Performance of “JFE FRAME KIT”[†]

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Abstract:
“JFE FRAME KIT” is the structural system which includes structure design and building materials for the high-performance housing. This article explains the outline of structural performance such as strength, stiffness and deformation capacity, that are evaluated through WKH IXOO VFDOH ORDGLQJ WHVW RI EUDFHG SDQHO ¿UH UHVLVWDQW VWUXFWXUH LQVXE Ó BL WVXQ- ÓBL¿ÓBBL WXQLWVB ÓV H XE ppV pV Ó surement of the model house of recommended insulation VSHFL¿FDWLRQV DUH GLVFXVVHG DORQJ ZLWK VWUXFWXUDO SHU formance.

1. Introduction

A series of major earthquakes exceeding 7 on the seismic intensity scale have struck Japan in recent years, including the Hyogo Nanbu Earthquake (1995) and Niigata Chuetsu Earthquake (2004), and massive Tokai and Nankai earthquakes may occur in the future. Due to heightened anxiety regarding these natural disasters, interest in the seismic performance of housing is also high. Therefore, JFE Steel developed “JFE FRAME KIT” (Photo 1) as structural steel materials for low-ULVH EXLOGLQJV VXFK DV KRXVLQJ structures of 3 stories or less. The advantages of this product include high durability (long life) and excellent seismic performance.

This paper presents an evaluation of the rigidity, strength, and deformation performance of “JFE FRAME KIT” based on a structural loading test of braced panels, DQ RXWOLQH RI LWV ¿UH UHVLVWDQFH RI LWV KHDW LQVXODWLRQ DQWL UHVXOWV RI SHUIRUPDQFH YHUL¿FDWLRQ RI WKH UHFRPPHQGHG KHDW LQVX

2. Features

“JFE FRAME KIT” uses steel materials in the construction system members in the frame construction (skeleton system) method, combining the freedom of ÀRRU SODQ GHVLJQ RI IUDPH- FRQVW ability of steel frame construction. Because all members used are manufactured from hot dip zinc coated steel sheets, high durability is secured. All connections, including the columns and beams, are bolt connections XVLQJ PHWDO ¿WWLQJV GHYHORSHG joints are frequently used in the connections in general steel frame structures, imposing a heavy load on welding control, but in contrast, no welding processes are used with “JFE FRAME KIT,” in either the steel frame fabrication process or during erection at the site. This is a factor in securing uniform performance of products. Unlike industrialized housing, “JFE FRAME KIT” is a Do-It-kind steel construction method. Therefore, structural design drawings and documents are necessary

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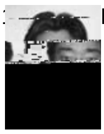
Construction Engineering Services Dept.,
Construction Materials & Services Center,
JFE Steel



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when making applications for building construction, and shop drawings are necessary during fabrication of the steel frame. However, all types of data are prepared H I ¿ F L H Q W O \ E \ D Q L Q W H J U D W H G design and fabrication processes, beginning with the proprietary design support program "AI-FRAME" developed by JFE Steel. The fact that the product is supplied as a set, including the structural steel materials, structural calculation documents, structural drawings, etc., is also a major feature of "JFE FRAME KIT."

3. Structural Performance of Braced Panels

3.1 Performance Evaluation Method

In "JFE FRAME KIT," seismic loads, wind loads, and other horizontal loads are all borne by braced panel load-bearing walls, which comprise vertical braces, the columns on the two sides, and the upper and lower beams. Structural safety technical appraisals of braced panels including connections were carried out using full-scale models in accordance with the Building Letter "Technical Regulations for Structural Strength Performance of Low-Rise Steel Frame Structures"[1] issued by the Building Center of Japan, and "Documents of Performance Evaluations for Approvals under Article 1.3.1 of the Enforcement Regulations of the Building Standard Law (Steel Frame Buildings and their Parts)"[2]. A test specimen and the loading apparatus are shown in Fig. 1. The experimental parameters were the brace diameter, beam connection method, sheet thickness of the columns, and sizes of the upper and lower beams. As loading conditions, after cyclic loading comprising story drift ±1/200 rad × 1 time, ±1/100 rad × 2 times, and ±1/50 rad × 1 time, loading was applied up to 1/12.5 rad and the fact that there was no failure of the bolted con- Q H F W L R Q V R U H [F H V V L Y H O R F D O G H

3.2 Outline of Results of Performance Evaluation

Figure 2 V K R Z V W K H O R D G G H À H F W L R loop) for a continuous beam model and a segmented beam model of standard test specimens (brace M20, column sheet thickness; 3.2, upper beam: BH-250 × 99 × 4.5 × 4.5, lower beam: H-100 × 100 × 6 × 8). All specimens showed stable hysteresis characteristics of the slip type due to yielding of the brace, which is a characteristic of tension braces.

Figure 3 shows the rigidity, allowable strength, strength, and Ds-value (structural characteristic coef- ¿ F L H Q W Z K H Q P R G H O H G D V D Q H Q curve (skeleton curve). The Ds values in the experiments were from 0.29 to 0.33. However, as a design value, a

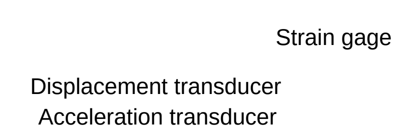
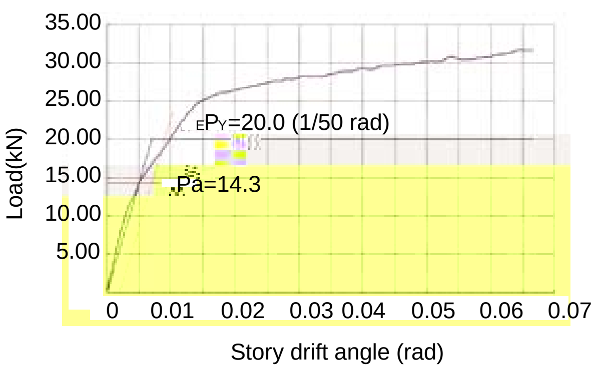


Fig.1 Apparatus of braced panel test



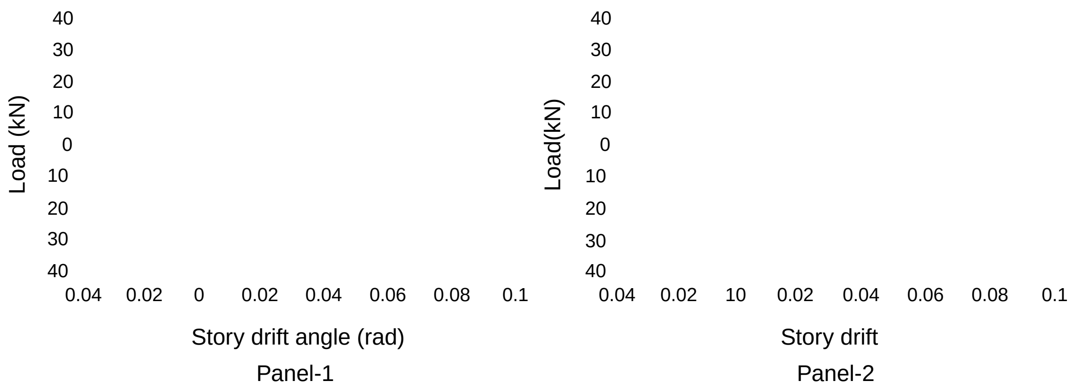


Fig.

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conservative value of 0.35 is adopted in all cases. The
IDFW WKDW WKH FRHI¿FLHQW RI GDPSLQJ LV RQ WKH RUGHU RI

sprayed slag wool is set lower than in the existing con-struction method, at a thickness of 25 mm and density of 0.2. Special reinforcement is not necessary at joints with the sprayed slag wool.

Because beams act as heat bridges, the web part on WKH RXWGRRU VLGH RI WKH mm of EHDPV LV ¿OOHG ZLWK slag wool 32K to prevent condensation on the indoor side under room temperature conditions. As in the exte-rior walls, combined use with additional insulation is possible. The applicable insulating materials are the same those as for the exterior walls.

2XWOLQH RI ¿UH UHVLVWDQFH WHVW UHVXOWV

,Q WKH KRXU ¿UH UHVLVWDQFH WHVW ORDGHG KHDWLQJ of exterior walls, the main judgment standards are maximum temperature rise at back side: 180°C or less, average: 140°C or less, maximum axial shrinkage: h/100 mm (31.5 mm) or less, maximum axial shrinkage rate: 3h/1000 mm/min (9.45 mm/min) or less (where h: initial height of the test specimen) in a test with a total time of 4 hours, comprising heating for 1 hour and natural cooling for 3 hours. Under the same conditions, WKH MXGJPHQW VWDQGDUGV IRU EHDPV DUH PD[LPXP GHÀHF-tion: L2/4 000 d mm (200.1 mm) or less, and maximum GHÀHFWLRQ L2/9 000 d mm/min (11.6 mm/min) or less (where L: beam span, d: beam depth).

The conditions of the specimens after the loaded heating tests are shown in Photo 2 (exterior bearing wall outside), Photo 3 (exterior bearing wall inside), and Photo 4 FRPSRVLWH ¿UH SURRI FRQVWUXFWLRQ EHDP 7KH tests were conducted by the General Building Research Corporation of Japan.

In the exterior wall (outside) test, there were no par-ticularly large changes during heating. After an elapsed time of 5–18 PLQ IROORZLQJ WKH HQG RI KHDWLQJ ¿UH occurred on the heated side from the joints in the ALC. 7KLV ¿UH EXUQHG IRU DERXW PLQ 2Q WKH EDFN VLGH from the heated surface, no problems were observed with

To verify the performance of the outside insulation/foundation insulation construction method, the indoor environment and crawl space environment of a "JFE FRAME KIT" house with outside insulation and foundation insulation were measured over a period of 1 year. An outline of the results is presented here.

Outline of the House

The object of measurements was a house (Sumeru SI skeleton infill) with outside insulation and foundation insulation, which was constructed in Nagoya City, Aichi Prefecture. The model house (non-resident) was completed in January 2006. A view of its external appearance is shown in Photo.

In the object house, ALC 50 mm was applied directly to the exterior walls, and folded steel plates were used in the roof. As outside and foundation insulation, 25 mm of extruded polystyrene foam was applied externally, and 200 mm of glass wool was laid in the ceiling.

As interior materials, with the exception of the second floor ceiling, utility and [illegible] room spaces, the model house was [illegible] skeleton form with the structural members visible. On the second floor, half of the entrance [illegible] well, and the structural materials, wall studs, and substrate (shina plywood) for the exterior were left unfinished. Thus, the entire indoor area on the second floor was an open space. A view of the entrance well is shown in Photo 6.

Measurements

Measurements, including preparatory measurements, were carried out from January 14, 2006 to February 9, 2007. The main measurement items were as follows.

(1) Temperature and humidity conditions and condensation in crawl space of model house with foundation insulation: Crawl space air temperature, Humidity, Surface temperature of slab concrete

(2) Interrelationship between indoor environment and crawl space in model house with outside insulation and foundation insulation: Air temperature (center of living room space, lavatory), Humidity (center of living room space, lavatory), [illegible] temperature (Japanese-style room, lavatory)

(3) Condensation on steel materials: Temperature of [illegible]

(4) Measurements of test environment: Outside air temperature, Humidity (measured on the north side of the building)

Measurement Results

(1) Indoor Environment

The outside air temperature and temperature and humidity in the living room and crawl space are shown in Fig. 6. The indoor surface temperature and dew point temperature are shown in Fig. 7.

Because the model house has high insulation and air-tightness, the highest air temperature in summer was at maximum 2–4°C lower than the outside air, even without air-conditioning. In winter, the indoor temperature was always higher than the outdoor temperature, being 2–6°C higher even at the time of the outside air temperature in winter. Although crawl VSDFH KXPLGLW\ H[FHHGHG- LQ $XJXVW LW JUDGX ally decreased thereafter. In the crawl space environment, the effect of the indoor environment is greater than that of the outside air, and the temperature and humidity in the crawl space varied depending on air-conditioner operation. Figure 8 also show the results of a trial calculation for a model with ordinary crawl space ventilation (case in which water vapor in the RXWVLGH DLU ÀRZV LQWR WKH FUDZO VSDFH :LWK FRQYHQ tional construction, the frequency of condensation in the crawl space was higher than with the foundation insulation method, and crawl space condensation generally occurred in June and July.

'XUDELOLW\ RI FUDZO VSDFH

The condition of the crawl space 1 year after the completion of construction is shown in Photo 7. The “JFE FRAME KIT” members, nuts, and bolts all show