

PART

# 2

CHAPTER **6 Materials for Hull Construction –  
Fiber Reinforced Plastics (FRP)**

SECTION **6 Repair**

## **1 General**

This Section specifies the requirements for repairs of defects during construction. These details are also applicable for repair of damaged laminates due to collisions, allisions or other extreme forces.

All repair work relies on the use of proper secondary bonding technique (see 2-6-3/9.13). Therefore, additional replacement material is required to achieve the original strength of the laminate. Details of the area to be repaired, the materials to be used (resins, reinforcing materials, cores, etc.) and the repair process is to be submitted for review. Damage to the gel-coat and/or skin coat is not part of the ABS survey unless it has an adverse effect on the laminate structural layers.

## **3 Materials**

### **3.1 Resins**

In general, isophthalic polyester, vinyl ester or epoxy resins are to be used for all repairs. Special consideration will be given for the use of other resins, provided they are used in accordance with the manufacturer's recommendations. In all cases, the shipyard is to demonstrate to the satisfaction of the attending Surveyor that the resin is capable of bonding to the cured laminate of the craft being repaired.

### **3.3 Fiber Reinforcements**

The original, primary fiber reinforcement is to be used in repair, whenever practical. Where alternative reinforcements are used, they are to be similar in type and weight to those being replaced. Dissimilar fiber types are not to be used in a repair unless they were part of the original laminate.

## 5 Repair Procedures – Single Skin Laminate

### 5.1 Damage Assessment

Damages can be found either by visual inspection, probing or hammer sounding of the structure. Damage can be found from indicators such as the following:

- i)* Cracked or chipped paint or abrasion of the surface
- ii)* Distortion of a structure or support member
- iii)* Unusual build-up or presence of moisture, oil or rust
- iv)* Structure that appears blistered or bubbled and feels soft to the touch
- v)* Surface and penetrating cracks, open fractures and exposed fibers
- vi)* Gouges
- vii)* Debonding of joints

For the proper inspection of suspect areas, the removal of insulation, outfitting or equipment may be required. The extent of damage is to be clearly indicated on the hull and is to be agreed upon by all parties prior to removal.

Where water is found in the laminate or core, the area is to be rinsed by fresh water and be allowed to dry for a minimum of 48 hours. Work is not to be performed on the laminate until the moisture is 0.5% by weight or less.

### 5.3 Removal of Damaged Laminate

#### 5.3.1 Damage Partially Through the Thickness

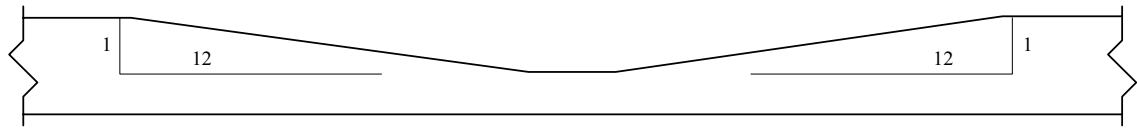
For damage extending partially through the thickness of a laminate, the damaged laminate can be removed using a coarse grit grinder. The damaged area is then to be shaped for repair using a fine grit grinder. See 2-6-6/Figure 1a or b for preparation details.

#### 5.3.2 Damage Through the Thickness

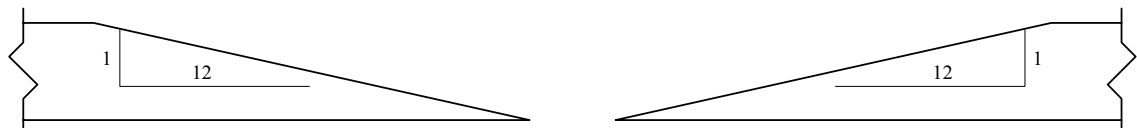
For damage that extends through the thickness of the laminate, the damaged area can be cut away. The laminating surfaces are to be prepared as indicated in 2-6-6/5.3.1 and 2-6-6/Figure 1a or 1b.

**FIGURE 1**  
**Scarf Joint Preparation**

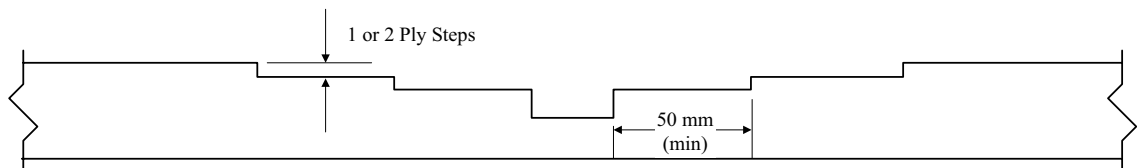
a) SINGLE-SIDED SCARF



12:1 Tapered Scarf

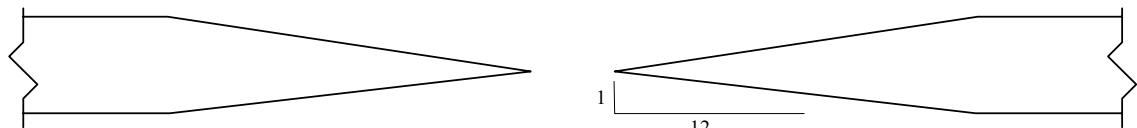


12:1 Tapered Scarf Through Thickness Damage

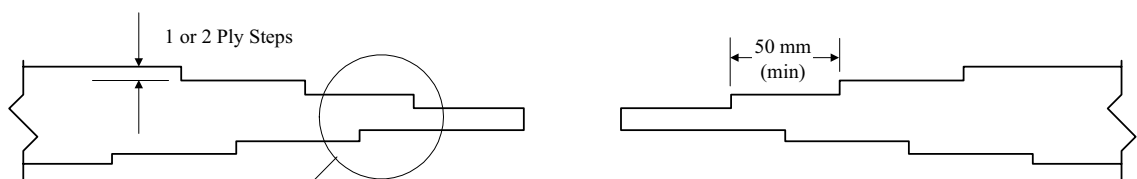


Stepped Scarf Joint

b) DOUBLE-SIDED SCARF



12:1 Tapered Scarf



Stepped Scarf Joint

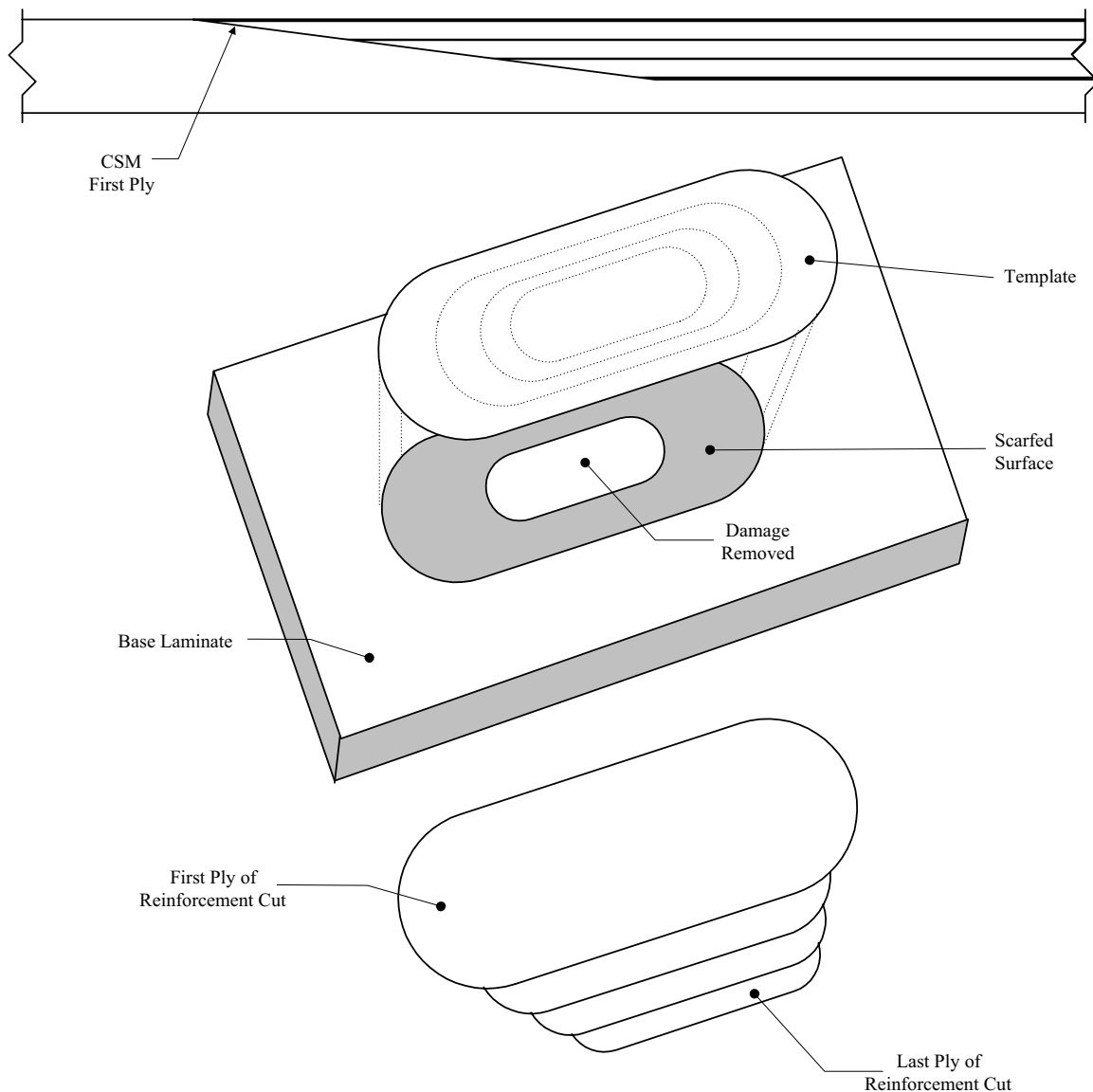
## 5.5 Laminating Procedures

### 5.5.1 General

All laminating procedures consist of using secondary bonding and the requirements in 2-6-3/9.13 are applicable. Generally, the lay-up is to have the smallest ply first with each successive ply being larger, as indicated in 2-6-6/Figure 2. Each of the successive plies are to be slightly oversized and trimmed as it is being laminated in place. Care is to be taken in using undersized plies as this may create a resin pocket along the bond line. The fiber orientation is to be maintained during lamination. Alternative methods for laminating will be subject to special consideration.

**FIGURE 2**  
**Repair Sequence**

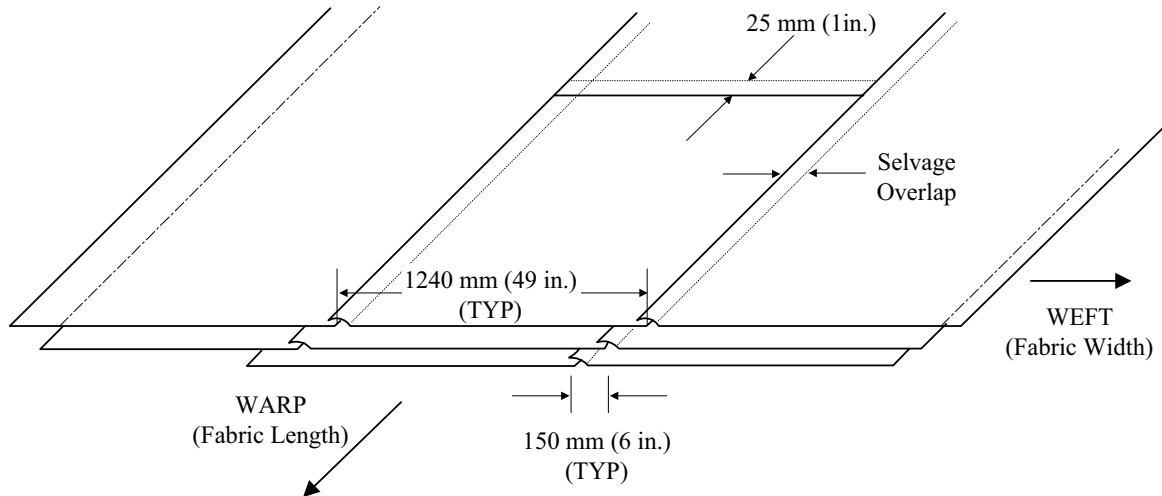
#### BUTTED LAY-UP



### 5.5.2 Overlap Requirements

Adjacent plies of reinforcement are to be overlapped when fitted with a selvage edge. Other reinforcements may be butt jointed. Edge joints in successive layers are to offset 150 mm (6 in.) relative to the underlying ply. Lengthwise joints are also to be staggered 150 mm (6 in.). The ply overlap is to be a minimum of 25 mm (1 in.). See 2-6-6/Figure 3.

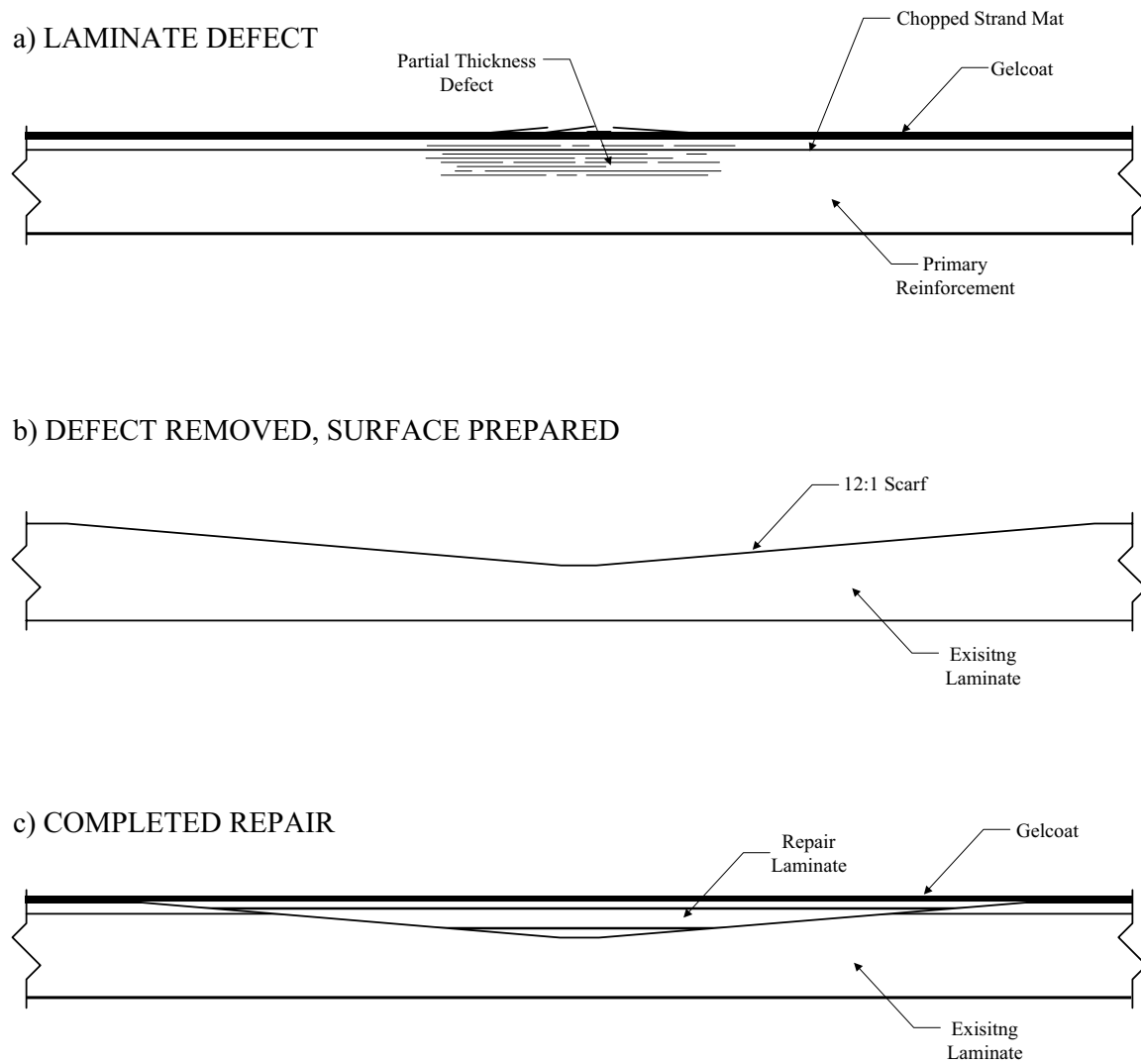
**FIGURE 3  
 Ply Overlap Requirements**



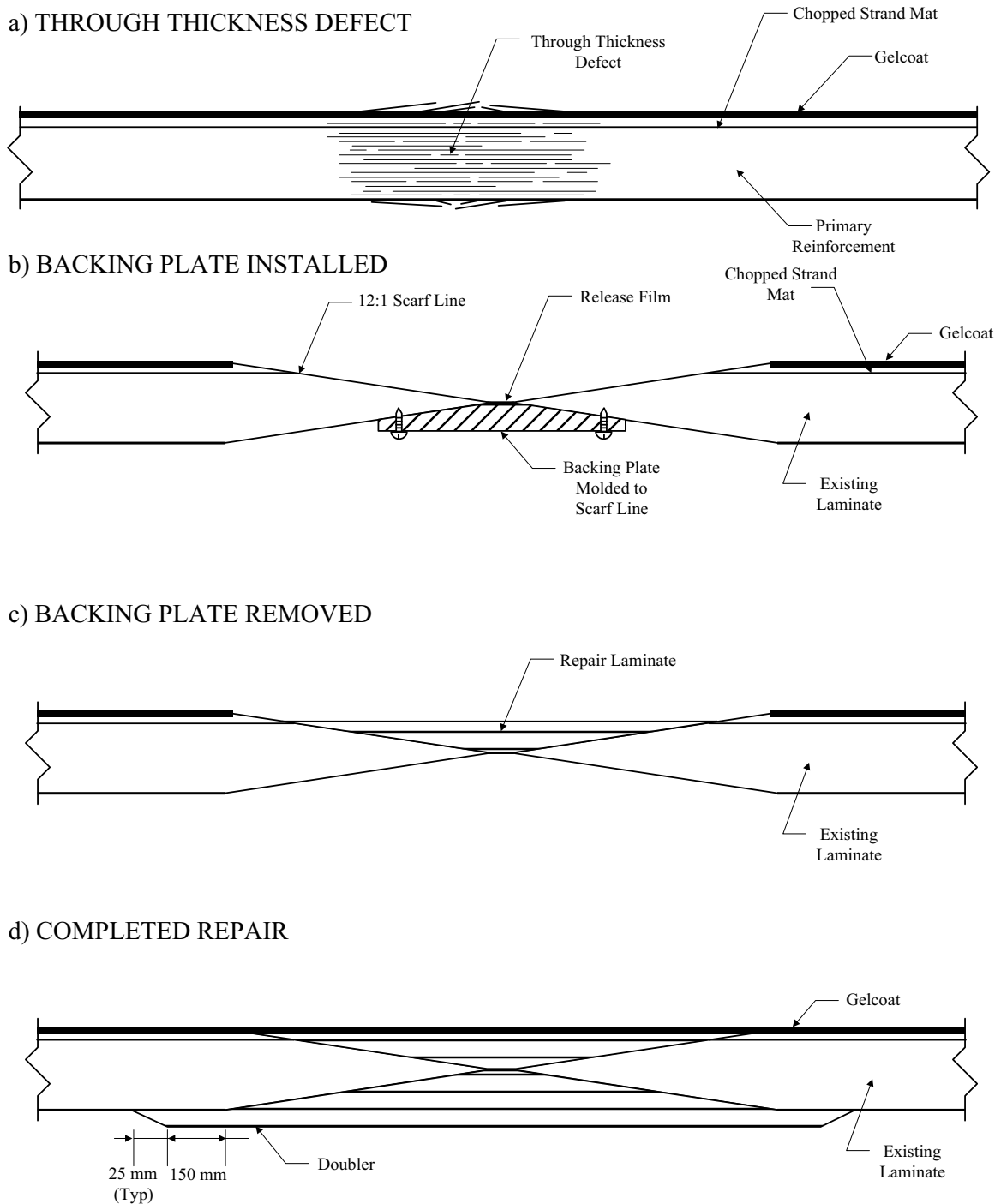
### 5.7 Laminating Process

In all cases, the first ply applied to the existing surface is to be chopped strand mat. This layer is to cover the entire faying surface and is to be saturated in the laminating resin. The laminating procedures, as outlined in 2-6-3/9.7, are to be followed. When lamination is required on an inclined or overhead surface, precautions are to be taken so that the wet reinforcements do not fall. Acceptable laminating repairs can be seen in 2-6-6/Figures 4 through 11.

**FIGURE 4**  
**Partially Through Thickness Defect Repair**

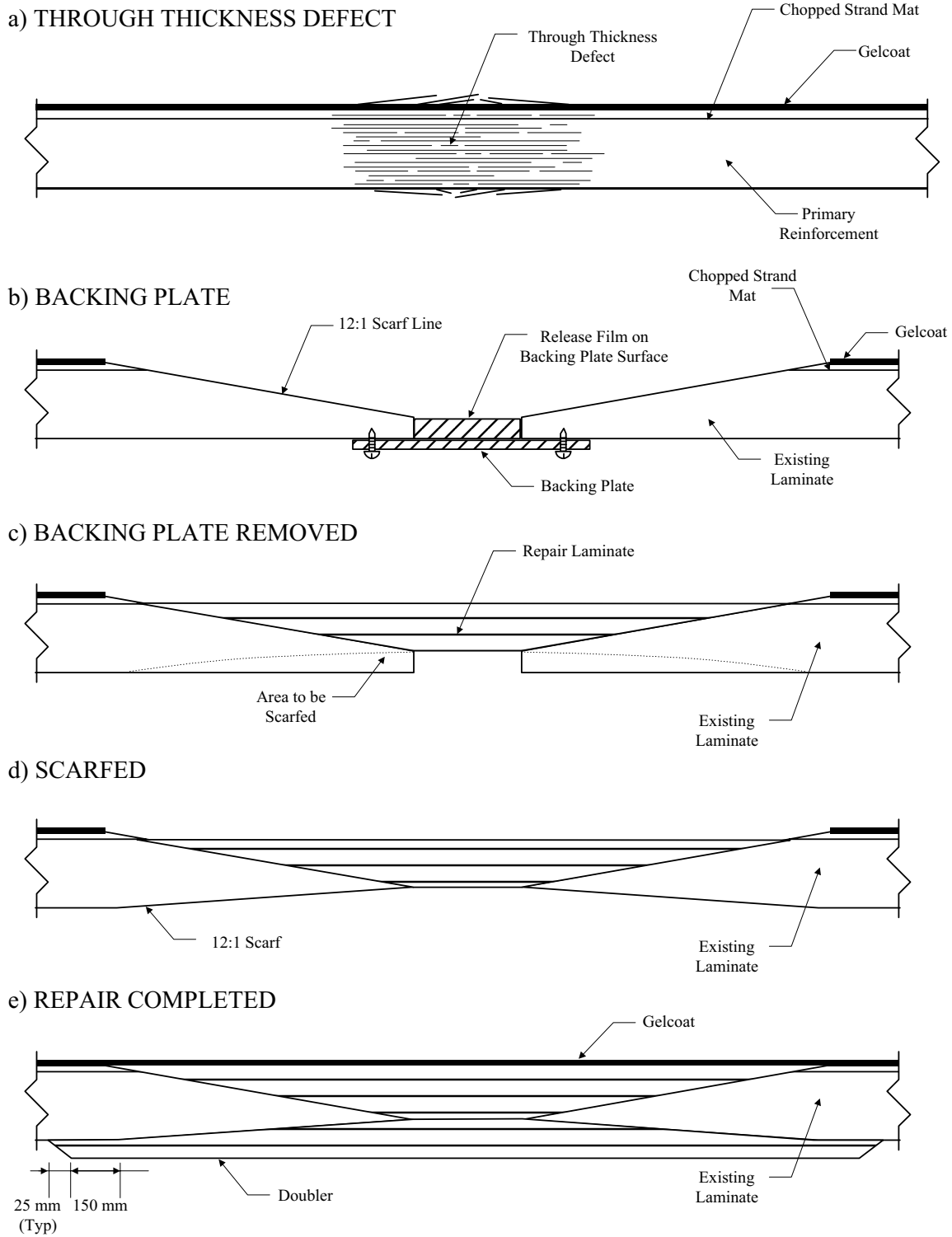


**FIGURE 5**  
**Double Sided Scarf Repair**



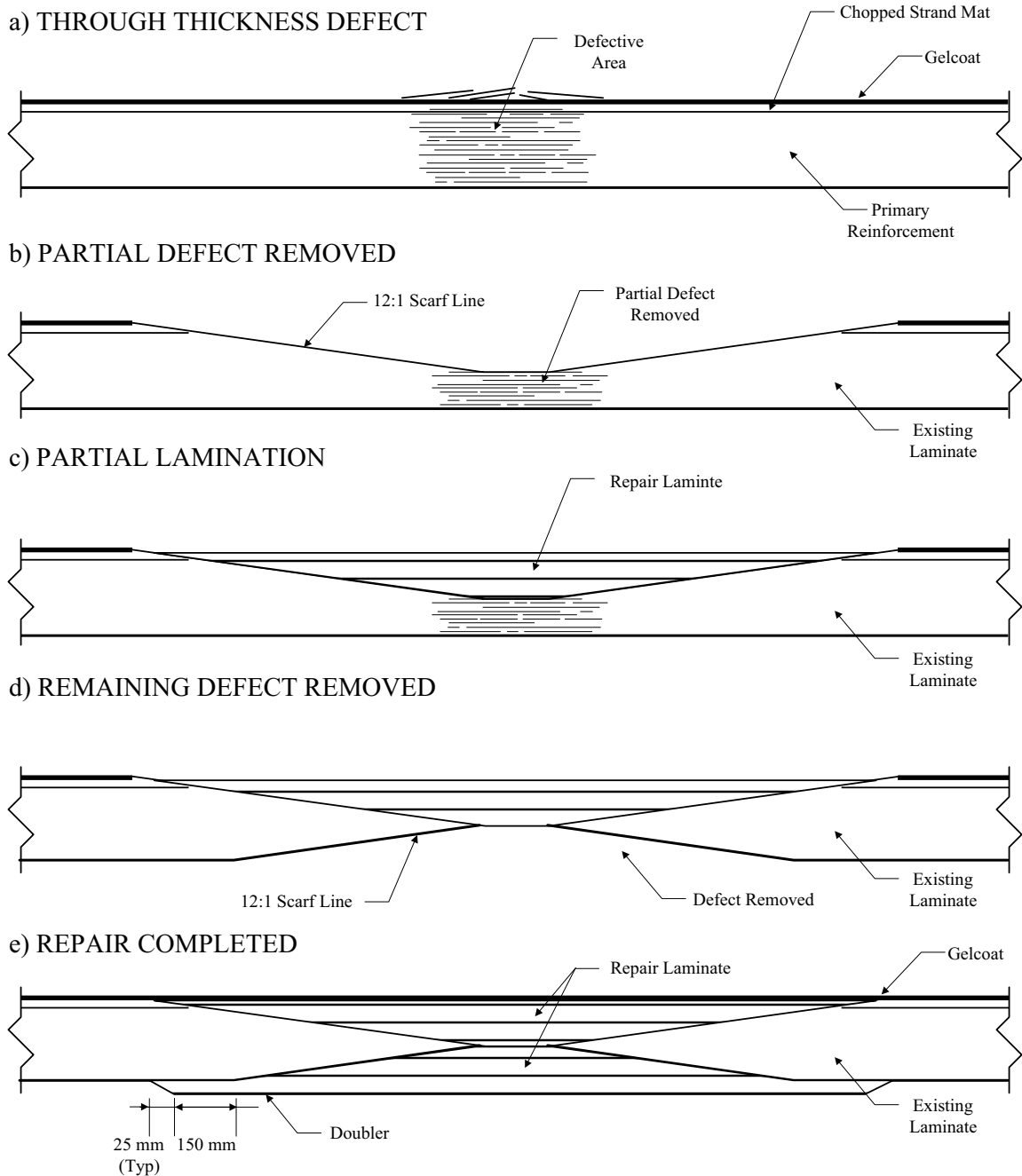
Note: Repair shown with additional plies onto non-molded side.

**FIGURE 6**  
**One Sided Scarf Repair – Backing Plate Installation**



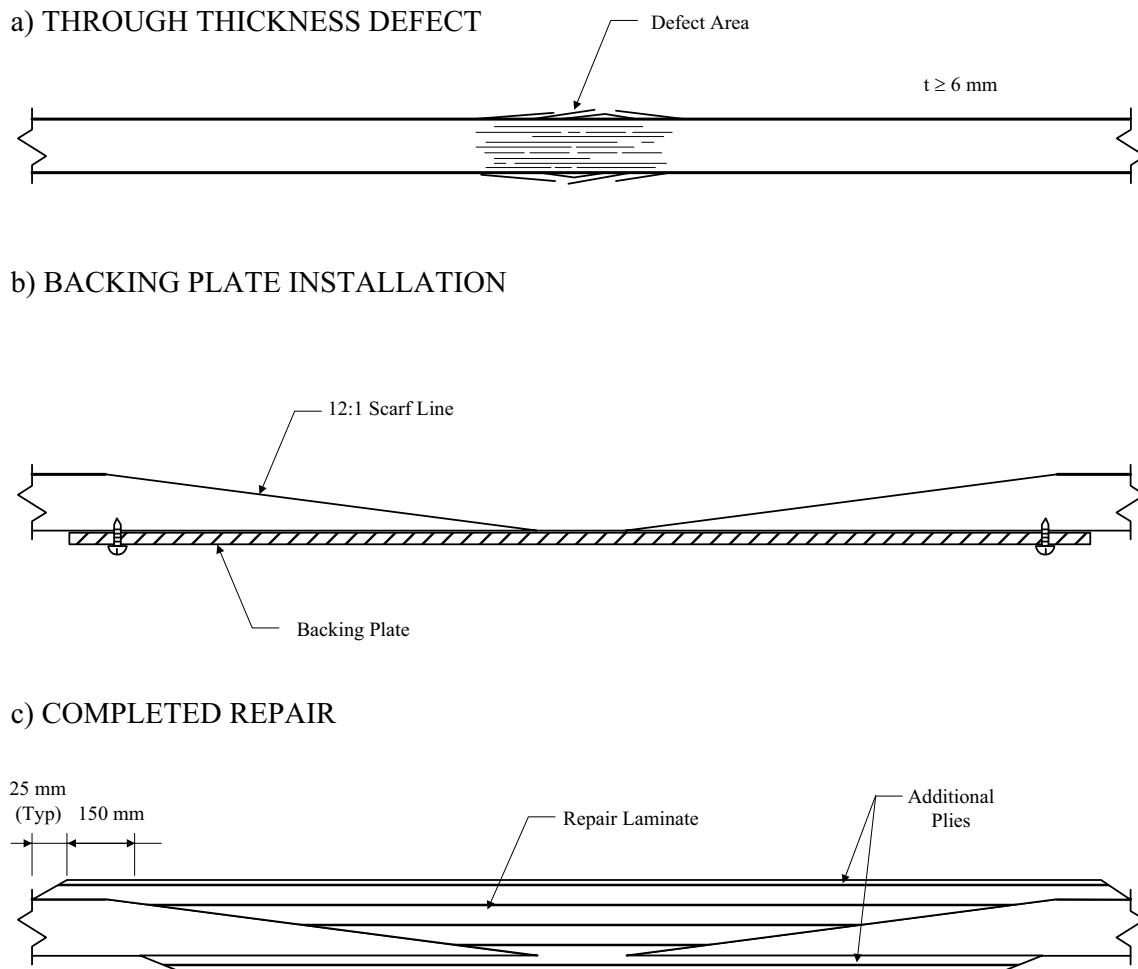
Note: Repair shown with additional plies onto non-molded side.

**FIGURE 7**  
**Repair Using Defective Section as Backing Plate**



Note: Repair shown with additional plies onto non-molded side.

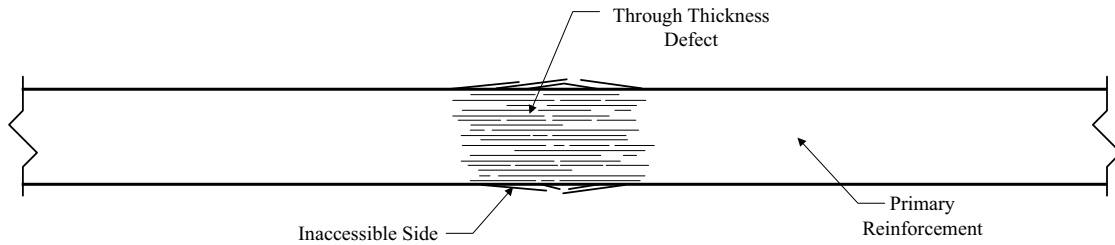
**FIGURE 8**  
**Single Sided Scarf Repair on Thin Laminate**



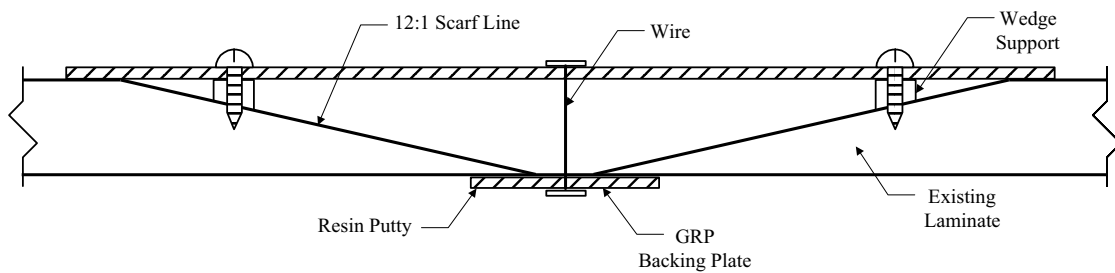
Note: Repair shown with additional plies onto non-molded side.

**FIGURE 9**  
**Backing Plate Installation – Access from One Sided Repair**

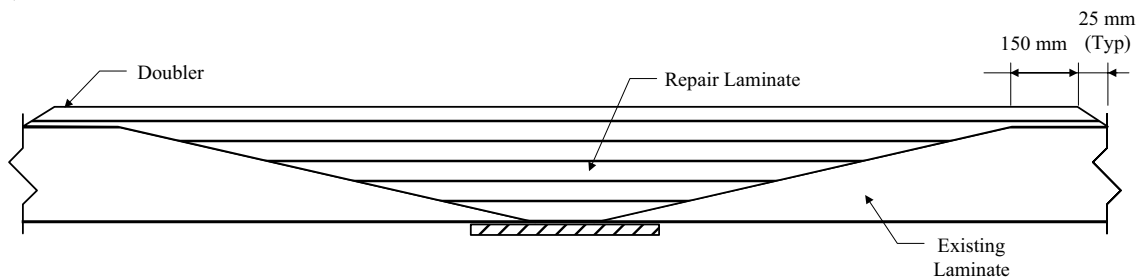
a) DEFECTIVE LAMINATE



b) BACKING PLATE INSTALLATION



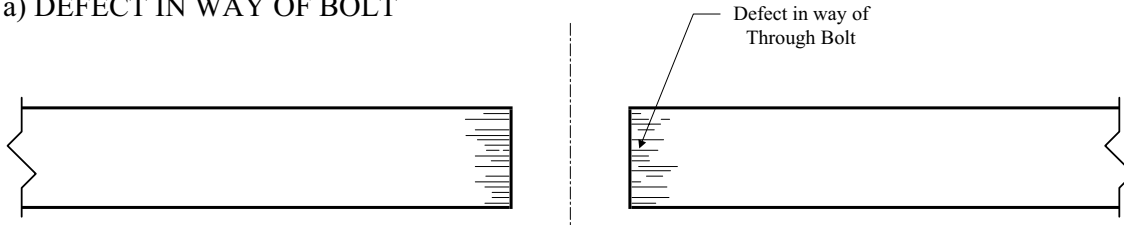
c) COMPLETED REPAIR



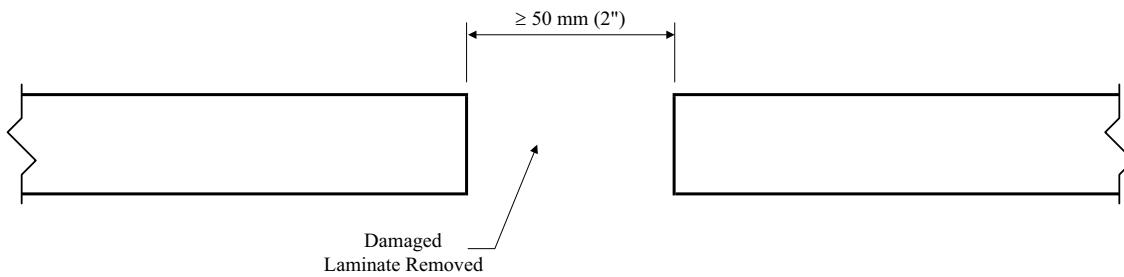
*Note:* Repair shown with additional plies onto non-molded side.

**FIGURE 10**  
**Repair in Way of Through Bolt Failure**

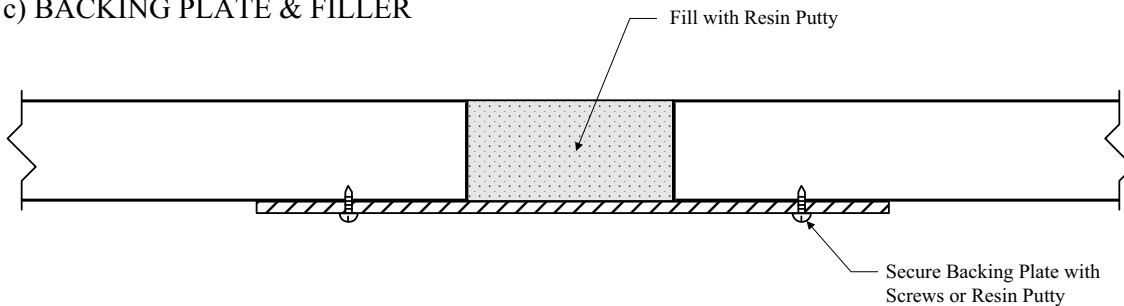
a) DEFECT IN WAY OF BOLT



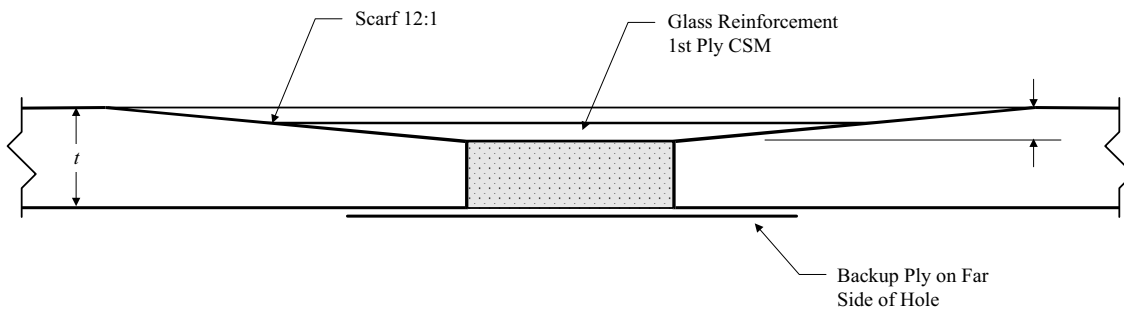
b) LAMINATE REMOVAL



c) BACKING PLATE & FILLER

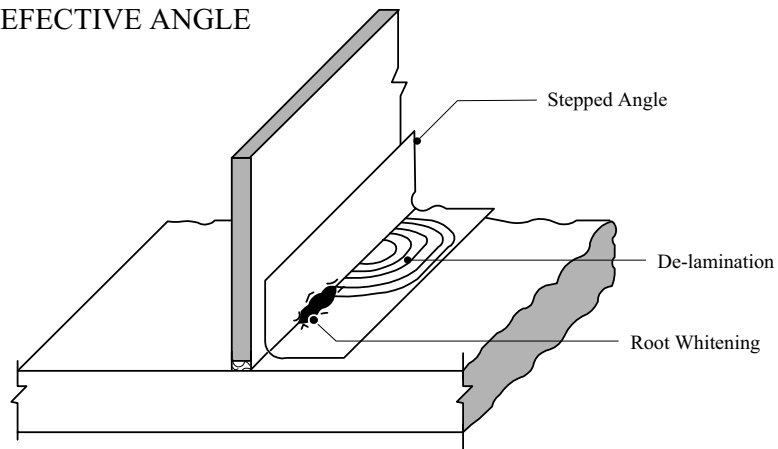


d) COMPLETED REPAIR

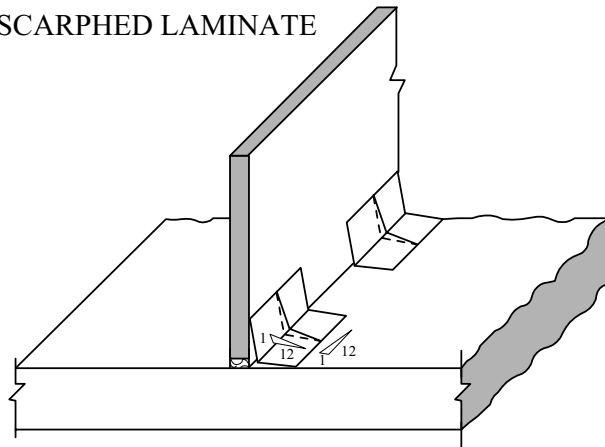


**FIGURE 11**  
**Stepped Angle Defect Repair**

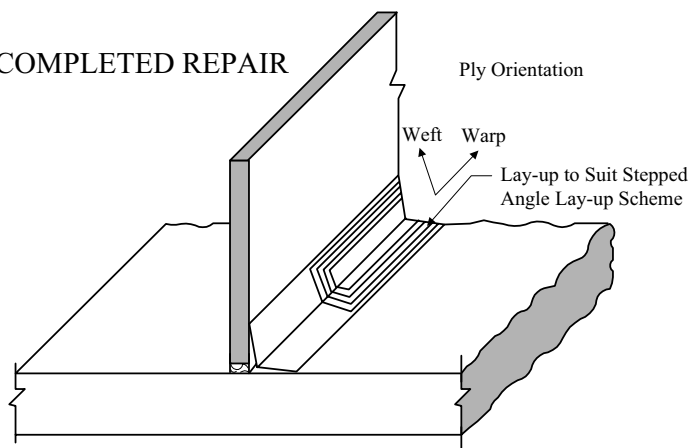
a) DEFECTIVE ANGLE



b) SCARPED LAMINATE



c) COMPLETED REPAIR



## 7 Repair Procedure – Sandwich Construction

### 7.1 Damage Assessment

The techniques outlined in 2-6-6/5.1 are to be applied to sandwich laminate. However, the extent of damage may extend far beyond the area of visible damage.

### 7.3 Removal of Damaged Laminate

The requirements in 2-6-6/5.3 are, in general, applicable to sandwich laminates. The cut back area will be increasingly larger, proceeding from the outer skin to the inner skin.

### 7.5 Laminating Procedure and Process

In general, the skins of a sandwich laminate are to be as indicated in 2-6-6/5.5 and 2-6-6/5.7. The new core is to be similar in type and density to the core that is being replaced. The new core will need to be slightly thinner than the existing core to accommodate the additional repair laminate thickness. The laminating procedure outlined in 2-6-3/9.9 is to be followed.

## 9 Repair Acceptance

Prior to the acceptance and painting of the repair, the area is to be inspected for the following:

- i) There are to be no open voids, pits, cracks, crazing, delaminations or embedded contaminants in the laminate.
- ii) There is to be no evidence of resin discoloration or other evidence of extreme exotherm.
- iii) There is to be no dry reinforcement as indicated by white laminate
- iv) There are to be no wrinkles in the reinforcement and no voids greater than 12 mm (1/2 in.)

The surface of the repair is to be smooth and conform to the surrounding surface contour. The degree of cure is to be within 10% of the required BARCOL hardness, as indicated in 2-6-5/3.