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Aluminum-Alloy Maintenance Trolleys for the Super-Long Bridge

Shin-ichi Endo, Atsushi Shiga, Eitatsu Yamamoto, Kanji Fukushima

Synopsis :
The design of the aluminum-alloy-made maintenance trollies, which was to be equipped to the Bannosu-Bridge as a part of the Kojima-Sakaide route linking Honsyu and Shikoku Island of Japan, was started taking into consideration the characteristics of the aluminum-alloy materials such as the galvanic corrosion problem between different materials - aluminum alloy for structural parts and steel for mechanical parts - and the welding procedure of the aluminum-alloy structure which posed most important problems. As the trollies were to be operated under the limited spaces of bridge girders, the compact size and the maintenance-free operation were emphasized in designing. For welding of the aluminum alloy, a fundamental experiment with a structure model, was carried out before starting of manufacture. Based upon the data obtained, control standards and circumstantial conditions for welding settled, and the manufacturing process of the aluminum-alloy structure with minimum distortion was established.

The body can be viewed from the next page.

Aluminum-Alloy Maintenance Trolleys for the Super-Long Bridge*

Shin-ichi Endo
General Manager,
Quality Control
Dept., Harima Works
Kawaden Co., Ltd.

Atsushi Shiga
Senior Researcher,
Construction Method
Lab., Research &
Development Center
Engineering Div.

Eitatsu Yamamoto
Staff Officer,
Planning Sec.,
Development Dept.,
Kawaden Co., Ltd.

Kanji Fukushima
Industrial Machinery
Manufacturing Sec.,
Harima Works
Kawaden Co., Ltd.

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1 Introduction

Kawaden Co., Ltd., a Kawasaki steel's affiliate, headquartered in Tokyo, Japan, manufactured aluminum-alloy maintenance trolleys to be used for the Bannosu Bridge as a part of the Kojima-Sakaide route linking the Honshu-Shikoku Islands in Seto Inland Sea. Aluminum-alloy is used in the trolleys to reduce the load on the bridge girder proper, thereby contributing to economical construction of the super-long bridge, while the corrosion resistance of aluminum-alloy ensures superior service life. In the following, an outline of the maintenance trolley is introduced.

2 Maintenance Trolley for Combined Highway/Railway Bridge

This trolley, shown in **Fig. 1**, is an external-surface maintenance trolley which travels in a narrow space between the upper highway girder and the lower railway facilities. It is used for checking and maintaining the upper highway girder. Its structure consists of two plate girders which are assembled into an inspection frame and suspended at four points. Each suspension point has a built-in travelling wheel. Travelling equipment is arranged at the center of the trolley and drives the wheels via a long shaft and universal joints. Travelling speed is variable within 4 to 10 m/min. The weight of the trolley is 13 t, of which about one half is aluminum alloy, excluding steel travelling equipment and electrical equipment. Further, since the bridge girder is curved, it is banked in the width direction; therefore, the 19 maintenance trolleys have dimensions slightly different from

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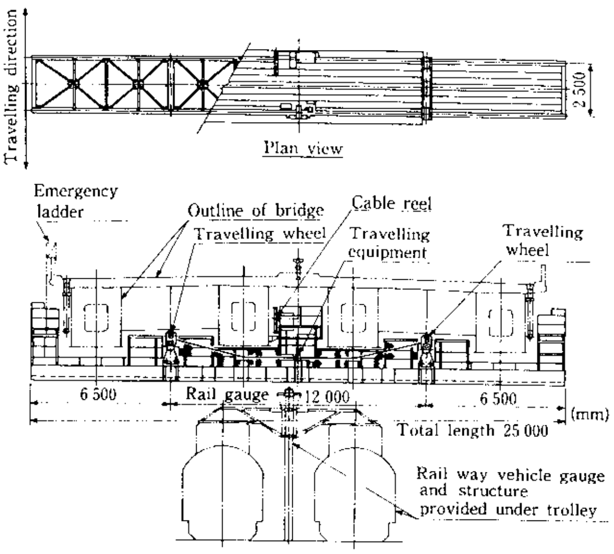

Fig. 1 Trolley for combination bridge of auto road and rail way

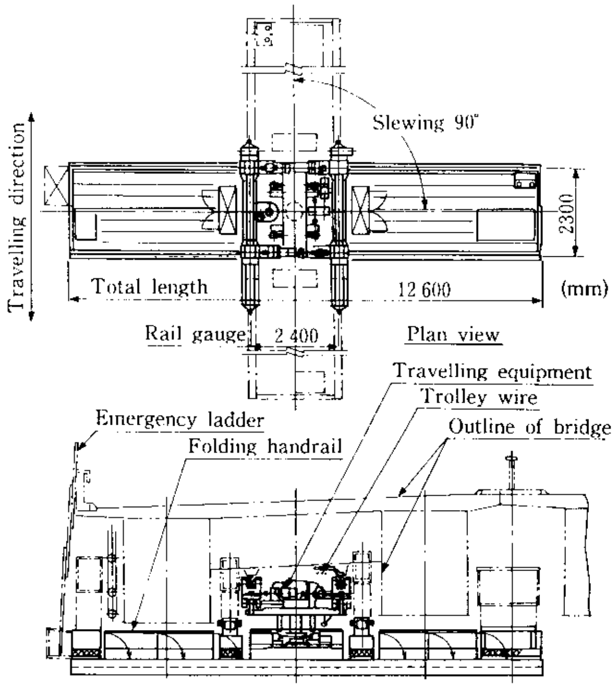

Fig. 2 Trolley for auto road bridge

each other, corresponding to bridge girder configuration at use positions. Electric power for travelling is supplied by cable, which is wound on a reel.

3 Maintenance Trolley for Highway Bridge

This is also an external-surface maintenance trolley, but of a different type from that used on the combined bridge. Unlike the combined bridge, the highway bridge consists of 15 spans, totaling about 1 km in length, and divided into two sections, corresponding to the lanes to and from Honshu. These sections are covered by two trolleys each, for a total of four trolleys. Since these trolleys travel in the narrow space above the bridge portal and must be able to move to the next span, the frame proper is designed so as to be lifted and slewed as shown in **Fig. 2**. The inspection stand on the trolley and hand rails can be extended vertically. Operating specifications

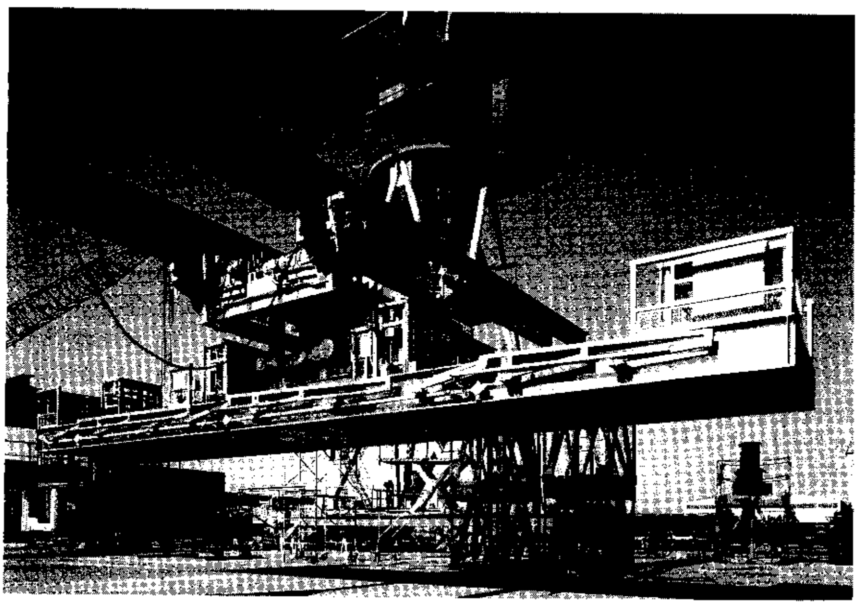

Photo 1 Trolley for auto road bridge

of these trolleys are given below.

Travelling: 2 to 10 m/min variable; 1.5 kW squirrel-cage motor (with brakes)

Slewing: 0.5 rpm; 1.5 kW squirrel-cage motor (with brakes)

Lifting: 0.33 m/min; 5.5 kW squirrel cage motor (with brakes)

These four trolleys also have dimensions slightly different from each other corresponding to bridge configuration. The average weight of the four trolleys is about 12 t, out of which about 2.5 t consists of aluminum alloy. For electrical pick up while travelling, an insulated trolley line is used because the trolley must travel long distances over many spans. This type of trolley is shown in the test depicted in **Photo 1**.

Mechanical components such as travelling unit, slewing unit, and lifting unit are concentrated in the top block, and the lifting portion is connected to the inspection-work frame via a slewing bearing. The slewing unit drives the outer race gears of the slewing bearing with a geared motor via a worm speed reducer. The lifting unit drives four screw jacks by a motor via a speed reducer. In the travelling unit, there are tow saddles, each provided with a geared motor to drive the four wheels, all of which are connected by means of long shafts and bevel gears. Each travelling saddle includes an emergency wedge-roller type rail clamp to fix the trolley on bridge girder under unexpected external force such as by sudden high wind; this device is shown in **Fig. 3**. When the trolley is parking, the clamp roller is pressed lightly into a gap between the travelling rail and the clamp guide by a spring. When external force is applied, the roller immediately bites into the gap and acts as a clamp. When the travelling notch is on, the roller is held free on the outer side by a solenoid, so that travelling is not obstructed.

4 Special Design Considerations

Since aluminum-alloy is particularly susceptible to contact corrosion when in contact with other metals,

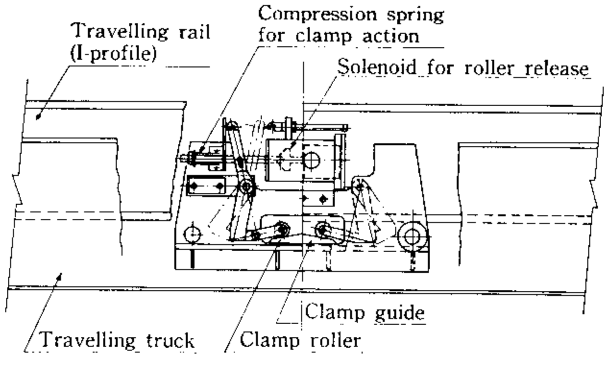

Fig. 3 Wedge-roller type rail clamp

the following countermeasures were incorporated in the design of the maintenance trolleys:

(1) For bolts in the aluminum-alloy portion, stainless steel (JIS G4303) was used as a rule, and where strength was prescribed, as with high tensile strength bolts, a hot-dip galvanizing was applied.
(2) At the portions of the motor, speed reducer, bearings, electric equipment, etc., which come into contact with steel, SUS304 (JIS G4304) stainless steel shim were inserted.
(3) For grease piping which comes into contact with the aluminum-alloy, copper pipes were used.
(4) For pins, stainless steel (SUS304) was used as a rule, and when the pin was large and required steel, a SUS304 stainless steel bush was applied between the pin and the aluminum-alloy.

5 Special Manufacturing Considerations

Since the hydrogen solubility of aluminum-alloy at the solidification is smaller than steel, blowholes occur more easily in welding aluminum-alloy than in welding steel, and the degree of distortion is also larger. From analysis of the gas composition in blowholes generated in the aluminum-alloy welding, it was found that the gas contained 80 to 90% hydrogen, meaning it was important to take measures to cope with moisture, which is the primary cause of blowhole formation.

Prior to the fabrication of the main body of the trolley, welding test[1,2] and sample test were conducted to establish proper welding conditions and standards for environmental control, and countermeasures for coping with distortion. Therefore, a welding yard exclusively for aluminum-alloy welding was set up and the control standards were enforced with satisfactory results.

6 Conclusion

The manufacture of maintenance trolleys commenced in May 1985 and the first lot, consisting of five trolleys, was delivered in February 1986, and the final lot, consisting of three units, was delivered in December 1986, completing the order.

To maintain the super-long bridge, the aluminum-alloy maintenance trolleys are expected to be utilized effectively.

References

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