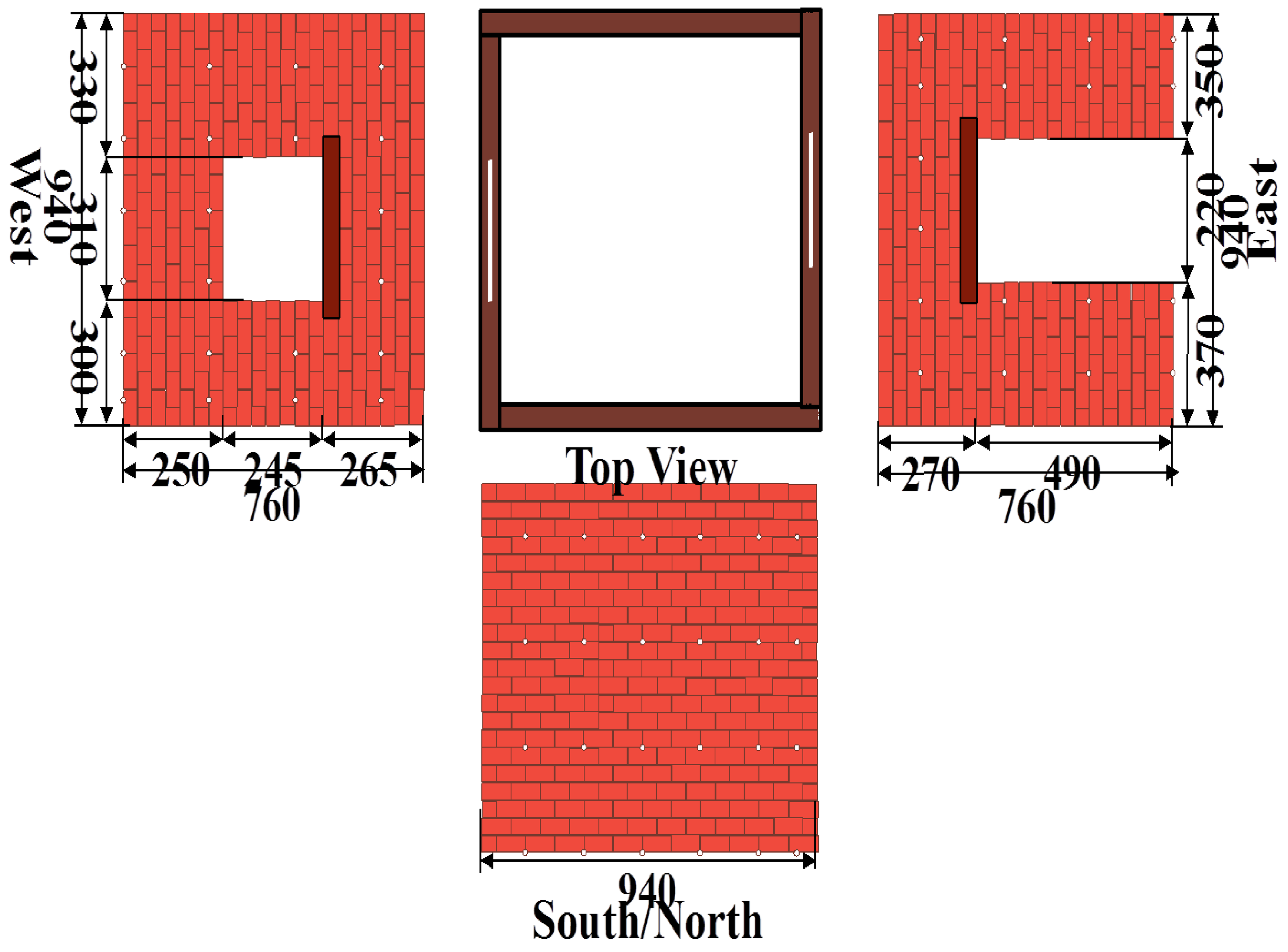
ガラス繊維塗料で補強した1/4スケールの組積造建物の振動台実験

SHAKE TABLE TESTS ON ONE-QUARTER SCALED MODELS OF MASONRY HOUSES RETROFITTED WITH FIBER REINFORCED PAINT

In the last century, there were many earthquakes and they have caused a total loss of lives exceeding 1.53 million people. Unreinforced masonry buildings are highly vulnerable and common in seismic areas around the world. The collapse of masonry buildings is the major cause of the deaths in the past earthquakes (Coburn and Spence, 2002). Therefore, retrofitting masonry structures is one of the most important issues for reducing casualties by earthquakes in the world. A new retrofitting technique using glass fiber reinforced paint (SG-2000) has been suggested. The material needed for this technique is only SG-2000, which significantly reduces the amount of time and labor for retrofitting. Also, paint is usually used to make houses look fine, and many masonry structures are coated with paint. Therefore, SG-2000 can be easily used by local people as the form of paint. The experiments in-plane diagonal shear tests and out-of-plane bending tests showed that wallettes coated with SG-2000 whose ratio of fiber was 1.5 % achieved larger deformation capacities than unretrofitted wallettes did (Yamamoto, 2014). In this study, a shake table test using one-quarter scaled model of a masonry structure retrofitted with SG-2000 was conducted to investigate its dynamic responses.

Shake table test

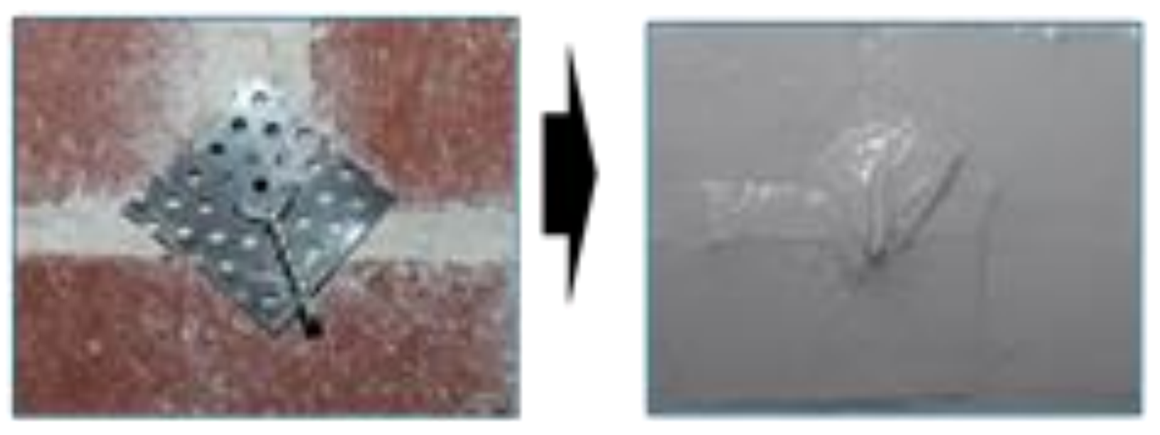
Specimen



Retrofitting procedure

●fiber ratio of paint: 1.5(Wt%)
●how to paint: full coating (inside and outside , cross sections)
●thickness of coating: 1mm(volume of paint/surface area of coating. Actual thickness is about 0.5mm due to its shrinking after drying)

●upper part of walls: put the wooden frame to connect the walls with the roof



●on walls: insert steel wires in holes (Figure1, left) to connect the paint inside and outside

Input motion and damage level

Run No.	01	···		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
WRH					light	light	light	light	light	light	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate
SG-2000					light	light	light	light	light	light	light	light	light	light	light	light	light	light	light	light	light
Amplitude(g)				0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8
Frequency (Hz)				30	25	20	15	10	5	35	35	35	30	30	30	25	25	25	20	20	20
SI(JMA scale)				~4																	

Run No.	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
WRH	moderate	moderate	moderate	heavy	heavy	heavy	partially collapse	partially collapse									
SG-2000	light	light	moderate	moderate	moderate	moderate	heavy	heavy	heavy	heavy	heavy	heavy	heavy	heavy	partially collapse	partially collapse	collapse
Amplitude(g)	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.4	0.8	1.0	1.2	1.4	0.4	0.6	0.8	1.2
Frequency (Hz)	15	15	15	10	10	10	5	5	2	5	5	5	5	2	2	2	2
SI(JMA scale)	~4						5-			5+		6-				6+	7

Color	Damage level
(white)	no damage
(gray)	light structural damage
(green)	moderate structural damage
(yellow)	heavy structural damage
(orange)	partially collapse
(red)	collapse

SPECIMEN: The specimens were built with burnt bricks in reduced scale (1/4). Joints between bricks were filled by mortar with c/w ratio of 0.14 (cement:lime:sand=1:7.9:20). These materials were made in Japan, but the specimens were made with great attention that it could be a suitable replica of masonry buildings in developing countries, following previous experiments conducted by our research group (for example: Meguro et al., 2005). The model was one-story building with wooden frame roof, with the dimensions of 940mm×940mm×760mm with 50mm thick walls and the sizes of door and window on the east/west walls were 220mm×490mm and 310mm×245mm, respectively as shown in figure above. The dimension of the bricks used was 75mm×50mm×35mm and the same bricks had been used for the previous experiments conducted by our research group.

ACCELERATION AND INPUT MOTIONS: Totally 54 runs were conducted applying sinusoidal wave motions whose frequency and amplitude range from 35Hz to 2Hz and 0.05g to 1.4g, respectively, to investigate the dynamic response of the house model retrofitted with SG-2000. The number of cycles was constant for all runs. Therefore, the lower the frequency of the run's wave is, the longer the run endures. The experiment was started with a sweep motion whose amplitude is 0.05g and frequency changes from 60 to 2 Hz to identify the dynamic property of the model. The sequence of these runs was determined by the values of the seismic intensity of Japan Meteorological Agency (JMA) scale from smaller to larger one.

CONCLUSION: As the SG-2000 did not improve the structure's stiffness, the damage inside the coating was observed in the same way as the unretrofitted house. However, SG-2000 connected bricks after the mortar joints of them had been broken. It is concluded that SG-2000 improved both the structure's deformation capacity and energy dissipation capacity, and make the structure resistant against much stronger ground motions. Also, SG-2000 covers the mortar joints and bricks, and therefore it prevents the dust from spreading and bricks from falling down inside the house. From the failure patterns of the retrofitted house, SG-2000 could save the lives of residents in earthquake, but could not enable them to use the house again because of its heavy structural damage.

Future researches should improve SG-2000 as it prevents heavy structural damage so that the residents can use the retrofitted house even after a large earthquake.