May 31, 2007

Four-Story Steel Building Collapse Analysis
Blind Prediction Contest Rules

1. Purpose

A blind prediction contest is held in order to contribute to development of computational prediction for seismic response, numerical prediction of collapse behavior, and efficient modeling techniques for steel frame buildings. The final goal is to improve seismic performance of steel frames through numerical simulation. The contest is carried out for collapse test of full-scale four-story steel frame building. Each participant should predict the responses before and after the test, and the closest prediction to the test result will be awarded.

Because the actual dynamic load patterns will be determined during the course of the testing based on observed response of the shaking table, the contest has two parts:

1. Pre-test blind predictions based on anticipated earthquake loadings.
2. Post-test predictions using the actual loadings. The same analytical model as that used for Part 1 is to be used for Part 2 predictions.

2. Judge and acting committee

The contest is a part of the NIED E-Defense steel research team project, and will be carried out by two working groups (WGs) of the team: The Analysis Method and Verification Working Group (WG) will do all the tasks including announcement, distribution of data, answering questions, and judgment. The Building Collapse Simulation WG will produce the experimental data for the collapse of the four-story building.

3. Qualification of the participants

The participants can be either an individual or a team, but one individual can be involved in only one team or as an individual. However, an individual or a group can participate in both categories of 3D-analysis and 2D-analysis described below. A member of the aforementioned WGs or a person who has an access to test specifications prior to the official announcement can still submit his/her prediction results, but is not eligible to compete for awards.

4. Category

The contest is categorized by the types of analysis methods and participants. Winners will be selected for each of the following categories:

(a) 3D-analysis:

Three-dimensional (3D-) analysis may be carried out by (but not limited to) finite element analysis with shell and/or solid elements, or frame analysis using fiber elements and/or beam-column line elements with plastic hinges.

(b) 2D-analysis:

Two-dimensional (2D-) analysis may be (but not limited to) plane frame analysis, including fiber elements and/or line elements.

Each category will have two winners according to type of participant as follows.

1. Researchers (including students)
2. Practicing Engineers.

A total of four winners will receive awards according to Section 10.

5. Schedule (by 12 midnight, Japan time)

May 28:	Announcement of outline and schedule of the contest, and distribution of specification of structural components and basic material properties.
August 10:	Deadline of entry application.
September 10:	Submission of pre-test analysis results by participants.
September 20-30:	Shaking-table test at E-Defense
October 20:	Distribution of actual base acceleration record.
November 30:	Submission of post-test analysis results by participants.
December 20:	Announcement of the winners.

6. Plan of test and analysis.

- The shaking-table tests will be conducted consecutively with increasing levels of seismic motion. The seismic levels are not fixed a priori; the seismic level of the subsequent test will be decided according to the actual deformation and damage observed in the current test.
- For pre-test analysis, the seismic levels for which the analysis results should be submitted will be announced before the deadline of entry application mentioned above.
- For post-test analysis, exact recorded table motion at each seismic level will be provided for use in the analysis. Analysis results should be submitted for the *incipient-collapse level*, the seismic level immediately prior to the *collapse level* at which collapse of the building occurred. The analysis should be performed continuously from the seismic level at which the first plastification occurs up to the collapse level, by serially combining the corresponding table motions. If no significant plastification is observed prior to the collapse level, the data described in Section 8(a)-[A] below may be presented for collapse level. The complete data specification for judgment is to be provided immediately after the test.

7. Specimen data to be provided.

The following data will be distributed via website: http://www.bosai.go.jp/hyogo/ehyogo/index.html.

(a) Structural geometry: plan, elevation, cross-sectional properties of structural members, and detailed description of the specimen including connections to non-structural components.
(b) Details of loading conditions: weights of parts and non-structural components.
(c) Preliminary analysis results: pushover analysis, free vibration analysis (modal analysis), and preliminary time-history analysis carried out by the organizing committee.
(d) Component test results: beam, column, composite beam, and anchor bolt.
(e) Material test results: properties of steel and concrete, which are obtained by the test based on Japanese specification.

(f) Methods of measurement and data processing.

(g) Time-history and response spectrum of seismic motion: ideal acceleration for pre-test analysis, and measured acceleration for post-test analysis.

Photographs showing specimen preparation will be available from website.

8. Analysis results to be submitted.

Pre-test analysis.

(a) Maximum values of relative displacement from base, absolute acceleration and overturning moment at each floor; maximum values of story shear, story drift angle; maximum strain at a specified point (center of certain column in 1st story) in a elastic region; and residual story drift angle at each story (the story drift at the end of the specified duration of the seismic motion).

(b) Supplemental data:

Figures describing the global deformation and plastification of the frame, and the time-histories of relative displacements should be submitted as supplemental data.

(c) Input files to the analysis program:

Data should be in ASCII format, and all the non-default values such as damping factor, hardening parameters, etc., should be explained. The input echo of the analysis program is preferred, and the geometry data such as nodal coordinates and node-element relations are not needed.

(d) Description of analysis model:

Finite elements, constitutive model, method of time-integration, method of geometrically nonlinear analysis, and so on, should be explained.

(e) Computational environment:

Name of computer, analysis program availability (free, commercial, or for research), CPU time, and wallclock time, etc. should be described.

Post-test analysis.

(a) Data for judgment.

[A] For *incipient-collapse level*: Maximum values of relative displacement from base, absolute acceleration and overturning moment at each floor; maximum values of story shear, story drift angle; maximum engineering strain at a specified point (center of the column in 1st story) in an elastic region; and residual story drift at each story (the story drift at the end of the specified duration of the seismic motion).

[B] For *collapse level*: Time, measured from the beginning of the collapse-level motion, at which the drift angle of any story in *X*- or *Y*-direction reaches 0.2 or -0.2 rad. for the seismic motion.

(b) Supplemental data:

Figures describing the global deformation and plastification of the frame, and the time-histories of relative displacements should be submitted as supplemental data. Note that the analysis results obtained from the time-history that differs widely from that of test results will be rejected to prevent accidental agreement of the numerical and test results.

(c) Input files to the analysis program:

Exactly the same input data, except the base acceleration and material properties of concrete, should be

used for pre-test analysis and post-test analysis. The geometry data such as nodal coordinates and node-element relations are not needed.

General remarks.

i The forms for submittal will be distributed by the committee.

ii The responses in X- and Y-directions should be presented for 3D analysis, while only Y-directional responses are to be presented for 2D analysis.

iii Evaluate maximum (absolute value) relative displacement and total acceleration envelopes on the upper surface at the center of each floor.

iv Formulas for computing story drift, overturning moment and story shear will be supplied by the committee. The weight of each story is given.

v The strain of a column to be reported is that due only to the dynamic response, that is it does not contain the value due to dead load.

vi ‘Maximum’ is defined as the absolute value peak response (independent of sign).

vii Predictions shall be in SI units (mm, kN, sec, rad); do not use ‘g’ or ‘%’; and each number should have four significant figures. For example, a story drift angle can be reported as 0.01234 rad., and an overturning moment can be reported as 0.1234E+10 kN mm. Conversions: 1 inch = 25.4 mm, 1 kips = 4.448 kN.

9. Method of judgment.

(a) Compare the RMS errors for each response quantity, which is computed from

$$E_i = \sqrt{\sum_j (F_{i,j} - F^*_{i,j})^2}$$

$F_{i,j}$: analysis result of *i*th response quantity at *j*th floor/story.

$F^*_{i,j}$: test result of *i*th response quantity at *j*th floor/story.

E_i : RMS error of *i*th response quantity

(b) The basic point b_i for *i*th response quantity is 8 for the minimum error, 5 for the second, 3 for the third, and 1 for the fourth. The total point *P* is computed from

$$P = \sum_{i=1}^{n} w_i b_i$$

w_i : weight for ith response quantity

n: number of response quantities

The team/individual with maximum total point will be the winner for each category. The weight w_i will be announced by the committee before the pre-test analysis results submission.

(c) The judgment will be carried out completely anonymously. Judges will only know the participant submission name only via an alias.

(d) In each category, up tp and including the third place winners will be announced and the names of all the participants will be asked to disclose their names and affiliations.

10. Awards.

The four first-place award winners will be invited to and will be honored at the 14th World Conference on Earthquake Engineering (WCEE), 2008, Beijing, P.R. China. NIED will cover the travel and accommodation expenses for the winners' participation in the WCEE.