TECHNICAL OPINION REPORT

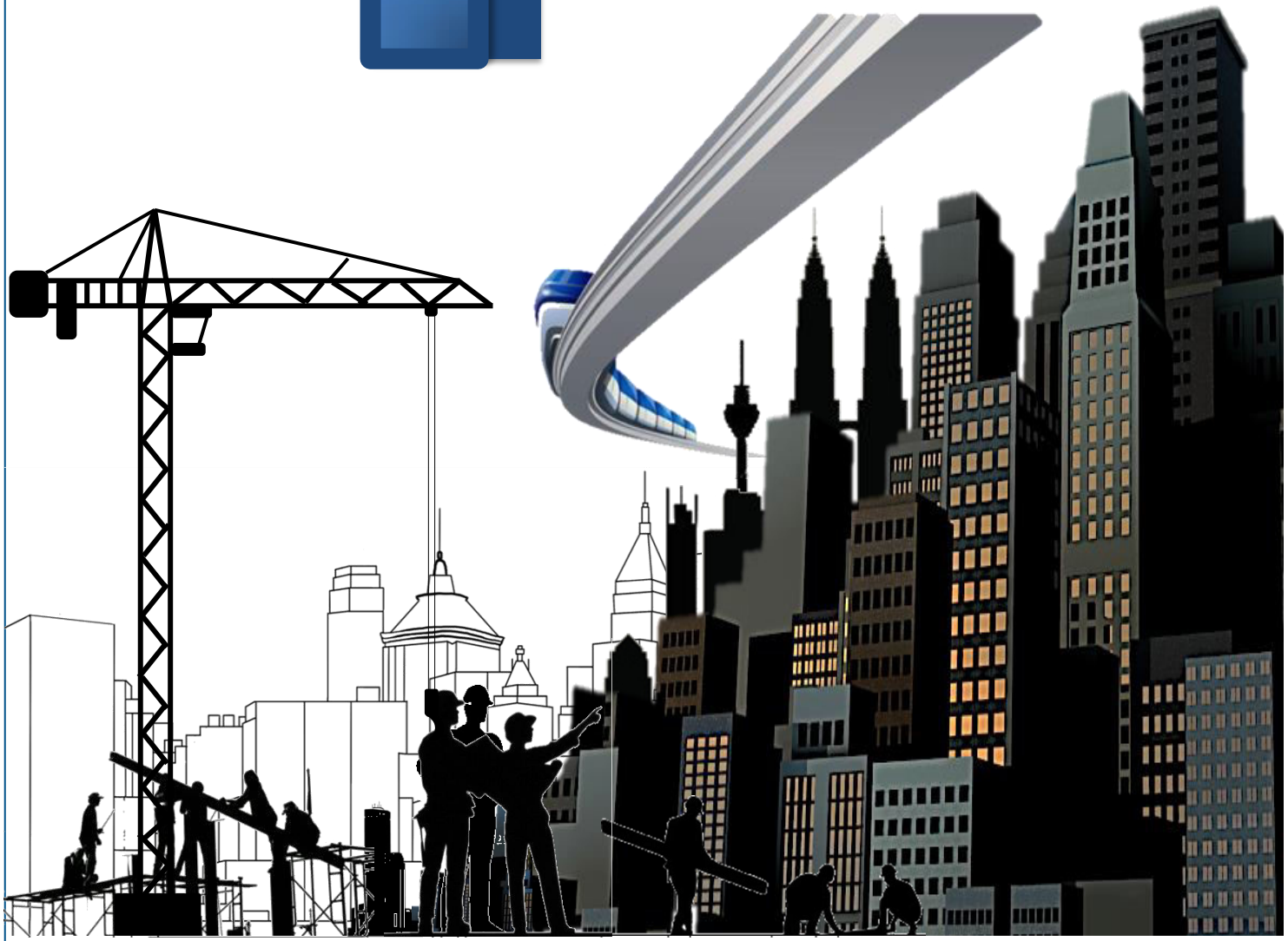
SUBMITTED TO CIDB MALAYSIA | JANUARY 2015

PRODUCT

Glass Fiber Reinforced Polymer (GFRP)

APPLICANT

GFRP Technologies Sdn. Bhd.



FOREWORD

Construction Industry Development Board (CIDB Malaysia) is a statutory body enacted under the Act 520 in 1994. Its mission is to develop Malaysian Construction Industry towards global competitiveness. To support that mission, a number of functions were formulated and one of them is to encourage the improvement of construction techniques and materials. Under that function, CIDB is to carry out assessment and appraisal of innovations of any kind of product and technology related to construction and to publish its finding, in the form of Technical Opinion.

This Technical Opinion will provide a reference to the relevant / interested parties in the construction industry. CIDB assess innovation based on application and evaluation by its Technical Opinion. Applicants may use it as a supporting document for regulatory and approving authorities, architects, engineers and others in dealing with the new products and technologies.

This Technical Opinion is prepared on behalf of CIDB by The Technical Expert Panel on construction products, construction material and technology in Construction Industry. The Technical Expert Panel was set-up by CIDB and its members are drawn from experts that represent relevant sectors in the construction industry.

This Technical Opinion has been modeled based on international recommended practice.

CIDB Technical Expert Panel Committee for Glass Fiber Reinforced Polymer (GFRP)

Technical Expert Panel

Dr. Foo Chee Hung	(Chairman)	Construction Research Institute of Malaysia (CREAM)
Ir. Dr. Lim Char Ching	(Technical Expert Panel)	Jabatan Kerja Raya (JKR)
Dr. Teng Wan Dung	(Technical Expert Panel)	Standards and Industrial Research Institute of Malaysia (SIRIM)
Associate Professor Dr. Zulkiflle Bin Leman	(Technical Expert Panel)	Universiti Putra Malaysia (UPM)

Secretariat

Natasha Binti Dzulkalnine	CREAM
Suhaila Binti Abdul Halim	CREAM

GENERAL PROVISIONS

The purposes of this report are to assist respective parties concerned both applicant and granting approval authority, includes specification and also use of the subject. This report shall not be considered as approval.

Special note should be taken of the provisions and limitations set out and the period of validity of the Technical Opinion.

Technical Opinion is initially given a term of validity of three (3) years from the date of issue in the expectation that, after that period, the subject will no longer be an innovation. They can be reviewed within the first (12) twelve months and again as necessary during the life of the products or system described in the document. The limitation on the validity of the opinions should not be interpreted as implying a similarly limited life expectancy of the products or system described in the Technical Opinion. However, if experience shows poor overall standard of quality or performance, the Technical Opinion will be withdrawn.

The legitimacy and validity of the Technical Opinion can be verified at office of CIDB Head Office.

CIDB and the Technical Expert Panel shall accept no responsibility for the quality and performance of the products.

Disclaimer

While every effort is made to ensure accuracy of the information presented in this report, neither the Technical Expert Panel nor its Secretariats or CIDB will accept responsibility for any loss or damage that may arise in connection with the use of this document.

Definitions

Technical Opinion Programme	A programme initiated by CIDB with the aim to evaluate products, materials, components or system with regard to, but not limited to IBS. It normally covers wide range of innovative products to be used in local construction industry
Technical Expert Panel	Individuals are selected based on their expertise in building material, particularly in Fiber Reinforced Polymer.
Glass Fiber Reinforced Polymer	Based on the definition given by "Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars": i. Fiber Reinforced Polymer (FRP) is composite material consisting of continuous fibers impregnated with a fiberbinding polymer then molded and hardened in the intended shape. ii. Fiber Reinforced Polymer (FRP) bar is a composite material formed into a long, slender structural shape suitable for the internal reinforcement of concrete and consisting of primarily longitudinal unidirectional fibers bound and shaped by a rigid polymer resin material. iii. GFRP is glass fiber reinforced polymer.

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
CAN	Canada
CIDB	Construction Industry Development Board
CNR	National Research Council
CREAM	Construction Research Institute of Malaysia
CSA	Canadian Standards Association
DIN	Deutsches Institut Fur Normung E.V
EN	European Standards
FRP	Fiber Reinforced Polymer
GFRP	Glass Fiber Reinforced Polymer
GOST	State Union Standard
IBS	Industrialised Building System
JBDPA	Japan Building Disaster Prevention Association
JKR	Jabatan Kerja Raya
JSCE	Japan Society of Civil Engineers
MKRM	Makmal Kerja Raya Malaysia
QA	Quality Assurance
QC	Quality Control
SIRIM	Standards and Industrial Research Institute of Malaysia
UPM	Universiti Putra Malaysia
USA	United States of America
UV	Ultra Violet

Symbols

g	gram
mm	millimetre
mm^2	square millimetre
K	Kelvin
N	Newton
^oC	degree Celsius

List of Tables

Table 4.1:	Tensile Test and Modulus of Elasticity	4
Table 5.1:	Standards and Design Guides	5

	CONTENT	PAGE
1.0	**IDENTIFICATION**	**1**
	1.1 Name of Product	1
	1.2 Country of Origin	1
	1.3 Dates of Evaluation	1
	1.4 Purpose	1
	1.5 Applicant & Address	1
2.0	**DESCRIPTIONS**	**1**
	2.1 General Descriptions of Product	1
	2.2 Element of Product	2
	2.2.1. Bar Diameter and Length	2
	2.2.2. Materials	2
	2.2.3. Process	2
	2.3 Usage Application	2
	2.4 Usage Limitation	2
	2.5 Usage Advantages	2
	2.6 Special Conditions for Storage and Transportation	2
	2.6.1 Storage	2
	2.6.2 Transportation	3
3.0	**BASIS OF APPRAISAL**	**3**
	3.1 Document Received from the Applicant	3
	3.1.1 Test reports on the product	3
	3.1.2 General Information	3
	3.1.3 Product Description	3
4.0	**MATERIAL: STANDARDS, SPECIFICATIONS AND TESTS**	**3**
	4.1 Technical Properties of GFRP Reinforcement bar	3
	4.1.1 Tensile Test and Modulus of Elasticity	3
	4.1.2 Coefficient of Thermal Expansion using Dilatometer	4
5.0	**COMPLIANCE TO INTERNATIONAL / MALAYSIAN STANDARDS**	**4**
6.0	**QUALITY ASSURANCE / QUALITY CONTROL**	**6**
	6.1 QA / QC Plan	6
7.0	**VALIDITY OF OPINION**	**6**
	7.1 Condition	6
	7.2 Recommendations from Technical Expert Panel	6
	7.3 Validity	6

8.0 APPROVED OPINION ABSTRACT 7

9.0 REFERENCE 8

10.0 APPENDICES

Appendix A: Test Report on Fiber Reinforced Polymer Material Testing

Appendix B: Evaluation Report on Coefficient of Thermal Expansion using Dilatometer

Appendix C: General Information of GFRP

Appendix D: Product Description of GFRP

1.0 IDENTIFICATION

1.1 Name of Product

Glass Fiber Reinforced Polymer (GFRP) Reinforcement Bar

1.2 Country of Origin

Russian Federation

1.3 Date of Evaluation

17th April 2014	:	First meeting of Technical Expert Panel
15th May 2014	:	Second meeting of Technical Expert Panel
26th June 2014	:	Third meeting of Technical Expert Panel
18th December 2014	:	Fourth meeting of Technical Expert Panel

1.4 Purpose

GFRP is a composite material consisting of glass fiber and epoxy ester resin which can be used as reinforcement bars in concrete construction.

1.5 Applicant & Address

GFRP Technologies Sdn. Bhd.

37-2, Block D1, Jalan PJU 1/41, Dataran Prima, 47301 Petaling Jaya, Selangor, Malaysia.

Contact Person	:	Ms. Huang Mei Si
Telephone	:	03 – 7804 3101
Fax	:	03 – 7805 1529
Email	:	mei.c@airosat.sg

2.0 DESCRIPTIONS

2.1 General Descriptions of Product

The description of the product is in accordance with American Concrete Institute (ACI) 440.1R-06: Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars;

Fiber-Reinforced Polymer (FRP) is a composite material consisting of continuous fibers impregnated with a fiber-binding polymer then molded and hardened in the intended shape.

FRP bar is a composite material formed into a long, slender structural shape suitable for the internal reinforcement of concrete and consisting of primarily longitudinal unidirectional fibers bound and shaped by a rigid polymer resin material. The bar may have a cross section of

variable shapes and may have a deformed or roughened surface to enhance bonding with concrete.

GFRP is an acronym for Glass Fiber Reinforced Polymer.

2.2 Element of Product

2.2.1. Bar Diameter and Length

Diameter of reinforcement bar may range from 4 mm to 40 mm.

2.2.2. Materials

GFRP Reinforcement Bar is produced from materials such as glass fibers, epoxy resin and modifier.

2.2.3. Process

This product can be manufactured by means of pultrusion process.

2.3 Usage Application

GFRP reinforcement bar may be used as an alternative reinforcement to steel reinforcement bar in concrete constructions, for example, precast concrete elements, buildings, marine structures, etc. Structures can be designed with GFRP reinforcement bar according to accepted guidelines, such as ACI 440.1R-6 (USA), CSA-S806-02 (Canada) or DIN1045-1 (Germany).

2.4 Usage Limitation

GFRP reinforcement bar is brittle and cannot be bent or rebent on-site as compared to steel reinforcement bar. GFRP reinforcement bar should be shaped and bent in the manufacturing factory.

2.5 Usage Advantages

The advantages of using GFRP are lightweight, easy to handle, high tensile strength, and resistance to corrosions.

2.6 Special Conditions for Storage and Transportation

2.6.1 Storage

a) Prevent exposure to UV radiation and sunlight
b) Should be covered and stored in a dry environment

2.6.2 Transportation

a) To avoid damage to the ribs, the material should not be dragged on the ground

3.0 BASIS OF APPRAISAL

3.1 Documents Received from the Applicant

The following documents were received from GFRP Technologies Sdn. Bhd. for product evaluation by the Technical Expert Panel.

3.1.1. Test reports on the product

a) Test Report on Fiber Reinforced Polymer Material Testing (see Appendix A, Metallurgical Consultancy and Services Sdn. Bhd.)

b) Test Report on Coefficient of Thermal Expansion using Dilatometer (see Appendix B, SIRIM Berhad)

3.1.2. General Information

General information of GFRP product (see Appendix C, the Product Brochure of GFRP Reinforcement Bar submitted by GFRP Technologies Sdn. Bhd.)

3.1.3 Product Description

Product description of GFRP (see Appendix D, Frach Aeronautica Product Description of GFRP Reinforcement bar)

4.0 MATERIAL: STANDARDS, SPECIFICATIONS AND TESTS

4.1 Technical Properties of GFRP Reinforcement bar

The following test results have been provided by GFRP Technologies Sdn. Bhd.

4.1.1 Tensile Test and Modulus of Elasticity

Tensile test was performed by Metallurgical Consultancy and Services Sdn. Bhd. on 14th November 2014. The results are shown in Table 4.1.

Table 4.1: Tensile Test and Modulus of Elasticity

Type of Test	Result
Nominal Tensile Area (mm^2)	59.53
Yield Load (N)	N/A
Yield Stress (N/mm^2)	N/A
Maximum Load (N)	59,692
Tensile Strength (N/mm^2)	1,002.75
Mode of Failure	Brittle
Modulus of elasticity (N/mm^2)	46, 690

(Note: Refer to Appendix A)

4.1.2 Coefficient of Thermal Expansion using Dilatometer

The test was performed by the Technical Services and Consultancy Section, Advanced Materials Research Centre, SIRIM Berhad, on 13th November 2014. The test was conducted in a temperature range between 30^0C to 100^0C. Typical coefficient of thermal expansion was found to be between 6.19 x 10^{-6} K^{-1} to 8.08 x 10^{-6} K^{-1} for GFRP bar of 10mm nominal diameter . The full test report is attached in Appendix B.

5.0 LIST OF INTERNATIONAL STANDARDS

A list of International Standards related to this product is shown in Table 5.1:

Table 5.1: Standards and Design Guides

No.	Country	Standard/Design Guide *(Reference from documents received from the Applicant)*
1.	USA	**ACI 440.1R-06** "Guide for the design and Construction of Structural Concrete Reinforced with FRP Bars", American Concrete Institute
		ACI 440.3R-04 "Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures"
		AASHTO CFRP-1 "AASHTO LFRD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings", American Association of State Highway and Transportation Officials
		ASTM D7617 "Standard Test Method for Transverse Shear Strength of Fiber-reinforced Polymer Matrix Composite Bars", American Standard Test Method (ASTM) International
		ASTM D7205 "Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars"

2.	Canada	**CAN/CSA-S807-10** "Specifications for Fiber-Reinforced Polymers", Canadian Standard Association
		CAN/CSA-S806-12 "Design and Construction of Building Components with Fiber-Reinforced Polymers"
		CAN/CSA-S6-06 Fiber-Reinforced Structures, "Canadian Highway Bridge Design Code", pp.693 – 728
		CSA-S806-02 Design and Construction of Building Components with Fiber-Reinforced Polymers
3.	Switzerland	**Fib Bulletin No.40** "FRP Reinforcement in RC structures"
4.	Japan	**JSCE Series 23** "Recommendation for Design and Construction of Concrete. Structures Using Continuous Fiber Reinforcing Materials", Japan Society of Civil Engineers
		JBDPA Design Manual "Japanese Design and Construction Guidelines for Seismic Retrofit of Building Structures with FRP Composites", Japan Building Disaster Prevention Association (JBDPA)
5.	Germany	**DIN1045-1** "EN-Concrete Reinforced and Pre-stressed Concrete Structures – Part 1: Design and Construction" , Deutsches Institut Fur Normung E.V
6.	Russia	**GOST 9.071-76 "**Unified system of corrosion and ageing protection. Vulcanized rubbers for articles working in liquid corrosive media. Technical requirements" Russian Standards and Technical Regulation
		GOST 11262-80 "Plastics. Tensile test method"
		GOST 25.604-82 "Design calculation and strength. Testings. Methods of mechanical testing of polymeric composite materials. Test for bending properties at normal, elevated and low temperatures"
		GOST 17320-71 "State system for ensuring the uniformity of measurements. Plain gauges for dimensions over 500 mm. Verification methods and means"
		GOST 9550-81 "Plastics. Test methods for the determination of elasticity modulus at strength, compression and bending"
		GOST 4651-82 "Plastics. Compression test method"
		GOST 11262-80 "Plastics. Tensile strength test method"
7.	Europe	**EN-13706** "Reinforced plastics composites. Specifications for pultruded profiles Method of test and general requirements", European Committee for Standardization

8.	Italy	**CNR-DT 203 "**Guide for the Design and Construction of Fiber-Reinforced Concrete Structures", CNR – Advisory Committee on Technical Recommendations for Construction
		CNR-DT 205 "Guide for the Design and Construction of Structures made of FRP Pultruded Elements"

6.0 QUALITY ASSURANCE / QUALITY CONTROL

6.1 QA / QC plan

The information on QA / QC is not available at the time of writing this report. Users may contact the Applicant for further details on QA / QC.

7.0 VALIDITY OF OPINION

7.1 Condition

The Technical Opinion Report given herein is based on a comprehensive evaluation of the product based on formal discussion with the Applicant together with documents and product information made available by the Applicant to the Technical Expert Panel.

This Technical Opinion report is valid for the product specification submitted for evaluation by GFRP Technologies Sdn. Bhd. It is the responsibility of the Applicant to notify CIDB of any changes in the product specification mentioned in this report.

7.2 Recommendations from Technical Expert Panel

The recommendations are made after a thorough evaluation conducted by the Technical Expert Panel. In the opinion of the Technical Expert Panel, the product has a potential to be used in the local construction industry. However, it is recommended that more information should be made available with respect to the product performance in the local climatic environment and in the following areas:

i. Long term durability performance of GFRP as reinforcement bar in concrete
ii. Structural design performance of GFRP as reinforcement bar in concrete
iii. Any other tests deemed necessary for GFRP to be used as reinforcement bar in concrete

7.3 Validity

This Technical Opinion Report shall become invalid and irrelevant in the event the product does not comply with relevant International Standards or any approved equivalent Standards

currently in use. CIDB has the right to publicly announce any withdrawal related to this report subject to the terms above. This report is valid for three (3) years from the date of issuance.

8.0 APPROVED OPINION ABSTRACT

The Technical Expert Panel concludes that this product has a potential to be used in Malaysian construction industry. However, further research and development of the product performance in the local environment are encouraged. Applicant is advised to develop a QA / QC plan for GFRP production in Malaysia.

Dr. Foo Chee Hung
Chairman

Ir. Dr. Lim Char Ching
Technical Expert Panel

Dr. Teng Wan Dung
Technical Expert Panel

Associate Professor Dr. Zulkiflle Leman
Technical Expert Panel

January 2015

9.0 REFERENCE

ACI Committee 440 (2006), “Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars (ACI 440.1R-06),” American Concrete Institute, Farmington Hills, Michigan.

Appendix A

This page is intentionally left blank

CLIENT
GFRP Technologies Sdn. Bhd.
37-2, Block D-1, Jalan PJU 1/41,
Dataran Prima, 47301 Petaling Jaya,
Selangor Darul Ehsan, Malaysia.

JOB NO.: GFRPT-1 DOC. NO.: MCS 14-421

METACOS

MS ISO/IEC 17025
TESTING
SAMM No. 442

FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Control No.	MCS 14-172	**Our Ref.**	MCS/168/14
Our Job No.	GFRPT-1	**Our Document No.**	MCS 14-421
Testing Date	14th November 2014	**Report Issued Date**	14th November 2014
Subject	Fibre Reinforced Polymer Material Testing	**Attention**	Ms. Huang Mei Si

Our Condition *Please do not accept this report if it is defaced in any way.*

Sample Description	Reinforced bar	**Type of Fiber**	Glass
Fibre Volume Fraction	N/A	**Environment Temperature**	25.7°C
Nominal Diameter	10 mm	**Relative Humidity**	71%
Fibre Binding Material	1. Resin ED-20 2. Resin IMTGFA 3. Modifier DEG-1 4. Alcohol	**Conditioning**	The sample was left at the tested humidity and temperature for at least 24 hours before proceeding with the test.
Type of Liquid Used for Volume Measurement	Water	**Surface Modification**	Only at the area within the sleeve of the tensile specimen

Test Required

Item	Description	Test Code	Qty
1	Cross-Sectional Area Determination	ACI 440 3R-04	1
2	Full Tensile Test	ASTM D7205 : 2006 ACI 440.3R-04	1

Thank You for choosing Metallurgical Consultancy And Services Sdn. Bhd. as your preferred testing laboratory

Please check photocopy of this report with the original

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

PREPARED BY Ameer

REVIEWED BY Dr. C. L. Lim

FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%
Our Condition : Please do not accept this report if it has been altered or defaced in anyway			

1. *Cross-Sectional Area Determination*

Formula as provided by ACI 440.3R-04, Part 2, B.1 under clause 9.1:

$$A = \frac{\Delta V}{L} \times 1000 = \frac{V_1 - V_0}{L} \times 1000$$

Where, A = Cross-sectional area

ΔV = Volume of the GFRP
V_0 = Volume before submerging GFRP
V_1 = Volume after submerging GFRP
L = Average specimen length

Specimen	Length (mm)	L (mm)	V_1 (ml)	V_0 (ml)	ΔV (ml)	A (mm^2)	Equivalent Ø (mm)	Equivalent Circumference (mm)
1	202.76 202.66 202.34	202.59	232	220	12	59.23	8.68	27.28
2	202.02 201.48 202.62	202.04	232	220	12	59.39	8.70	27.32
3	201.82 202.22 202.52	202.19	232	220	12	59.35	8.69	27.31
4	202.60 202.58 202.64	202.61	232	220	12	59.23	8.68	27.28
5	200.22 200.12 200.20	200.18	232	220	12	59.95	8.74	27.44
Grand Average						**59.43**	**8.70**	**27.33**

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%
Our Condition : Please do not accept this report if it has been altered or defaced in anyway			

Mean of nominal tensile area	**59.43 mm^2**
Standard deviation of tensile area	**0.30**
Equivalent Diameter per Set	**8.70 mm**
Equivalent Circumference per Set	**27.33 mm**

Test conducted by : *Mr. Sharifah Binti Mohd. Nazri*

2. *Full Tensile Test*

Control No.	**MCS 14-172**
Nominal Tensile Area (mm^2)	59.53
Yield Load (N)	N/A
Yield Stress (N/mm^2)	N/A
Maximum Load (N)	59692
Tensile Strength (N/mm^2)	1002.75
Mode of Failure	**Brittle**
Conversion of N/mm^2 to psi is through multiplying N/mm^2 by 145.04	

Test conducted by : *Mr. Ameer Khan Bin Ibram Khan*

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

PREPARED BY Ameer

REVIEWED BY Dr. C. L. Lim

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%
Our Condition : Please do not accept this report if it has been altered or defaced in anyway			

Calculation of Young's Modulus

The Young's Modulus also known as the Elastic Modulus is the measure of the material's stiffness. Naturally, the greater the stiffness, the greater the value of the Young's Modulus.

An extensometer was attached to the sample during the tensile test to obtain an accurate measurement of the sample's elongation; thus, providing the alternate tensile graph on page 7/7. The formula and calculation of the Young's Modulus for MCS 14-172 is as below:

$$\text{Young's Modulus} = \frac{\text{Stress}}{\text{Strain}}]$$

$$= \frac{(27{,}100 - 8{,}600)/59.430}{(0.41 - 0.13)/42}$$

$$= 46.69 \text{ GPa}$$

Young's Modulus of Other Materials[1,2]:

Mild Steel	210 GPa	Concrete	16.5 - 17 GPa
Glass	50 - 90 GPa	Epoxy Resins	2 - 3 GPa

Reference:

[1] SchoolPhsics, Elastic Moduli and The Young Modulus
Sourced from: http://www.schoolphysics.co.uk/age16-19/Properties%20of%20matter/Elasticity/text/Elastic_moduli_and_Young_modulus/index.html

[2] The Engineering Toolbox, Young Modulus for Some Common Materials
Sourced from: http://www.engineeringtoolbox.com/young-modulus-d_417.html

CLIENT
GFRP Technologies Sdn. Bhd.
37-2, Block D-1, Jalan PJU 1/41,
Dataran Prima, 47301 Petaling Jaya,
Selangor Darul Ehsan, Malaysia.

JOB NO.: GFRPT-1 DOC. NO.: MCS 14-421

METACOS

MS ISO/IEC 17025
TESTING
SAMM No. 442

FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%
Our Condition : Please do not accept this report if it has been altered or defaced in anyway			

This is to certify that the statements in this report are correct. The above test is based solely on the test coupon submitted by client. The specimens were tested based on principles stated in ASTM D7205-06 and ACI 440.3R-04.

Approved Signatory :

Dr. Lim Ching Liang B. Sc (Hons) Ph. D. AIMMM FIMM
(Metallurgist)

Please check photocopy of this report with the original
This report should not be photocopied or transmitted electronically without written permission from MCS

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

PREPARED BY Ameer

REVIEWED BY Dr C. L. Lim

CLIENT
GFRP Technologies Sdn. Bhd.
37-2, Block D-1, Jalan PJU 1/41,
Dataran Prima, 47301 Petaling Jaya,
Selangor Darul Ehsan, Malaysia.

JOB NO.: GFRPT-1 DOC. NO.: MCS 14-421

METACOS

MS ISO/IEC 17025
TESTING
SAMM No. 442

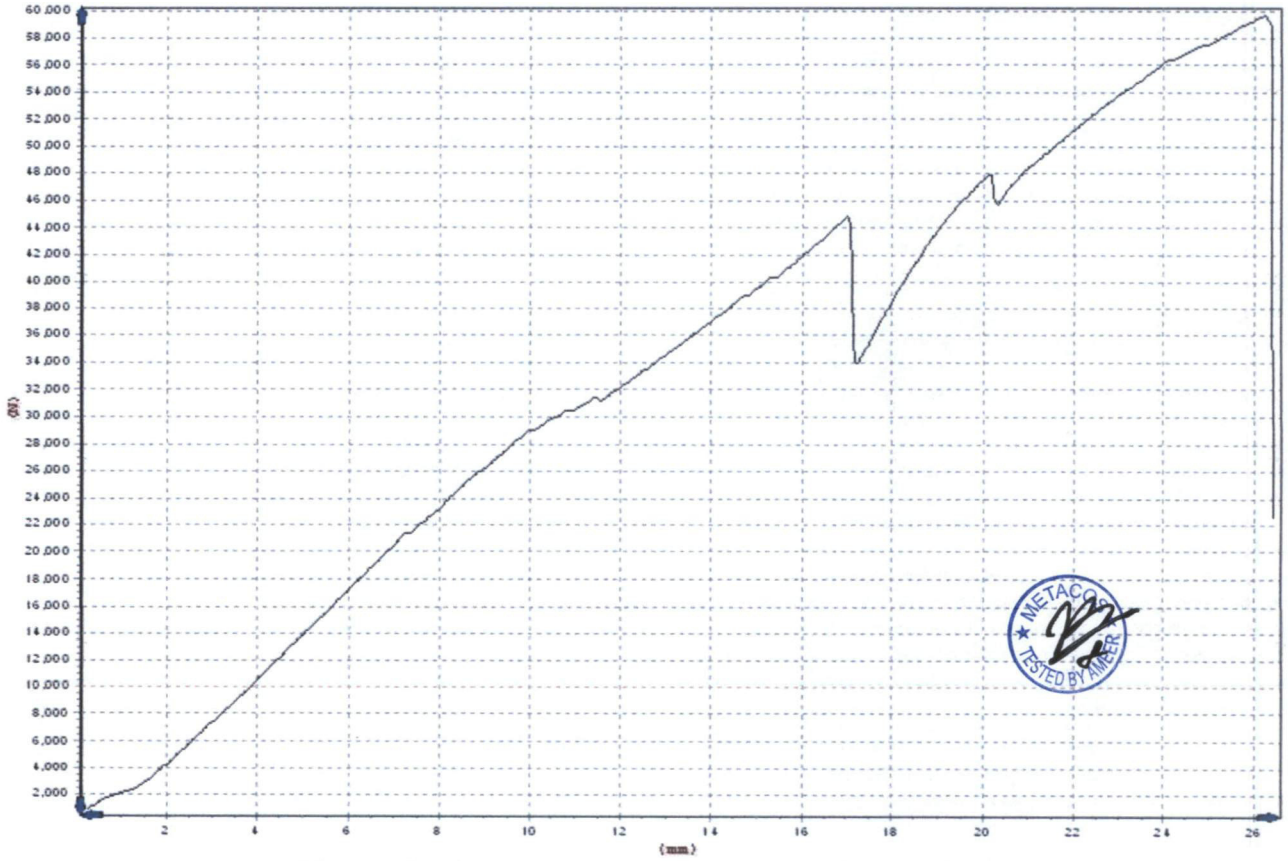
FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%

Our Condition : Please do not accept this report if it has been altered or defaced in anyway

Full Tensile Test: Graph of Load Against Displacement

Spec. No.	Test Specimen	Area mm^2	Max Force N	Tensile Strength N/mm^2
TT1	MCS 14-172 FT-1	59.53	59692	1002.75



Please check photocopy of this report with the original

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

PREPARED BY Ameer

REVIEWED BY Dr. E. L. Lim

CLIENT
GFRP Technologies Sdn. Bhd.
37-2, Block D-1, Jalan PJU 1/41,
Dataran Prima, 47301 Petaling Jaya,
Selangor Darul Ehsan, Malaysia.

JOB NO.: GFRPT-1 DOC. NO.: MCS 14-421

METACOS

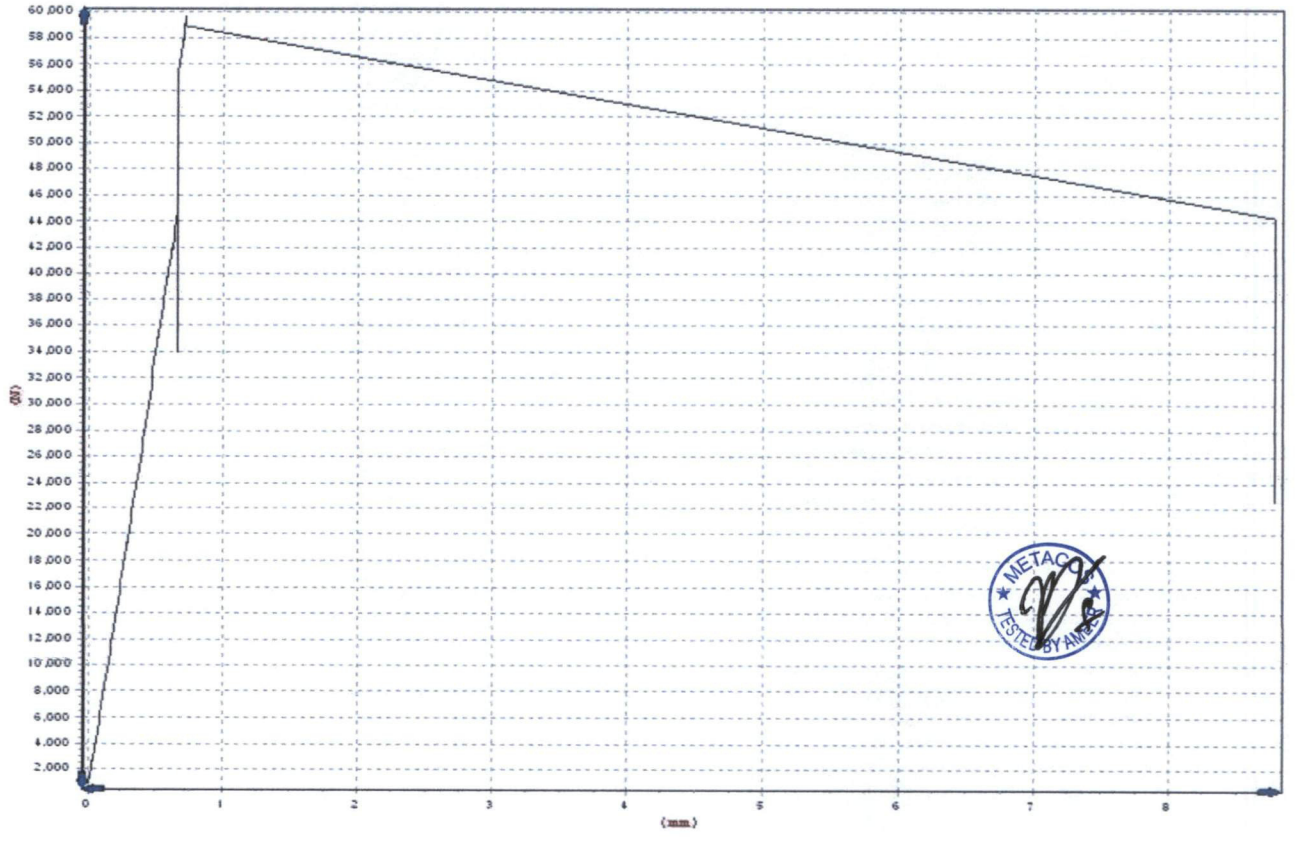
MS ISO/IEC 17025
TESTING
SAMM No. 442

FIBRE REINFORCED POLYMER MATERIAL TESTING

Our Ref. No.	MCS/168/14	**Control No.**	MCS 14-172
Temperature	25.7°C	**Humidity**	71%
Our Condition : Please do not accept this report if it has been altered or defaced in anyway			

Full Tensile Test: Graph of Load Against Displacement Measured by Extensometer

Spec. No.	Test Specimen	Area mm^2	Max Force N	Tensile Strength N/mm^2
TT1	MCS 14-172 FT-1	59.53	59692	1002.75



Please check photocopy of this report with the original

METALLURGICAL CONSULTANCY AND SERVICES SDN. BHD. (72515-X)
No. 20 Jalan U5/17, Seksyen U5 (PS), 40150 Bandar Shah Alam, Selangor, Malaysia
Tel : 603-78450730/40 Fax : 603-78450729/37/39

PREPARED BY *Ameer*

REVIEWED BY *Dr. C. L. Lim*

Appendix B

This page is intentionally left blank

SIRIM Berhad (Company No. 367474-V)
Technical Services and Consultancy Section
Advanced Materials Research Centre
Tel: (603) 5544 6856/58Fax: (603) 5544 6867

CONFIDENTIAL

EVALUATION REPORT

Title:	**Coefficient of Thermal Expansion using Dilatometer**
Report No:	ER 14084
Date:	13 November 2014
Job No.:	TS 14196
Sample:	GFRP Reinforcement Rebar
Company Name:	GFRP Technologies Sdn. Bhd.
Address:	37-2, Block D1 Jalan PJU 1/41, Dataran Prima 47301 Petaling Jaya Selangor

Checked by:

.....
Zalena Saem

Approved by:

.....
Mazlan Mohamad
Section Head

SIRIM Berhad
(No. Syarikat 367474 - V)
1, Persiaran Dato' Menteri
Seksyen 2, Peti Surat 7035
40700 Shah Alam
MALAYSIA
Tel: 60-3-55446000
Hotline: 60-3-55103535
Faks: 60-3-55108095
Website : www.sirim.my

ADVANCED MATERIALS RESEARCH CENTRE * SIRIM BERHAD

SAMPLE IDENTIFICATION

Five (5) samples of GFRP reinforcement rebar, length 60 cm with diameter of 4 mm, 6 mm, 8 mm, 10 mm and 12 mm respectively were received on 16 October 2014 for coefficient of thermal expansion (CTE) test.

SPECIFICATION/ TEST METHOD

The coefficient of thermal expansion (CTE) test from 30°C to 100°C with heating rate of 5°C /min was conducted using Linseis, Dilatometer.

RESULTS

The CTE results are shown in Tables 1 to 5. The CTE curves are exhibited in Appendix.

ADVANCED MATERIALS RESEARCH CENTRE * SIRIM BERHAD

SIRIM Berhad
(No. Syarikat 367474 - V)
1, Persiaran Dato' Menteri
Seksyen 2, Peti Surat 7035
40700 Shah Alam
MALAYSIA
Tel: 60-3-55446000
Hotline: 60-3-55103535
Faks: 60-3-55108095
Website : www.sirim.my

Table 1. CTE of GFRP reinforcement rebar 4 mm

Temperature (°C)	Coefficient of Thermal Expansion (x $10^{-6}K^{-1}$)			
	1	2	3	Average
30	3.23	8.63	5.61	5.82
40	6.41	9.21	7.07	7.56
50	7.06	9.47	7.26	7.93
60	6.54	9.28	7.48	7.77
70	5.57	7.65	7.03	6.75
80	5.24	7.53	6.84	6.54
90	4.96	7.34	6.68	6.33
100	5.04	7.07	6.52	6.21

Table 2. CTE of GFRP reinforcement rebar 6 mm

Temperature (°C)	Coefficient of Thermal Expansion (x $10^{-6}K^{-1}$)			
	1	2	3	Average
30	6.50	5.74	4.48	5.57
40	7.52	7.26	6.16	6.98
50	8.46	8.41	7.02	7.96
60	8.64	8.85	7.47	8.32
70	8.61	8.67	7.47	8.25
80	6.98	6.83	5.87	6.56
90	3.66	1.79	5.43	3.63
100	3.44	0.76	5.38	3.19

SIRIM Berhad
(No. Syarikat 367474 - V)
1, Persiaran Dato' Menteri
Seksyen 2, Peti Surat 7035
40700 Shah Alam
MALAYSIA
Tel: 60-3-55446000
Hotline: 60-3-55103535
Faks: 60-3-55108095
Website : www.sirim.my

Table 3. CTE of GFRP reinforcement rebar 8 mm

Temperature (°C)	Coefficient of Thermal Expansion (x $10^{-6}K^{-1}$)			
	1	2	3	Average
30	5.44	7.25	4.98	5.89
40	6.39	7.52	6.08	6.66
50	7.26	8.12	6.85	7.41
60	7.80	8.60	7.19	7.86
70	7.87	8.55	7.38	7.93
80	7.74	7.48	7.46	7.56
90	7.08	6.93	7.33	7.11
100	6.91	6.81	7.13	6.95

Table 4. CTE of GFRP reinforcement rebar 10 mm

Temperature (°C)	Coefficient of Thermal Expansion (x $10^{-6}K^{-1}$)			
	1	2	3	Average
30	5.14	6.96	6.47	6.19
40	6.60	7.24	6.69	6.84
50	7.49	7.59	7.33	7.47
60	7.87	8.27	7.78	7.97
70	7.93	8.33	7.99	8.08
80	7.86	8.11	8.27	8.08
90	7.78	7.94	7.91	7.88
100	7.76	7.84	7.50	7.70

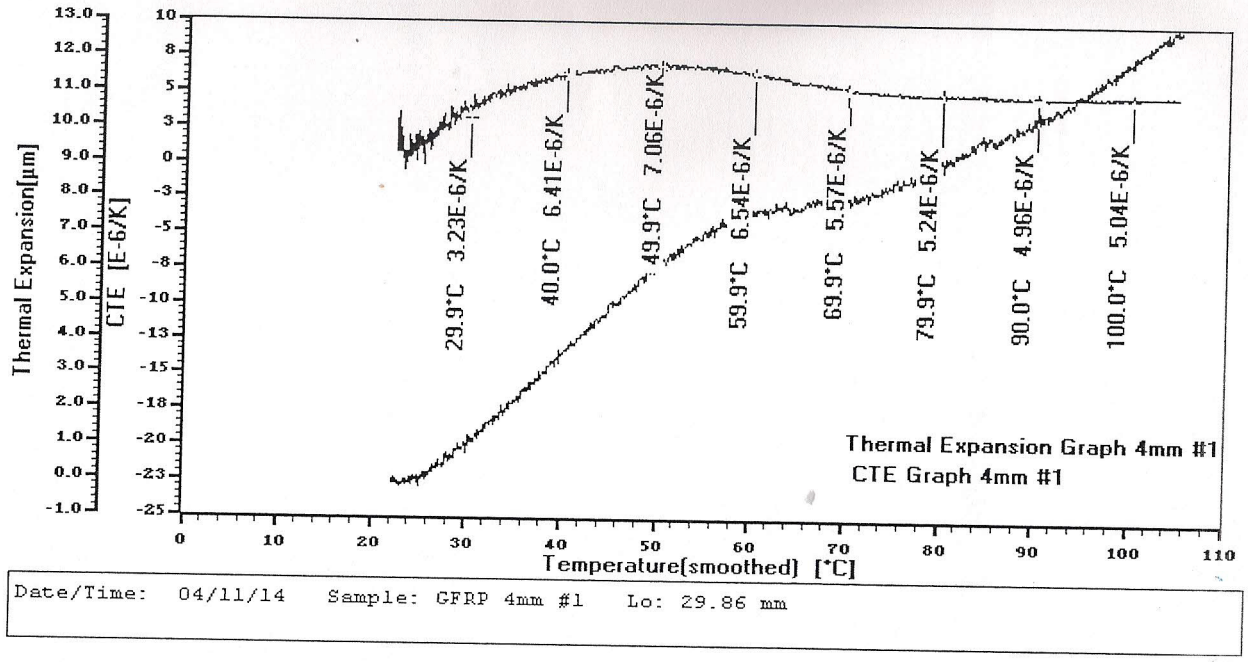
SIRIM Berhad
(No. Syarikat 367474 - V)
1, Persiaran Dato' Menteri
Seksyen 2, Peti Surat 7035
40700 Shah Alam
MALAYSIA
Tel: 60-3-55446000
Hotline: 60-3-55103535
Faks: 60-3-55108095
Website : www.sirim.my

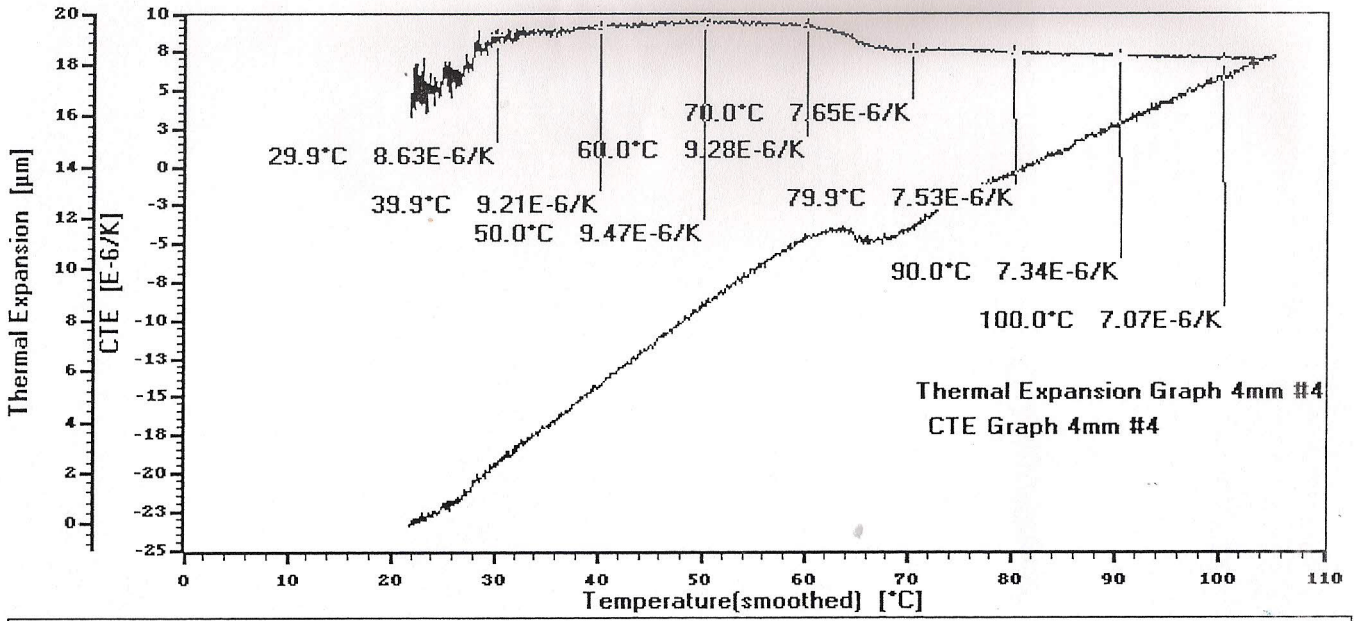
Table 5. CTE of GFRP reinforcement rebar 12 mm

Temperature (°C)	Coefficient of Thermal Expansion (x $10^{-6}K^{-1}$)			
	1	2	3	Average
30	6.48	6.58	6.79	6.62
40	7.41	6.80	7.67	7.29
50	7.82	7.51	8.18	7.84
60	8.15	7.86	8.52	8.18
70	8.38	7.90	8.60	8.29
80	8.33	7.92	8.68	8.31
90	8.01	7.75	8.38	8.05
100	7.58	7.35	7.92	7.62

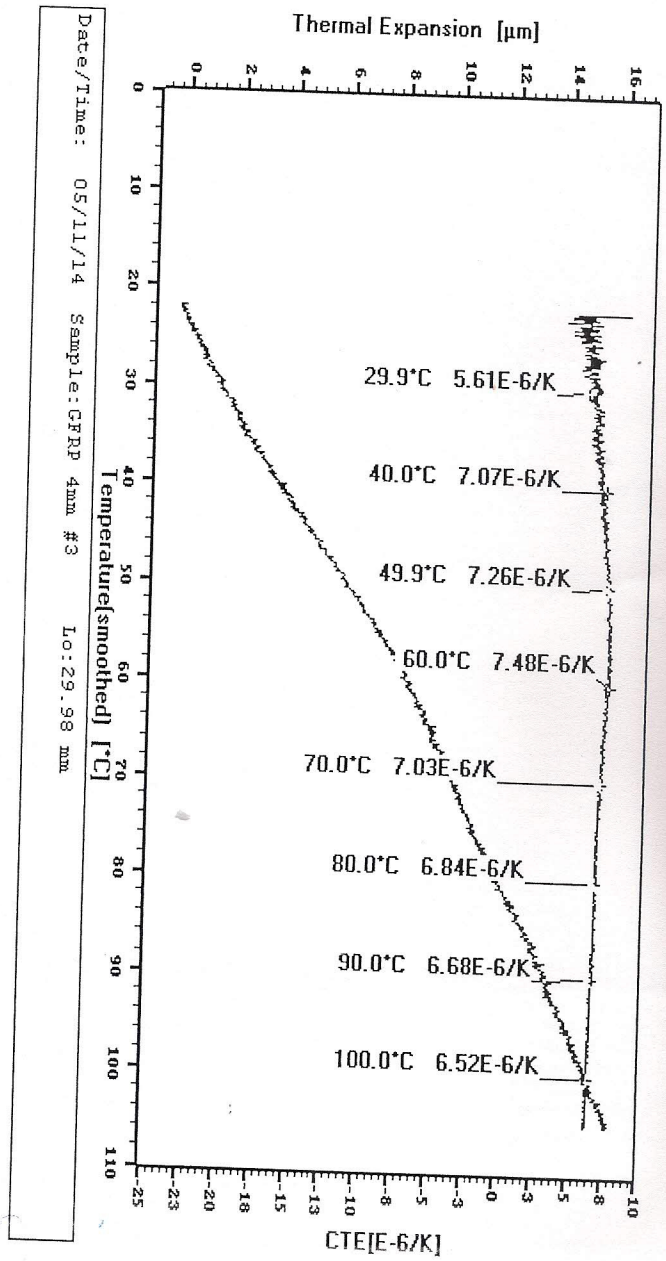
ADVANCED MATERIALS RESEARCH CENTRE * SIRIM BERHAD

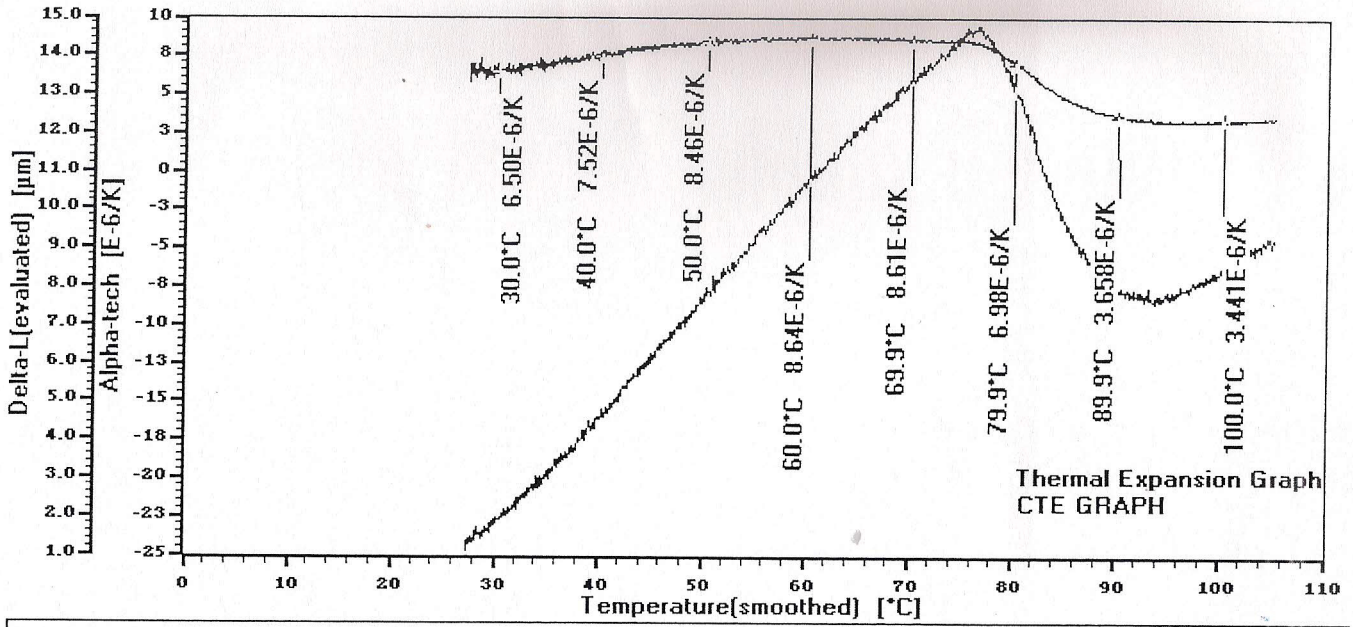
SIRIM Berhad
(No. Syarikat 367474 - V)
1, Persiaran Dato' Menteri
Seksyen 2, Peti Surat 7035
40700 Shah Alam
MALAYSIA
Tel: 60-3-55446000
Hotline: 60-3-55103535
Faks: 60-3-55108095
Website : www.sirim.my

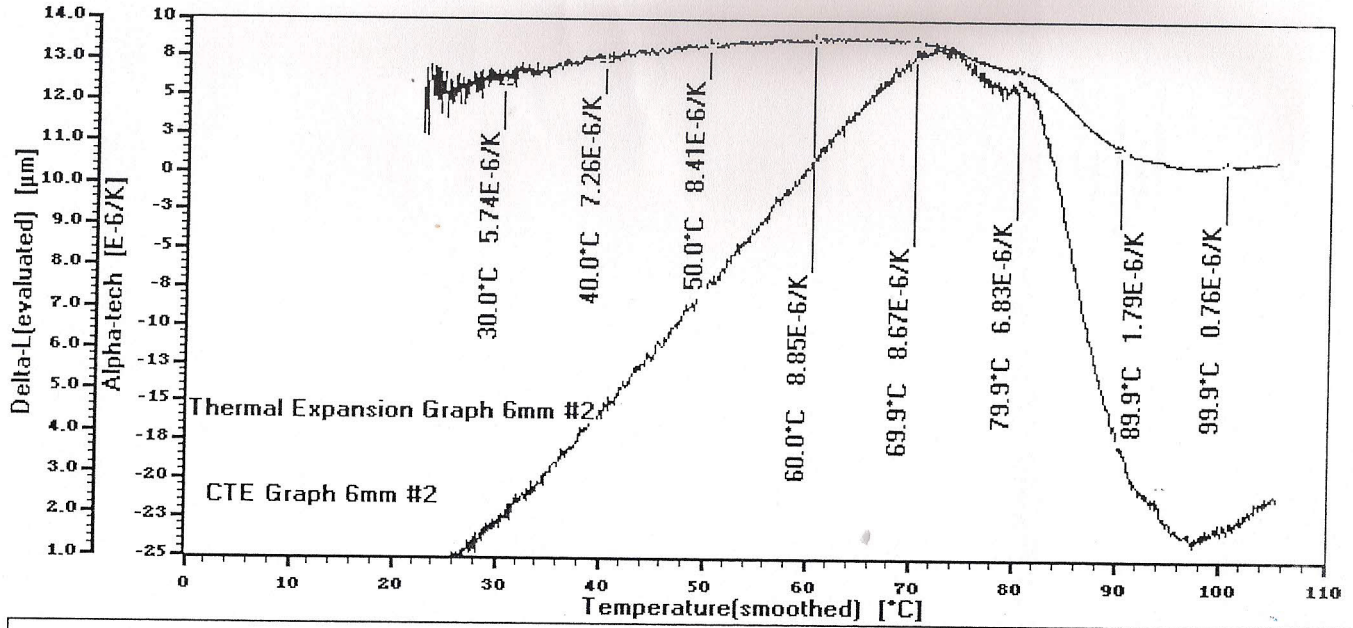


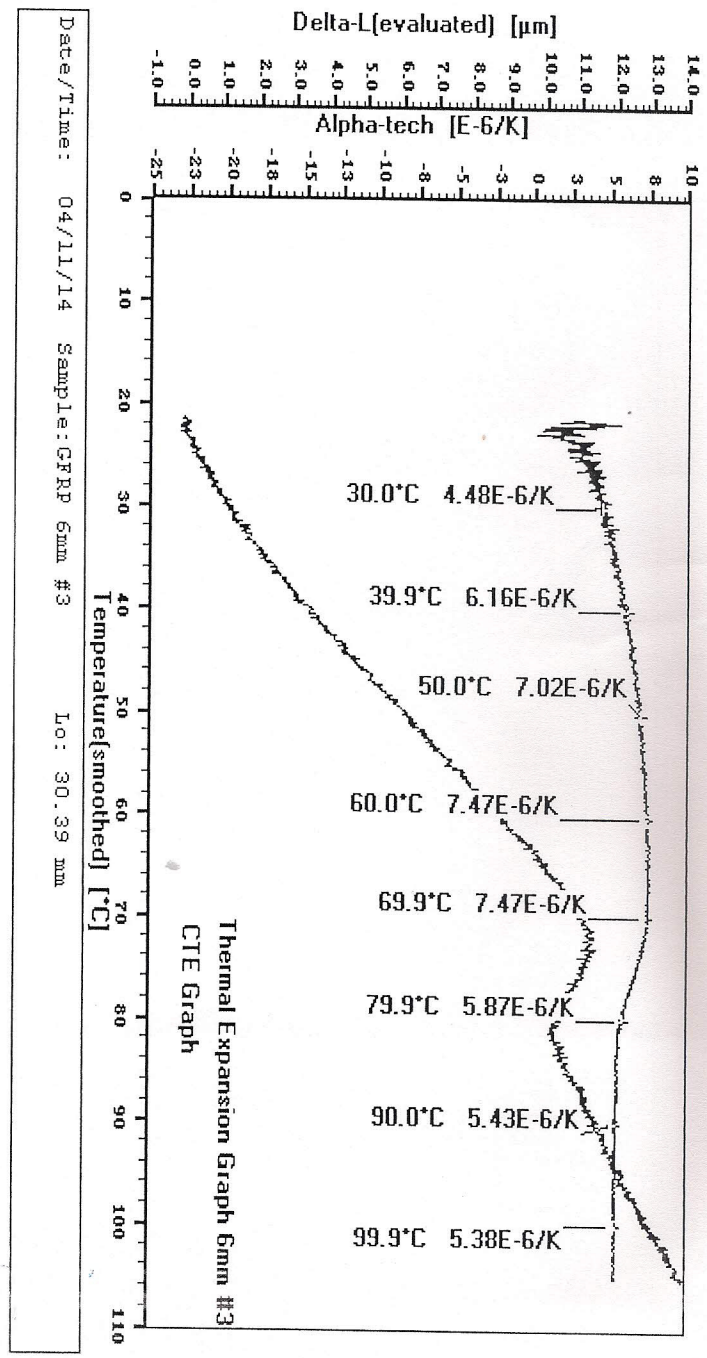


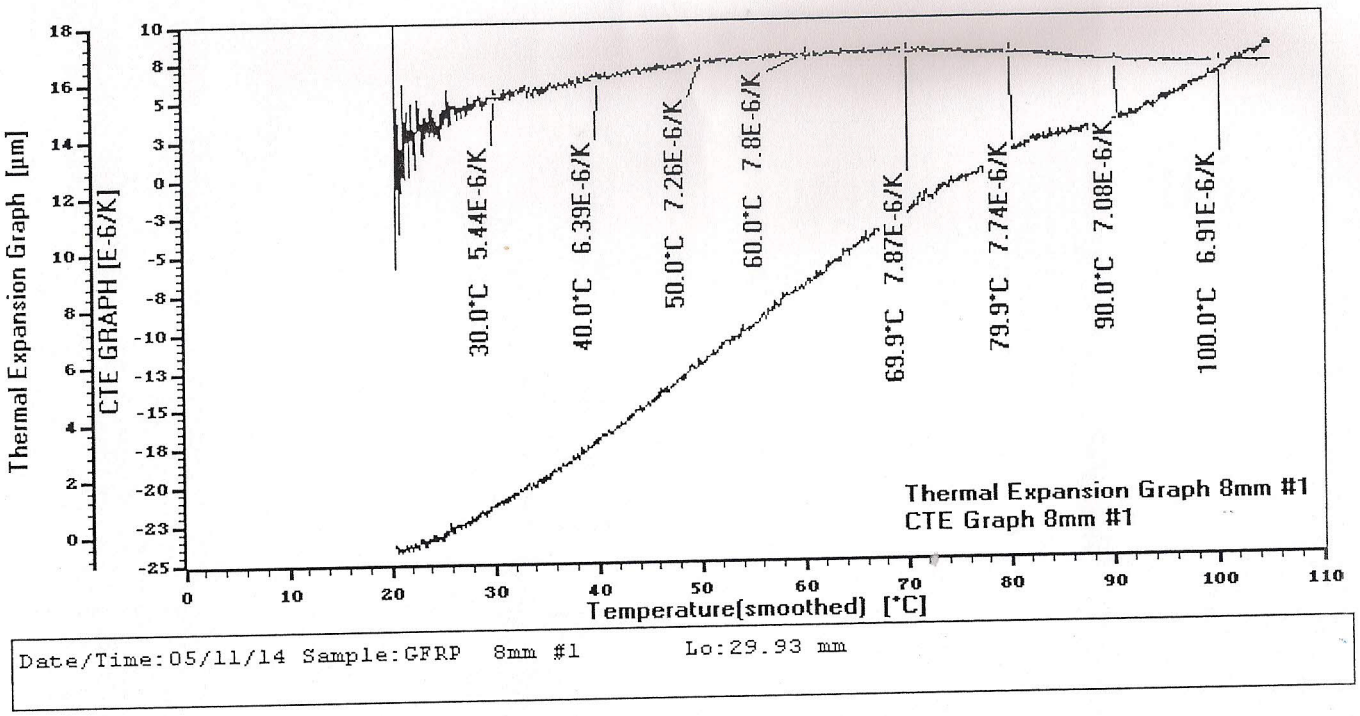
Date:13/11/14 Sample:GFRP 4mm #2 Lo:31.07 mm

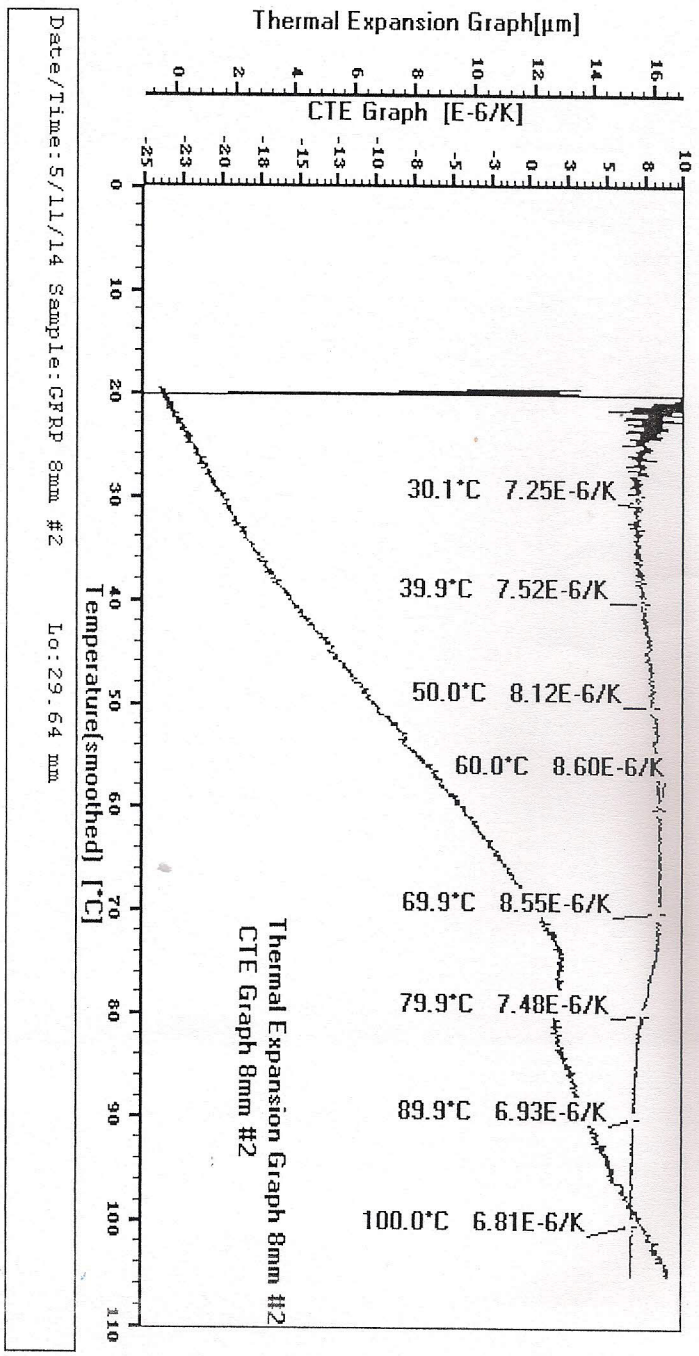


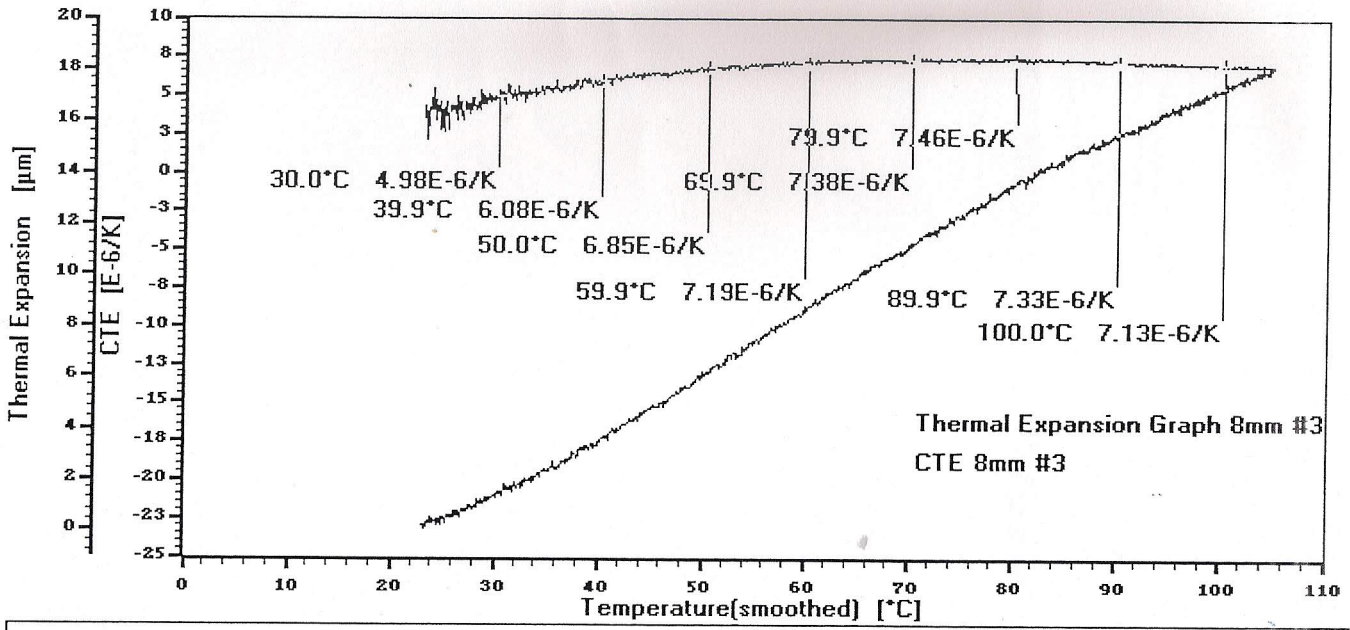




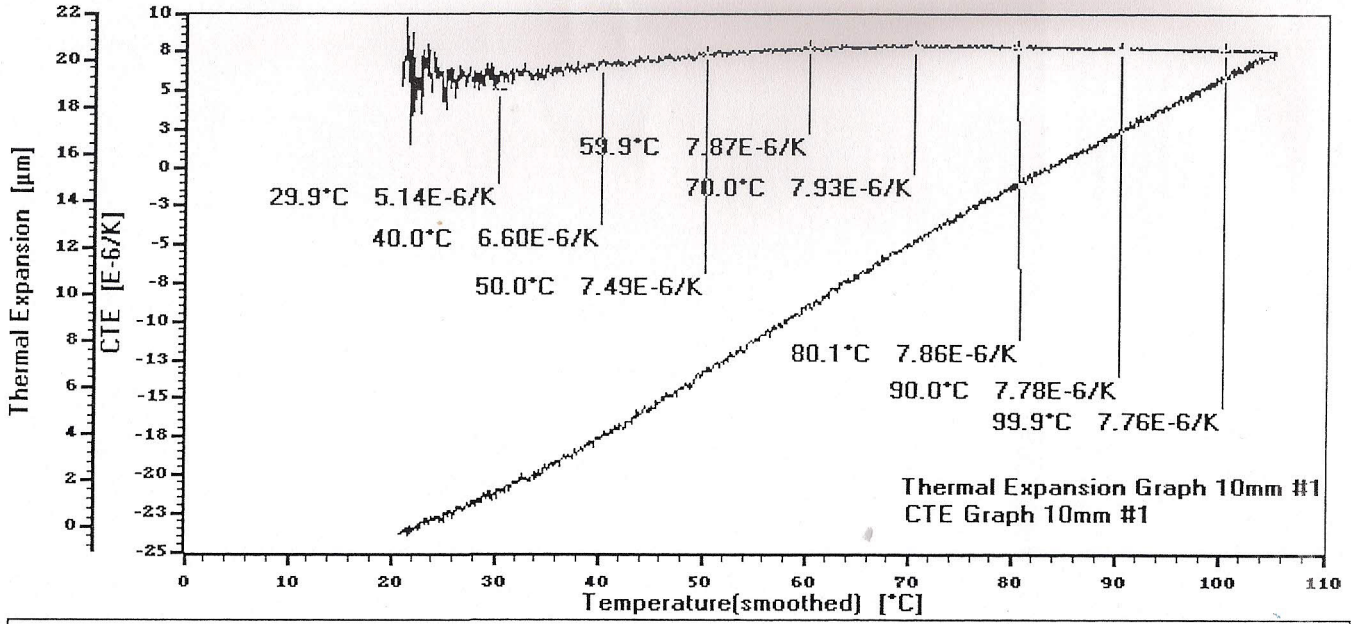




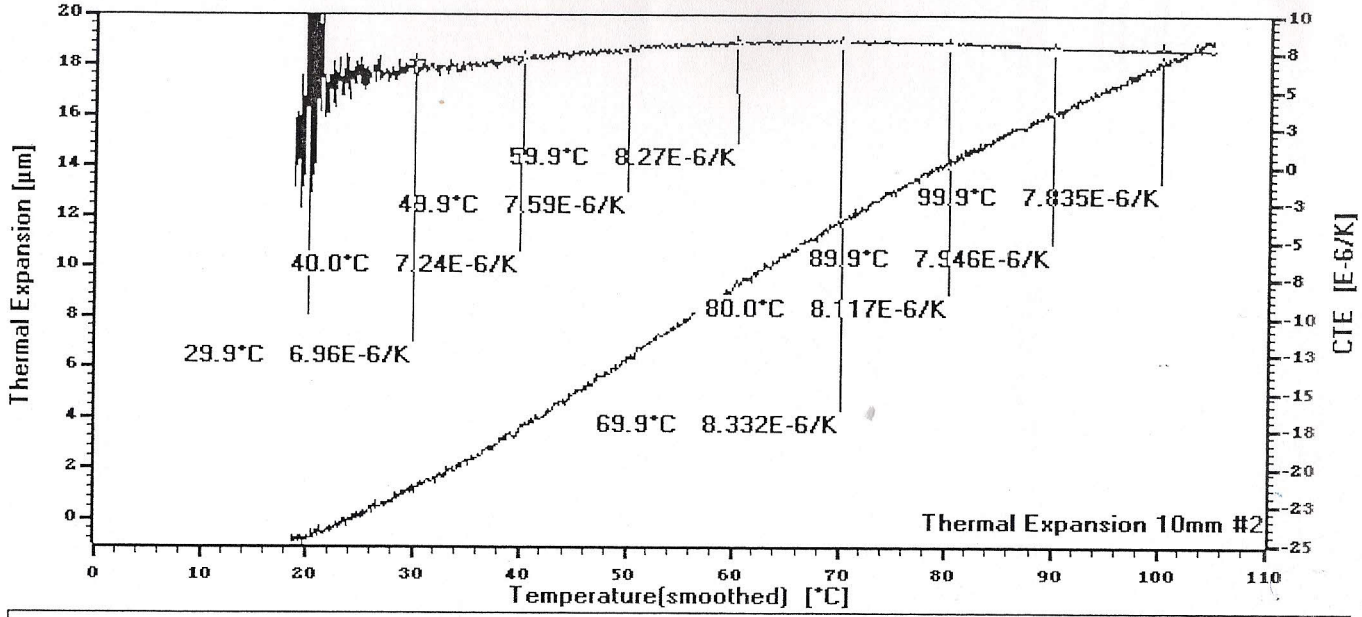




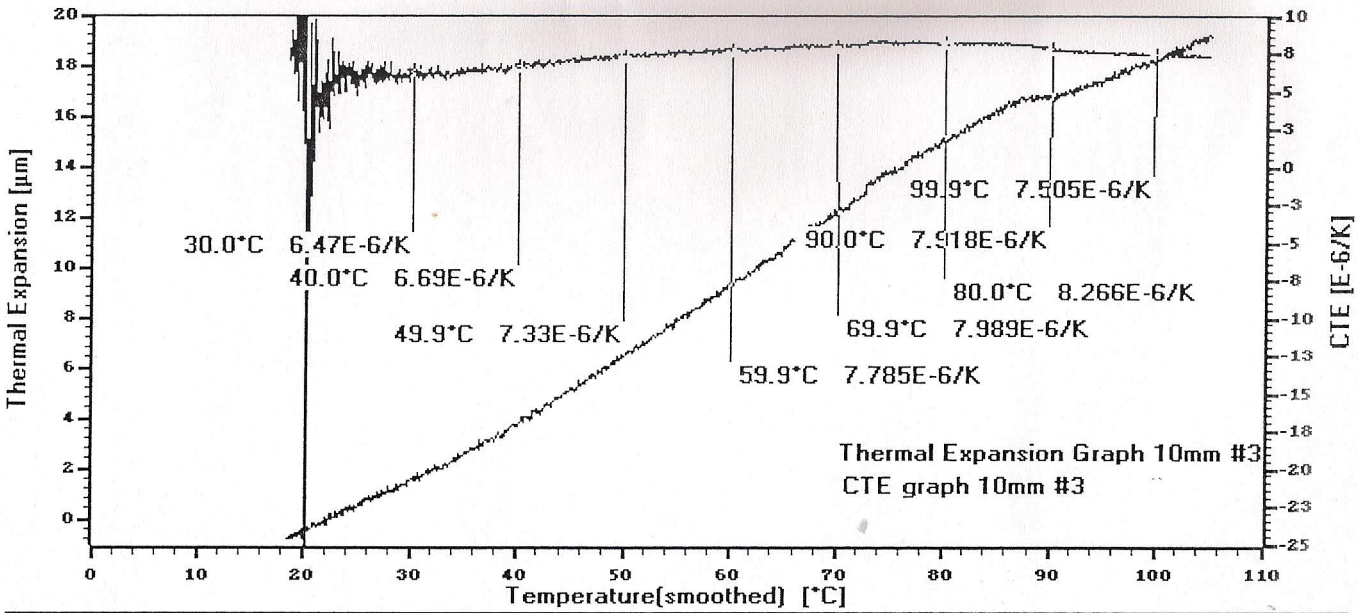
Date:06/11/14 Sample:GFRP 8mm #3 Lo:30.67 mm



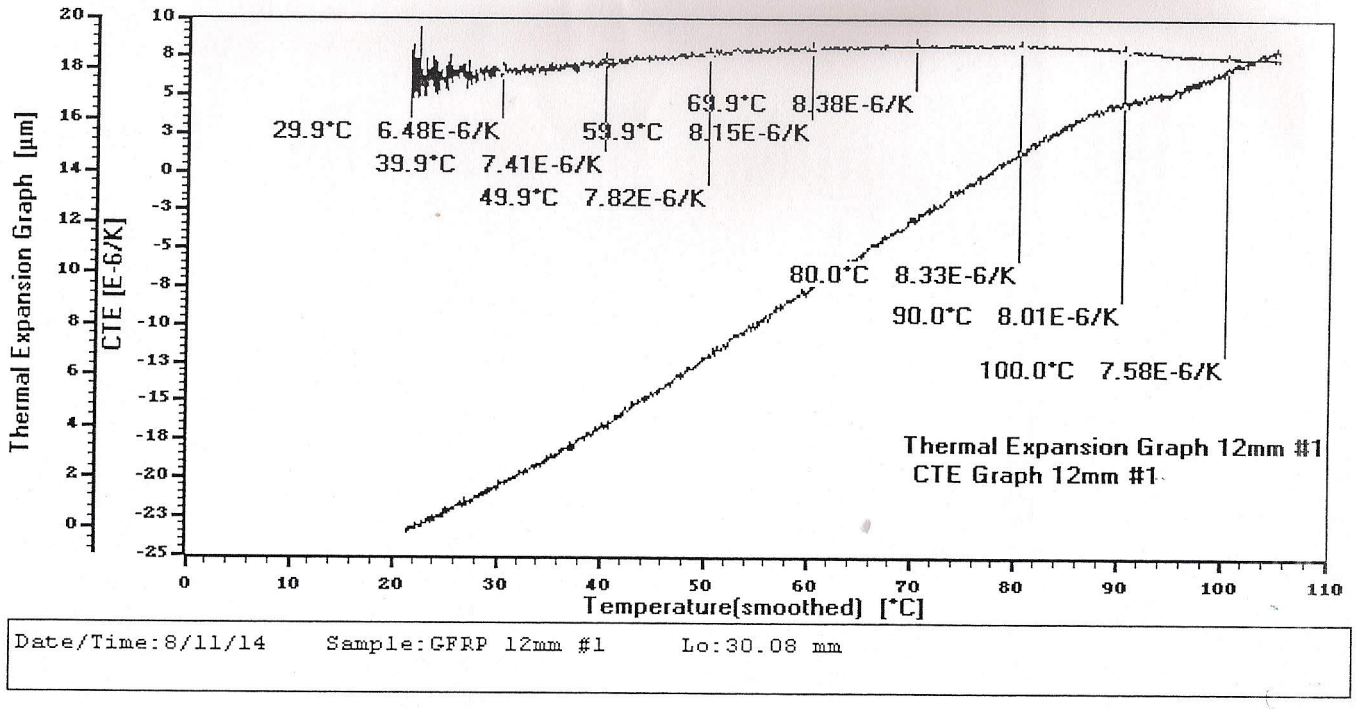
Date:11/11/14 Sample:GFRP 10mm #1 Lo:31.77 mm

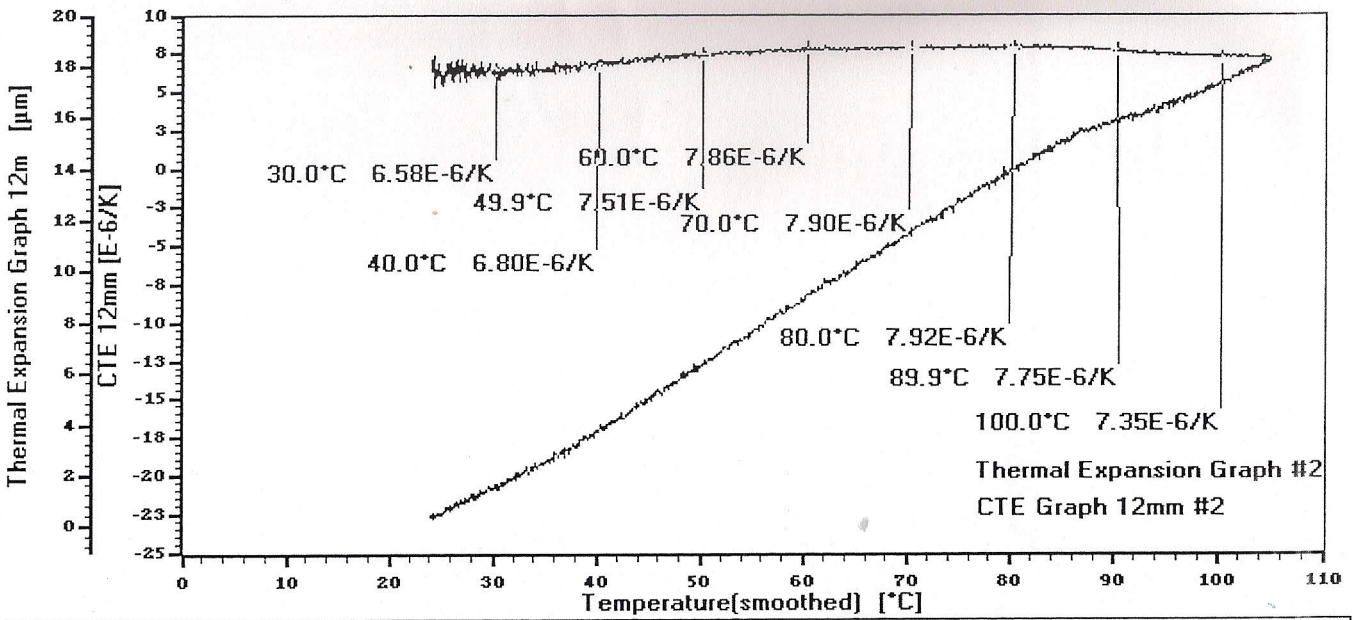


Date: 11/11/14 Sample: GFRP 10mm #2 Lo: 30.33 mm

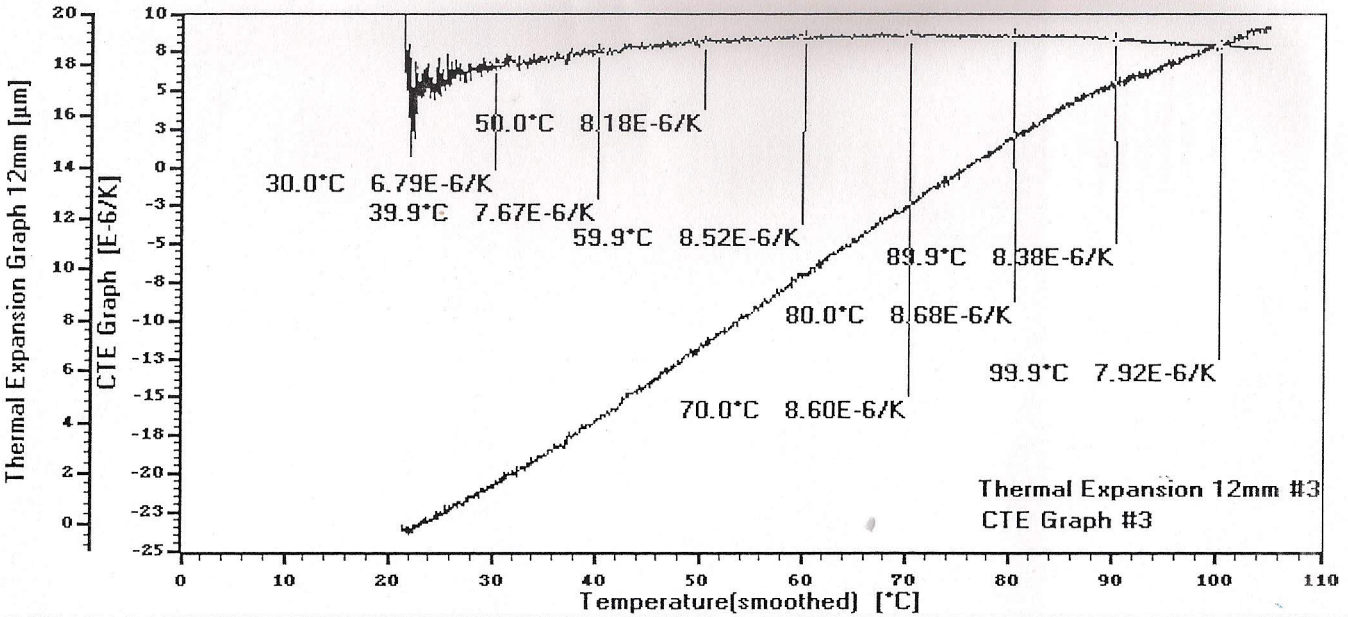


Date: 11/11/14 Sample: GFRP 10mm #3 Lo:31.21 mm





Date/Time:08/11/14 Sample:GFRP 12mm #2 Lo:30.03 mm



Date:8/11/2014 Sample:GFRP 12mm #3 Lo:30.21 mm

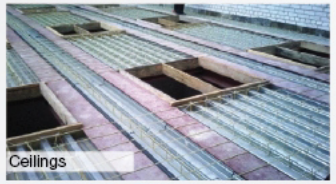
Appendix C

This page is intentionally left blank

References


Foundations


Petrol Stations


Ceilings


Rail traverse


Industrial floors


Sea walls


Bridges


Railroads

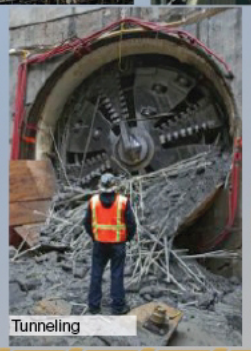

Road paving

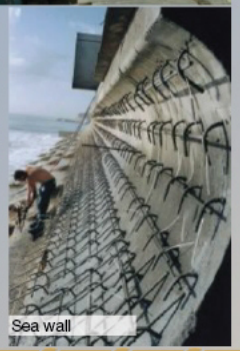

Concrete/masonry strengthening


Bridge deck

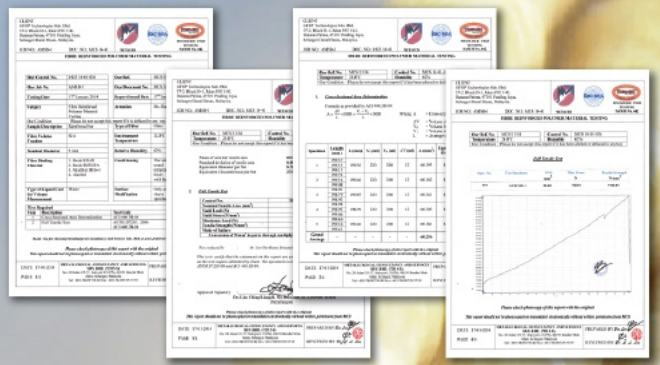

Dry dock


Concrete/ masonry strengthening


Tunneling


Sea wall

GFRP Technologies Sdn Bhd



Contact Us

Address:
Malaysia office: 37-2, Block D1, Jalan PJU 1/41, Dataran Prima, 47301 Petaling Jaya, Malaysia

Tel : **+603 7804 3101**
Fax : **+603 7805 1529**
e-mail : **enquiries@gfrp-tech.com**
Website : **www.gfrp-tech.com**

GFRP Technologies Sdn Bhd
875558-A

FIBREGLASS REINFORCEMENT

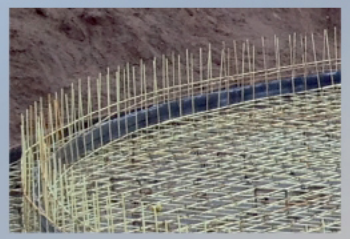
COST EFFECTIVE

Description of GFRP reinforcement

Fibreglass reinforcement "GFRP Technologies" is a fibreglass rod with a diameter of 4 mm to 20mm with a spiral ribbed profile consisting of fibreglass related polymer-based epoxy resin. Non-toxic,the degree of impact on the human body and the environment relates to hazard class 4 (low hazard) Standard (rOCT 12.1.007.)

GFRP Technologies is a dynamic company specializing in the distribution of reinforcements made of composite materials. GFRP Technologies offers an innovative reinforcement system, that can be utilized in many applications within the construction industry.

There is enormous potential for composite materials, especially in the construction industry. No other material is so versatile, meets sustainability requirements and has clear economic advantages for clients.

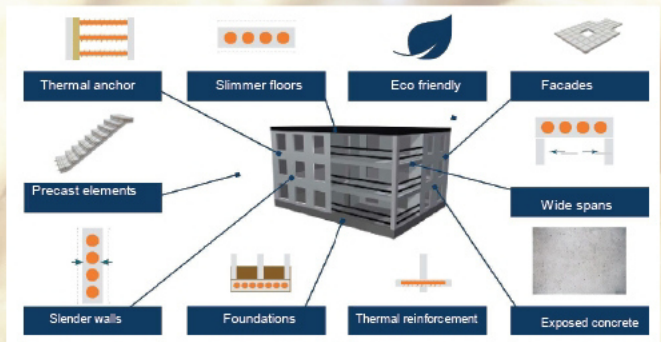


Resistance Chart

LIGHTWEIGHT

Range of Applications

Composite rebar can be successfully applied in the following areas of construction:



Industrial flooring | Chemical plants, oil and gas refineries | Parking garages

Treatment plant | Quay walls and wharfs | Hydropower plant

RELIABLE

Comparative characteristics of

STEEL AND FIBERGLASS REINFORCEMENT

CHARACTERISTICS	Rebar	
	Metal reinforcement MS500	FRP reinforcement GFRP Technologies
Material	Steel	Fiberglass, soaked in a polymer based on epoxy resin
Ultimate tensile strength, MPa	500	1200
Modulus of elasticity, MPa	200 000	55 000
Elongation, %	25	2,2
Corrosion resistance to aggressive media	Subject to corrosion	Not subject to corrosion
Heat conduction	Is a head-conducting	Is not heat-conducting
Electroconductivity	Conducts electricity	Non-conducting - is a dielectric
Produced profiles	6 - 80	4 - 20
Length	The rods of length 6-12 m	According to customer request
Environmentally friendly	Is environmentally friendly	Is not toxic, the degree of impact on humans and the environment belongs to the 4 hazard class (low hazard).
Longevity	In accordance with building standards	Predicted life at least 80 years
GFRP equivalents for steel rebar	6 mm	4 mm
	8 mm	6 mm
	10 mm	7 mm
	12 mm	8 mm
	14 mm	10 mm
	16 mm	12 mm
	18 mm	14 mm
	20 mm	16 mm
Weight (with equal strength on the replacement), kg	6 mm - 0.222	4 mm - 0.02
	8 mm - 0.395	6 mm - 0.05
	10 mm - 0.67	7 mm - 0.07
	12 mm - 0.92	8 mm - 0.08
	14 mm - 1.28	10 mm - 0.12
	16 mm - 1.58	12 mm - 0.20
	18 mm - 2.0	14 mm - 0.26
	20 mm - 2.47	16 mm - 0.35

Appendix D

This page is intentionally left blank

FRACHT Aeronautica

Производство стекловолокна арматуры

Product Description

Glass Fiber Reinforced Polymer

Contents

Fracht Aeronautica.....4
GFRP Rebar 4
Properties 5
Advantages of Rebar compared to reinforcing steel..6
Advantages of the use of Rebar.....8
Precast concrete elements.....9
Road and Rail infrastructure.....10
Building.....11
Tunneling & Civil Engineering.....12
Industry.....13
Water and Marine.....14
Technical Data.....15
Product.....16
References.....17
Guidelines.....18

FRACHT AERONAUTICA

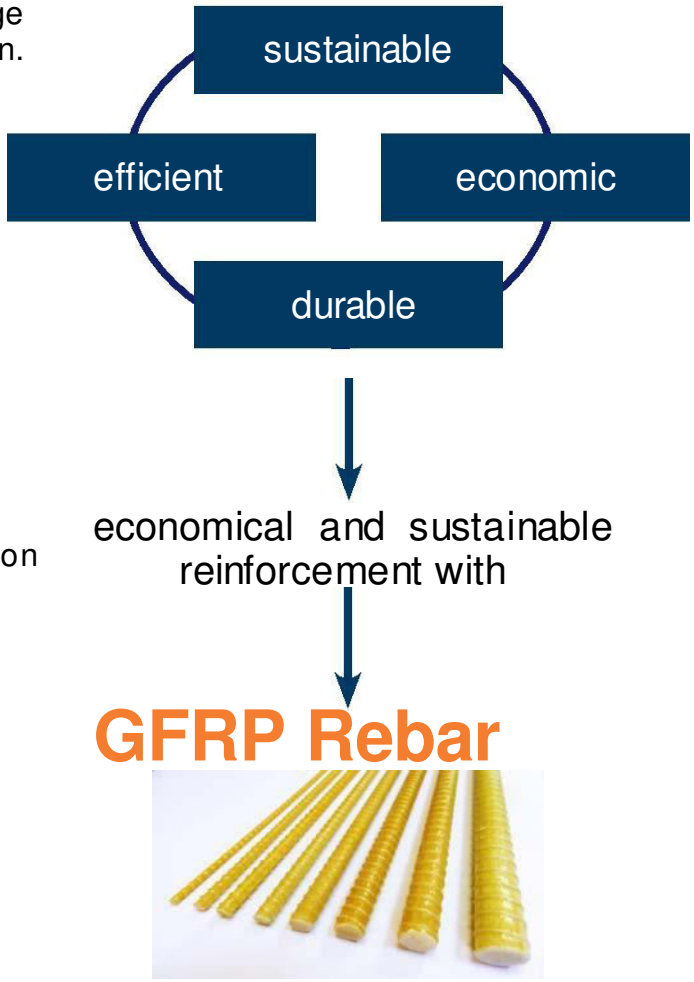
Fracht Aeronautica is a dynamic company specializing in the distribution of reinforcements made of composite materials. Fracht Aeronautica offers an innovative reinforcement system, that can be utilized in many applications within the construction industry.

There is enormous potential for composite materials, especially in the construction industry. No other material is so versatile, meets sustainability requirements and has clear economic advantages for clients.

GFRP REBAR

As constructional material, steel has been a huge success story ever since the industrial revolution. However, steel also has its disadvantages, such as its low resistance to corrosion and the resulting limited lifetime, which has lead engineers to look for alternative solutions. Fiber composites are a good alternative which have been successfully used since the 1980's in various industries (e.g. automotive, aircraft ships and construction). One of the most prominent among composites is glass fiber reinforced plastics (GFRP).

With its desirable physical properties and major advantages over steel, GFRP is destined to be used in many applications in modern construction industry and remedy a magnitude of previously unsolvable problems. One of its most interesting applications is its use as concrete reinforcement. After extensive development and certified testing



Properties of **GFRP REBAR**

The product properties of **GFRP Rebar** are proven to offer clear advantages in economy quality and technology of construction. The product is easy to handle and has numerous applications in the most demanding applications. It is characterized by a high tensile strength and strong resistance to corrosion, chemicals and chlorides. It is highly suitable for applications that are sensitive to electric or magnetic fields or require thermal conductivity.

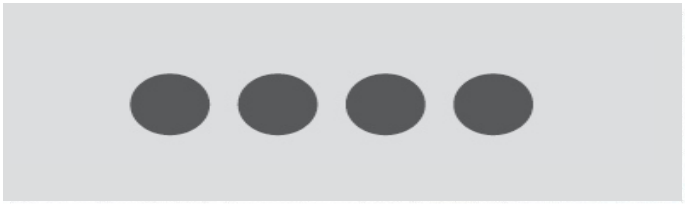
GFRP Rebar allows for the possibility of reduced concrete cover and extending the life of the construction element considerably. Therefore a new standard of sustainability is achieved.

GFRP Rebar of Fracht Aeronautica creates a reinforcement technology, which combines modern construction with a clear economic value.

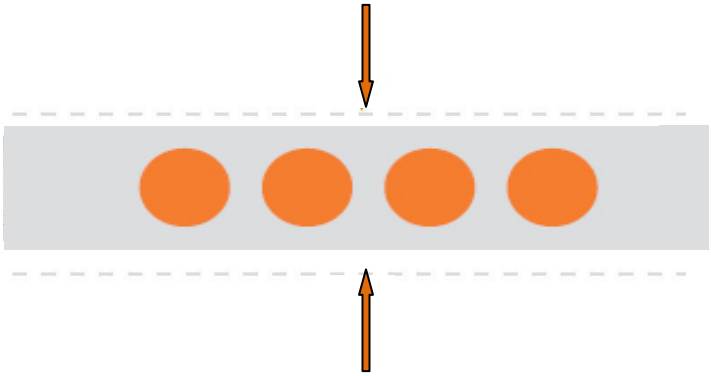
- corrosion resistant
- high tensile strength
- resistant to Chemicals
- chloride resistant
- electrically insulated
- thermally insulated
- non-magnetic
- lightweight
- easily workable
- economical

Advantages of **GFRP Rebar** in comparison to reinforcing steel

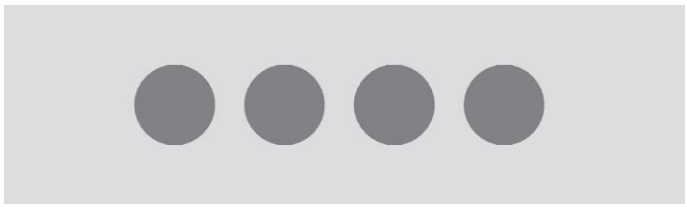
reinforcing steel



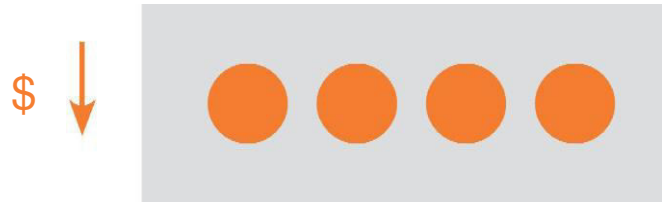
GFRP Rebar



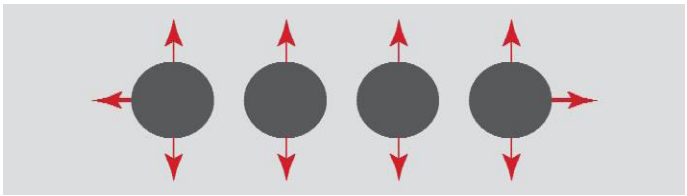
- thinner concrete sections
- less concrete usage
- ideal for exposed concrete
- easier to handle

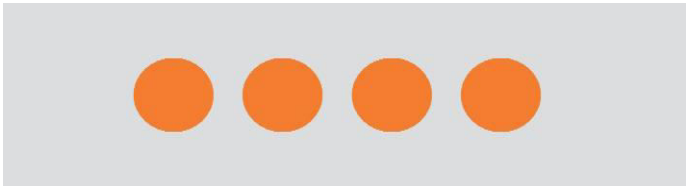


the cost of reinforcement with stainless steel is many times more than **GFRP Rebar**



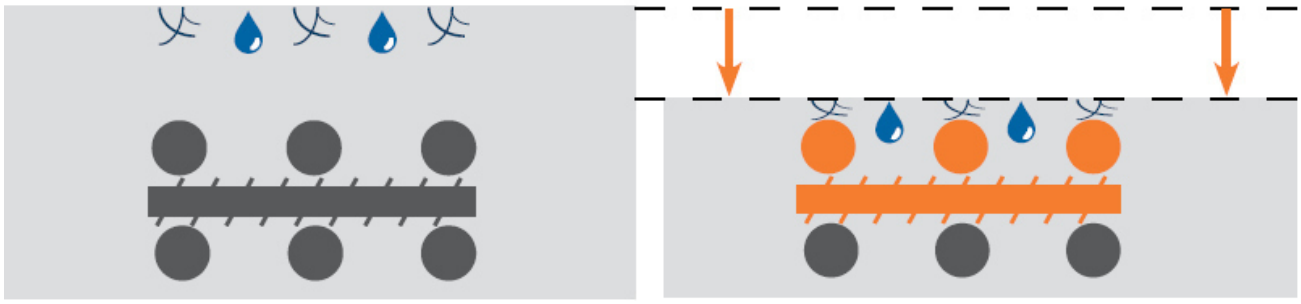
GFRP Rebar is a much more favourable alternative to reinforcement than using stainless steel, epoxy coated or galvanised steel. It is even less costly than black steel in many applications.





GFRP Rebar is thermally non-conductive and does not interfere with electric nor magnetic fields.

- Thermal anchor
- Transistor rooms
- Lab and MRI
- Signaling (Rail)



GFRP Rebar can be used for surface reinforcement and for crack limitation.

- Industrial floors
- Dry shrinkage prevention
- Parking garages
- Tunneling

Due to the significantly higher tensile strength of **GFRP Rebar** ,when compared to conventional steel rebars much smaller diameters can be used.

Due to the significantly higher tensile strength of **GFRP Rebar** ,when compared to conventional rebars, wider spacing between rebars can be selected.

GFRP Rebar is approximately 10% the weight of steel for the equivalent size diameter and length.

Advantages of using **GFRP Rebar**

GFRP Rebar is...

corrosion resistant, thereby the amount of concrete cover can be reduced to a minimum. → thinner concrete cover

cost-efficient, which in addition to less concrete reduces the overall construction costs. In many instances, using this material works out to be less expensive than steel. → lower total construction costs

resistant, being resistant to corrosive environments significantly extends the overall lifespan. → longer life

sustainable, because fewer materials are required, the lifespan of structures are extended with less environmental impact. → sustainable & resource efficient

corrosion resistant, thereby no rusting occurs as a result of carbonation of the concrete. → no carbonation

corrosion-free, which extends the intervals between renovations and minimizes maintenance costs. → minor rehabilitation costs

not a conductor, therefore the rebar does not conduct any electrical current and is transparent to magnetic fields and radio waves. → non-magnetic

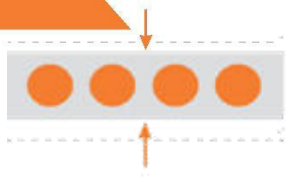
non-magnetic, thereby no currents can be induced. → no heating by induction

insulated, against electric and magnetic currents and therefore will not affect high voltage appliances used in structures. → no disturbance of signal transmission

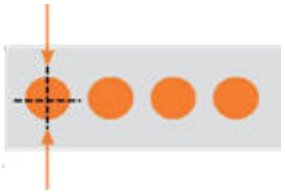
Precast concrete elements

Lower cost and shorter construction periods is of paramount importance in modern construction projects. For this reason, use of precast concrete sections has become common-place in todays construction sites.

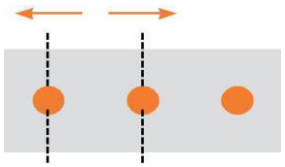
The requirement for lower costs and shorter times however, do not mean that quality and workmanship can be compromised. This adds ever more increasing demands for prefabricated precast concrete elements. Due to its advantages, **Fracht Aeronautica** is an ideal reinforcement for these elements.



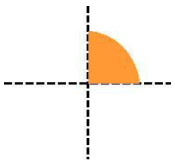
less concrete



smaller diameters

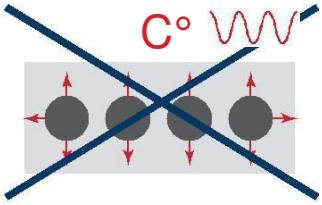


less reinforcement



lighter

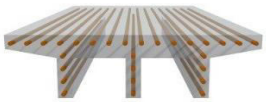
Another great advantage of **Fracht Aeronautica** is the significantly reduced amount of reinforcement and concrete cover. This results in much lighter elements, creating design freedom and more importantly, cost savings.



non-conductive

economical cost

Pipe



Girder

Walls and Ceilings

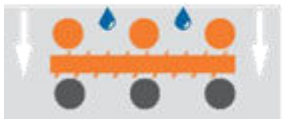
Road barriers

Stairs

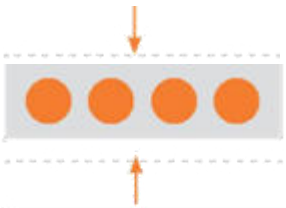
- Pipe segments
- Profiles (T/L/U)
- Facade elements
- Railway sleepers
- Road barriers
- Prefabricated elements

Road and Rail infrastructure

Growing infrastructure and increasing demand for more roads, rail networks and bridges, and inevitable contact with harsh natural forces of nature, leads to the need for costly regular repair, restoration and maintenance.



chloride resistant



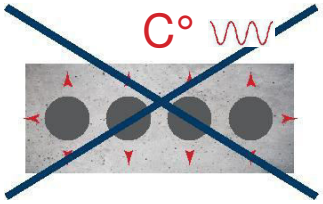
less concrete

Fracht Aeronautica can reduce costs of any initial investment, maintenance and renovation. The protection of structures against chlorides usually require expensive alternatives and require increased concrete cover.
These issues can be eliminated with the use of Fracht Aeronautica rebars.

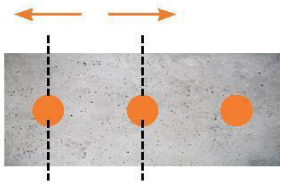
cheaper than other steel reinforcements

more economical

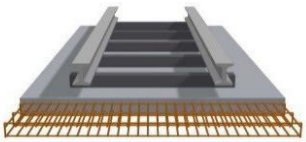
Bridge piers



non-conductive

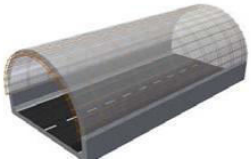


less reinforcement required

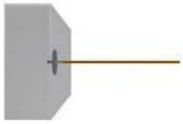


Rail tracks

Abutment



Tunnel



Thermal Anchor

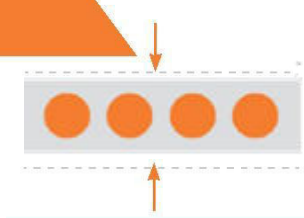
- In situ concrete
- Highway reinforcement
- Noise reduction
- Railway sleepers
- Ramps
- Railway (Signal)

Buildings

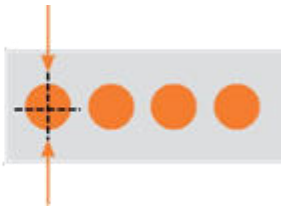
The increasing sophistication of residential and working structures poses higher requirements and challenges. Aspects such as healthy living, more efficient building methods, aesthetics and the wish for exceptional design, all play a major role in the building of structures.

The relationship between people and the structures they live in, is becoming ever more important. This point is also a major concern for modern achitects, investors and owners.

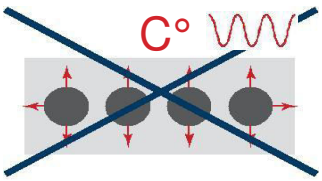
GFRP Rebar offers excellent attributes for such structures from both a design and sustainability perspective, as well as being extremely cost efficient and durable.



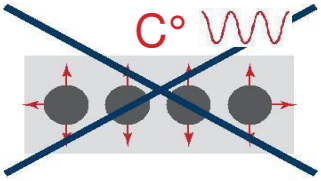
less concrete



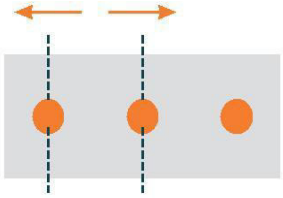
smaller diameters



non-conductive



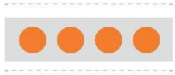
durable



less reinforcemet required

cost effective

Thermal anchor

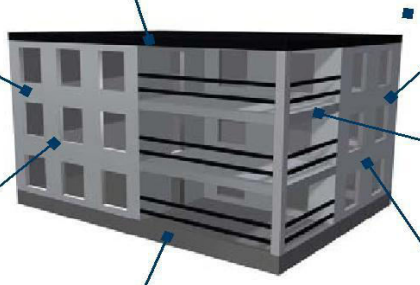


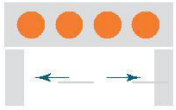
Slimmer floors

Eco friendly

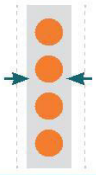
Facades

Precast elements

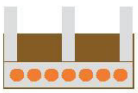




Wide spans



Slender walls



Foundations

Thermal reinforcement

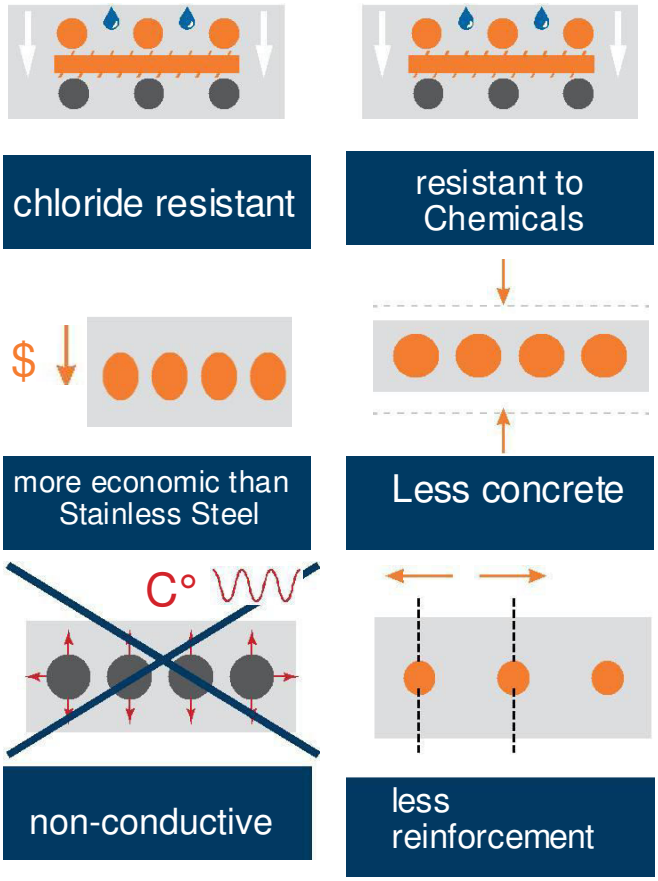
Exposed concrete

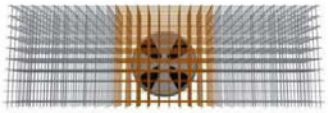
Tunneling and Civil Engineering

In Tunneling, Civil Engineering and Mining, there are various applications for reinforcement. Installations that use GFRP in diaphragm walls or piles, enable easy and time-efficient boring of tunnels.
In parallel, the cost of any manual removal of steel reinforcement in the bored area may be avoided, with the additional benefit of less damage to any of the tunelling equipment being used.

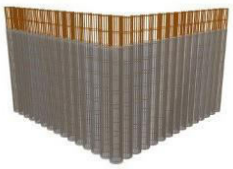
Fracht Aeronautica offers other advantages; Due to the high resistance to aggressive media, permanent reinforcement is possible, whereby alternative expensive corrosion protection is not necessary. Repair and maintenance costs are also significantly reduced.

Enormous savings can be achieved by using GFRP bolts and shotcrete in tunneling.





TBM - Softeye – Cut-off wall reinforcement (easy machinability)



Bored pile

Viaducts and Tunnels

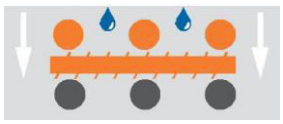
Sewer

- Diaphragm Wall
- Various foundations
- Back anchoring
- Underpass
- Micro-pile foundations

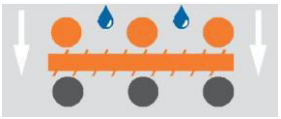
Industry

Industrial buildings are an essential part of everyday life. In industrial enterprises, different products are produced that make modern life easier. Such structures can usually be heavily loaded due to different production methods corrosive environments and strong magnetic fields.

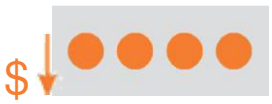
Fracht Aeronautica offers cost effective ways to address such problems. An example of this can be outlined in the use of expensive Stainless-Steel reinforcement in Substations which can be replaced by **Fracht Aeronautica** This was previously necessary to prevent magnetic fields. Other such examples are Car Parks and Petrol Stations, that can avoid the cost of using protective materials and layers to prevent salt induced corrosion.



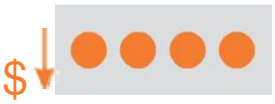
chloride resistant



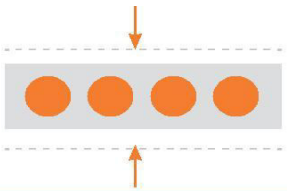
resistant to Chemicals



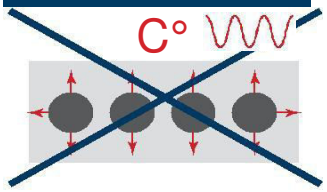
cheaper than steel or stainless steel



economic and cost effective



less concrete



non-conductive

Industrial flooring

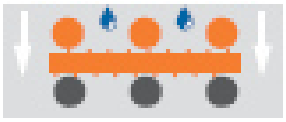
Chemical plants, oil and gas refineries

Parking garages

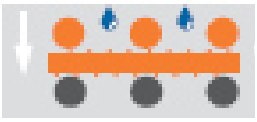
- Airports
- Production and Assembly halls
- Substations
- Aluminium and Steel Works
- Sewage treatment
- Cooling towers
- Hospital MRI
- Laboratories
- Incineration plants
- Car Washes
- Petrol Stations
- Desalination plants

Water and Marine

The use of water, whether for travel, energy or treatment, is an essential part of industry and construction. These structures are highly exposed to aggressive media, such as pollution, salts and chemicals, resulting in high and recurring rehabilitation costs.

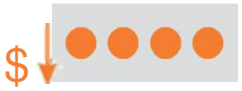


chloride resistance



resistant to Chemicals

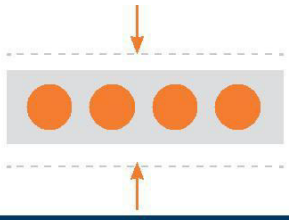
GFRP Rebar of Fracht Aeronautica counteracts this by protecting against chemicals & chlorides which consequently destroy the rebar and concrete. Therefore, it is not necessary to use costly Stainless Steel or thicker concrete cover that protects the steel.



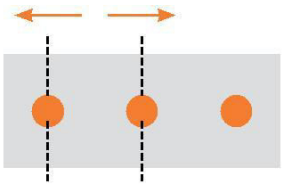
cheaper than steel and stainless steel

lower lifetime costs

Likewise, it makes economic sense that these concrete structures can be built at significantly lower cost and have a much higher service life.



less concrete



less reinforcement

Treatment plant

Quay walls and wharfs

Hydropower plant

- Port facilities
- Jetties
- Sea walls
- Canals
- Piers
- Breakwater
- Coastal reinforcement
- Tidal Power plant
- Floating structures
- Cut-off Wall
- Dry docks

Products

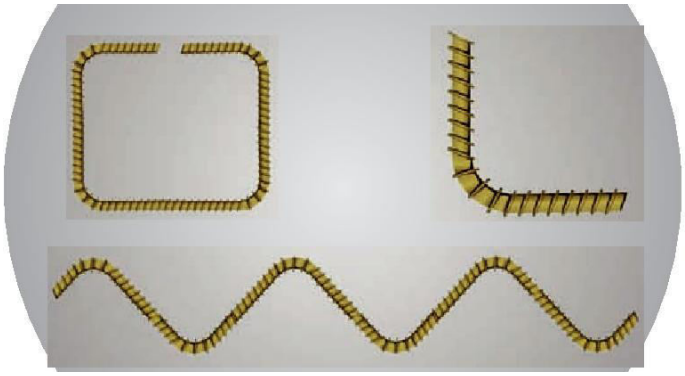
Straight rebar

Length:
up to 12 Meters
Diameters (mm):
4, 6, 7, 8, 10, 12, 14, 16, 18, 20
(other diameters available on request)

Coiled rebar

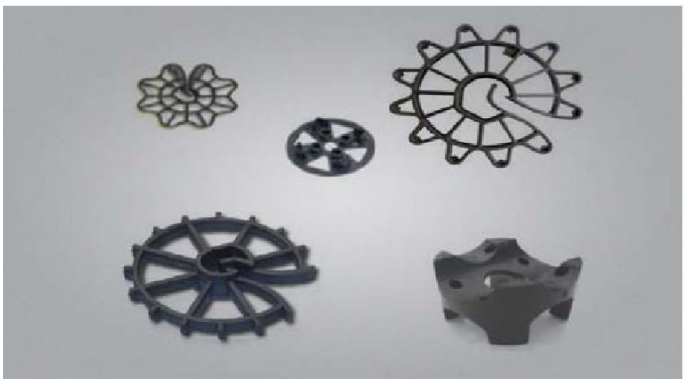
Length:
50 meters per coil

Diameters (mm):
4, 6, 7, 8, 10



Shapes

Different shapes available on request:
L-, U-, O- shapes



Accessories

Clips
Spacer
Binder

References

Foundations

Petrol Stations

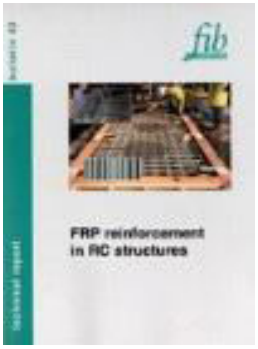
Ceilings

Rail traverse

Industrial floors

Sea walls

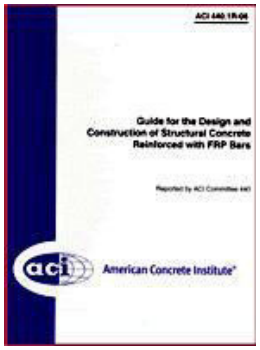
Guidelines



fib Technical Report

Technical Overview Lausanne Switzerland

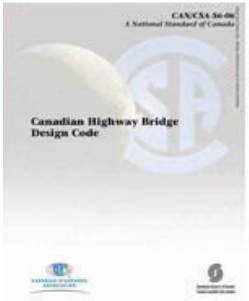
EPFL; International Federation of Concrete



ACI 440.1R-06

Design Guidelines USA

American Conrete Institute



CAS-S806-02

Design Guidelines Canada

Canadian Standards Association

JSCE

Design Manual Japan

Japan Society of Civil Engineers

ISBN 978-967-5317-94-1

CONSTRUCTION INDUSTRY DEVELOPMENT BOARD
Tingkat 10, Menara Dato' Onn,
Putra World Trade Centre (PWTC), No. 45,
Jalan Tun Ismail, 50480 Kuala Lumpur

CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA
Makmal Kerja Raya Maysia (MKRM),
CIDB Wilayah Persekutuan, 1st Floor, Block E, Lot 8,
Jalan Chan Sow Lin, 55200 Kuala Lumpur