Seismic Isolation of the Roof over a Large Space Design of the Roof for Kyoto Aquarena

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1. OVERVIEW OF ARCHITECTURE

1.1 Summary of structure:

Kyoto Aquarena is an indoor sports arena (Fig.1,2).
The roof structures over the main pool was made of beam string structure. Isolators, dampers and sliding bearings were installed at the junction between the roof of main pool structure and supporting structure to isolate the roof from seismic vibrations (Fig.3).

Fig.1: Exterior view

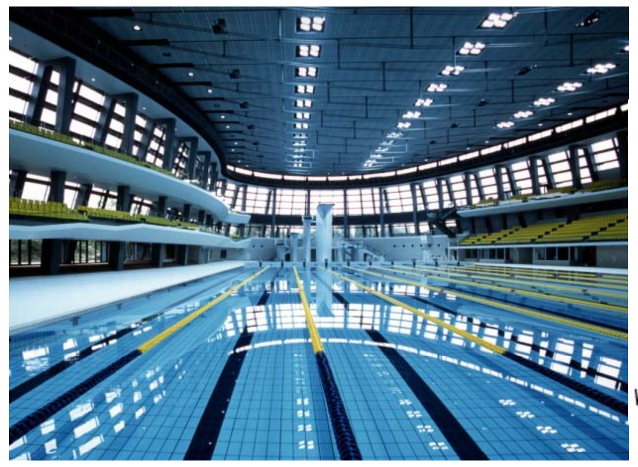


Fig.2: Interior view

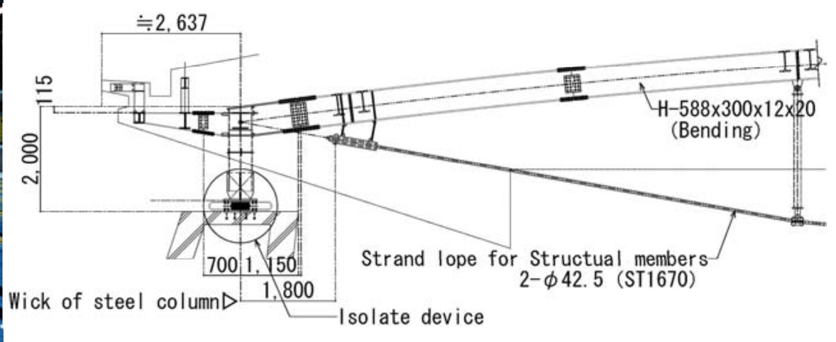


Fig.3: Beam string structure detail Dotted lines show final locations of roof and ceiling surfaces

1.2 Objectives of Seismic Isolation of Roof:

The self-balanced beam string structure design exerts no horizontal forces on the supporting structure during ordinary loading conditions. Accordingly, seismic protection was placed at the junction between the roof structure and the supporting structure in order to isolate the roof from seismic shaking (Fig.3).

1.3 Isolated protection components:

Three kinds of roof bearings were combined to provide the longest period of natural vibration possible. Type A bearing was a laminated natural rubber isolator incorporating a U-shaped steel hysteretic damper. Type B was a bearing consisting only of an isolator. Type C was a sliding bearing (Fig. 4 – 6).

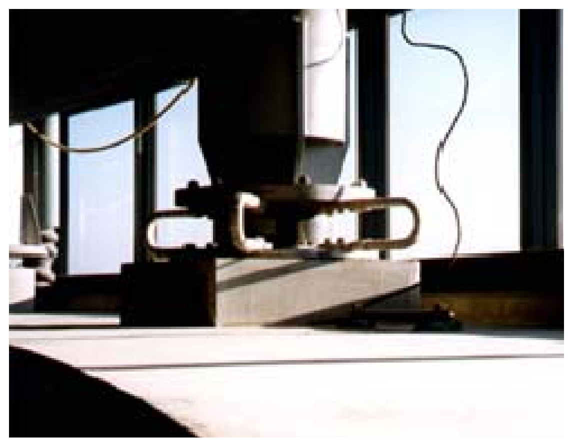


Fig.4: Type A

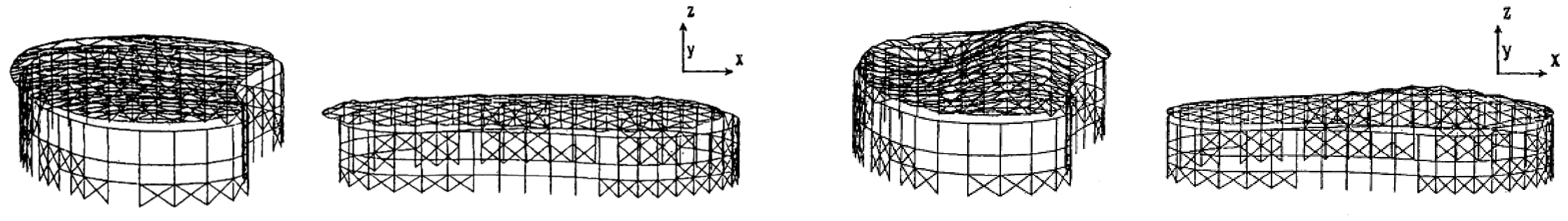
Fig.5: Type B

Fig.6: Type C

2. ANALYSIS OF RESPONSE TO VIBRATIONS

2.1 Characteristic Values:

As can be seen in the vibratory modes of the two models in the horizontal direction, the isolated structure showed almost no deformation of the roof structure as it rocked in the horizontal direction. The non-isolated structure showed large deformations of the roof structure in the vertical direction as it rocked horizontally (Fig.7).



Mode 1 (T_1=1.297sec.) Mode 2 (T_1=1.201sec.)
Base-Isolated

Mode 1 (T_1=0.880sec.) Mode 2 (T_2=0.815sec.)
Non Base-Isolated

Fig.7: Model for Vibration mode

2.2 Results of Analysis of Response:

The chief differences between the isolated and non-isolated structures were as follows (Fig.8):

- In the base-isolated structures is the response acceleration dramatically reduced.
- In the non-isolated structures, the storey shear coefficient increased with distance up the laminations, while the coefficient was roughly constant throughout the damper body in the seismic structure.
- The vertical deformation of the roof structure in response to horizontal shaking was greatly reduced.

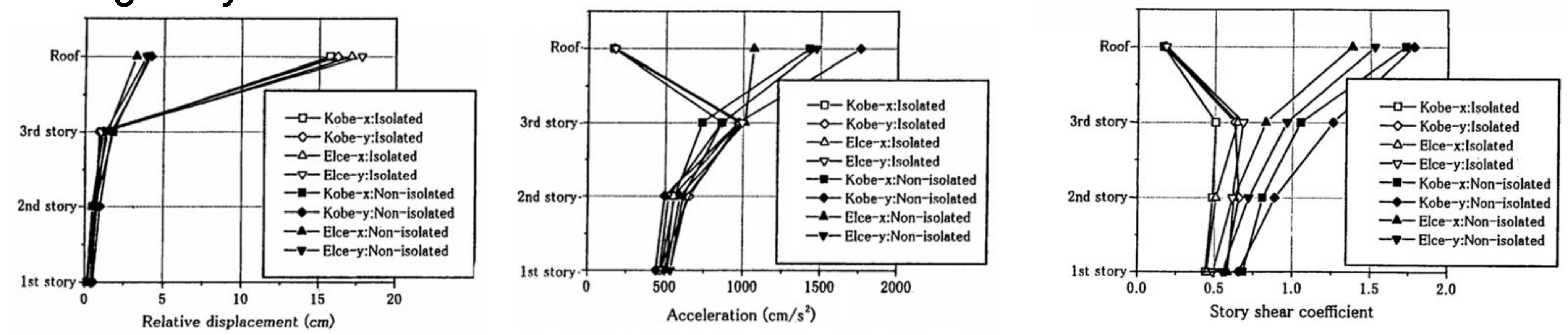


Fig.8 : Comparisons of horizontal response displacements in seismic and non-seismic structures

3. SUMMARY

The main benefits from installation of seismic isolation :

- A large reduction was realized in both the vertical and horizontal motions of the roof body in response to horizontal seismic shaking.
- At the support points for the roof structure, there are nearly zero horizontal thrust loads from external forces.
- Skeleton costs were reduced.