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**Rolling stock — Bogie — General rules
for design of bogie frame strength**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Land, Infrastructure, Transport and Tourism through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Association of Rolling Stock Industries (JARI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS E 4207:2004** is replaced with this Standard.

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Rolling stock — Bogie — General rules for design of bogie frame strength

Introduction

This Japanese Industrial Standard was established in 1984 and has gone through three revisions up to the present. The last revision was made in 2004, and the revision at this time is to respond to the recent advances in technology.

No corresponding International Standard has been established at this point.

1 Scope

This Japanese Industrial Standard specifies the conditions of strength design that are common to steel components used for bogie frames and beams comprising main strength members (excluding unsprung components and carbody mounting components), among bogies used for a rolling stock (excluding that for specified railway cars).

This Standard does not apply to the bogie frames used for specified railway cars (such as a trolleybus, a monorail car, a modified-personal-rapid-transit car, a magnetically supported vehicle, etc.), which use e.g. a rubber tire; however, this Standard may apply to the allowable stress of material used for bogie frames of these cars.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS E 4001 *Railway rolling stock — Vocabulary*

JIS G 3106 *Rolled steels for welded structure*

JIS G 3114 *Hot-rolled atmospheric corrosion resisting steels for welded structure*

JIS G 3445 *Carbon steel tubes for machine structure*

JIS G 5101 *Carbon steel castings*

JIS G 5102 *Steel castings for welded structure*

JIS Z 2273 *General rules for fatigue testing of metals*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS E 4001** and **JIS Z 2273**, and the following apply.

3.1

bogie frame

structure, being located between a carbody and wheel set, which supports the wheel set, bears the carbody mass and performs rotating movements (carbody displacement) when passing a curve

A bogie frame generally consists of such parts as side beams, cross beams and end beams.

3.2

beam

main strength member other than a bogie frame but including bogie bolster, tilting beam and steering beam all of which always bear the carbody mass

3.3

bogie bolster

beam which is placed between a bogie frame and a carbody in order to deal with the rotary displacement and vertical displacement of a bogie equipped with a bolster

NOTE No bolster is used in a bolsterless bogie.

3.4

tilting beam

beam installed on a roller type tilting bogie of tilting rail car for the tilting motion of the carbody

3.5

steering beam

beam installed on a bogie controlled by steering wheel sets for the steering motion of the wheel set

3.6

dimension A

distance between gauge marks used for measuring the reference height of an axle spring part

3.7

dimension B

distance between gauge marks used for measuring the reference height of a bolster spring part

4 Classification of common design conditions

The common design conditions are classified into a loading condition, a strength design condition, a structure design condition and a rigidity design condition, and shall be as follows.

a) **Classification of loading condition** The loading condition is classified into a static

load condition and a dynamic load condition.

- b) **Classification of strength design condition** The strength design condition is classified into stress calculation and allowable stress.
- c) **Classification of structure design condition** The structure design condition is classified as follows :
 - shape and material;
 - matters to be considered concerning the structure design and the welded joint design;
 - example of evaluation method using a nominal stress limit diagram which provides a rough standard of pipe bracket welds;
 - example of the method for evaluating fatigue strength of weld roots and welds existing on the back side of members.
- d) **Classification of rigidity design condition** The rigidity design condition is classified as follows :
 - flexural stiffness and torsional stiffness;
 - torsional rigidity.

5 Loading condition

5.1 Static load condition

The static load is defined as the load applied to the bogie frames when the rolling stock car is in a stationary condition (the load which the axle spring bears), and shall be calculated according to Formula (1).

$$W = W_1 + W_2 + W_3 \dots\dots\dots(1)$$

- where,
- W : static load applied to bogie frame (N)
 - W_1 : load by mass of carbody which one bogie bears (N)
 - W_2 : load by the mass of loads given in Table 1 which one bogie bears (N)
 - W_3 : load by mass of bogie frames and bogie frame components (N)

When the load is applied to the beam, the static load shall be calculated according to Formula (2).

$$W_B = W_1 + W_2 + W_{B3} \dots\dots\dots(2)$$

- where,
- W_B : static load applied to beam (N)
 - W_{B3} : load by mass of beams and beam components (N)

Table 1 Mass of loads ^{a)}

Classification		Remarks
Passenger stock		Passenger ^{b)} , crew, water, fuel, sand, secondary battery, food (dining car), baggage (baggage car)
Locomotive		Crew, water, fuel, sand, secondary battery, baggage
Freight-train car	General freight-train car	Freight ^{c)}
	Tank car Container car	Loaded object ^{d)}
Notes ^{a)} When the mass of loads is nonuniformly distributed to the bogies used for a rolling stock car, the larger mass of distributed loads is adopted. ^{b)} Mass between 1 time and 3 times the passenger loads (scaling factor agreed between the interested parties) ^{c)} Mass between 1 time and 1.1 times the maximum mass (scaling factor agreed between the interested parties) ^{d)} Maximum mass		

5.2 Dynamic load condition

The dynamic load is defined as the load applied to the bogie frame when the rolling stock car is in a running condition, which includes the load expressed by the product of a static load multiplied by an addition factor and the load determined by the characteristics of mounting components. The magnitude of such loads shall be normally as given in Table 2.

The magnitude of the addition factor practically applied and the magnitude of load according to characteristics of components shall be as agreed between the interested parties in consideration of the track conditions and the magnitude of oscillation expected to be practically generated with a rolling stock car.

Table 2 Dynamic load conditions

Classification	Type		Loading condition	Application (example)
Vertical direction	Load by bouncing of burden mass N		$W_{Z\ 1} : (0.2 \text{ to } 0.5) \times W^{a)}$	—
	Load by bouncing of mass of mounting component N	Side beam mounting component	$W_{Z\ 2} : (1 \text{ to } 2) \times L_p^{b)}$	Brake component
		Cross beam mounting component	$W_{Z\ 3} : (3 \text{ to } 10) \times L_p^{b)}$	Traction motor, driving unit
		End beam mounting component or side beam tip mounting component	$W_{Z\ 4} : (5 \text{ to } 10) \times L_p^{b)}$	Brake component Rail guard Snow plough ^{h)}
	Load acting on driving unit bracket by driving force ^{f)} N		$W_{Z\ 5} : (0.2 \text{ to } 0.4) \times L_a^{c)}$	Gear box suspension bracket Reducer support bracket
	Load acting on brake equipment bracket by brake force N		$W_{Z\ 6} : p^{d)}) \times f^{e)}$	Brake unit, disc brake units
	Load acting on vertical motion damper bracket N		$W_{Z\ 7} : \text{Load by damper characteristics}$	Axle spring damper
	Load acting on anti-rolling device bracket N		$W_{Z\ 8} : \text{Load by anti-rolling device characteristics}$	Anti-rolling device bearing part
	Lateral direction	Load by oscillation of burden mass and load by centrifugal force N		$W_{Y\ 1} : (0.2 \text{ to } 0.4) \times W^{a)}$
Load acting on lateral stopper bracket N		$W_{Y\ 2} : \text{Load obtained by subtracting air spring supporting load, etc. from } W_{Y\ 1}.$	Lateral stopper rubber	
Load by oscillation of mass of mounting component N		$W_{Y\ 3} : (2 \text{ to } 4) \times L_p^{b)}$	Traction motor, brake component	
Load acting on lateral damper bracket N		$W_{Y\ 4} : \text{Load by damper characteristics}$	Lateral damper	
Longitudinal direction	Load by oscillation of burden mass N		$W_{X\ 1} : (0.2 \text{ to } 0.4) \times W^{a)}$	—
	Load by tractive force N		$W_{X\ 2} : (0.2 \text{ to } 0.4) \times L_a^{c)}$	—
	Load by oscillation of mass of mounting component N		$W_{X\ 3} : (1 \text{ to } 3) \times L_p^{b)}$	Traction motor, brake equipment
	Load by brake N		$W_{X\ 4} : p^{d)})$	—
Torsion	Torsional displacement due to e.g. a gradual decrease in the superelevation of an outer rail mm		Lateral displacement is given at a diagonal wheel position of one bogie. $\delta_T^{g)}$: 10 to 15	—
Notes ^{a)} Static load applied to a bogie frame as given in Formula (1). When the static load is applied to a beam, use Formula (2). ^{b)} Static load by mass of mounting components (mass $\times$ gravitational acceleration) ^{c)} Axle load: Load applied to the track (rail) from a wheel set mounted in a bogie ^{d)} Brake block force ^{e)} The coefficient of friction between a brake shoe and a wheel tread, and/or a brake lining and a brake disc ^{f)} Take the tangential force between a wheel and a rail as $W_{Z\ 5}$, and then calculate the specific magnitude of load in consideration of e.g. the reduction gear ratio and support position of, for example, the driving unit to be adopted. ^{g)} δ_T : Displacement at the position of wheel ^{h)} For the part to which a snow plough is fitted, apply a force caused by the snow-removal resistance which is produced only when snow is cleared from the track, in addition to a force caused by snow plough vibrations.				

6 Strength design condition

6.1 General

When a load is applied to a beam, W shall be replaced by W_B .

The subscripts z, y and x of load symbols indicate vertical, lateral and longitudinal directions, respectively.

6.2 Stress calculation

In the stress calculation, the stress produced when the static load and the dynamic load are applied to the bogie frames, shall be calculated for each type of load and shall be classified into mean stress and varying stress to be combined. The combining method of stresses shall be as follows.

- a) **Mean stress** The mean stress is defined as the algebraic sum of two or more stresses calculated for each type of static load. In the case where the stress produced by a dynamic load fluctuates between zero and the maximum value or between zero and the minimum value, the mean stress shall be obtained by adding one-half the stress by the dynamic load to the stress by static load.
- b) **Varying stress** The varying stress can be obtained by combining the stresses by dynamic load, and calculated according to Formula (3).

$$\sigma_a = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \dots + \sigma_n^2} \dots\dots\dots (3)$$

where, σ_a : varying stress (MPa)
 $\sigma_1, \sigma_2, \sigma_3, \dots, \sigma_n$: stress calculated for each type of dynamic load (MPa)

However, when stresses are caused by forces generating in synchronization, such as a brake block force and a friction force of a wheel tread brake, the value obtained by adding individually squared stress values may result in an underestimation. Therefore, the algebraic sum of stresses caused by each force shall first be obtained and then squared to be added.

In the case where the stress produced by a dynamic load fluctuates between zero and maximum/minimum value, the varying stress shall be obtained by combining one-half the stress by the dynamic load according to Formula (4).

$$\sigma_a = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \dots + \left(\frac{\sigma_i}{2}\right)^2 + \dots + \sigma_n^2} \dots\dots\dots (4)$$

where, σ_a : varying stress (MPa)
 $\sigma_1, \sigma_2, \sigma_3, \dots, \sigma_n$: stress calculated for each type of dynamic load (MPa)
 σ_i : stress calculated according to a dynamic load, which fluctuates between zero and maximum/minimum value (MPa)

6.3 Allowable stress

The allowable stress shall be within the limit shown in the stress limit diagram of Figure 1.