16）岩手県指定文化財吉田家住宅の再生をめざして －救出された部材の被災状況調査－

岩手県指定文化財吉田家住宅の救出

吉田家住宅は、仙台藩領気仙郡の大肝入の住宅遺構で、享和２（1802）年に建設されました（図１）。仙台藩の大肝入は、村方役人の中でも最上位に位置する役職であり、地方の有力者が藩から任命されました。旧仙台領内におけるほとんどの大肝入住宅遺構がすでに失われている中で、当該住宅遺構は建設年代や大工棟梁名、藩政期における使用法の一部が明らかにされており、母屋以外の各種付属屋（土蔵、味噌蔵、納屋）も残されているなど、学術的にきわめて貴重とされ、平成18（2006）年に岩手県有形文化財として指定されました。

当住宅は建築後400年の間、11回に及ぶ津波や、洪水、大火を経験し、その都度それらを乗り越えてきましたが、平成23（2011）年３月11日に発生した東北地方太平洋沖地震による大津波によって主屋と各種付属屋が全て流失する等、壊滅的被害を受けました。座敷廻り部分は屋敷の裏側に、茅葺屋根は南西側に位置する諏訪神社を回った気仙小学校側に300mほど流されてしまいました。しかし、岩手県立博物館、八戸工業大学・月舘敏栄教授とその学生、所有者らによる懸命な部材の救出活動が行われ、同年6月中旬には主要構造部材の7割程度に相当する1016本の部材を救出することができました（図２）。陸前高田市の復興計画の中にも、生涯学習拠点の設置としての吉田家住宅復元が掲げられており、今後、救出した部材を用いた住宅の復元が行われる予定です。

救出された吉田家住宅建築部材の脱塩実験

救出された部材は海水損したことにより、内部にまで汚泥や塩類が入り込んでいました。このような状態のまま乾燥し部材を再利用した場合、塩分が吸湿してカビが発生し、腐敗が進む危険性があります。そこで、部材に固着した汚泥の状況、塩類の含有状況、細菌の繁殖状況等を調査し、海水損の実態を明らかにした後、被災状況に応じた措置を講ずることとし、肉眼では判定が困難な塩類の含有状況、とりわけ塩化物イオンの含有状況を以下に述べる手順で調査しました。

ア．調査用部材の選別

調査用部材を肉眼観察し、表面に相当量の土砂や泥が固着し、多量の塩分を含有すると推定される資料（図3a、表１で保悪部材と記載）、表面に土砂や泥の固着は確認されず健全と判断される部材（図3b、表１で保良部材と記載）の２種類についてそれぞれ３本ずつ選別しました。

イ．選別した部材の記録

選別した部材について、以下の４項目の調査を実施しました。

①部材の重量測定（乾燥完了を判定するための乾燥重量）

②外観形状写真撮影（脱塩実験後の形態変化を確認す

16) For the Restoration of the Yoshida Family Residence, a Designated Cultural Property of Iwate Prefecture -Survey of a Damage to Salvaged Building Material-

Salvage of the Yoshida Family Residence, a cultural property designated by Iwate Prefecture.

The Yoshida Family Residence is the remains of a residence of an *okimoiri* (a village official) in the Kesen District of the former territory of Sendai Clan, which was built in 1802 (Fig.1). The *okimoiri* of the Sendai Clan was the highest position for village officers, appointed from local influential persons by the clan. Most of the remains of *okimoiri* residences in the former Sendai territory have already been lost. Therefore, these residential remains are considered very valuable from an academic perspective, because of the date of its construction, the master carpenter's name, some its usage during the clan administration period is known, and because various types of attached buildings in addition to the main building (a storehouse with thick earth walls, a miso warehouse, and adwelling) remained. It was designated as a tangible cultural property by Iwate Prefecture in 2006.

This residence has survived tsunamis, floods and fires eleven times in the 400 years since it was built. However, all of the main building and attached buildings suffered devastating damage: they were washed away by a tsunami caused by the Great East Japan Earthquake on March 11, 2011. The guest room was pushed to the back of the residence and the thatched roof was carried about 300m to Kesen Elementary School beyond the Suwa Shrine, which is located southwest of the building. However, strenuous salvage activities were carried out by the Iwate Prefectural Museum, Professor Toshiei Tsukidate and his students at the Hachinohe Institute of Technology, and the owner of the residence. By mid-June of that year, 1,016 building components which make up about 70 percent of the primary structural components were salvaged (Fig.2). The restoration of the Yoshida Family Residence as a center for lifelong education is declared in the restoration project of Rikuzentakata City. Restoration of the residence using salvaged structural material will soon begin.

Desalination experiment using salvaged building material from the Yoshida Family Residence

The salvaged building material contained sludge and a high saline content, because of seawater damage. If the building material was dried without processing and was reused, the salt would absorb moisture and it could get moldy and rotten. Therefore, it was decided that measures should be taken according to the state of damage after the condition of sludge affixed onto the building material,the salinity content, and the propagation of bacteria was confirmed and the actual condition of the damage from seawater was surveyed. Research was carried out on the salinity content, in particular, the content of chloride ions, which is difficult to determine with the naked eye, by the following procedures.

A. Screening of building material for research

The building material to be researched was observed. The material was screened for two things. First, items onto which a substantial amount of dirt, sand, and mud was affixed and which were presumed to contain a large amount of salts (Fig.3a,

表1　建築部材脱塩の推移
Table 1　Desalination process on building material

脱塩日数 Day of desalination	保悪部材 Material in poor condition (ppm)	保良部材 Material in good condition (ppm)	水道水 塩化物イオン濃度 (保悪部材脱塩時) Chloride ion concentration in tap water (in desalination of material in poor preservation) (ppm)	水道水 塩化物イオン濃度 (保良部材脱塩時) Chloride ion concentration in tap water (in desalination of material in good preservation) (ppm)	溶出した塩化物 (g) Chloride elution volume (g)	
脱塩1日目 Day 1	6.64	3.33	2.49	2.67	6.05	0.97
脱塩2日目 Day 2	9.94	3.86	2.48	2.47	10.9	2.03
脱塩3日目 Day 3	7.88	3.02	2.16	2.32	8.33	1.02
脱塩4日目 Day 4	7.02	3.04	2.39	2.20	6.75	1.22
脱塩5日目 Day 5	6.41	5.86	2.54	2.65	5.65	4.68
脱塩6日目 Day 6	4.65	4.75	1.99	2.89	3.87	2.71
計 Total					41.54	12.63

注1）水槽水量は1,458L。　Note 1) The amount of water in the tank is 1,458 l.

図1　震災以前の吉田家住宅（母屋）
東北工業大学　高橋恒夫氏提供
Fig. 1　The Yoshida Family Residence (main building) before the earthquake
Provided by Prof. Tsuneo Takahashi of the Tohoku Institute of Technology

図2　回収した部材
Fig. 2　Collected building material

るため、六面全てを記録）
③形状記録（反り等脱塩後の形状変化の有無を確認するため）
④樹種同定用の木屑サンプリング（樹種の違いと塩分含有量を確認するため）

ウ．部材の洗浄・脱塩

洗浄・脱塩手順は以下のとおりです。
①部材表面を高圧洗浄機（精和産業株式会社）で丁寧に洗浄し、表面に固着する土砂や泥を可能な限り除去する
②水槽に約1,500ℓの水道水を入れ、部材を水槽底面にロープで固定し、完全に浸漬する（図４）
③水槽内の水を撹拌し、部材から溶出した塩化物イオンが水槽内に均一になるよう、水槽の２箇所にポンプを設置する（図５）
④部材浸漬後、24時間ごとに部材を引き上げ、部材から滴る水を採水する。また、水槽の中心と右上端および左下端に採水ポイントを設け、各々表層、中層、底層の計３か所から約100mlの脱塩液を採取する。

エ．

採水終了後、水槽の水を全て交換し水槽内を掃除した後、水槽に新しい水道水約1,500ℓを入れる

オ．

ハンディ塩素イオンメータ（TiN-5102i型、東興化学研究所製）を用い、採水した脱塩液に含まれる塩化物イオン濃度の測定を実施する（図６）。

カ．

脱塩終了後、仮設陸前高田市立博物館の被災資料乾燥庫を借り、部材重量が脱塩実験前の重量に戻るまで乾燥を行う

部材の脱塩結果

脱塩は木材から滴る水の塩化物イオン濃度の値が５ppm未満になるまで継続しました。表１は脱塩実験結果です。保存状態の良好な部材では、脱塩開始の翌日には５ppm未満になりましたが、保存状態の劣悪な部材は当該濃度に達するのに６日を要しました。表によると、溶出塩化物イオン濃度に増減がみられますが、これは木材の内部に浸透した塩分が徐々に溶出したことに起因すると考えられます。また、保存状態が良好な部材からは６日間で総量約13gの塩化物イオンが、保存状態が劣悪な部材からは総量約42gの塩化物イオンが溶出しました。

海水損した建築部材の脱塩は前例がありません。今回の実験によって含有が確認された塩化物イオンが部材の劣化進行に深刻な影響を及ぼすかどうか、この点についての見極めが必要です。また、脱塩終了後の部材にどの程度の塩化物イオンが残っているかも確認しなければなりません。今後更なる実験を実施し、これらの点を明確にしたうえで、部材の安定化処理方法を構築していく予

referred to as building material in poor condition in Table 1). In addition, material which was judged to be sound with no dirt, sand, and mud affixed onto its surface (Fig.3b, referred to as well preserved building material in Table 1).

B. Records of the screened building material

Concerning the screened building material, the following four things were measured.
(1) Weighing of the building material (measuring their dry weight to confirm the completion of drying)
(2) Taking photographs of their external shapes (recording all six sides to confirm changes in shape after the desalination process)
(3) Recording their shapes (for confirming whether there are changes in shape including warping after desalination)
(4) Chip sampling for identifying tree species (for confirming the difference between tree species and their salinity concentration)

C.Washing and desalination of building material

The washing and desalination procedures were as follows.
(1) Wash the surface of the material carefully using a high-pressure washer (manufactured by Seiwa Spray Pump Inc.) to remove as much, dirt, sand, and mud on the surfaces as possible.
(2) Put 1,500 L tap water in a tank and attach the building material to the bottom of the tank to immerse it completely (Fig.4).
(3) Stir water in the tank and set pumps at two points in the tank so that the amount of chloride ions flowing out from the building material will be even (Fig.5).
(4) After the building material is immersed, it is taken out of the tank every 24 hours and the water dripping from it was collected. In addition, water sampling points were set at the center, the upper right and the lower left of the tank, and about 100 ml of desalinated water was sampled at those three points (top layer, middle layer, and bottom layer) respectively.

D. After water sampling, all the water in the tank was replaced and the tank was cleaned. After that, about 1,500 L of fresh tap water was pumped into the tank.

E. Use a Handy Chloride Ion Meter (TiN-5102i type, manufactured by Toko Kagaku Kenkyusho) to measure the chloride ion concentration contained in the desalinated water (Fig.6).

F. After desalination, we used a dry warehouse to store damaged items of the temporary Rikuzentakata City Museum and continued to dry the building material there until their weight returned to what it was before the experiment.

The results of desalination of building material

Desalination continued until the level of chloride ion concentration in the water dripping from the lumber decreased to less than 5 ppm. Table 1 shows the results of the desalination experiment. The chloride ion concentration of the building material in good condition decreased to less than 5 ppm the day after the desalination started. However, it took six days for the building material in poor condition to reach the appropriate

定です。

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図3a　保悪部材
Fig. 3a Building material in poor condition

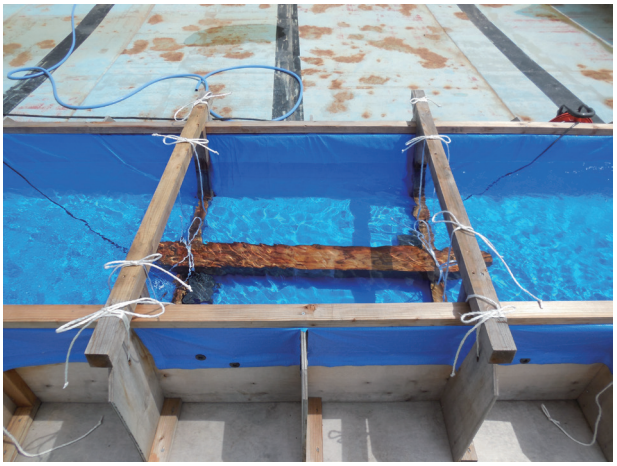

図4　部材脱塩実験
Fig. 4 Desalination process on building material

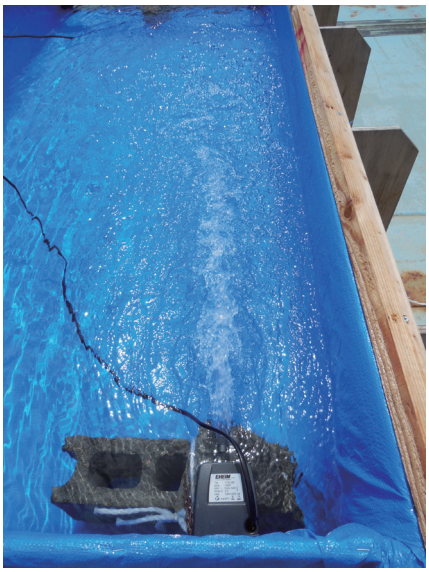

図5　水槽内に設置した水中ポンプ
Fig. 5 A submersible pump placed in the tank

concentration level. According to the table, there were increases and decreases in eluted chloride ion concentration. It is thought that this is because salts contained in the lumber eluted gradually. In addition, about 13 g of chloride ions was eluted from the building material in good condition, while about 42 g was eluted from the building material in poor condition during the six days.

There are no previous precedents of desalination of sea-damaged building material. It is necessary to confirm if the chloride ions which were identified by this experiment would have a serious impact on the deterioration of the building material. Also, it is necessary to confirm to what extent chloride ions remain in the building material after desalination. These points will be clarified by carrying out more experiments, and then proper stabilizing processes on building material will be developed.

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図3b　保良部材
Fig. 3b Building material in good condition

図6　塩化物イオン濃度計測に用いた機材
Fig. 6 A device used to measure chloride ion concentration