Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 10 (1976)

Artikel: Structural behavior including hybrid construction

Autor: Kato, Ben

DOI: https://doi.org/10.5169/seals-10546

Va

Comments by the Author of the Introductory Report

Remarques de l'auteur du rapport introductif

Bemerkungen des Verfassers des Einführungsberichtes

BEN KATO
Prof. Dr.-Eng.
University of Tokyo
Tokyo, Japan

Structural Behavior Including Hybrid Construction

The state-of-the-art on the structural behavior of members and structures made of high-strength steels is outlined in this report according to sub-items listed in Table 1. Characteristics of the structural behavior of those made of high-strength steels are discussed in relation to those made of mild steel in order to provide the information by which a designer can decide whether a grade of high-strength steel should or should not be used in a particular part or in a particular structure in association with the imposed loading conditions.

1.MATERIAL	BEEDLE et.al.
2.TENSION MEMBERS	
3.BEAMS & BEAM-COLUMNS -In Plane Behavior-	FISHER et.al. (composite beam)
4.STABILITY	
4.1.COLUMN BUCKLING	
4.2.LOCAL BUCKLING	FUKUCHI et.al.
4.3.LATERAL-TORSIONAL BUCKLING	FUKUMOTO SUZUKI et.al.
4.4.ROTATION CAPACITY	BEEDLE et.al.
5.FRAMES	
6.PLATE & BOX GIRDERS	KUNIHIRO et.al. MAEDA et.al. YAMASAKI et.al.
7.FRACTURE & FATIGUE	

Table.1 Outline of the Theme and Contributors

In this table, authors and topics which were contributed to the preliminary report are identified, and the synthesis of these contributions will be made in the following together with the key points of the introductory report.

Structural steels can be grouped into three classes as shown in Fig.1. Of which C-class steels are called as "extra high-strength steel", and mechanical properties of these steels in plastic region such as strain at initial strain hardening, strain hardening modulus and the yield ratio of material are considerably small compared with those of mild steel.

Dr.Beedle and his colleagues had studied a new type steel, designated as A572, Grade 65. This steel is a low-alloy columbium-vanadium steel and mechanical properties are in between of B and C-class steels as shown in Fig.2.

The poor capacities of deformation and energy absorbtion of tension members, beams, beam-columns and frames made of C-class steels are attributed to these characteristics of mechanical properties.

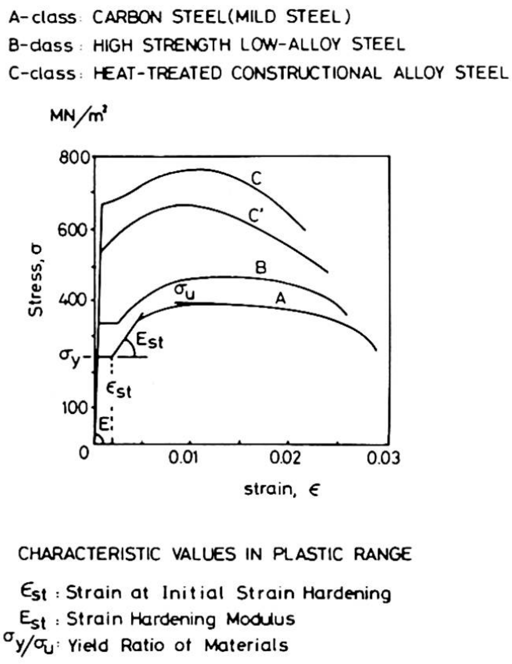


Fig.1 Classification of Structural Steels

The buckling behavior of members can be discussed by categorizing them into three groups according to their slenderness.
Since all compression elements have the same Eulerian strength regardless of the yield strength of the material, there will be no merit to use high-strength steels for slender members. For compression members with intermediate slenderness, the secondary factors such as

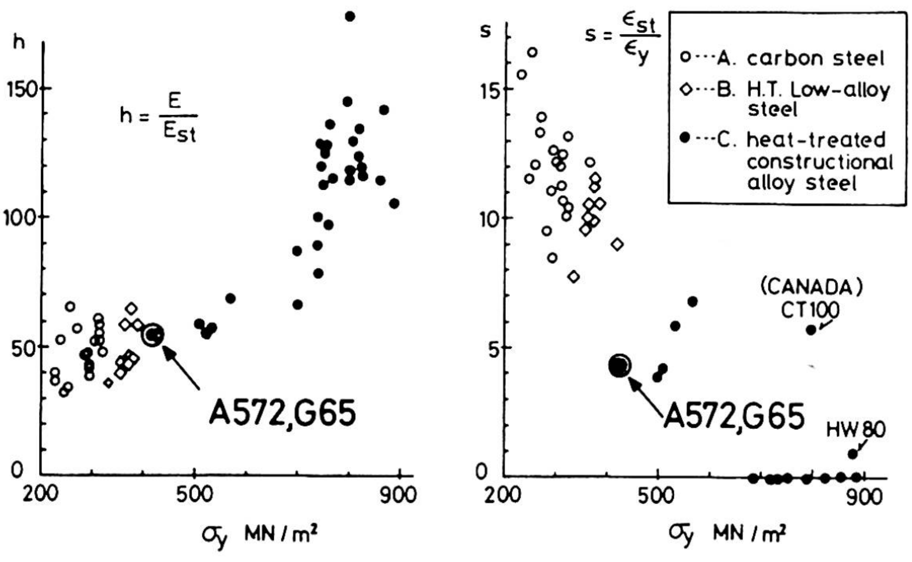


Fig.2 Characteristic Values in Plastic Region

residual stress,initial curvature and eccentricity have the greatest effect on tneir buckling strength. It is known that the effect of residual stress is less pronounced for higher strength steels than it is for mild steel,thus as the yield stress increases,initial curvature and eccentricity take on increasing importance in relation to residual stress. Dr.Fukumoto had carried out the lateral buckling tests of beams made of B and C-class steels with intermediate slenderness. A total 36 beam-type and 7 girder-type members was tested under uniform moment and moment gradient,and test results were compared with theoretical prediction. Fog.4 shows a non-dimensional presentation of the critical moment to slenderness relationship, and a comparison is made between the annealed beams and the as-weld beams having the same sizes for the residual stress effect. It has been concluded that the welding residual stress distributions may reduce the buckling strength for about 11% for B-class steel,and 6% for C-class steel against the beams without residual stress, and that initial lateral deflection of 0.1% of the beam length may explain the lower bound estimate against the plotted test results.

The deformability and ultimate strength of members or member elements with very small slenderness are the topics of increasing interest in relation to the development of plastic design and of earthquake resistant design. Because the behavior is determined almost entirely by the plastic properties of the material in such a short and stocky members,characteristic behavior of extra high-strength steels or C-class steels will be paramount in this range. Fig.5 shows the relationship between the rotation capacity and the slenderness of beams which subject to lateral buckling under uniform moment. Shown by the double circle is the Beedle's test

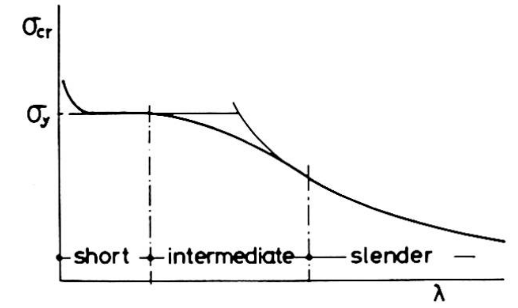


Fig.3 Categories of Slenderness of Compression Elements

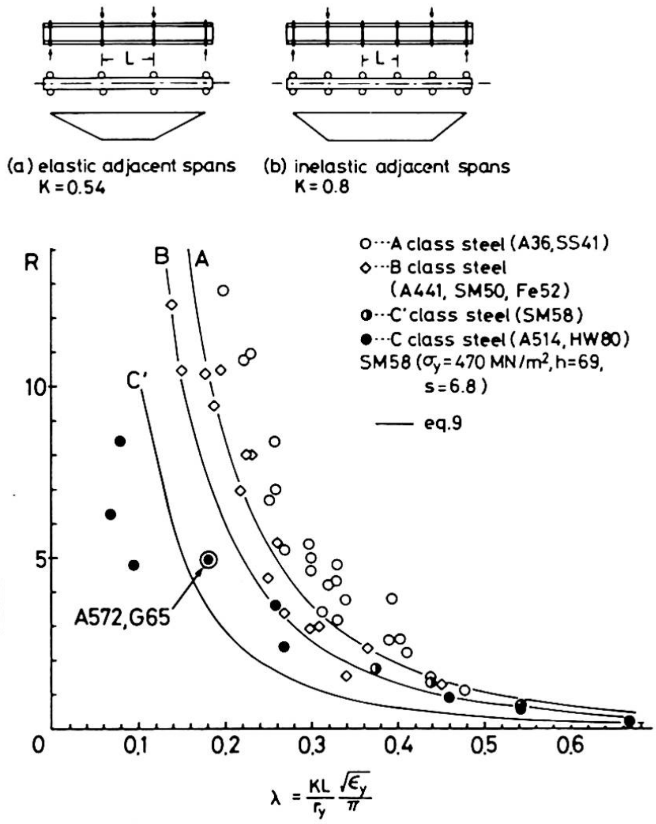


Fig.5 Rotation Capacity under Uniform Moment

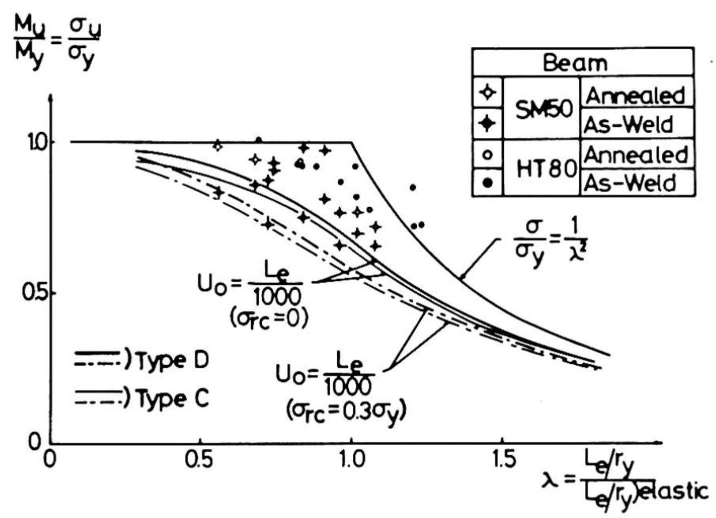


Fig.4 Test results and Theoretical Predictions

result of which the beam is made of columbium-vanadium steel as refered previously. Rotation capacity falls in between those of B and C-class steels as is expected from mechanical properties of this steel.
Dr.Suzuli and Mr.Ono had carried out lateral buckling tests of beams and beam-columns with short slenderness. Steels used are of A,B and C-class. Fig.6 shows the relationship between the axial load and the slenderness of beam-columns. Theoretical prediction by Suzuki that assures the rotation capacity of 3 are shown by bold solid lines,and test results rotation of which were less than 3 are checked by x-mark. On the other hand,a suggested axial load limitation given by eq.(12) in the introductory report is shown by the fine solid lines. It seems that eq.(12) be not satisfactory for C-class steel. Considering the fact that the information on the rotation capacity of beam-columns is insufficient as yet,this contribution is very important. Test results on beams reported by Suzuki were already refered in the introductory report.

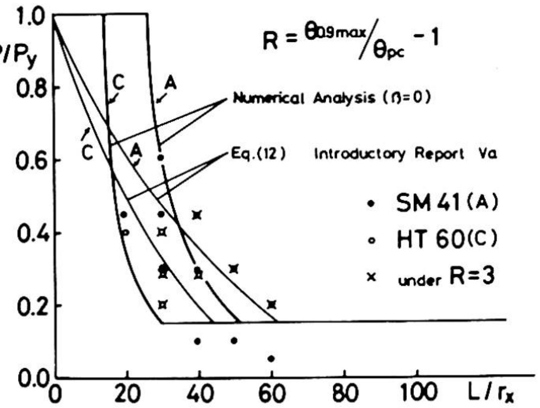


Fig.6 Rotation Capacity of Beam-Columns

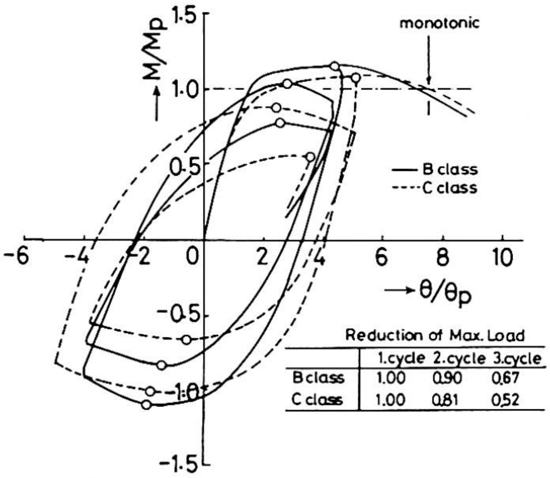
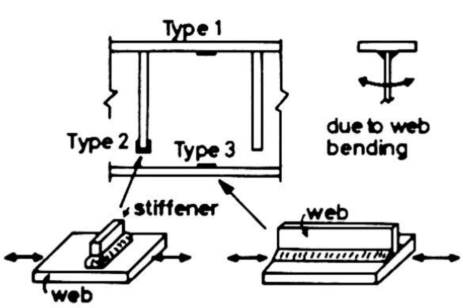


Fig.7 Cyclic Behavior of Beams

Behavior of beams under cyclic loading were investigated by Dr.Fukuchi and his colleagues. Fig.7 shows cyclic behavior of beams which subject to lateral and local buckling in their course of loading. Beams made of B-class and C-class steels which have almost the same rotation capacity when subjected to monotonic loading were tested and compared in this figure. Reduction of maximum load at each cycle is shown in the table,and it can be said that the rotation capacity of higher strength steel beams under cyclic loading will be more severely impaired than that expected from the monotonic test.

Hybrid beams are fabricated beams and girders which use a stronger steel in the flanges than in the web. The design of hybrid beams is based on the shakedown phenomenon, which ensures that the members will behave elastically after local yielding of the web. It seems that high-strength steels can be most efficiently utilized in this field of application as far as static loading is concerned. However this concept can not be applied to the fatigue desigr. off hand,since metallurgical discontinuity and local stress condition around the welded joints will affect the fatigue strength considerably.

Typical patterns of fatigue cracks which will occur in hybrid girders are shown in Fig.8.



Fug.8 Typical Patterns of Fatigue Cracks

Type 1 crack will be caused by web breathing due to initial bending of the web, Type 2 crack initiated at the toe of vertical stiffener-to-web fillet weld can be compared to that of a transverse non-load carrying fillet welded joint,and Type 3 crack initiated at tension flange-to-web fillet weld can be compared to that of a longitudinal fillet welded joint as shown in the figure.

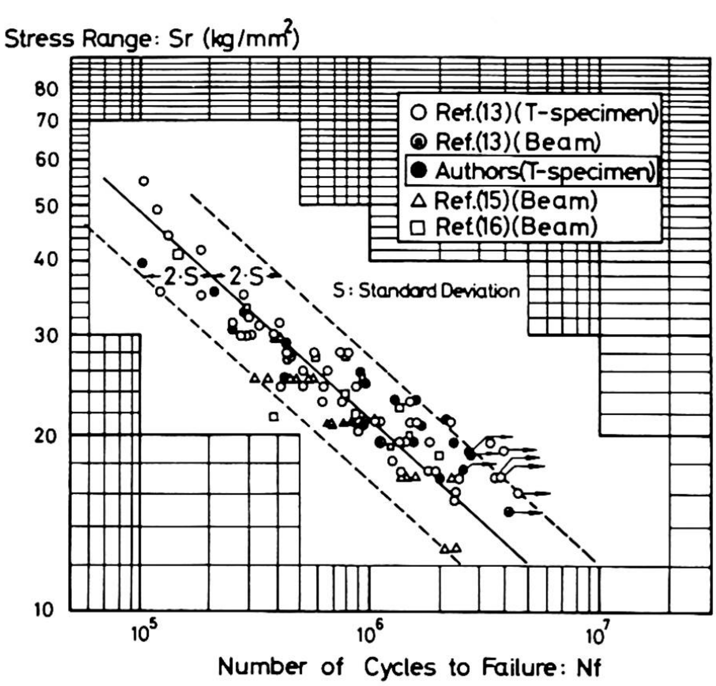


Fig.9 S-N Diagram of Hybrid Specimens

Three papers were contributed to this topic. Dr.Maeda and his colleagues had studied Type 1 and Type 2 fatigue phenomena and found out that Type 1 crack can be prevented up to 2 million cycles of loading by limiting out of plane movement of web plate, depending on web slenderness and rigidity of a horizontal stiffener, and also found out that Type 2 crack can be prevented by controlling a tensile web stress bellow the fatigue strength of transverse non-load carrying fillet welded joints.
Dr.Kunihiro's group and Dr.Yamasaki 's group had investigated the fatigue strength of Type 3. Solid circles in Fig.9 represent the test results for hybrid specimens and open circles are for homogeneous specimens. As seen in this figure,test points are somewhat scattered and no statistical difference was found between fatigue strengthes of homogeneous and hybrid specimens. This might mean that the influence of geometrical and metallurgical imperfections of welded joints is large enough to cover up the characteristics of hybrid joints. In any case,the results of these two groups had supported the conclusion of Joint ASCE-AASHO Committee that "hybrid beams can generally be designed for fatigue as if they were made entirely of the grade of steel used in the flanges". In addition to these fatigue studies,Dr.Maeda and Dr.Kunihiro had discussed on the static behavior and economy of hybrid girders, and Dr.Yamasaki had analysed the problem of fatigue crack propagation by applying a theory of fracture mechanics.

Finally,the design problem of composite beams were discussed by Dr.Fisher and his colleagues. With respect to the composite beam in which a concrete floor slab with formed steel deck and a steel beam made of mild steel are connected by means of shear connectors,a design formula based on the ultimate strength concept has been already proposed by Fisher himself. At present study,Dr.Fisher and his colleagues had examined the possibility of extensive application of high strength steel beams to this composite beam system by a series of tests,and concluded that "the flexural capacity of a composite beam utilizing high-strength steel is not adversely affected by the increased slab force and can be predicted provided that the connector capacity is known".

As reviewed herewith,the problems of fracture and fatigue in their proper sense were not contributed to the preliminary report,and the author hopes these problems would be discussed in prepared and free discussions.

Leere Seite
Blank page
Page vide