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New Design of the France-Japan Friendship Monument

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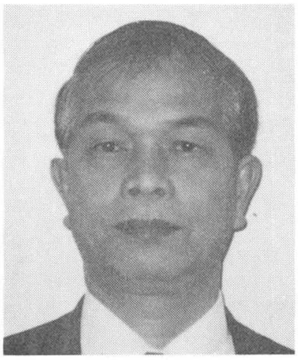

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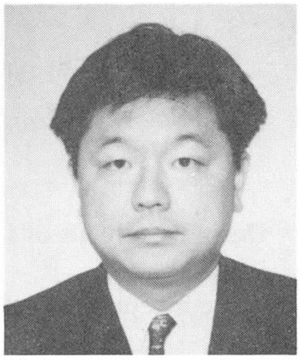

Summary

The construction of the "France-Japan Friendship Monument" introduced at the IABSE Symposium Birmingham 1994, had to be interrupted due to the Great Hanshin-Awaji Earthquake, which occurred on 17 January 1995. In August 1996, a new concept based on the learnings from the Earthquake was proposed from the French side to the Japanese side as "Revised Proposal", and since then the Japanese side has promoted the project by elaborating the basic and detail design based on said "Revised Proposal".

1. Outline of the Monument Project

1.1 Progress of the Design Work

This is a project being promoted jointly by Japan and France to construct a monument symbolizing the friendship between Japan and France under the theme of "friendly exchange and communication".

The concept of the Monument is that its table, covered with bronze and positioned in the north-south direction, is supported by glass-covered pillars located at the both ends.

The "France-Japan Friendship Monument" introduced at the IABSE Symposium Birmingham 1994 represented Plan No. 1 as in Fig. 1, and the construction work was commenced on 12 January 1995 at the north end of the Awaji Island in Hyogo Prefecture, Japan according to this Plan No. 1. However, on 17 January 1995, that is, five (5) days after the work commencement, the Hyogo Prefecture South District Earthquake took place so that the construction work based on Plan No. 1 was interrupted.

In August 1996 a new "Revised Proposal" of the Monument based on the learnings from the

Earthquake as well as the re-recognition of the importance of "communication" and of the coexistence of nature and mankind was presented from the French side to the Japanese side (Plan No. 2 as in Fig. 1).

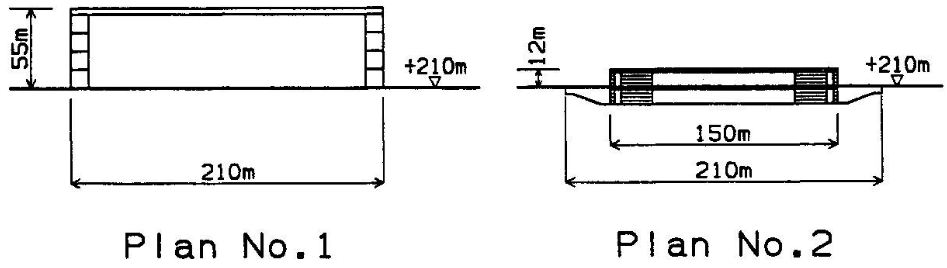

Fig. 1 Transitional change of "France-Japan Friendship Monument" design

1.2 Design Concept of the "Revised Proposal"

The design concept of the "Revised Proposal" for the Monument is as follows:

1) With an emphasis upon horizontality, "communication", which is the theme of the Monument, will be visually expressed.
2) The monument has a basement which will serve exhibition as well as communication promotion functions.
3) Foundations and basement structure, which will be designed to be rigid and very heavy, will be placed in the ground to improve earthquake resisting performance.
4) Steel-and-rubber sheets laminated bearings and dampers will be used at the table bearing portions to reduce seismic loads to act both on the table and on pillars.

The outline diagram in the north-south direction of the Monument as per "Revised Proposal" will be shown in Fig. 2. Ground level of the Monument is 210 m above sea level. The basement is 210 m in longitudinal length. The bronze covered table is 150 m long and 15 m wide, the top level being 222 m above sea level.

2. Outline of the Structural Design

2.1 Structural System

Fig. 3 shows the outline of the structural system of the Monument as per "Revised Proposal". This shows the configurations as of the stage when the basic design has almost been completed.

The depth of the bronze-covered table is 2.2 m, approximately 1/45 of supported span of 100.3 m, and to hold this table truly horizontally is one of the structural features of the Monument design. For this purpose, the structural system of the table is basically made of a steel box-girder within which prestressing tendons are arranged (hereinafter "PS steel girder").

The two (2) inside pillars at each end are planned to support the "PS steel girder" of the table at four (4) bearing points at each ends.

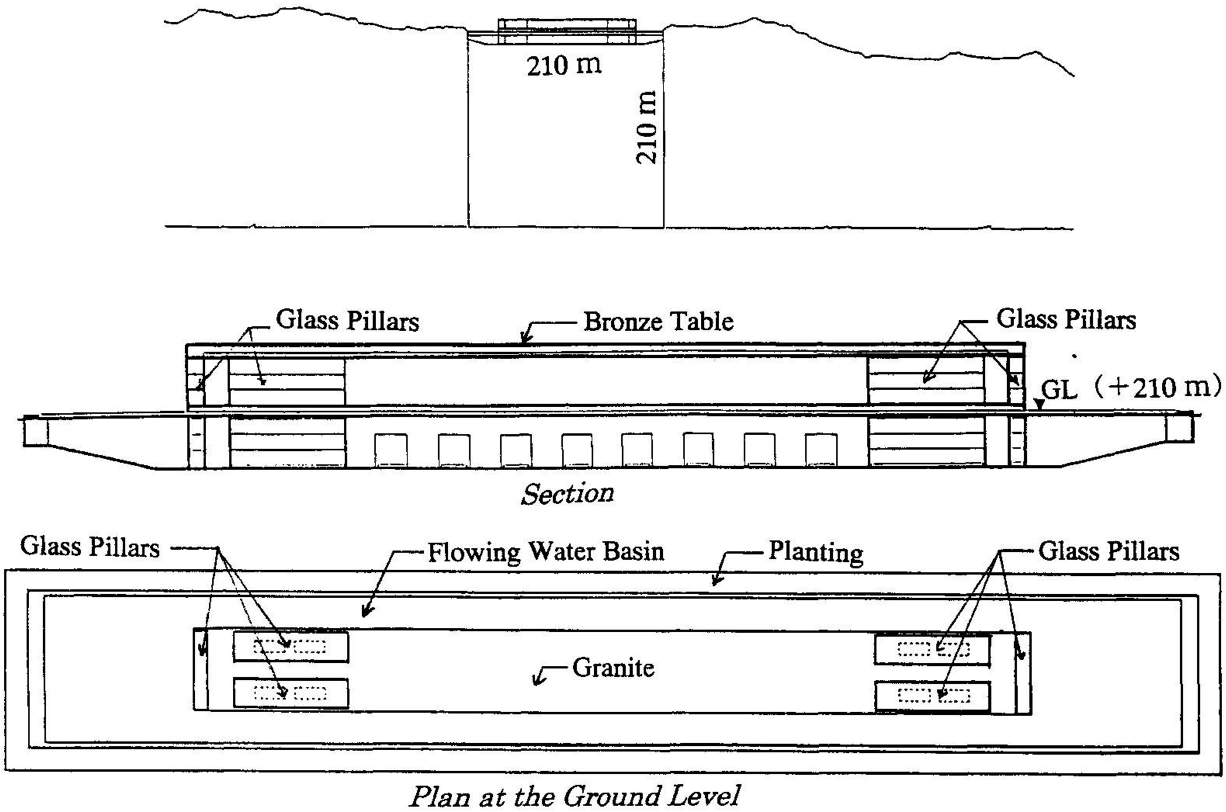

Fig. 2 Outline diagram of New Design

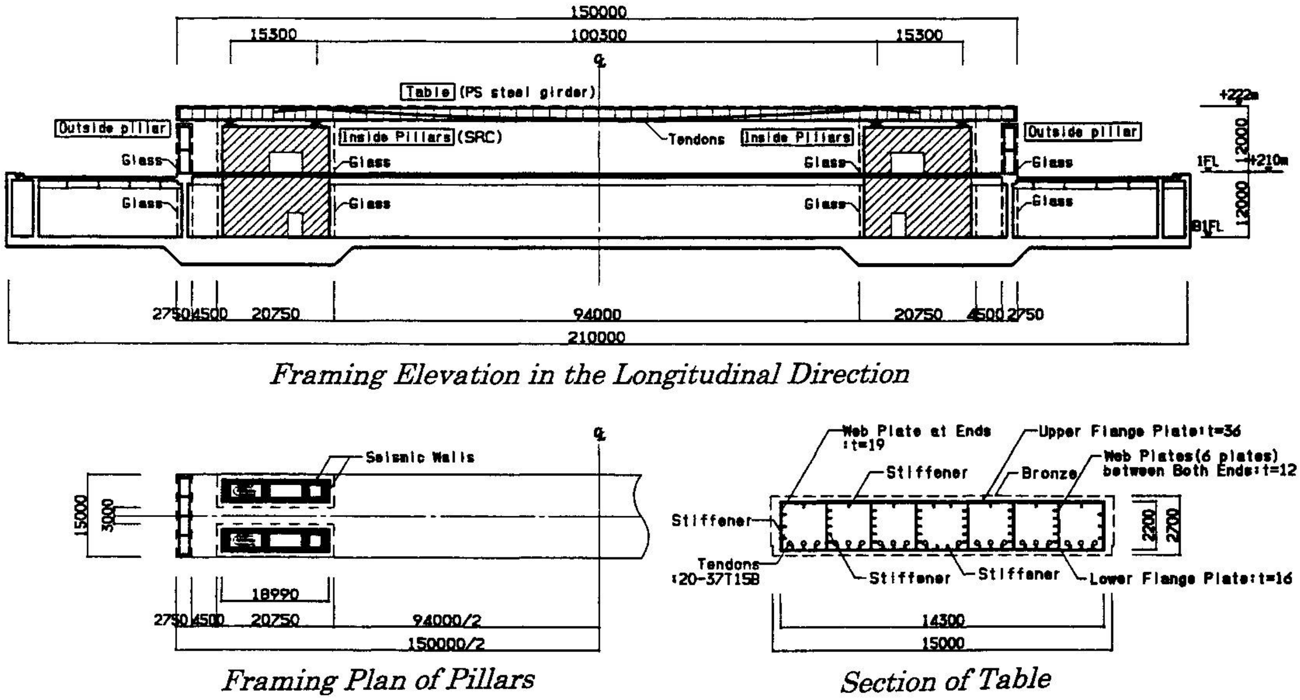

Fig. 3 Outlined structural diagram

2.2 Structure of the Table

Fig. 4 shows the typical diagrams of the structural systems of the "PS steel girder" of the table.

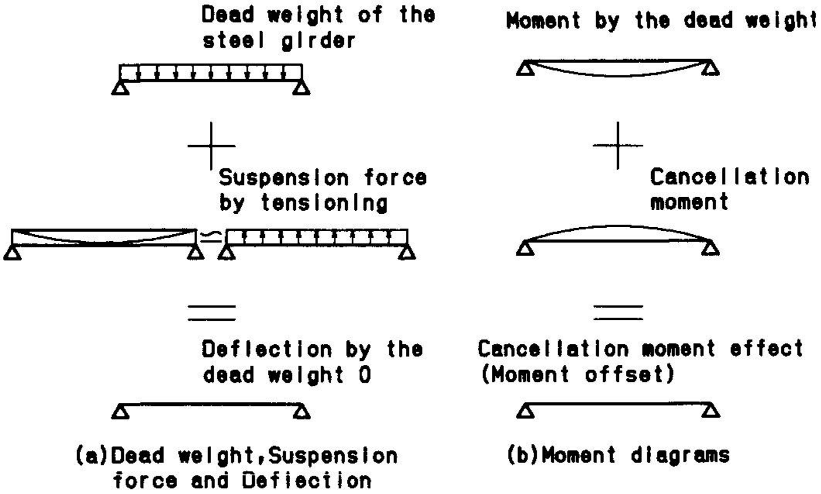

Fig. 4 Structural system of "PS steel girder"

The tensioning force applied to the tendons required for the cancellation moment can be calculated by the following formula:

$$T = \frac{WL^2}{8e}$$

where T : Tensioning force
W : Weight of table per unit length
L : Steel girder bearing span
e : Distance between the centroid of the steel girder and the lowest level of tendon

The tensioning force level is determined to be not more than 60% of the tensile strength considering the fatigue of the tendon material.

2.3 Structure of the Pillar

The two (2) inside pillars at each end are planned as the steel reinforced concrete structure (hereinafter "SRC") to support the table at four (4) bearing points on each end. Seismic walls are distributed to secure sufficient structural strength and rigidity against major earthquakes.

At the present stage, it is planned to use an isolator made by laminating steel plate and rubber sheet, and a damper on each bearing point to distribute the reaction force due to earthquake force or temperature load to the inside pillars of both ends. Further, steel-and-rubber sheets laminated bearings and dampers will be used at the table bearing portions to reduce seismic loads to act not only on the table but also on pillars.

The one (1) outside pillar at each end is planned as the steel structure to support its cladding glass only.

2.4 Structures of the Foundation and the Underground Facilities

The foundations of the Monument and the underground facilities are planned to be directly supported on the rock formation. The foundation of the Monument and the underground facilities are rigid and very heavy so that if they are buried underground, vibration damping by underground dispersion effect can be expected during an earthquake.

2.5 Materials of Structural Members

The major structural materials expected to be employed are as follows:

Structural steel	:	SN490 (tensile strength 490N/mm^2 or over), and SA440 (tensile strength 590N/mm^2 or over)
Prestressing tendon	:	SWPR7B (tensile strength 1865N/mm^{2}or over)

3. Design Load

3.1 Long-term Load

Dead load and live load are mainly considered as the long-term loads that act at all times.

The temperature load and construction work load are also considered as special loads.

The total weight of the table is assumed to be around 27,000kN.

3.2 Seismic Load

The design earthquake load will be determined by the dynamic analysis. The earthquake intensity levels inputted are as follows:

(1) Level 1 Earthquake intensity:
The moderate earthquake intensities that may possibly occur more than once over the life of the Monument, the maximum horizontal ground motion velocity being 25 cm/sec.

(2) Level 2 Earthquake intensity:
The severest earthquake intensity occurred in the past at the site of the Monument or assumed to occur in the future there, the maximum horizontal ground motion velocity being 50 cm/sec.

In the seismic design, the effects by vertical motion is also taken into account.

Further, the seismic safety is to be confirmed by inputting simulation earthquake, reproducing the ground vibration that occurred at the site of the Monument at the time of the Hyogo Prefecture South District Earthquake 1995.

3.3 Wind Load

Design wind load is to be determined based on the assumed design wind velocity and reflecting the result of static and dynamic wind tunnel experiments. The design wind velocity will be calculated considering two return periods.

The return period to be employed will be 150 years for Level 1 and 500 years for Level 2.

The design wind velocities (U_H) for Level 1 (60m/s) and Level 2 (67m/s) will respectively be as follows:

$$U_H = U_O \cdot E_H \cdot R$$

- U_O : Basic wind velocity;
- E_H : Wind velocity vertical distribution coefficient;
- R : Wind velocity return period conversion coefficient;

The design wind load shall take into consideration the average wind load and variable wind loads.

4. Structural Experiment and On-site Observation

One of the features of this project is to perform the structural design reflecting the results of structural experiment as well as the results of observation. Major items are as follows.

- Structural Experiment of PS Steel Girder
  Cancellation moment effects, friction loss, relaxation, strength and deformation property, eigen values, damping ratio
- Wind Tunnel Tests
  Wind force coefficients, dynamic responses of vibration
- On-site Earthquake Observation
- On-site Wind Observation

5. Afterword

The outline of the basic design of the "France-Japan Friendship Monument" was introduced. While proceeding with the design, the details of the table steel girder, pillars and bearings will further be studied for finalization.

Reference

1. Maeda, M. and Uchida, N.: Design of the France-Japan Friendship Monument, IABSE SYMPOSIUM BIRMINGHAM 1994, pp. 97-102