Chapter 5 Appendix 16

COMMENTS ON ^{60}Co MEASUREMENTS

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Radioactivity of ^{60}Co induced in iron of reinforcing bars (rebars) in ferro-concrete by atomic bomb radiations was reported by Hashizume et al.[1] In view of the discrepancy found by Loewe (Chapter 5) between the calculated and the measured values of ^{60}Co, we undertook a review of the measurements. The following is the result of our review of the report of Hashizume et al.

Radioactivity Measurement

Analysis of Cobalt Obtained from Iron Sample. To determine the ratio of ^{60}Co radioactivity per unit nonactive cobalt (^{60}Co/Co), cobalt was separated from the iron sample and its beta radioactivity was measured. Kawamura et al[2] reported the results using the following chemical process. After dissolving about 50 g of the iron sample in hydrochloric acid, the hydrochloric acid solution was adjusted to 8 N. Iron was removed from the solution by the solvent extraction method and the remaining fraction was passed through an exchange resin to purify the cobalt. The purified cobalt was determined by colorimetric analysis, and the remaining cobalt was electrodeposited and its radioactivity measured by a coincidence type beta-particle spectrometer. The chemical process was reviewed, and it was considered that there were no problems in the process in view of the present findings.

Measurement of Radioactivity of ^{60}Co. After the chemical processing, cobalt was electrodeposited on a platinum plate (0.15 mm thick and 25.4 mm in diameter) to make a circular source 19 mm in diameter (2.835 cm^2). The amount of cobalt deposited was at most about 9 mg. The cobalt density was assumed to be 8.8 $g\,cm^{-3}$. The thickness of the source was thus considered to be 3.6 μm (= 9 mg/2.835 cm^2/8.8 $g\,cm^{-3}$).

A coincidence type beta-particle spectrometer was used for the measurement of ^{60}Co activity. This spectrometer (commercial name Picobeta), is widely used for the measurement of low level radioactivity. The beta particles from ^{60}Co (maximum energy, 318 keV) were analyzed by the pulse height analyzer. The spectrometer gate was opened by a pulse from a pancake type gas-flow GM tube. A pulse from a plastic scintillation detector in coincidence

with the GM counter was analyzed by a 256-channel pulse height analyzer. Assuming that there was no contamination from other nuclides, ^{60}Co activity was evaluated according to the number of pulses counted with energy between 25 and 250 keV.

A standard ^{60}Co source was prepared by electrodepositing ^{60}Co of known activity on a platinum plate, and the detection efficiency of the coincidence type beta-particle spectrometer was measured. As a result, the efficiency was determined to be 12%. Energy calibration of the spectrometer was made using internal conversion electrons of ^{137}Cs. The background in the measurement condition was 0.069 ± 0.002 counts per minute. The ^{60}Co measurements for assessment of the A-bomb doses were measurements of low level beta-particle activity, and it often took 10 or more days to measure one sample. The operation of the measuring instrument was very stable as maintenance work was done on it constantly.

It was reconfirmed that no revision should be made to the data from the chemical analysis of cobalt and the radioactivity measurement of ^{60}Co.

Collection of Iron Samples

In Hiroshima, iron samples collected from four buildings were used for the estimation of dose. However, no description was given in the report[1] concerning the type and size of those buildings. Information on these matters will be provided here.

Buildings from which Samples were Collected. Structures from which the iron samples were collected were the Hiroshima Bank building, a water trough for horses, a powder

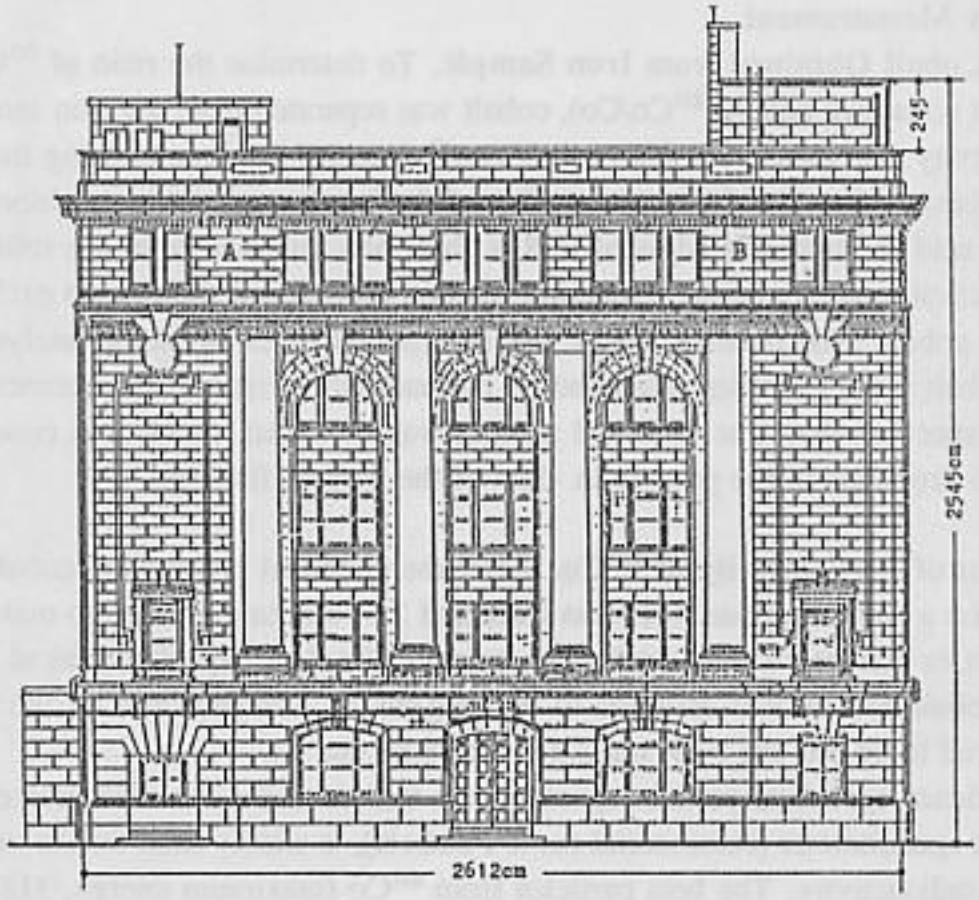


Figure 1. The Hiroshima Bank. The exact location of the samples is not known, but they were probably around the points A and B indicated

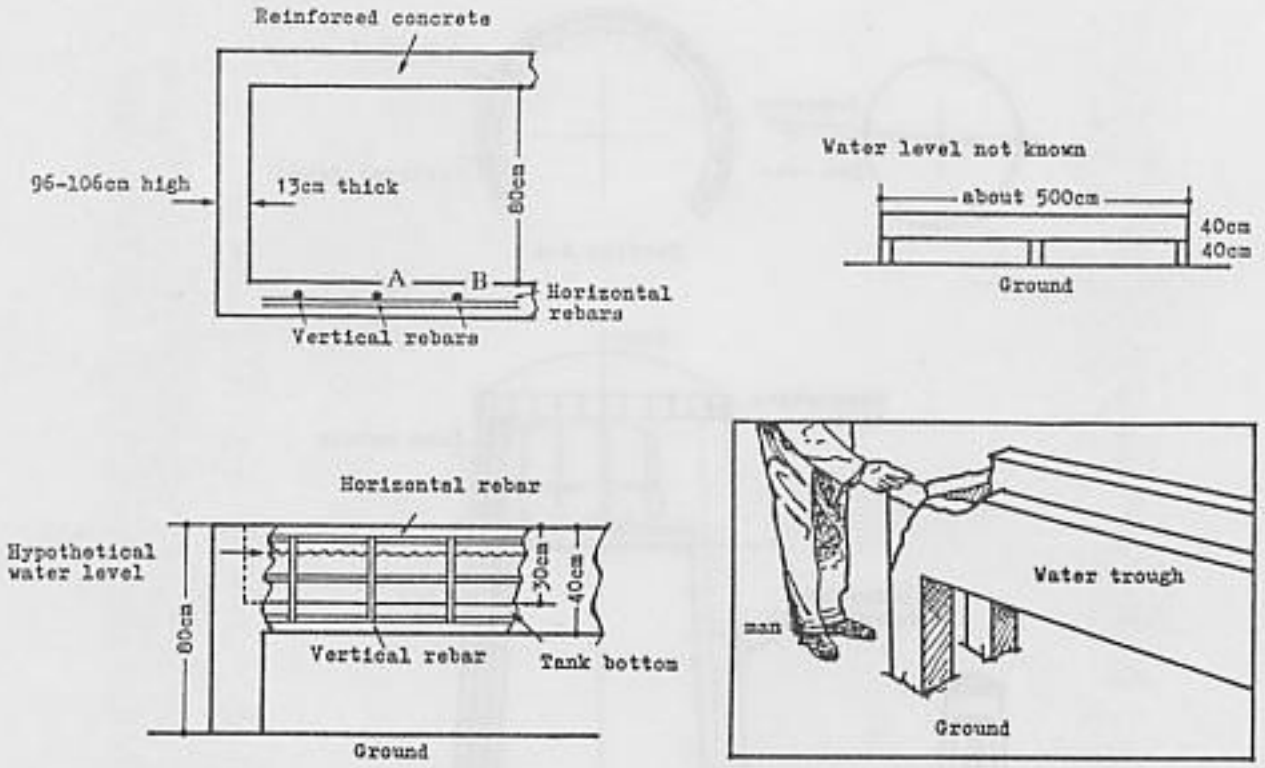


Figure 2. The trough for horses. The vertical reinforcing bars at A and B were used for the ^{60}Co activity measurement

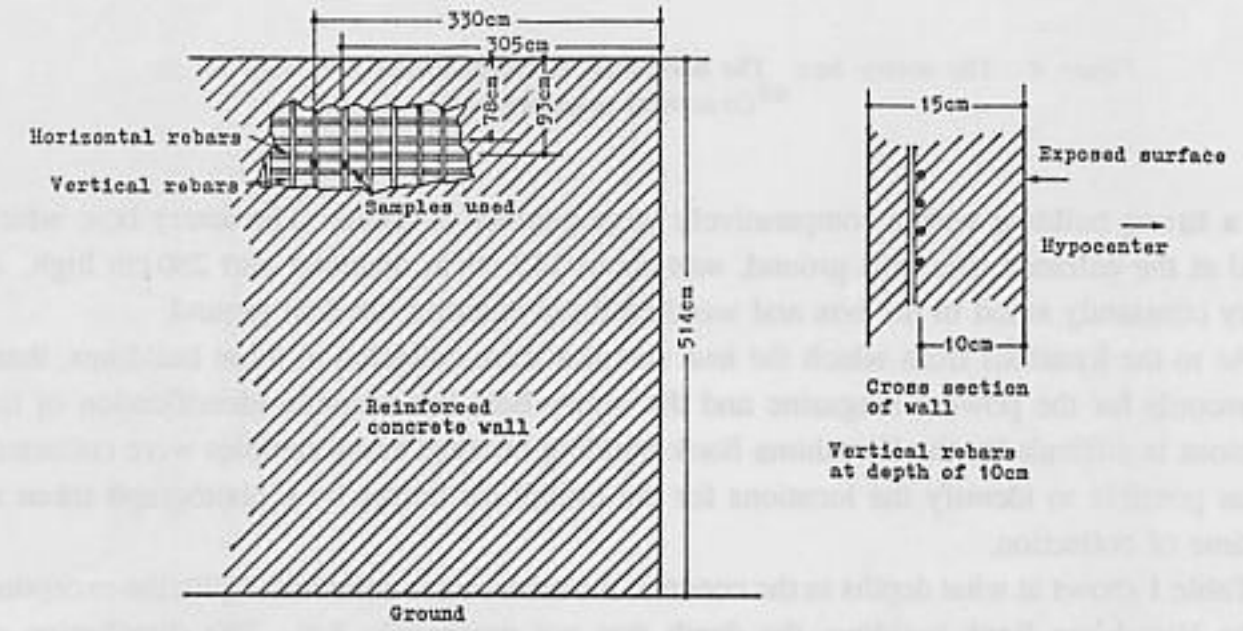


Figure 3. The powder magazine. The vertical reinforcing bars were used for the ^{60}Co activity measurement

magazine, and a sentry box. Among these structures, only the Hiroshima Bank was an actual building. Figures 1 to 4 show sketches of these structures. For the Hiroshima Bank building, a sketch made at the time of dismantling is available that provides information on its structrue. The trough, for military horses, was a concrete water tank about 100 cm wide, 40 cm deep, and 500 cm long placed on a stand about 40 cm high. The powder magazine

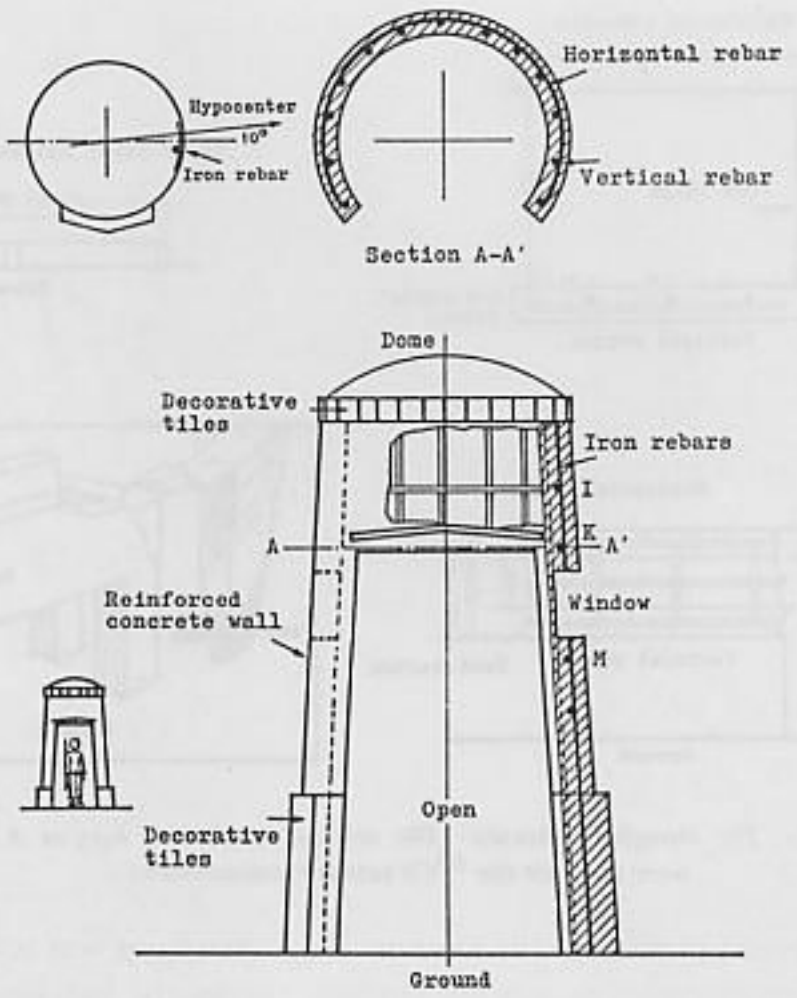


Figure 4. The sentry box. The horizontal reinforcing bars were used for the ^{60}Co activity measurements

was a strong building with a comparatively large number of rebars. The sentry box, which stood at the entrance to a drill ground, was about 140 cm in diameter and 250 cm high. A sentry constantly stood in the box and watched those entering the drill ground.

As to the locations from which the iron samples were collected in these buildings, there are records for the powder magazine and the sentry box, but accurate identification of the locations is difficult for the Hiroshima Bank building because many samples were collected. It was possible to identify the locations for the trough for horses by a photograph taken at the time of collection.

Table 1 shows at what depths in the concrete the rebars were collected. With the exception of the Hiroshima Bank building, the depth was not necessarily 8 m. The distribution of thermal neutron flux in concrete was measured using neutrons from the Be(d,n)B reaction with deuterons accelerated to 2.5 MeV by a Van de Graaff machine. No significant difference was observed in the distribution of thermal neutron flux at a depth of 6 to 10 cm. Thus, iron specimens collected from depths of 6 to 10 cm were regarded as being collected from a depth of 8 cm on the average.

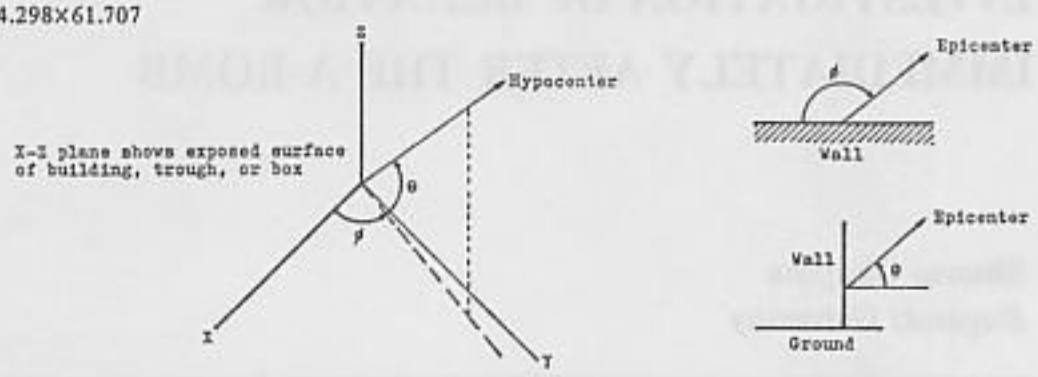
Alteration of Location of Sample Collection

Based on the coordinates of the hypocenter as altered in the present reassessment of

Table 1. Physical Parameters of the Reinforcing Bar Samples Measured for ^{60}Co Activity for the Neutron Dosimetry of the Hiroshima Bomb

Sample Number	Sampling Location	Coordinates[a]	Distance		Incident Angle[b]		Thickness of Concrete Wall	Depth in Concrete	Specific Activity
			Old	New	θ	φ			
1-1	Hiroshima Bank	44.59X61.67	260 m	269 m	66°	80°	18 cm	8 cm	2.07 ±0.17 cpm/Co mg
1-2	Sentry Box	44.68X61.38	640 m	640 m	42°	104°	15 cm	6 cm	0.324 ±0.0204 cpm/Co mg
1-3	Trough	44.17X62.56	779 m	793 m	36°	66°	13 cm	6 cm	0.146 ±0.0013 cpm/Co mg
1-4	Powder Magazine	44.54X62.99	1180 m	1197 m	26°	81°	15 cm	10 cm	0.0124±0.0023 cpm/Co mg

[a]Coordinate of hypocenter: 44.298X61.707
[b]Height of explosion: 580 m



dosimetry, the distance from the hypocenter to the buildings from which iron samples were taken was partly revised (Table 1). The location of the sentry box was revised according to an accurate aerial photograph that was not available previously, but, because of alteration of the coordinates of the hypocenter, the distance was determined to be 640 m, the same as described in the previous report.

Recalculation of the theoretical ^{60}Co activities is required on the basis of the new information provided above regarding the location of sample collection and the structure of the buildings concerned.

References

1. Hashizume, T., Maruyama, T., Shiragi, A., Tanaka, E., Izawa, M., Kawamura, S., and Nagaoka, S., 1967. Estimation of air dose from the atomic bombs in Hiroshima and Nagasaki. Health Physics 13:149-161.
2. Kawamura, S., Izawa, M., Maruyama, T., Tanaka, E., and Hashizume, T., 1967. Determination of ^{60}Co to Co ratio for the estimation of fast neutron dose from the atomic bombs in Hiroshima and Nagasaki. Health Physics 13:801-806.