*16th World Conference on Earthquake, 16WCEE 2017*

*Santiago Chile, January 9th to 13th 2017*

*Paper N° 4012*

*Registration Code: S-D1464715599*

# 2015 Three-dimensional Shaking Table Test of a 10-story Reinforced Concrete Building on the E-Defense

## Part 1: Overview and Specimen Design of the Base Slip and Base Fixed Tests

K. Kajiwara[(1)], Y. Tosauchi[(2)], E. Sato[(3)], K. Fukuyama[(4)], T. Inoue[(5)]
H. Shiohara[(6)], T. Kabeyasawa[(7)], T. Nagae[(8)], H. Fukuyama[(9)], T. Kabeyasawa[(10)], T. Mukai[(11)]

[(1)] *Director, E-Defense, National Research Institute for Earth Science and Disaster Resilience, kaji@bosai.go.jp*
[(2)] *Researcher, Fujita Corporation, yusuke.tosauchi@fujita.co.jp*
[(3)] *Chief Researcher, E-Defense, National Research Institute for Earth Science and Disaster Resilience, eiji@bosai.go.jp*
[(4)] *Visiting Researcher, E-Defense, National Research Institute for Earth Science and Disaster Resilience, fuku-kn@bosai.go.jp*
[(5)] *Vice Director, E-Defense, National Research Institute for Earth Science and Disaster Resilience, dinoue@bosai.go.jp*
[(6)] *Professor, The University of Tokyo, shiohara@arch.t.u-tokyo.ac.jp*
[(7)] *Professor, Earthquake Research Institute, The University of Tokyo, kabe@eri.u-tokyo.ac.jp*
[(8)] *Associate Professor, Nagoya University, nagae@nagoya-u.jp*
[(9)] *Director, National Institute for Land and Infrastructure Management, fukuyama-h92ta@nilim.go.jp*
[(10)] *Associate Professor, Tokyo Metropolitan University, tosikazu@tmu.ac.jp*
[(11)] *Senior Researcher, Building Research Institute, t_mukai@kenken.go.jp*

## *Abstract*

The E-Defense, which is the world's largest three-dimensional (3D) full-scale earthquake shaking table test facility, was built by the National Research Institute for Earth Science and Disaster Resilience (NIED) with the aim of shedding light on the failure mechanisms of full-scale structures during earthquakes and for verifying the effects of seismic retrofitting. Since its start of operations in April 2005, a wide variety of structures have been tested on this facility.

In December 2015, NIED performed tests on a 10-story reinforced concrete building frame on the E-Defense in order to gain building engineering knowledge that will enable continued use of buildings after a major earthquake. In this experiment, data were obtained from a structure equipped with a base slip mechanism in order to study the efficacy of the base slip construction method. After the base slip construction test, the base of the same specimen was fixed in place to simulate conventional construction conditions and testing was conducted in order to compare fixed-in-place behavior with the base slip response behavior, determine the damage process of each member, and examine damage and response evaluation methods.

This paper provides an overview of the base slip and fixed base tests while also presenting information on the specimen design and dimensions. In this building specimen, the sections were designed against the stresses acting in each member, whereas design loads were based on dead and live loads derived from the actual conditions during the test and the seismic load specified by the current standards.

*Keywords: Earthquake resistance, Damage mitigation, Base slip*

## 1. Introduction

The E-Defense, which is the world's largest three-dimensional (3D) full-scale earthquake shaking table test facility, was built by the National Research Institute for Earth Science and Disaster Resilience (NIED) with the aim of shedding light on the failure mechanisms of full-scale structures during earthquakes and verifying the effects of seismic retrofitting. Since its start of operations in April 2005, a wide variety of structures have been tested on this facility.

As part of its “Social Infrastructure Research Utilizing the 3D Full-Scale Earthquake Testing Facility” project, NIED conducted shaking table tests on a 10-story reinforced concrete building frame in December 2015. Previously, NIED had also conducted tests on reinforced concrete buildings using the E-Defense. In 2006, two sets of experiments were conducted on reinforced concrete buildings fabricated based on design methods common around 1970 [1, 2]. In the experiment using a six-story specimen, collapse phenomena due to shear failure of the first-story shear wall and short columns were observed. The experiment using a three-story specimen demonstrated the mitigating effect on ground motion input by spread foundation slippage and the effectiveness of seismic retrofitting with external frames.

In 2010, tests were carried out on a four-story reinforced concrete building fabricated according to current standards, in which the damage process of each member and failure behavior under seismic motion was observed, and an evaluation of the building frame response during an earthquake was performed [3, 4]. In that experiment, the building was still self-supporting after being subjected to ground motion replicating the 1995 Hyogo-ken Nanbu Earthquake, which showed that it had sufficient seismic capacity in terms of being able to avoid building collapse. Based on the damage observed at the shear wall bottom and beam-column joints of the frame, continued use of the building, repair costs, and other economic issues that arise in such conditions were identified. In the 2011 Great East Japan Earthquake, which was centered off the coast of Tohoku, there were numerous cases of buildings that incurred damage in nonstructural members that made the continued use of those buildings difficult, even though they did not collapse [5].

The aim of the test carried out by NIED in 2015 was to gain building engineering knowledge that will enable continued use of buildings after a major earthquake. Data were obtained from the base slip construction test in order to determine its effectiveness as a method of enabling continued use. Moreover, the conventional fixed base condition was likewise tested in order to compare its response behavior with that from the base slip construction method, determine the damage process of each member, and examine damage and response evaluation methods.

This paper will provide an overview of the tests and specimen design.

## 2. Test Overview

In this experiment, shaking table tests were conducted using the 10-story reinforced concrete building specimen shown in Fig. 1. The specimen dimensions were 15.7 m in the longitudinal direction and 9.7 m in the transverse direction on the 1st floor, and 13.5 m in the longitudinal direction and 9.5 m in the transverse direction on standard floors. The longitudinal direction had three spans at 4.0 m each, whereas the transverse direction had three spans with 3.1, 1.8, and 3.1 m lengths. A cantilever slab was placed at the ends of each floor in order to observe the damage sustained by each member.

The floor heights were 2.80 m for the 1st floor, 2.60 m for the 2nd to 4th floors, 2.55 m for the 5th to 7th floors, and 2.50 m for the 8th to 10th floors. The specimen height was 27.45 m from the shaking table floor surface, with an aspect ratio of about 3.4. The longitudinal direction was a simple frame structure composed of beams and columns, whereas the transverse direction was a frame structure with a multi-story shear wall at the 1st to 7th floor. The floor slab was 130 mm thick.

An open passageway in the 1st floor slab was provided in order to permit foundation damage observations and permit repair work on the specimen position. Openings and stairways were provided at the center of the standard floors in order to facilitate the movement of researchers up and down the specimen.

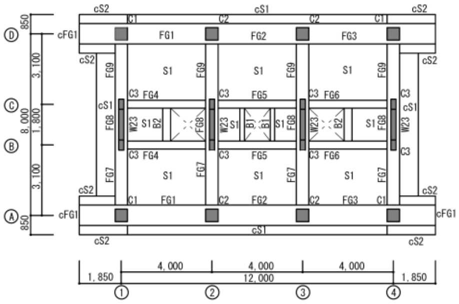
The steel beam on the 6th floor, which was provided to facilitate transportation of the upper portion of the specimen (discussed later in Part 2), was fabricated with H 1000 × W 500 × 19 × 40 H-steel in the longitudinal direction and H 300 × W 305 × 15 × 15 H-steel in the transverse direction, and a weight of approximately 16 t. This additional weight was taken into account in the specimen’s design live load shown in Table 1. The design load per unit area is also shown in Table 1. To reduce the external force acting on the specimen during a major earthquake, plates made of cast iron (referred to hereinafter as cast iron bearings) were placed at the bottom of the specimen’s footing beam on 16 column locations (Fig. 2). These cast iron bearings were expected to function as sliding supports. Hence, clearances of 450 mm or more were provided around the footing beam and stiff rubber fenders were installed for cushioning in order to prevent specimen impact related failure.

The cast iron bearings were made of 40 mm-thick cast-iron plates, with 20 mm of this thickness embedded into the bottom of the specimen's footing beam. Thus, when the specimen was mounted on top of the base concrete, a 20 mm gap existed between the bottom of the specimen’s footing beam and the base concrete surface. The specimen weight was transmitted to the base concrete only through the cast iron bearings at the bottom of the footing beam, with bearing pressure on the cast iron bearings ranging 2.2 to 4.5 $N/mm^2$ for the long-term load. In other words, only the base concrete was fixed to the shaking table during the test for base slip construction.

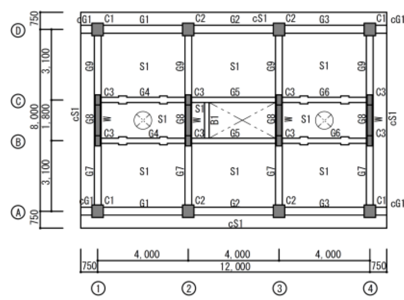
Since the specimen was supported by the base concrete via the cast iron bearings alone, the foundation was allowed to lift and slide during excitation. Furthermore, since previous tests [6] showed that the coefficient of friction between the cast iron and concrete surface was about 0.2, it was assumed that slippage would generally occur when the inertial force from seismic loading specified in the allowable stress design for temporary loading acts on the specimen foundation.

The edges of the cast iron bearing seat were tapered to 45 degrees to facilitate smooth base slippage. Since it was presumed that residual displacement would result from the base slip construction test, hydraulic jacks were positioned beforehand in order to restore the specimen to its original position after the test, and thus prepare the specimen for the fixed base condition test. Residual displacement was considered as a separate issue in this study.

The rises fabricated at the base concrete edges were used as reaction walls by the hydraulic jacks when restoring the specimen to its original position after the base slip test. These rises were fabricated to the required strength for use as reaction walls.

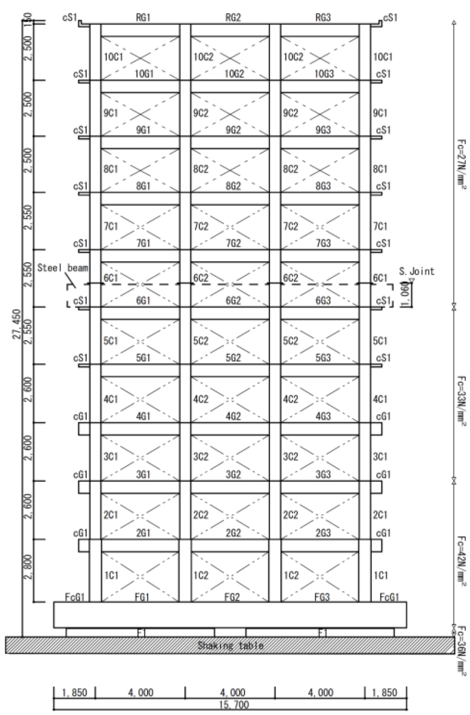


(a) 1st floorplan

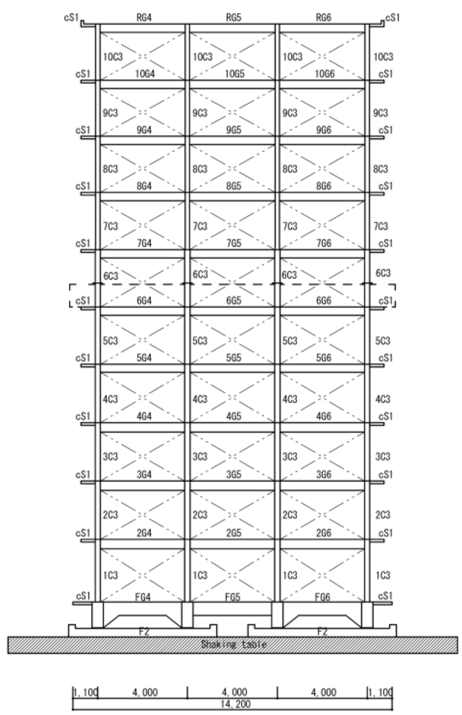


(b) 2nd to 7th floor plan

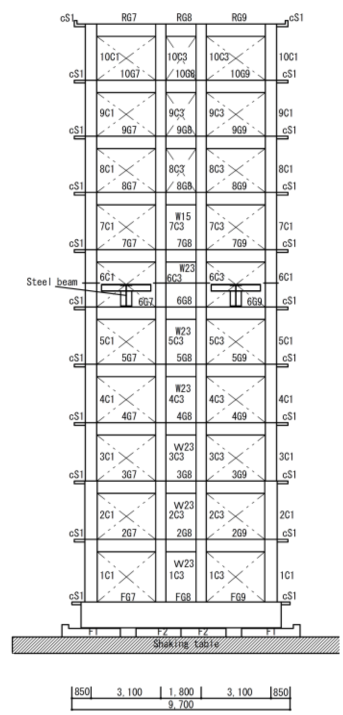
(c) Perspective



(d) A, D frame



(e) B, C frame



(f) 1-4 Frame

Fig. 1: Plan and Elevations

Table 1 Weight of specimen

| | D.L. [kN] | L.L. [kN] | Sum. [kN] | Sum. [kN/m$^2$] |
|---|---|---|---|---|
| R | 725 | 0 | 725 | 5.7 |
| 10 | 740 | 57 | 1,522 | 6.2 |
| 9 | 694 | 28 | 2,244 | 5.6 |
| 8 | 716 | 28 | 2,988 | 5.8 |
| 7 | 949 | 28 | 3,965 | 7.6 |
| 6 | 618 | 188 | 4,771 | 6.3 |
| 5 | 780 | 28 | 5,579 | 6.3 |
| 4 | 798 | 28 | 6,405 | 6.4 |
| 3 | 817 | 28 | 7,250 | 6.6 |
| 2 | 889 | 57 | 8,196 | 7.4 |
| 1 | 1,830 | 29 | 10,055 | 12.2 |

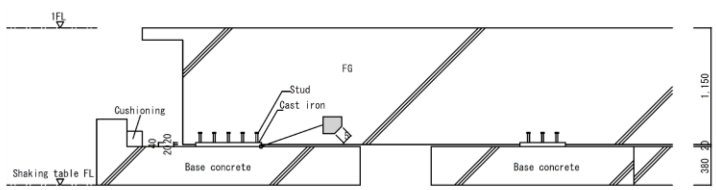



Fig. 2: Section of specimen's base

## 3. Specimen Design

The structural calculation of the specimen was performed according to current seismic design standards, and complies with the Architectural Institute of Japan (AIJ) Standard for Structural Calculation of Reinforced Concrete Structures [7] and the Technological Standard Related to Structures of Buildings, Japan [8]. In the primary design, the allowable stress design test was performed with the standard shear coefficient $C_0$ of 0.20.

In the secondary design, the horizontal load bearing capacity was verified with Ds = 0.30 to 0.35 in the simple frame direction (hereinafter referred to as frame direction), whereas in the direction of the frame with multi-story shear wall (hereinafter referred to as wall direction), Ds = 0.35 to 0.40 at the 1st to 7th floors with shear wall and Ds = 0.30 at the 8th to 10th floors without shear wall. The maximum story drift angle during horizontal load bearing capacity verification was 1/70 in the frame direction and 1/100 in the wall direction, while the member rank was determined when roughly twice the maximum story drift angle was generated during horizontal load bearing capacity verification. The frame was designed with the aim of ensuring the member maintained sufficient deformation capacity while moving toward a total collapse mechanism.

The column and beam cross sections and are listed in Tables 2 and 3, respectively. In the structural design, the sections were designed against stresses acting in each member, with the design load based on dead and live loads from the actual conditions during the test and the seismic load specified according to the current standards. The dead load includes the main frame weight, whereas the live load includes the steel stairway installed to allow researchers to move up and down the interior of the specimen, steel fixtures, and other weights, for a total specimen frame weight estimated as 1,026 t.

The design story shear force was calculated based on the Ai distribution. The beams and columns used SD345 with diameters D19 to D22, and the amounts of reinforcement were set such that the ratio of column-to-beam capacity was roughly 1.0 or more at the end of the analysis. The shear reinforcement bars were, in principle, weld-closed, although inner ties and a portion of the joint hoops were hooked for construction reasons. A portion of the beam and column shear reinforcement used S10 of high-strength reinforcing bar KSS785 to ensure member strength and ductility, whereas all the rest used D10 or D13 of SD295A. Double-layer mesh reinforcement was placed in the wall using D10 or D13 of SD295A, as well as in the slab using D10. The concrete design strength was Fc = 42 $N/mm^2$ from the footing beam to the 3rd floor slab, Fc = 33 $N/mm^2$ from the 3rd floor column to the 6th floor slab, and Fc = 27 $N/mm^2$ from the 6th floor column upward.

The structural design system BRAIN III [9] was used for the static pushover analysis, during which beams and columns were modeled as beam elements with elastoplastic rotational springs placed at member ends and rigid zones at connections between beams and columns. The shear wall was modeled as a beam element attached to rigid beams at the top and bottom, and the secondary column was modeled as a rod with axial elastoplastic springs and pins at both ends. The yield moments of members were calculated according to the Technological Standard Related to Structures of Buildings, Japan [8] with reinforcement yield strength of 1.1 times the specification value.

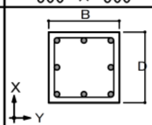
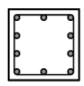
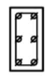
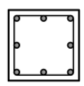
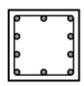
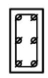
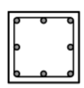
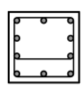
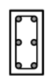
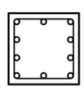
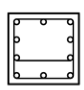
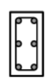
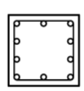
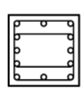
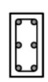
In the allowable stress design for temporary loading, the verification ratios for each member section were set at 0.32 to 0.80 for the columns, 0.43 to 0.93 for the beams, and 0.50 to 0.65 for the shear walls. The ductility factor of beams at horizontal load bearing capacity was set at 3.03 for the 5th floor slab beam in the frame direction and 3.06 for the 4th floor slab beam in the wall direction. At the shear wall, axial yielding occurred in the tension side of the secondary column on the 1st floor. At this time, the story shear coefficients on the 1st floor were 0.36 in the frame direction and 0.42 in the wall direction. Moreover, the ratio of shear force over shear strength acting on beam-column joints, which were calculated based on the Design Guidelines for Earthquake Resistant Reinforced Concrete Buildings Based on Inelastic Displacement Concept [10], was set at 1.0 or below for all beam-column joints.

# 4. CONCLUSIONS

The following points were discussed with regard to the overview and specimen design of the shaking table tests conducted by NIED on a 10-story reinforced concrete building in December 2015:

- The aim was to gain building engineering knowledge that will enable continued use of buildings after a major earthquake.
- Tests were carried out on a base slip construction and on a base with the fixed condition.
- The design of the specimen was performed according to the philosophy of current standards in Japan.

Table 2: Column section list

| | | C1 | C2 | C3 |
|---|---|---|---|---|
| 10F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |   |  |  |
| | Rebar | 8 - HD19 | 10 - HD19 | 6 - LD16 |
| | Hoop | LD10[2,2]@100 | LD10[2,2]@100 | LD10[2,2]@100 |
| 9F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 8 - HD19 | 10 - HD19 | 6 - LD16 |
| | Hoop | LD10[2,2]@100 | LD10[2,2]@100 | LD10[2,2]@100 |
| 8F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 8 - HD19 | 10 - HD19 | 6 - HD19 |
| | Hoop | LD10[2,2]@100 | LD10[3,2]@100 | LD10[2,2]@100 |
| 7F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 10 - HD22 | 10 - HD22 | 6 - HD19 |
| | Hoop | LD10[2,2]@100 | LD10[3,2]@100 | LD10[2,2]@100 |
| 6F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 10 - HD22 | 12 - HD22 | 6 - HD19 |
| | Hoop | LD10[2,2]@100 | LD10[4,2]@100 | LD10[2,2]@100 |

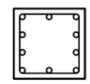
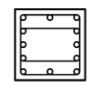
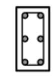
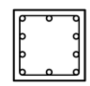
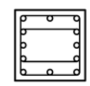
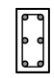
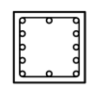
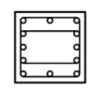
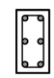
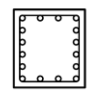
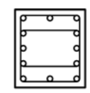
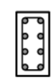
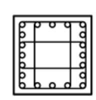
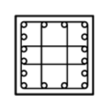
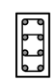
| | | C1 | C2 | C3 |
|---|---|---|---|---|
| 5F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 10 - HD22 | 12 - HD22 | 6 - HD19 |
| | Hoop | LD10[2,2]@100 | S10[4,2]@100 | LD10[2,2]@100 |
| 4F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 10 - HD22 | 12 - HD22 | 6 - HD19 |
| | Hoop | S10[2,2]@100 | S10[4,2]@100 | LD10[2,2]@100 |
| 3F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 500 | 500 × 500 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 12 - HD22 | 12 - HD22 | 6 - HD19 |
| | Hoop | S10[2,2]@100 | S10[4,2]@100 | LD10[2,2]@100 |
| 2F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 500 × 550 | 500 × 550 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 16 - HD22 | 12 - HD22 | 8 - HD19 |
| | Hoop | S10[2,2]@100 | S10[4,2]@100 | LD10[2,2]@100 |
| 1F | Joint | 2,2-D10@150 | 2,2-D10@150 | 2,2-D10@150 |
| | B×D | 550 × 550 | 550 × 550 | 230 × 450 |
| | Section |  |  |  |
| | Rebar | 20 - HD22 | 16 - HD22 | 8 - HD19 |
| | Hoop | S10[4,4]@100 | S10[4,4]@100 | S10[4,2]@100 |

Table 3: Beam Section list

| Floor | Item | G1, G3 | G2 | G4, G6 | G5 | G7, G9 | G8 |
|---|---|---|---|---|---|---|---|
| RF | Location | All | All | All | All | All | All |
| | b×D | 300×500 | 300×500 | 230×370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Bottom | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @200 | LD10 [2] @ 200 | LD10 [2] @ 150 |
| 10F | Location | Outer end / Center / Inner end | All | All | All | All | All |
| | b×D | 300 × 500 | 300 × 500 | 230 × 370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 4 - HD19 / 3 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Bottom | 3 - HD19 / 3 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 |
| 9F | Location | End / Center | End / Center | All | All | All | All |
| | b×D | 300 × 500 | 300 × 500 | 230 × 370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 4 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Bottom | 3 - HD19 / 3 - HD19 | 3 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 |
| 8F | Location | Outer end / Center / Inner end | End / Center | All | All | All | All |
| | b×D | 300 × 500 | 300 × 500 | 230 × 370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 5 - HD19 / 3 - HD19 / 4 - HD19 | 5 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Bottom | 4 - HD19 / 3 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 200 | LD10 [2] @ 150 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 | LD10 [2] @ 200 |
| 7F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | All |
| | b×D | 350 × 550 | 350 × 550 | 230 × 370 | 230 × 370 | 400 × 470 | 400 × 470 |
| | Section | | | | | | |
| | Top | 4 - HD22 / 3 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 5 - HD19 / 3 - HD19 / 5 - HD19 | 5 - HD19 |
| | Bottom | 4 - HD22 / 3 - HD22 / 3 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 5 - HD19 / 4 - HD19 / 6 - HD19 | 6 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 200 | LD10 [2] @ 175 | LD10 [2] @ 75 | LD10 [2] @ 200 | LD13[4]@150 / LD13[2]@200 / LD13[4]@150 | LD10 [2] @ 200 |
| 6F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | End / Center | All |
| | b×D | 350 × 550 | 350 × 550 | 230 × 370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 5 - HD22 / 3 - HD22 / 4 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Bottom | 4 - HD22 / 3 - HD22 / 3 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 150 | LD10 [2] @ 125 | LD10 [2] @ 75 | LD10 [2] @ 200 | S10 [2] @ 175 | LD10 [2] @ 200 |
| 5F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | End / Center | All |
| | b×D | 350 × 550 | 350 × 550 | 230 × 370 | 230 × 370 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 5 - HD22 / 3 - HD22 / 4 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Bottom | 4 - HD22 / 3 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD19 / 4 - HD19 / 4 - HD19 | 4 - HD19 / 3 - HD19 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 125 | LD10 [2] @ 100 | LD10 [2] @ 75 | LD10 [2] @ 200 | S10 [2] @ 175 | LD10 [2] @ 200 |
| 4F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | End / Center | All |
| | b×D | 350 × 550 | 350 × 550 | 230 × 420 | 230 × 420 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 5 - HD22 / 3 - HD22 / 5 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Bottom | 5 - HD22 / 3 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 100 | LD10 [2] @ 100 | LD10 [2] @ 50 | LD10 [2] @ 200 | S10 [2] @ 175 | LD10 [2] @ 200 |
| 3F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | End / Center | ALL |
| | b×D | 350 × 550 | 350 × 550 | 230 × 420 | 230 × 420 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 6 - HD22 / 3 - HD22 / 5 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Bottom | 5 - HD22 / 3 - HD22 / 4 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 4 - HD19 / 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 100 | LD10 [2] @ 100 | LD10 [2] @ 50 | LD10 [2] @ 200 | S10 [2] @ 175 | LD10 [2] @ 200 |
| 2F | Location | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | End / Center | Outer end / Center / Inner end | All |
| | b×D | 350 × 550 | 350 × 550 | 230 × 420 | 230 × 420 | 300 × 470 | 300 × 470 |
| | Section | | | | | | |
| | Top | 6 - HD22 / 3 - HD22 / 5 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 4 - HD19 / 3 - HD19 / 3 - HD19 | 3 - HD19 |
| | Bottom | 5 - HD22 / 3 - HD22 / 4 - HD22 | 5 - HD22 / 3 - HD22 | 3 - HD22 / 4 - HD22 / 4 - HD22 | 4 - HD22 / 3 - HD22 | 3 - HD19 / 3 - HD19 / 3 - HD19 | 3 - HD19 |
| | Web | — | — | — | — | — | — |
| | Stirrup | LD10 [2] @ 100 | LD10 [2] @ 100 | LD10 [2] @ 50 | LD10 [2] @ 200 | S10 [2] @ 175 | LD10 [2] @ 200 |
| 1F | Location | Outer end / Inner end | All | Center / Haunch end | All | All | All |
| | b×D | 900 × 1150 | 900 × 1150 | 350 × 600 / 350 × 1150 | 350 × 600 | 550 × 1,150 | 550 × 1,150 |
| | Section | | | | | | |
| | Top | 10 - UD29 / 10 - UD29 | 10 - UD29 | 6 - HD25 / 6 - HD25 | 4 - HD25 | 8 - HD25 | 8 - HD25 |
| | Bottom | 16 - UD29 / 14 - UD29 | 14 - UD29 | 6 - HD25 / 6-HD25, 2-HD22 | 4 - HD25 | 7 - HD25 | 7 - HD25 |
| | Web | 4 - LD10 | 4 - LD10 | — / — | — | 4 - LD10 | 4 - LD10 |
| | Stirrup | LD13 [2] @ 125 | LD13 [2] @ 125 | LD10 [2] @ 200 / LD10 [2] @ 200 | LD10 [2] @ 200 | LD13 [2] @ 125 | LD13 [2] @ 125 |

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