

**Autoadaptive Structural Systems**  
- WG Research Activities -

by

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**1. Objective**

The main objective of this working group is to develop structural systems with autoadaptive features using smart materials and/or smart methods. These systems are expected to show higher performances relying on the embedded functions of sensors, actuators or processors than the conventional structural systems.

**2. Activities in 1999-2000**

The working group has been researched about the following items to develop the autoadaptive structural systems in 1999-2000.

- (1) Proposal of feasible autoadaptive structural systems
- (2) Classification of autoadaptive structural systems
- (3) Preliminary study of the performance evaluation guideline for autoadaptive structural systems

In the following chapters, the outputs about the above research items are summarized.

**3. Proposal of feasible autoadaptive structural systems**

The working group proposed some feasible autoadaptive structural systems in last year. These are the rocking systems, the base isolated systems using smart devices or materials, the frame systems using smart devices or materials and so on. Now, the performance of these proposed systems are being investigated. Particularly, the seismic performance of the rocking systems will be verified by the vibration tests illustrated in Fig.1.

**4. Classification of autoadaptive structural systems**

The classification of autoadaptive structural systems is now studied in the working group. Perhaps, the autoadaptive structural systems will be classified according to the degree of the autoadaptive features, the degree of dependence on the electromechanical devices or materials, the performance of the systems or devices and so on. By the classification, the characteristics of the smart structural systems are more effectively presented to the structural engineers. Further studies are necessary to classify the systems appropriately.

**5. Preliminary study of the performance evaluation guideline for autoadaptive structural systems**

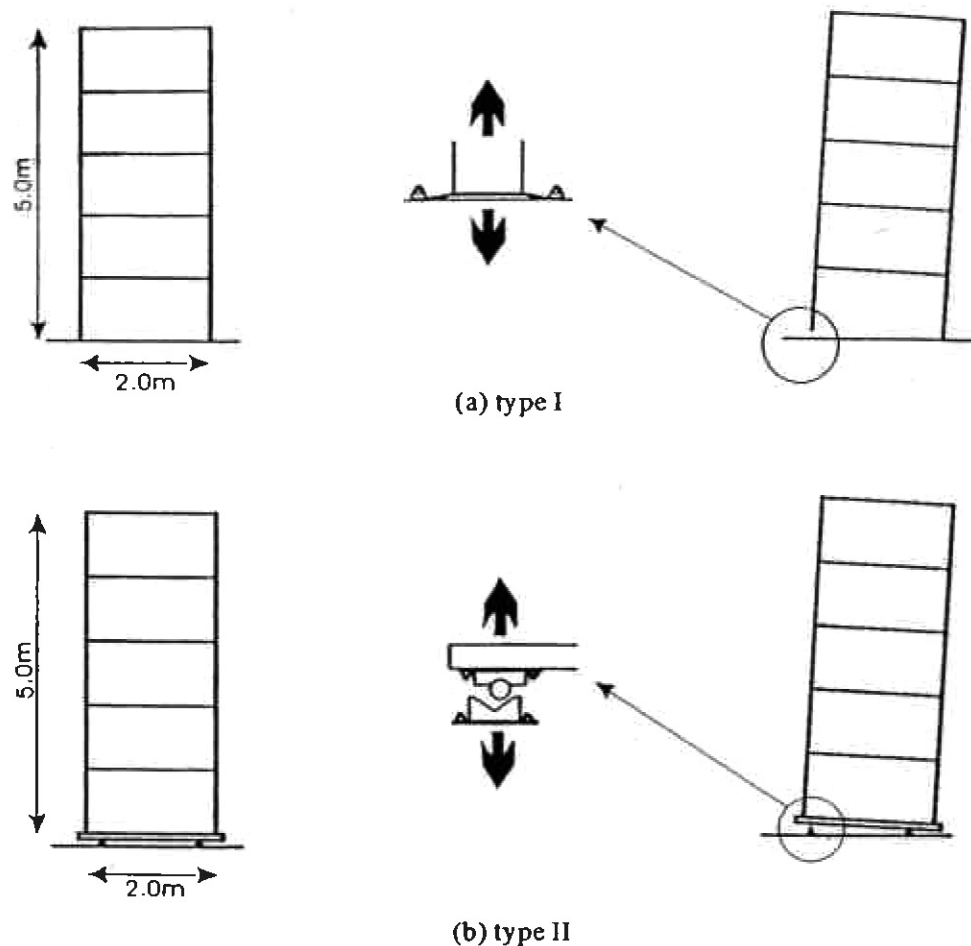


Fig.1 Vibration tests for two types of rocking systems

The working group starts the preliminary study to establish the performance evaluation guideline for autoadaptive structural systems. The current subjects are composing performance matrixes, providing performance evaluation methods and designing theme structures.

An example of the proposed performance matrixes is shown in Table 1. These are the matrixes for the structural elements and devices. The performance matrixes for facilities and non-structural elements have to be also composed.

The tentative performance evaluation method of the smart structural systems against the earthquake ground motions are summarized as follows:

- (1) Evaluation of the target response spectrum
- (2) Preparation of the artificial ground motion data fitting to the target response spectrum
- (3) Preparation of the numerical model for the smart structural systems
- (4) Evaluation of the limit values for the smart structural systems
- (5) Calculation of the response values using a time history analysis method
- (6) Evaluation of the seismic performance using the relationship between the limit values and the response values
- (7) Estimation of the reliability of the systems and devices
- (8) Estimation of the durability of the systems and devices

Table 1. The performance matrix for structures and smart devices (tentative)

	Load level	L1	L2	L3	L4
	Return period	20 years	100 years	500 years	1000 years
Grade of structural elements	A	Serviceability 1	Serviceability 1	Serviceability 2	Reparability
	B	Serviceability 1	Serviceability 2	Reparability	Safety
	C	Serviceability 2	Reparability	Safety	
	D	Reparability	Safety		
Grade of smart devices	A	Functionality 1	Functionality 1	Functionality 2	Reparability
	B	Functionality 1	Functionality 2	Reparability	
	C	Functionality 2	Reparability		

(9) Health monitoring of the systems and devices after construction

The above method will be investigated in detail, furthermore. And the performance evaluation methods against other disturbance such as wind loads will be also provided.

The proposed performance evaluation guideline will be applied to some theme structures.

6. Research plan

Research items of the working group are enumerated as follows:

- (a) Proposal of feasible autoadaptive structural systems and classification of them
- (b) Integration of smart materials or devices/members to achieve target performance of structural systems
- (c) Investigation of the performance of the proposed structural systems by analytical and experimental simulations
- (d) Establishment of performance evaluation guidelines for autoadaptive structural systems

The time schedule of the research plan is shown in Fig.2

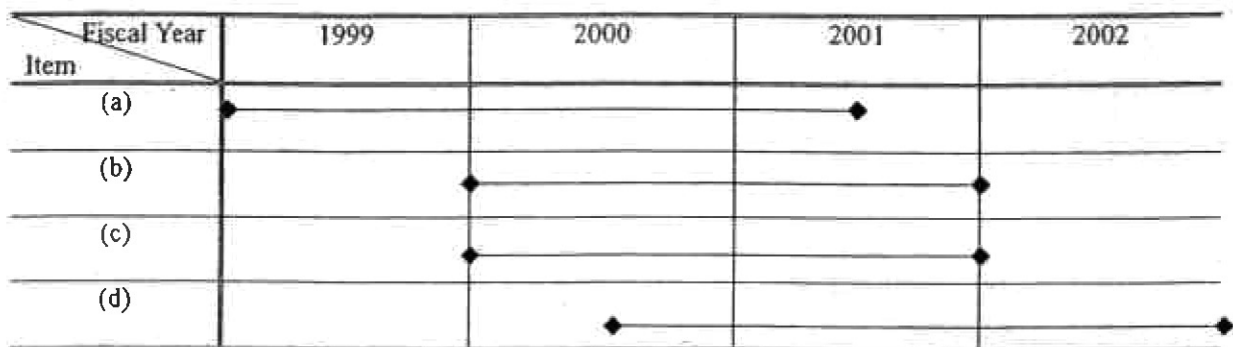


Fig.2 Time schedule of Autoadaptive structural system WG

7. Members of WG

**Chairman:**

**Akira Wada**

**Tokyo Institute of Technology**

**Member:**

**Yukio Tamura**

**Tokyo Institute of Polytechnics**

**Ken'ichi Kawaguchi**

**University of Tokyo**

**Satoru Aizawa**

**Takenaka Corporation**

**Yasushi Akahoshi**

**Fujita Corporation**

**Atsushi Sasaki**

**Nishimatsu Corporation**

**Keiji Shiba**

**Shimizu Corporation**

**Hiroshi Matsuba**

**Maeda Corporation**

**Yoshiyuki Matsushima**

**Fudo Kenken Corporation**

**Kenji Yoshimatsu**

**Kumagaigumi Corporation**

**Mitsumasa Midorikawa**


**Building Research Institute**

**Tatsuya Azuhata**

**Building Research Institute**

**Tadashi Ishihara**

**Building Research Institute**



Chairperson: Prof. A. Wada (Tokyo Institute of Technology)

### Objective

- ✦ Development of structural systems with autoadaptive features using smart materials and/or smart methods
- How do we improve the performance of structures using the functions of sensors, actuators or processors?

### Current Activities

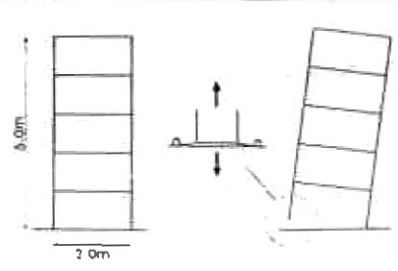
- ✦ Proposal of feasible autoadaptive structural systems
- ✦ Classification of autoadaptive structural systems
- ✦ Preliminary study of the performance evaluation guideline for autoadaptive structural systems

### Examples of the proposed systems

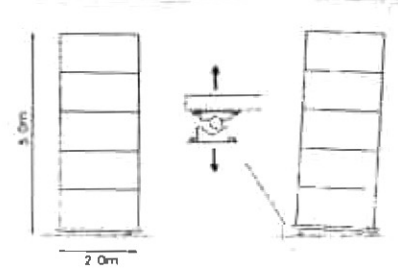
- ✦ Rocking systems
- ✦ Base isolated systems with smart devices or smart materials
- ✦ Frame systems with smart devices or smart materials
- ✦ Etc.

Now, we are investigating the performance of these systems by analytical and experimental simulations.

### Vibration test for the rocking system (type I)



### Vibration test for the rocking system (type II)



## Preliminary study of the performance evaluation guideline

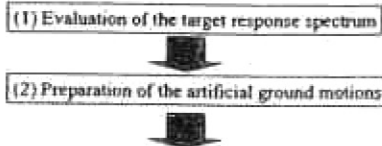
- ✦ Performance matrixes
  - structural elements/ smart devices/ facilities/ non-structural elements
- ✦ Performance evaluation methods
  - earthquake/ wind/ snow
- ✦ Theme structures

## Example of performance matrix

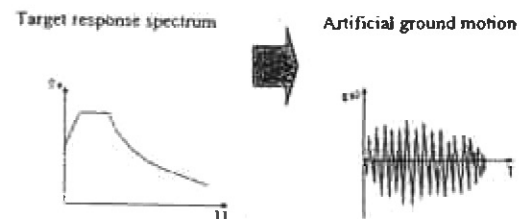
Level	LI	LE	LS	LA
Service life	20 years	50 years	100 years	500 years
A	Repairability	Repairability	Repairability	Repairability
B	Repairability	Repairability	Repairability	Repairability
C	Repairability	Repairability	Repairability	Repairability
D	Repairability	Repairability	Repairability	Repairability
A	Repairability	Repairability	Repairability	Repairability
B	Repairability	Repairability	Repairability	Repairability
C	Repairability	Repairability	Repairability	Repairability

## Outline of the performance evaluation method (1)

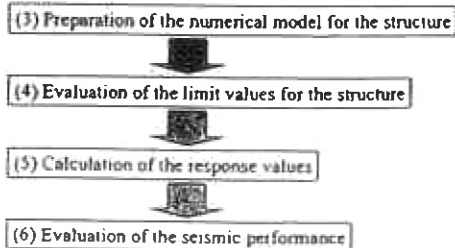
- ✦ The seismic performance of structures is evaluated according to the following nine steps. (Tentative)



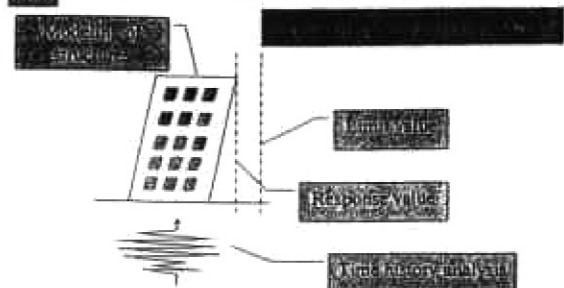
## Outline of the performance evaluation method (1)



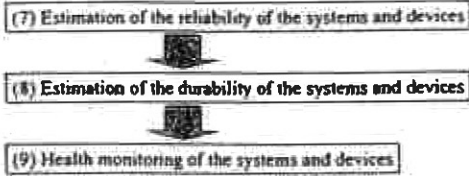
## Outline of the performance evaluation method (2)



## Outline of the performance evaluation method (2)



### Outline of the performance evaluation method (3)

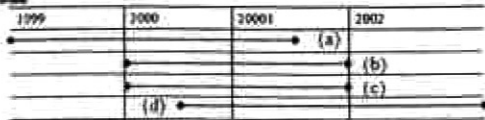


### Outline of the performance evaluation method (3)

✦ Following items should be also considered in the performance evaluation method.

- Reliability of the systems and devices
- Durability of the systems and devices
- Health monitoring

### Time schedule



- (a) Proposal and classification of autoadaptive structural systems
- (b) Integration of smart materials or devices/members
- (c) Investigation of the performance of the structural systems
- (d) Establishment of performance evaluation guidelines