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Design of Fiberglass-Reinforced Plastic (FRP) Stacks

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ANSI/ASCE 1-82 N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures

ASCE/EWRI 2-06 Measurement of Oxygen Transfer in Clean Water

ANSI/ASCE 3-91 Standard for the Structural Design of Composite Slabs and ANSI/ASCE 9-91 Standard Practice for the Construction and Inspection of Composite Slabs

ASCE 4-98 Seismic Analysis of Safety-Related Nuclear Structures

Building Code Requirements for Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02) and Specifications for Masonry Structures (ACI 530.1-02/ASCE 6-02/TMS 602-02)

ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures

SEI/ASCE 8-02 Standard Specification for the Design of Cold-Formed Stainless Steel Structural Members

ANSI/ASCE 9-91 listed with ASCE 3-91

ASCE 10-97 Design of Latticed Steel Transmission Structures

SEI/ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings

ASCE/EWRI 12-05 Guideline for the Design of Urban Subsurface Drainage

ASCE/EWRI 13-05 Standard Guidelines for Installation of Urban Subsurface Drainage

ASCE/EWRI 14-05 Standard Guidelines for Operation and Maintenance of Urban Subsurface Drainage

ASCE 15-98 Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

ASCE 16-95 Standard for Load Resistance Factor Design (LRFD) of Engineered Wood Construction

ASCE 17-96 Air-Supported Structures

ASCE 18-96 Standard Guidelines for In-Process Oxygen Transfer Testing

ASCE 19-96 Structural Applications of Steel Cables for Buildings

ASCE 20-96 Standard Guidelines for the Design and Installation of Pile Foundations

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ANSI/ASCE/T&DI 21.2-08 Automated People Mover Standards—Part 2

ANSI/ASCE/T&DI 21.3-08 Automated People Mover Standards—Part 3

ANSI/ASCE/T&DI 21.4-08 Automated People Mover Standards—Part 4

SEI/ASCE 23-97 Specification for Structural Steel Beams with Web Openings

ASCE/SEI 24-05 Flood Resistant Design and Construction

ASCE/SEI 25-06 Earthquake-Actuated Automatic Gas Shutoff Devices

ASCE 26-97 Standard Practice for Design of Buried Precast Concrete Box Sections

ASCE 27-00 Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction

ASCE 28-00 Standard Practice for Direct Design of Precast Concrete Box Sections for Jacking in Trenchless Construction

ASCE/SEI/SFPE 29-05 Standard Calculation Methods for Structural Fire Protection

SEI/ASCE 30-00 Guideline for Condition Assessment of the Building Envelope

SEI/ASCE 31-03 Seismic Evaluation of Existing Buildings

SEI/ASCE 32-01 Design and Construction of Frost-Protected Shallow Foundations

EWRI/ASCE 33-01 Comprehensive Transboundary International Water Quality Management Agreement

EWRI/ASCE 34-01 Standard Guidelines for Artificial Recharge of Ground Water

EWRI/ASCE 35-01 Guidelines for Quality Assurance of Installed Fine-Pore Aeration Equipment

CI/ASCE 36-01 Standard Construction Guidelines for Microtunneling

SEI/ASCE 37-02 Design Loads on Structures During Construction

CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data

EWRI/ASCE 39-03 Standard Practice for the Design and Operation of Hail Suppression Projects

ASCE/EWRI 40-03 Regulated Riparian Model Water Code

ASCE/SEI 41-06 Seismic Rehabilitation of Existing Buildings

ASCE/EWRI 42-04 Standard Practice for the Design and Operation of Precipitation Enhancement Projects

ASCE/SEI 43-05 Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities

ASCE/EWRI 44-05 Standard Practice for the Design and Operation of Supercooled Fog Dispersal Projects

ASCE/EWRI 45-05 Standard Guidelines for the Design of Urban Stormwater Systems

ASCE/EWRI 46-05 Standard Guidelines for the Installation of Urban Stormwater Systems

ASCE/EWRI 47-05 Standard Guidelines for the Operation and Maintenance of Urban Stormwater Systems

ASCE/SEI 48-05 Design of Steel Transmission Pole Structures

ASCE/EWRI 50-08 Standard Guideline for Fitting Saturated Hydraulic Conductivity Using Probability Density Functions

ASCE/EWRI 51-08 Standard Guideline for Calculating the Effective Saturated Hydraulic Conductivity

ASCE/SEI 52-10 Design of Fiberglass-Reinforced Plastic (FRP) Stacks

FOREWORD

In early 1994, the American Society of Civil Engineers was approached by a group interested in formulating a standard for the design, fabrication, and erection of fiberglass reinforced plastic (FRP) stacks and their appurtenances. They felt there was a need for an FRP stack standard, similar to the ASME steel stack standard STS-1, to establish a better level of standardization in the industry and for safeguarding the community.

Therefore, in 1994 a group comprising FRP stack users, researchers, designers, fabricators, and erectors convened under the auspices of the American Society of Civil Engineers to formulate such a standard.

With the aforementioned mission in mind, the group subdivided and began gathering information to formulate guidelines for material selection, mechanical and structural design, vibration, access, safety, electrical, fabrication, erection, inspection, and maintenance requirements.

The following publication is a result of their work and investigation.

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INTRODUCTION

The following standard applies to fiberglass-reinforced plastic (FRP) stacks, that is, those stacks where the primary supporting shell is made of FRP. This standard can be applicable to both single- and multiple-walled FRP stacks, guyed FRP stacks, or certain aspects of tower stacks. The stack may be supported on a foundation or from another structure.

This Standard covers the design of FRP stacks. The Standard outlines the considerations which must be made for both the mechanical and structural design; emphasizes what consideration must be taken for wind and seismic-induced vibrations; gives guidelines for the ultraviolet protection, selection of materials, linings, and coatings; states the requirements for lighting and lightning protection based upon existing building and federal codes; gives the requirements for climbing and access based upon current Occupational Safety and Health Administration (OSHA) standards; emphasizes the important areas regarding fabrication and construction; and outlines areas requiring maintenance and inspection following initial operation.

The information presented has been prepared in accordance with established engineering principles utilizing state-of-the-art information and is intended for general information. While every effort has been made to ensure its accuracy, the information should not be relied upon for any specific application without the consultation of a competent, licensed professional engineer, to determine its suitability. It is therefore recommended that Engineering/Design drawings and related documents of the stack bear the Professional Engineer Seal, signature, and date.

Nothing in the Standard shall be construed to alter or subvert the requirements of any existing code or authority having jurisdiction over the facility. Furthermore, alternate methods and materials to those herein indicated may be used, provided that the engineer can demonstrate their suitability to all agencies and authorities. Note that several of the sections are similar to ASTM D 5364 and ASME Steel Stack STS-l Standard, and many members of that committee are also on the FRP Stack Standard Committee.

CONTENTS

CHAPTER 1 DEFINITIONS AND MATERIALS 1

1.1 DEFINITIONS 1

1.2 MATERIALS 4

1.3 RESINS 4
1.3.1 Polyester Resins 4
1.3.2 Vinyl Ester Resins 4
1.3.3 Phenolic Resins 5
1.3.4 Epoxy Resin 5

1.4 REINFORCEMENTS 5
1.4.1 Glass Reinforcements 5
1.4.2 Rovings 5
1.4.3 Mats 6
1.4.4 Combination Woven Roving/Chopped Strand Mat 6
1.4.5 Woven And Weft Inserted (Unidirectional) Fabrics 6
1.4.6 New Technology 6

1.5 RESIN ADDITIVES 6
1.5.1 Fire Retardants 6
1.5.2 Promoters 6
1.5.3 Inhibitors 6
1.5.4 Thixotropic Agents 6
1.5.5 Pigments, Coatings, Gel Coats 7
1.5.6 Light Inhibitors 7

CHAPTER 2 MECHANICAL DESIGN 7

2.1 DESIGN BASIS 7
2.1.1 General 7
2.1.2 Mechanical Section Symbols 7
2.1.3 Mechanical Section Definitions 7

2.2 SIZE SELECTION 7
2.2.1 Height 7
2.2.2 Diameter 8
2.2.3 Shape 8

2.3 AVAILABLE DRAFT 8
2.3.1 Natural Draft 8
2.3.2 Draft Losses 8

2.4 HEAT LOSS 9
2.4.1 Ambient Conditions 9
2.4.2 Film Coefficients 9
2.4.3 Heat Loss Calculations 9

2.5 THERMAL EXPANSION 9

2.6 OPTIONAL APPURTENANCES 10

CHAPTER 3 STRUCTURAL DESIGN 10
3.1 SCOPE 10
3.2 GENERAL 10
3.2.1 Design Limitations 10
3.2.2 Drawings and Computations 10
3.2.3 Location 10
3.2.4 Shop Drawings 10
3.3 TYPES OF FRP STACKS 11
3.3.1 Self-Supported Stacks 11
3.3.2 Braced Stacks 11
3.3.3 Guyed Stacks 11
3.4 APPLIED LOADING 11
3.4.1 Dead Load 11
3.4.2 Live Load 11
3.4.3 Wind Load 11
3.4.4 Thermal Load 11
3.4.5 Drag Load Interference Effects 12
3.4.6 Concentrated Loads due to Braced or Guyed System 12
3.4.7 Other Loads 12
3.5 MATERIAL 12
3.5.1 Selection of Material of Construction 12
3.6 LOAD AND RESISTANCE FACTOR DESIGN PROCEDURE (LRFD) 12
3.6.1 General 12
3.6.2 Load Factors (LF) 12
3.6.3 Resistance Factors (RF) 12
3.6.4 Loading Combinations 13
3.6.5 Allowable Longitudinal Stress 13
3.6.6 Allowable Circumferential Stress 13
3.6.7 Allowable Bending of Stiffeners or Base Plate Elements 13
3.6.8 Circumferential Stiffener Requirements 13
3.6.9 Interaction Equation for Longitudinal and Circumferential Stress 13
3.7 DEFLECTION 13
3.8 DISCONTINUITIES IN THE SHELL 13
3.9 BASE DESIGN 14
3.10 ANCHOR BOLTS 14
3.10.1 Material–Anchors Bolts, Washers, and Nuts 14
3.11 FOUNDATION 14
3.12 SPECIAL CONSIDERATIONS 14
3.13 SYMBOLS 14
CHAPTER 4 VIBRATION 15
4.1 SCOPE 15
4.1.1 Loads 15
4.2 GENERAL 15
4.2.1 Basis for Vibration Consideration 15

4.3 DYNAMIC RESPONSES 15
4.3.1 Dynamic Characteristics 15
4.3.2 Frequencies 15
4.3.3 Mathematical Modeling 15
4.3.4 Earthquake Responses 16
4.3.5 Wind Responses 16
4.4 PREVENTION OF EXCESSIVE VIBRATION 17
4.4.1 General 17
4.4.2 Aerodynamic Methods 17
4.4.3 Stiffness Methods 18
4.5 ESTIMATION OF VIBRATION CYCLES 19
4.6 SYMBOLS 19
CHAPTER 5 ACCESS, SAFETY, AND ELECTRICAL 19
5.1 SCOPE 19
5.2 GENERAL 19
5.3 LADDERS 20
5.3.1 Ladders, Design Loads 20
5.3.2 Ladder Parts 20
5.3.3 Pitch 20
5.3.4 Safety Cages and Wells 20
5.3.5 Ladder Safety Devices 20
5.3.6 Prevention of Unauthorized Access 21
5.4 PLATFORMS AND LANDINGS 21
5.4.1 Work and Sampling Platforms 21
5.4.2 Aviation Light Platforms 21
5.4.3 Rest Landings 21
5.4.4 Catwalks between Stack and Adjacent Structures 21
5.4.5 Parts 21
5.5 ELECTRICAL 21
5.5.1 Codes, Standards, and Other Documents 21
5.5.2 Aviation Obstruction Marking Light System 21
5.5.3 Lighting Protection 22
5.5.4 Convenience Lighting 22
5.5.5 Convenience Power Outlets 22
CHAPTER 6 FABRICATION AND ERECTION 22
6.1 PURPOSE 22
6.2 SCOPE 22
6.3 FABRICATOR'S RESPONSIBILITES 22
6.3.1 Written Procedure 22
6.3.2 Qualification Laminates 22
6.4 QUALITY ASSURANCE 23
6.4.1 Resin Cure 23
6.4.2 Acetone Test 23
6.4.3 Surface Condition 23
6.4.4 Internal Corners 23

6.5 TOLERANCES 23
6.5.1 Peaking 23
6.5.2 Cylindrical Sections 23
6.5.3 Matching Cylindrical Sections 24
6.5.4 Rectangular Sections 24
6.5.5 Height 24
6.5.6 Squareness of Ends 24
6.5.7 Fittings 24
6.5.8 Straight Connections / Butt Joints 24
6.5.9 Vertical Butt Seams 24
6.5.10 Diameter 24
6.5.11 Wall Laminate Thickness 24

6.6 INSPECTION 24
6.6.1 Dimension and Thickness Checks 24
6.6.2 Physical Property and Laminate Tests 24
6.6.3 Visual Inspection 24
6.6.4 Penetrant Inspection 24

6.7 SHOP FABRICATION AND FIELD ERECTION 24
6.7.1 Assembly of Bolted Connections 24
6.7.2 Flanges 24
6.7.3 Exterior Laminate 25
6.7.4 Cut Edges 25
6.7.5 Joints 25
6.7.6 Inner Surfaces 25
6.7.7 Sampling Ports 25
6.7.8 Electrical Requirements 25
6.7.9 Straightening 25
6.7.10 Anchor Bolt Straightening 25
6.7.11 Plumbness 25
6.7.12 Cranes 25
6.7.13 Temporary Devices 26
6.7.14 Erection Equipment 26

6.8 GROUTING 26
6.8.1 Use 26
6.8.2 Grout Properties 26
6.8.3 Surface Areas 26
6.8.4 Temperature 26
6.8.5 Sleeves 26
6.8.6 Torque 26

6.9 HANDLING AND STORAGE 26
6.9.1 Safety 26
6.9.2 Cleanliness 26
6.9.3 Rigging 26
6.9.4 Storage 26

CHAPTER 7 INSPECTION AND MAINTENANCE 26

7.1 INSPECTION DURING FABRICATION AND INSTALLATION 26
7.1.1 Scope 26
7.1.2 Inspection and Responsibility 26
7.1.3 User's Inspection 26

7.1.4 Dimensions and Inspection Requirements . . . 26
7.1.5 Packaging, Shipment, and Installation . . . 27

7.2 FACTORS THAT INFLUENCE THE NEED FOR STRUCTURAL EXAMINATIONS . 27
7.2.1 General . . . 27
7.2.2 Original Design Basis versus Operating Basis . . . 28
7.2.3 Exposure to Weather, Chemical, and Thermal Conditions . . . 28
7.2.4 Operations Records . . . 28
7.2.5 Cumulative Effect of Exposure and Operating Conditions . . . 29
7.2.6 Ensuring Structural Adequacy . . . 29

7.3 FIELD EXAMINATION TECHNIQUES . . . 29
7.3.1 General . . . 29
7.3.2 Preparation and Planning . . . 29
7.3.3 Safety Considerations . . . 30
7.3.4 Equipment . . . 30
7.3.5 Identification of Critical Stack Sections . . . 31
7.3.6 Exterior Inspections . . . 31
7.3.7 Interior Inspections . . . 31
7.3.8 Thickness Measurements . . . 32
7.3.9 Sounding Measurements . . . 32
7.3.10 Temperature Monitoring . . . 32
7.3.11 Displacement Measuring . . . 32
7.3.12 Surface Hardness Measurements . . . 32
7.3.13 Infra-Red Survey . . . 32
7.3.14 X-ray Tests . . . 32
7.3.15 Laboratory Test Samples . . . 32
7.3.16 Documentation . . . 33

7.4 POTENTIAL DAMAGE AREAS . . . 33
7.4.1 General . . . 33
7.4.2 Indicators . . . 33
7.4.3 Structural Elements . . . 34

7.5 EXAMINATION DATA, EVALUATION, AND DISPOSITION . . . 35
7.5.1 General . . . 35
7.5.2 Examination Data Assimilation . . . 35
7.5.3 Repairs . . . 35
7.5.4 Evaluation and Disposition Considerations . . . 35
7.5.5 Final Report . . . 36

7.6 MAINTENANCE . . . 36
7.6.1 Program . . . 36
7.6.2 Guidelines . . . 36

FURTHER READING . . . 37

INDEX . . . 39

CHAPTER 1 DEFINITIONS AND MATERIALS

1.1 DEFINITIONS

Acoustic Emission (AE): The class of phenomenon whereby transient elastic waves are generated by the rapid release of energy from localized sources within a material, or the transient waves so generated (ASTM E 1316). In FRP, AE is caused by cracking of the matrix, debonding of the matrix from the fibers, laminate separation, fiber pullout, and fiber breakage.

Acoustic emission monitoring: A non-destructive test method by which the location and severity of active flaws are determined by monitoring the acoustic emission from the defects. This particularly useful NDT technique determines structural integrity.

Aggregate: Siliceous sand conforming to ASTM C 33, except that the requirements for gradation need not apply.

Barcol hardness: A hardness value obtained by measuring the resistance to penetration of a sharp steel point under a spring load. The instrument, called the Barcol impressor, gives a direct reading on a 0 to 100 scale. The hardness value is often used as a measure of the degree of cure of the resin. The resin must be properly cured to develop intended degradation resistance.

Bell and Spigot Joint: A typical field joint consisting of a deterioration barrier and reinforcing layer.

Bi-directional laminate: A reinforced polymer laminate with the fibers oriented in various directions in the plane of the laminate: a cross laminate. See also unidirectional laminate.

Binder: The agent applied to glass mat or forms to bond the fibers prior to laminating or molding.

Bisphenol A fumarate: A condensation product formed by reaction to two (bis) molecules of phenol with acetone (A) used as a component in one type of traditional corrosion-resistant FRP resin.

Blister: An undesirable rounded elevation of the surface of a plastic, whose boundaries may be more or less sharply defined. The blister may burst and become flattened.

Bond strength: The amount of adhesion between bonded surfaces; a measure of the stress required to separate a layer of material from the base to which it is bonded. See also peel strength.

Benzoyl peroxide/dimethylaniline (BPO/DMA): A resin catalyst system that provides improved deterioration resistance in some chemical environments that are reactive to the cobalt in the more commonly used MEKP/CoNap catalyst system.

Bromine: A fire retardant (halogen), which is used to reduce or eliminate a resin's tendency to burn. Often used in conjunction with chemicals such as antimony trioxide and pentoxide to achieve a maximum Class I fire retardancy rating and often used in ducting systems.

Butt wrap joint: A secondary laminate wrapped around two or more components in an edge-to-edge configuration used to join them together.

Catalyst: A substance which changes the rate of a chemical reaction without itself undergoing permanent change in its composition; a substance which markedly speeds up the cure of a compound when added in minor quantity compared to the amounts of primary reactants (hardener, initiator, or curing agent).

C Glass: A special type of glass used as a fiber reinforcement, made and applied specifically for high chemical resistance. The symbol C was originally chosen for chemical resistance.

Composite: A homogeneous material created by the synthetic assembly of two or more materials (selected reinforcing elements and compatible matrix resin) to obtain specific characteristics and properties.

Contact molding: A process for molding reinforced plastics in which reinforcement materials, such as mat and woven roving saturated with resin, are applied to a mold. The cure is either at room temperature using a catalyst-promoter system or heated in an oven with no additional pressure.

Corrosion liner: *see* Liner.

Cross-link: The formation of a three dimensional polymer by means of inter-chain reactions resulting in changes in physical properties.

Cure: To change the properties of a resin by chemical reaction, which may be condensation or addition - usually accomplished by the action of either heat or catalyst or both, and with or without pressure.

Delamination: To split a laminated polymer material along the plane of its layers. Physical separation or loss of bond between laminate plies.

Discontinuity stress: Additional stress produced where abrupt changes in geometry, materials, and/or loading occur in an FRP laminate.

Differential scanning calorimetry (DSC): DSC is used to determine the glass transition temperature and the degree of cure of an FRP laminate by measuring the heat flow into and out of a sample as the material is heated at a constant heating rate under a nitrogen purged atmosphere. The degree of cure may be determined by repeated heating of a