I－24 A Study on Design Approach of Stiffened Compression Flanges

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1. Introduction This study is aimed at the evaluation of approaches for the design of stiffened compression flanges which are recommended by Technical Committee 8 Structural Stability of ECCS[1]. There are two approaches, that is, column approach and orthotropic plate one, in the ECCS recommendations. Regarding the evaluation of the approaches, few studies have been seen but they are not based on the final draft (July 1990) of the recommendations, and seem not to cover a wide range of parameters of compressive stiffened plates[2]. Therefore, it is impossible to evaluate superiority of the approaches and their ranges of application for design under the present conditions. In this paper effective conclusions concerning the design approaches are derived from a parametric study using a small computer.

2. Main Features of Study The present study consists of the following contents, (a) selection of parameters which dominate the ultimate strength of the stiffened plates, (b) range of the selected parameters, (c) approaches for design of stiffened compression flanges, (d) numerical analysis and results of parametric study, (e) comparison of approaches with theoretical and experimental studies, (f) further studies on design approach.

3. Selection of Parameters (1) Properties of Ultimate Strength Results of numerous investigations on the ultimate strength of stiffened plate have been obtained for more than 20 years[3]. Therefore, a lot of parameters which dominate the ultimate strength of the stiffened plates are selected based on behavior of the stiffened plates. Design variables of the stiffened flange which mainly dominate the ultimate strength are as follows, a/i_s: slenderness ratio of a stiffener, a/b : aspect ratio of the stiffened panel, b'/t : width-thickness ratio of an individual sub-panel. A number of stiffeners m and ratio of cross-section δ are important parameters, however, it can be assumed that m and δ are dependent on a/b and a/i_s, respectively. Because, b'/t is distributed within the narrow range in the case of steel bridges, and width-thickness ratio of the stiffener d/t_w is limited from tortional buckling point of view. i_s denotes radius of gyration of a stiffener.

(2) Design Variables (a) Steel grade specified by Eurocode 3[4] is listed in Table 1. (b) Variables of stiffened plate panels are plate slenderness b'/t and aspect ratio a/b. (c) Longitudinal stiffener has three parameters, which are cross-section, number of stiffeners m, and slenderness ratio a/i_s. Fig. 1 shows assumed cross-sections of stiffeners.

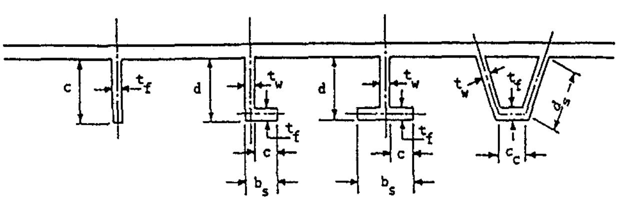

Fig. 1 Assumed Cross-Sections of Longitudinal Stiffeners

Table 1 Nominal Values of Yield Strength f_y and Ultimate Tensile Strength f_u for Structural Steel to EN 10025

Nominal steel grade	Thickness t (mm)			
	t ≦40		40< t ≦100	
	f_y(N/mm²)	f_u(N/mm²)	f_y(N/mm²)	f_u(N/mm²)
Fe E 235	235	360	215	340
Fe E 275	275	430	255	410
Fe E 355	355	510	335	490

(3) Range of Parameters According to the steel girder bridges, the range of the parameters are as follows, $20 \leqq a/i_s \leqq 80$, $0.3 \leqq a/b \leqq 2.5$, $15 \leqq b'/t \leqq 60$. Therefore, the values of the variables are assumed as follows, a/i_s=20, 30, 40, 50, 60, 80, a/b=0.3, 0.5, 0.9, 1.4, 2.5, b'/t=20,

30, 40, 50, 60, m=3, 6, 9.

4. Approaches for Design of Stiffened Compression Flanges The following three approaches are examined, (1) European column approach recommended by ECCS[1], (2) European orthotropic plate approach recommended by ECCS[1], and (3) extended column approach developped by Nara-Fukumoto[5]. References [1,5] describe the details of these approaches, respectively.

5. Numerical Analysis and Results of Parametric Study Procedure of the present parametric study is as follows, (1) assumption of geometrical quantities of flange plates, (2) calculation of parameters of cross-sections and common design variables for each approach, (3) ultimate strength by the ECCS column approach, the ECCS orthotropic plate approach, and the extended column approach, (4) storage of design variables and ultimate strength. Ranges are determined for the parameters, in accordance with practice situations. Obtained are 270 data on ultimate strength for each steel grade and design approach. Figs. 2 and 3 make a comparison of ultimate strength between these three approaches. Significant differences are laid on large a/i_s and small b'/t.

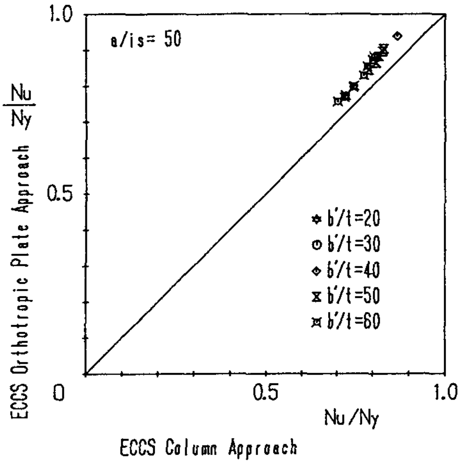

Fig. 2 Comparison between Design Approaches

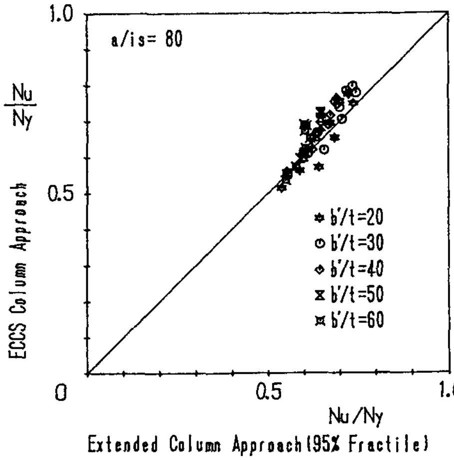

Fig. 3 Comparison between Design Approaches

6. Conclusion The conclusions of the paper are as follows, (1) a parametric study covering the whole ranges of parameters is carried out to produce numerical results relevant to both European approaches, (2) the extended column approach is also calibrated, because, a recommendation for design of steel plated structures on the basis of ultimate strength has already been published in Japan, (3) several improvements in the approaches and further studies are proposed. Finally, this study is expected to contribute to the development of Eurocode 3 - Part 2, which is just being started.

References [1] ECCS - Technical Committee 8 - Structural Stability Technical Working Group 8.3 - Plated Structures, "*Recommendations for the Design of Longitudinally Stiffened Webs and of Stiffened Compression Flanges,*" July, 1990. [2] van Dansik, M., Puthli, R.S., Wardenier, J. and Bijlaard, F.S.K., "*Initial Development of A CAD System on Steel Plated Structures,*" TNO-IBBC Report No.BI-89-169, September, 1989. [3] Dubas, P. and Gehri, E., "*Behavior and Design of Steel Plated Structures,*" ECCS Publication, Zürich, 1986. [4] Eurocode 3 Editorial Group, "*Design of Steel Structures,*" Part 1-General Rules and Rules for Building, Eurocode No.3, Final Draft, 1990. [5] Nara, S. and Fukumoto, Y., "Evaluation of Ultimate Strength and Ductility of Longitudinally Stiffened Plates under Uniaxial Compression," *Proc. Annual Technical Session,* SSRC, Chicago, Illinois, April 15-17, 1991, pp.391-402.