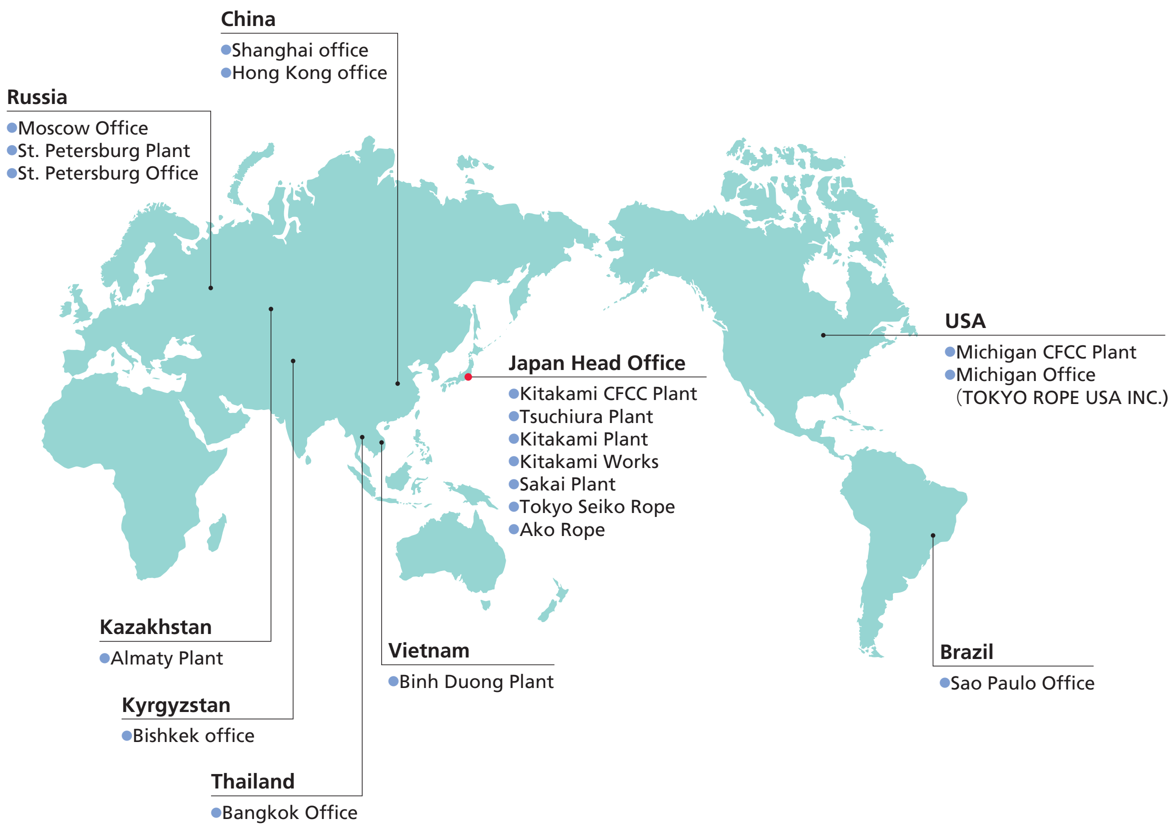
About Tokyo Rope Group

Tokyo Rope was established in 1887 and has been the leader in Japan's wire rope industry. Our global operations are expanding. Our main products are Steel Wire Rope, Fiber Rope, Steel Cord for tire, and CFCC.



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19-10-SA

Innovative HTLS Transmission Conductor With CFCC® Core

ACFR®

ALUMINUM CONDUCTOR FIBER REINFORCED

TRI
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Today's Overhead Conductor's market

Current Status

ACSR is a conventional type of conductor which has three drawbacks as follows:

- **Heavy steel core**
- **Large Thermal Expansion**
- **Corrosion**

Challenge

Transmission Owners are facing the following requirements:

- **Huge Electric Demand**
- **Environmental Concern(CO_2)**
- **Sag Violations**
- **Right of Way Issue**
- **Construction Cost & Period**
- **Lower Life Cycle Cost**

Solution

Next generation conductor cable= ACFR®

- **Low Transmission Loss**
- **High Transmission Capacity**
- **Low Sag**
- **Longevity**
- **Easy Handling**

ACFR®

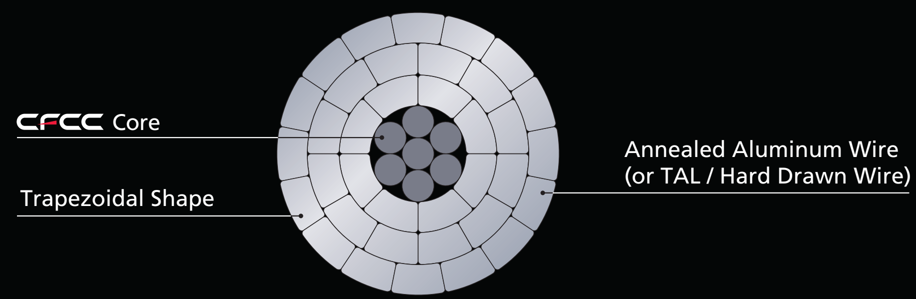
ALUMINUM CONDUCTOR FIBER REINFORCED

ACFR Structure

ACFR stands for Aluminum Conductor Fiber Reinforced

CFCC Core ▶ Light Weight and Small Thermal Expansion

Trapezoidal Aluminum Wire ▶ Large Cross Sectional Area



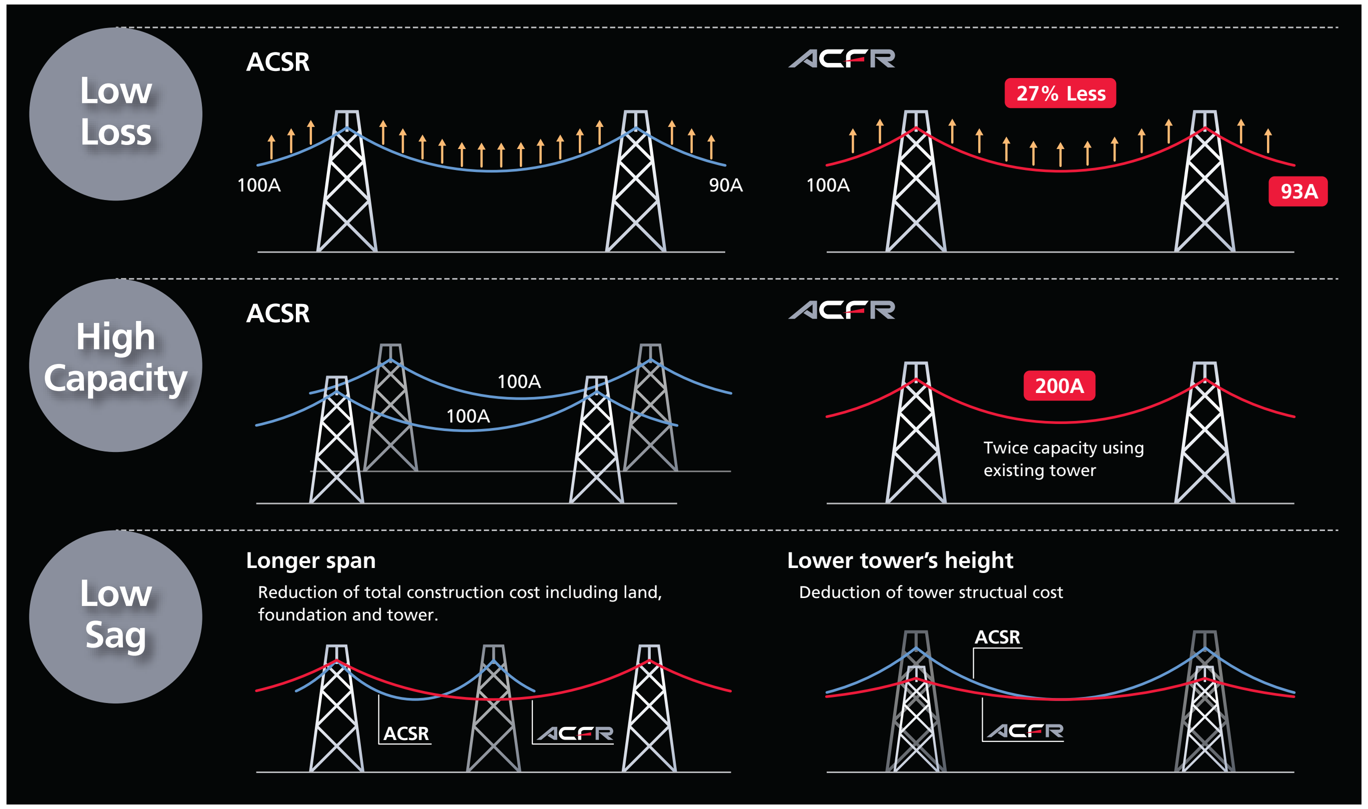
ACFR ALUMINUM CONDUCTOR FIBER REINFORCED

Case Study

Performance Example compared to ACSR

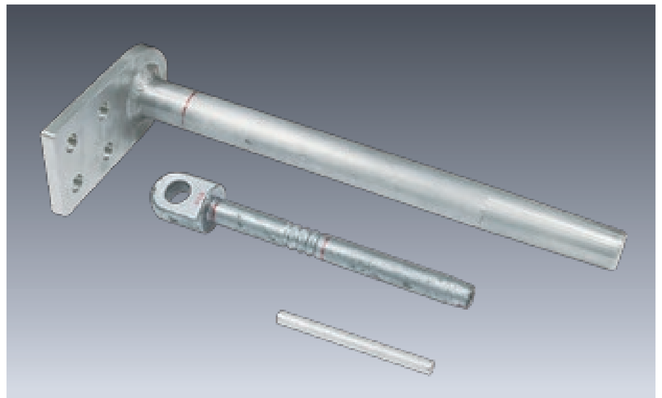
Design Concept	Transmission Loss	Transmission Capacity	Sag
Low Loss	27% Less	Same	Same
High Capacity	More	120% More	Same
Low Sag-Low Loss	9% Less	Same	12% Less
Low Sag-High Capacity	More	103% More	10% Less

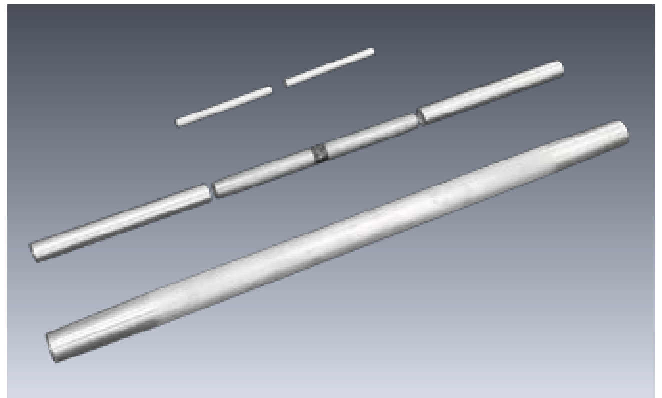
*This figure depends on design and operating conditions.



Accessories (Dead End Clamp and Mid Span Joint)

Basic Design is the same as those for the conventional ACSR conductor, except for using an aluminum buffer which grabs the CFCC core securely.


Dead End Clamp

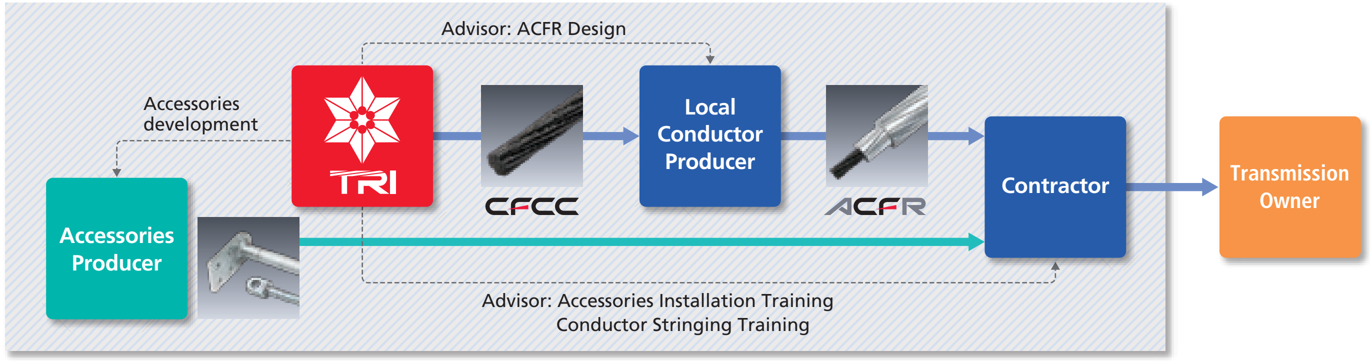

Mid Span Joint

*These pictures are for example purposes. Actual design to be decided by the customer's requirements.

Supply Scheme

Tokyo Rope provides CFCC to local conductor producer which will make ACFR.

Reference



Standard ACFR Design Example

The following is standard ACFR Design Example. Final design should be agreed with the conductor's manufacturer.

ACFR PRODUCT CODE (Equivalent conventional ACSR)		ACFR 121/17-FA-TT (Dog equivalent)	ACFR 213/28-FA-TT (Linnet Equivalent)	ACFR 267/37-FA-TT (Panther Equivalent)	ACFR 410/50-FA-TT (Grosbeak Equivalent)	ACFR 492/55-FA-TT (Zebra Equivalent)	ACFR 658/66-FA-TTT (Moose Equivalent)
Mechanical Specifications							
Overall Diameter of Conductor	mm	14	18.29	20.75	25.15	28.14	31.6
Nominal Aluminum Cross-sectional Area	mm²	121.3	212.7	267.2	407.18	491.8	657.7
Nominal Diameter of Composite Core (from CFCC data sheet)	mm	5.3	6.8	7.8	9	9.5	10.4
Nominal Cross-sectional Area of Core	mm²	17.2	28.2	37.2	49.5	55.1	66.1
Nominal Cross-sectional Area of the Conductor	mm²	138.5	240.9	304.3	456.68	546.94	723.8
Ultimate Tensile Strength of Conductor	kN	43.7	72.7	94.8	129.1	146.2	179.1
Rated Strength of Core	kN	36.8	60.3	79.5	105.8	117.7	141.3
Core Nominal Mass per unit length	kg/km	27	44	60	78	86	104
Aluminum Nominal Mass per unit length	kg/km	335	588	738	1124	1358	1819
Conductor Nominal Mass per unit length	kg/km	362	632	798	1202	1444	1923
Maximum Allowable Operating Temperature	°C	180	180	180	180	180	180
Coefficient of Linear Expansion Above Thermal Kneepoint	$\times 10^{-6}$/°C	1.0	1.0	1.0	1.0	1.0	1.0
Coefficient of Linear Expansion Below Thermal Kneepoint	$\times 10^{-6}$/°C	17.8	18.0	17.7	18.2	18.5	18.9
Final Modulus of Elasticity Above Thermal Kneepoint	GPa	122	122	126	126	126	126
Final Modulus of Elasticity Below Thermal Kneepoint	GPa	63.32	62.85	63.67	62.73	62.16	61.48
Electrical Specifications							
Nominal Resistivity of Aluminium at 20°C, DC 63% IACS	ohm/km	0.2307	0.1314	0.1047	0.0686	0.0568	0.0426
Current carrying capacity at maximum operating temperature@180 °C	Amps	674	968	1127	1476	1680	2009
Emergency operating temperature	°C	200	200	200	200	200	200

Note: Current Carrying Capacity is Calculated as per the following Assumptions: Wind Velocity (m/sec) : 0.6, Solar Absorption Co-efficient : 0.5, Emissivity : 0.5, Ambient Temperature (°C) : 35, Solar Radiation (Watt/Sq.m) : 1033

CFCC Development History

CFCC core's development was started in the 1980s. Initially, CFCC was used for civil engineering applications. In 2002, Tokyo Rope supplied CFCC core to conductor partners which produce ACFR, and since then, more than 15 years have passed with satisfactory operations.

- *1980s* Started development of CFCC
- *1986* Supplied for PC Bridge project in Japan
- *2001* Supplied for PC Bridge project in Michigan/USA.
- *2002* Supplied for ACFR project in Japan
- *2002* ACFR presentation in CIGRE* session 2002
- *2011* Established Gamagori CFCC Plant in Japan (First full-scale integrated CFCC factory.)
- *2012* Supplied for ACFR project in China
- *2015* Supplied for ACFR project in Indonesia
- *2016* Established Michigan CFCC Plant in USA (First overseas CFCC production facility.)
- *2018* Established TOKYO ROPE INTERNATIONAL INC.
  Established Kitakami CFCC Plant in Japan
- *2019* Supplied for ACFR project in India, USA

*CIGRE is international council on Large Electric System

Installed ACFR（Twin Bundle）

ACFR Installation

Kitakami CFCC Plant

Michigan CFCC Plant in USA

CFCC

CARBON FIBER COMPOSITE CABLE

CFCC Advantage

CFCC core is uniquely stranded CFRP and has eight advantages:

Non-magnetic	No Iron Loss
Lightweight	1/5 of Steel
High Flexibility	Can be wound to the small Drum
High Corrosion resistance	Against acid, alkali, water and UV
High Tensile Fatigue	Able to withstand wind vibration
Small Thermal Expansion	1/10 of Steel (CFCC: 1.0×10^{-6}; Steel : 11.5×10^{-6})
High Modulus	Superior to other FRP
Low Creep	Similar to Steel

Standard Characteristics

Properties	Item			1×7 7.8ϕ HT Type
General mechanical properties	Tensile strength	(MPa)	*1	2.137
	Tensile elastic modulus	(GPa)	*1	126
	Elongation at break	(%)		1.70
	Density			1.60
Static properties	Relaxation	(%)	*2	1.3
	Creep strain		*3	0.07×10^{-3}
	Coefficient of linear expansion	($\times10^{-6}$/℃)	*4	Less than 1
	Specific resistance	(μΩcm)		3,000
	Creep failure load ratio		*5	0.85
Others	Fatigue capacity(Stress range)	(N/mm^2)	*6	780
	Bending stiffness	($kN\cdot cm^2$)		56.9
	Heat resistance	(℃)		180℃(Operating) 200℃(Emergency)
	Acid resistance			Superior to steel
	Alkaline resistance			Almost the same as steel

*1: Calculated by nominal cross sectional area
*2: 0.7pu, 1000hrs(20±2℃), according to JSCE-E534.
*3: 0.6pu, 1000hrs(20±2℃)
*4: 20℃～200℃, according to JSCE-E536.
*5: Tests of CFCC 1×12.5ϕ according to JSCE-E533 "Test Method for Creep Failure of Continuous Fiber Reinforcing Materials" gave a load ratio of 0.85 at 1 million hours.
*6: Average load is 75% of breaking load. The number of cycles is 2×10^6, according to JSCE-E535.
pu: breaking load

Standard Specification of CFCC

Designation (Configuration diameter)	Diameter (mm)	Nominal cross sectional area (mm^2)	Breaking load (kN)	Unit Weight* (g/m)	Tensile Modulus* (GPa)
U 5.0ϕ	5.0	19.6	41.9	30	135
1×7 5.3ϕ	5.3	17.2	36.8	27	122
1×7 6.8ϕ	6.8	28.2	60.3	44	
1×7 7.8ϕ	7.8	37.2	79.5	60	126
1×7 8.5ϕ	8.5	44.1	94.2	69	
1×7 9.5ϕ	9.5	55.1	117.7	86	
1×7 9.9ϕ	9.9	59.9	128.0	95	
1×7 10.8ϕ	10.8	71.3	152.4	112	
1×7 12.5ϕ	12.5	95.4	203.9	147	
1×7 15.2ϕ	15.2	141.1	301.5	224	
1×7 21.2ϕ	21.2	274.5	586.6	432	

*Reference value