Joint Development of Bogies between DB AG and JR East

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As part of the program for exchange of railway technologies, DB AG and JR East have been engaged in the joint development of a bogie for high-speed rail cars. Based on joint specifications, both companies have manufactured bogies for the Japanese Series E2 and German ICE2 according to their proprietary design techniques, and have verified the performances of the bogies developed through stationary tests on rolling stock test stands and current car running tests. This paper reports the overview of the bogies developed and the general procedures of various stationary tests and running tests of the bogies.

● Keyword : Riding comfort, Shinkansen car, Lateral vibration acceleration, Car body elastic vibration

1 Introduction

In 1992, BD AG and JR East signed a basic agreement on the technological railway development for the purpose of improving railway technologies. Since then, these companies have been making efforts for the exchange of railway technologies through the exchange of information and running test of STAR 21 (Shinkansen Test Cars) using the bogie manufactured by a German company, MAN.

In the process of this technological exchange program, the two companies reached an agreement for joint development of a bogie intended for application to the next generation high-speed rail car in 1995.

Based on this agreement, DB AG and JR created joint specifications defining the bogie weight, dimensions and maximum axle weight, and developed bogies according to these specifications using respective designing techniques.

The development target was directed toward the Japanese E2 Shinkansen car (Fig. 1) and the German ICE2 (Fig. 2). Each company developed two types of bogies; one for E2 and the other for ICE2, and conducted tests on the rolling stock test stand to verify the running stability, stationary tests to verify the strength of the wheel set, bogie frame and brake device, and final evaluation and verification tests through running tests on the specified lines.

In the process of this development project, JR considered that, in addition to development of high-performance bogies for high speed train, another objective of the project was to grasp the differences between Japan and Germany in the bogie development process, concept of bogie designing, performance tests and evaluation procedures, thereby upgrading the subsequent development procedure and enhancing the technological development capabilities applicable both in Japan and overseas countries.

The following introduces the overview of a series of tests conducted for this joint development project:

2 Development schedule

Table 1 shows the performance verification test schedule. As shown in this Table, JR East and DB AG manufactured a total of four types of bogies; two types for Series E2 and two types for ICE2. We conducted stationary tests and running tests of each bogie.

Fig. 1 E2 Shinkansen car

Fig. 2 ICE2 high-speed car

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Table 1 Test schedule

		Stationary test	Running test
JR East	For E2	Nov. 1997	May. 1998
	For ICE2	Oct. 1998 (Japan) Nov. 1999 (Germany)	Feb. 2000
DB AG	For E2	Mar. 1999	Oct. 1999
	For ICE2	Sep. 2000	May. 2001

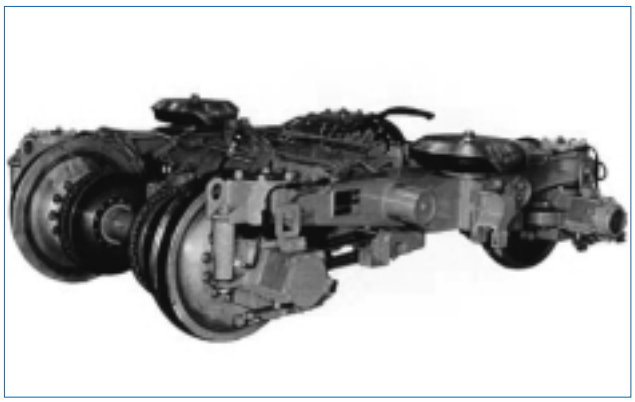

Fig. 3 Bogie for Series E2 developed by JR East

3 Overview of bogies developed

3.1 E2 bogies developed by JR East

The bogie for Series E2 Shinkansen developed by JR East is given in Table 3.

The following describes the major features:

(1) Lightweight

The weight of the bogie developed was reduced to 5.5 tons by application of high tensile strength steels to bogie frames, optimization of plate thickness, adoption of aluminum alloy brake disks and hollow axles machined by enlarged boring operation, use of high strength axle springs, and use of aluminum for the production of axle boxes and brake calipers. This reduces weight by 1 ton, as compared to the current bogie for Series E2 that weighs 6.5 tons.

(2) Riding comfort

To improve the riding comfort during high-speed running, we adopted a device for preventing the car body from vibrating in the lateral direction by means of a pneumatic actuator. Further, to upgrade the riding comfort on curves, we adopted the non-linear air spring for reducing the lateral motion of the car body.

(3) Noise reduction

To minimize the rolling noise and squeal noise of the wheels, we adopted a soundproof wheel equipped with a soundproofing ring made of an iron ring on which rubber was wound.

(4) Enhanced maintainability

To enhance maintainability of the wheel set, we used the vertical two-split type axle box that allowed easy removal of the wheel set from the bogie.

3.2 Bogie for Series E2 developed by DB AG

Fig. 4 shows the bogie for Series E2 Shinkansen developed by DB AG. The following describes its major features:

(1) Inside bearing system

The bogie of the Japanese Shinkansen has an axle box mounted outside the wheel. The bogie developed by DB AG is an inside bearing type bogie where the axle box (journal) is located inside the wheel. The inside bearing type bogie has an advantage of being light in weight since the bogie frame can be designed in a compact configuration.

(2) Anti-rolling device

This bogie comprises a primary anti-rolling device for reducing rolling between the bogie frame and wheel set, and a secondary anti-rolling device for reducing rolling between the car body and bogie frame.

(3) Vertical motion damper

In addition to the vertical motion damper for reducing the lateral motion of the bogie, this bogie is provided with a damper for vertical motion between the car body and bogie frame. This damper is installed on the side of the bolster spring.

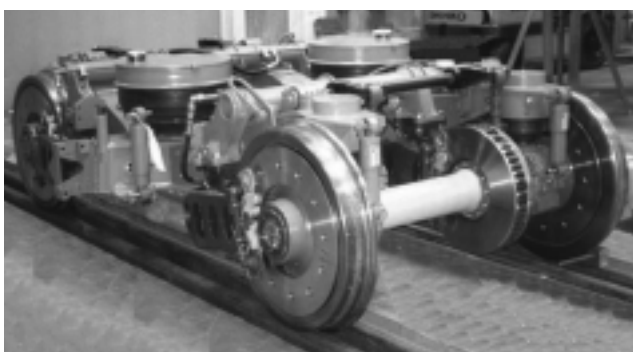

Fig. 4 Bogie for Series E2 developed by DB AG

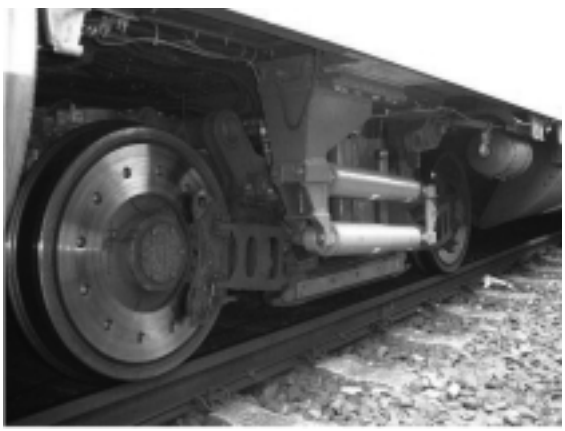

Fig. 6 Bogie for ICE2 developed by DB AG

3.3 Bogie for ICE2 developed by JR East

Fig. 5 shows the bogie for ICE2 developed by JR East. Basically, it has the same structure as that of the bogie developed for Series E2, but the following modifications were made in order to conform to the German ICE2:

(1) Adoption of anti-rolling device

(2) Adoption of electromagnetic rail brake equipment

(3) Four yaw dampers per bogie

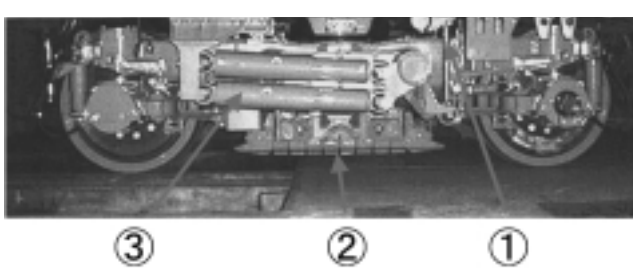

Fig. 5 Bogie for ICE2 developed by JR East

3.4 Bogie for ICE2 developed by DB AG

Fig. 6 shows the bogie for ICE2 developed by DB AG.

Basically, it has the same structure as that of the bogie developed for Series E2, except that a semi-active controlled vertical motion damper is provided between the car body and bogie.

4 Test using rolling stock test stands

To check the basic performances of the bogie, a stationary test was conducted by the Railway Technical Research Institute (RTRI) using the bogie test stand, and by DB AG using the rolling stock test stand in Munich. The major difference between the two is that the test stand of the DB AG is designed in such a way that the rail wheel serving as a rail moves separately to the right and left in conformity to track deviation, whereas the test stand of RTRI is designed so that it moves simultaneously to the right and left

In the stationary test, mainly, the stability during high-speed running was verified. In the case of the bogie for Series E2, this test was conducted under the condition of one bogie plus half a car body. In the case of the bogie for ICE2, however, the test was made under the condition of two bogies plus one car body.

Fig. 7 shows the stationary test of the bogies for Series E2 developed by JR East and DC AG. Fig. 8 shows the stationary test of the bogie for the ICE2 developed by JR East.

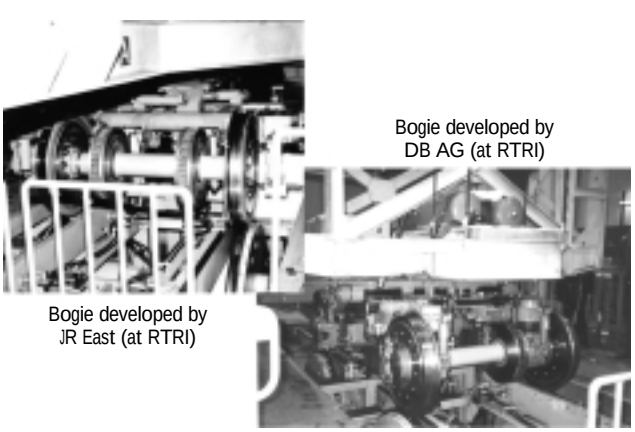

Fig. 7 Stationary test for bogies developed for E2 Series

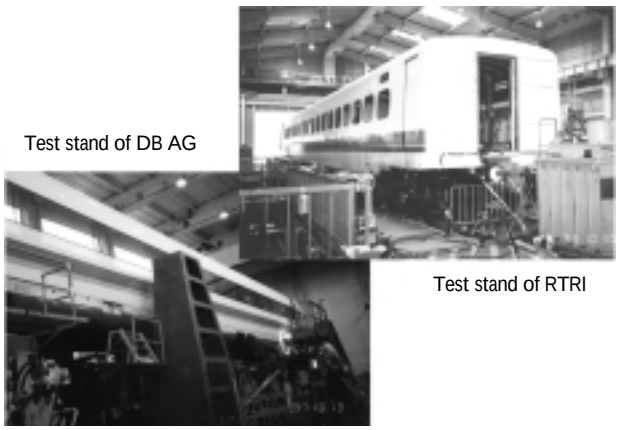

Fig. 8 Stationary test of the bogies developed by JR East for ICE2

5 Running test

5.1 Running test of the bogie developed for Series E2

After the basic performances had been checked in the stationary test, bogies developed by JR East and DB AG were connected to the cars of Series E2, and were put to the running test. The following describes the overview of this test.

- Test period:
Bogie developed by JR: May to July 1998
Bogie developed by DB AG: October to November 1999
- Test section: Sendai to Kitakami of Tohoku Shinkansen (Fig. 9)
- Test car: Series E2 Shinkansen (8-car trainset)
- Maximum test speed: 320 km/h

The major test items in the running test included improved speed test, yaw damper and air spring characteristics test and active control test and brake performance test. We measured the running stability including wheel load and transversal pressure, riding comfort and brake performances.
Fig.10 shows a state of connecting car bogies to the Series E2 car.

5.2 Running test of the bogie developed for ICE2

The following describes the overview of the running test conducted when the bogies developed by JR and DB AG were connected to the ICE2 car.

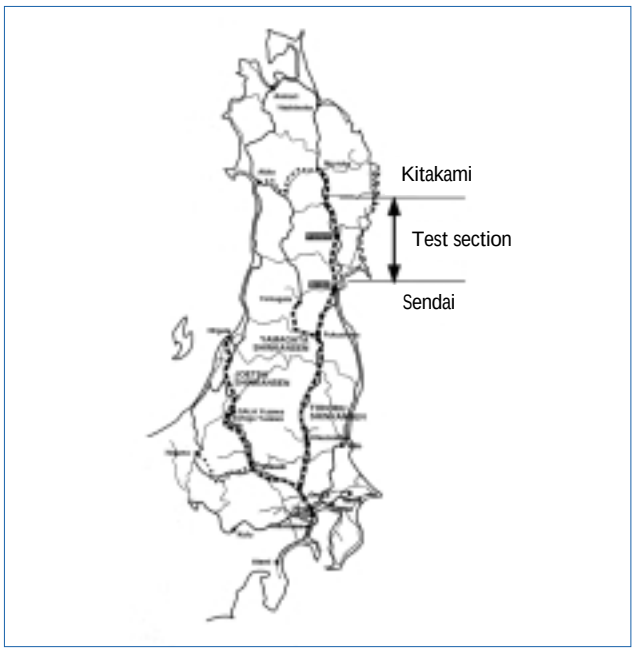

Fig. 9 Running test section of the bogie for Series E2

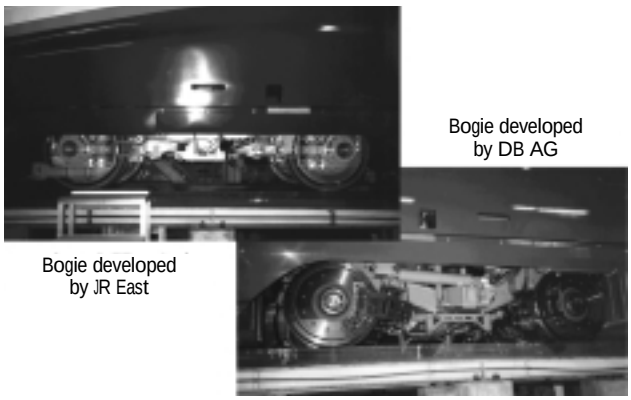

Fig. 10 Installation of the developed bogie to the Series E2 car

- Test period:
Bogie developed by JR: February to March 2000
Bogie developed by DB AG: May to July 2001

- Test section: (See Fig. 1)
(1) Hanover to Gottingen
(2) Wolfsburg to Berlin
(3) Trier and its surrounding area
(4) Ulm and its surrounding area

- Test ca (4-car trainset)

ICE-S test car (Test car for testing the components of the next-generation ICE)

Two bogies are connected to the ICE2 passenger car

- Maximum test speed:

Bogie developed by JR: 385 km per hour

Bogie developed by DB AG: 393 km per hour

The major test items included yaw damper and air spring characteristics and active performance tests in Section (1), improved speed test in Section (2), and cornering performance tests in Sections (3) and (4).

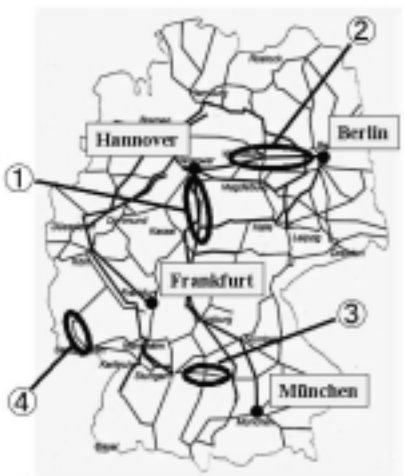

Fig. 11 Bogie test section for ICE2

6 Major test results

The following describes the major results of the stationary test and running test on the main line:

- The strength of the bogie frames, wheel sets and brake devices of both the JR bogie and DB AG bogie successfully passed the test, including the dynamic load test.

- In the running test of the bogies developed by JR and DB AG for Series E2, the speed was increased to the maximum test speed of 320 km per hour. Differences in lateral force of rails and wheel load variation were observed at the time of high-speed running and cornering due to the difference of running characteristics resulting from the differences in bogie characteristics. However, excellent results were obtained in the running stability and riding comfort of both bogies.

- The bogie developed by JR for ICE2 was subjected to the stationary test using the car rotary test stand of the RTRI. Then it was subjected to the stationary test where actual track irregularities of the Freiman test stand of the DB AG was input. Differences occurred in the test results on the hunting motion limit speed and others because of the difference in the concept between the two countries on the equivalent tread gradient between the wheel and rail. To solve this problem, we conducted an additional test by modifying the spring and other characteristics of the bogie, thereby improving the running stability and riding comfort.

- In the running test using the ICE2 on the new German high-speed line, satisfactory results could be obtained in the running stability and lateral riding comfort.

7 Conclusion

In the project discussed in this paper, we took part jointly with DB AG in the process from development to the performance test. As a result, we were able to grasp the differences between Japan and Germany in the bogie development process, the concept of the bogie designing, and test and evaluation procedures. Especially, we have learnt a great deal about the test and evaluation procedures, centering on the rolling stock test stand used by the German railway.

In German railways, the joint specifications created in this project will be used as a basis for the subsequent specifications required of the bogie by the car. Further, it has been confirmed that the performances of the bogie capable of running at 350 km per hour, lateral active control and a tread cleaner are effective in improving the riding comfort of the existing car.

Our subsequent objective is to study the high-speed bogie specification designing method and rational bogie performance verification test and evaluation procedures, based on these test results and achievements of the joint development projects discussed so far.