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Development of Corrosion Protection Methods Using S-shaped Wire Wrapping System

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Abstract

The cables of a suspension bridge which are the components that support girders require long term endurance. A new corrosion protection system for cables was developed, which consists of S-shaped wire wrapping and elastic type coating. The new system prevents infiltration of water better than previous systems. In addition, a dehumidification system for the cables is applied at the same time, which makes it a more reliable corrosion protection system.

1. Introduction

Having seen the inaugurations of the Akashi Kaikyo Bridge and the Hakucho Ohashi Bridge in Hokkaido in 1998, and the Kurushima Kaikyo Bridges in 1999, the peak period of consecutive constructions of long suspension bridges in Japan is coming to an end[1)]. Technical developments regarding bridge cables have advanced keeping pace with the long suspension bridge projects. While in the field of cable materials, 1,800 MPa class high tensile strength wires[2)] began to be used as substitutes for conventional 1,600 MPa class materials, various research and development has been carried out in the field of corrosion protection for maintaining the cables in sound servicable conditions for long periods of time[3-5)].

The development of new corrosion protection systems has as its background a series of corrosion investigations at the Innoshima Bridge and the Ohnaruto Bridge between 1989 and 1991. Observations made during the investigations showed that the cables were suffering advanced states of corrosion due to defects in the paint coating layers such as swellings and cracks, and corrosion-inducing humidity present inside the cables[4,5)]. Various similar corrosion investigations were also made of suspension bridge cables abroad and an increasing number of people in the industry began to recognize the importance of the protection of the cables from corrosion[1,3,6)]. In such a circumstance it was felt that there was an urgent need for clarification of the corrosion mechanisms inside the cables and elaboration of new anti-corrosion measures so that new measures could become available in time for their application to the Akashi Kaikyo Bridge and the Kurushima Kaikyo Bridges then under construction.

Based on those investigations, the main cause of the corrosion was presumably that water present inside the cables created a strongly corrosive environment[3-6)]. On the basis of this requirements arose for a structural mechanism to minimize water infiltration into the cables and further, since it was impossible to completely prevent water infiltration, measures to deal with the water inside the cables[4,5)].

This report mainly describes the development of an S-shaped wire wrapping system wherein a new type of wire having an S-shaped section is used, engaged together lap by lap, in place of conventional round section wire for cable wrapping. It also details the design concept and effects of a dehumidifying system for removing water from inside the cables by dry air blowing.

The developed wire wrapping system was actually first applied to the Hakucho Ohashi Bridge in Hokkaido, then to the Kurushima Kaikyo Bridges and the Akinada Bridge, and the dehumidifying system to the Akashi Kaikyo Bridge and the Kurushima Kaikyo Bridges.

2. The latest situation of suspension bridge cables

2.1 Outline of corrosion protection of existing bridge cables

Fig.1 shows an example of a corrosion protection structure commonly used in suspension bridge cables. The cable is composed of high strength steel wires of about 5 mm in diameter hot dip galva-

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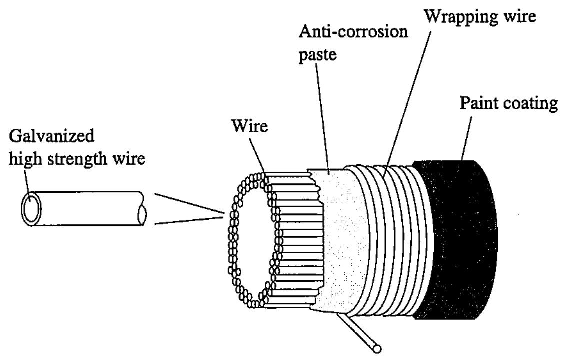

Fig.1 Commonly used corrosion protection structure of cables

nized with 300 g/m^2 (minimum required amount) or more of zinc. As protection from a corrosive environment, the cable surface is coated with anti-corrosion paste, then wrapped with an annealed and galvanized soft steel wire of about 4 mm in diameter wound onto the cable surface and finally coated with a paint layer. The paste used here is an oil-based corrosion resistant paste for smoothing uneven cable surfaces where water condensation tends to form and is meant for prevention of water infiltration and to provide corrosion protection7).

Historical changes in the corrosion protection systems for bridge cables in Japan and abroad are shown in **Table 1**1,3,7-11). As a corrosion proofing paste, red lead pastes have been mainly used abroad and organic lead-based pastes in Japan. With regard to the paint coating in Japan, phthalic acid-based paint was used for the old bridges, chlorinated rubber-based paint for the Innoshima Bridge and then a combination of epoxy resin-based paint (primer and intermediate coats) and urethane-based paint (finish coat) for the Ohnaruto Bridge and thereafter.

In some cases cables are wrapped with a neoprene rubber or plastic coating instead of the compound paste/wire wrapping/paint coating system12). The neoprene rubber wrapping method is a process whereby an unvulcanized rubber sheet 1.6 mm thick is wound onto the wrapping wire with a 50% overlap to form a 3.2 mm thick corrosion protection lining around the cable. This method was applied to the Akashi Kaikyo Bridge because of its highly promising waterproofing performance.

2.2 Results of corrosion investigations at bridges in service

A cable corrosion investigation was carried out at the Innoshima Bridge after more than 6 years in service, and another at the Ohnaruto Bridge. As seen in Table 1, the corrosion protection systems of both bridges are the same except for the paint coating. Many cracks were observed on the paint coating of the Ohnaruto Bridge while the Innoshima Bridge had many swellings in its cable paint coating. Corrosion was witnessed in the cables of both the bridges accompanied by water present inside the cable and rust scattered on the surfaces of the wires. This is presumably because of a severely corrosive environment formed by wetting with condensation from the water present inside the cable at the outer layers where temperature fluctuation is large. Corrosion was found also on the wire surfaces coated with the paste. The suggestion is that corrosion is accelerated, possibly as the paste deteriorates in the lapse of time and begins to contain water4,5).

2.3 Corrosion protection measures of bridge cables

The following measures were proposed as being effective for preventing this type of corrosion from occurring:

Firstly, improvement of the wrapping structure. As shown in **Fig.2**, in the conventional wire wrapping method using round wire, gaps are made between the wire laps as the cable expands and contracts longitudinally under changing loads and temperatures, causing paint cracks to allow infiltration of rain water into the cable. In contrast, a wrapping method with wire having an S-shaped section (S-shaped wire wrapping)13-16) prevents the water intrusion into the cable body since displacement of wire laps is restricted and paint cracks occur with difficulty thanks to the structure where laps of the wire are engaged with each other.

Secondly, improvement of the paint system. Defects in the paint

Table 1 History of corrosion protection specifications for bridge cables

Japan

Bridge name	Paste	Wrapping wire	Paint/Coating type
Wakato (1962)	Zinc chromate	Round	Phthalic resin
Kammon (1973)	High molecular organolead	Round	Phthalic resin
Hirato (1977)	High molecular organolead	Round	Chlorinated rubber
Innoshima (1983)	Calcium plumbate + High molecular organolead	Round	Chlorinated rubber
Ohnaruto (1985)	Calcium plumbate + High molecular organolead	Round	Epoxy resin + polyurethane
Rainbow (1994)	Aluminum phosphate	Round	Neoprene-Hypalon (paint type)
Hakucho (1998)	Aluminum phosphate	S-wire	Epoxy resin + fluoro resin (Flexible type)
Akashi Kaikyo *1 (1998)	–	Round	Neoprene rubber winding + Hypalon paint
Kurushima *1 (1999)	–	S-wire	Epoxy resin + fluoro resin (Flexible type)

Abroad

Bridge name	Paste	Wrapping wire	Paint/Coating type
Brooklyn (1883)	Red lead	Round	Oil paint *2
Williamsburg *3 (1903)	Red lead	Round*4	Oil paint *2
Golden gate (1937)	Red lead	Round	Oil paint *2
Newport (1968)	–	–	Plastic wrapping (ERP)
Chesapeake No.2 (1973)	–	–	Neoprene rubber winding + Hypalon paint
Humber (1979)	Red lead	Round	Primer + MIO*5

*1 With dry air blowing system
*2 Neoprene rubber winding + Hypalon paint often used for recent repairs
*3 Bare steel wires used for cable wires
*4 Bare steel wires used for cable wire wrapping
*5 Epoxy resin paint containing MIO (micasious iron oxide) pigment.

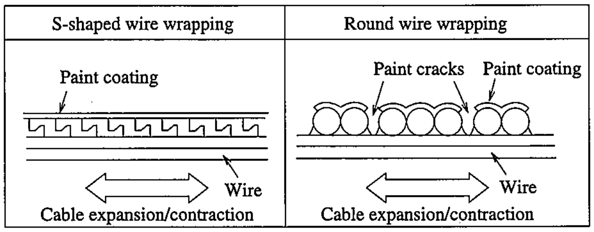

Fig.2 Cable wrapping structure

coating can be prevented from occurring for a long period via the use of painting materials having higher weatherability and flexibility than conventional ones[15-17)].

Thirdly, improvement of the environment inside the cable body. Water infiltration from the outside can be remarkably reduced by a combination of S-shaped wire wrapping and flexible paint coating in comparison with conventional corrosion protection systems but it cannot be reduced to zero. On the other hand, it was feared that the proposed system might cause corrosion rather than prevention, since its waterproof performance was such that water once inside the cable, could not escape easily.

Accordingly, it was considered most effective as a corrosion protection method for the bridge cables available at present to use a dry air blowing system[4,5)] for improving the environment inside the cable, in combination with the anti-corrosion structure described above meant for protecting the cables from the external environment. The dry air blowing system is a new anti-corrosion system for bridge cables which blows dry air into the cable body for the purpose of dehumidifying the atmosphere inside the cable to prevent the corrosion of the cable wires. The same concept has been applied overseas for corrosion protection of box girders at the Faroe Bridges and the Little Belt Bridge and there are several examples of the same application also in Japan[18,19)], but it had not been used for cables till the system was first installed at the Akashi Kaikyo Bridge.

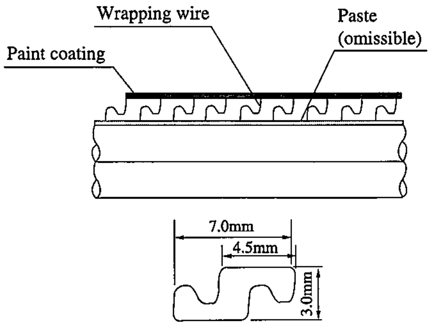

Fig.3 S-shaped wire wrapping

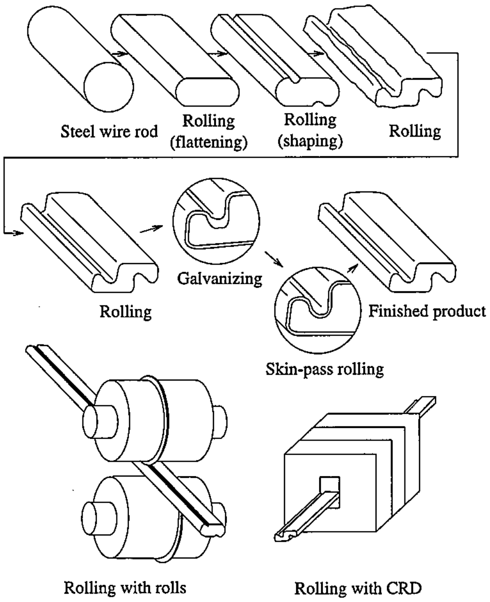

Fig.4 Manufacturing process of S-shaped wire

Table 2 Mechanical Properties of S-wire

Material	Wire rod		Mild steel wire rod JIS G3505 SWRM6~12
	Zinc		Pure Zinc Metal JIS H2107
Mechanical properties	Tensile properties	Tensile strength	55 kgf/mm^2 (540MPa) or higher
		Elongation	1.5% or more
	Twisting		6 times or more
Zinc coating weight			280 g/m^2 or more

3. New corrosion protection systems

3.1 S-shaped wire wrapping method

3.1.1 Construction of S-shaped wire wrapping method

The S-shaped Wire Wrapping method is one where a wrapping wire having an S-shaped section is wound around a cable in a spiral, the hook portions being engaged with each other at each lap, as shown in **Fig.3**. One advantage it offers is that excellent waterproofing and air-tightness are obtained since the surface of the wrapping is free from gaps due to restriction between adjacent laps by the tight engagement of the hooked portions. Further, the method provides a better surface for paint coating than the conventional round wire wrapping thanks to a flat and even outer surface.

3.1.2 Manufacturing of S-shaped wrapping wire

The S-shaped wrapping wire is manufactured from mild steel wire rod through annealing, rolling into an S-shaped section and hot-dip galvanizing, as shown in **Fig.4**. The manufacturing process is characterized by a rolling process comprising rolling steps with rolls and CRD (Cassette Roller Dice), wherein the material is rolled by small rollers arranged around the material. **Table 2** shows the mechanical properties of the S-shaped section wire.

3.1.3 Verification of Effects of S-shaped Wire Wrapping Method

1) Prevention of paint coating defects

One advantage of the S-shaped Wire Wrapping method is that paint coating defects are unlikely since displacement of the wrapping wire by changes of load and temperature are restricted by the engagement of the hooked portions. In this respect a freezing and thawing test was carried out jointly with the Hokkaido Development Bureau using real size cable specimens for the purpose of verifying the performance of paint coating defect prevention[15,16)].

Wire-wrapped and paint-coated real size cable specimens (300 mm in diameter, 1,000 mm long) were prepared for the test. In fact, four specimens under different specifications were prepared: two kinds of wire wrapping (S-shaped wire and round wire) and two types of paint coating (flexible paint and hard paint). Water was poured into the specimens in an amount equivalent to 10% of the total voids between the wires (approx. 2 liters), then the specimens underwent heating/cooling cycles from –30°C to 5°C for 90 days, during which time the water in the cable body froze and thawed alternately, causing radial deformations of the cable bodies. Thereafter, the performance of paint coating defect prevention was evaluated based on the development of paint cracks and pinholes.

The result was that more paint cracks were observed in the specimens with round wire wrapping than those with S-shaped wire wrapping and in those with hard paint than those with flexible paint, and the one with S-shaped wire wrapping and flexible paint proved to be the best regarding prevention of paint coating defects.

2) Impermeability of S-shaped wire wrapping against water

The advantages of the S-shaped wire wrapping include high water sealing performance which is important especially in the prevention of infiltration of rain water and the like. A vapor penetration test as shown in **Photo 1** was carried out to confirm the impermeability of the wrapping surface. The test consisted of preparing two model wire wrapping planes, one with an S-shaped wire and the other with a round wire, keeping one side of each of the planes in high humidity, and measuring the amount of vapor penetrating from the high humidity side to the other (low humidity) side. The amount of the penetrating vapor was measured by measuring the weight changes of calcium chloride placed on the low humidity side.

The results are shown in **Fig.5**. The vapor impermeability of the S-shaped wire wrapping was found to be 2 - 3 times better than that of the round wire wrapping. When the model wrapping surfaces were hit by water drops, the water went through the round wire wrapping easily while the same did not occur with the S-shaped wire wrapping and the water drops remained on the surface. Thus, the S-shaped wire wrapping was confirmed to be superior to the round wire wrapping in terms of waterproofing performance.

3) Air-tightness of S-shaped wire wrapping

Another advantage of the S-shaped wire wrapping is its high-level air-tightness. This aspect is important especially in combination with the dry air blowing system, which will be explained hereafter in detail. In this respect, an air-tightness test was carried out as shown in **Fig.6**. Here, two specimens were prepared each made of 450 mm diameter pipes with small holes in the wall, wire-wrapped, one with an S-shaped wire and the other with a round wire, and both coated with the flexible paint. A certain amount of internal pressure was initially imposed on the specimens and the air-tightness was evaluated by historical changes (drop) to the pressure.

As a result, as shown in **Fig.7**, the air-tightness of the S-shaped wire wrapping was confirmed to be superior to that of the round wire wrapping. It was further confirmed that with damages intentionally inflicted on the paint coating layer, the S-shaped wire wrapping showed a smaller volume of air leak than the round wire wrapping, certifying its superior level of air-tightness.

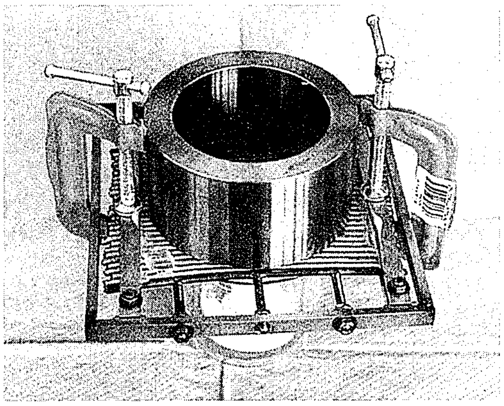

Photo 1 Vapor penetration test

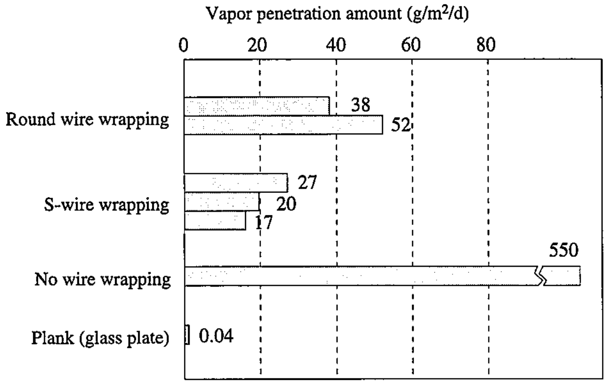

Fig.5 Vapor Permeability of Cable Wrapping

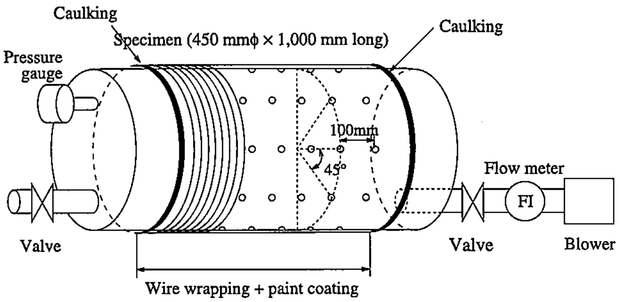

Fig.6 Air-tightness test

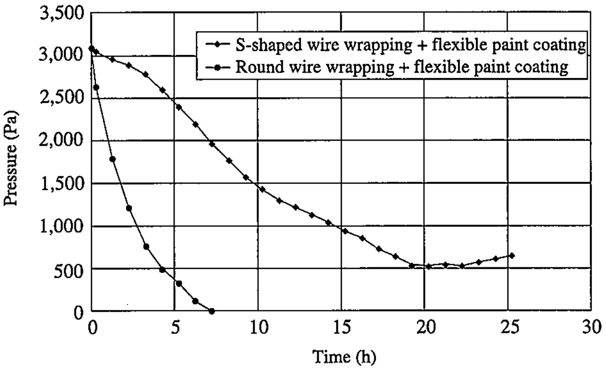

Fig.7 Pressure drop during air-tightness test

3.1.4 S-shaped wire wrapping machine

Fig.8 and **Photo 2** show the S-shaped wire wrapping machine used in cable wrapping operations. The machine is designed to wind the S-shaped wire around a cable by rotating a drum equipped with two bobbins of S-shaped wire coil.

It should be noted that, unlike conventional round wire, the S-shaped wire can be wound in certain directions only. To avoid bending the wire in the wrong direction or twisting the S-shaped wire, therefore, the routes from the bobbins to the points of winding onto the cable are designed to be roughly in one plane. In the actual wrapping operation it is necessary to synchronize the drum rotation and travelling of the machine along the cable in order to firmly engage the hooked portions of adjacent laps of the wrapping. Since it is difficult to minutely control the travelling speed of the machine by the conventional method using winches installed at the tower top, the developed machine is designed to travel by drawing guide ropes. Specifically, two driven travelling rollers are installed at the lower

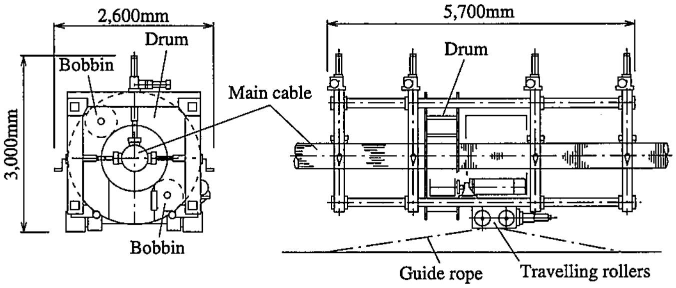

Fig.8 S-shaped wire wrapping machine

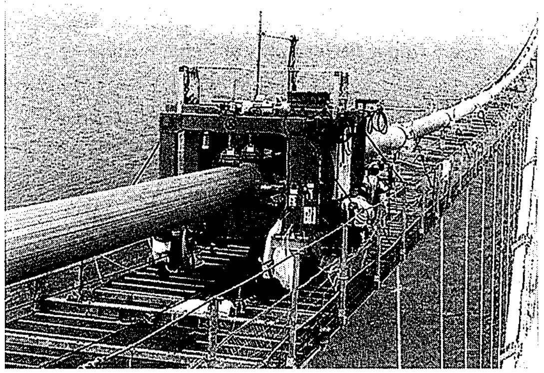

photo 2 S-shaped wire wrapping machine

Table 3 Specifications of S-wire wrapping machine

Rough dimension	5,700mm l × 2,600mm w × 3,000mm h
Applicable wrapping wire	S-shape section wire
No. of wires to wind	2
Winding speed	Max. 30rpm
Winding tension	Max. 2,500 N, each wire
Wrapping wire load	Max. 300 kg × 2 bobbins
Travelling speed	Max. 270 mm/min (winding) Max. 2,700 mm/min (Travelling)
Climbing ability	Max. gradient approx. 30° (up/down)

ends of both the machine sides, a guide rope is wound around each of the rollers, and the machine travels along the cable by driving the rollers. Minute speed control is made possible by this mechanism.

Conventionally, manual wrapping work was necessary at the end of each panel (span between two cable bands). The dimensions and construction of the new machine were designed so that manual operation could be eliminated as far as possible to realize a nearly 100% machine wrapping operation. The machine also has the function of going through the cable bands and hanger ropes as do conventional ones. It has the function too, of being able to measure wrapping wire tension in the drum and transmit it to a control panel by radio, as do conventional machines, for real-time monitoring for quality assurance at the work site.

The machine characteristics related above were determined through feedback of results of operation performance tests using real size cable models and introducing improvements to the results. **Table 3** summarizes the specifications of the wrapping machine.

3.2 New painting specifications for cables

It was confirmed by the freezing and thawing test mentioned in 3.1.1 that the flexible painting system was effective when used together with the S-shaped wire wrapping. In this regard the authors developed a new flexible paint system for bridge cables on the basis of a system[20] with a fluoro-resin-based finish coat, which is considered to have an excellent weatherability and the longest service life among the latest paint systems used for steel structures, and to add flexibility to the base system. Generally speaking, special attention has to be paid to paint application on galvanized surfaces (especially newly galvanized ones) for securing good adhesion as compared with bare steel surfaces[21,22].

3.2.1 Flexible type paint system

As shown in **Fig.9**, the developed paint system comprises four coating layers, namely, an epoxy resin-based primer coat having good adhesion to galvanized surfaces, two intermediate coats of epoxy resin-based paint with excellent waterproofing and corrosion protection properties, and a fluoro-resin-based finish coat with excellent weatherability. The total coating thickness is approximately 200μm.

Flexibility is given to the paint system by making an appropriate mixture of paint materials so that the coating layers follow the movement of the wrapping surface. **Fig.10** shows an elongation measurement result of two kinds of flexible type paint coats having different material mixes and one non-flexible type paint coat at different temperatures. The flexible paint coat A showed a higher elongation at low temperatures than the other flexible paint coat B but its elongation fell at high temperatures due to decrease in coagulation strength. Nonetheless, it is clear that either of the flexible type coats has larger elongation than the non-flexible type.

3.2.2 Confirmation tests of corrosion protection performance of flexible type paint system

Hot dip galvanized steel sheets were painted with the flexible type painting system and the following tests were carried out for the purpose of confirming the corrosion protection performance (adhesion to the galvanized surface) of the system:

1) Atmospheric exposure tests simulating actual service conditions

(i) 4-month outdoor exposure test (in Sagamihara, Kanagawa, Ja-

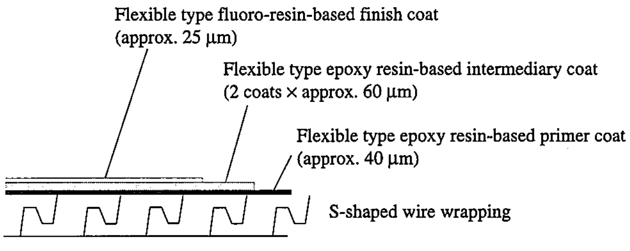

Fig. 9 Paint system for corrosion protection systems

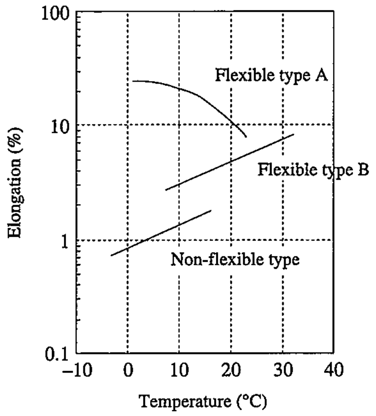

Fig. 10 Elongation of paint coats

Table 4 Corrosion protection performance test of flexible type paint system

No.	Paint system	Atmospheric exposure test		Accelerated laboratory test		
		4-month exposure test	4-month exposure test with salt spray	2-month immersion test	28-day temperature gradient test	Combined cycle test (8 cycles)
1	Flexible A	◎	◎	◎	◎	○
2	Flexible B	◎	◎	◎	○	◎

◎: No problems in adhesive strength or shape of fracture, ○: Enough adhesive strength though with unstable factors such as delamination,
△: Remarkable delamination or signs of peeling on galvanized surfaces, ×: Remarkable peeling on galvanized surfaces

pan)
(ii) 4-month outdoor exposure test with salt spray
(3% NaCl solution sprayed once every day)
2) Accelerated laboratory corrosion tests
(i) 2-month immersion test (in water at 20°C)
(ii) 28-day temperature gradient test
(An accelerated immersion test under an increased water permeability of the coating layer by a temperature gradient of 20°C at the tested surface and 10°C at the other surface)
(iii) Combined cycle test
(Repetition of a cycle comprising salt spray, heating/cooling and drying)

The corrosion protection performance was evaluated by visual inspection of the coating surface, cross hatch tape peeling test, pull-off adhesion test and crosscut peeling width test after each of the above tests. The results are summarized in **Table 4**. As can be clearly seen here, the developed flexible type paint system has an excellent adhesion to the S-wire wrapping surface and durability over long periods.

3.3 Dry air blowing system

As the water captured in the cable body is not easily discharged automatically, it is effective to eliminate it by force. The dry air blowing system was devised for this purpose. This is a new corrosion protection system for cables to prevent the corrosion of cable wires via the elimination of the water inside the cable body by blowing dry air into it. There were, however, two important tasks to tackle before bringing the system into reality: one was to work out a design method for determining air blowing conditions (pressure, distance and flow rate) and the other was a quantitative definition of the drying effect created by the air blowing.

3.3.1 Equation for estimating air flow in cable body

The bridge cable is made waterproof by the wrapping system and cable bands are fixed to it at intervals of ten-odd meters. When air is blown inside the cable body there is a possibility of an air leak through cracks in the paint coatings and cable band joints.

A cable is composed of many wires of about 5 mm in diameter and there are many gaps between them amounting, in total, to as much as 20% or so of the cable section area. But as each of the gaps between wires is very small, pressure loss is significant when air is made to flow through it. With regard to the viability of air blowing into bridge cables, it was confirmed through tests at the Innoshima Bridge and the Kita Bisanseto Bridge that air flowed through the cable body at a comparatively low pressure and with leaks[4].

On the basis of these test results, the following equations were proposed regarding the air flow in the cable body[23]:

$$Q_n = Q(1 - \chi)^{n-1}$$

$$\Delta P = CQ\{1 + (1 - \chi) + (1 - \chi)^2 + ... + (1 - \chi)^{n-1}\}$$

where: Q_n : air flow rate at distance n from the blow-in point
Q : initial flow rate
χ : leak ratio per unit length
ΔP : pressure loss along distance n
C : coefficient determined by cable conditions (such as shape of gaps, gap ratio in the section area, etc.)

As can be understood from the equations, pressure loss is determined by the air blowing rate and leaks. The most important factor in designing a dry air blowing system is setting of the value of leak ratio χ. But it changes depending on the specifications and actual conditions of the wrapping system since the leaks meant here are those through the corrosion protection structure.

It is therefore considered necessary that the results of various tests be accumulated at bridges in service and reflected in the design of this system hereafter. The leak ratio χ can be obtained from the air blowing distance, initial flow rate and pressure values measured along the distance (blow-in point, middle and exhaust point).

3.3.2 Confirmation of drying effect by air blowing

The inside of the cable body is in a humid condition due to water captured inside it. The question is whether or not it is possible to remove the water by means of dry air blown into the cable body. The fundamental concept of humidity removal is as follows:

- There is a differential vapor pressure between the space occupied by the water and the space where dry air passes.
- Humidity is transferred from the water to the dry air body till vapor

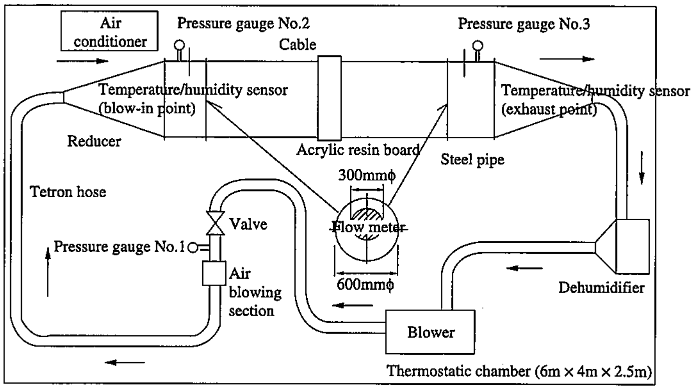

Fig.11 Conceptual illustration of dry air blowing system

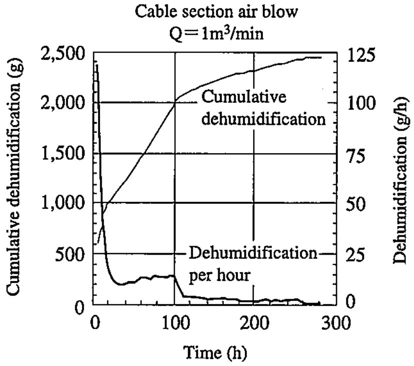

Fig.12 Result of dry air blowing test

pressure of the air is raised to saturation point.

- Humidity is removed by blowing a body of air into the cable by which the humidity is moved and the exhausted.

A test was carried out[4] in this respect using a real size cable model (600 mm in diameter and 2,000 mm long) shown in **Fig.11** in order to confirm whether or not the water inside the cable can be removed by the flow of air containing the transferred humidity in parts of the cable body. As is clear from **Fig.12**, which shows the relationship between humidity removal and time, 2,500 g of water in the cable was dried up in 300 hrs and thus the possibility of removing humidity in the cable body by blowing dry air was confirmed.

3.3.3 Relationship between wrapping system and dry air blowing system

Although it was confirmed that the internal space of the bridge cable is slowly dried by blowing dry air through it, when it comes to applying this concept to the bridges in actual service, it is important to know how long it takes for the humidity to dry up. The time it takes to remove the humidity is determined by the amount of water going into the cable during the construction and service periods and the amount of water the dry air blowing system can take out, but if the amount of water coming into the cable during the service period is larger than that which dry air blowing removes, it is impossible to dry up the cable. Also, for effective drying of the cable by the dry air blowing, it is desirable to use the system together with a wrapping system with as a high sealing performance as possible in order to suppress water infiltration to the lowest possible level. It is therefore efficient and effective for corrosion protection at bridges in service to apply the dry air blowing system in combination with a wrapping system having as high a shielding performance as possible, such as the S-shaped wire wrapping system.

3.3.4 Actual application at the Akashi Kaikyo Bridge

The design conditions of the dry air blowing system for the Akashi Kaikyo Bridge are presented below[23]. Also shown are results of air blowing tests carried out between 3P and 4A of the Bridge for the purpose of obtaining basic data for operation planning of the dry air blowing system in **Fig.13**. Design conditions were set out so that the water volume was 15% of the percentage of voids of the cable, the leak rate was 0.014/m or less, and the air blowing pressure was 3,000 Pa or less and under these conditions, a cable section 140 m long was selected as the air blowing section to be dried out within one year. An efficient piping route was set out according to the above conditions and the capacities of the dehumidifier and the blower of the air drying equipment and the piping diameter were designed accordingly. As seen in Fig.13, it was verified in the tests that a cable span of about 56 m, up to the fourth panel from the blow-in point, was dried out within a blowing period of three months at a pressure of 2,000 Pa. It was also confirmed that a total length of 140 m, all the way down to the air exhaust point, would be dried out in less than one year, and that the dry air blowing system worked as designed.

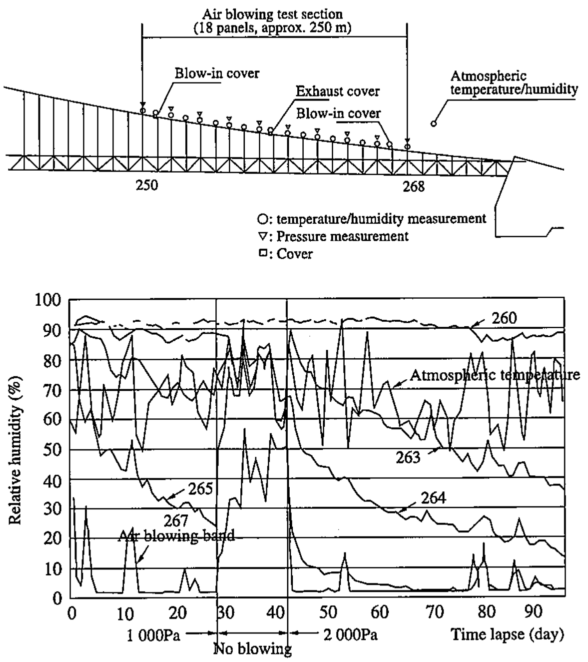

Fig.13 Measurement of relative humidity inside cable body of Akashi Strait Bridge

4. Conclusion

In this paper use of the S-shaped wire wrapping method and flexible type paint system was proposed as new measures for effectively protecting bridge cables against corrosion for long periods. Further, a dry air blowing method was mentioned as a means of removing the water present inside the cable body.

As the cables are the most important members of suspension bridges, to maintain the sound service function of this type of bridge for a long period, their protection against corrosion will become more and more significant as the bridges age. It is necessary to further refine the developed S-shaped wire wrapping method as a system through corrosion tests on actually operating bridges and feedback of the obtained results.

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