

COOLING TECHNOLOGY INSTITUTE

Structural Design of FRP Components



July 2002

CTI Bulletin ESG-152 (02)

FOREWORD

This Cooling Technology Institute (CTI) publication is published as an aid to cooling tower purchasers and designers. It may be used by anyone desiring to do so, and efforts have been made by CTI to assure the accuracy and reliability of the data contained herein. However, CTI makes **NO WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY** nor any other warranty expressed, implied or statutory. In no event shall CTI be liable or responsible for **INCIDENTAL, CONSEQUENTIAL OR COMMERCIAL** losses or damage of any kind resulting from this publication's use; or violation of any federal, state, or municipal regulation with which this publication may conflict or for the infringement of any patent resulting from the use of this publication.

All CTI codes and standards are copyrighted with all rights reserved to CTI. The reproduction of any part of this or any other CTI code or standard is a violation of Federal Law. One must recognize and appreciate commitment by a number of volunteer members who donate their time to develop and update CTI codes and standards. The monies spent for code development, administrative staff support and publication are essential and constitute a substantial drain on CTI. The purchase price of these documents helps to offset these costs. Reproduction and distribution by others, in addition to being unethical, undermines this system and constitutes a further financial drain on CTI. When copies are needed, you are requested to call or write the Cooling Technology Institute, P.O. Box 73383, Houston, Texas 77273, (281) 583-4087. Please request that your associates buy the required codes and standards rather than copy them. Your cooperation in this matter is greatly appreciated.

Nothing contained herein is to be construed as granting any right for the manufacture, sale or use in connection with any method, apparatus, or product covered by letters patent, nor as insuring anyone against liability for infringement of letters patent.

This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



This document has been reviewed and approved as part of CTI's Five Year Review Cycle. This document is again subject to review in 2007.

Approved by the
CTI Executive Board

Copyright 2002
by Cooling Technology Institute
Printed in U.S.A.

CTI-Guideline
ESG 152 (02)

Structural Design of FRP Components

Preface

FRP composites structural members are the newest building materials available for constructing cooling towers. As with any new material, designers must understand FRP's unique properties and the performance differences from other structural materials.

This Structural Design Guideline provides minimum design standards and cautionary recommendations to designers of FRP structural cooling towers. STD 137(07) is incorporated in this guideline as the material specification for FRP pultruded structural products and is the basis for the various tables of values.

1. MANUFACTURING STANDARDS

1.1 Strength Reduction Factors for Temperature

Due to the behavior of composite material strengths in elevated temperature, it is necessary to account for the loss in strength and stability. The resulting loss is related to the resin system used in the construction of the member. The associated reduction factors reflect the percentage of strength and modulus of elasticity retained at that temperature. The following tables present these factors for poly and vinyl resin systems. This temperature reduction factor does not account for loss of strength of the composite material due to moisture exposure. (Comparisons were done dry at elevated temperatures.

Table 1.1-1

APPLICATION CONDITION VS. "AVERAGE" COMPRESSION STRENGTH REDUCTION, ASTM D695		
Temperature, °F	REDUCTION FACTOR	
	POLY	VINYL
77	1.0	1.0
100	0.85	0.90
125	0.70	0.80
150	0.50	0.80
175	NR	0.75
200	NR	0.50

Table 1.1-2

APPLICATION CONDITION VS. "AVERAGE" MODULUS OF ELASTICITY REDUCTION, ASTM D638(* also reference modulus of elasticity procedure written for this application)		
Temperature, °F	REDUCTION FACTOR	
	POLY	VINYL
77	1.0	1.0
100	1.0	1.0
125	.90	.95
150	.85	.90
175	NR	.88
200	NR	.85

The reduction factor is multiplied by the Ultimate Strengths or Modulus of Elasticity prior to applying service factors. Thus, the location of the member within the tower will dictate the exposure (i.e. fill support beams will be exposed to a lower temperature environment than the hot water distribution piping support beams). If the tower is to experience a short-term hot temperature excursion in excess of the design temperature this would be considered a live load condition. The following example illustrates the use of temperature effects.

Table 1.1-3

EXAMPLE: FILL SUPPORT BEAMS
DESIGN TEMPERATURE – 125°F

PARAMETER (Minimum Design Values)	Applicable ASTM	77°F	125°F	
			POLY	VINYL
Ultimate Bearing, PSI	D953	30,000	21,000	24,000
Flexure Strength, PSI	D790	30,000	21,000	24,000
Ultimate Shear, PSI	D2344	4,500	3,150	3,600
Full Section Modulus Elasticity, 10 ⁶ PSI		2.6 and 2.8	2.34	2.66

NOTE: Even though the polyester resin system strength is reduced more than a vinyl system this does not mean that a polyester system cannot be used and still achieve the desired long term behavior. Additionally, the appropriate service factors must be used to minimize long-term creep regardless of