EARTHQUAKE RESISTANT INSTALLATION DEVICE OF COMPUTERS

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SYNOPSIS

A new earthquake resistant installation device for computers has been developed by the authors in order to prevent their sliding or overturning which can lead to the loss of their functions. This device is to fix computers on the supports which are anchored tightly to the concrete slab passing through the free-access floor. The Authors have also proposed a design calculation method based on floor response spectra. These methods were applied practically for the installation of the computers in the International Telecommunications Center Building (32 stories high) in Tokyo. Their safeness against strong earthquakes were verified by means of vibration tests on a shaking table using floor-response time-histories obtained from the dynamic design analyses of the said building.

I. Introduction

When Kokusai Denshin Denwa Company, Ltd. (KDD) constructed the ITC Bldg. (32 stories high, 164.7m in height) at the new business center, Shijuku, in Tokyo, KDD decided to conduct a research on earthquake resistant installation of computers to be placed in the ITC Bldg. The Muto Institute of Structural Mechanics, Inc., which had been awarded the structural design of the ITC Bldg., also launched force on this research in collaboration with KDD and Nippon Telegraph and Telephone Public Corporation (NTT).

As the result of this research, it was clarified that the computers proper could resist the vibration during a severe earthquake but the problem existed in its method of installation. The conventional method was usually to only place the computers on a "free-access" floor without any sort of fixation or tie. Under these conditions if a severe earthquake should hit, then computers would slide or overturn and would lead to the loss of their functions. In order to prevent these damages the authors conceived the new installation device for computers which were planned for placement in the ITC Bldg. This device is to fix computer on the supports which are anchored tightly to the concrete slab passing through the free-access floor. The authors also verified their efficient safeness against strong earthquakes by means of dynamic vibration tests.

II. The Aseismic Design Criteria for the Installation Apparatus

For the aseismic design of the installation method for computers in the ITC Bldg., the adopted principle was that they should be fixed to the concrete floor slab. The aseismic design criteria established are as follows:

(1) The design lateral force of the supporting apparatus of the computers must be decided based on the lateral acceleration response spectra of the.

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floors, at which the computers are to be installed.

These floor-response spectra should be obtained from the earthquake response analyses of the building structure. In these cases the input earthquake waves applied to the base of the lateral vibration model of this building are the following two waves, the EL CENTRO '40(NS) and the TAFT '52(EW), and the maximum accelerations are 300 gal respectively, where the importance factor of 1.2 times is adopted than for ordinary high-rise buildings.

(2) The design vertical force of the supporting apparatus must also be decided based on vertical acceleration response spectra of floors, at which the computers are to be installed.

In these cases the input earthquake waves applied to the base of vertical vibration model are the following two waves, the EL CENTRO '40(UD) and TAFT '52(UD), and the maximum accelerations are 150 gal respectively.

(3) Since the computer is the important facility, additional importance factor of 1.5 is adopted.

Fig. 1 shows examples of the lateral acceleration floor-response spectra in a typical floor of the ITC Bldg. The range of natural vibration periods of computers is 0.05-0.20 sec as shown in Table 1. According to these spectra, the maximum acceleration acting on them of the 2nd floor is about 0.3G at 0.05 sec, and it increases in this range in proportion as the period is longer, and becomes about 0.7G at 0.20 sec. Whereas in the upper stories the maximum accelerations are reduced. For example, in the 18th floor the maximum acceleration is about 0.2G.

III. New Earthquake Resistant Installation Device

Two types of supporting systems for the new installation device are available which one is called the "Direct" and the other the "Indirect" system. The Direct system being more standard is described herein.

As shown in Fig. 2,this system is to joint the four legs of the computer on the special supports which pass through the free-access floor and are fixed to the concrete slab with anchor-bolts. There are certain devices which have been conceived in the interface of the support to connect the legs of the computers. Fig. 3 shows the most standard supporting system which is called the "Coupler" type. The procedure of the installation of this "Coupler" type is as follows: First, the supports to the concrete slab are fixed just under the position where the computer is prearranged to be installed, and the level of the support can be adjusted to any required height. The couplers are preconnected to the legs of the computer. The legs with the couplers are set on the saucers of the supports, and the couplers are screwed tightly to join the separate components. Furthermore, prior to the tightening an electric insulation sheet and cover are inserted in between so as to provide a perfect electric insulation between the computer and the slab.

Photo. 1 and Photo. 2 show the view of the computers to which the new installation device above mentioned is applied.

IV. Verification by Vibration Test

Outline of Test

The types of computers used for the vibration tests are "Central Processing Unit (CPU)", "Magnetic Drum (MD)" and "Magnetic Tape (MT)". As shown in Photo 3, the concrete slab and the free-access floor were reconstructed on the shaking table as it would actually be at the computer room and the computers were set there applying the new installation device. Then the shaking table located at the Musashino Electrical Communication Laboratory of NTT was used for the test. The input waves used in the test are the floor-response time-histories of the 2nd, 10th, 18th and roof level, which were obtained from the earthquake response analyses of the ITC Building.

By the way natural vibration periods and damping factors of these computers to be measured are as shown in Table 1. Providing the range of natural vibration periods of the computers to be 0.05-0.20 sec and damping factors to be 5% in the calculation of the design force, from Fig. 1 the seismic coefficient of the maximum earthquake force acting on computers on the 2nd floor, which is most severe, is 0.7 in lateral direction and 0.4 in vertical.

During these tests, the functions of the computers which were placed in the state of operation were also checked out.

Result of Test

The result of lateral vibration test in case of the maximum acceleration of 300 gal of input earthquake waves are shown hereunder. Fig. 4 shows the maximum base-shear coefficients in the longitudinal direction of the computers corresponding to the floor story number of input response wave. Each computer presents the maximum response at the 2nd floor. Next Table 2 shows the maximum base-shear coefficients both in longitudinal and transvers direction of the computers for the 2nd floor-response wave. The maximum base-shear coefficients are 0.4-0.8, which nearly agree with 0.3-0.7 expected on the 2nd floor-response spectra.

Fig. 5 shows the maximum response acceleration at each point of computers in their longitudinal direction. The maximum observed is about 1.0G at the top of "MT", but some of the internal parts of "CPU" attained the maximum acceleration of about 2.0G.

During the vibration an occurrence of the door of computer flying open or loosening of some anchor-bolts took place. But even for the 2nd floor-response wave to 450 gal input earthquake no substantial damages occurred either in the computers or the supporting apparatus. Further, normal functions of computer operation were observed during the vibration test.

V. Conclusion

(1) As the result of vibration test, in the maximum acceleration of 300 gal of input earthquake no substantial damages occurred either in the computers or the supporting apparatus, and further more no error of operation took place. Even for the 2nd floor-responses to 450 gal, the supporting apparatus were not damaged and the anchor-bolts did not pull out. Therefore, this installation device was verified to be efficiently safe against strong earthquakes.

(2) The maximum base-shear coefficients, expected on the floor-response spectra, were in a good agreement with the value obtained from the vibration test. Therefore, the design calculation method based on these spectra was verified to be appropriate.

Acknowledgement

This research was entrusted to us by KDD, and the authors express sincere gratitude for being offered the opportunity to participate in this research. Further more appreciations are extended to Dr. Eiich Kimura and Dr. Yoneo Sugimoto of NTT for their advices to us in the execution of the vibration test.

Reference

1. Kiyoshi Muto, Masayuki Nagata "The Earthquake Resistant Installing Method of Telecommunication Instruments in High-rise Building", a discussion at National Conference on the Planning and Design of Tall Building, Tokyo, Japan, August 1973.

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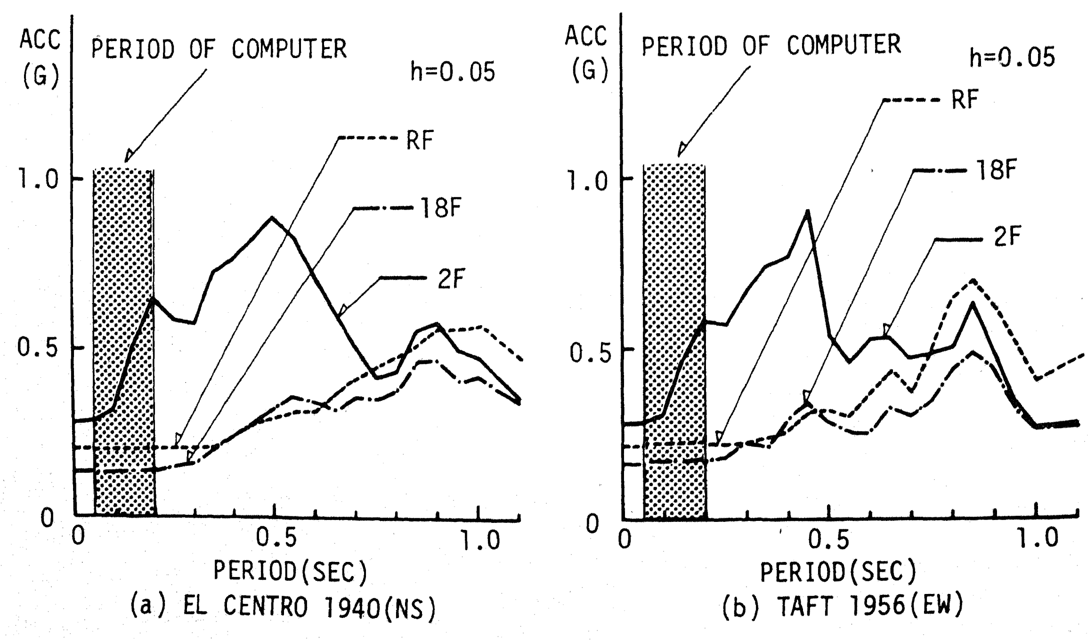

FIG.1 ACCELERATION FLOOR RESPONSE SPECTRA ($G\alpha_{max}$=300gal)

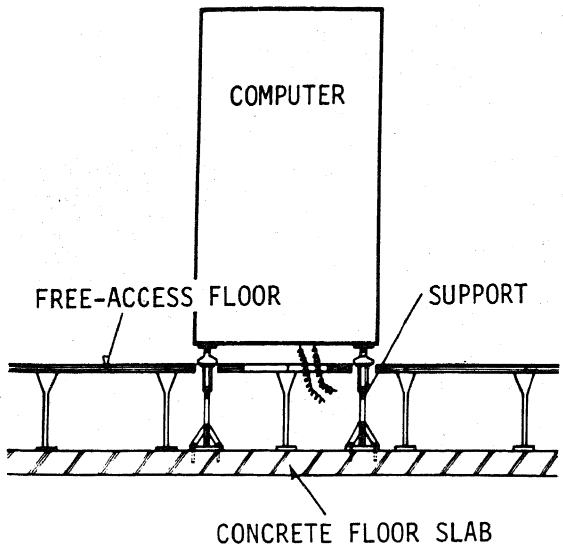

FIG.2 NEW INSTALLATION DEVICE

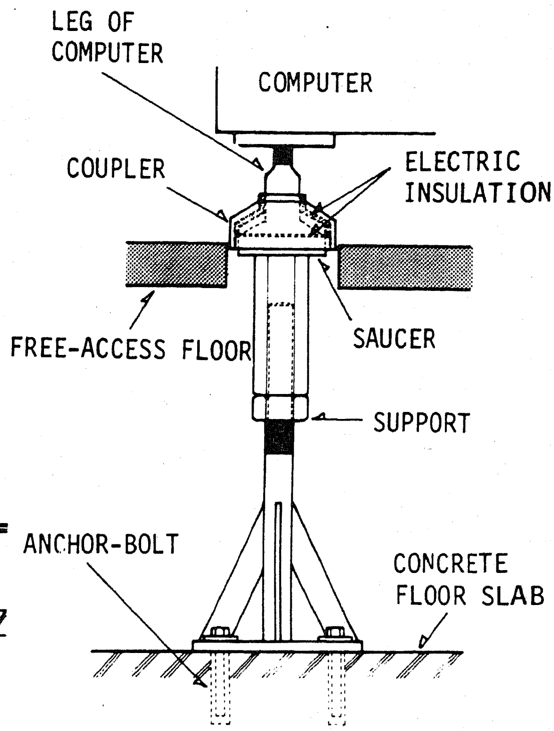

FIG.3 SUPPORTING SYSTEM (COUPLER TYPE)

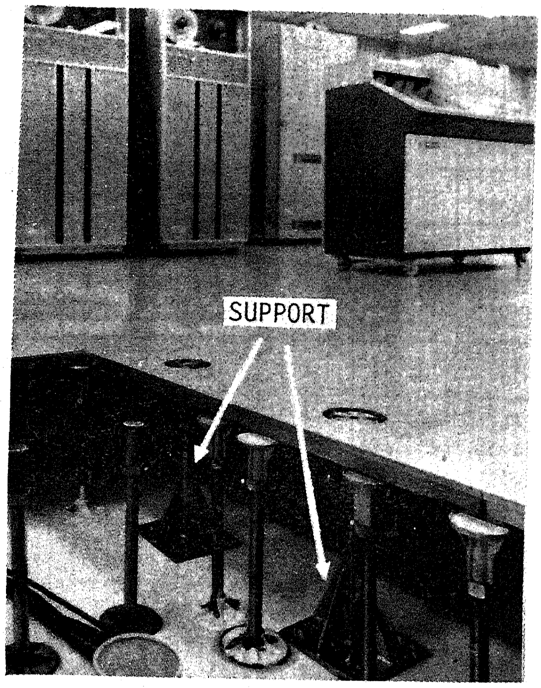

PHOTO.1 VIEW OF COMPUTER ROOM WHERE THE NEW INSTALLATION DEVICE IS PREPARED

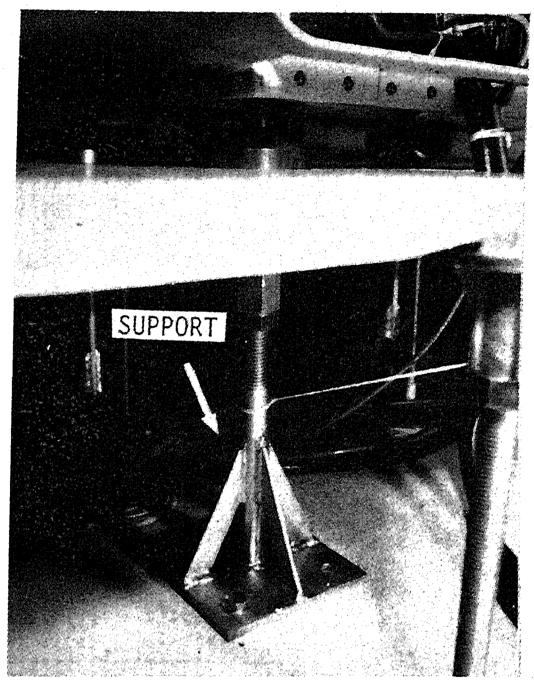

PHOTO.2 VIEW OF COMPUTER TO WHICH THE SUPPORTING SYSTEM IS APPLIED

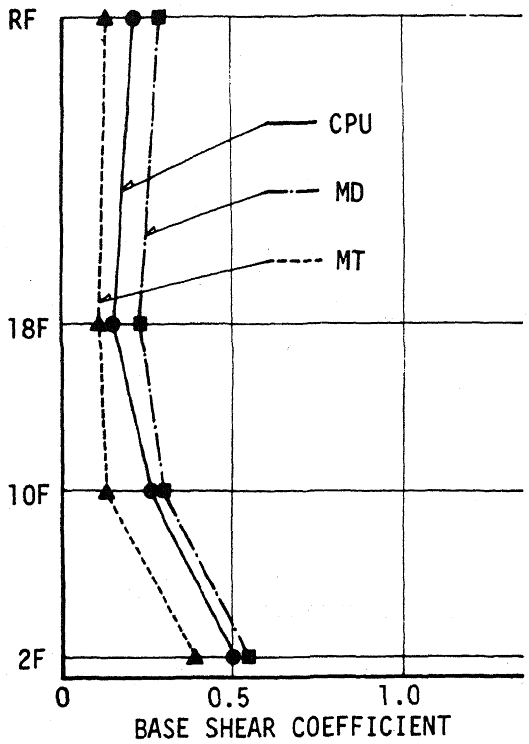

FIG.4 MAX. BASE SHEAR COEFFICIENTS OF COMPUTERS (IN LONGI. DIR.)

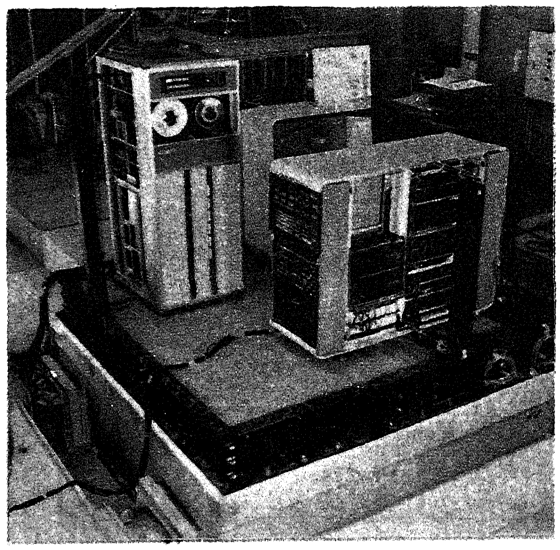

PHOTO.3 VIEW OF COMPUTERS IN DYNAMIC VIBRATION TEST

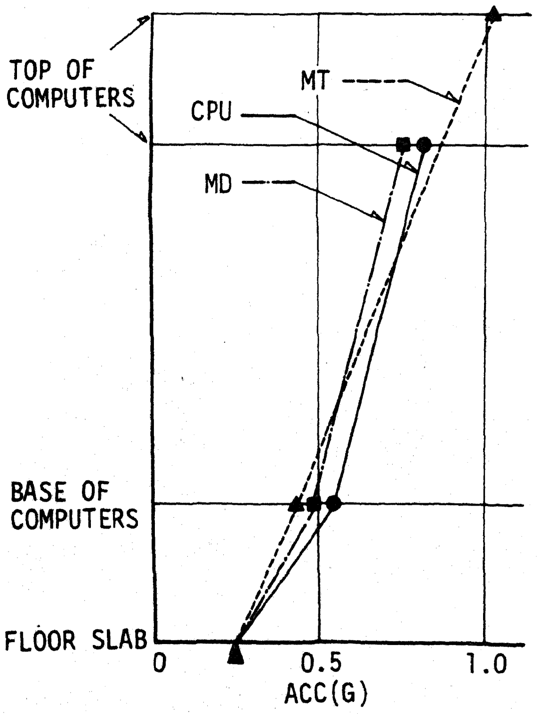

FIG.5 MAX. RESPONSE ACC. ON EACH POINT (IN LONGI. DIR.)

TABLE 1 NATURAL PERIODS AND DAMPING FACTORS OF COMPUTERS

	LONGI. DIR.		TRANS. DIR.	
	T(SEC)	h(%)	T(SEC)	h(%)
CPU	0.14	7.2	0.15	8.2
MD	0.10	2.9	0.06	2.4
MT	0.15	10.0	0.16	12.0

TABLE 2 MAX. BASE SHEAR COEFFICIENTS OF COMPUTERS

	LONGI. DIR.	TRANS. DIR.
CPU	0.51	0.79
MD	0.55	0.40
MT	0.39	0.46