Guide on Improvement for Structural Connections and Sample Structural Details — Service Experience and Modifications — for Tankers

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Incorporated by the Legislature of
the State of New York 1862

1.0 GENERAL

This Guide identifies the influential parameters and provides guidelines on improvement of structural connections. It also provides for reference illustrations of local structural failures experienced in some existing tankers and the corrective measures as compiled by the Tanker Structure Cooperative Forum (1986) and from the American Bureau of Shipping's data files.

2.0 INFLUENTIAL PARAMETERS

For design of structural details, due consideration is to be given to the following influential parameters.

2.1 Loading Patterns and Nominal Stresses

The load distribution among the surrounding structural members and the corresponding nominal stresses at the location considered should be examined for the combined load cases specified in 5/2A3.5.2 of the Rules. It is important to consider the combined effects of all the simultaneously imposed load components, rather than only one selected dominating load component. The stress distribution may be obtained from a 3D finite element structural analysis as specified in 5/2A5.3 of the Rules or by other equivalent means.

2.2 Stress Concentration

Due to load transmission and diffusion at a structural connection, it is inevitable that some form of stress concentration is going to occur in the loaded structure. Therefore, particular attention is to be paid to structural notches, abrupt changes in structural properties and excessive distortions and deformations; such as locations at the bracket toes, cut-outs, terminations of heavily loaded members, the connection of flexible elements with much stiffer members, the ends of unbalanced structural members, just to name a few. For ship structures designed with relatively low working stresses and high safety margins, the

detrimental effects of such stress concentrations may not be readily apparent. On the other hand, for structures designed with relatively high working stresses and low safety margins, damaging effects of such stress concentrations could appear sooner than the anticipated period of time.

Appropriate stress concentration factors (SCF's) obtained from either experimental data or structural analyses are required to evaluate the design of structural details.

2.3 Weld Effects and Fatigue Strength

Another important factor to be considered is the effects of welding on the properties of material (heating effects) and on structural continuity (profile of the weld deposit and under-cuts). This factor which highly depends on the welding methods, processes and workmanship is vital for assessing the fatigue strength of the joint. To date, the welding effects on the fatigue strength are primarily determined by experimental data presented in the form of S-N curves and characteristics of the test specimens, as shown in the Appendix 5/2AA of the Rules.

3.0 CONSIDERATIONS FOR DESIGN OF STRUCTURAL DETAILS

In light of the discussions given in 5/2A5.4, it is apparent that the necessary criterion for the design of structural details is simply to offer a well balanced joint which is "compatible" with the anticipated working stresses. To this end, the solution is to be tailored to a specific location of a specific design. In addition, there is no unique solution to the problem. Many alternatives may exist. The designers/builders would have to exercise their judgment based on their fabrication facilities, techniques and experience. The information offered below is provided for reference.

3.1 Structural Configuration and Arrangement of Brackets

When selecting the structural configurations and sizing the brackets connecting primary supporting members, due consideration is to be given to the load transmission and the

relative stiffnesses of the members to be connected. A smooth pattern of load transmission is essential. The connecting bracket is to be of sufficient size to withstand the highly concentrated loads and to shift the critical spots (bracket toes) to the lower stressed regions. An appropriate stiffening system is also required for large brackets to prevent local structure instability and tripping. Sample illustrations are shown in Fig. 1 and Fig. 2 for damages experienced in existing tankers with recommended modifications.

3.2 Installation of Brackets and Collar Plate

To prevent local distortions and to minimize the magnifying effects of structural notches, consideration is to be given to additional brackets and collar plates (or lugs) at the critical joints and cut-outs, respectively. Sample illustrations are shown in Fig. 3 for local damages recorded and the recommended modifications.

Alternatively, different stiffening systems may be considered to minimize the critical spots in highly stressed regions. For example, utilization of the horizontal stiffeners with appropriate tripping brackets for floors in the double bottom, instead of vertical stiffeners would eliminate the critical spots at the face bar toes on the flange of longitudinal as shown in Fig. 3c.

3.3 Softening Hard Spots

To minimize the stress concentration at hard spots, such as bracket toes, tapered face plate, and welded connections of the face plate of transverses and bulkhead plating, the welded joints may be softened by providing a large radius at bracket toes or a cope hole with proper reinforcement of the surrounding panel to prevent local instability. Some sample illustrations are shown in Fig. 4.

To minimize the detrimental effects of knuckles in structural elements, sample illustrations are shown in Fig. 5.

3.4 Improvement of Fatigue Strength

At critical structural joints, the fatigue strength can be improved, as discussed in the previous paragraphs, by reducing the magnitudes of nominal stresses (working stresses) and/or minimizing the stress concentrations.

In addition, it may also be advisable to consider the following improvements on the fatigue strength:

1) Utilizing better contour shapes for cut-outs, such as the cope holes shown in Fig. 6.
2) Having bracket toe and the surrounding weld deposit ground smooth with an appropriate radius as shown in Fig. 7.

4.0 SAMPLE STRUCTURAL DETAILS

These examples are divided into the following five groups:

Figure 1 - Examples for Bracket Enlargement

a) Connection of Bottom Girder and Vertical Web
b) Bottom Girder End Bracket
c) Bottom Transverse End Bracket
d) Reinforcement at Connection of Bottom Girder and Oil Tight Bulkhead

Figure 2 - Examples for Bracket Modification

a) Connection of Centerline Girder and Oil Tight Transverse Bulkhead
b) Connection of Horizontal Girder and Side Longitudinal
c) Longitudinal End Bracket

Figure 3 - Examples for Additional Brackets and Collar Plate

a) Connection of Bottom Girder and Swash Bulkhead
b) Tripping Bracket on Transverse Web
c) Connection of Longitudinal to Floor in Double Bottom
d) Connection of Longitudinal to Transverse Web

Figure 4 - Examples for Hard Spot Effects

a) Tapered Face Plate of Horizontal Girder
b) Connection of Transverse Face Plate and Bulkhead Plating
c) Bracket Toe on Bottom Transverse
d) Bracket Toe on Longitudinal
e) Sniped Tripping Bracket on Horizontal Girder

Figure 5 - Examples for Knuckle Effects

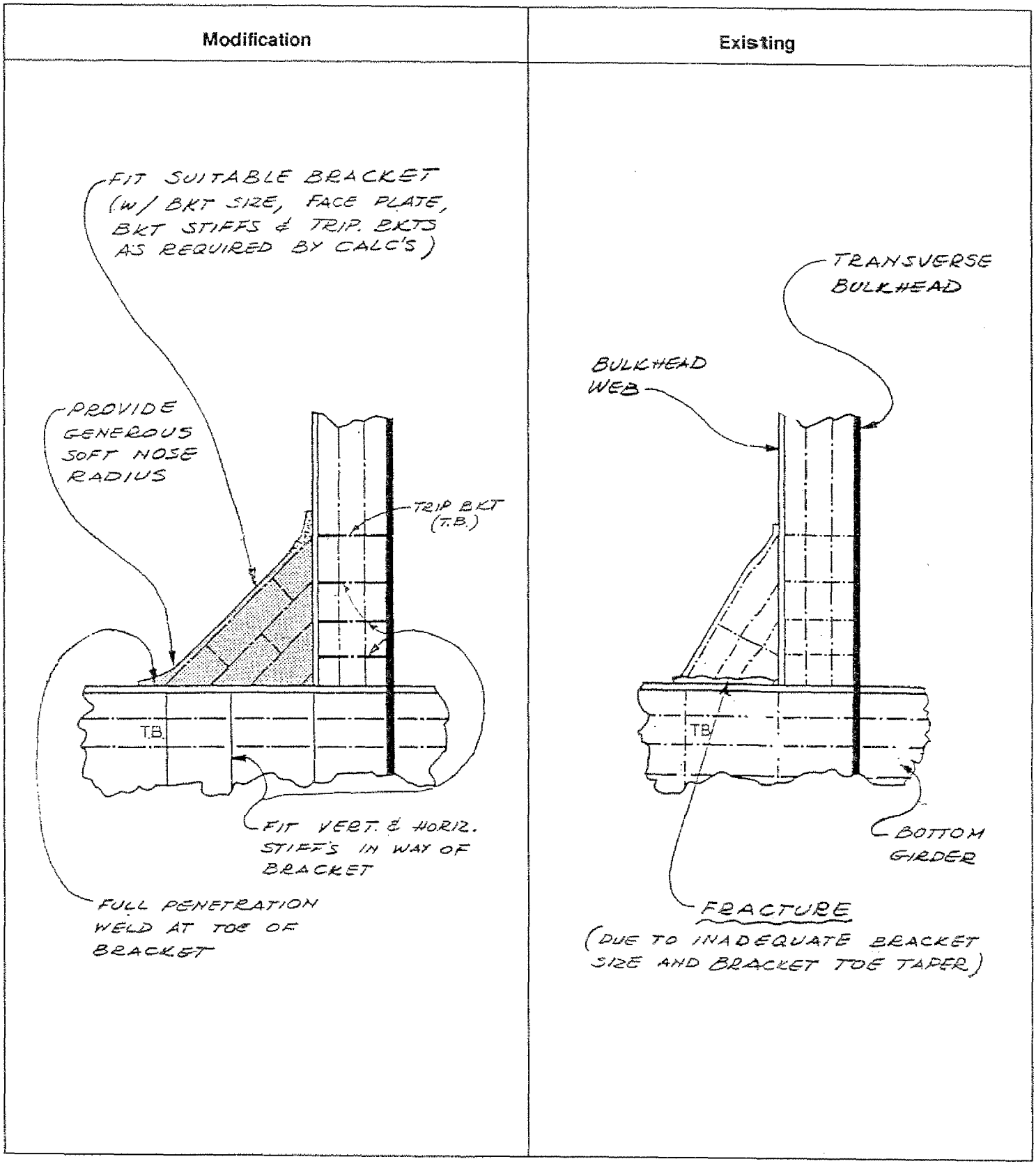


Figure 1(a) Connection of Bottom Girder and Vertical Web

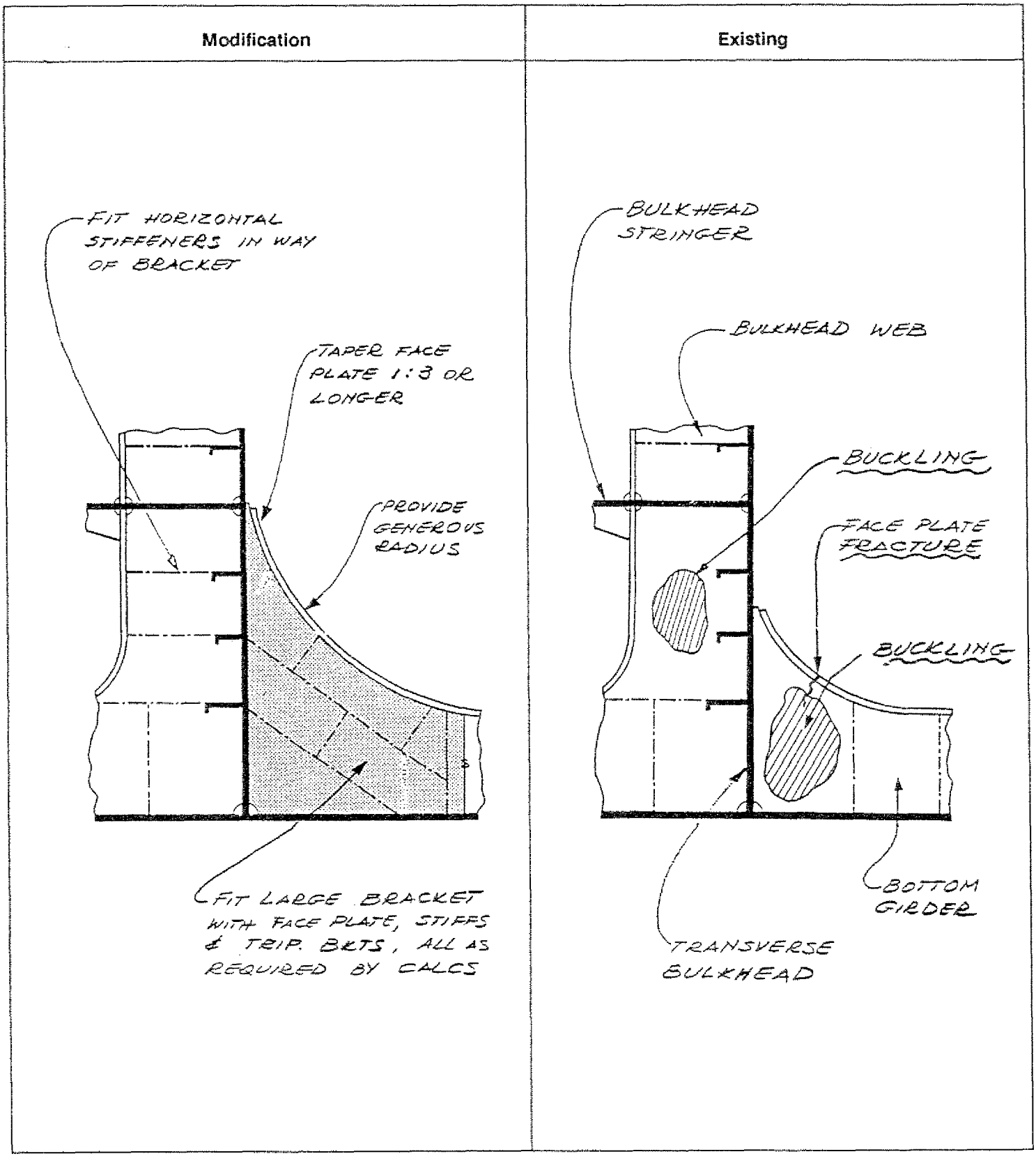


Figure 1(b) Bottom Girder End Bracket

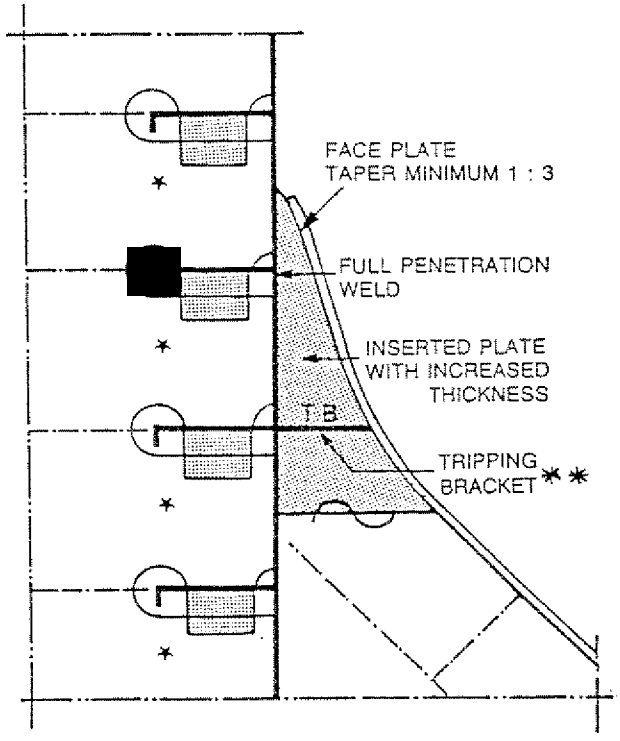
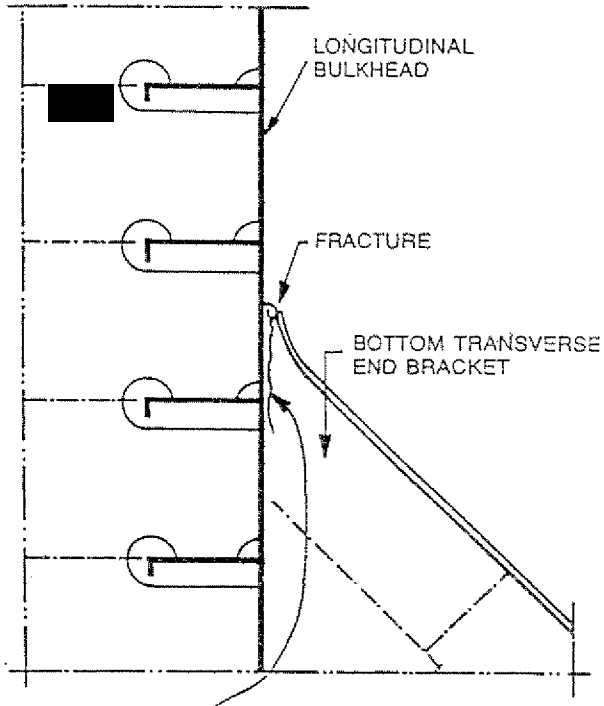
Modification	Existing
 * LUGS ** INTENDED TO SUPPORT FACE PLATE AND ABSORB FACE PLATE LOAD BEFORE SOFT NOSE TAPER.	 FRACTURE (DUE TO ABRUPT BRACKET TERMINATION, WITHOUT PROPER SOFT NOSE, FACE PLATE TAPER AND TRIPPING BKT).

Figure 1(c) Bottom Transverse End Bracket

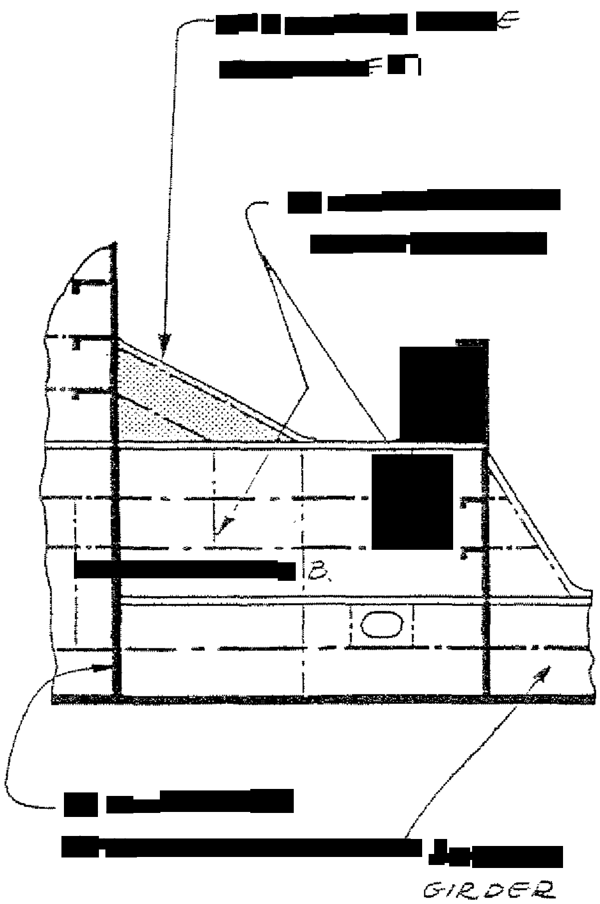
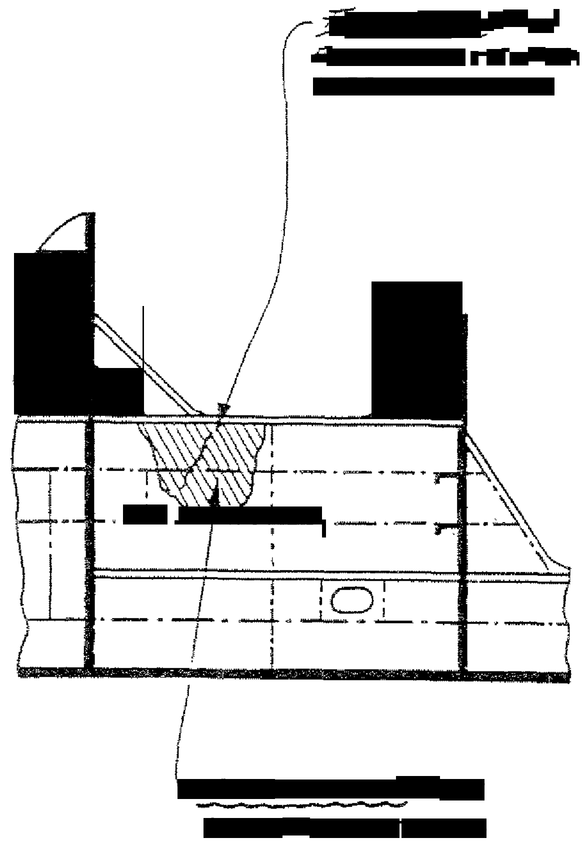
[redacted]	[redacted]
	

Figure 1(d) Reinforcement at Connection of Bottom Girder and Oil tight Bulkhead

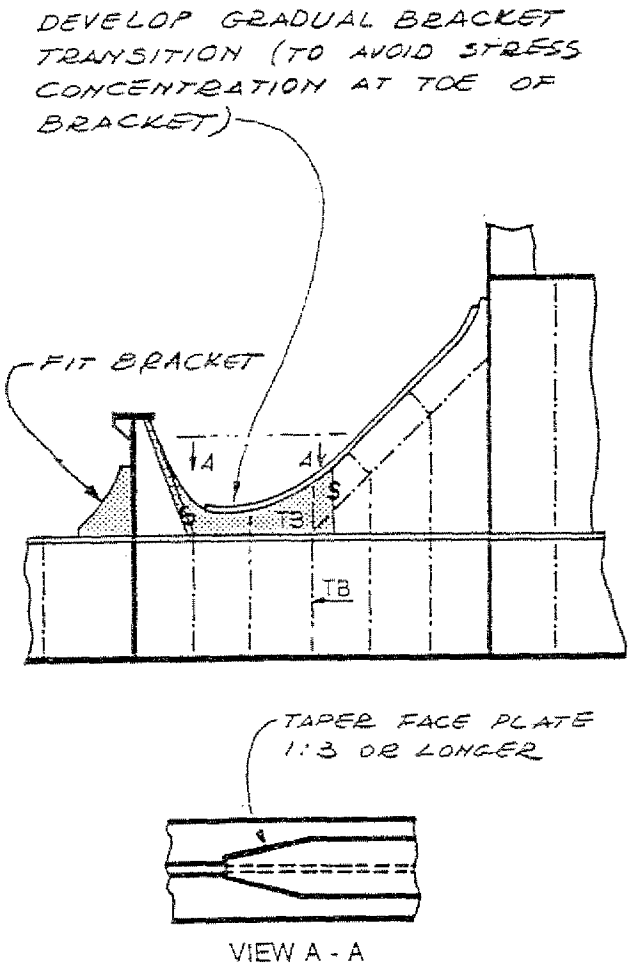
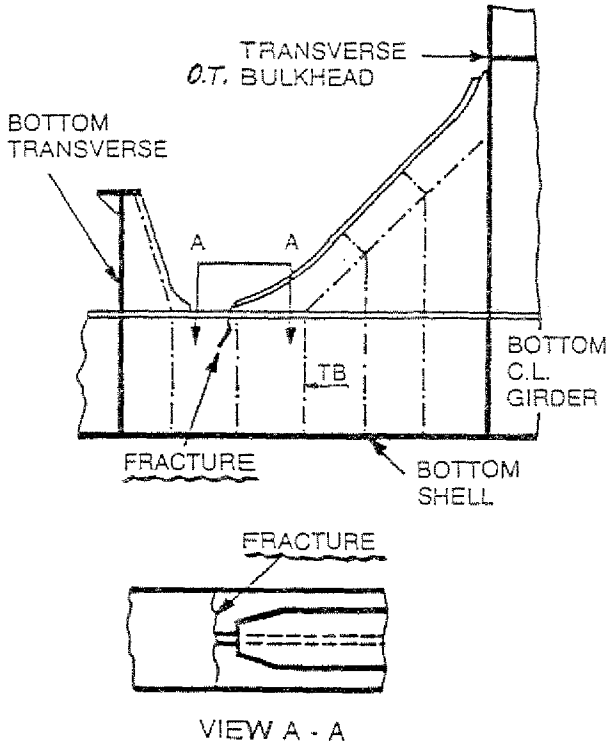
Modification	Existing
	

Figure 2(a) Connection of Centerline Girder and Oil tight Trans Bulkhead

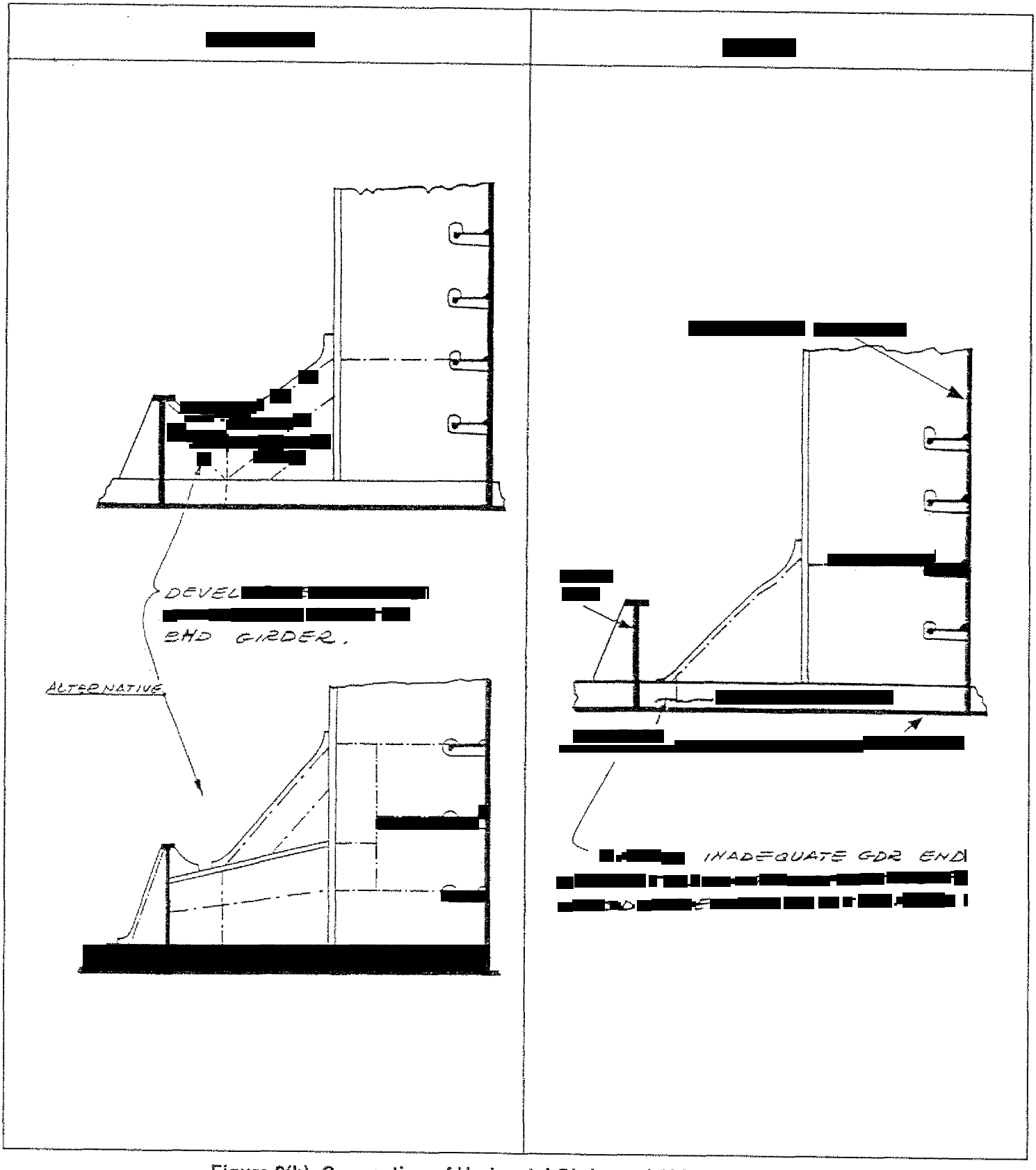


Figure 2(b) Connection of Horizontal Girder and Side Longitudinal

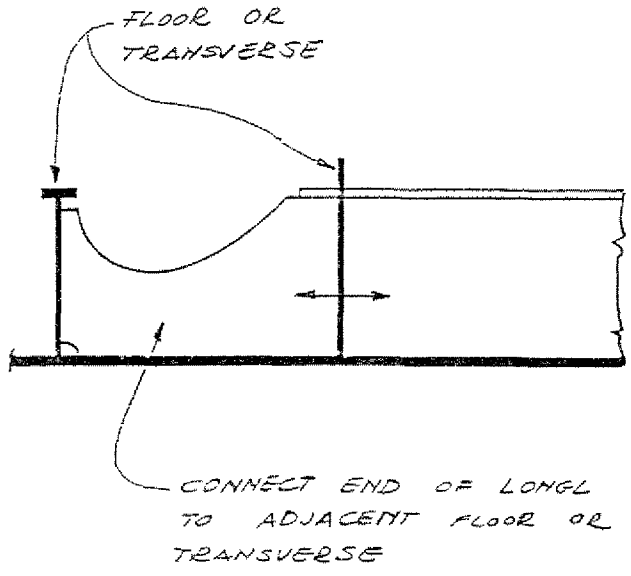
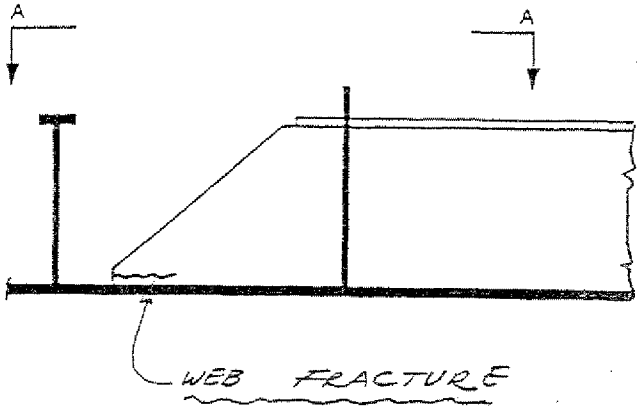
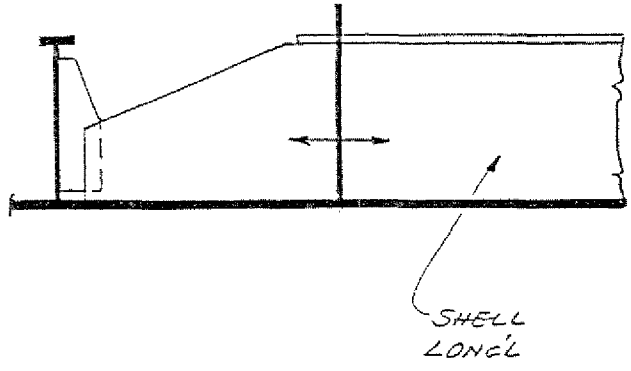
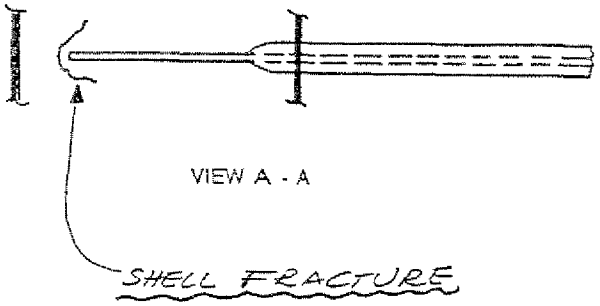
Modification	Existing
	
ALTERNATIVE : 	

Figure 2(c) Longitudinal End Bracket

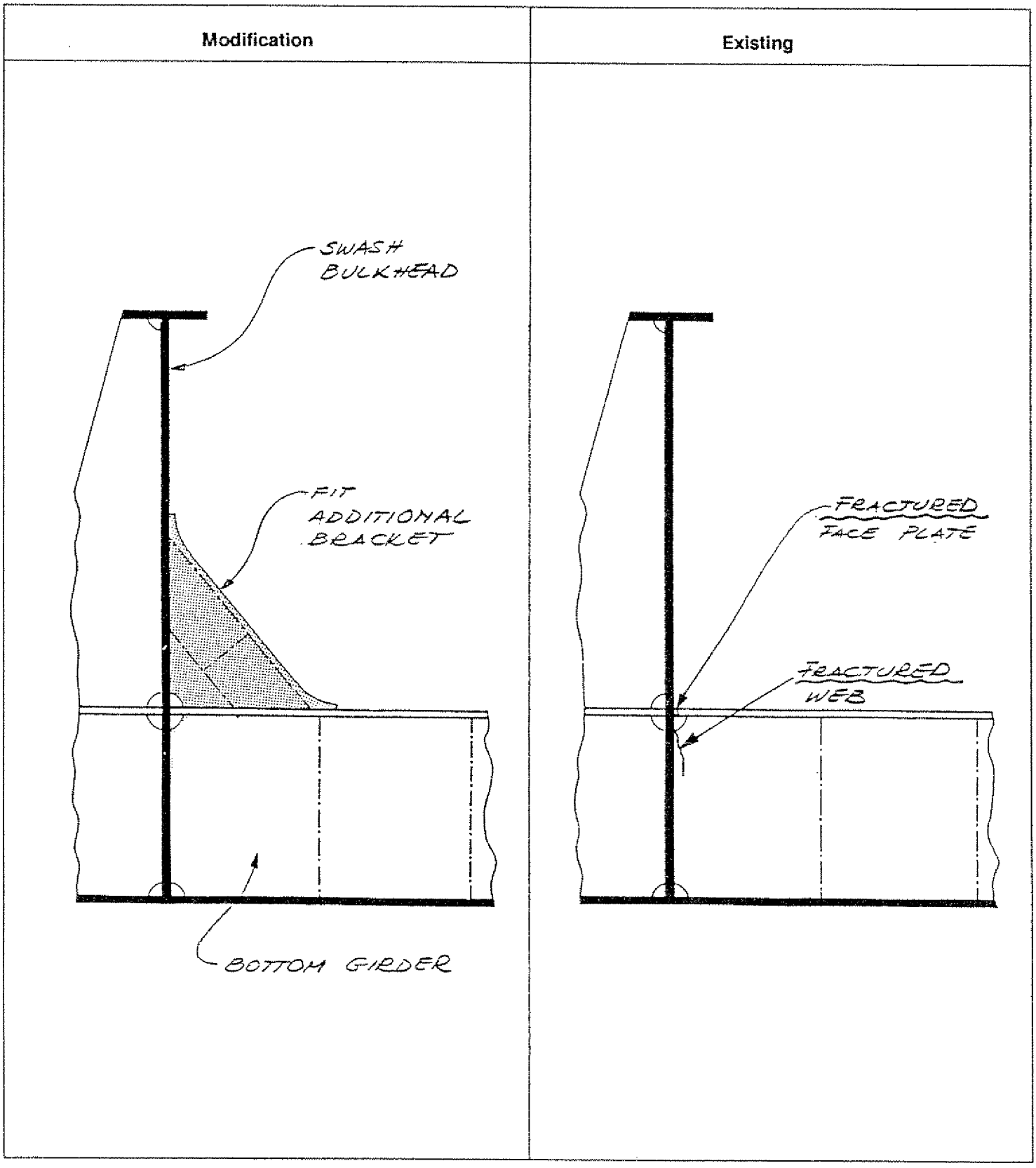


Figure 3(a) Connection of Bottom Girder and Swash Bulkhead

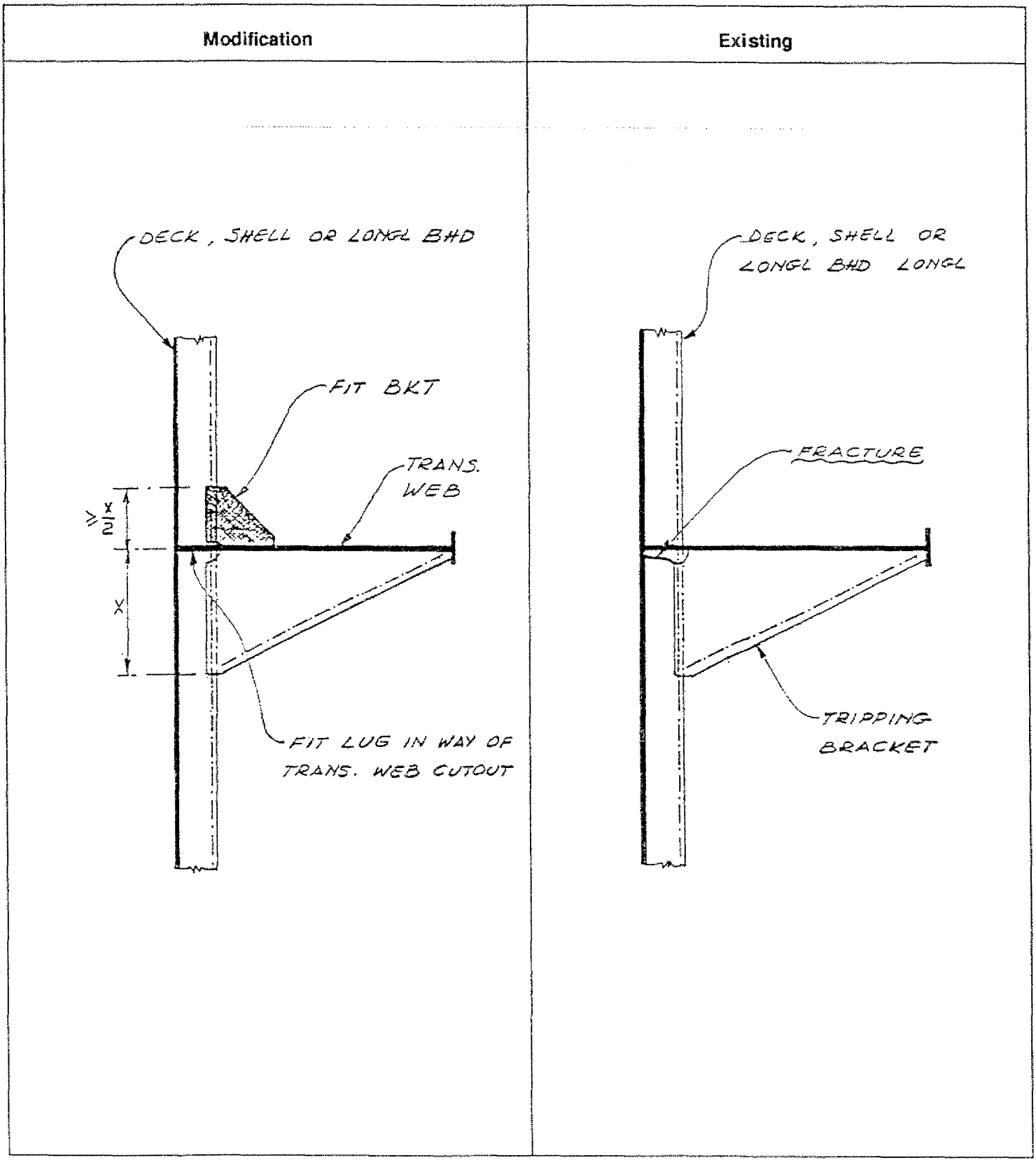


Figure 3(b) Tripping Bracket on Trans. Web

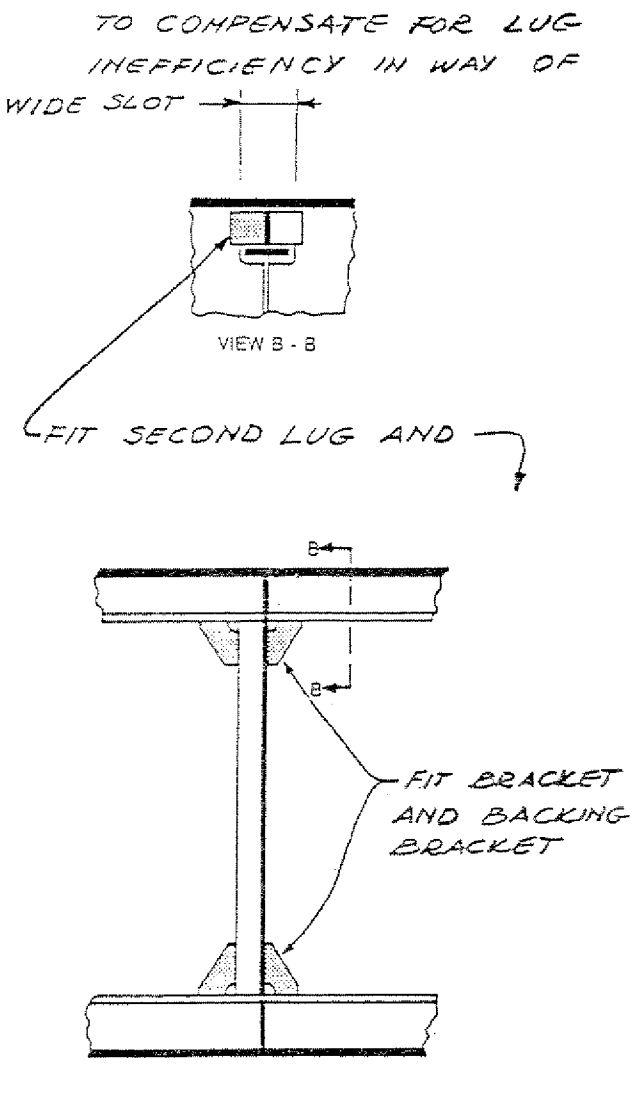
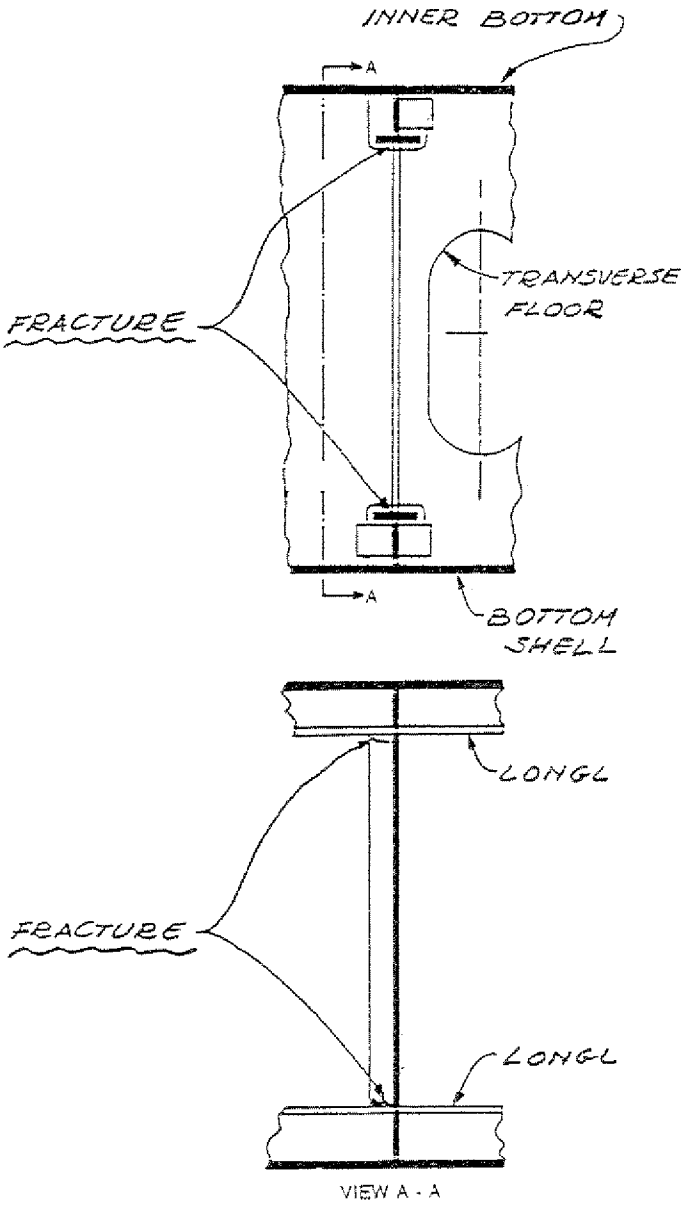
Modification	Existing
	

Figure 3(c) Connection of Longitudinal to Floor in D.B.

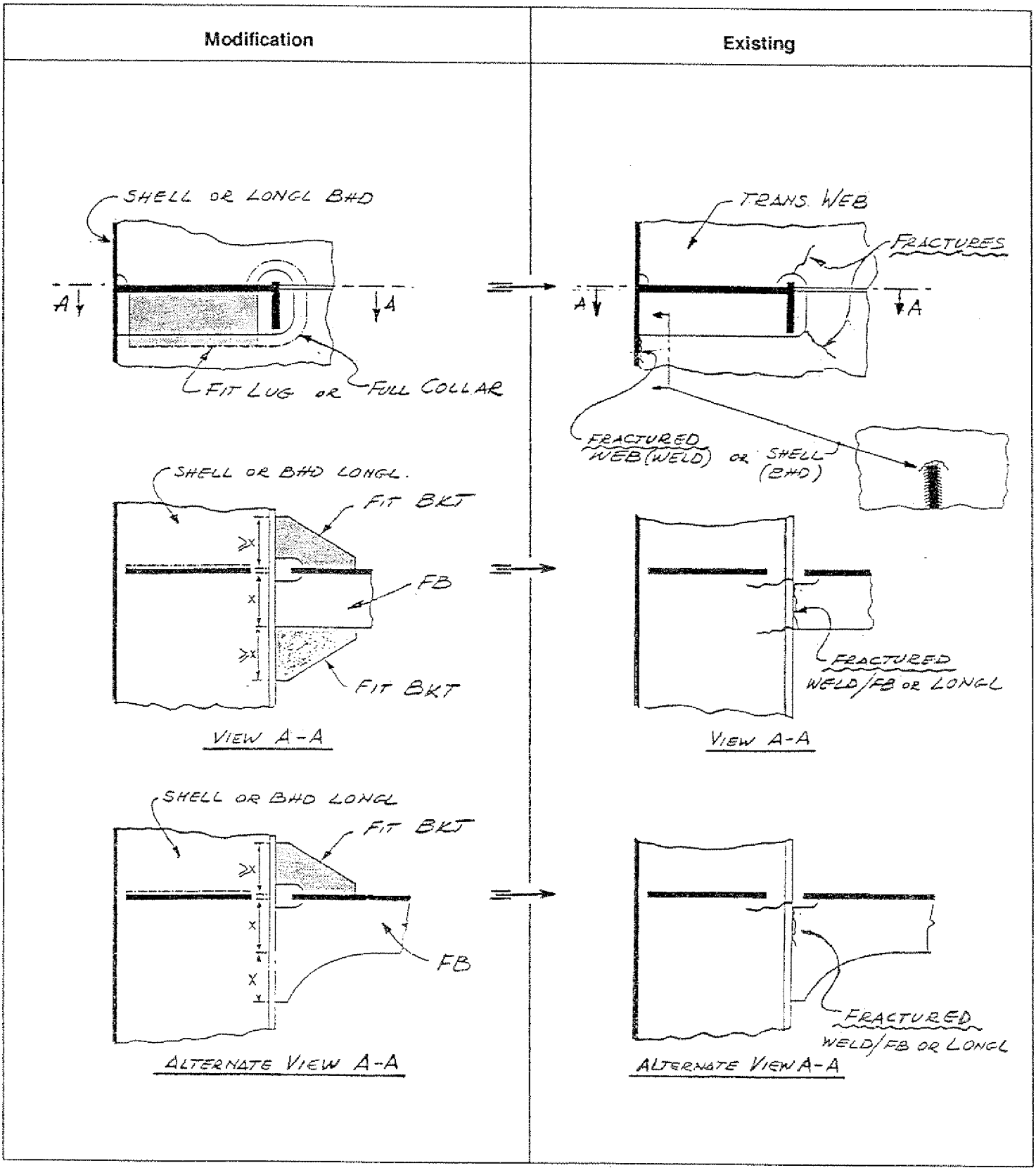


Figure 3(d) Connection of Longitudinal to Trans. Web

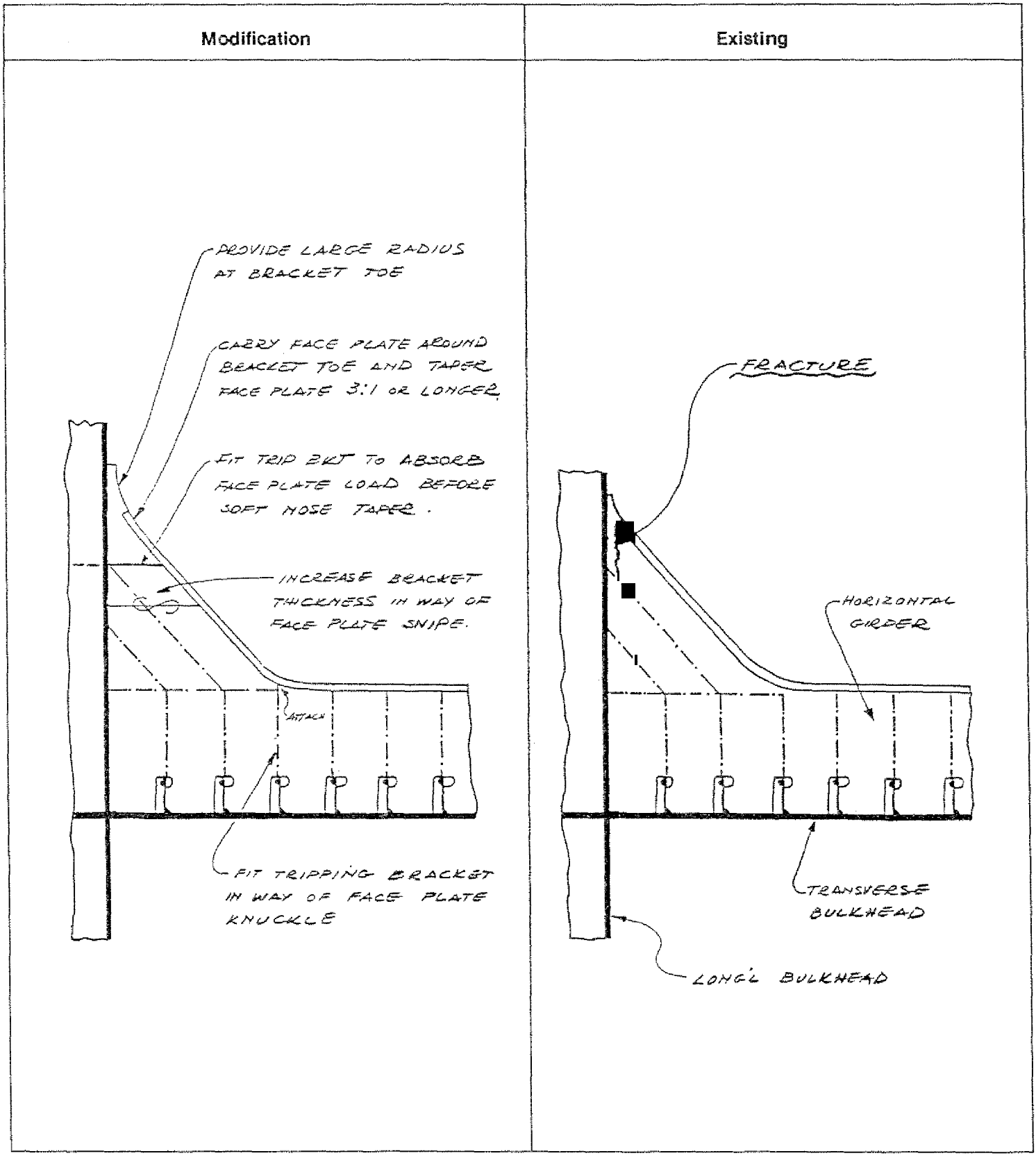


Figure 4(a) Tapered Face Plate of Horizontal Girder

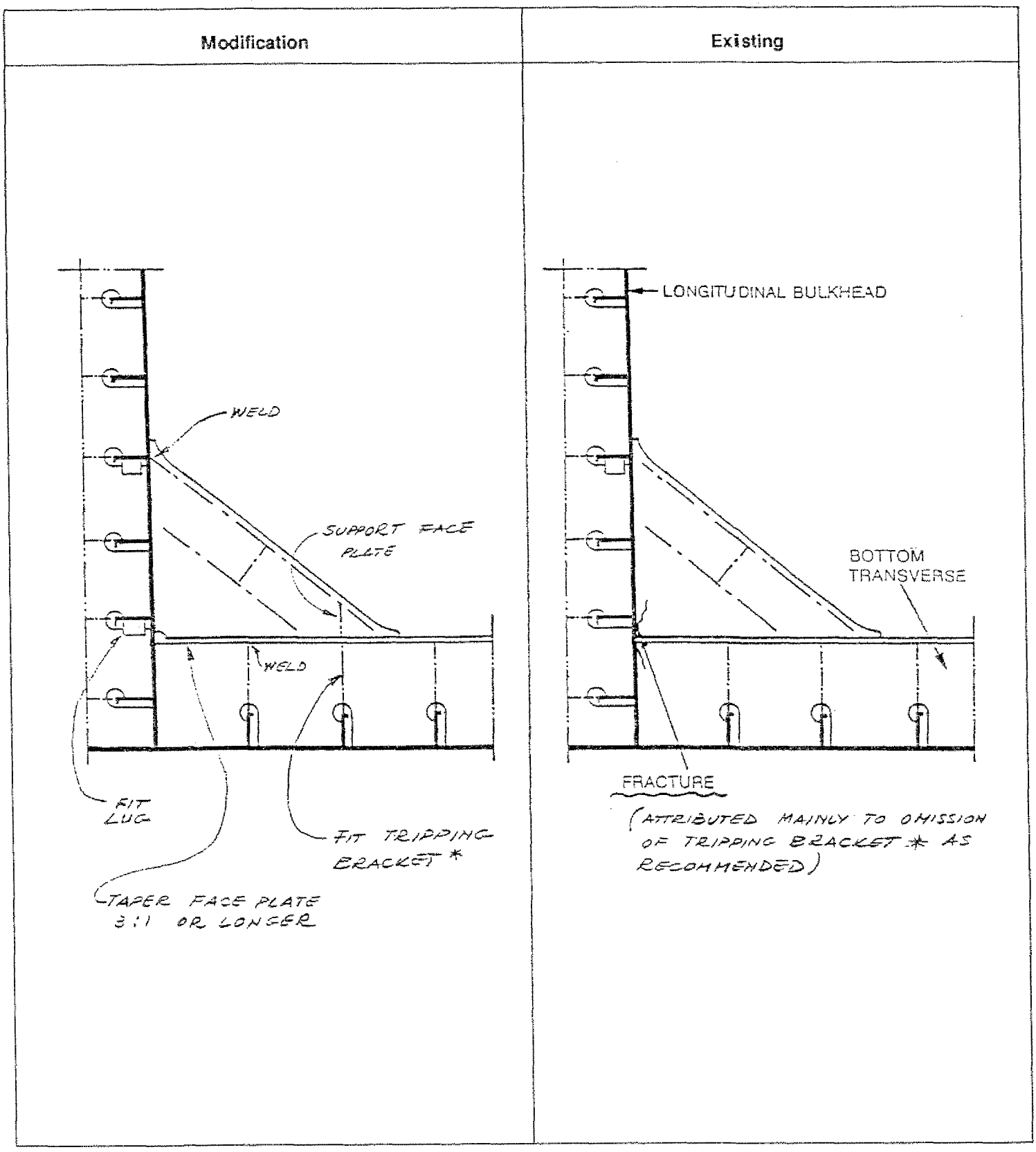


Figure 4(b) Connection of Transverse Face Plate and Bhd Plating

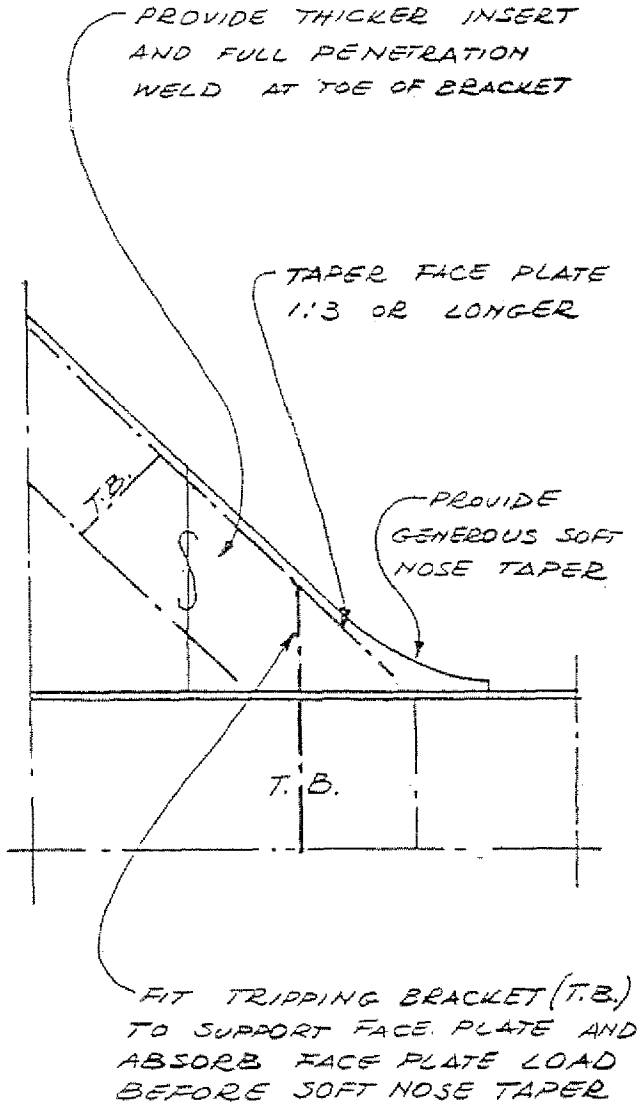
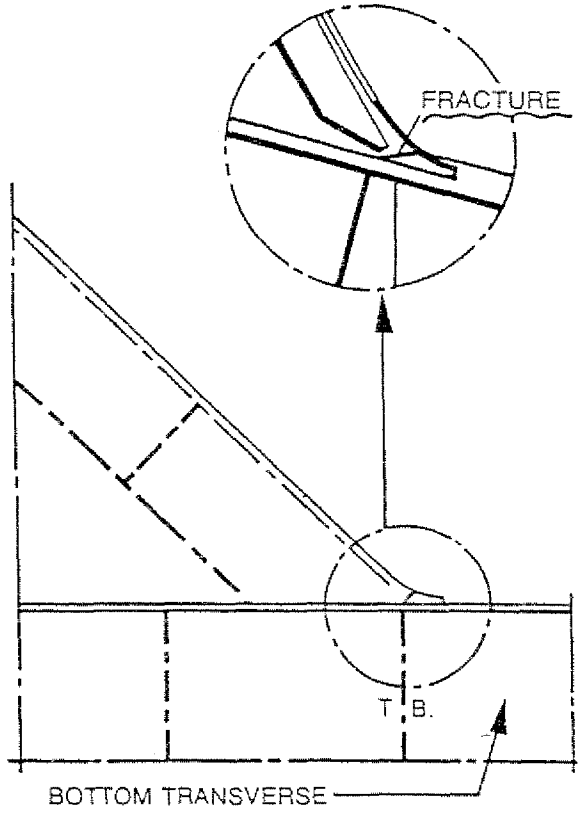
Modification	Existing
	

Figure 4(c) Bracket Toe on Bottom Transverse

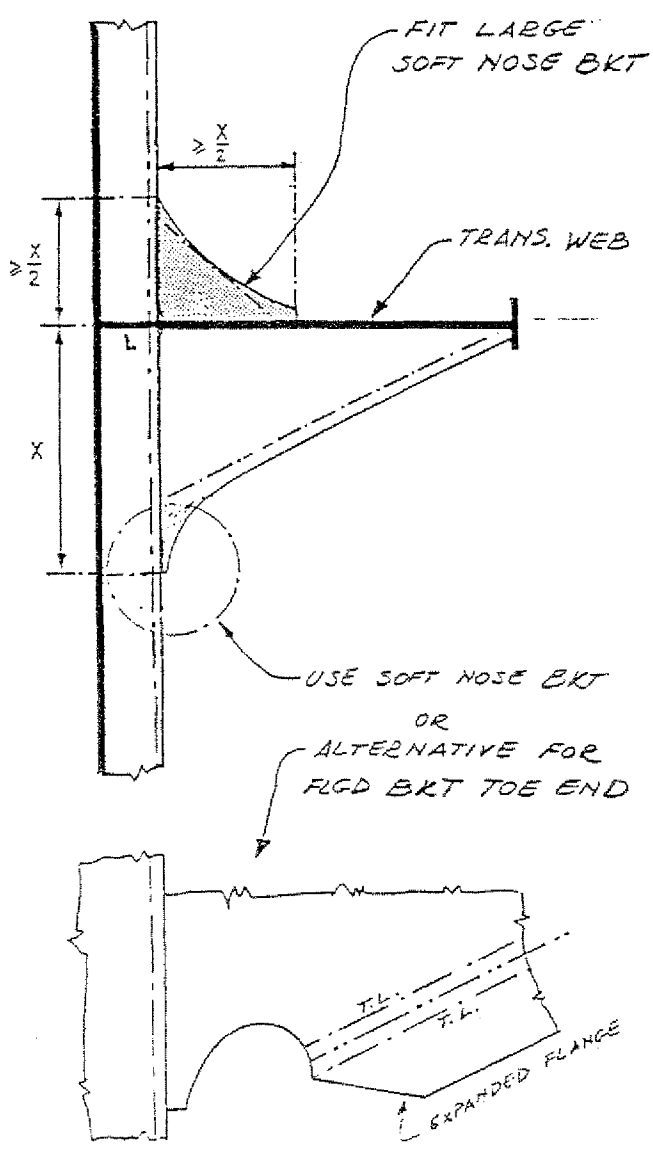
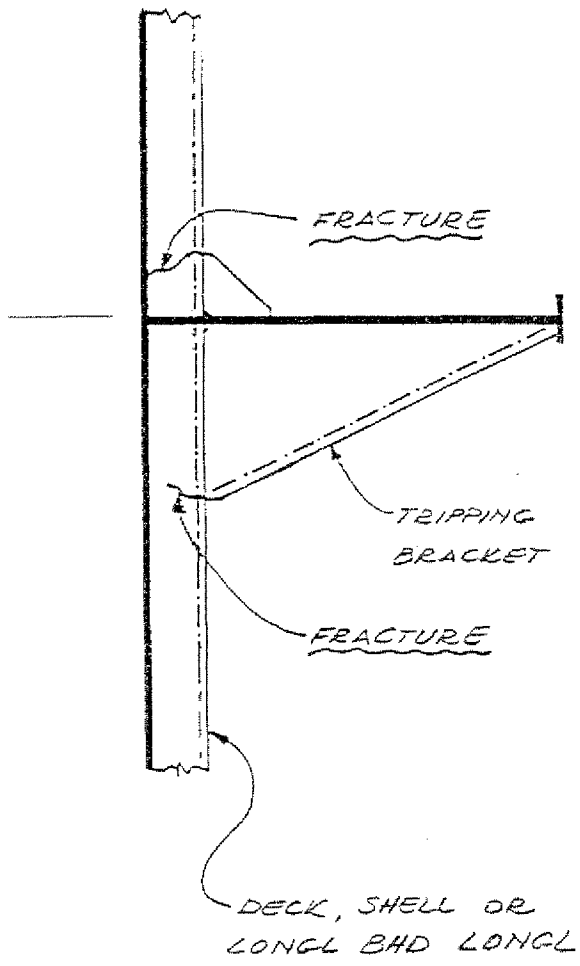
Modification	Existing
	

Figure 4(d) Bracket Toe on Longitudinal

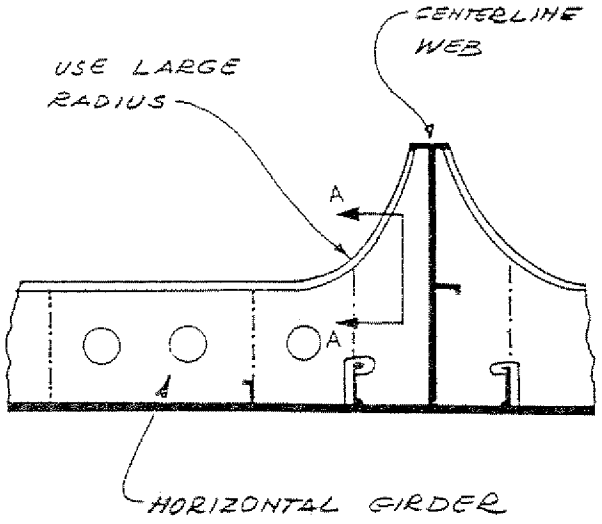
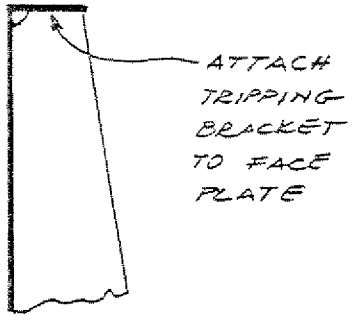
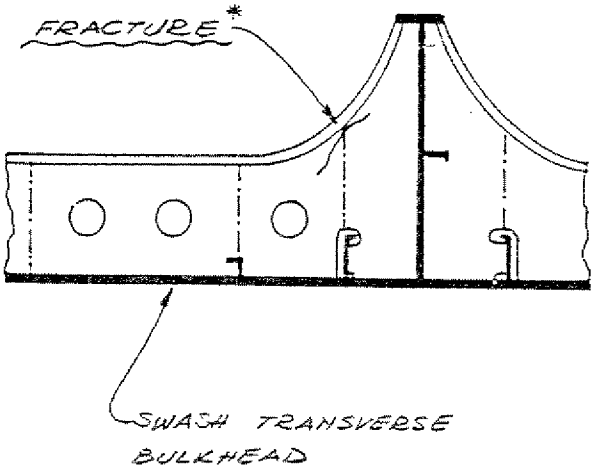
Modification	Existing
  VIEW A-A	 * DUE TO SLOSHING LOADS IN PARTIALLY FILLED TANK AND STRESS CONCENTRATION IN WAY OF SNIPED TRIPPING BRACKET.

Figure 4(e) Sniped Tripping Bracket on Horizontal Girder

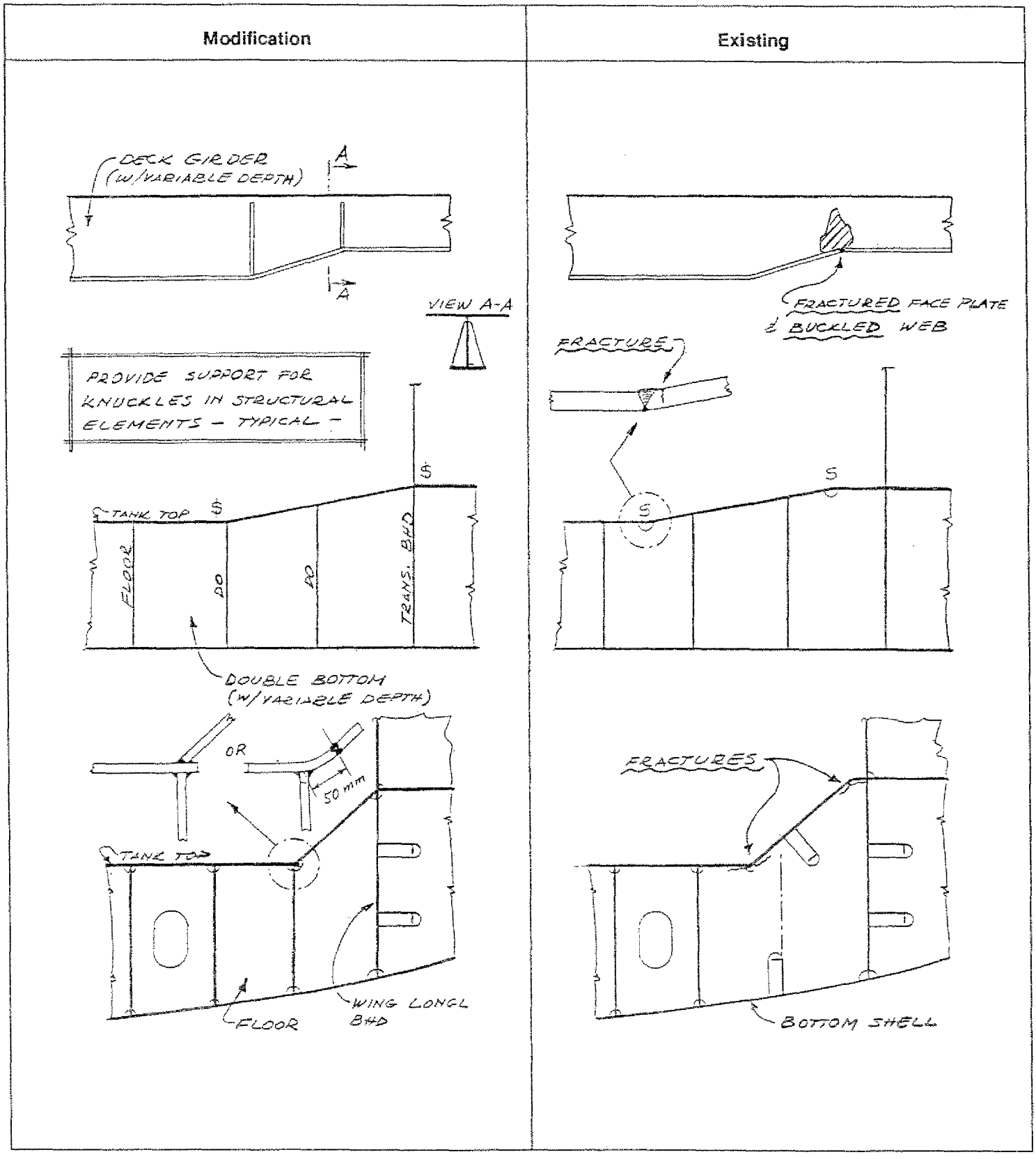


Figure 5 Examples for Knuckle Effects

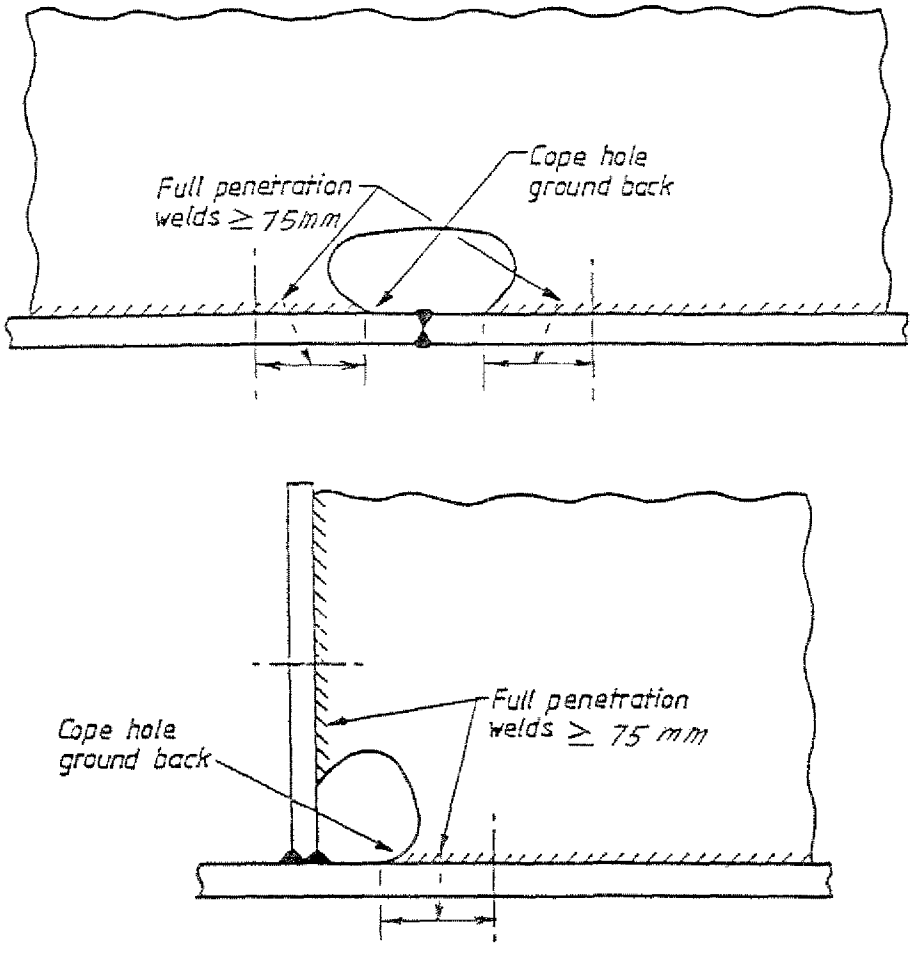


Figure 6 Improved Cope Hole Details

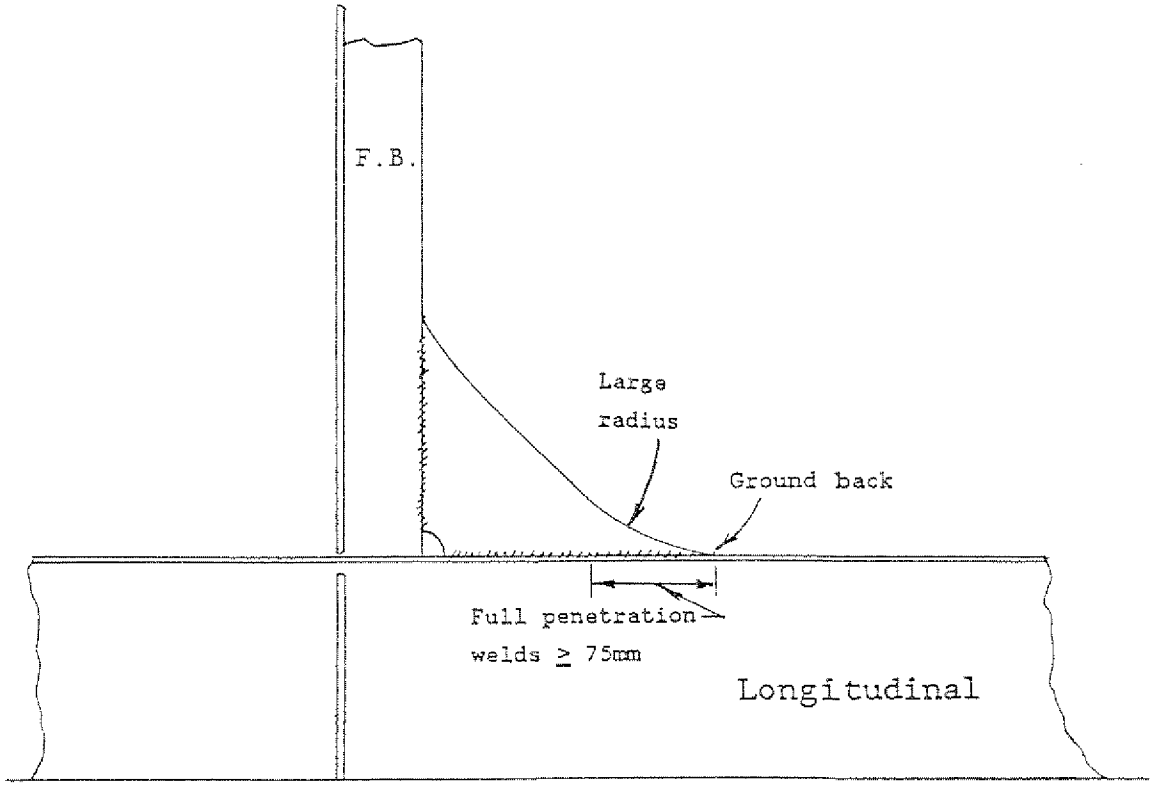


Figure 7 Improved Brackets Toes