TechBrief

The Scour Program is an integrated national effort to address or mitigate erosion of streambed or bank material due to flowing water, including erosion localized around bridge abutments and piers.

The Scour Program also addresses bridges with foundation elements that are or have the potential to be unstable for the observed or evaluated scour condition.

The Federal Highway Administration manages the Program through partnerships with State highway agencies, industry and academia.

The Program's primary goals are to improve safety and resilience of the Nation's bridges.

Office of Bridges & Structures
FHWA-HIF-23-040
March 2023

U.S. Department of Transportation
Federal Highway Administration

Scour Design within AASHTO LRFD Limit States

This nonbinding Technical Brief provides programmatic and technical considerations for understanding the interaction of limit states and scour depths in shallow and deep foundation design related to provisions of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design Bridge Design Specifications, Eighth Edition (2017) (AASHTO LRFD-8) (incorporated by reference at 23 CFR § 625.4(d)(1)(v)).

1 INTRODUCTION

The Federal Highway Administration (FHWA) incorporated, by reference, the AASHTO LRFD Bridge Design Specifications (BDS), 8th edition (2017) (hereinafter AASHTO LRFD BDS (2017)) that govern various bridge engineering design elements:

- structural (e.g., bridge superstructures, decks, piers),
- geotechnical (e.g., foundations, abutments, retaining walls, *scour*),
- hydraulic (e.g., hydrology, hydraulics, and *scour*), and
- other elements for these types of highway infrastructure.

This Technical Brief (TechBrief) is a companion document to FHWA's non-regulatory February 16, 2021 TechBrief "Scour Considerations within AASHTO LRFD Bridge Design Specifications" (FHWA-HIF-19-060.

This TechBrief describes how AASHTO LRFD provisions consider *scour* and *limit states* when designing *foundations*. Additionally, the TechBrief describes how this aligns with FHWA regulatory requirements for Design Standards and, for scour, National Bridge Inspection Standards (23 CFR § 650.313(o)).

The AASHTO describes LRFD as taking the *"variability in the behavior of structural elements into account in an explicit manner. LRFD relies on extensive use of statistical methods, but sets forth the results in a manner readily usable by bridge designers and analysts."* (AASHTO LRFD). Additionally, AASHTO LRFD specifies "*Load and Resistance Factor Design*" as *"a reliability-based design methodology in which force effects caused by factored loads are not permitted to exceed the factored resistance of the components."* (AASHTO LRFD BDS (2017) Foreword and Section 1.2)

As the term "LRFD" denotes, quantification and probabilistic considerations related to forces (i.e., loads) and responses to those forces (i.e., resistance) that inform application of the design specifications. The AASHTO LRFD accomplishes this through consideration of *limit states*. The AASHTO LRFD specifies this *limit state* term as a *"condition beyond which the bridge or component ceases to satisfy the provisions for which it was designed."* In practice, bridge engineers would factor the capacity and demand upon bridge superstructures, substructure and foundation elements for evaluation at all applicable *limit states*.

This is not the case for *scour* design. Federal regulation at 23 CFR § 650.305 defines *scour* as *"erosion of streambed material due to flowing water; often considered as being localized around piers and abutments of bridges"*, with "erosion" being the operative word.

Similarly, AASHTO LRFD considers *scour* not as a force, but a change in foundation conditions (i.e., loss of bed material above the scour line). In other words, (1) *scour depth* is a condition that has resulted from erosive forces and (2) AASHTO LRFD considers this condition within the context of *limit states*. There are currently no statistically based factors applied to *scour depth* or its effect to foundation**.**

This may become problematic as the design of bridge foundations to accommodate *scour* involves close coordination and collaboration between hydraulics, geotechnical, and structural engineering disciplines. While each of these disciplines have specifications, guidance, and terminology specific to scour, they are not necessarily aligned among all three.

This TechBrief describes various AASHTO LRFD and FHWA terms and scenarios to illustrate the various conditions for *limit states*. Refer to FHWA's Hydraulic Engineering Circular No. 18 (HEC-18) "Evaluating Scour at Bridges" for detailed descriptions of the individual scour components and conditions for foundation analysis and design, and for the various methods available to compute the scour magnitude for each component (FHWA, 2012). Finally, this TechBrief provides clarification on FHWA approaches.

This TechBrief does not update, change nor supersede any information in the HEC-18 document nor other FHWA materials.

1.1 A NOTE ON NOMENCLATURE

To assist the audience, this nonbinding TechBrief signifies terms provided by the FHWA or AASHTO by combining *italics* and font color. Examples include *limit state* or *scour* or *design flood for waterway opening*. Likewise, when directly citing text from a source document, this TechBrief will *italicize that language*.

To assist in presenting specific AASHTO LRFD language, this TechBrief adopts a shaded text box with the relevant citation, as depicted below.

> **AASHTO LRFD Article, Commentary, Section**
>
> Language of that citation.

Finally, to aid in understanding various terms taken from AASHTO LRFD BDS (2017) (incorporated by reference at 23 CFR § 625.4(d)(1)(v)) and FHWA HEC-18 used within this document, this TechBrief provides a Glossary at the end of the document.

1.2 REGULATORY BASIS

This nonbinding TechBrief will help bridge owners and designers with compliance of the FHWA's regulations found in the Code of Federal Regulations (CFR), Title 23, Highways (23 CFR). Compliance with 23 CFR and other regulations for a project is required to be eligible for Federal-aid or other FHWA participation or assistance [23 CFR § 1.36].

The following Federal regulations apply to all bridges over waterways (paraphrased for brevity):

23 CFR part 625 – Design Standards

a. National Highway System (NHS) projects require following hydrologic, hydraulic, and scour related sections of the AASHTO LRFD Bridge Design Specifications [23 CFR § 625.3(a)(1) and 23 CFR § 625.4(d)(1)(v)].

b. Non-NHS projects require following State DOT drainage and/or bridge standard(s) and specifications [23 CFR § 625.3(a)(2)].

23 CFR 650 subpart A – Location and Hydraulic Design of Encroachments on Flood Plains

a. Hydraulic Design Standards [23 CFR § 650.107] applies to all Federal-aid projects, whether on the NHS or Non-NHS.

b. Content of Design Studies [23 CFR § 650.117] requires that studies contain *hydrologic and hydraulic data and design computations* [23 CFR § 650.117(b)(1)]. As both hydrologic and hydraulic factors and characteristics lead to scour formation, such data and computations apply to scour as well. Project plans must show the water surface elevations of the base flood (i.e., 100-year flood) and overtopping flood [23 CFR § 650.117(c)].

23 CFR 650 Subpart C – National Bridge Inspection Standards

a. Defines *Scour* and *Scour Critical Bridges* [23 CFR § 650.305].

b. Requires bridge owners to perform a scour appraisal for all bridges over water, and document the process and results in the bridge file. Re-appraise when necessary to reflect changing scour conditions. Scour appraisal procedures should be consistent with Hydraulic Engineering Circulars (HEC) 18 and 20.[23 CFR § 650.313(o)(1)].

c. For bridges which are determined to be scour critical or have unknown foundations, prepare and document a scour POA for deployment of scour countermeasures for known and potential deficiencies, and to address safety concerns. The plan must address a schedule for repairing or installing physical and/or hydraulic scour countermeasures, and/or the use of monitoring as a scour countermeasure. Scour plans of actions should be consistent with HEC 18 and 23.[23 CFR § 650.313(o)(2)].

2 FOUNDATION DESIGN WITHIN THE CONTEXT OF AASHTO LRFD BDS

FHWA Regulation 23 CFR § 625.4(d)(1)(v) [Standards, policies, and standard specifications] requires use of the “AASHTO LRFD” for projects on the National Highway System (NHS). Additionally, under the 23 CFR § 625.4(d)(1)(v) authorities, many State DOTs adopt this document for use on non-NHS projects as well.

As a result, this TechBrief focuses on how *scour* and *limit states* are considered in the provisions of AASHTO LRFD. To do so, this section of the TechBrief provides a more detailed explanation of how the strength, service and extreme event limit states influence the design of both shallow and deep foundation, without considering the effects of scour. Unless derived from the AASHTO LRFD BDS (2017) or specifically cited with a regulation, these TechBrief discussions only represent technical and non-regulatory considerations and processes.

2.1 AASHTO LRFD BDS (2017) Deep Foundation Design

This section illustrates how AASHTO LRFD BDS (2017) provisions would apply to *deep foundation* analysis under a scenario where *scour* does not affect the *deep foundation*.[1]

Figure 1 depicts a hypothetical example where a pile or shaft load for a specific limit state is determined resulting in a minimum pile or shaft penetration length, L_{MIN}.

In the design of a *deep foundation*, AASHTO LRFD BDS (2017) specifies the consideration of structural and geotechnical conditions, and the load combinations specified in Service, Strength, and Extreme Event *limit states*. Note, the load combinations specified in the Fatigue limit state are not considered when designing deep foundations for scour.

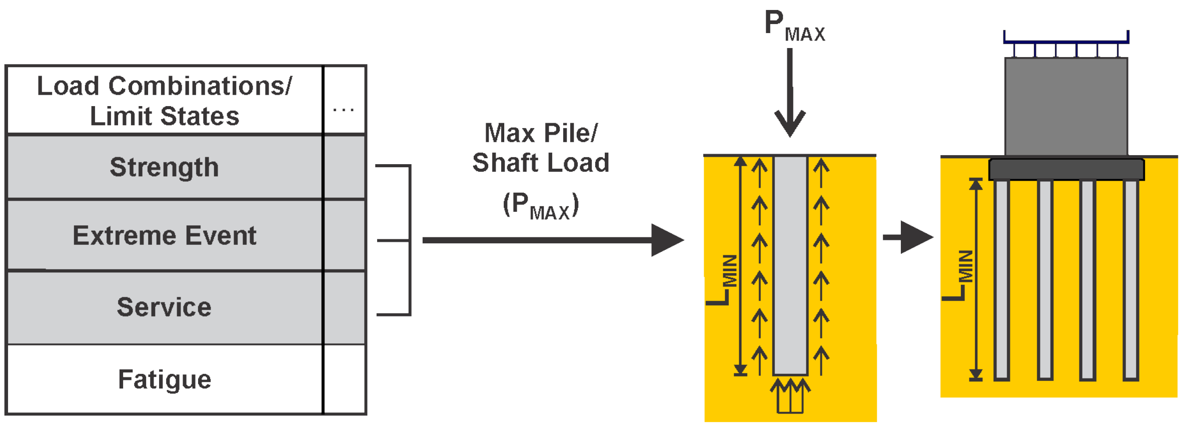

Figure 1. Schematic of AASHTO LRFD BDS (2017) pile/shaft design.

The AASHTO LRFD BDS (2017) design methodology uses *load factors* to account primarily for the variability of loads, the uncertainties in load evaluation, and the probability distribution for potential combinations of different loads, but also related to the statistics of the resistance through the calibration process. It uses *resistance factors* to account primarily for uncertainties in material properties, geometric variation from fabrication process, and capacity analysis, but also related to the statistics of the loads through the calibration process.

The combination of *factored loads* (i.e., the sum of products of *nominal loads* and *load factors*) cannot exceed the *factored resistance* (i.e., *nominal resistance* of the component multiplied by a *resistance factor*). If it does, the bridge or bridge component no longer satisfies the specific *limit state* and therefore, no longer fulfills the target reliability embedded in AASHTO LRFD BDS (2017).

2.2 AASHTO LRFD BDS (2017) Shallow Foundation Design

This section illustrates how AASHTO LRFD BDS (2017) provisions would apply to *shallow foundation* analysis under the scenario that *scour* does not affect the *shallow foundation*.[2]

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[1] This TechBrief has greatly simplified the AASHTO LRFD BDS (2017) process solely for clarity and is not intended for design. Compliance with AASHTO LRFD BDS (2017) is a regulatory requirement [23 CFR 625.4(d)(1)(v)].

[2] This TechBrief has greatly simplified the AASHTO LRFD BDS (2017) process solely for clarity and is not intended for design. Compliance with AASHTO LRFD BDS (2017) is a regulatory requirement [23 CFR 625.4(d)(1)(v)].

Figure 2 depicts a hypothetical example where a spread footing is designed where the soil resistance satisfies the loading conditions for specific limit states.

In the design of a *shallow foundation*, AASHTO LRFD BDS (2017) specifies the consideration of structural and geotechnical conditions, and the load combinations specified in *Service*, *Strength*, and *Extreme Event limit states*. Note, the load combinations specified in the Fatigue limit state are not considered when designing shallow foundations for scour.

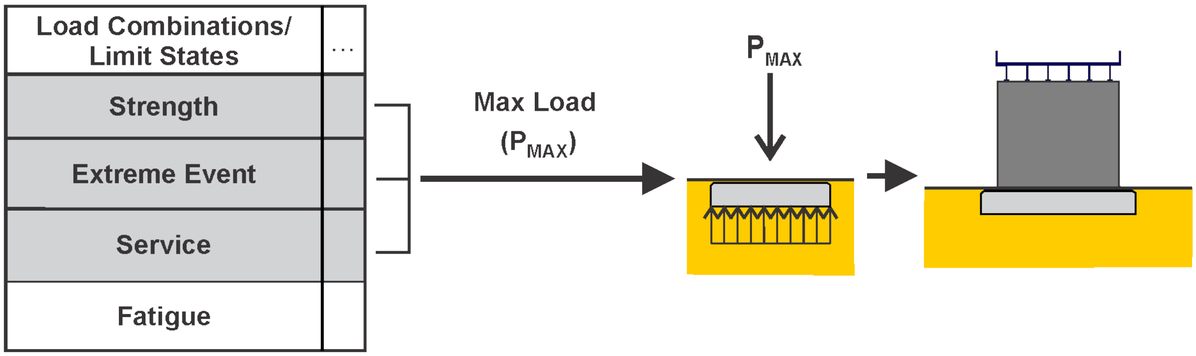

Figure 2. Schematic of AASHTO LRFD BDS (2017) shallow foundation design.

3 BEARING DEPTH FOR SPREAD FOOTINGS CONSIDERING SCOUR

For the shallow foundation design considering scour, AASHTO LRFD BDS (2017) has the following language:

1. Scour

> AASHTO LRFD BDS (2017) Section 2.6.4.4.2
>
> Spread footings on soil or erodible rock shall be located so that the bottom of footing is below scour depths determined for the check flood for scour. Spread footings on scour-resistant rock shall be designed and constructed to maintain the integrity of the supporting rock.

2. Bearing Depth

> AASHTO LRFD BDS (2017) Section 10.6.1.2
>
> Where the potential for scour, erosion or undermining exists, spread footings shall be located to bear below the maximum anticipated depth of scour, erosion, or undermining as specified in Article 2.6.4.4.

Figure 3 illustrates an example where the minimum bearing depth (d_{MIN}) considering *total scour* for the *scour check flood* is linked to the *extreme event II limit state*. The top half of the figure 3 shows that the minimum footing dimensions are determined by the maximum load for *strength* or *service limit states* and *extreme event limit states*, while the lower half of the figure shows that the top of footing is located below the scour depth determined for the check flood for scour (note, this aligns with the recommendation from HEC-18 whereas AASHTO LRFD BDS (2017) specifies bottom of footing.).

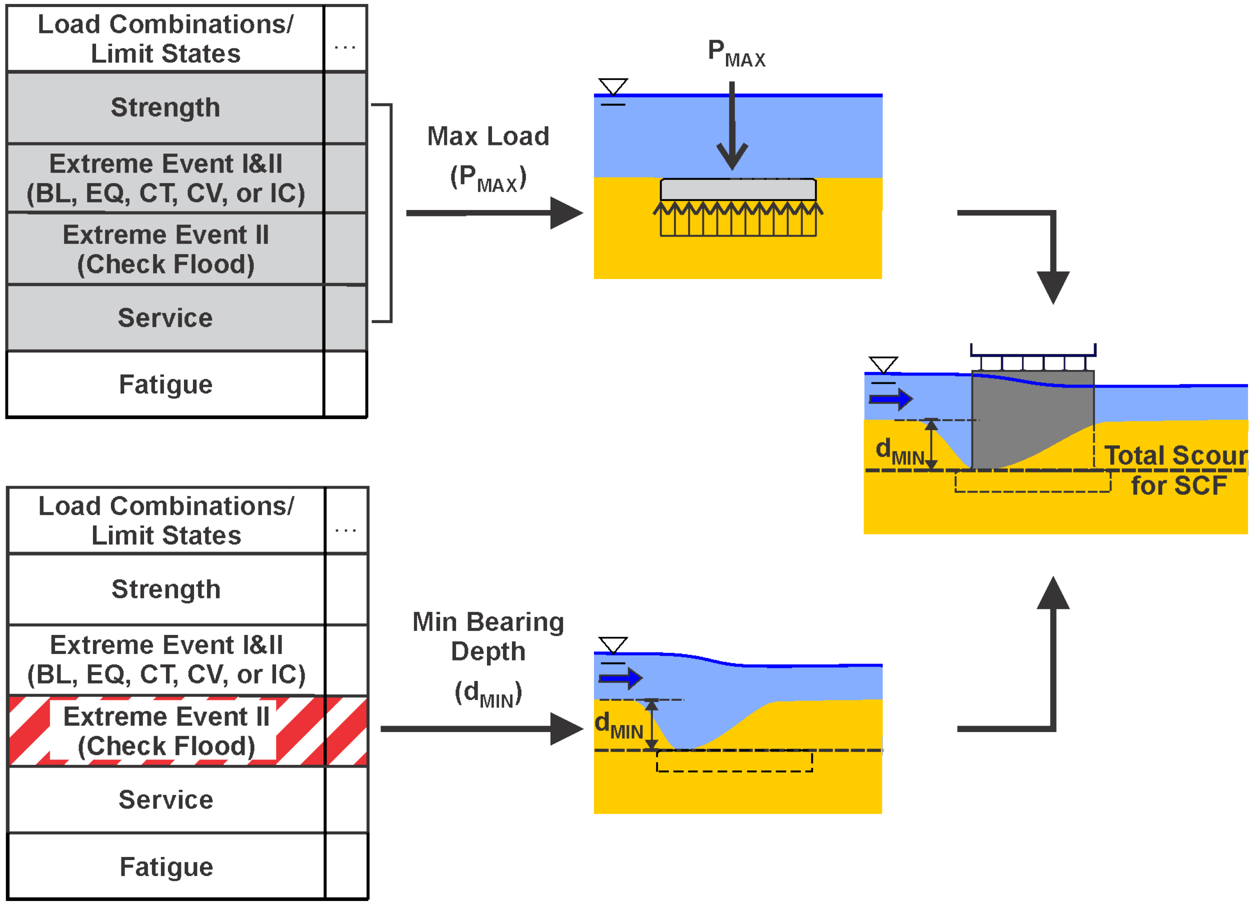

Figure 3. The minimum footing dimensions and minimum bearing depth (d_{MIN}) considering *total scour* for the *scour check flood (SCF)* linked to the *extreme event II limit state.*

4 MINIMUM PILE/SHAFT PENETRATION LENGTH CONSIDERING SCOUR AND PILE CAP ELEVATION

For the bridge design considering scour, AASHTO LRFD BDS (2017) has the following:

1. Change in Foundations Due to *Limit State* for *Scour*, which is discussed further in sections 4.1 and 4.2.
2. Scour Considerations for Driven Piles.

> **AASHTO LRFD** BDS (2017) **Section 10.7.3.6**
>
> The pile foundation shall be designed so that the pile penetration after the design scour event satisfies the required nominal axial and lateral resistance.

4.1 Change in Foundations Due to the Scour Design Flood and Associated Limit State for Scour

> **AASHTO LRFD** BDS (2017) **Section 3.7.5**
>
> The consequences of changes in foundation conditions resulting from the design flood for *scour* shall be considered at *strength and service limit states*.

Figure 4 shows an illustrative minimum pile/shaft penetration length considering *total scour* for evaluation at the *strength or service limit states* for the scour design flood. The minimum pile/shaft penetration depth considering *scour* is determined by the required pile/shaft penetration length (AASHTO LRFD BDS (2017) Section 10.7.3.6) for strength or service limit states, ignoring soil capacity within the total scour prism for the scour design flood at the bridge foundation. As indicated, the streambed material above the total scour line is assumed to be removed and does not contribute to the frictional capacity of the pile/shafts in the scour zone, which results in extended pile/shaft penetration lengths. There is a pile drivability analysis that includes the total scour depth as one of the strength limit state checks. Note, scour is not necessarily the governing factor in foundation design.

Figure 4 also depicts a hypothetical example where the maximum pile or shaft loads for *strength or service limit states* are determined resulting in required pile or shaft penetration length, L_{MIN1} (AASHTO LRFD BDS (2017) Section 10.7.3.6).

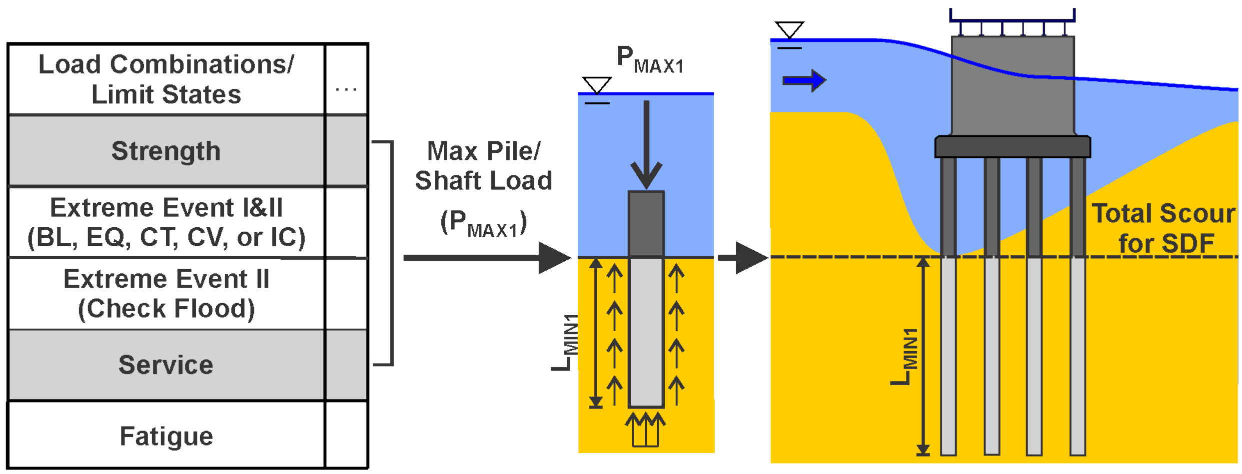

Figure 4. Pile/shaft penetration for *strength or service limit states* considering the *scour design flood (SDF)*.

4.2 Change in Foundations as a Result of the Scour Check Flood and Associated Limit State for Scour

> **AASHTO LRFD** BDS (2017) **Section 3.7.5**
>
> The consequences of changes in foundation conditions due to *scour* resulting from the *scour check flood* and from hurricanes shall be considered at the *extreme event limit state*.

Figure 5 shows an example where the required pile/shaft penetration length, L_{MIN2}, (AASHTO LRFD BDS (2017) Section 10.7.3.6) for the *extreme event II limit state* considers *total scour* for the *scour check flood*, which assumes this is the *worst-case scour* for this *limit state,* ignoring soil capacity within the total scour prism for the *scour check flood* at the bridge foundation.

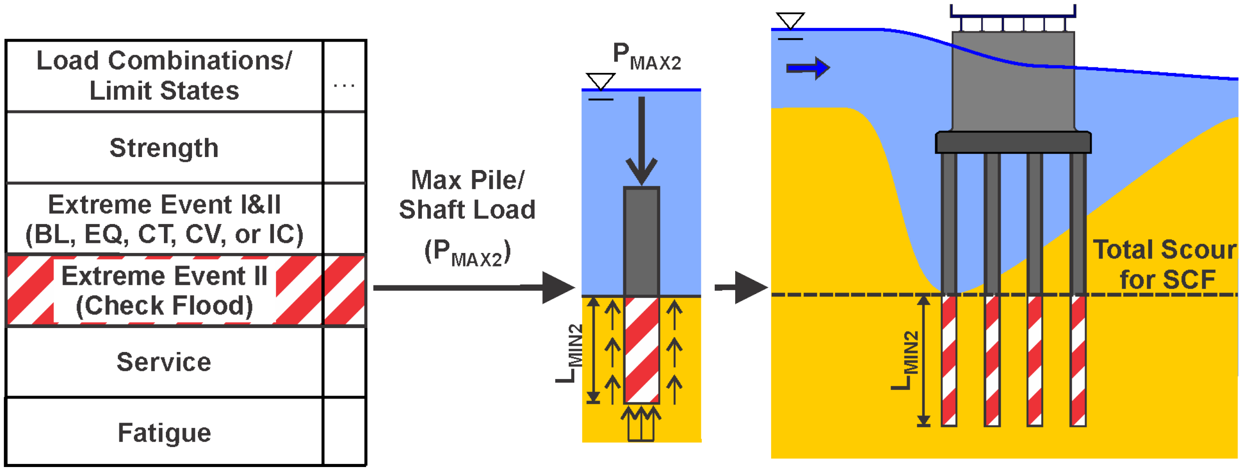

Figure 5. Pile/shaft penetration for *extreme event II limit state* considering *scour check flood (SCF).*

4.3 Change in Foundations as a Result of the Scour Design Flood and Associated Extreme Event Limit States

AASHTO LRFD BDS (2017) **Section 3.4.1 and Commentary**

The cases of check floods shall not be combined with BL, CV, CT, or IC.

Although these limit states include water loads, WA, the effects due to WA are considerably less significant than the effects on the structure stability due to scour. Therefore, unless specific site conditions dictate otherwise, local pier scour and contraction scour depths should not be combined with BL, EQ, CT, CV, or IC. However, the effects due to degradation of the channel should be considered. Alternatively, one-half of the total scour may be considered in combination with BL, EQ, CT, CV, or IC.

Recognizing the unlikelihood that an extreme event loading, BL for example, would occur at the same time of the scour check flood within the design life of a bridge, the AASHTO LRFD BDS (2017) state that the conditions resulting from the scour check flood should not be combined with the extreme event loadings. However, recognizing that there is a small probability of a simultaneous major flooding event, many owners choose to include a lowering of the streambed to a lesser degree than the full scour check flood (see recommendation in the Commentary for long-term degradation or half the total scour depth).

Figure 6 shows the required pile/shaft penetration length, L_{MIN3}, (AASHTO LRFD BDS (2017) Section 10.7.3.6) for the *extreme event I and II limit states* for earthquake, blast load, vehicular collision, vessel collision and ice load, considering the long-term degradation (LTD) or half of the total *scour depth* for *scour check flood*. The pile/shaft penetration depth is determined by the necessary pile/shaft penetration length for *extreme event I and II limit states* except check flood, ignoring soil capacity within the LTD or half of the total scour prism for the *scour check flood* at the bridge foundation.

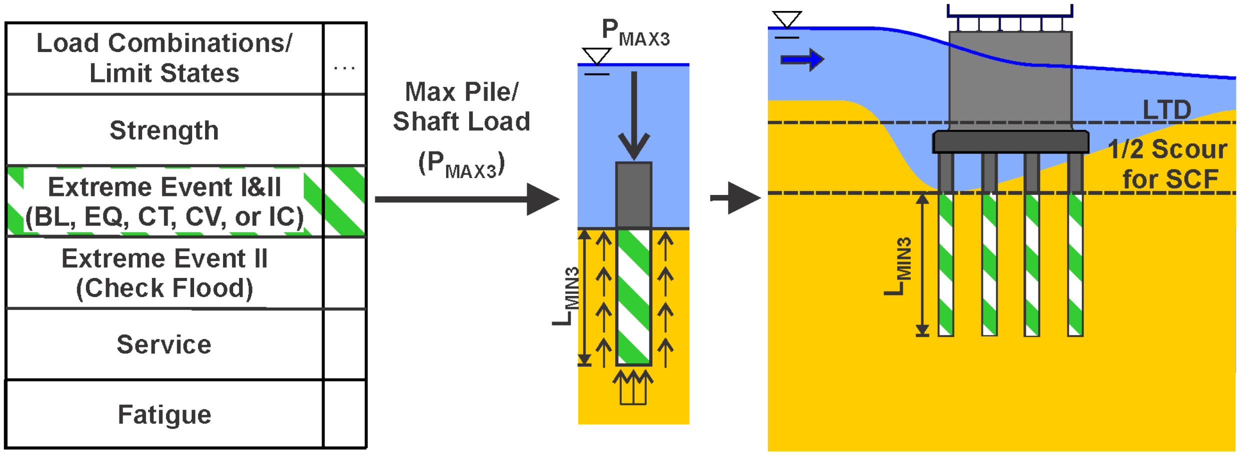

Figure 6. Pile/shaft penetration for *extreme event I and II limit states* except check flood considering LTD or half of the total scour depth for *scour check flood (SCF).*

4.4 Scour at Deep Foundations and Pile Cap Elevation

> **AASHTO LRFD** BDS (2017) **Section 2.6.4.4.2**
>
> Deep foundations with footings shall be designed to place the top of the footing below the estimated contraction scour depth where practical to minimize obstruction to flood flows and resulting local scour. Even lower elevations should be considered for pile-supported footings where the piles could be damaged by erosion and corrosion from exposure to stream currents. Where conditions dictate a need to construct the top of a footing to an elevation above the streambed, attention shall be given to the scour potential of the design.

To satisfy AASHTO LRFD BDS (2017) specifications, Figure 7 shows that the top of the pile cap should be placed below the *contraction scour* at the *scour check flood,* where practical. In this scenario, the pile/shaft penetration length has been previously determined by another design method.

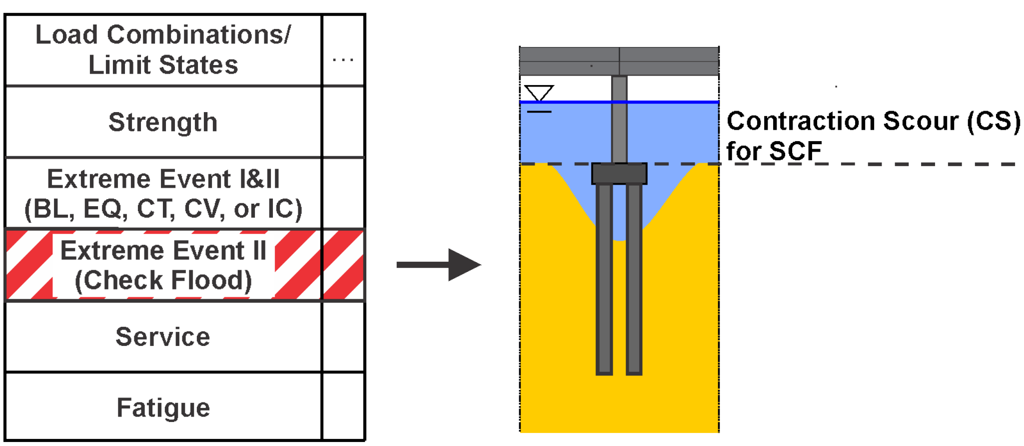

Figure 7. Contraction scour at the *scour check flood (SCF)*.

5 HYPOTHETICAL SCENARIOS (FOR DEEP FOUNDATIONS ONLY) OF GOVERNING FOUNDATION CONDITIONS DUE TO LIMIT STATES FOR SCOUR

A deep foundation design is governed by considerations of the load combination at each *limit state* (*strength, service, or extreme event limit state*) and the corresponding scour depth (*scour design flood or scour check flood*). Figures 8 through 10 show three cases considering the different hypothetical scenarios introduced in Figures 4, 5 and 6. In each figure, the left plot shows a hypothetical relationship between flood discharge Q and the *total scour depth* y_s. The three design illustrations show the resulting pile/shaft penetration lengths L_{MIN1}, L_{MIN2}, or L_{MIN3} to determine the governing foundation condition due to limit states of scour (there may be other geotechnical considerations that may govern the final pile lengths).

Figure 8 shows a scenario in which the pile/shaft penetration design is dominated by *strength or service limit states and scour design flood*. Figure 9 shows a scenario where the pile/shaft penetration design is governed by *extreme event II limit states and scour check flood*. Figure 10 shows a scenario where the pile/shaft penetration design is governed by *extreme event I and II limit states* and LTD or half of the total *scour depth* for *scour check flood*. In practice, (as illustrated) the necessary pile/shaft penetration lengths are site specific and could be different.

In Figure 8, the required pile/shaft penetration length (L_{MIN1}) (AASHTO LRFD BDS (2017) Section 10.7.3.6) satisfying *strength and service limit states* are longer than those for the *extreme event II limit state* check flood case (L_{MIN2}) and for the *extreme event I and II limit state* (L_{MIN3}).

The illustrations in the middle and on the right show the scour estimate of the deep foundation during *scour design flood, scour check flood*, LTD and half of the total *scour depth* for *scour check flood*, as well as the required pile/shaft penetration length (AASHTO LRFD BDS (2017) Section 10.7.3.6) under *strength or service and extreme event limit states*, respectively.

Comparing Figure 9 to Figure 8,

- In both cases, the worst-case scour for *scour design flood and scour check flood* coincide with Q_{100} and Q_{500}, respectively.
- In these same figures, the difference between *scour design flood and scour check flood* scour is greater than the difference between the pile/shaft penetration length required for *strength or service limit states* (L_{MIN1}) and that for *extreme event II limit states* (L_{MIN2}) (AASHTO LRFD BDS (2017) Section 10.7.3.6).
- Further, one must make a comparison between *extreme event II limit state* check flood case and other *extreme event I and II limit states*, as illustrated in Figure 9 where the pile/shaft penetration design is governed by *extreme event II limit states and scour check flood*.

Figure 10 shows that the pile/shaft penetration length resulted from *extreme event I and II limit states* (L_{MIN3}) is much longer than those from the other limit states (L_{MIN1} or L_{MIN2}) in the scenario. The difference between the LTD or half of total *scour depth* of *scour check flood* and the total *scour depth* for *scour design flood or scour check flood* is less than the difference between the pile/shaft penetration length required for *extreme event I and II limit states* (L_{MIN3}) and that for the *strength or service limit states* (L_{MIN1}) or *extreme event II limit* states check flood case (L_{MIN2}) (AASHTO LRFD BDS (2017) Section 10.7.3.6). The design is governed by *extreme event I and II limit states* and the associated *scour depth*.

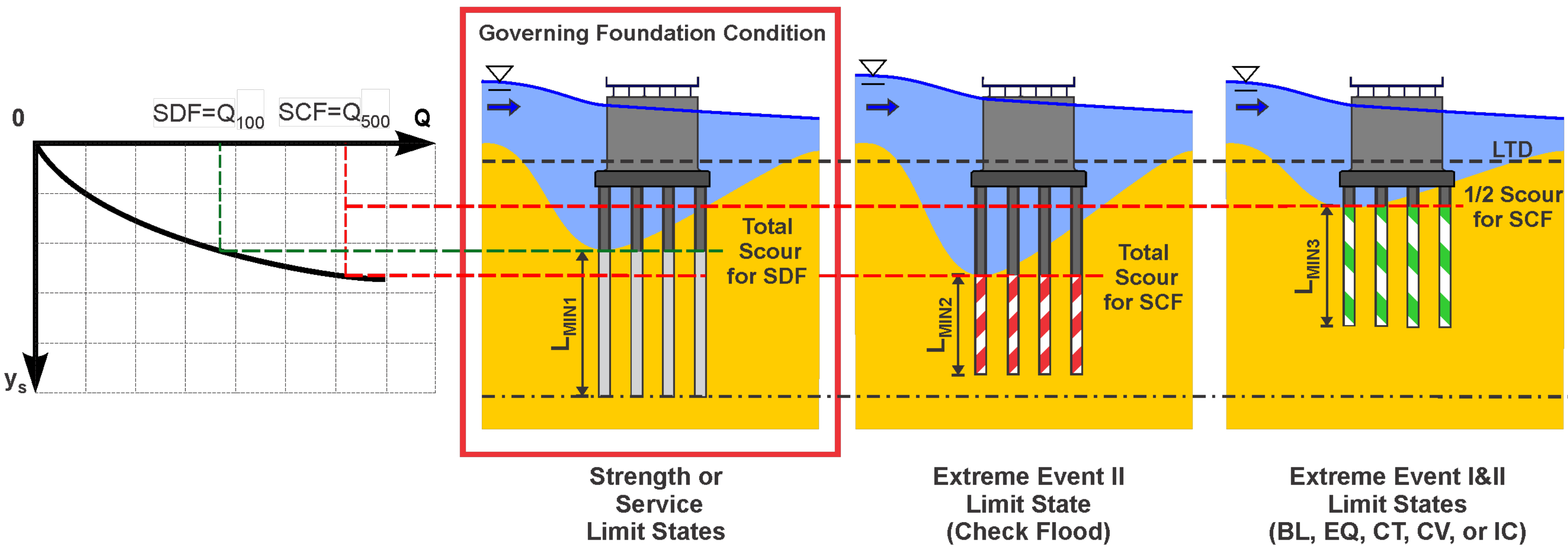

Figure 8. Pile/shaft penetration governed by *strength or service limit states and scour design flood (SDF).*

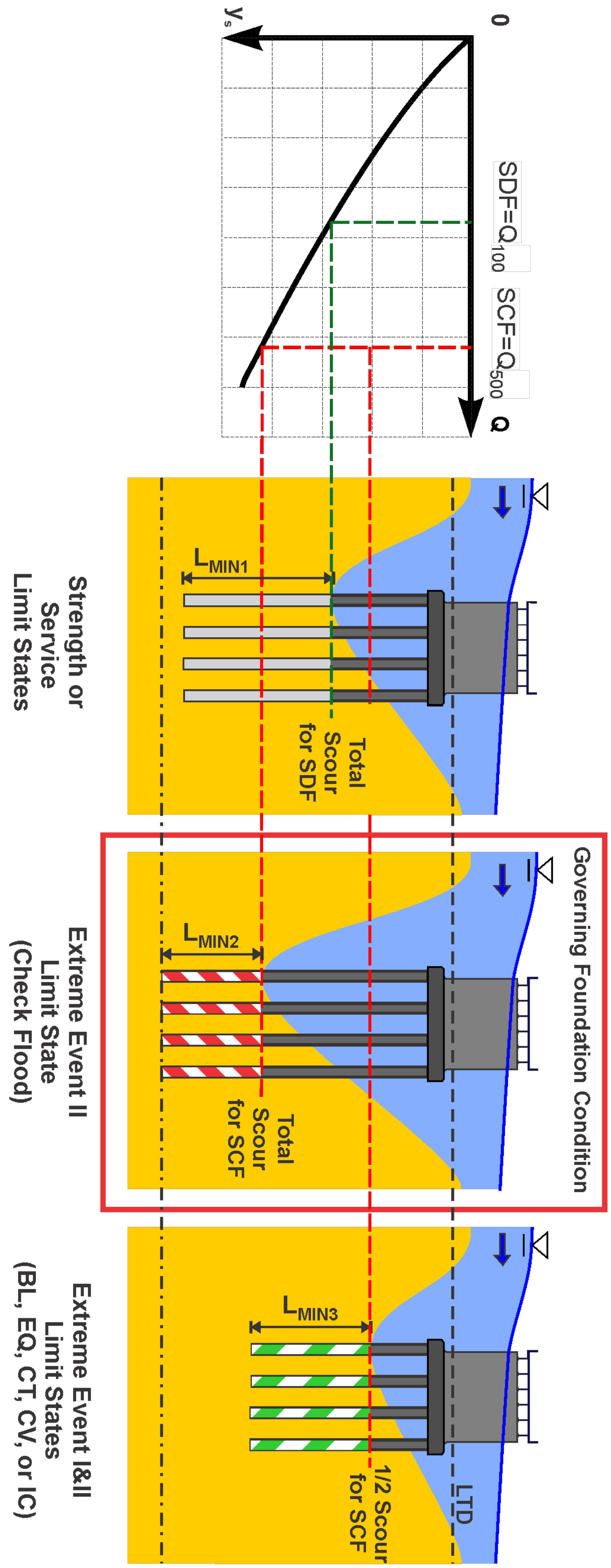

Figure 9. Pile/shaft penetration governed by *extreme event limit states and scour check flood (SCF)*.

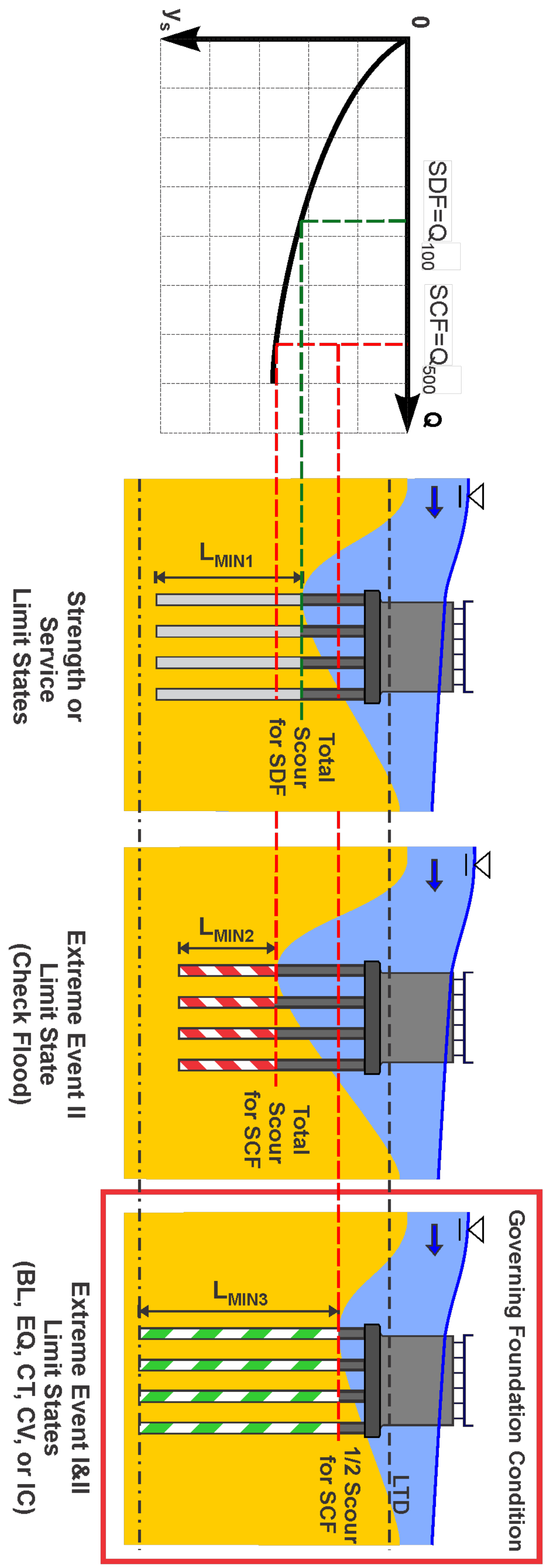

Figure 10. Pile/shaft penetration governed by *extreme event I and II limit states and the associated scour depth.*

6 SUMMARY

- The AASHTO LRFD BDS (2017) (incorporated by reference at 23 CFR § 625.4(d)(1)(v)) forms the basis for nearly all recent highway bridge and structure design practices and standards.
- Bridge engineers factor the capacity (resistance) and demand (load) upon bridge superstructure, substructure and foundation elements for all *limit states*.
- This document describes *scour design flood and scour check flood* and how they relate to AASHTO LRFD BDS (2017)'s *Strength or Service limit states and Extreme Event limit states*, respectively.
- A few hypothetical scenarios discuss how deep foundation design is governed by considerations of load combinations and the corresponding scour depth prescribed in various *limit states*.

7 CITED REFERENCES

AASHTO. 2017. "Load and Resistance Factor Design Bridge Design Specifications," Eighth Edition, AASHTO. Washington D.C.

Office of the Federal Register, 2022. "Code of Federal Regulations, Title 23 – Highways," U.S. Government Publishing Office, Washington, D.C., December 9, 2022.

FHWA, 2012. "Evaluating Scour at Bridges," Hydraulic Engineering Circular No. 18, Fifth Edition, FHWA-HIF-12-003, FHWA, Washington, D.C. (Arneson, L., L. Zevenbergen, P. Lagasse, and P. Clopper).

FHWA, 2021. "Scour Considerations within AASHTO LRFD Bridge Design Specifications."

8 GLOSSARY

This nonbinding TechBrief uses and references the following terms obtained from AASHTO LRFD BDS (2017) Sections, Articles and Definitions (incorporated by reference at 23 CFR § 625.4(d)(1)(v)). The Glossary also includes specific terms from several non-regulatory FHWA Techbriefs to aid in readability and context. Finally, this Glossary provides the relevant citation of each source:

AASHTO LRFD BDS (2017) § 1.2 – Definitions

> ***Design Life*** *– Period of time on which the statistical derivation of transient loads is based: 75 years for these Specifications.*
>
> ***Extreme Event Limit States*** *– Limit states relating to events such as earthquakes (EQ), ice load (IC), and vehicle (CT) and vessel collision (CV), with return periods in excess of the design life of the bridge. Blast loads (BL) are also considered an Extreme Event transient load, although they are introduced in Section 3.4.1.*
>
> ***Factored Load*** *– The nominal loads multiplied by the appropriate load factors specified for the load combination under consideration.*
>
> ***Factored Resistance*** *– The nominal resistance multiplied by a resistance factor.*
>
> ***Limit State*** *– A condition beyond which the bridge or component ceases to satisfy the provisions for which it was designed.*

Load and Resistance Factor Design (LRFD) *– A reliability-based design methodology in which force effects caused by factored loads are not permitted to exceed the factored resistance of the components.*

Load Factor *– A statistically-based multiplier applied to force effects accounting primarily for the variability of loads, the lack of accuracy in analysis, and the probability of simultaneous occurrence of different loads, but also related to the statistics of the resistance through the calibration process.*

Nominal Resistance *– Resistance of a component or connection to force effects, as … by permissible stresses, deformations, or specified strength of materials.*

Resistance Factor *– A statistically-based multiplier applied to nominal resistance accounting primarily for variability of material properties, structural dimensions and workmanship, and uncertainty in the prediction of resistance, but also related to the statistics of the loads through the calibration process.*

Service Limit States *– Limit states relating to stress, deformation, and cracking under regular operating conditions.*

Strength Limit States *– Limit states relating to strength and stability during the design life.*

AASHTO LRFD BDS (2017) § 2.2 – Definitions

Check Flood for Bridge Scour *– Check flood for scour. The flood resulting from storm, storm surge, tide, or some combination thereof having a flow rate in excess of the design flood for scour, but in no case a flood with a recurrence interval exceeding the typically used 500-year.*

Design Flood for Bridge Scour *– The flood flow equal to or less than the 100-year flood that creates the deepest scour at bridge foundations. The highway or bridge may be inundated at the stage of the design flood for bridge scour. The worst-case scour condition may occur for the overtopping flood as a result of the potential for pressure flow.*

AASHTO LRFD BDS (2017) § 3.2 – Definitions

Load *– The effect of acceleration, including that due to gravity, imposed deformation, or volumetric change.*

Nominal Load *– An arbitrarily selected design load level.*

AASHTO LRFD § 10.2 – Definitions

Deep Foundation *– A foundation that derives its support by transferring loads to soil or rock at some depth below the structure by end bearing, adhesion or friction, or both. Examples of these foundations are driven piles and drilled shafts.*

Shallow Foundation *– A foundation that derives its support by transferring load directly to the soil or rock at shallow depth.*

HEC-18– Definitions

Contraction Scour *– is equivalent to AASHTO LRFD BDS (2017) definition of Contraction Scour.*

Scour Check Flood (SCF) *– is equivalent to AASHTO LRFD BDS (2017) definition of Check Flood for Bridge Scour.*

***Scour Design Flood (SDF) –** is equivalent to AASHTO LRFD BDS (2017) definition of Design Flood for Bridge Scour.*

***Scour Depth or Depth of Scour** – The vertical distance a streambed is lowered by scour below a reference elevation.*

***Long-term Degradation (LTD)** – The lowering or scouring of the streambed over relatively long reaches due to a deficit in sediment supply from upstream and contributes to total scour.*

***Total Scour –** The sum of long-term degradation, contraction scour and local scour.*

TechBrief Definitions (non-regulatory)

***Foundation Element** – A footing, pile, or other type of foundation associated with a bridge (or culvert).*

***Incipient Overtopping** – The point at which overtopping is beginning to occur.*

***Low Tailwater Flow** (Q_{LT}) – This condition occurs if high flow from a channel enters a low water boundary condition, in relatively close proximity, downstream of a structure.*

***Worst Case Scour Depth** – The conditions (e.g., discharge, velocity, depth, tailwater, geometry, orientation, type of foundation, etc.) that would produce the maximum scour depth at a particular foundation element.*

***Pile Drivability Analysis** – Involves selection of appropriate hammer, determination of cushion stiffness, hammer stroke and other driving system parameters that optimize blow counts and pile stresses during pile driving.*

Q_{100} *– Discharge having a recurrence interval of 100 years, ft^3/s*

Q_{500} *– Discharge having a recurrence interval of 500 years, ft^3/s*

***TW** – the depth of water downstream of the structure of interest*

Scour Design within AASHTO LRFD Limit States

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Research — This TechBrief was developed by the FHWA Scour Working Group and the FHWA Foundation Working Party (Paul Sharp, Khalid Mohamed, Silas Nichols, Kornel Kerenyi, James Pagenkopf, Jerry Shen and Joe Krolak) as part of FHWA's effort to update certain materials within Hydraulic Engineering Circular No. 18 (Evaluating Scour at Bridges). Technical support was provided by the Genex Systems in the J. Sterling Jones Hydraulics Research Lab at the Turner-Fairbank Highway Research Center.

Distribution — FHWA is distributing this TechBrief according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Key Words — scour, foundations, hydraulics, loads, resistance, LFRD

Figure Credits — The FHWA produced all figures used in this TechBrief.