SCDOT
South Carolina
Department of Transportation

December 18, 2019

GEOTECHNICAL DESIGN BULLETIN NO. 2019-2

SUBJECT: Corrections and Additions to 2019 GDM

EFFECTIVE DATE: Immediately

SUPERSEDES: 2019 Geotechnical Design Manual – Additions and Revisions

RE: None

The Geotechnical Design Support Office is making the following Additions and Revisions (see attachments) to the SCDOT Geotechnical Design Manual (2019).

Section 2.2 – Add new definitions and figures
Section 6.2.1.10 – Delete and replace 1st Paragraph
Section 7.19 – Delete and replace Table 7-34
Section 13.9.5 – Delete and replace 2nd Paragraph
Section 17.1 – Add new paragraph after Numbered List
Section 17.9.1 – Delete and replace Table 17-8 and Remainder of Section
Section C.12.4 – Add new Section

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Geotechnical Design Support Engineer

JCS:neh
Attachments
ec:
John Boylston, Director of Preconstruction
Robert Isgett, Director of Construction
David Cook, Director of Maintenance
Robert Perry, Director of Traffic Engineering
Chris Gaskins, RP Engineer – Design Build
Rob Bedenbaugh, Preconstruction Support Engineer
Ladd Gibson, Dir. of Mega Projects
Jennifer Necker, RP Engineer – Lowcountry
Leah Quattlebaum, RP Engineer – Pee Dee
Philip Sandel, RP Engineer – Midlands
Julie Barker, RP Engineer – Upstate
Tad Kitowicz, FHWA

2.2 DEFINITIONS

Backwall Height:

The distance measured from the bottom of the bent cap to the top of the bridge deck at the beginning or end of bridge. The backwall height is typically measured at the centerline of the bridge, but shall be taken as the largest height along the bent at the beginning or end of bridge. For cored slab superstructures, exclude the wearing surface in the backwall height.

Bridge Embankment:

The portion of the approach embankment that requires an Extreme Event limit state global stability check, unless indicated otherwise within the GDM. The longitudinal length of Bridge Embankment shall be based on the specified mitigation method (either geotechnical or structural) that is required to achieve satisfactory global stability for the Extreme Event limit state check.

> <u>Geotechnical Mitigation Required:</u> The Bridge Embankment shall include the front slope and shall extend from either the end of the front slope plus 3.25 times the height of the backwall measured from the end of the approach slab, if present, or to the point where the need for geotechnical mitigation terminates, whichever is longer (see Figure 2-1).
> <u>Structural Mitigation Required:</u> The Bridge Embankment shall include the front slope plus 3.25 times the height of the backwall measured from the end of the approach slab, if present (see Figure 2-2). This distance shall be taken as the minimum Bridge Embankment.

In the event mitigation is not required for the Extreme Event limit state global stability analysis, the Bridge Embankment shall include the front slope plus 3.25 times the height of the backwall measured from the end of the approach slab, if present (see Figure 2-2).

Geotechnical Mitigation:

When ground improvement or ground reinforcement is used to minimize loads and deflections induced by global instability that occur during the Extreme Event limit state check from being transferred to the bridge structure. Typically geotechnical mitigation extends from either the toe of slope (see Figure 2-1) or outside of the toe slope and extends beyond the begin/end of bridge to a point where the global stability analysis surface exits the ground surface and achieves a resistance factor less than or equal to 1.0 ($\varphi \leq 1.0$). If vertical elements other than the bridge foundation are used as the selected mitigation method, contact the PCS/GDS for further guidance. Further, geotechnical mitigation is typically limited transversely by the Right-of-Way lines. If geotechnical mitigation is only required to maintain stability in the transverse direction for the Extreme Event limit state check, the longitudinal extent of transverse mitigation shall be limited to the end of the front slope plus 3.25 times the height of the backwall measured from the end of the approach slab, if present.

Structural Mitigation:

When bridge structural elements are used to resist loads and deflections induced by global instability that occurs during the Extreme Event limit state check.

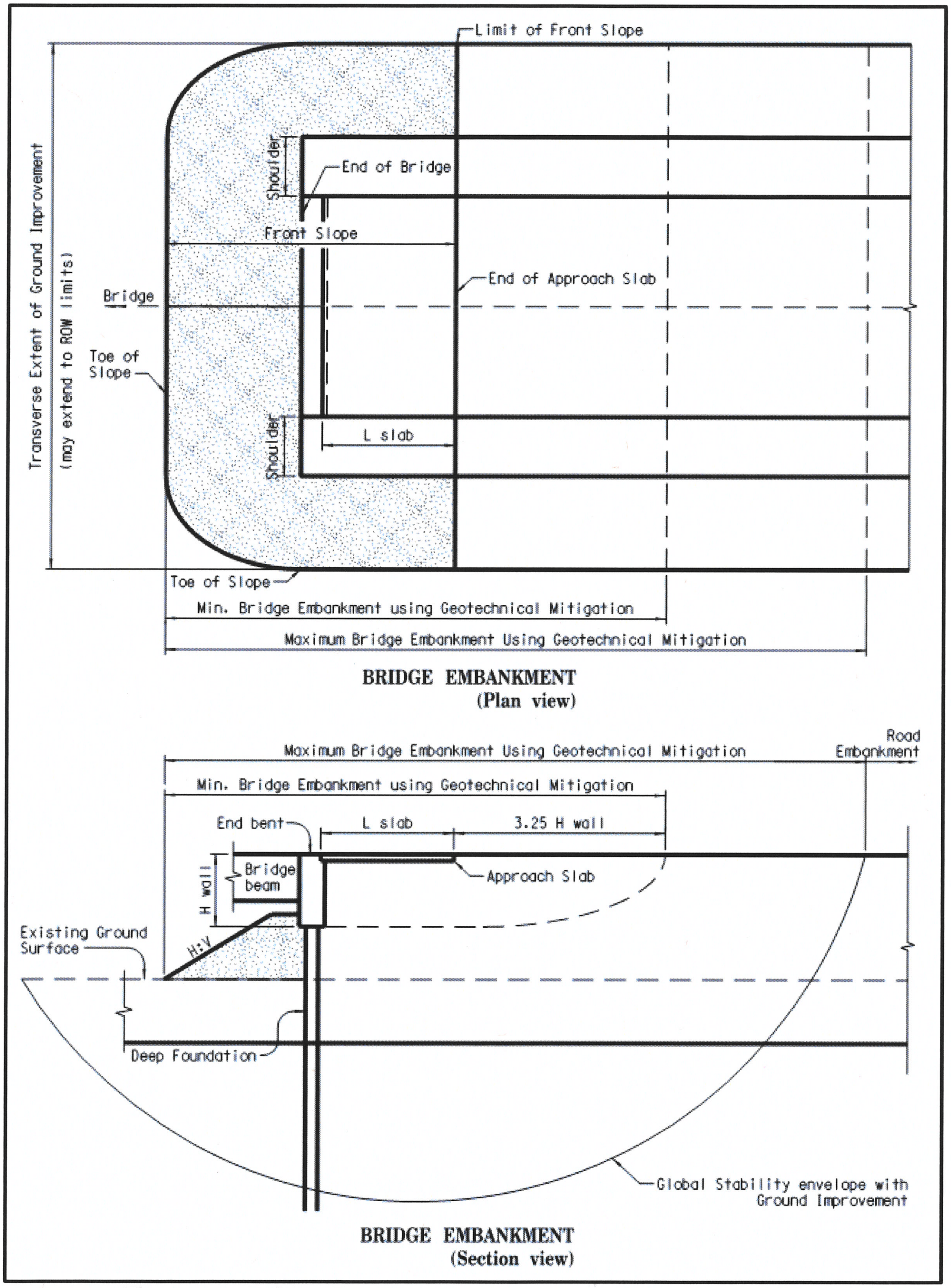

Figure 2-1, Bridge Embankment using Geotechnical Mitigation

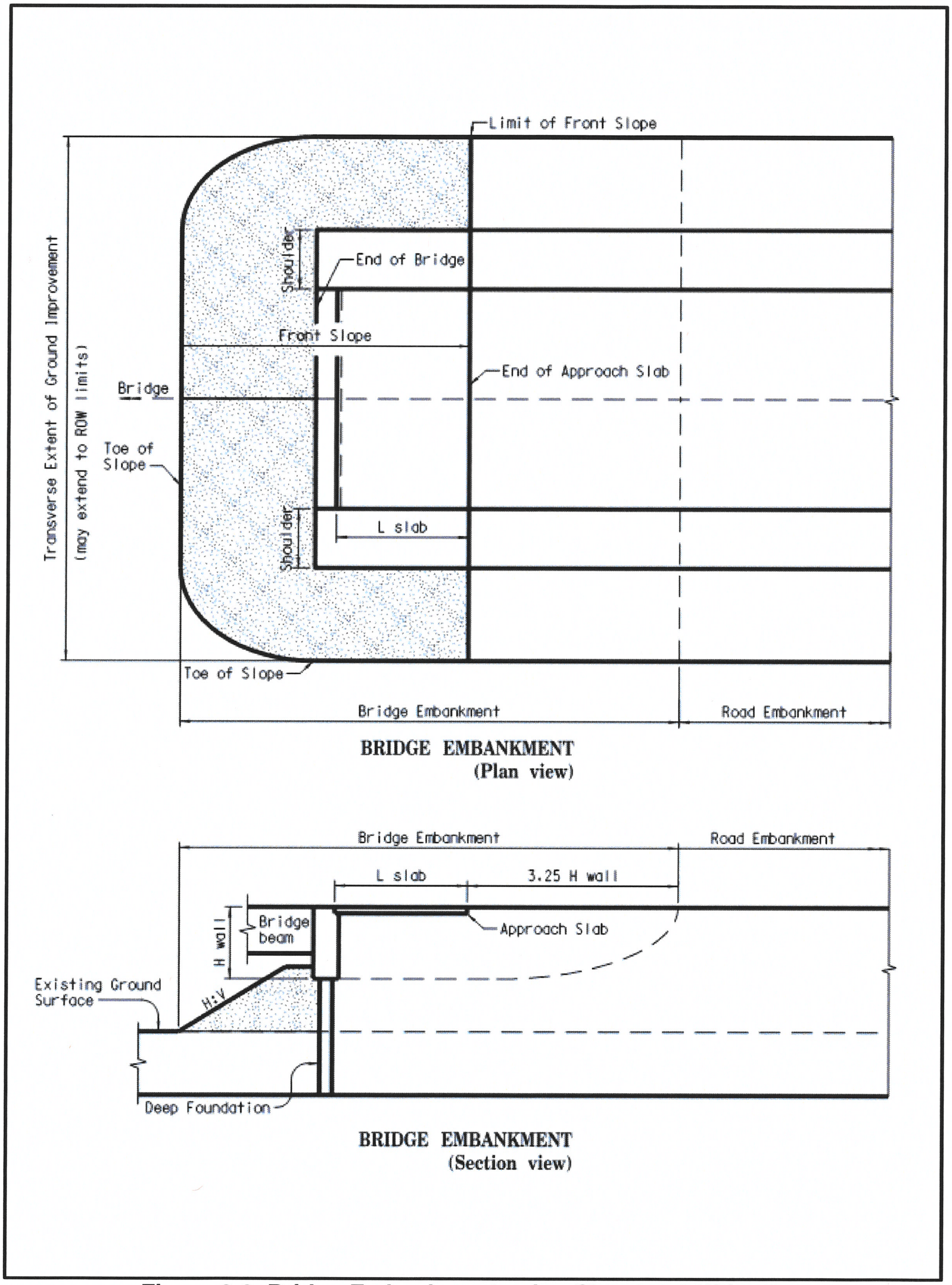

Figure 2-2, Bridge Embankment using Structural Mitigation

6.2.1.10 Soil Electro-Chemical Classifications

Electro-chemical testing is required for soil and water samples collected from project sites, so that appropriate materials may be used on the project site. Electro-chemical testing is performed in accordance with the requirements contained in Chapter 5 and consists of pH, resistivity, sulfate and chloride contents. The aggressiveness or non-aggressiveness shall be determined using Table 7-34. In addition, to the electro-chemical tests, the location of the ground water table should also be noted. Fluctuations in the ground water table may lead to aggressive soil environments by allowing increased oxygen content around the foundation. The results of all electro-chemical testing shall be reported to the SEOR and project team for their consideration in the design of the structure.

Table 7-34, Criteria for Substructure and ERS Environmental Classifications

Environmental Classification	Electro-Chemical Component	Units	Soil	Water
Aggressive (if any of these conditions exist)	pH	-	< 5.5	< 5.5
	Cl	ppm[1]	> 500	> 500
	SO_4	ppm[1]	$> 1{,}000$	> 500
	Resistivity	Ohm-cm	$< 2{,}000$	$< 5{,}000$
Non-aggressive	This classification must be used at all sites not meeting the requirements for Aggressive Environments			
pH = acidity ($-\log_{10}H^+$; potential of hydrogen); Cl = chloride content; SO_4 = sulfate content				

[1]ppm (part per million) = mg/L (milligram per liter)

13.9.5 Age Correction Factor (K_{DR})

Soil formations that are Pre-Pleistocene (>1.6 MYA) typically will have a lower susceptibility to experience cyclic liquefaction. Therefore, Pre-Pleistocene (>1.6 MYA) soils should be considered not susceptible to cyclic liquefaction. However, Pre-Pleistocene soils that have been subjected to cyclic liquefaction during previous seismic events should be treated similar to soils formed during the Holocene period. Evidence to justify the Pre-Pleistocene (>1.6 MYA) soils susceptibility to cyclic liquefaction shall be submitted to the PC/GDS for review and acceptance. Figure 13-4 provides the location of paleoliquefaction sites that have been previously studied. In addition, Figure 13-5 maps the areas in South Carolina that potentially have experienced Quaternary liquefaction (USGS website).

17.1 INTRODUCTION

In the case of a bridge embankment (see Chapter 2), the global stability of the front slope (see Chapters 2 and 10) is determined along the longitudinal axis of the project for the Extreme Event limit state check. Typically global instability along the longitudinal axis of the project has the greatest potential for impacting the bridge; therefore, in the transverse direction within the front slope similar results are anticipated. However, if in the opinion of the GEOR the global stability in the transverse direction may impact the bridge at the Extreme Event limit state, then the GEOR may perform global stability analysis in the transverse direction within the front slope.

Table 17-8, Primary Consolidation Settlement Equations

Condition	Equation	No.
e-log p		
$\sigma'_p < \sigma'_{vo} < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * \left[\left(\frac{C_c}{1+e_o}\right) * \left(log\frac{\sigma'_{vo}}{\sigma'_p}\right) + \left(\frac{C_c}{1+e_o}\right) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)\right]$	Equation 17-28A
$\sigma'_{vo} = \sigma'_p < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * \left(\frac{C_c}{1+e_o}\right) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)$	Equation 17-28B
$\sigma'_{vo} < \sigma'_f < \sigma'_p$	$S_c = \sum_{i=1}^{n} H_o * \left(\frac{C_r}{1+e_o}\right) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)$	Equation 17-29
$\sigma'_{vo} < \sigma'_p < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * \left[\left(\frac{C_r}{1+e_o}\right) * \left(log\frac{\sigma'_p}{\sigma'_{vo}}\right) + \left(\frac{C_c}{1+e_o}\right) * \left(log\frac{\sigma'_f}{\sigma'_p}\right)\right]$	Equation 17-30
ε-log p		
$\sigma'_p < \sigma'_{vo} < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * \left[(C_{\varepsilon c}) * \left(log\frac{\sigma'_{vo}}{\sigma'_p}\right) + (C_{\varepsilon c}) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)\right]$	Equation 17-31A
$\sigma'_{vo} = \sigma'_p < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * (C_{\varepsilon c}) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)$	Equation 17-31B
$\sigma'_{vo} < \sigma'_f < \sigma'_p$	$S_c = \sum_{i=1}^{n} H_o * (C_{\varepsilon r}) * \left(log\frac{\sigma'_f}{\sigma'_{vo}}\right)$	Equation 17-32
$\sigma'_{vo} < \sigma'_p < \sigma'_f$	$S_c = \sum_{i=1}^{n} H_o * \left[(C_{\varepsilon r}) * \left(log\frac{\sigma'_p}{\sigma'_{vo}}\right) + (C_{\varepsilon c}) * \left(log\frac{\sigma'_f}{\sigma'_p}\right)\right]$	Equation 17-33

Where,

H_o = Thickness of i^{th} layer
e_o = Initial void ratio of i^{th} layer
σ'_f = Final pressure on the i^{th} layer

$$\sigma'_f = \sigma'_{vo} + \Delta\sigma_v \qquad \textbf{Equation 17-34}$$

Where,

σ'_{vo} = initial vertical effective stress on the i^{th} layer

$\Delta\sigma_v$ = change in stress on the i^{th} layer

Where,

$\sigma'_p < \sigma'_{vo} < \sigma'_f$ = Soils that meet this condition are Underconsolidated

$\sigma'_{vo} = \sigma'_p < \sigma'_f$ = Soils that meet this condition are Normally Consolidated

$\sigma'_{vo} < \sigma'_f < \sigma'_p$ = Soils that meet this condition are Overconsolidated and are undergoing recompression only (i.e., these soils remain Overconsolidated)

$\sigma'_{vo} < \sigma'_p < \sigma'_f$ = Soils that meet this condition are Overconsolidated and transition to Normally Consolidated

C.12.4 <u>Inundation Design</u>

MSE Walls may be designed for inundation, with permission from the PCS/SDS, PCS/GDS, PCS/HDS, from water that has been determined to be non-aggressive (see Chapter 7 for determination of aggressive versus non-aggressive). Inundation is defined as the process of water entering into the reinforced backfill materials of an MSE Wall, typically from a water level in front of the wall. To prevent the buildup of hydrostatic pressure behind the MSE Wall facing, the reinforced backfill materials in the inundation zone shall consist of stone backfill (see STS SC-M-713 – *Mechanically Stabilized Earth (MSE) Walls*) except Macadam, which is not permitted in the inundation zone. The stone backfill shall extend to 1 foot above the 100-year flood level for non-aggressive water. Granular backfill may be used above the stone backfill; however, a geotextile soil separator is required between the granular backfill and the stone backfill. In addition, the stone backfill shall be encapsulated with a geotextile soil separator to prevent soil from migrating into the stone backfill under certain hydraulic conditions. The use of either metallic or geosynthetic reinforcement is permitted for MSE Walls designed for inundation by non-aggressive water.

The top of the leveling pad shall be placed below the maximum scour depth but no less than 3 feet below the bottom of the stream bed. The excavated area in front of the MSE Wall shall be backfilled with Rip Rap. The Rip Rap shall extend at least 3 feet from the front of the wall toward the centerline of the stream and shall extend at least 3 feet above the leveling pad. The size of the Rip Rap shall be determined by the GEOR in consultation with the HEOR. The Rip Rap shall conform to the requirements of the Standard Specifications.

The inundation of MSE Walls by water that has been determined to be aggressive is allowed only if the conditions that follow are met. Place MSE Walls 5 feet above the 100-year flood level, in areas where the water has been determined to be aggressive. For these MSE Walls, the use of metallic reinforcement is not allowed. Therefore, the MSE Wall shall use geosynthetic reinforcement within the reinforced backfill. In addition, the geosynthetic reinforcement shall extend the full height and length of the wall. Mixing geosynthetic reinforcement and metallic reinforcement is not allowed either vertically or horizontally. No metallic connectors are allowed within the backfill that may be exposed to water that has been determined to be aggressive. In addition, the reinforced backfill shall be encapsulated with a geotextile soil separator to prevent the retained soil from migrating into the reinforced backfill under certain hydraulic conditions. Further the GEOR should consider the effect of the Extreme Event II hydraulic condition (i.e., the check (500-year) flood) on the reinforced backfill.

If inundation of the MSE Wall is anticipated, the GEOR shall indicate on the MSE Wall drawings whether the water will be non-aggressive or aggressive. The MSE Wall supplier shall be responsible for accounting for the effects of the aggressiveness of the water in the design of the MSE Wall panel. The MSE Wall supplier shall be required to provide a statement and design indicating that the panel was designed for an aggressive environment.