MASARU SEKINO

SOME METHODS OF CONSERVATION APPLIED ON THE GREAT IMAGE OF BUDDHA AT KAMAKURA, JAPAN

Kamakura is a small city on a seacoast about 50 km southwest of Tokyo where the world-famous great bronze Image of Buddha is located in the vicinity of the Kotoku-in Temple.

It was on the 8th of August, 1252 that the casting of the great bronze image was started. This statue, originally housed in the Great Hall of Buddha, had been left in the open air for more than five hundred years, ever since the demolishment of the hall. In the meantime, two great earthquakes attacked the Kamakura area, in 1703 and 1923, causing the statue to slip and damaging its pedestal, which subsequently was rebuilt with reinforced concrete with the statue fixed thereon.

The National Commission for Protection of Cultural Properties, which undertook a minute investigation of the Image in 1957, became seriously concerned about the cracks on its neck, and after having given the matter due consideration, advised the Kotoku-in Temple to have the neck reinforced against another possible large earthquake in the future.

On the 1st of February, 1959 a nine-men committee was formed of scientists and specialists with myself as its chairman. The committee had met twenty-eight times by the 31st of July, 1961, the day of the completion of the conservation project. The total expenditure amounted to Y22,616,000 ($62,800).

The conservation programme centred around the neck reinforcement and the earthquake-proofing of the statue and pedestal. The statue is obviously of bronze, cast on the spot; remnants of clay moulds are still visible on the inside surface of the bronze wall. The hollow statue was cast in several horizontal sections: eight for the body and five or six for the head. At each junction of two consecutive sections, however, the fusion of cast bronze was found to be imperfect. To cover this imperfect cohesion, devices were adopted for the mechanical reinforcement of joints. Each section was cast in succession in such a way as to form a "cast-in" joint with the section previously cast. Defects on the surface at the junctions of planes were filled with copper in the finishing process after the overall casting, and such chiselled finishing touches are found in part. Originally the statue seems to have been gilded, though today gold remains only in small particles on the face.

By Dr. Takakazu Maruyasu, Professor of the University of Tokyo, and his staff, photogrammetry has been applied for the first time in order to prepare precise drawings of the statue. The total surface area of the statue has been calculated to be 267.405 m^2, the height above pedestal of the statue 11.375 m, and the height of the centre of gravity 4.5 m.

On the other hand, Dr. Kenzo Toishi, technical officer of the Tokyo National

Research Institute for Cultural Property, prepared eighty-five sheets of radiographs using radio-isotope 60 Co. He analysed the structure of junctions and the condition of blowholes and cracks and measured the thicknesses of different parts of the bronze wall making up the statue. A particularly close study was made of the complex mechanism of junctions between the neck and the shoulder, in the course of which serious cracks on the back neck were brought to light. As for the thicknesses of the wall, they varied between less than 10 mm and more than 100 mm, the mean being assumed to be 50.8 mm. An examination was also made of a metal test piece taken from an inner part of the statue, finding out the specific gravity to be 8.8 and the maximum tensile strength to be 15.12 kg/mm^2.

Having thus obtained figures respectively for the total surface area, for the thickness of the wall, and for the specific gravity, it was now possible by multiplying these three figures to calculate the total weight of the statue at 120 tons, and the weight of its head at 20 tons. Since Kamakura is situated in one of the greatest earthquake zones in Japan, it was assumable that a major earthquake might cause the maximum horizontal force, equal to the acceleration of gravity. That is to say, twenty tons of horizontal force might act at the centre of gravity of the head. The necessary strength for the neck was duly calculated and steps were taken for required reïforcement.

The result of the chemical analysis of the metal piece was as follows: Cu 65.9%, Sn 7.4%, Pb 25.8%, Fe 0.17%, Al 0.12%, etc. Inasmuch as the electric stud-welding, which had been suggested at first as a reinforcement measure, proved inadequate because of the insufficient strength of welded studs, Dr. Minoru Hamada, Professor of the University of Tokyo, proposed the use of glassfiber-reinforced plastics (FRP). The Nittobo Co. took part in the examination and application of this new material. Firstly, the inside of the neck was cleaned with a sandblast and lined with putty of epoxy synthetic resin. On this base was conducted the initial laminating, with three plies of glass cloth, thirty centimetres wide, by means of epoxy synthetic resin. The second laminating, performed on the initial one, again involved three plies of glass cloth with polyester synthetic resin. Then came the major reinforcing laminating of twenty-seven plies of glass cloth, likewise with polyester synthetic resin, followed by the final laminating with three plies, with polyester synthetic resin of a required colour. So what is referred to as glassfiber-reinforced plastics is a lamination of thirty-nine plies in total, making up a thickness of ten milimetres. As for its durability or life, it is assumed that its strength would have been reduced by 20% one hundred years hence in the semi-dark condition inside the statue, unpenetrated by sunshine, wind, or rain.

From the point of view of further security for the neck, as well as of protection of any other weak point on the body, no small danger seemed to exist in the fact that the statue had been fixed on the pedestal. Steps, accordingly, were taken to place the statue on a new flat surface of the pedestal raised fifty-five centimetres and covered with granite slabs. Along the inside of the bottom rim of the statue was fixed a horizontal curved beam of reinforced concrete, accompanied by some tie beams. These beams were shoed with stainless steel plates to slip should another great earthquake attack the area in future. Now the friction ratio between stainless steel and granite is supposed to be about 0.5. In a small earthquake, therefore, in which the ratio between its acceleration and the gravity is under 0.5, the statue will move with the pedestal. If, however, there should occur an earthquake so large that the ratio be over 0.5, the statue might slip on the pedestal.

The work of statue-lifting and earthquake-proofing was conducted by the Shimizu Construction Company. With the use of an electric strain metre they have given the accurate figure for the total weight of the statue as 118.5-122.8 tons.

MASARU SEKINO

QUELQUES MÉTHODES DE CONSERVATION APPLIQUÉES À LA GRANDE IDOLE DE BOUDDHA À KAMAKURA, AU JAPON.

RÉSUMÉ.

L'Idole du Grand Bouddha à Kamakura, coulée en bronze en 1252, a été réparée de 1959 à 1961, en prévision d'un éventuel grand tremblement de terre.

J'étais le Président du Comité de réparation.

Les recherches préliminaires scientifiques et techniques ont été les suivantes:

1) Etude radiographique de la paroi de bronze (ou gaine de bronze) à l'aide de radio-isotope, cobalt soixante.
2) Photogrammétrie de la statue de Bouddha.
3) Calcul du poids total de la statue.
4) Détermination de la position du centre de gravité.
5) La composition du bronze et ses propriétés phisiques.
6) Calcul de la résistance aux tremblements de terre.

Le programme final de conservation centré sur des méthodes techniques a été le suivant:

1) Renforcement du cou par une espèce de cage de fibre de verre renforcée de plastique (FRP).
2) Amélioration du rapport entre la statue et le piédestal (conditions d'un tremblement de terre non centré mais ondulatoire)

RÉFÉRENCES:

Hauteur totale de la statue au-dessus du piédestal: m 11,375;
Superficie totale de la statue: m^2 267.405;
Epaisseur moyenne présumée: mm 50. 8;
Poids spécifique du bronze (moyenne): 8. 8;
Résistance maximum à la tension du bronze: Kg/mm^2 15. 12;
Poids total calculé: T. 120;
Analyse chimique du bronze: CU 69,9%, Su 7,4%, Pb 25,8%, Fe 0,12%, Al 0,12% etc...;
Poids réel: T. 118,5-122,8;
Résistance maximum à la tension du polyester FRP: Kg/mm^2 26,7.