3D NONLINEAR RC STRUCTURE MODELING AND REAL EARTHQUAKE DYNAMIC RESPONSE VERIFICATION

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1. Introduction

Today's advanced computer technologies makes easier to solving of engineering problems. In the structural dynamic, the nonlinear response analysis of complex structures is very complicated, however can be simulated in computer even in 3D numerical models. Also, measurement of actual response, computation of dynamic properties can be done by using sensors. This paper presents full-scale 3D seismic response of an irregular mid-rise RC building. Then the model response and dynamic properties have been checked with the measurement of fiber optic sensors for experimentally verification. The model later will be used for the performance evaluation of retrofitting schemes.

2. Structure modeling

2.1. Mathematical tool

The finite element analysis program used in this study called "CANNY", which was developed using the multi spring model, fiber model for 3D analysis of frame wall structure - shown in Fig.01, Fig.02. CANNY is able to predict the dynamic response of space frames under dynamic loading, taking into account both geometric and material nonlinearities as well as damage assessment of structural members both flexural and shear failure.

2.2. Building studied: structure and modeling

The building considered in this study is a 9 stories RC building with two basement floors located in Hongo Campus of the University of Tokyo. The building was constructed in the 1968, its plan is irregular 'L' shape and the building needs to be retrofitted for the high lateral imbalance stiffness problem. The building height is about 40 m (above ground floor height is 3.6 m). The building structure consists of columns, beams, and walls elements. The typical plan, dimensions and full model are shown in Fig.03, Fig.04, and Fig.05. For the material properties for steel and concrete are the actual values from testing, sectional details based on initial drawings.

3. Real earthquake verification of the model

3.1 Optical Strand

The optical strand has been installed at the 5^{th} Floor, 3 of them are being used for the monitoring purpose (Fig.06). This fiber optical sensor can measure changes in geometric shape and position over the measurement paths. The measuring accuracy is ± 0.002 mm during dynamic monitoring and measuring frequency up to100 Hz.

3.2 Real earthquake motion records and comparisons with numerical analysis results

At the year 2003, 5 small earthquakes have recorded. The result obtained from CANNY (by using the ground motion record to shake the model) has checked with all of these earthquake sensor records. The seismic records also have been used for modal analysis in order to estimate the response frequencies of the building. The result of 15^{th} Oct 2003 Earthquake can be seen in Fig.07, Fig.08. Table 01 is the comparison of dynamic properties from numerical and measurement.

4. Conclusions

An irregular mid-rise RC building structure has been 3-dimentionaly modeled. The dynamic responses produced by the model have good agreement with the actual responses recorded by optical strand sensors. From the sensors measurement data, the actual structure response frequencies of the first and second mode have been computed and match with the results from numerical analysis. The full-scale model can be concluded that it describes the real behavior of the building. The model now can be used for further study such as seismically retrofitting of RC building.

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Keywords: Numerical model, multi spring model, building structure, 3D frame, seismic response, optical strand

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Tables and Figures

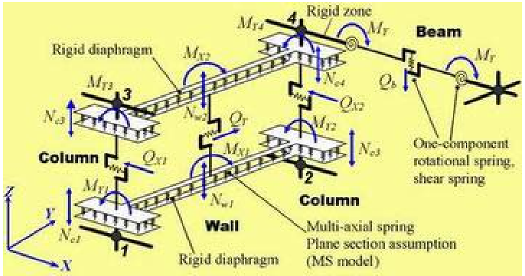

Fig.01: Idealization of beam, column and shear-wall for 3-D frame model

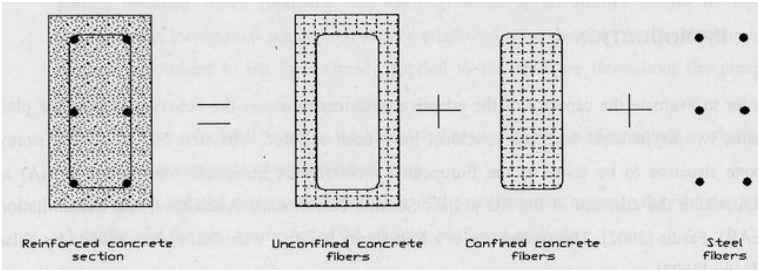

Fig.02: Fiber discretization in a concrete section

Fig.03: Picture of the building

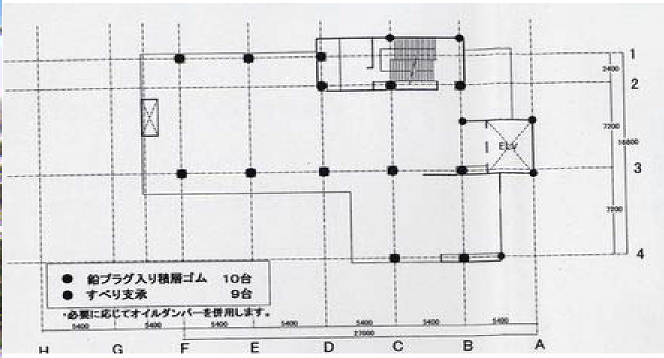

Fig.04: Typical building plan

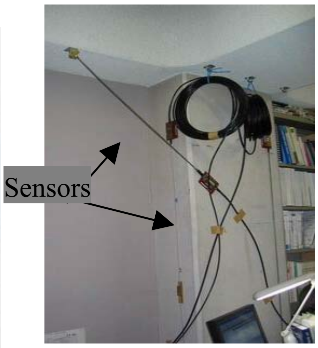

Fig.06: optical strand sensors at the 5th floor

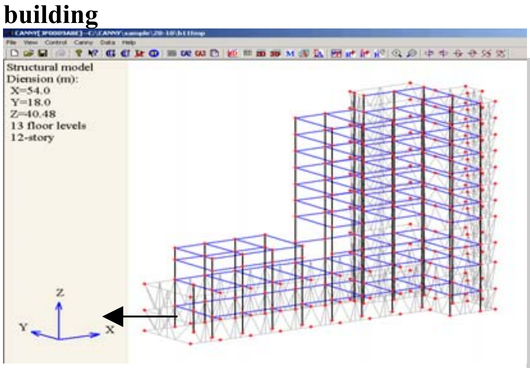

Fig.05: Numerical model in Canny Program

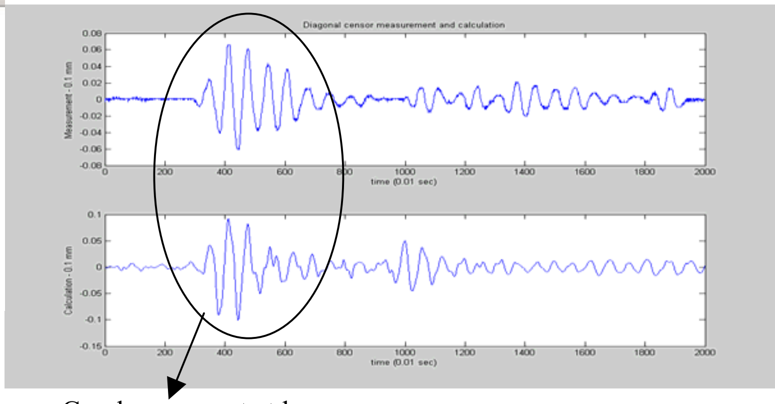

Fig.07: Comparison of actual recorded dynamic response and numerical result of the 15th Oct 03 earthquake

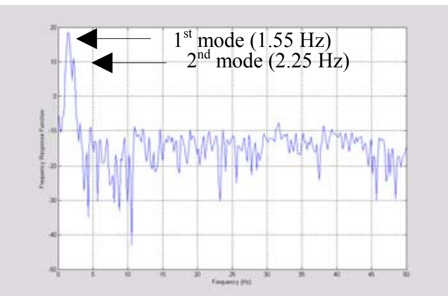

Fig.08: Frequency response function

	Numerical results	Modal analysis from measurement data	
Mode	*f (Hz)*	*f (Hz)*	*Note*
1	1.54	1.55	1st Trans Y-dir
2	2.31	2.25	1st Trans X-dir

Table 01: comparison of structure dynamic properties