Earth Retaining Structures (ERS) – Selection Process

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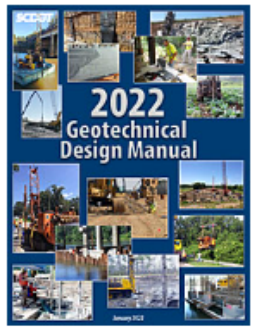
SCDOT

https://www.scdot.org/business/geotech.aspx



Geotechnical Design Manual (2022)

The Geotechnical Design Manual (GDM) provides uniform design practices for designers preparing geotechnical reports and contract plans for SCDOT projects.

Manual by Chapter | Complete Manual

This Manual should be used in conjunction with:

- gINT Files (incorporates Rock Coring Summary & Shelby Tube Log)
- ERS and Ground Improvement Selection Matrix
- ERS Selection Matrix Example
- Reasons for Selecting Specific IRs Example
- Pile Cost-PDAvsNo-PDA
- Bridge Design Manual
- Seismic Design Specifications for Highway Bridges
- Borrow Materials Database Spreadsheet
- GDF-001 - Bridge Load Datasheet

- CPTLIQ_v1.42 (Jan2022)
- UT-22.02 CPTLIQ v.1.42 User Manual

YouTube Training Videos

- SPLIQ v1.42 Users Manual Nov2021
- SPLIQ version 1.43

Geotechnical Drawings & Details

Drawings are available in Microstation DGN and PDF formats.

Drawings & Details

Updates

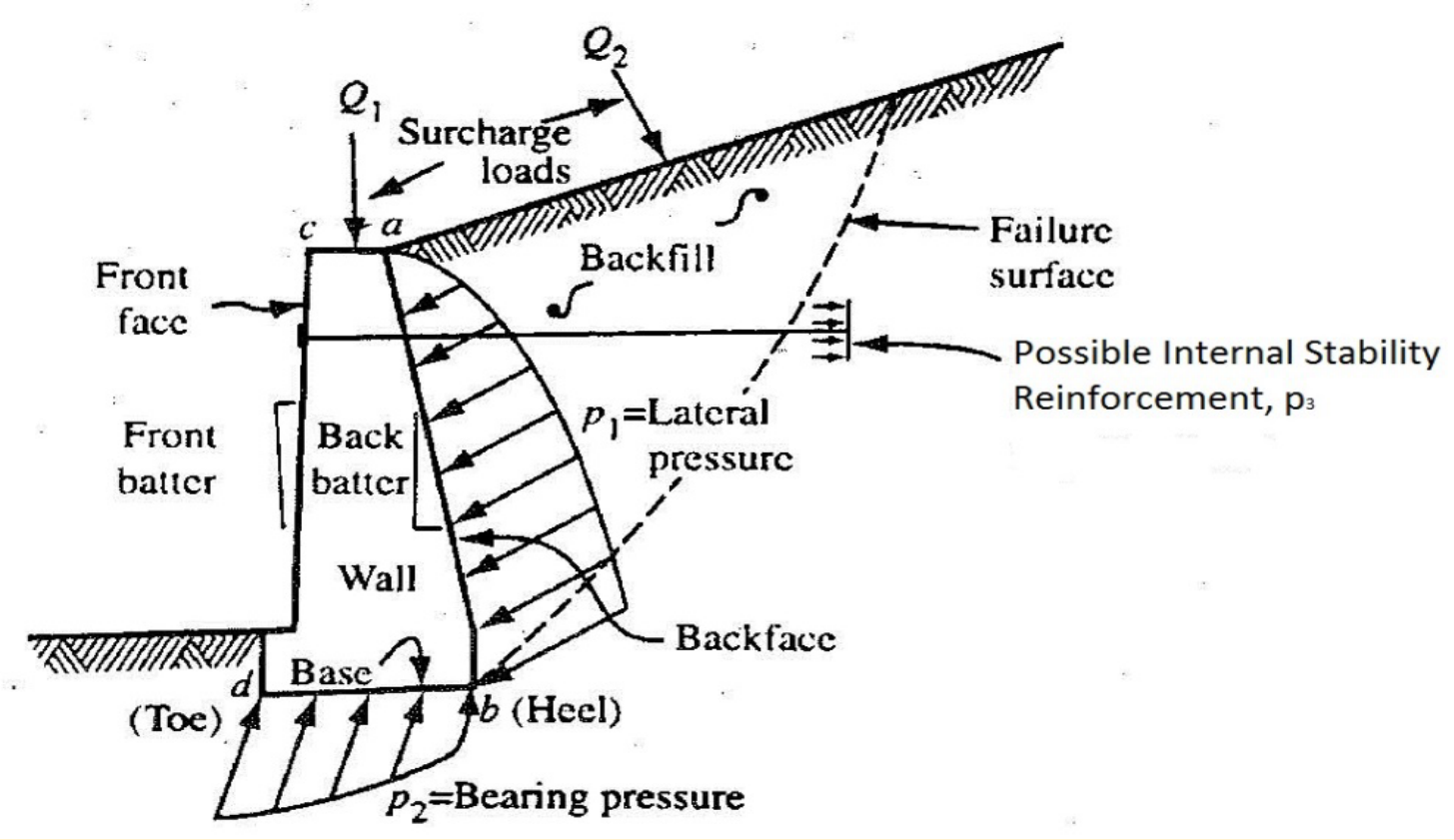
Geotechnical Design Bulletins are issued to supplement or revise the GDM.

Overview

- Earth Retaining Structures (ERS) – Definition
- Application
- Classification
- Selection process

Definition

- Holds back earth and maintain a difference in elevations of the ground surface
- Designed to withstand forces exerted by the retained ground, and to transmit them to a foundation and or restraining elements located beyond the failure surface

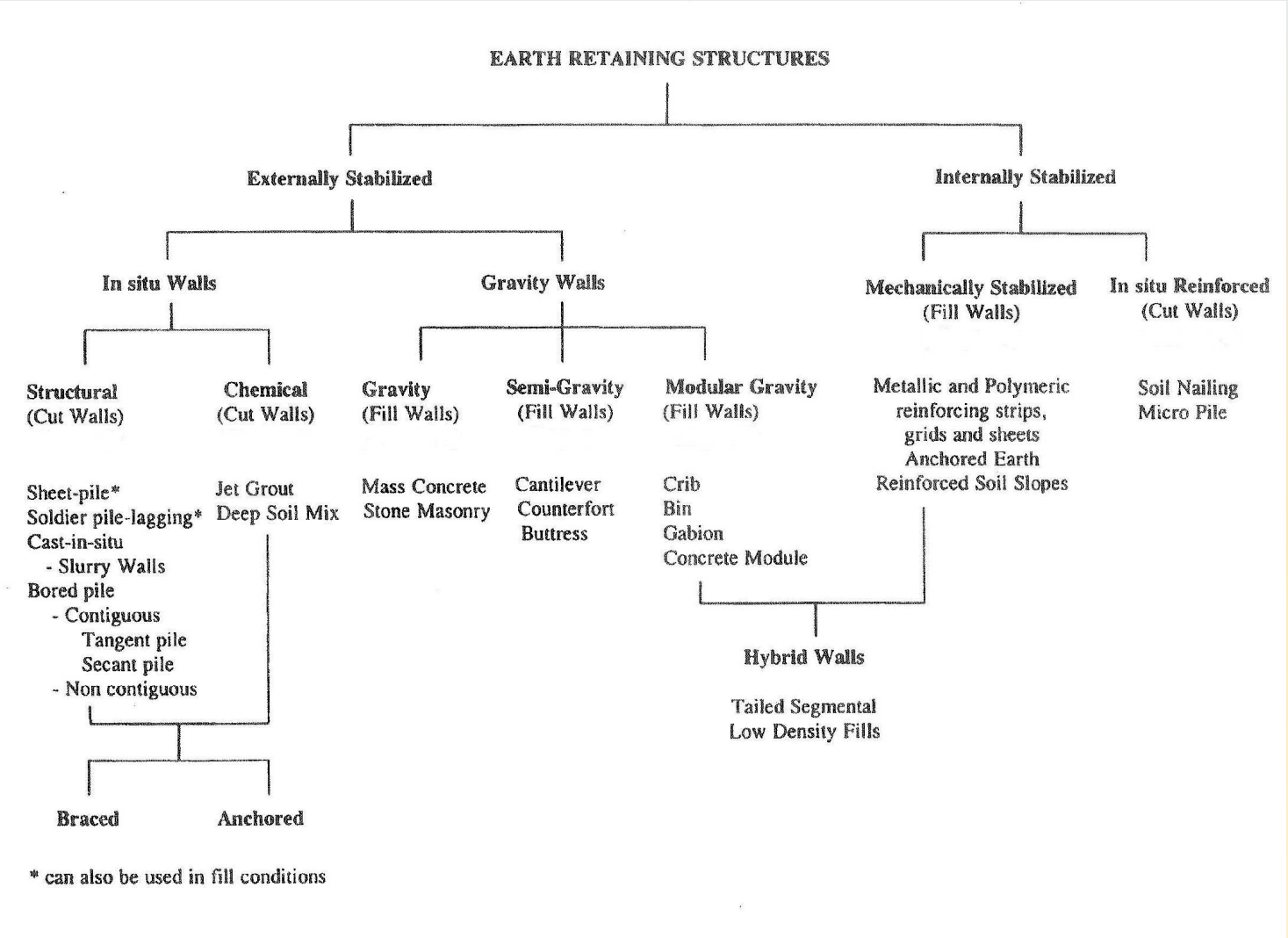


Applications in highway construction

- Highways in developed areas
- Highways at mountains or steep slopes
- Grade separations
- Bridge abutments, wing walls and approach embankments
- Culvert walls
- Tunnel portals and approaches
- Cofferdams for construction of bridge foundations
- Stabilization of slopes
- Groundwater cut-off barriers for excavations

Categories of classification

- Load Support Mechanism (externally or internally stabilized)
- Construction Concept (cut or fill)
- System Rigidity (rigid or flexible)
- Service Life (permanent or temporary)

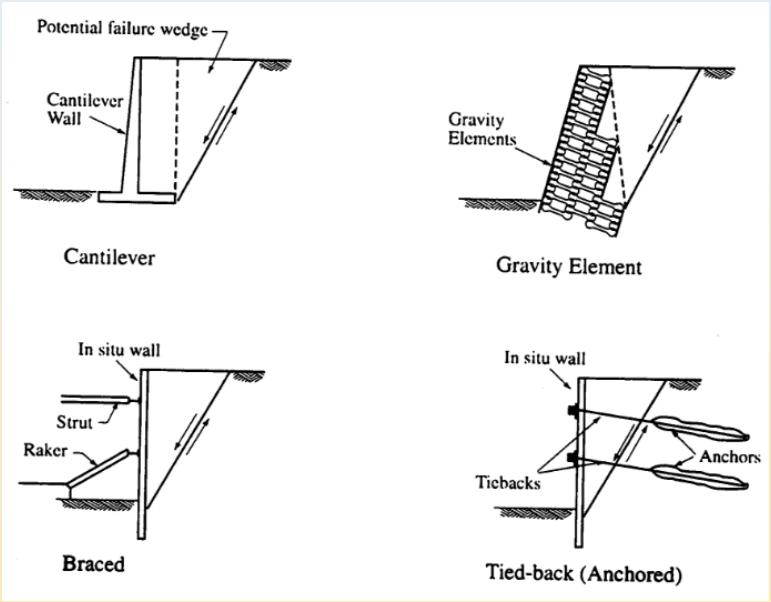


Load Support Mechanism

Externally stabilized

ERSs use an external structure to resist the imposed loads

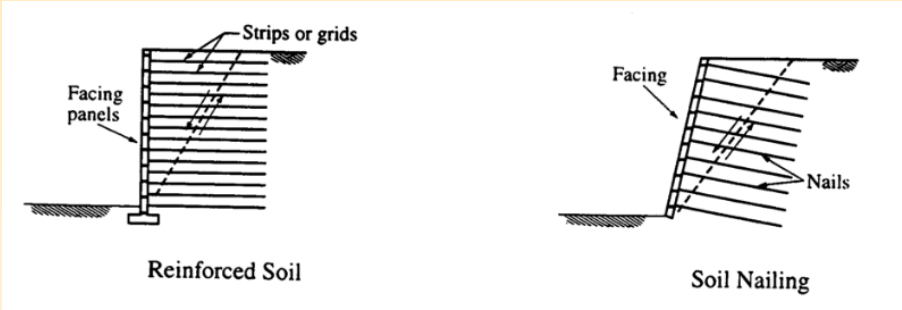
- Face units are the structural support



Internally stabilized

ERSs use an reinforcements installed within the soil mass to resist the imposed loads

- Reinforcement added to the wall system to increase wall heights
- Reinforcement is the structural support, face elements alone could not resist imposed loads



Construction Concept

Fill construction is from base to the top of the ERS (**bottom-up** construction)

- MSE Wall
- Gravity Wall

Cut construction is from the top to the base of the ERS (**top-down** construction)

- Soil Nail
- Soldier Pile and Lagging
- Sheet Pile

System Rigidity

Rigid

- ERS moves as a unit - Rigid body rotation and/or translation
- Does not experience flexural deformations

Flexible

- ERS undergoes not only rigid body movements, but experiences flexural deformations as well
- Deformations allowed for redistribution of lateral pressures

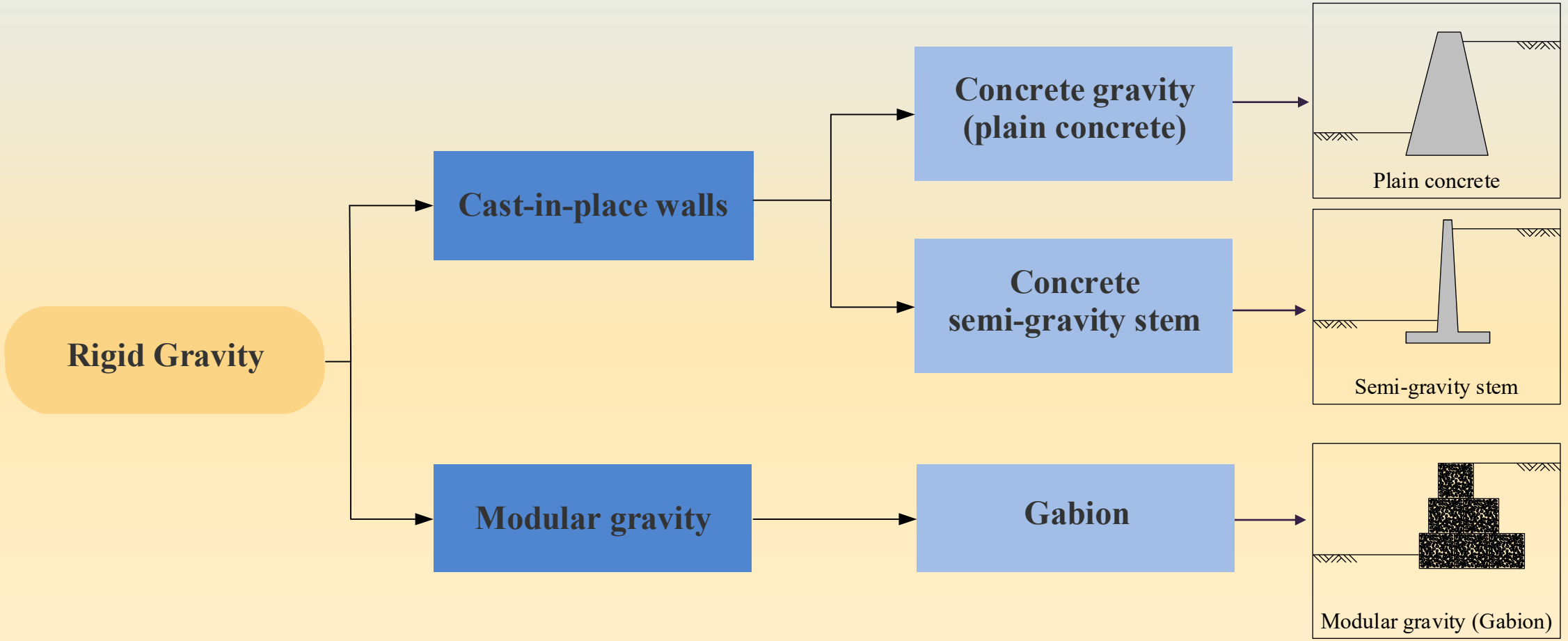
Service Life

Permanent designed for a service life of 100 years

Temporary designed for a service life of less than 5 years

- Temporary ERSs that remain in service longer than 5 years are designed as permanent ERS

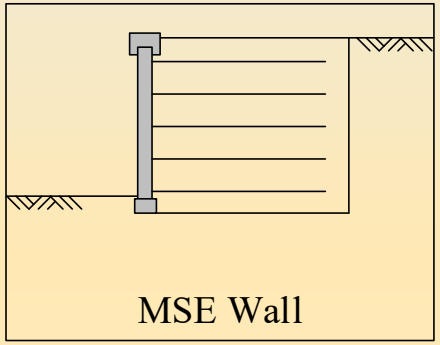
ERS types covered by GDM

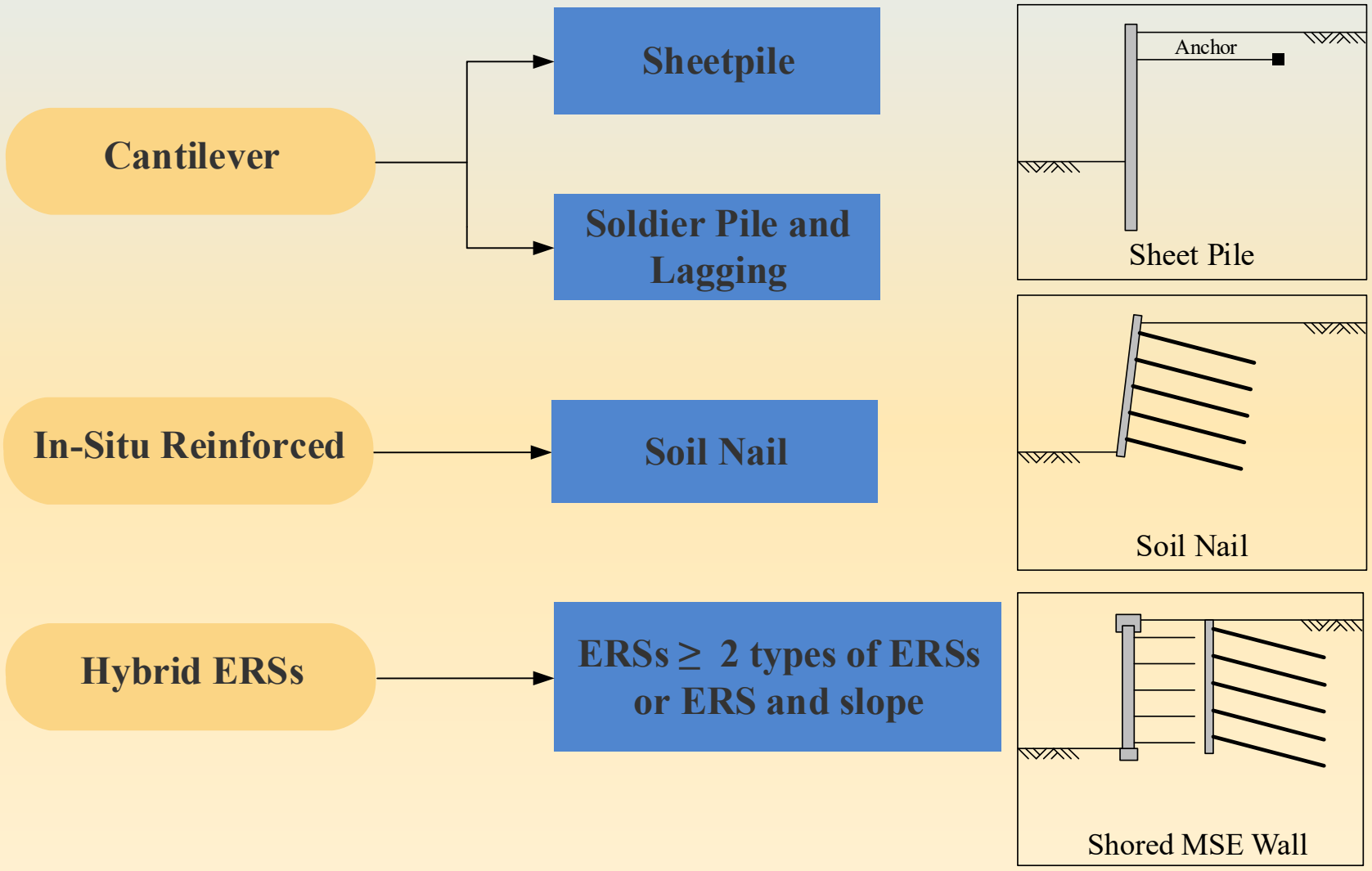


Flexible Gravity

Mechanically Stabilized Earth (MSE) Wall

- Panel facing
- Block facing
- Tilt up panel
- Modular gravity (i.e. welded wire)




Cantilever
Sheetpile
Soldier Pile and Lagging
In-Situ Reinforced
Soil Nail
Hybrid ERSs
ERSs ≥ 2 types of ERSs or ERS and slope
Anchor
Sheet Pile
Soil Nail
Shored MSE Wall

New ERS systems

- Written approval from the OES/GDS is required
- Additional review times will be required

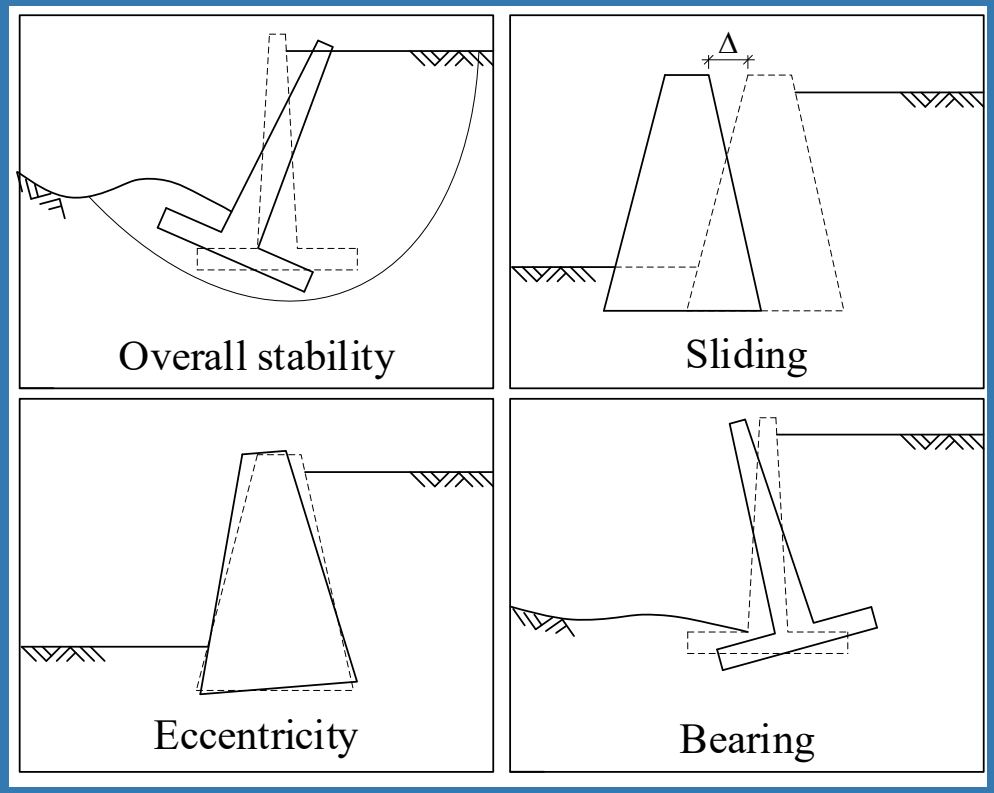
Design Overview

External design

- Overall stability
- Sliding
- Eccentricity
- Bearing

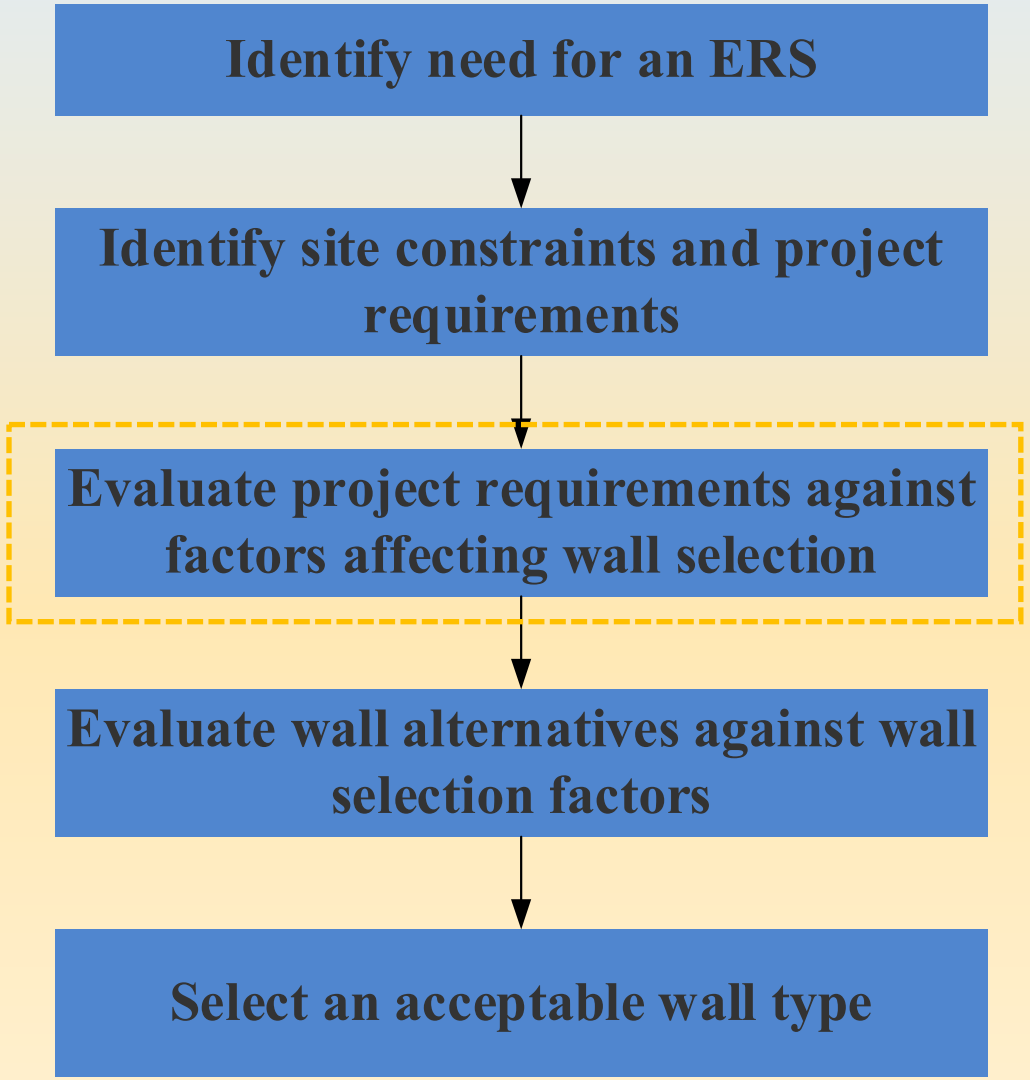
Internal design

- Pullout failure of soil anchors and/or reinforcements
- Structural component failure



ERS Selection Philosophy

- The selection of the type of ERS is based on numerous factors
- More than one ERS type may be applicable for a given site
- Flowchart used for general guidance



Necessity for ERS

- Should be determined by the project team

- ERSs may be **required to mitigate** the following conditions
  - Additional ROW cannot be obtained
  - Environmental permitting issues
  - Adjacent roadways
  - Adjacent major utilities

- One of the most important factors in determining the necessity for an ERS is making this determination **early in the design process**

Site Constraints and Project Requirements

- Site accessibility and space restrictions
  - Limited ROW
  - Limited headroom
  - On-site material storage areas
  - Access for specialized construction equipment
  - Traffic disruption restrictions
- Utility locations, both above and underground
- Nearby structures
- Aesthetic requirements
- Environmental concerns
- Exposed wall face height

The **design team** should assess the relative importance of these items - Determine which of these items should be given priority during the selection process

ERS Selection

To assist in selecting the type of ERS SCDOT uses a **weighted scoring system**

- Importance Selection Factors (ISFs) are identified
- Each ISF is assigned an Importance Rating (IR)
  - 1 - least important
  - 3 - most important

Exception - if the Project Development Team (PDT) determines that context sensitive design is required for a specific ERS location (i.e., aesthetics), then select the ERS type that best fits the context sensitive design

- Written explanation/justification is required for this selection

Importance Selection Factor (ISF)

1	Ground type	7	Environmental concerns
2	Groundwater	8	Durability and maintenance
3	Construction considerations	9	Tradition
4	Speed of construction	10	Contracting practices
5	ROW	11	Cost
6	Aesthetics	12	Displacements (lateral and vertical)

More ISFs may be added based on the requirements of the design team

- Written explanation of the selection of additional ISFs is required

Weighted ERS Selection Factors

Earth Retaining Structure Selection Matrix GDM Section 18.4 SCDOT v1.1 - 03/06/2020																
ISF[1]		Ground Type	Groundwater	Construction Considerations	Speed of Construction	ROW	Aesthetics	Environmental Concerns	Durability and Maintenance	Tradition	Contracting Practice	Cost	Displacement	X^8	X^8	X^8	**Total Weighted Rating (WR_T)**
ERS Type[5,6]	IR[2,7]	1	1	3	3	1	3	1	3	2	2	3	3				

[1]Importance Selection Factor

[2]Importance Rating - Ranges from 1, least important, to 3, most important

[3]Suitability Factor - Ranges from 1, least suitable, to 4, most suitable

[4]Weighted Rating - Product of IR * SF

[5]ERS type per Chapter 18 of latest version of GDM

[6]Reinforced Soil Slopes (RSS) may be used as an ERS

[7]GEOR to provide written justification for selection of IRs by **project team**

[8]Additional ISFs may be added; however, GEOR to provide written justification for additional ISFs as well as selection of IRs by **project team**

Ground Type

- For the foundation soils determine
  - Bearing capacity
  - Sliding potential
  - Anticipated settlement

- Foundation soils that are anticipated to undergo large horizontal and vertical movements, may require a more flexible type wall
  - A rigid type ERS will attempt to resist the deformations which in turn will increase the stress on the structural members
  - Alternatively a temporary flexible face may be used until the deformations are completed and permanent facing may then be installed

Ground Type

- Clay-like soils should not be used in fill type ERSs since these soils are difficult to compact, tend to be moisture sensitive and to undergo deformations under service loads

- Sand-like soils, especially in the Lower Coastal Plain, can be very sensitive to the effects of a seismic event

- Ground type should be considered when setting the length of bridge, since the savings from reduced bridge length can be offset by the additional cost of constructing of the ERS, especially if ground improvement is required

Groundwater

- SCDOT ERSs are never designed to retain water or control hydraulic forces

- Means of removing water from behind the ERS should be implemented (e.g., free-draining materials, weep holes)

- The groundwater table behind ERSs should be lowered for the following reasons:
  - reduce the hydrostatic pressures on the structure
  - reduce the potential for corrosion
  - prevent saturation of the soil, and limit displacements
  - reduce the potential for soil migration through or from the ERS

Construction Considerations

Material availability

Is it practical or economical?

Site accessibility

Is there enough ROW to construct the ERS?

Will the ERS have to be constructed completely from the backside of the ERS?

Equipment availability

Is specialized equipment required to construct the ERS?

Labor considerations

Does the labor force have to have specialized training to construct the ERS?

Speed of Construction

The faster the ERS can be constructed, the faster the project can be completed

Right-of-Way (ROW)

The need of additional ROW should be considered in the selection of an ERS

- ERSs that support the transportation facility typically require little or no additional ROW
- ERSs that support an adjacent property owner may require either additional ROW or easement to install internally stabilizing reinforcement

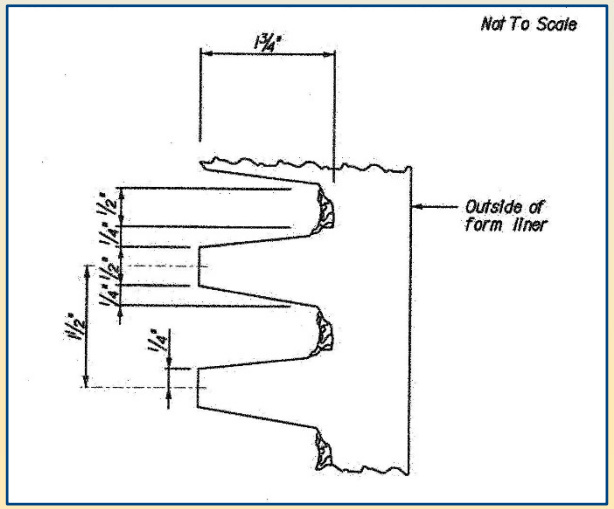
Aesthetics

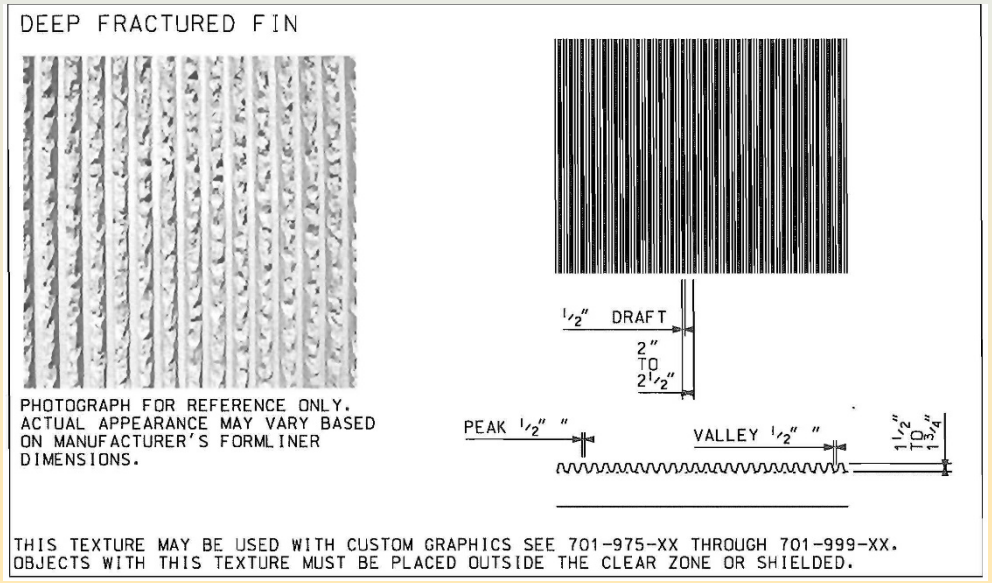
Aesthetics can have a significant impact on the ERS selection

- Heavily populated area, i.e. ERS with high visibility, the ERS should be aesthetically pleasing
- Industrial location, a more industrial looking ERS could be used
- In an environmentally sensitive area, the ERS may be required to blend in with the surrounding environment

Aesthetics

The use of fractured fin





All ERSs should be a natural light gray in color

AMS-STD 36307

AMS-STD 36373

AMS-STD 36492

Environmental Concerns

ERSs can both cause and alleviate environmental concerns

- Causes
  - If contaminated material/soil must be removed prior to construction
  - Noise and vibration can have a negative impact on the surrounding environment
  - Hard fascia can allow for bouncing or echoing of traffic noise

- Alleviate
  - ERSs allow for smaller footprints in environmentally sensitive areas
  - Caution should also be exercised with smaller footprints, since additional site work may be required in order for an ERS to work at a selected site

Durability and Maintenance

- The anticipated environmental conditions can affect the selection of ERS materials

- If site conditions indicate that the life of the ERS will be comprised, then a clearly defined maintenance plan should be developed and implemented
  - Include in the maintenance plan when periodic maintenance should be performed

Tradition

- Tradition (i.e., what is normally done) can impact the selection of an ERS type

- Traditionally SCDOT uses:
  - MSE
  - Gravity and semi-gravity
  - Soil Nail
  - Sheetpile (cantilevered or anchored)
  - Soldier pile and lagging (cantilevered or anchored)

Contracting Practices

Avoid sole source or patented ERSs if possible

Written permission is required for soil source or patented ERSs

Cost

Total ERS costs should include

- Structural elements
- Incidentals
- Drainage items
- Backfill materials (if required)
- ROW
  - Acquisition
  - Easement
- Excavation and disposal of unsuitable or contaminated materials
- Mitigation costs
  - Environmental impacts
  - Limit State (Extreme Event I)
- Time value of construction delays

Include any credits such as eliminating environmental permits or speeding up construction

Displacement

Determine the amount of displacement (horizontal and vertical) that an ERS will be required to handle

Some ERS types are more flexible than others

Other Selection Criteria

The Design Team, including the Project Manager, should determine if there are additional factors that need to be included

The Design Team should also determine if any of the prior ISFs should be given more weight (i.e., should aesthetics be counted twice, etc.)

Weighted Rating

- Each ISF has previously been assigned an Importance Rating (IR)

- Each ISF is assigned a Suitability Factor (SF) for each wall type
  - SF ranges from
    - 4 – most suitable
    - 1 – least suitable

- The Weighted Rating (WR) for each ISF is determined

$$IR_i * SF_i = WR_i$$

- The Total Weighted Rating (WR_T)

$$WR_T = \sum_{i=1}^{n} (IR_i * SF_i) = \sum_{i=1}^{n} WR_i$$

  - The WR_T is determined using a spreadsheet available on the SCDOT website
    - https://www.scdot.org/business/geotech.aspx

Weighted Rating Determination

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ERS Type[5,6]	IR[2,7]	**1**	**1**	**3**	**3**	**1**	**3**	**1**	**3**	**2**	**2**	**3**	**3**				
RSS	SF[3]	**3**	**3**	**2**	**2**	**2**	**3**	**4**	**4**	**3**	**4**	**2**	**4**				
	WR[4]	3	3	6	6	2	9	4	12	6	8	6	12	0	0	0	**77**
MSE Wall	SF	**2**	**3**	**2**	**2**	**2**	**4**	**4**	**4**	**4**	**4**	**1**	**3**				
	WR	2	3	6	6	2	12	4	12	8	8	3	9	0	0	0	**75**
Soil Nailing	SF	**3**	**3**	**4**	**3**	**2**	**3**	**4**	**4**	**1**	**3**	**3**	**4**				
	WR	3	3	12	9	2	9	4	12	2	6	9	12	0	0	0	**83**
Concrete Cantilever	SF	**2**	**2**	**1**	**1**	**2**	**3**	**4**	**3**	**2**	**4**	**1**	**2**				
	WR	2	2	3	3	2	9	4	9	4	8	3	6	0	0	0	**55**
Sheetpile Wall	SF	**2**	**2**	**3**	**3**	**2**	**2**	**4**	**2**	**2**	**3**	**3**	**3**				
	WR	2	2	9	9	2	6	4	6	4	6	9	9	0	0	0	**68**
Soldier Pile and Lagging Wall	SF	**2**	**2**	**3**	**3**	**2**	**1**	**4**	**2**	**2**	**3**	**3**	**3**				
	WR	2	2	9	9	2	3	4	6	4	6	9	9	0	0	0	**65**
	SF																
	WR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	SF																
	WR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**

Weighted Rating Determination

Once the WR_T is developed, the ERS type with the highest WR_T is the most appropriate wall type for the specific location

- Unless context sensitive design is required, then the ERS type with the highest rating that meets the context sensitive design requirement should be selected
- If context sensitive design is required, then the ERS type that meets aesthetic requirements and has a reasonably high WR_T should be selected
  - Note the use of context sensitive design should be justified in writing

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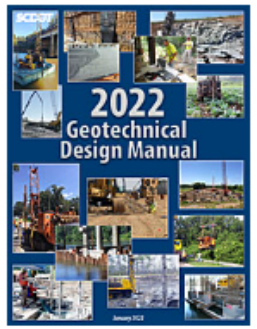

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