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Prediction of Seismic Response of Value-added Five-story Steel Frame

Blind Analysis Contest Rules

1. Purpose

A blind analysis contest is held in order to contribute to development of computational prediction of seismic response and efficient modeling techniques for steel frame buildings. The final goal is to improve seismic performance of steel frames through numerical simulation. Last year, we organized the blind analysis contest for prediction of incipient collapse behavior of a full-scale four-story steel frame. This year, the seismic responses of the steel frames with Japanese steel dampers and American viscous dampers, respectively. Simulations are to be carried out before and after the test, the results of the best accuracy 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 steps:

1. Pre-test blind predictions based on the anticipated earthquake loadings.
2. Post-test predictions using the actual loadings and the test results of concrete strength. The same analytical models are to be used both for pre-test and post-test 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 working group (WG) of the team: Isolation and Damper System Working Group (WG) will do all the tasks including announcement, distribution of data, answering questions, judgment, and producing the experimental data for the value-added five-story steel 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 team can participate in several categories described below. A member of the aforementioned WG 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:

(Category1) 3D-analysis, Steel damper
(Category2) 3D-analysis, Viscous damper
(Category3) 2D-analysis, Steel damper
(Category4) 2D-analysis, Viscous damper

Each category will have one winner and a total of four winners will receive awards according to Section 11. The teams with three best results in each category will be reported in the website of NIED, and will receive the certificate for recognition of the good results.

5. Schedule

December 5, 2008 : Distribution of schedule of the contest, specification of structural components and basic material properties
February 15, 2009 : Deadline of registration
March 2 : Submission of pre-test analysis results by participants
March 5 : Shaking-table test with steel damper at E-Defense
March 12 : Shaking-table test with viscous damper at E-Defense
April 30 : Distribution of acceleration for post-test analysis
May 31 : Submission of post-test analysis results by participants
June 30 : Announcement of the winners

*Note: The deadline is at 9:00am (JST). JST is GMT +9:00.

6. Plan of test and analysis.

(a) All the structural components except the dampers are used without replacement. The steel, viscous, oil and visco-elastic dampers will be tested and replaced in this order. Only the responses of the frame with steel dampers or viscous dampers are to be predicted in this contest.
(b) The seismic motion used in the test is the 1995 Hyogo-ken Nanbu Earthquake Takatori wave. The scales of the wave, for which the responses are to be predicted, are 1.0 for pre-test analysis, and 0.4 and 1.0 for the post-test analysis.
(c) The direction of the Takatori wave is diagonally defined such that South-East component in X direction and North-East component in Y direction of the frame.
(d) The shaking-table tests will be conducted consecutively with increasing scales of the seismic motion. The scales are not fixed *a priori*; the scale of the subsequent test will be decided according to the observed responses in the current test.
(e) The analysis model and method for analysis are to be fixed by the pre-test analysis.
(f) The same model and method as the pre-test analysis should be used in the post-test analysis except the seismic motion, which is replaced by the measured motion of the shaking-table, and the constitutive model of the concrete material, which is available after the test.

7. Specimen data to be provided.

The following data will be distributed via website: http://www.blind-analysis.jp/index_e.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 and preliminary time-history analysis carried out by the organizing committee. (paper presented at 14WCEE)
(d) Material test results: properties of steel and concrete, which are obtained by the test based on Japanese specification. (results of concrete are available after the test)
(e) Time-history and response spectrum of seismic motion: ideal acceleration for pre-test analysis, and measured acceleration for post-test analysis.
(f) Snapshots of the specimen during the construction process will be uploaded to the website.

8. Analysis results to be submitted.

Pre-test analysis.

See the file "Appendix: Instruction for preparation of analysis results for judgment" for details of definition of the responses.

(a) Predicted responses:
Fill the file *Sheet1-pre* (for 3D or 2D analysis). The responses to be predicted are:

- Maximum absolute values of relative displacement from base and absolute acceleration at each floor.
- Maximum absolute values of story shear and story drift angle.
- Maximum and minimum values of axial deformations and axial forces of the dampers in 1st and 4th stories in Y1 and X2 sections for 3D analysis and, in X2 section only for 2D analysis.
- Maximum absolute value of strain at a specified point in an elastic region.

(b) Description of computational environment, and model and method for analysis:
Fill the file *Sheet2-pre*. Name of program, type of availability of program (free, commercial, research purpose), name of computer, CPU time, number of degrees of freedom, constitutive models, definition of damping, method of time integration, etc. should be described.

(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, while the geometry data such as nodal coordinates and node-element relations are not needed.

(d) Supplemental data:
Figures illustrating the deformation and plastification, the relation between force and deformation of a damper, the time histories of shear force and drift angle of a story, and so on.

Post-test analysis.

(e) Predicted responses： (data for judgment)
Fill the file *Sheet1-post*. The responses to be predicted are same as (a) for the pre-test analysis.

(f) Description of computational environment, and model and method for analysis:
Fill the file *Sheet2-post*. Items are same as (b) for the pre-test analysis.

(g) Input files to the analysis program:
Make sure that the same data except or the seismic motion and constitutive model of concrete, should be used for pre-test analysis and post-test analysis.

(h) Supplemental data:
Figures illustrating the deformation and plastification, the relation between force and deformation of a damper, the time histories of shear force and drift angle of a story, and so on. Note that the results in *Shee1-post* will be rejected if they are not consistent with the supplemental data.

General remarks.

i) The forms for submittal (Sheet1-pre, Sheet1-post, Sheet2-pre, Sheet2-post) will be distributed by the committee on the Webpage.

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) Any method including frame model, lumped mass model, FEM, etc., can be used for prediction of the responses.

iv) Shaking-table test is first carried out for a frame with steel damper, followed by a frame with viscous

damper. Therefore, in the latter test, the frame members and slabs already experienced deformation in the former test. The participants are free to use any method and engineering judgment for evaluating the effect of residual deformation.

v) The maximum absolute values of relative displacement and absolute acceleration are evaluated on the upper surface at the center of each floor.

vi) Formulas for computing story drift and story shear, as well as the weight of each story, are given in Appendix in the separate file.

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. 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

$$E_k = \sqrt{\sum_k (F_{k,j} - F^*_{k,j})^2}$$

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

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

E_k : RMS error of *k*th response quantity

Note that only the responses in 1st and 4th stories are considered for dampers.

(b) The point *bi* for the *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

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

n : number of response quantities

The team/individual with maximum total point will be the winner for each category.

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

(d) In each category, up to 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. Distribution of detailed test results

All the detailed results will be available in two years, in the latest, after the shaking-table test at a website that can be reached from the website of NIED. Note that the detailed results cannot be distributed to anyone before the official distribution.

11. Awards

The four first-place award winners will be invited to and will be awarded at the 7th International Conference on Urban Earthquake Engineering, 2010, held by the Center for Urban Earthquake Engineering (CUEE), Tokyo Institute of Technology, Japan. NIED will cover the travel and accommodation expenses for the winners' participation in the CUEE. The teams with three best results in each category will be reported in the website of NIED, and will receive the certificate for recognition of the good results.