

Lessons in the Strengthening and Reinforcement of Historical Buildings from Rescue Projects Following the Great Hanshin Earthquake

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Introduction

An extremely strong earthquake of intensity 7 on the Seismic Intensity Scale of Japan, the first earthquake of that size ever recorded in the history of earthquake observation in Japan, hit Hanshin area on January 17, 1995. Kobe Marine Meteorological Observatory which is located on solid ground near the epicenter, indicated that the maximum acceleration were North-South 818 gal, East-West 617 gal and Up-Down 332 gal.

A total of 10 cities and 10 towns in those areas with a population of over 3,500,000 were devastated in an instant. Over 6,000 people were killed. 200,000 houses were destroyed or burned, and the total amount of damage exceeded 10 trillion yen. It was the worst earthquake to strike Japan since the Great Kanto Earthquake (1923).

The timber buildings, especially dwellings built in the poor conditions immediately after the World War II, were suffered very serious damage, partly owing to the deterioration of materials as a result of aging. Dr. Prof. Emeritus Nobuo Ito says that damage was most devastating in wooden buildings with:

- 1) poor foundations and sills;
- 2) insufficient diagonal bracing;
- 3) inadequate connecting elements;
- 4) insufficient areas of solid wall;
- 5) heavy roofs.

Outline of the Damage to Historic Buildings (note 1)

In Japan Legal provision has started in 1897 for the protection of historic buildings as cultural properties. The government has designated buildings mainly from temple and shrine structures, castle buildings, and upper-class residences. In the post-war period, it has widened the designation categories such as vernacular houses and western-style buildings, dating from the mid-late early modern period and extending to modern times. However, the number of designated buildings dating from the 18th century or later is still below what it should be. Alongside this system, however, since 1975, the government has designated for conservation areas in which traditional buildings have survived, under the title "Important Preservation Districts for Groups of Historic Buildings".

The Agency for Cultural Affairs is the government department responsible for designated buildings, and it has specific officials charged with their protection. In addition there is an incorporated foundation which is the "Japanese Association for the Conservation of Architectural Monuments" (J.A.C.A.M.) where three quarters of conservation architects in Japan are working who are capable of the recognition for the restoration subsidy works of designated buildings.

Consequently, a notably systematic investigation of the damage to national cultural property buildings has been carried out. In the case of the Great Hanshin Earthquake Government's and J.A.C.A.M stuffs investigated systematically and planned rescue projects immediately.

In order to offset the tendency for the designation system not to extend protection to younger aged buildings, prefectures, cities, towns and village have been designating historic buildings from their aspects.

Furthermore, since such local authorities have no system corresponding to the preservation districts for groups of historic buildings in Hanshin area. They have tried to plan the conservation or promotion of old buildings by establishing independent categories of their own, such as "District for the Preservation of the Cultural Environment" and "Municipally Designated

Buildings in Urban Scenic Areas".

At the level of prefectures, cities, towns and villages the number of architectural conservator is extremely low. Accordingly, the investigation of earthquake damage to designated buildings by local authorities and undesignated historic buildings apart from national cultural properties, was supported by the Architectural Institute of Japan (A.I.J.) in stead of local authority stuffs. The A.I.J. Committee for the Study of History and Design at the Institute's Kinki Branch took the initiative. And Architectural historians and other researchers from various universities and technical colleges in the Kinki region made a concerted effort to survey the damage to those historic buildings which were already known as a result of earlier research.

The report which they produced was entitled "Report of the Survey on Historic Buildings Damaged by the Great Hanshin Earthquake" (Japanese edition, April 1995).

1) Designated cultural property buildings

The conditions of damage incurred by cultural property buildings as a result of the earthquake is noted in the Table 1. There were 116 cultural property buildings designated by the nation that were damaged, 81 of those designated by prefectures, and 34 (100%) historic buildings within Preservation Districts for Groups of Important Historic Buildings (hereafter, Historic Buildings Group).

Table 1 Summary of the conditions of Damage to Historic Buildings

□(National Designation) □□□□□□□□□□□□□□□□ □□□□

Region (Prefecture)	Shiga	Kyoto	Osaka	Hyogo	Nara	Wakayama	Sum
Number of Designated Buildings	(22) 176	(46) 277	(5) 92	(11) 99	(61) 256	(7) 73	(152) 973
Number of Damaged Buildings	6	(10) 47	31	(2) 29	3	0	□(12) □ 116
Number of Preservation districts for Groups of Important Historic Buildings	1 [295]	5 [454]		1 [34]	1 [504]		8 [1287]
Number of damaged Districts	0	0		1 [34]	0		1 [34]

□(Prefecture Designation) □□□□□□□□□□□□

Number of Designated Buildings	59	132	53	184	92	50	570
Number of Damaged Buildings	2	20	14	44	0	1	□ □ 81

INDEX: () National treasure [] historic buildings within Preservation District

2) Historic buildings, including undesignated buildings

The A.I.J investigated a total of 1211 buildings, among them historic buildings designated by municipalities and candidate buildings as well as those undesignated buildings that have already been introduced in publications as historical buildings. This investigation showed that close to 40% of these buildings were damaged, including 154 buildings (13%) that were totally collapsed, 100 (8%) that were semi-collapsed and 218 (18%) that were partially damaged. If we add to these numbers those buildings which had tilted or were only slightly damaged, the ratio of damaged historic buildings amounted to 74%.

Furthermore, the half a year later investigation about damaged undesignated historic buildings showed that 62 out of 104 farmhouses (60%), 7 out of 14 townhouses (50%), and 18 out of 45 modern residential houses (40%) had already been dismantled and removed from their locations. A look at the damage degree of demolished those buildings showed what involved 18 semi-collapsed buildings and 35 partially damaged buildings.

Table-2 □ Historic houses remaining status in Takarazuka

Organization	Modern house						Farm house						Town house						Sum	
	C	S	P	S	G	N	C	S	P	S	G	N.	C	S	P	S	G	N		
A.I.J Feb. 1995	2	2	4	16	23	11	6	2	9	6	2	5	-	3	2	-	-	-	93	
After Quake																				
Pref. board of Education	R	-	1	3	15	22	7	-	-	3	1	2	1	-	2	-	-	-	-	57
July 1995	D	2	1	1	1	1	4	6	2	6	5	-	4	-	1	2	-	-	-	36
Pref. Board of Education	R	-	1	3	15	22	7	-	-	3	1	2	1	-	1	-	-	-	-	56
July 1996	D	2	1	1	1	1	4	6	2	6	5	-	4	-	2	2	-	-	-	37

R:remaining D:demolished

C: complete collapsed S: semi-collapsed P: parcial damaged S: slight damaged G: good N: non-investigated

Thus we can see that sudden changes in the environment due to the earthquake had created conditions difficult for the maintenance and management of buildings which in the future may have been designated cultural properties. We cannot but say that this, from the point of view of the protection of cultural properties, is a critical condition.

Damage Trends Related to Different Building Types (note 2)

1) The damage to temples and shrines

The designated temples and shrines were not located in the area of severe shocks, but rather in peripheral areas. On the other hand, the number of undesignated modern shrines and temples located within the area of severe shocks, which were badly damaged, was by no means small.

In the case of shrines, the collapse of the one-bay Nagare style Yakujin Honden of the Rokko Hachiman Shrine is worthy of note. The way in which it had collapsed, just as if its legs had been kicked from under it, makes one think that it was thrown off balance in an instant and the body of the building was crushed by the weight of the roof. There can be little doubt that, as Dr. Kuroda has reported, the main cause was that the roof covering had been changed from cypress bark roofing to heavy classic roof-tile, but it is thought that the rather unbalanced Nagare roof form was also a contributory factor. In the case of the Kasuga style Honden within the precinct, only the veranda collapsed, but if the direction of the earthquake forces had been different, it is thought that this could have led to greater damage. Also, the worship hall (haiden) was leaning over at an angle, similar damage occurred in many cases with this kind of worship hall, it may be said that improving the earthquake resistance of worship hall, with their lack of walls to absorb horizontal forces is a difficult problem.

Among other things, one type of damage particularly associated with shrines was that caused by the collapse of the shelters (oiya). Shelters are essentially very simple structures in many cases, but in some instances the roofs are covered with heavy tiles, and some shrine buildings such as the main shrine structure at Hachiman Shrine in Takarazuka were damaged by the collapse of the shelter.

In the case of temples located in the area of severe shocks, the main hall of Kakujoji was demolished. There were many temples in this area, but the bulk of them were modern period buildings and unfortunately had not been surveyed.

Yet even in the surrounding areas, where the shocks had been rather weaker, there was widespread damage. But damage amounting to complete destruction was rare, and for the most part it was limited to semi-collapse. The guest hall and domestic quarters of Joonji, temple in Amagasaki suffered severe damage, such as posts breaking and leaning. But this illustrates the difficulties associated with buildings of residential type (as opposed to a Buddha hall) in a temple context, since they call for the support of a spacious open hall with enclosing few walls, using only slender posts.

2) The damage to vernacular houses

Considered as a building type, vernacular houses, along with modern Japanese-style houses, suffered particularly heavy damage. In the areas of severe shocks, the damage was so devastating that it was difficult to grasp what had happened to the buildings, but in peripheral areas, it is possible to identify some of the trends.

Firstly let us consider traditional urban commoners' houses (machiya). By their nature, they line the street and have openings facing it, while at right angles to the street frontage there are walls dividing neighboring plots. As a result, their earthquake resistance varies enormously depending on the direction of the seismic shocks. The Ikawa house in Takarazuka, was built along a street running from north-east to south-west, and it is thought that the seismic waves hit it from the south west, its weak side. As a result, the entire building leant over heavily to the north. On the other hand, in the case of the nearby Wada house, there were numerous walls running in a south-westerly direction, and for that reason, it is thought, it suffered little damage, although earthquake forces caused some twisting.

In farmhouses, as Dr. Prof. Oba's report explains, the construction of the old loft type of upper story involved simply supporting the upper-floor posts on the beams of the lower-story frame, and this led to distortion or collapse of the upper-floor structure only when the quake struck.

Among other things, in the earth-floored area (doma) of farmhouses, posts are close together and the surrounding walls are more or less continuous, making this part of the house comparatively strong, whereas the reception rooms (zashiki) at the other end of the house are more open, with fewer walls and posts. For this reason, it is reported, there was a characteristic trend for damage to be concentrated in the reception rooms.

Another point that has been noted with respect to farmhouses is the strength of thatched vernacular houses. The Kosaka house, in Ashiya, was one of the few thatched farmhouses still surviving in the area of severe shocks, and it suffered only slight damage. The center of gravity of a thatched vernacular house as a whole is low. Moreover the whole roof frame is a flexible network held together with rope, and as a result the roof frame can evade earthquake forces, making it highly earthquake resistant.

With the kind of vernacular houses mentioned above, there is a need to inform widely that one of the advantages of the traditional method of building is that, even in the case of severe damage such as cracking of the walls and inclination of the posts, it is possible to repair the structure. Craftsmen known as house pulling carpenters (hikiya daiku) make a profession of moving buildings, but they can also undertake this kind of straightening of the frame of a building. Since they can easily correct a degree of inclination of the structural frame that ordinary carpenters would regard as hopeless, we have come to appreciate their true worth in the aftermath of this earthquake. In the Hanshin area there are no longer any such craftsmen, and it is deeply regret that there are not more hikiya daiku .

3) The damage to sake breweries

Eastern part of Kobe is famous for sake breweries. Before the Earthquake there were over 300 sake breweries' traditional factory buildings. In Kobe it was reported the level of damage suffered by sake breweries was 95%, while in Nishinomiya, 3 sites in 5 were totally destroyed. This level is strikingly higher than for any other building type, and revealed its weakness in the face of earthquakes. Sake breweries have a large internal space with few walls, and many of them are tall structures of two stories and with no-tie beams.

Moreover, many of the sake breweries in Kobe were built on the most unstable ground of the coastal strip, close to the fault.

4) The damage to modern buildings

In this survey, modern architecture (i.e. architecture dating from the Meiji Period to the World War□) is divided broadly into two categories, namely modern architecture and modern housing, "Modern architecture" thus here refers to non-residential structures, representative types being

public buildings schools, offices, religious architectures, station buildings, etc. Residential buildings principally comprise the merchant houses of the former Foreign Concession, the houses built by foreigners, known as "foreign residences", and the "Western style residences" built by Japanese who had absorbed foreign culture. However gradually, from the late-Meiji period, these types blended with the Japanese domestic tradition, and an eclectic "Euro-Japanese" (Wayo) house type, which it would be difficult to define as either Japanese or Western, began to appear. Alongside and not unrelated to the above, houses in what is generally called the "Japanese" (Wafu) architectural style continued their development. These constituted a modernized form of the sukiya style and the Japanese vernacular tradition.

i) Foreign residences

These buildings also exhibit certain structural characteristics with posts spaced at half-bay (i.e. about 1m.) intervals and walls faced on both faces with timber siding and laths. Compared with the traditional Japanese house, the frame is strongly constructed, and it seems that in no case was the main frame broken in this earthquake. There are cases such as, for instance, the building of the Chinese Overseas Merchants Association where there was partial damage caused by rotten posts. And if one were to venture to point out a disadvantage with this system, it would probably be that there is no way of visually checking the walls for rot, thus making maintenance difficult.

It has been widely reported that the problem in these foreign residences was the collapse of their brick chimneys. In Kobe sever damage caused by the collapse of chimneys was seen at such houses as the Hassam Residence and the Hunter Residence, the Mon Residence, the building of the Chinese Association and the former house of Catherine Andersen in Kitano, as well as the Shioya Hostel of the Takeuchi Oil Manufactory. Since Western style residences in other areas suffered similar damage, this will be a problem for building preservation in the future.

ii) Western-style residences

More than 10% suffered damage equivalent to total or semi collapse. The fact that posts were spaced more widely than in the foreign residences, and that they tended to become slenderer as time went by, the use of tiles to make a base for external walls, and the tendency to spread thick mortar on the external walls, making them remarkably heavy, all appear to have contributed to this.

Among examples in this category, special mention should be made of the Shibakawa Residence (1912) in Nishinomiya. Although it stands on a unstable hillside and moreover has an open and delicate layout, in which a western design has been given a sukiya treatment in a pioneering manner, remarkably it survived with no more than partial damage. From the investigation, we found that almost all the members were fastened together with metal fittings and that diagonal braces had been used almost perfectly. It was also discovered that in a Japanese style room on the second floor where there was an opening over two bays wide, the lintel had been strengthened with a tie bar and diagonal bracing, in a very original manner.

It is thought that this careful design may have been prompted by two factors: firstly, the designer underwent his architectural training in the aftermath of the Great Nobi Earthquake (1891) and more importantly, immediately before designing the Shibakawa Residence, he actually went to visit the site of an earthquake which had just occurred in southern Italy (Messina, 1908), apparently absorbing a number of lessons.

iii) Japanese-style houses

In the Kansai region, where there had been no earthquakes for a long period, countermeasures against typhoons had been given priority. The use of comparatively heavy tiled roofs, despite the light eaves detailing and the wide south facing openings, seems to have been an adaptation to cope with such local climatic conditions. Sukiya houses of the kind referred to as modern Japanese-style houses were built in large numbers in Hanshin area until the last war. These houses developed as if each were competing to be the most delicate and the least enclosed, but it

cannot be denied that, with their lack of solid walls and ill-balanced layouts, they were ill conceived for an encounter with an earthquake on this scale.

iv) Brick-built architecture

In Japan it is generally said that the need for earthquake resistant measures to strengthen brick buildings has been recognized since the Great Nobi Earthquake(1891), but it was not only old buildings, such as the former Koizumi Linen Factory (1890 or later) and brick brewery buildings like the Hakushika Brewery Museum, brick buildings dating after Nobi Earthquake were also completely destroyed. However, care is called for when we consider that even in the case of two buildings by the same designer, there could be a considerable difference between the way brick structures performed. For instance, at the former Hyogo office of Tokyo Soko (the Ishikawa Building, Sone Tatsuzo, 1906), differential slippage occurred between brick courses, while in the former Kobe Branch of Mitsubishi Bank, there was little damage. It is possible that there may have been steel reinforcement in the floor of the latter building.

Issues Arising from Stricken Important Cultural Properties

The Japanese national cultural property buildings are exempt under Article 3 of the Building Standards Law from application of building standards. While the Law for the Protection of Cultural Properties provides that the director-general of the Agency for Cultural Affairs may supervise and control the management and repair of national cultural properties. In the situation surrounding the Great Hanshin Earthquake, which involved many deaths, questions could have arisen concerning responsibility in the case of cultural properties.

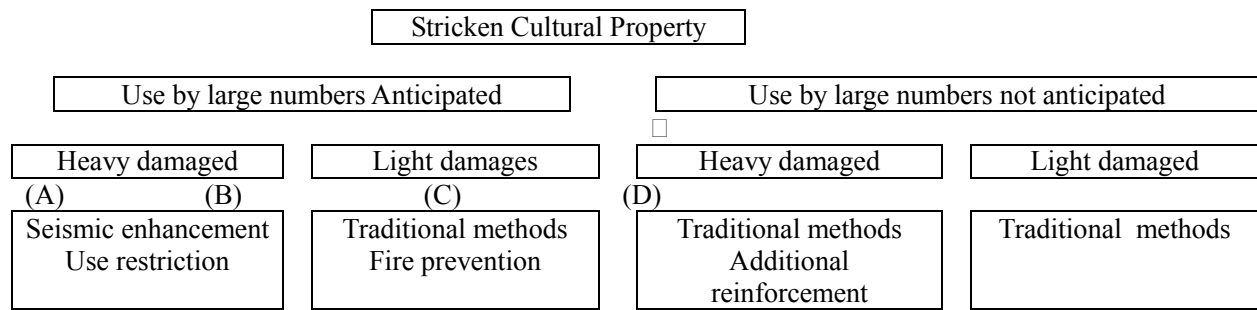
For the buildings which are designated as cultural properties by prefecture or local authorities, according to Article 3 of the Building Standards Law, restoration or repair work requires a permit to be issued upon the consent of the Building Council in local authorities advised by the national Ministry of Construction. However, some of the buildings damaged by the earthquake underwent unapproved construction. Concerning the safety of cultural property buildings, preservation measures will face difficulties so long as clear proposals are not forthcoming, and hence the need arises for model policies for the enhancement of safety through repair.

Enhancement of Seismic Resistance

Precise understanding of earthquake damage and studies on enhancement of seismic-resistance are indispensable requirements for consideration of the future preservation of cultural property buildings. Therefore the Council on Earthquake Resistance (hereafter, the Council) was established at the sites and charged with organizing the repair measures for six damaged national cultural properties of various structural types which required large-scale repairs with reinforcements.

The Council was made up of architectural historians, structural engineers and researchers, conservation architects and experts related architectural restorations from each of the project teams, under the overall supervision of a government official with responsibility for cultural properties.

The tasks of the Council were to analyze the earthquake damage to each structure; assess the seismic-resistance of cultural property buildings based on the results of a structural diagnosis of each building; investigate modes for providing the requisite structural enhancement in the cases where seismic performance was questionable; and in cases where the methods for structural reinforcement were unclear, to perform destructive or non-destructive testing and make proposals for reinforcement methods utilizing new techniques.



(A) Difficult to guarantee the safety of human life in present condition.

Use restriction or enhancement of seismic resistance necessary.

(B) Little danger to human life. Limited measures such as prevention of falling members feasible.

(C) No danger to human life. Danger only to preservation of building elements.

(D) No danger to human life. No danger to preservation of building elements

Fig. 1 Scheme of Repairs to Stricken Cultural Properties

The basic approach to reconstruction of the stricken cultural properties, as shown in [Figure 1](#), was to separate them first into those for which use by large numbers of people was anticipated or not anticipated, and then categorize them as lightly or heavily damaged.

The job of the Council was to organize repairs for the buildings which fell under category A. They are listed in [Table 3](#).

Table 3 Earthquake Recovery Projects Organized by the Council on Earthquake Resistance

Structure species	Cultural Property	Topics Investigated
Half-timber build.	House 15, Former Foreign Settlement	Subsoil reinforcement Enhancing seismic resistance of half-timbered brick structures
Wooden framed brick build.	Former Thomas Residence	Reinforcement of brick walls and brick chimneys
Wooden framed build. with mud walls	Former Okada Residence	Enhancing seismic resistance of wooden structure
R.C. build.	Former Yamamura Residence	Enhancing seismic resistance of reinforced concrete structure
Traditional wooden build.	Arch-bishop Quarters & Founder's Hall, Honkouji Temple	Reinforcement of traditional wooden structure and broken post
Wooden framed build. with mud walls	Akashi Castle	Reinforcement of stone walls, subsoil and foundation

Problems

It is hoped that the reinforcement methods for cultural property buildings will harmonize the two objectives of Authenticity and Safety, but at the present time no definite assessment method has been found for striking such a balance. No reinforcement methods which consider the balance of these objectives are mentioned in the Principles for the Preservation of Historic Timber Structures of the ICOMOS International Wood Committee.

At the Symposium on Risk Preparedness for Cultural Properties, held in Kobe and Tokyo in January 1997 and attended by representatives of UNESCO, ICOMOS, ICCROM and other international agencies for the preservation of cultural properties as well as experts from 16 nations, the priority of human life in the preservation of cultural properties was not referred.

Concerning judgments of authenticity, on the global level many standards of judgment have been discussed, such as those involved in the Venice Charter, and at the national level in Japan a legal system is established, based on regulation of alterations to the existing state.

I would propose that the methods for structural reinforcement of buildings such as those in category A be chosen according to the following approaches, in order of priority:

1. Additions using traditional techniques and traditional materials.

2. Additions using traditional techniques and techniques derived from them, and traditional and modern materials.
3. Additions using modern techniques and modern materials.
4. Replacements using modern techniques and modern materials.

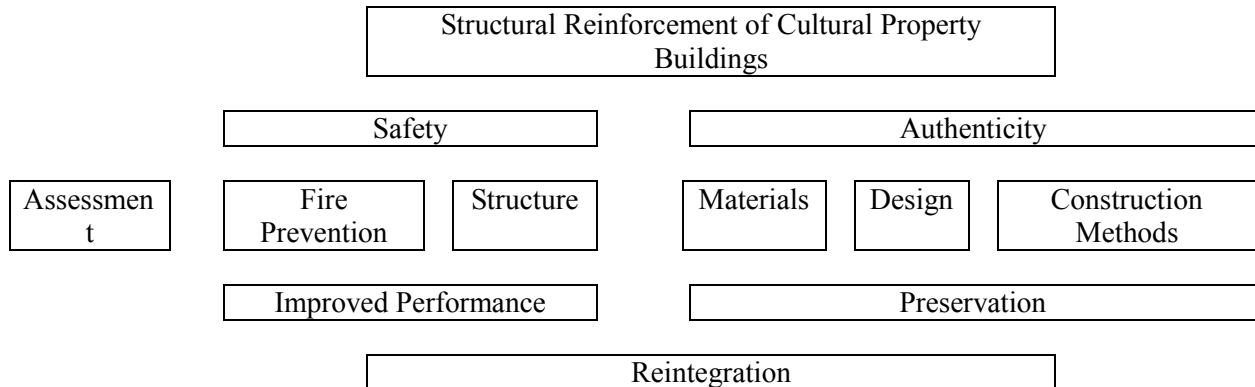


Fig. 2 Author's Approach to Structural Reinforcement of Cultural Property Buildings

Taking as an example the reinforcement of a broken post, approach (1) might include strengthening the foundation joint with a fishplate splice which is the traditional good joint system, while approach (2) could involve covering the traditional joint by wrapping the post with carbon fiber thread. An example of approach (3) would be to add a steel frame in order to reduce the load on the existing structural materials. Approach (4), for cases when safety cannot be guaranteed by adding reinforcement to the existing structural system, could involve the introduction of something like anti-vibration apparatus as a replacement for part of the existing structural system.

In adopting approach (4), careful consideration must be given to keeping a balance with the preservation of the authenticity of the building, including soft measures such as entry restrictions for protection of human life. Since alteration of the structural system of a designated building is involved, this should be regarded as the last resort.

Performance assessment is an important consideration for the first priority approach in this proposal, that of traditional techniques and traditional materials. Since the strength of structural systems employing traditional techniques and materials is difficult to reckon unlike with current structural systems, it is essential to combine several different structural assessments to obtain measurements of strength.

I will now review some of the proceedings of the Council from the standpoint of my proposal.

Proceedings of the Council on Earthquake Resistance

(1) Akashi Castle Towers

At the first meeting, the expert on building structure offered two opinions. First, modern foundation engineering holds that to insure the safety of a building, the weight of the upper section must be transmitted directly to a sturdy supporting layer. And second, during the recent earthquake there was uneven subsoil subsidence beneath the towers (about 18 cm), and another earthquake of similar strength could cause them to collapse.

In response, the expert on cultural property conservation offered two opinions. First, it ought to be possible to build the stone walls back up without reinforcement. (The stone walls outside the towers, which are not designated, were to be built back up in the traditional way, with the work subsidized by the Ministry of Construction.) And second, if a large area of the stone walls is dismantled, authenticity will be lost.

At the second meeting, judgment of the subsoil was deferred because the survey results were insufficient. The expert on cultural properties claimed that the corners of the castle's stone walls

were very solid, noted that they hadn't even fallen down during the recent earthquake, and demanded that traditional construction techniques be followed since the walls would become still sturdier if the building weight were increased.

At the third meeting, the results of the subsoil survey were presented, confirming that the ground had dropped substantially, and six construction plans were presented. (See Table 4) As plans D and E were technically impossible because of inability to transport heavy equipment to the site, only four of the plans, A, B, C and C', were discussed.

The expert on building structure noted that in principle, (1) footings should be built on stable ground, and (2) buildings should not be erected on uneven footings.

He suggested that C' was the best plan. On the other side, the expert on cultural properties presented the opinions that; (1) he felt resistance to the idea of reinforced-concrete footings; (2) a method that matches the lay of the ground, along the lines of the ancient HANCHIKU method of spreading successive layers of an earthlime mixture, might be possible; and (3) the C' plan would not solve the problem of

Table 4 Reinforcement Plans for Akashi Castle

表18 明石城築構・坤構耐震補強案

形 式	A案 (地盤改良)	B案 (マット埋設)	C案 (ラフト基礎)	C'案 (C+片持梁)	D案 (杭基礎)	E案 (壁杭)
概要図						

subsidence after construction of the stone walls.

The expert on building structure rebutted that there had indeed been problems with previous use of traditional construction techniques, and a careful comparison with modern engineering was necessary. Another speaker supported him, stating that a traditional method could not be undertaken without some guarantee as to exactly how safe it would be, but the room was divided and the decision was postponed.

At the fourth meeting, it was said that at least 3 meters of fill would be needed, and perhaps 10 meters or more at some points. A plate load test showed that the ground resistance force would be at least 10 t/m², and the results of related tests including the circular slip method were heard and discussed.

In the end, new data was presented confirming the safety of plan A, which was similar to the HANCHIKU-type compound ground-matching idea that the cultural property expert had pushed for during the third meeting, and as a result the group settled on that plan.

(2) House 15 of the Former Kobe Foreign Settlement

At the first meeting, after background on the character and structure of the building was presented, the discussion progressed as follows:

1. The building had been one of the first cases where full-scale efforts were made for utilization as a cultural property, so it should be made earthquake resistant on the premise of public use.
2. There is a need to consider the extent to which the essence of the cultural property might be sacrificed through reinforcement.
3. A plan to alter the building by reinforcing it in installments split the room into two vigorous camps.

At the second meeting, five construction techniques were presented: a traditional technique, three earthquake-proofing techniques (an outer-perimeter steel frame, wood with reinforced concrete, and a steel frame with reinforced concrete), and an anti-vibration technique. They were compared with respect to the goal of maintaining the existing 70% level of wood materials

(which was surprised reuse ratio cause the building was collapsed into pieces completely), and it became clear that safety could not be assured with the traditional technique.

A steel frame on the outside perimeter was unacceptable on aesthetic grounds. Both of the reinforced concrete options were rejected as involving too much alteration of the construction system. As the relatively attractive option, the anti-vibration plan was adopted. It was then supplemented with ground improvements in view of the fact that liquefaction had occurred.

(3) Conclusion

In the rescue projects following the Great Hanshin Earthquake traditional construction method were used mainly like Akashi castle rescue project did. And the case required the change of the structure system, for instance introducing of Base Isolation Device, were 2 examples of 29 projects.

Also, in Joonji temple main hall, the inclined pillars returned with time passing. The main gate of Koyadera temple moved 20cm and the ridge was inclined, with the process of jacking up we found such a phenomenon that the roof distortion returned.

It is hardly understood with only a current thought in those of both. The important element of the cultural property is to remain the system which has grown through the long history, since the high originality needs a evaluation about a individual case. In such examination we should avoid the judgement that eliminates different ideas and systems with a dogmatic evaluation. It is important to observe to equivalence of value from the idea when a historic building was constructed, to the present idea. The aspects of the committee mentioned above are so important that specialists gathered from various fields and they discussed with including diversity viewpoints and had decided the reconstruction methods.

On the other hand, especially historic buildings have the faculty people use inside and which is difficult to separate safety. Every committee chose the reinforcement methods from traditional techniques as much as possible after recognition of the actual data through various experiences. At the many rescue projects sites they tried to evaluate the traditional mud walls, we found such walls had the strength over our expectation. And the restoration project of Hotoji temple in Kyoto analyzed the mud wall was damaged by the Fushimi Earthquake of 400 years ago and they compared with the repaired old wall and the new wall by the traditional technique. They show the data which repaired old wall is stronger.

In the case of Joonji temple projects they tried to introduce carbon fiber sheets to the broken wooden pillars as a reinforced material and succeeded to reuse those pillars we abandoned in ordinal methods. Through the experience of the evaluation during the rescue projects, we found incomplete materials we thought were reused by supplemental reinforcements.

Of the two, the Kobe foreign settlement house clearly had a more comprehensible discussion process, and it resulted in adoption of one of the structural reinforcement alternatives. With Akashi Castle, on the other hand, the discussion was often tangled as the cultural properties expert pushed to the end for following traditional construction methods, and was unwilling to compromise on structural assessment of the traditional method. The result was that the most suitable option for preserving authenticity was adopted.

We may suppose that there are few cases like house 15 of the former Kobe foreign settlement, where the strength is being reckoned traditionally when problems clearly exist with respect to safety. The majority seem to lean toward the Akashi Castle pattern of assured safety, but without ever conducting a traditional structural evaluation.

It may be time-consuming to do make such an evaluation. Still, it would surely be worthwhile to open the discussion process into something more than an automatic progression from one modern structural reinforcement option to the next.

Note 1: cf. 1997 Kobe/Tokyo International Symposium Risk Preparedness for Cultural Properties -- Special Reports on the Great

Hanshin-Awaji Earthquake and Cultural Properties-- Nobuo Ito. Yasumichi Murakami. Hiroshi Adachi. Takayuki Yamazaki

Note 2: cf. Report on the Damage to Historic Buildings in the Great Hanshin Earthquake(1995) Commissioned and Sponsored by

UNESCO edited and co-ordinated by Nobuo Ito

We had discussed about the damage trends of Historic Buildings with the author and another researchers. I quoted the

Sentences from the report where historic building researchers agree with.

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