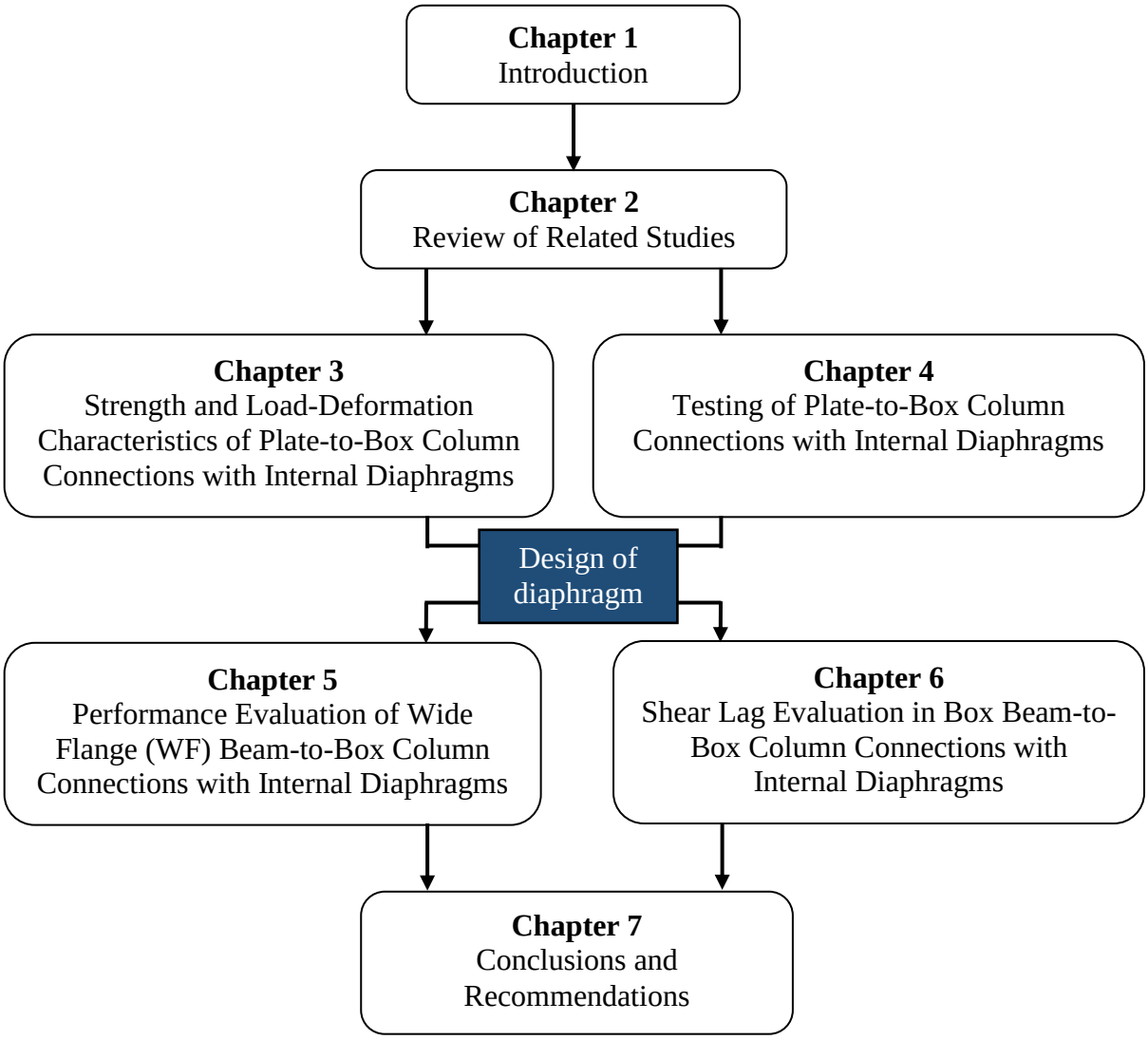

Fig. 1 Organization of the dissertation