INTERNATIONAL

**Designation: ~~F1455 – 92 (Reapproved 2011)~~ F1455 – 92 (Reapproved 2017)** An American National Standard

# Standard Guide for Selection of Structural Details for Ship Construction[1]

This standard is issued under the fixed designation F1455; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

The principal aim of this guide is to depict recommended practices related to the design of ship structural details. The importance of structural details is clear:

~~1) Their~~(*1*) Their layout and fabrication represent a sizable fraction of hull construction costs.

~~2) Details~~(*2*) Details are often the source of cracks and other failures which, under certain circumstances, could lead to serious damage to the ship hull girder.

~~3) The~~(*3*) The trend toward decreasing ship hull scantlings (that is, increasing average hull stresses) has the potential of increasing the damage to details.

(*4* ~~4) Researchers~~) Researchers have largely neglected the analysis of structural details at least in part because the configuration and purpose of these details vary greatly and are not commonly described or discussed in the literature.

Due to lack of analytical and experimental effort devoted to structural details, their determination has been left up to draftsmen and designers, with very little engineering input.

In two comprehensive reviews[2,3] of the performance of structural details, 86 ships were surveyed. These included naval and commercial ship types. The commercial ships included both U.S. and foreign built. The vessels ranged from 428 to 847 feet in length, from ~~18,000 to 90,000~~ 18 000 to 90 000 tons in displacement, and from five to twenty-six years in age. The details obtained were grouped into 12 typical families. Knife Edge Crossings (Family No. 6) and Structural Deck Cutout Details (Family No. 9) are shown but not covered in detail in this guide. The remaining ten detail families were further categorized into 53 groups comprising a total of 611 detail configurations. A number of these configurations are very similar to others in detail geometry and such duplicates have been excluded from this guide. A number of others were eliminated because of relatively infrequent observed use. As a result, a total of 414 details are included herein. However, all 611 details can be found in "Structural Details,"~~4~~[4] if desired.

In total, ~~607,584~~ 607 584 details were observed with a total of ~~6,856~~6856 failures. Failures were attributed to one or a combination of five categories: design, fabrication, welding, maintenance, and operation (see 4.1 through 4.1.5). This extensive, well documented research, together with engineering judgement, provides the principal support for this guide.



## 1. Scope

1.1 This guide provides a recommended list of selected ship structure details for use in ship construction.

1.2 Structural details which have failed in service and are not recommended for use in ship construction are included as well.

1.3 This guide is intended to convey the lessons learned on different configurations of ship structure details, not the dimensions, thickness, or construction methods which would result from structural calculations.[4]

[1] This practice is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.01 on Structures.
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[2] Jordan, C. R., and Cochran, C. S., "In-service Performance of Structural Details," SSC-272, *Ship Structure Committee Report*, March 1977, available through the National Technical Information Service, Springfield, VA 22161.

[3] Jordan, C. R., and Knight, L. T., "Further Survey of In-service Performance of Structural Details," SSC-294, *Ship Structure Committee Report*, May 1979, available through the National Technical Information Service, Springfield, VA 22161.

[4] Jordan, C. R., and Krumpen, P., Jr., "Structural Details," *American Welding Society Welding Journal*, Vol 63, No. 1, January 1984.

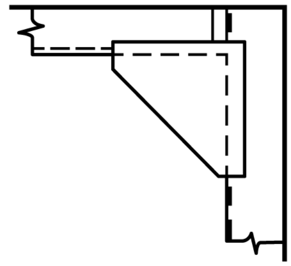

FIG. 1 Beam Brackets (Family No. 1)

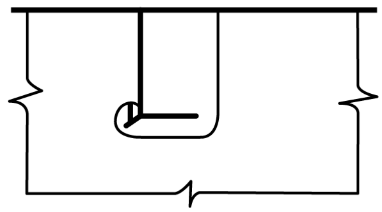

FIG. 2 Clearance ~~Cut-outs~~Cut-Outs (Family No. 8)

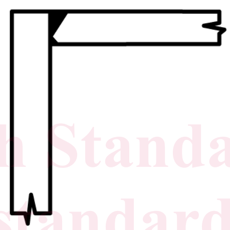



FIG. 3 Gunwale Connections (Family No. 5)

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*



**2. Terminology**

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *Terms:*

2.1.2 *beam bracket*—a bracket at the end of framing or stiffening members that is used for increased strength, continuity and end constraint.

2.1.2.1 *Discussion*—

~~see~~See Fig. 1.

2.1.3 *clearance cut-outs*—a hole or opening in a pierced member to allow passage of a piercing member.

2.1.3.1 *Discussion*—

~~see~~See Fig. 2.

2.1.4 *gunwale connection*—the connection of the sheer strake to the stringer strake of the uppermost deck of the hull.

2.1.4.1 *Discussion*—

~~see~~See Fig. 3.

2.1.5 *knife edge crossing*—the projected point intersection of members (plate members, stiffeners or bulkheads) on opposite sides of an intervening plate member. An undesirable condition to be avoided.

2.1.5.1 *Discussion—*

Included for information only, see 3.1~~3.1.~~.

2.1.5.2 *Discussion—*

~~see~~See Fig. 4.

2.1.6 *miscellaneous cut-out*—small holes or openings of a variety of sizes and shapes used for access, drainage, ease of fabrication, stress relief, and so forth.

2.1.6.1 *Discussion—*

~~see~~See Fig. 5.

2.1.7 *non-tight collar*—a fitting at the cut-outs in way of the intersection of two continuous members that provides lateral support for the piercing member which does not fully fill the cut-out area of the pierced member. May be a lug.

2.1.7.1 *Discussion—*

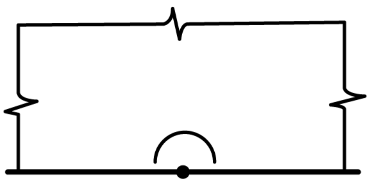

**FIG. 5 Miscellaneous ~~Cut-outs~~Cut-Outs (Family No. 7)**



~~see~~See Fig. 6.

2.1.8 *panel stiffeners*—intercostal, non-load-carrying members used to reduce the size of plate panels.

2.1.8.1 *Discussion—*

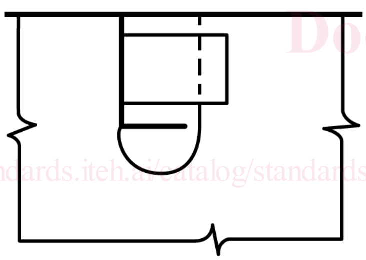

**FIG. 6 Non-Tight Collars (Family No. 3)**

~~see~~See Fig. 7.

2.1.9 *stanchion ends*—structural fittings at the ends (top and bottom) of a stanchion to transfer loads from the supported member to the supporting member.

2.1.9.1 *Discussion—*

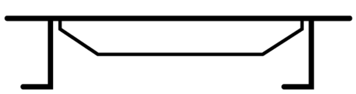

**FIG. 7 Panel Stiffeners (Family No. 12)**

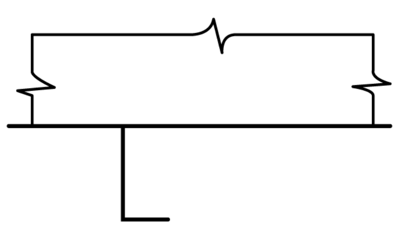

**FIG. 4 Knife Edge Crossing (Family No. 6)**

~~see~~See Fig. 8.

2.1.10 *stiffener ends*—the configuration of the end of an unbracketed, non-continuous stiffener.

2.1.10.1 *Discussion*—

~~see~~See Fig. 9.

2.1.11 *structural deck cuts*—allow passage through decks for access, tank cleaning, piping, cable, and so forth.

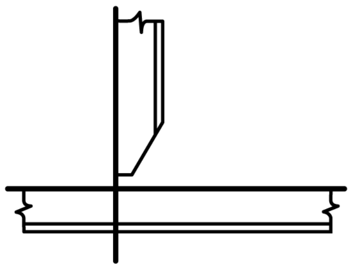

**FIG. 9 Stiffener Ends (Family No. 11)**

2.1.11.1 *Discussion*—

Included for information only, see 3.1~~3.1.~~.

2.1.11.2 *Discussion*—

~~see~~See Fig. 10.



2.1.12 *tight collar*—as per non-tight collar but the cut-out in the pierced member is fully filled and is air-, oil-, or watertight as required. Tight collars may be lapped or flush fitted.

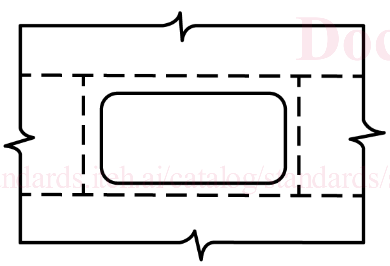

**FIG. 10 Structural Deck Cuts (Family No. 9)**

2.1.12.1 *Discussion*—



~~see~~See Fig. 11.

2.1.13 *tripping bracket*—a bracket or chock that provides lateral support to framing and stiffening members. Support may be provided to either the web or the flange, or to both.

2.1.13.1 *Discussion*—

~~see~~See Fig. 12.

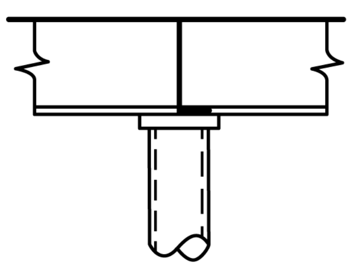

**FIG. 8 Stanchion Ends (Family No. 10)**

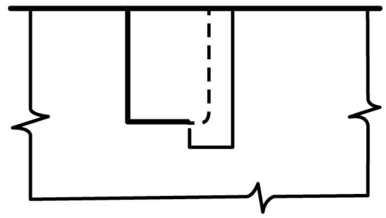

FIG. 11 Tight Collars (Family No. 4)

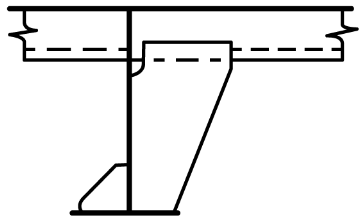

FIG. 12 Tripping Brackets (Family No. 2)

2.2 *Symbols:*

2.2.1 Symbols are as indicated in Fig. 13. The detail identification symbol (Fig. 13, 1-J-1 for example) is the same as that assigned in the original research reports and is retained throughout for all details for ease in referring back to the reports if desired.

## 3. Summary of Guide

3.1 In this guide, details are shown for the ten families of structural details identified above and as shown in ~~Fig. 1~~Figs. 1-3~~–3.~~, Figs. 5-9~~5–9.~~, Fig. 11~~11.~~, and Fig. 12~~12.~~. Knife Edge Crossings, Fig. 4, are not discussed further in this guide since none were observed in the research and fortunately so. This detail represents very undesirable structural conditions and is to be avoided. Structural Deck Cuts, Fig. 10, are not discussed in this guide since this detail must be considered in relation to the size of the opening and its proximity to primary structures.

3.2 Evaluation of details shown in Figs. 14-23 is based on in-service experience as described in "Design Guide for Structural Details".[5] Data for over 400 details is summarized and rated in the figures by observed relative successful performance. Each of the ten families of details include configurations with no signs of failures. The details without failures within each family group are shown in descending order of numbers observed. Those details with failures are shown in ascending order of failures (percentage are indicated for each). Thus the first detail shown in each family group has the best observed service performance and is most highly recommended while the last has the highest failure rate and therefore least desirable.

3.3 These details, rated as indicated above, provide guidance in the selection of structural detail configurations in future design and repair of such details.



[5] Jordan, C. R., and Krumpin, R. P., Jr., "Design Guide for Structural Details," SSC 331, *Ship Structure Committee Report*, August 1990, available through the National Technical Information Service, Springfield, VA 22161.

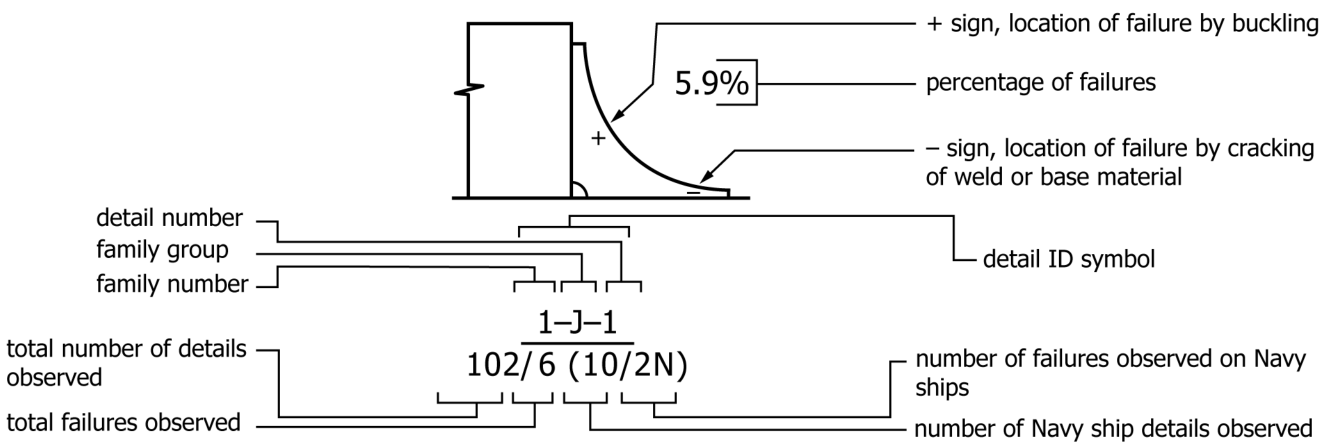


FIG. 13 Symbols

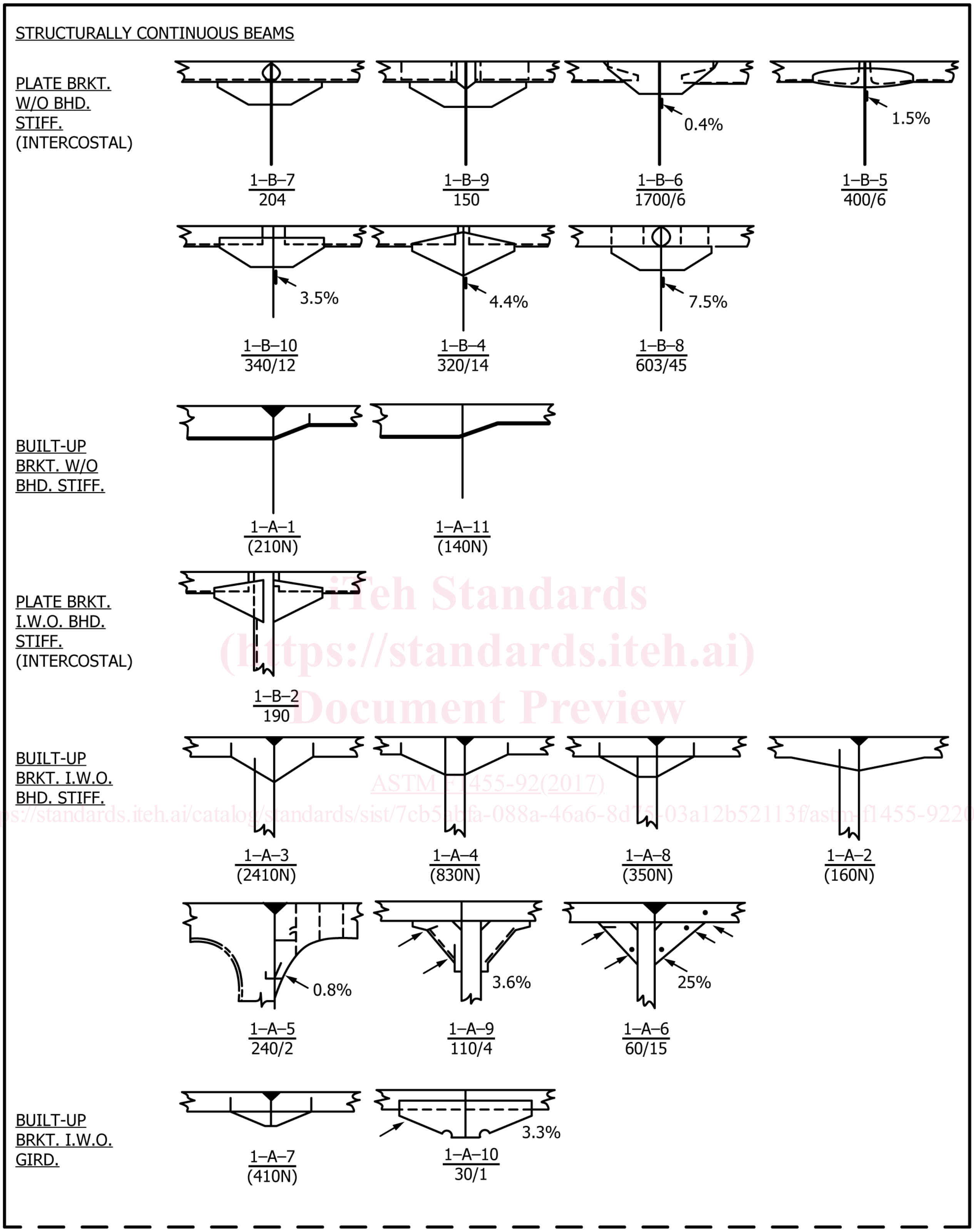




**FIG. 14 Performance of Beam Bracket Details (Family No. 1)**

## 4. Failure Causes

4.1 Failures in the details shown in Figs. 14-23 were attributed to either one or a combination of five categories: design, fabrication, welding, maintenance, and operation.

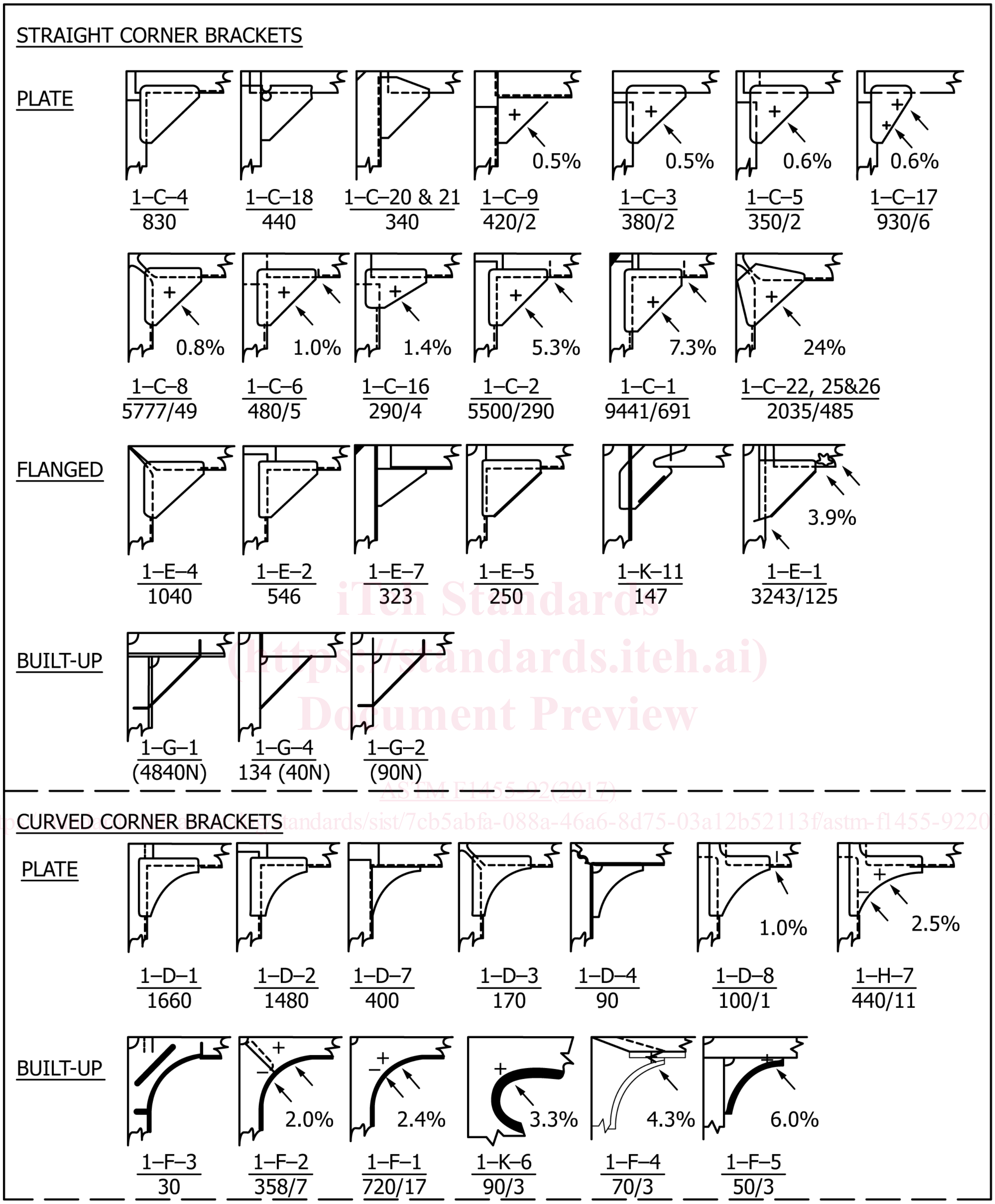




**FIG. 14 Performance of Beam Bracket Details (Family No. 1)** *(continued)*

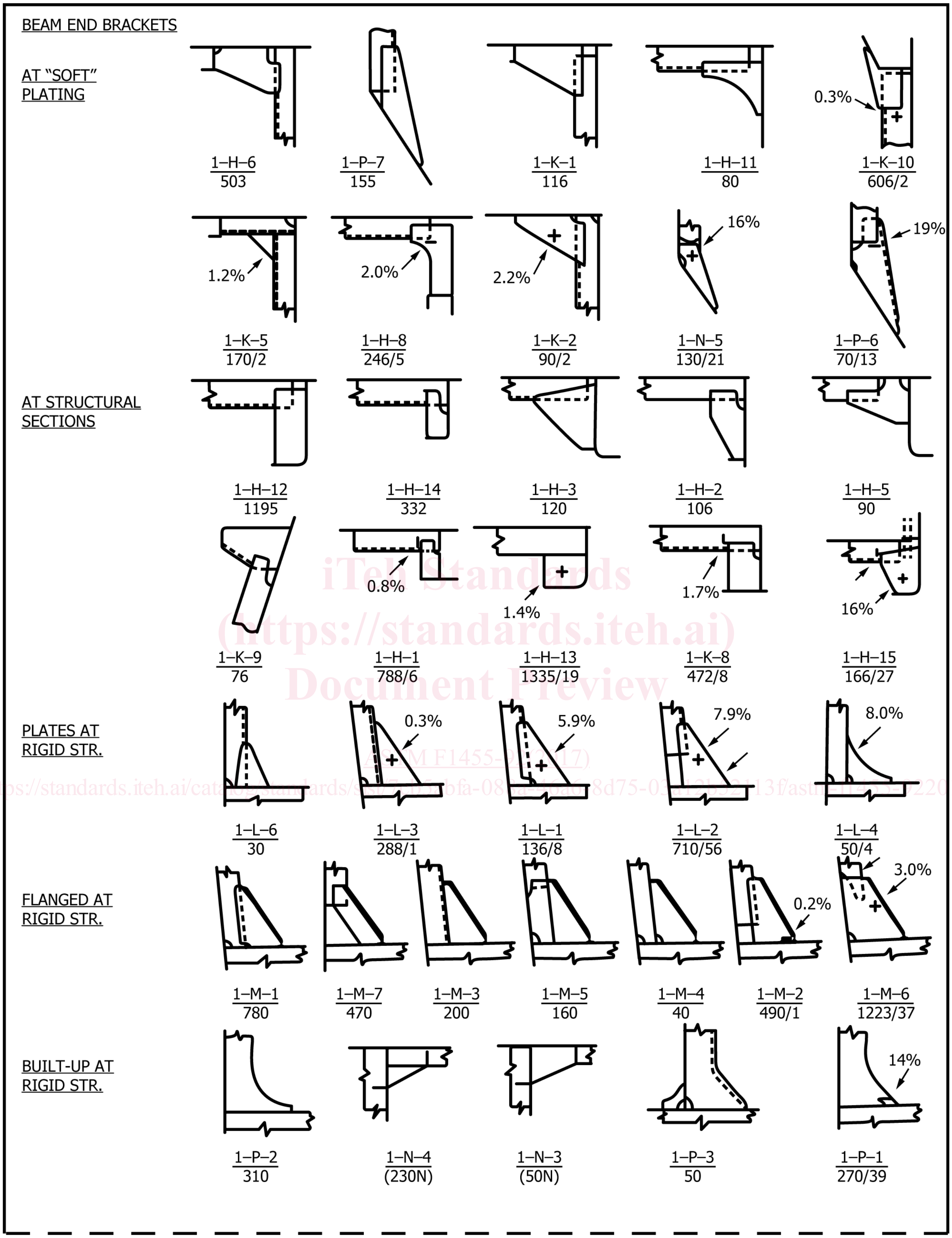




**FIG. 14 Performance of Beam Bracket Details (Family No. 1)** *(continued)*

4.1.1 *Design:*

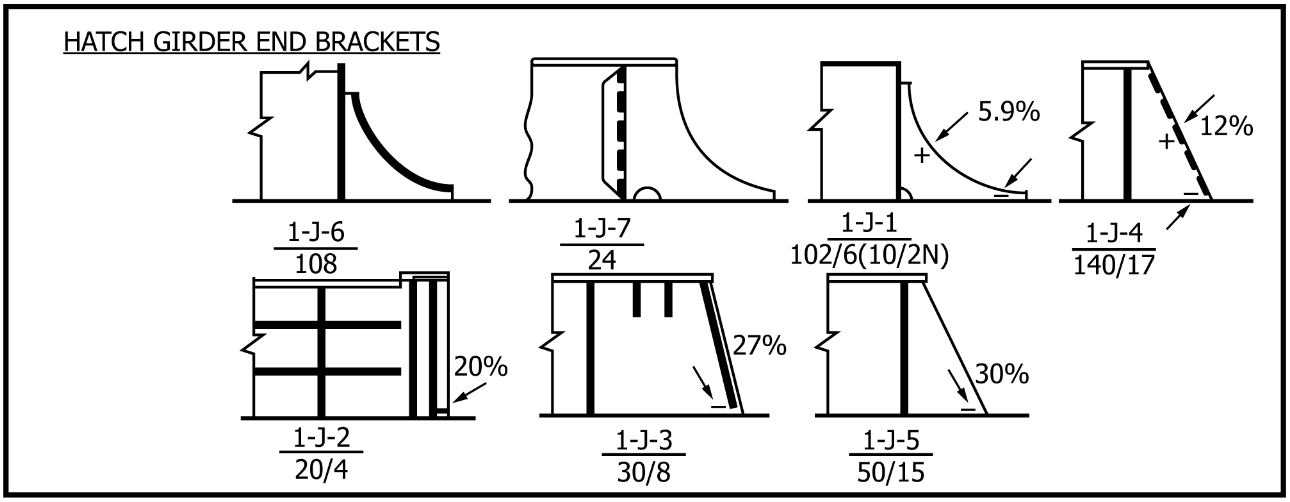


**FIG. 14 Performance of Beam Bracket Details (Family No. 1)** *(continued)*

4.1.1.1 Design failures generally resulted from the omission of engineering principles and resulted in a buckled plate or flange; the formation of a crack in a plate, flange or web; or the rupture of the bulkhead, deck or shell. Each of the families, with the exception of tight collars, had detail failures attributed to design.

4.1.1.2 Failures directly related to design in structural details and supporting members were the result of being sized without adequate consideration of applied forces and resulting deflections.

4.1.1.3 In the beam bracket configurations of ~~family no.~~Family No. 1 (Fig. 14), 20 % of the surveyed failures attributed to design were caused by instability of the plate bracket edge or by instability of the plate bracket panel. This elastic instability, which resulted from loads that produce critical compressive or shear stresses, or both, in unsupported panels of plating, can be eliminated when properly considered in the design process.

4.1.1.4 The failures of beam brackets by cracking occurred predominately where face plates had been sniped, at the welded connections, at the ends of the brackets, at cutouts in the brackets, and where the brackets were not properly backed up at hatch ends. The sniping of face plates on brackets prevents good transition of stress flow, creates hard spots and produces fatigue cracks due to the normally cyclic stresses of these members. Care must be taken to ensure proper transition with the addition of chocks, back-up structure, reinforcement of hole cuts, and the elimination of notches.

4.1.1.5 To reduce the potential for lamellar tearings and fatigue cracks in decks, bulkheads, and beams, transition brackets should be made continuous through the plating or supported by stiffeners rigid enough to transmit the loads.

4.1.1.6 The greater number of failures in the tripping bracket configurations of ~~family no.~~Family No. 2 (Fig. 15), occurred at hatch side girders, particularly in containerships. This will be a continuing problem unless the brackets are designed to carry the large lateral loads due to rolling when containers are stacked two to four high on the hatches. The brackets must, in turn, be supported by properly designed backing structure to transmit the loads to the basic ship structure.

4.1.1.7 Tripping brackets supported by panels of plating can be potential problems depending on the plate thickness. Brackets landing on thick plating in relationship to its own thickness may either buckle in the panel of the bracket, produce fatigue cracks along the toe of the weld, or cause lamellar tearing in the supporting plate. Brackets landing on plating with a thickness equal to, or less than its own thickness, may cause either fatigue cracks to develop or buckling of an unsupported panel of plating.

4.1.1.8 The non-tight collar configurations of ~~family no.~~Family No. 3 (Fig. 17) experienced only a few failures. There are considerations, however, that must be used by the designer to ensure the continuation of this trend. The cutouts should be provided with smooth well rounded radii to reduce stress risers. Where collars are cut in high stress areas, suitable replacement material should be provided to eliminate the overstressing of the adjacent web plating. These considerations should reduce the incidents of plate buckling, fatigue cracking, and stress corrosion observed in this family.

4.1.1.9 For detail ~~family no.~~Family No. 7, miscellaneous cutouts, (Fig. 20), the reasons for failure were as varied as the types of cutouts. Potential problems can be eliminated by the designer if, during detail design, proper consideration is given to the following:

~~1) Use generous radii on all cuts.~~

~~2) Use cuts of sufficient size to provide proper welding clearances.~~

~~3) Avoid locating holes in high tensile stress areas.~~

~~4) Avoid square corners and sharp notches.~~

~~5) Use adequate spacing between cuts.~~

~~6) Properly reinforce cuts in highly stressed areas.~~

~~7) Locate cuts on or as near the neutral axis as possible in beam structures.~~

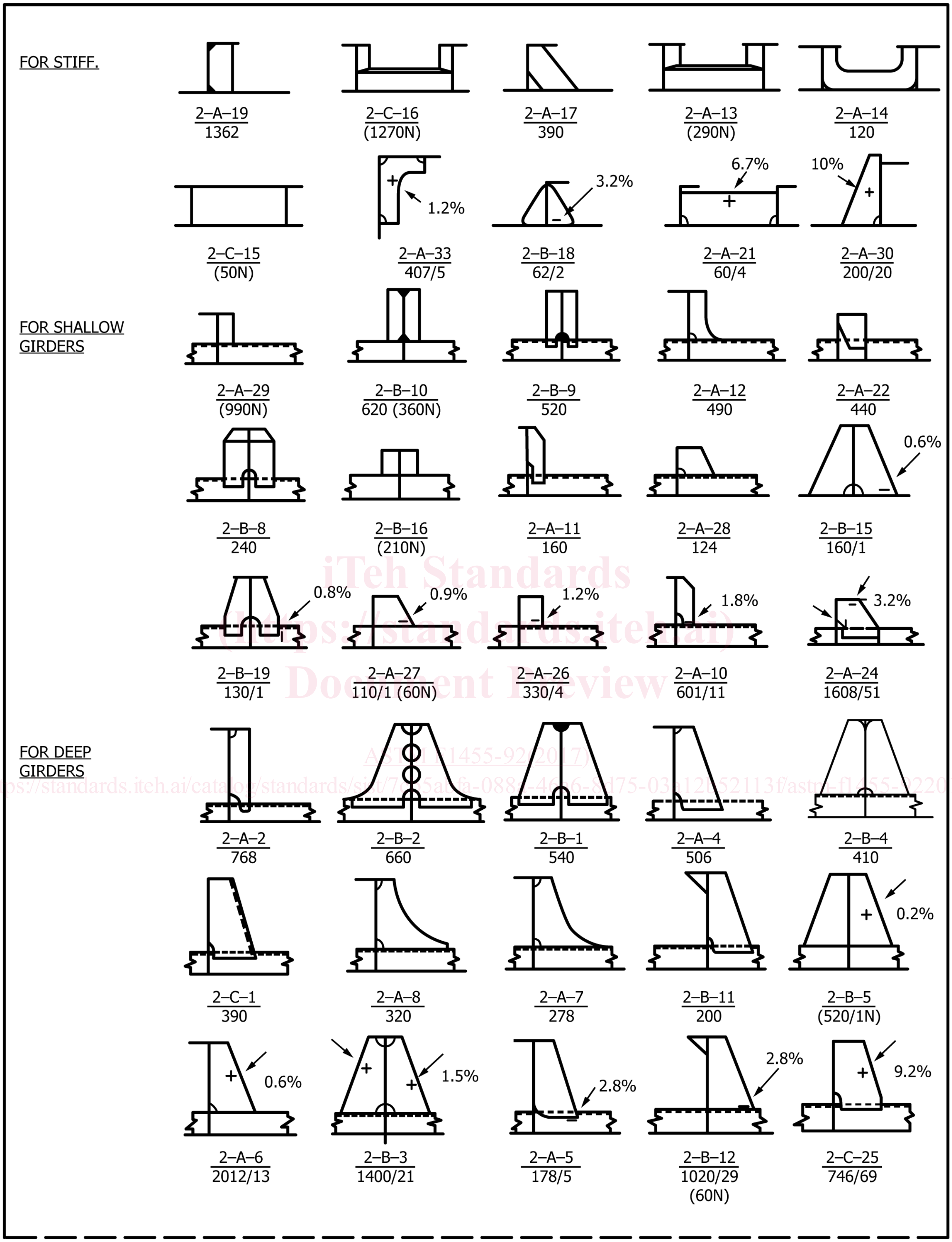




**FIG. 15 Performance of Tripping Bracket Details (Family No. 2)**