Table 6. DS02 Type 1 TFs estimated or adjusted based on analysis of DS86 TFs: Nagasaki

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	DS02 ht (m)	Elevation angle (deg)	Azimuthal angle (deg)	Angle of incidence (deg)	Meas. depth (cm)	Density (g/cm^3)	TF, no bldg gamma	TF with bldg gamma
NUE	Matsuyama cho	N-1		77	5	81.2	45	39.2	2.2-3.9	2.1	0.827	0.848
NUE	Oka machi	N-2		217	7	66.3	45	32.0	2.2-3.9	2.1	0.848	0.870
NUE	Oka machi	N-2'		217	7	66.3	45	32.0	2.2-3.9	2.1	0.848	0.870
NUE	Yamazoto cho	N-3		307	10	58.1	45	30.2	2.2-3.9	2.1	0.853	0.871
NUE	Yamazoto cho	N-3'		307	10	58.1	45	30.2	2.2-3.9	2.1	0.853	0.871
NUE	Yamazoto cho	N-3"		307	10	58.1	45	30.2	2.2-3.9	2.1	0.853	0.871
NUE	Shiroyama Elementary School	N-4		490	16	44.8	45	31.5	2.2-3.9	2.1	0.850	0.862
JNIRS	Urakami church			517	29	48.1	46.9	60.8	1-2	2	0.677	0.690
NUE	Shiroyama cho	N-6		623	12.5	38.2	45	33.9	0.2-1.9	2.1	0.983	0.992
NUE	Ueno cho	N-7		634	19	37.3	45	34.3	2.2-3.9	2.1	0.842	0.851
JNIRS	Nagasaki University Hospital			655	30	35.8	37	60.8	0.5-1.5	2	0.918	0.926
JNIRS	Nagasaki University Hospital			655	30	35.8	53	49.7	0.5-1.5	2	0.961	0.969
JNIRS	Nagasaki University Hospital			655	30	35.8	53	49.7	0.5-1.5	2	0.961	0.969
NUE	Shiroyama cho	N-8		760	12	32.9	45	36.5	2.2-3.9	2.1	0.836	0.842
NUE	Sakamoto cho	N-9		763	6	33.1	45	36.4	2.2-3.9	2.1	0.836	0.842
JNIRS	Hachiman jinja nearby house			861	16	34.2	74.8	36.9	1-2	2	0.932	0.938
JNIRS	Hachiman jinja			896	18	33.0	74.8	35.9	1-2	2	0.938	0.943
JNIRS	Sakamoto cho Gaijin Cemetery			1040	33	28.6	74.8	32.0	1-2	2	0.959	0.963
NUE	Urakami cho	N-10		967	9	27.1	45	39.9	2.2-3.9	2.1	0.825	0.828
JNIRS	Sakamoto-cho Gaijin Cemetery			1068	33	28.0	74.8	31.5	1-2	2	0.962	0.965
JNIRS	Sakamoto Cemetery			1040	26	24.6	70	31.3	0.5-1.5	1.7	0.997	0.999
JNIRS	Sakamoto Cemetery			1040	26	24.6	70	31.3	0.5-1.5	1.7	0.997	0.999
JNIRS	Sakamoto Cemetery			1040	26	24.6	70	31.3	0.5-1.5	1.7	0.997	0.999
JNIRS	Sakamoto Cemetery			1040	26	24.6	70	31.3	0.5-1.5	1.7	0.997	0.999
JNIRS	Nagasaki University Charnel			1452	9	18.8	72	25.8	0.5-1.5	1.7	1.014	1.015
JNIRS	Nagasaki University Charnel			1452	9	18.8	72	25.8	0.5-1.5	1.7	1.014	1.015
JNIRS	Nagasaki University Charnel			1452	9	18.8	72	25.8	0.5-1.5	1.7	1.014	1.015

Table 7. DS02 Type 1 TFs adopted from DS86 TFs: Hiroshima

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	DS02 ht (m)	TF used	TF, no bldg gamma	TF with bldg gamma
JNIRS	A-bomb Dome			128	4	Use DS86 TF	0.786	0.899
JNIRS	Naka Telephone Office	3	1-01	521	14	Use DS86 TF	1.019	1.079
JNIRS	Naka Telephone Office	2	1-19	537	14	Use DS86 TF	0.774	0.853
NUE	Naka Telephone Office	203-3	1-04	537	14	Use DS86 TF	0.962	1.032
NUE	Naka Telephone Office	204-2	1-04	537	14	Use DS86 TF	0.962	1.032
NUE	Naka Telephone Office	204-3	1-04	537	14	Use DS86 TF	0.962	1.032
JNIRS	Sanin Bank		12-02	630	13	Use DS86 TF	0.889	0.950
JNIRS	Chugoku Elec Co		2_01	670	0.16	Use DS86 TF	0.527	0.576
JNIRS	Chugoku Elec Co	2	2-03	694	0.5	Use DS86 TF	0.610	0.666
NUE	Chugoku Electric Co.	3-1-3	2-03	694	0.5	Use DS86 TF	0.592	0.642
NUE	Chugoku Electric Co.	3-1-3	2-03	694	0.5	Use DS86 TF	0.592	0.642
NUE	Chugoku Electric Co.	3-2-2	2-03	694	0.5	Use DS86 TF	0.592	0.642
NUE	Chugoku Electric Co.	3-2-2	2-03	694	0.5	Use DS86 TF	0.592	0.642
NUE	Chugoku Electric Co.	3-2-3	2-03	694	0.5	Use DS86 TF	0.592	0.642
NUE	Japanese House (Nobori-cho)		145	1145	4.8	Use DS86 TF	1.037	1.053
NUE	H.U.P.S. (Hiro. Univ.)	H-1	4-08	1279	14.72	Use DS86 TF	0.970	0.982
NUE	HUFS "I" Bldg	H1	4-08	1279	14.72	Use DS86 TF	0.970	0.982
NUE	HUFS "I"	"HP1"		1279	13.6	DS86 horizontal railing tiles at same loc (4-08)	0.970	0.983
NUE	H.U.P.S. (Hiro. Univ.)	H-2	4-07	1290	14.72	Use DS86 TF	0.987	0.998
NUE	H.U.P.S. (Hiro. Univ.)	H-3	4-09	1305	14.72	Use DS86 TF	0.979	0.991
NUE	H.U.P.S. (Hiro. Univ.)	H-4	4-01	1324	14.72	Use DS86 TF	0.987	0.997
NUE	H.U.P.S. (Hiro. Univ.)	H-5	4-03 horizontal	1346	14.72	Use DS86 TF	0.950	0.960
NUE		H-5B	4-03 vertical	1346	14.72	Use DS86 TF	0.852	0.862
NUE		H-5B	4-03 vertical	1346	14.72	Use DS86 TF	0.852	0.862
NUE	H.U.P.S. (Hiro. Univ.)	H-5B	4-03 vertical	1346	14.72	Use DS86 TF	0.852	0.862
NUE	HUFS "I"	"HP2"		1346	13.6	DS86 horizontal railing tiles at same loc (4-03)	0.852	0.861
JNIRS	H.U.F.S. (Hiro. Univ.)	7	3-07	1385	13.1	Use DS86 TF	0.981	0.991
NUE	HUFS "E" Bldg	HPl	3-08	1386	10.61	Use DS86 TF	0.972	0.983
NUE	HUFS "E"	"HP3"		1386	2.8	DS86 horizontal railing tiles at same loc (3-08)	0.972	0.981
JNIRS	H.U.F.S. (Hiro. Univ.)	10	3-10	1395	13.1	Use DS86 TF	0.951	0.959
NUE	H.U.F.S. (Hiro. Univ.)	H-6-1	3-20	1396	13.1	Use DS86 TF	0.885	0.893
NUE	H.U.F.S. (Hiro. Univ.)	H-6-2	3-20	1396	13.1	Use DS86 TF	0.885	0.893
NUE	H.U.F.S. (Hiro. Univ.)	H-6-3	3-20	1396	13.1	Use DS86 TF	0.885	0.893
NUE	HUFS "E" Bldg	HP2	3-11	1396	10.7	Use DS86 TF	0.957	0.965
NUE	HUFS "E" Bldg	HP3	(3-11)	1396	10.7	DS86 wall tiles at same loc (3-11, not 3-20 - ?)	0.957	0.965
NUE	HUFS "E"	"HP4"		1396	2.8	DS86 wall tiles at same loc (3-11)	0.957	0.965
NUE	HUFS "E"	"HP5"		1401	13.4	DS86 wall tiles at same loc (3-23)	0.982	0.990

Table 7. Continued

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	DS02 ht (m)	TF used	TF, no bldg gamma	TF with bldg gamma
U of U	H.U.F.S. (Hiro. Univ.)	UHFSO3	3-23	1401	13.1	Use DS86 TF	0.982	0.989
NUE	H.U.F.S. (Hiro. Univ.)	H-7	3-36	1401	13.4	Use DS86 TF	0.957	0.965
U of U	H.U.F.S. (Hiro. Univ.)	UHFSO2	3-22	1405	13.1	Use DS86 TF	0.959	0.967
NUE	H.U.F.S. (Hiro. Univ.)	H-8	3-18	1430	13.1	Use DS86 TF	0.885	0.892
JNIRS	H.U.F.S. (Hiro. Univ.)	I	3-29	1433	13.5	Use DS86 TF	0.961	0.968
JNIRS	H.U.F.S. (Hiro. Univ.)	IV	3-31	1434	13.4	Use DS86 TF	0.942	0.949
NUE	H.U.F.S. (Hiro. Univ.)	H- 9	3-17	1436	13.1	Use DS86 TF	0.860	0.867
JNIRS	Red Cross Hospital		5-01	1456	7	Use DS86 TF	0.923	0.931
NUE	Red Cross Hospital	"HP6"		1456	5	DS86 wall tiles at same loc (5-01)	0.923	0.929
JNIRS	Red Cross Hospital			1456	7	DS86 wall tiles at same loc (5-01)	0.923	0.929
JNIRS	Red Cross Hospital			1456	7	DS86 wall tiles at same loc (5-01)	0.923	0.929
JNIRS	Red Cross Hospital			1456	7	DS86 wall tiles at same loc (5-01)	0.923	0.929
JNIRS	Red Cross Hospital			1456	7	DS86 wall tiles at same loc (5-01)	0.923	0.929
JNIRS	Red Cross Hospital			1456	7	DS86 wall tiles at same loc (5-01)	0.923	0.929
NUE	Red Cross Hospital	HP4	5_01	1457	7	Use DS86 TF	0.961	0.969
JNIRS	H.U.F.S. (Hiro. Univ.)	R1	3-35	1457	13.1	Use DS86 TF	0.881	0.889
DUR	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	13.1	Use DS86 TF	0.885	0.892
DUR	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	13.1	Use DS86 TF	0.885	0.892
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	13.1	Use DS86 TF	0.885	0.892
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	13.1	Use DS86 TF	0.885	0.892
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	13.1	Use DS86 TF	0.885	0.892
U of U	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	13.1	Use DS86 TF	0.885	0.892
U of U	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	13.1	Use DS86 TF	0.885	0.892
NUE	H.U.F.S. (Hiro. Univ.)	H-10-1	3-15	1458	13.1	Use DS86 TF	0.897	0.905
NUE	H.U.F.S. (Hiro. Univ.)	H-10-2	3-15	1458	13.1	Use DS86 TF	0.897	0.905
NUE	H.U.F.S. (Hiro. Univ.)	H-10-3	3-15	1458	13.1	Use DS86 TF	0.897	0.905
NUE	H.U.F.S. (Hiro. Univ.)	H-10-4	3-15	1458	13.1	Use DS86 TF	0.897	0.905
U of U	H.U.F.S. (Hiro. Univ.)	UHFS04	3-24	1464	13.1	Use DS86 TF	0.955	0.961
U of U	H.U.F.S. (Hiro. Univ.)	UHFS07	3-27	1465	13.1	Use DS86 TF	0.942	0.948
NUE	H.U.F.S. (Hiro. Univ.)	H-11	3-16	1469	13.1	Use DS86 TF	0.821	0.827
NUE	Chokin-Kyoku (Postal Savings)		6-04	1608	20	Use DS86 TF	0.654	0.658
JNIRS	Chokin-Kyoku		6-00	1607	22	Use DS86 TF	0.857	0.861
NUE	HUFE clay wall tile	C-1		2050	3	DS86 wall tiles at same loc	0.978	0.979
NUE	HUFE clay wall tile	C-2		2050	3	DS86 wall tiles at same loc	0.978	0.979
NUE	HUFE clay wall tile	C-3		2050	3	DS86 wall tiles at same loc	0.978	0.979
NUE	HUFE	HP5	8-01	2056	6	Use DS86 TF	0.978	0.978
NUE	HUFE	HP8		2056	5.8	DS86 wall tiles at same loc	0.978	0.979

Table 8. DS02 Type 1 TFs adopted from DS86 TFs: Nagasaki

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	DS02 ht (m)	TF used	TF, no bldg gamma	TF with bldg gamma
JNIRS	Yamazoto-cho House			87	12.00	Use DS86 TF	1.018	1.040
JNIRS	Urakami		N4	517	24.00	Use DS86 TF	0.860	0.868
JNIRS	Urakami			517	24.00	DS86 for Urakami site "N4"	0.860	0.872
JNIRS	Sakamoto		N-6	1068	23.15	Use DS86 TF	1.055	1.057
JNIRS	Sakamoto			1068	26.75	DS86 for Sakamoto site "N-6"	1.055	1.057
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.992	0.992
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.775	0.776
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.688	0.689
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.992	0.992
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.775	0.776
DUR	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.688	0.689
JNIRS	Ieno	A	N-2-2	1421	10.10	Use DS86 TF	0.969	0.970
JNIRS	Ieno	B	N-2-2	1421	10.10	Use DS86 TF	0.965	0.966
NUE	Ieno wall	A	N-2-1	1421	10.10	Use DS86 TF	0.959	0.960
NUE	Ieno wall	B	N-2-1	1421	10.10	Use DS86 TF	0.817	0.818
NUE	Ieno wall	C	N-2-1	1421	10.10	Use DS86 TF	0.682	0.682
OXF	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.992	0.992
OXF	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.775	0.776
OXF	Ieno wall	NAIEO5	N-2-1	1421	10.18	Use DS86 TF	0.688	0.689
U of U	Ieno wall	NAIEO6	N-2-1	1421	10.18	Use DS86 TF	0.955	0.956
U of U	Ieno wall	NAIEO6	N-2-1	1421	10.18	Use DS86 TF	0.793	0.794
U of U	Ieno wall	NAIEO6	N-2-1	1421	10.18	Use DS86 TF	0.718	0.719
JNIRS	Zenza		N-7	1428	4.00	Use DS86 TF	1.060	1.061
JNIRS	Zenza			1428	4.00	Use DS86 TF for Zenza "N-7" site	1.060	1.061
JNIRS	Inasa	A	N-3	2050	-4.40	Use DS86 TF	1.025	1.025
JNIRS	Inasa A			2050	-4.40	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Yamada Oil Storehouse			2045	3.00	Use DS86 TF for Inasa "N-3" site	1.025	1.025
JNIRS	Chikugo		N-8	2329	17.00	Use DS86 TF	1.009	1.009

Although we could have devised a way to adjust the TFs without building gamma in Tables 7 and 8, for a new angle of incidence based on the DS02 height of burst and a GIS-evaluated DS02 ground distance, we would expect such adjustments to be small. The azimuthal angles given in

Kaul et al. were checked with the GIS in a number of cases and agreed quite well. The 20-m change in the height of burst causes only a small change in the angle of elevation. That change in angle is maximized at about 1° at a ground distance equal to the height of burst, whereas the change in the inverse cosine is maximized at about 3% at locations very near the hypocenter. The only sample at such a close distance for which we used a directly adopted DS86 TF is the JNIRS 1967 roof tile from the A-bomb dome, which was already a somewhat anomalous result that we do not understand well enough analytically to propose a correction. All other unadjusted TFs are for samples at ground distances >520 m, where the change in the inverse cosine of angle of incidence due to a 20-m change in HOB, hence the change in angled depth of the measured material, is <2%. Similarly, the changes in ground distances between the DS86 and DS02 estimates, at distances >520 m, would produce only very small changes in the elevation component of angles of incidence.

Comments on Sites for Which New TFs Were Estimated

Apart from the NUE 1966 measurements, which have various difficulties that have been discussed above, there are several new sites not calculated in DS86, for which questions arise about the TFs that can be calculated using the methods of this work. In Hiroshima, the Hiroshima University Radioisotope Building, the tower of the Red Cross Hospital, the tiles from the floor of the roof at the Postal Savings Bureau (except for one partially-shielded location, “B”), and the Japan Electrometer Inspection Corp. appear to be straightforward structural geometries and could be clearly checked with the GIS.

However, we could not use the GIS to obtain an unambiguous estimate of the azimuthal angles corresponding to the angles of incidence given by the authors for either the Myosenji temple or Hiramoto residence sample. Although we can use the georeferenced images shown in Figures 12 and 13 to measure the horizontal (azimuthal) angles of sides and corners of the buildings with respect to the direction to the hypocenter, the side(s) or corners from which the samples were taken are not documented well enough to resolve apparent inconsistencies with angle given by the authors. We used the authors’ estimates of 73.2° and 74.4° and assumed them to be azimuthal deflections from the perpendicular, which are quite oblique and give rather low TFs near 0.81 in both cases. In the case of the Myosenji sample, the situation is further complicated in that, as seen in the picture of the sample in Figure 1 of Hoshi et al. (1989), it was a rather small and somewhat rounded, protuberant sample, which may have affected its TF in ways that cannot be modeled with the methods of this work.

A very important site in Nagasaki is the Urakami church, from which bricks were taken and measured by JNIRS, with results reported by Hashizume et al. (1967), Maruyama et al. (1987), and Maruyama et al. (1988). Although it is well established that the bricks came from the west façade where the main entrance to the church was located, there was a question whether any of the samples measured could have come from the south corner of this wall, which would have had substantial frontal shielding by another large church building. No records available at the present time establish whether any of the samples came from this corner. There are also potential concerns about whether any of the samples may have been partly shielded by the wall itself, as the wall was very ornate with protruding columns. The north corner had collapsed due to blast damage, so that its original geometry vis-à-vis the line of sight to the epicenter may not have been obvious to sample collectors.

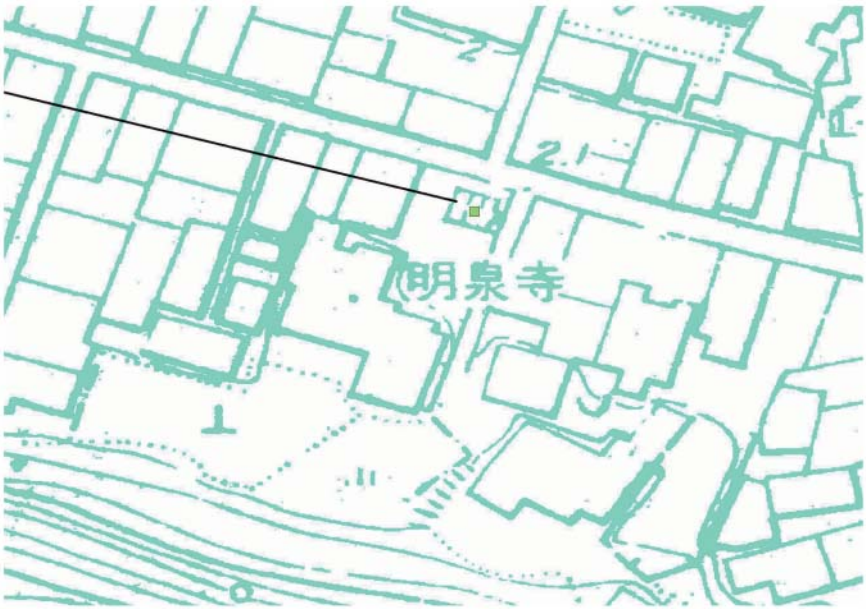

Figure 12. *Myosen temple. The black line indicates the direction to the hypocenter.*

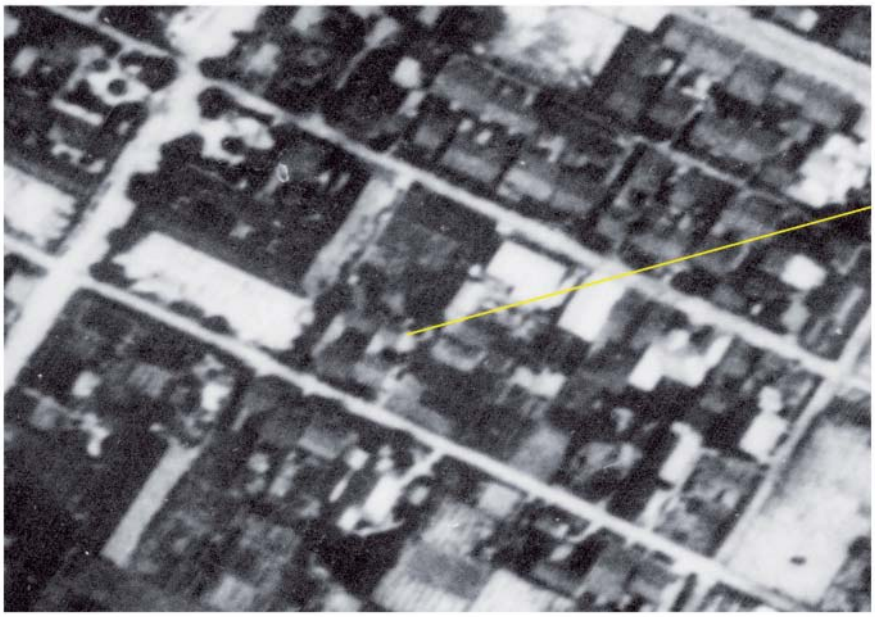

Figure 13. *Hiramoto residence. The yellow line indicates the direction to the hypocenter.*

Another somewhat problematic case involves three samples measured after DS86 by JNIRS, from a window casement on a tower at Nagasaki University Hospital, which yielded a wide range (25.2 Gy, 34.5 Gy, 41.8 Gy) of measured values. Further checking revealed that two of these samples were recessed into the window frame, although they had a slightly less oblique angle of incidence than the other sample (50° vs. 61°), which was from the exterior portion of the window casement, flush with or slightly protruding from the exterior wall, and gave the highest of the three values. The sample locations are shown in Figures 14 and 15. The TF that we can calculate using our methods for the exterior sample is probably a reasonable estimate, but the TF that we would calculate for the recessed samples is clearly too large because it fails to account for the shielding, which would depend strongly on the distance from the exterior wall surface to the sampled material, i.e., how deeply recessed the measured material was from the exterior wall surface.

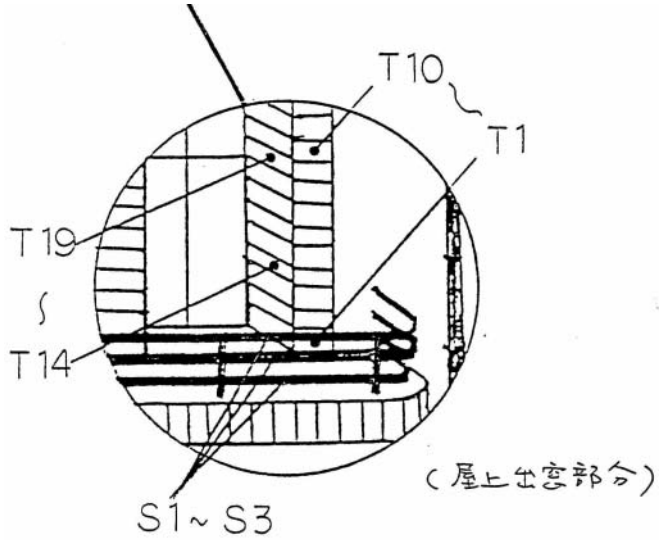

Figure 14. *Nagasaki University Hospital tower window.*

Another site of concern is the Yamada-Furukawa family graveyard gatepost, in the Sakamoto cemetery at 1,040 m, DS02 ground distance. The sampled bricks were stacked two to a layer in the post, in alternating directions in successive layers. If the sample material for all four reported measurements was taken from the north side of the post as shown in Figure 16, then the angle of incidence is very acute, and the calculated TF of 0.997 seems appropriate. However, if any material was taken from a side at right angles to the north side of the post, the angle of incidence would be very oblique. For example, the right side of the post in Figure 16 would have an angle of incidence of 72° and an estimated TF of about 0.728 by the methods used for this work, and the left side is actually shielded.

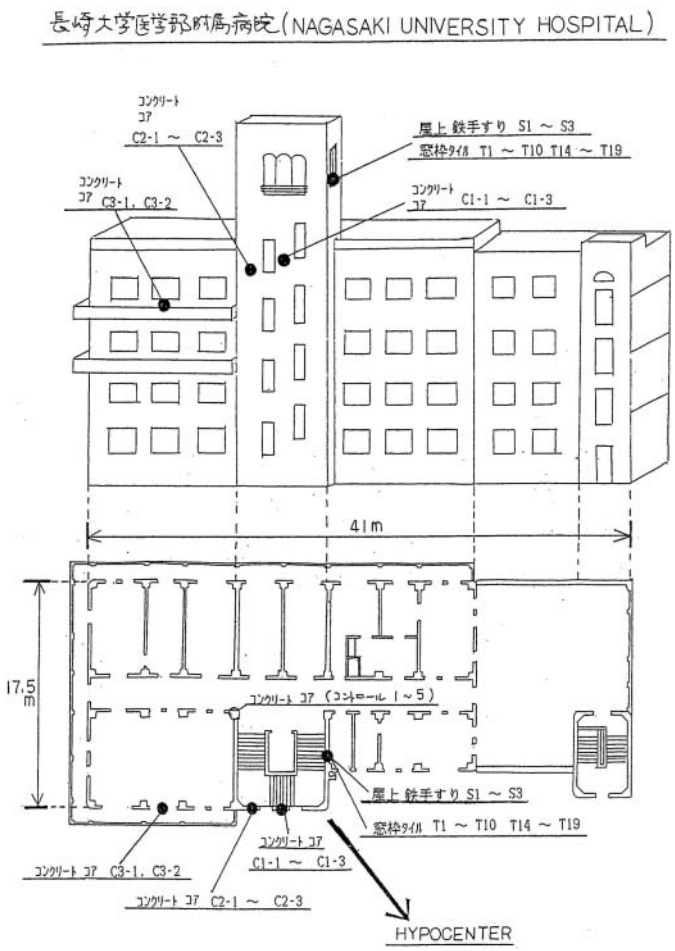

Figure 15. *Nagasaki University Hospital tower.*

Calculation of DS02 In Situ Dose to Quartz

To obtain the calculated *in situ* dose to quartz for each sample in this work, the interpolated free-in-air gamma kerma at the sample's height-and-altitude-corrected slant range (slant range as defined in equation (2) above) was multiplied by the DS86 or imputed TF and added to the building gamma dose to quartz. As discussed above, the distances used for the calculations of the TFs implicit in Appendix 11 were those for the new city map in Tables 1-5 of Appendix 11, as those are the distances on which the DS86 calculated values were based. For this work, however, new distances were calculated for *all* samples using the DS02 locations of the hypocenter on the new city maps. As map coordinates were necessary for these new distance calculations, a detailed review of each sample's total available site information was performed by using GIS with overlays of maps and aerial photographs, and by consulting various sources of information. The DS02 ground distances for all samples included in this work are given in Tables 5-8.

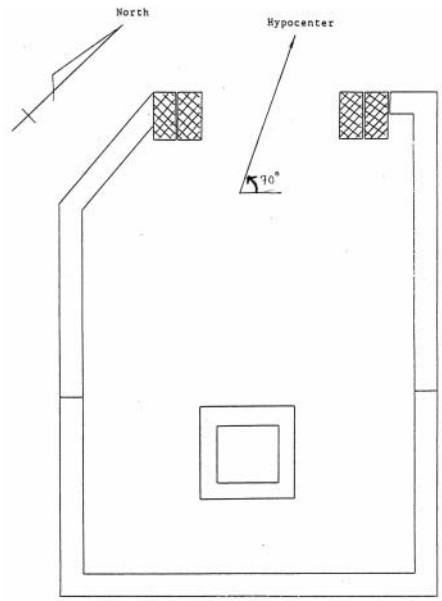

Figure 16. *Yamada-Furukawa family graveyard gatepost.*

Potential for Partial Frontal Shielding

In order to investigate the question of why the measured values might be lower than calculated values, as discussed below, the authors considered the implications of the large-scale geometry of Nagasaki sample sites in contrast to those in Hiroshima. In addition to having hilly terrain and a 100-m lower height of burst, sample locations in Nagasaki are generally closer to ground level, whereas a large proportion of samples in Hiroshima were located on the roofs of multi-story buildings. Initial reviews of sample sites in both cities using GIS have indicated that a number of sites in Nagasaki may have had some minor, partial frontal shielding from terrain, nearby buildings, or even groves of trees in the direction of the hypocenter, whereas virtually no sites in Hiroshima have similar conditions. Unfortunately, it was not possible within the scope of this work to perform a quantitative evaluation of this effect.

Calculation of DS02 Free-in-Air-Equivalent Measured Values

For comparison and plotting purposes it is desirable to quote a “measured free-in-air-equivalent” value at the sample’s ground range. This is the free-in-air kerma at that ground distance, at an elevation 1 m above the elevation of the hypocenter, which corresponds to the sample’s measured *in situ* dose to quartz at its specific height above the elevation of the hypocenter. That is, it is the free-in-air kerma that would correspond to the measured value, but at one meter above flat ground at the sample’s ground range if the structure containing the sample and any terrain feature departing from flat ground were not present. The free-in-air-equivalent measured value was calculated in units of tissue kerma by the formula

$$\text{kerma}_{meas,FIA,1} = \left(\frac{\text{kerma}_{calc,FIA,1}}{\text{kerma}_{calc,h}}\right)\text{kerma}_{meas,h} \tag{12}$$

This formula can be thought of as taking the *in situ* measured dose to quartz and multiplying it by the ratio of the calculated free-in-air kerma at one meter above hypocenter elevation to the calculated *in situ* dose to quartz for the sample. This free-in-air-equivalent measured value was converted from "kerma to quartz" to "kerma to tissue" by multiplying by the factor 1/0.916, which is based on the radiological properties of tissue vs. those of quartz (Maruyama et al. 1987), so that it can be plotted vs. free-in-air tissue kerma.

Hiroshima is exceptionally flat. The ground level elevation at the estimated hypocenter location is about 3 m above sea level, and ground level elevation at the measurement sites does not differ from this by more than 2 or 3 m for any of the sites. Therefore, ground level elevation is not considered in correcting for sample height in the calculation of "measured free-in-air-equivalent at 1 m above ground (level at hypocenter)" values for Tables 12 and 13 and Figures 17 and 18—only height above ground is used. Nagasaki, in contrast, is very hilly. The area near the hypocenter varies considerably in elevation, the ground level elevation at the exact estimated hypocenter location being about 5 m above sea level, but ground level at measurement sites varying from -2 m to about 35 m above sea level. Therefore, both ground level elevation and height above ground are included in calculating "measured free-in-air-equivalent at 1 m above ground (level at hypocenter)" values in Nagasaki for DS02, as was done for DS86. Detailed examples of calculations, both for samples calculated in DS86 and those calculated using the methods of this work, are given in Tables A1 and A2 of Appendix A to this chapter.

Adjustment of 1966 Ichikawa et al. Measured Values for Comparison to Calculated Dose to Quartz

In the case of the TLD measurements reported by Ichikawa et al. (1966), we did not use any of the original adjustments that they had included in their reported values. We did not use the authors' original adjustment for attenuation attributable to overlying material (protection factor of 1.09 for tiles that had a 2 cm layer on top of them *in situ*, 1.03 for the other tiles) or their correction factor of 1.05 for energy response. Instead, we estimated and used individual transmission factors for these measurements, using the log-linear model developed for this work, as described above. We did not use the authors' original calculated values proposed to account for doses due to induced activation and subtracted by the original authors from their measurements. Instead, an estimated background calculated from this work, which is shown in Table 9, has been subtracted.

Some justification for these corrections may be appropriate here. TLD dose due to induced activation (as opposed to prompt gammas emitted in neutron capture reactions) has not been considered for other reported measurements since these 1966 measurements, and was not calculated in Appendix 11. For consistency, the authors' estimates were removed from these particular data (Ichikawa et al. 1966). Although the calculations of Appendix 11 did not consider induced activation, Chapter 6 of DS86 on Radiation Doses from Residual Radioactivity did calculate doses from gamma rays due to induced activation of soil, for application to persons such as survivors who may have entered the city as "early entrants" after the bombing. The calculated total integrated doses at one meter above ground due to gamma rays neutron activation

of soil at locations near the hypocenter, stated as FIA tissue kerma at one meter above ground are shown in Figure 7 of Appendix 2 to Chapter 6 of the DS86 Final Report. The total integrated dose at the hypocenter from soil activation in Hiroshima is about 1.5 Gy, or 1.2% of the DS02 direct gamma dose from the bomb fluence. At 500 m ground distance, it is about 0.18 Gy (0.5%), and it is about 0.0032 Gy (0.07%) at 1 km. The relative contribution in Nagasaki is smaller still, e.g., about 0.7 Gy (0.2%) at the hypocenter and 0.06 Gy (0.07%) at 500 m. In addition to this dose from gamma rays arising from the activation of surrounding materials within a few tens of meters, the dose to tiles and bricks would have had another slight increment due to internal absorption of betas from neutron activation products produced within a few cm of the measured material in that material. However, Hashizume et al. (1967) concluded from experiments with neutron-irradiated samples that the dose contribution from activation of the sample was negligible. Thus, the corrections likely to be appropriate are on the order of a few percent or less of those applied by Ichikawa et al. (1966) and listed in Table 9.

On the other hand, the issue of background was not considered significant by the authors in 1966. However, the reanalysis done for this work indicates that the very old age of some of the tiles results in background estimates that represent appreciable if not large proportions of measured and calculated values, even at relatively close distances, and corresponding corrections have been made for the analyses reported here.

Therefore, we obtained values for this analysis as *in situ* dose to quartz by taking the "equivalent gamma doses" in Roentgens reported by Ichikawa et al. (1966), which are their measured gross *in situ* values calibrated against ^{60}Co test irradiations, multiplying by 0.87 rad(SiO_2) per R based on the value obtained by Kaul et al. (1987), dividing by 100 rad/Gy, and subtracting our estimates of total accumulated background in Gy(SiO_2) as given in Table 9.

Ichikawa et al. (1966) did not give "±" uncertainty estimates for their measurements. They noted only, without elaboration, that they felt the measurements suggested a best obtainable limit for the uncertainty of their method as equating to about a 10% coefficient of variation (CV). There are a few, unfortunately very limited sets in their data that appear to qualify as replicates for the purpose of estimating a random component of error among measurements on "the same sample." Sample standard deviations and means can be calculated for these subsets, although such calculations are truly "pushing the limit" in a statistical sense. The specifics are Zaimokucho Seiganji (2 measurements, CV estimate 6.5%), Hiroshima Castle ninomaru (2 measurements, CV estimate 3.6%), and Hiroshima Castle honmaru (3 measurements, CV estimate 38%) in Hiroshima, and Okamachi (2 measurements, CV estimate 1.2%) and Yamazatocho (3 measurements, CV estimate 11%) in Nagasaki. Based on these numbers and the other considerations involved, an error corresponding to a CV of 20% has been assigned to these measurements for the present analysis. This is strictly a judgment, not a valid statistical result, and thus a very rough estimate. While it would be possible to develop a formula for combining the CV estimates, they are very crude and imprecise. The consideration of other information about the reproducibility of the measurement process, e.g., information on the reproducibility of other contemporaneous measurements made with similar methods, such as the JNIRS measurements (Hashizume et al. 1967), can only be subjective or arbitrary in nature given the unclear relationship involved.

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