02 Description

2.Description

2.a. Description of Property

(i) Overview

Tomioka Silk Mill and Related Sites comprise a singular ensemble of industrial heritage properties that represent the international interchange and exceptional technological innovation, responsible for enabling mass production of high-quality raw silk. This was realized during a time when the world economy became unified through trade, from the mid-19th to the 20th century. Consequently, the property embodies developments in the silk industry that contributed to the popularization of silk consumption, as well as modernization of the Japanese economy, through a series of groundbreaking technological advancements in both silk-reeling and silkworm rearing that infused a large provision of Japanese raw silk into the global market.

Raw silk used to make thread for silk textile, is derived from cocoons spun by mature silkworms raised on mulberry leaves. Silk production originated around 3000 B.C. in China and its techniques spread to the countries of Asia, including Japan, and Europe. In the early 19th century, steam-powered mechanical reeling factories appeared in France and Italy which were centers of Europe's silk industry at the time. Although production capacity was increased and silk products became widely popular among the wealthy, mass rearing of silkworms lead to the diffusion of the pebrine disease in the 1850s. Silk provision in Europe then became unstable. Meanwhile in Japan, after opening of the ports in 1859 and having become a proper member of the international market by commencing free trade, the sericulture and silk-reeling industries were rapidly modernized through trade expansion to play a leading role in the development of the global silk industry, as will be described below.

Firstly, the new Meiji government[1] focused on export of raw silk as part of the national policy for gaining revenue for the country's modernization. Although Japan's silk industry developed so far as to be able to fulfill domestic demands, it was not sufficient to meet vigorous international demands in either quantity or quality. Therefore, regarding silk-reeling, the national government established Tomioka Silk Mill to act as a model equipped with machine reeling and factory systems introduced from the West, making leading-edge technology widely available to private companies. At the same time, developments made in the field of silkworm breeding by private establishments such as the Tajima farm and Takayama-sha Sericulture School, realized a stable production of cocoons. As a result, by the end of the 19th century, Japan became an exporter of raw silk in line with the world's leading countries of China and Italy.

1 Meiji government was established in 1868 renewing preceding Edo Bakufu, then called Edo Shogunate government.

Secondly, stimulated by competitive silk exports at the turn of the century, tech-

nological developments in both silkworm rearing and silk-reeling led by the private sector were seen in Japan. Regarding silkworm rearing, in early 20th century, the government, private silk-reeling entities and silkworm farmers collaborated in nationwide dissemination of methods for obtaining high-quality cocoons and for enabling multiple rearing seasons, resulting in the mass provision of standardized cocoons. In silk-reeling, the cutting-edge facilities such as the automatic cocoon dryer and multi-end reeling machine were put into practical use for mass production of high-quality raw silk. Due to such technological innovations, Japan became the world's top exporter of raw silk and induced dramatic development in the global silk industry as well as popularization of silk textile consumption.

Lastly, in the latter half of the 20th century, the automatic reeling machine, the long awaited "dream machine", was put into practical use, to responding the worldwide automation of manufacturing industries. This automation technology was disseminated from Japan to the entire world, together with domestically developed efficient sericulture techniques, and laid the foundation for today's modern silk industry. The popularization of silk textile in turn set the stage for the later invention of affordable synthetic fibers such as rayon and nylon and their wide acceptance as an alternative to silk.

(ii) Composition of the property

Tomioka Silk Mill and Related Sites is composed of four technological complexes portraying significant innovations, resulting from international interchange, that contributed to the development of the world's silkworm rearing and silk-reeling industries.

Japan's silk industry began to flourish from the 18th century and, within a very short period of time following the opening of ports in the mid-19th century, raw silk became a major export product. During this time, Gunma Prefecture was the breeding ground for many significant technological innovations in silkworm rearing and silk-reeling. As silk production became a chief export industry, international exchange of scientific knowledge through trade of technology and goods was vibrant in Gunma. Thus, while multiple historic properties[2] involved in aspects of technological innovation and international exchange of the silk industry remain standing in the prefecture, Tomioka Silk Mill and Related Sites form the fundamental core of this activity.

2 See Appendix 5-J, List of Gunma Silk Heritage Sites

The pivotal site of the nominated property is Tomioka Silk Mill (S1), a silk-reeling factory established by the national government. The mill was the first example in Japan of a full-scale introduction of Western steam-powered mechanical silk-reeling technology and factory system, where reeling had formerly been done only by traditional manual labor. The government encouraged silk-reeling establishments throughout Japan to visit and learn from this model factory, and at the same time, gathered female workers nationwide and trained them as capable leaders in mechanical reeling. As a result, modern mechanical reeling factories were founded all

over Japan and the silk-reeling industry began to gain momentum. Subsequently, a mass production system for raw silk was established through collaboration with silkworm farmers. This led to technical advancements for increased efficiency in the reeling industry through introduction of the automatic reeling machine in the mid-20th century. Tomioka Silk Mill continued to maintain its position as Japan's model factory by providing technological innovations that formed the basis of the present-day, global silk-reeling industry.

Remarkably, numerous structures involved in key developments of technological innovation described above remain in pristine condition at Tomioka Silk Mill. They are preserved intact with production facilities and machinery like a rare time-capsule from the period when factory ceased operation.

Three fundamental complexes worked together with Tomioka Silk Mill to increase raw-silk production by realizing a stable provision of high-quality cocoons. These related sites are: Tajima Yahei Sericulture Farm (S2), origin of the groundbreaking silkworm breeding room structure which focused on ventilation; Takayama-sha Sericulture School (S3), educational institute for silkworm rearing that established and disseminated a standard rearing method employing not only ventilation facilities but also a thermal-powered system for controlling temperature; and Arafune Cold Storage (S4), facility that made use of a natural cold airflow to store silkworm eggs, enabling cultivation of multiple crops of silkworms annually throughout Japan rather than once in spring.

The modern breeding methods cultivated at these three sites were spread through literature and education, and resulted in a reliable increase in production that had formerly been unstable due to repeated failures in silkworm rearing.

Furthermore, Tomioka Silk Mill took a leading role in collaboration with Tajima farm and Takayama-sha in developing a method for high-quality uniform cocoon[3] production essential for establishing a mass production system of raw silk in the early 20th century, and spread the technology throughout Japan. Concurrently, Arafune Cold Storage made full use of railways and the postal system to transport essential silkworm eggs and contributed greatly to the production system. Owing to such technological innovation and collaboration in both provision of material and factory production, a reliable system for mass production of high-quality raw silk was finally achieved.

3 See P93, column

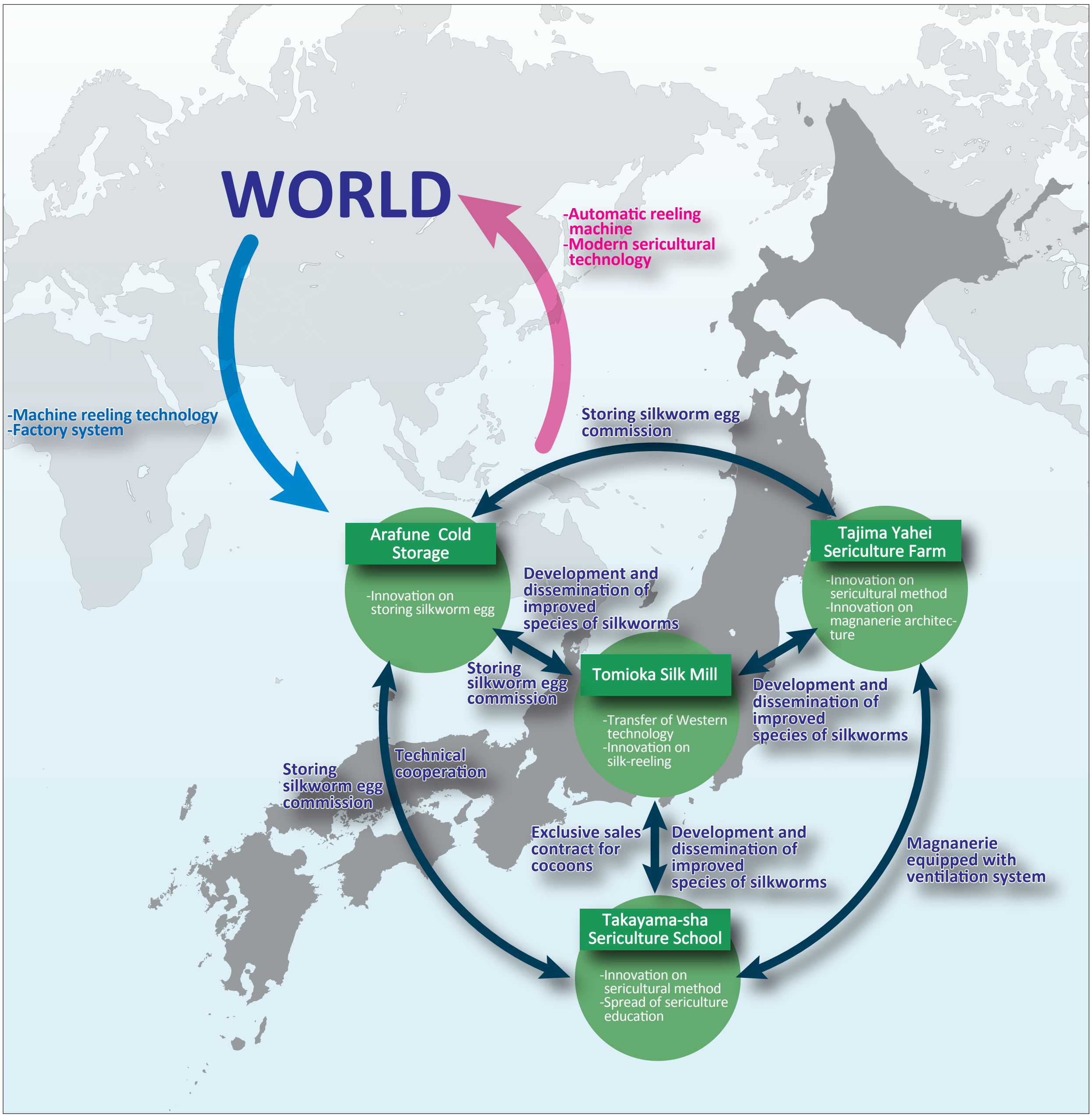


Figure 2-1 Interrelation of Components

(iii) Delineation of the property

The component area of Tomioka Silk Mill is composed of the original factory premises at the time of establishment and surrounding water drains together with the lot later extended for silkworm egg production.

The component area of Tajima Yahei Sericulture Farm is delineated by the boundaries of land on which Yahei lived and engaged in business. The area is centered on the residence with silkworm breeding rooms and includes additional facilities for raising silkworms and remains of other such structures.

The component area of Takayama-sha Sericulture School includes the premises of the family residence where Chogoro Takayama developed the *Seion-iku* silkworm breeding method and started its dissemination. The area is centered on the residence with silkworm breeding rooms and includes additional facilities for raising silkworms and remains of other such structures, as well as land within the premises that was formerly a mulberry field.

The component area of Arafune Cold Storage is comprised of the lot on which silkworm egg storage facilities utilizing natural cold airflow are located as well as adjacent roads.

The boundaries of all component areas match the delineation of each designated Historic Site protected under the Law for the Protection of Cultural Properties.

(iv) Individual description of components

S1 Tomioka Silk Mill

- A factory established by the national government that remains as a complete ensemble together with manufacturing facilities
- The first full-scale raw silk factory introducing mechanical-reeling technology from France
- Became a model factory for advanced silk-reeling in Japan and raised the country's industry to the world's top level
- Place for development and dissemination of improved species of silkworms
- Early examples of factory architecture merging Western technology with traditional Japanese technology

Tomioka Silk Mill is located on a cliff overlooking the Kabura-gawa River in the central part of Tomioka City. It was a machine-reeling mill built by the new Meiji Japanese government with technical cooperation of French engineers as a part of the progressive modernization policy in 1872. The very large factory site was selected because it was located in the center of a traditional sericultural region with sufficient supply of cocoons and easy access to fresh water and lignite cokes required for running the silk mill.

The Meiji government hired Paul Brunat, who was a raw silk quality inspector from

Photo 2-1 S1 Aerial view of Tomioka Silk Mill

France, to establish Tomioka Silk Mill in 1870. The architectural design of the buildings was carried out by the French engineer, Auguste Bastian, who had previously been appointed by the government to design the Yokosuka shipyard. Japanese carpenters, who were unfamiliar with Western architecture, were in charge of the building construction under the supervision of Brunat. While Western architectural skills such as timber-frame brick masonry, roof trusses, and glass windows were introduced, conventional Japanese architectural techniques and materials were widely used in construction. For example, the roofs were covered with Japanese roof tiles, Japanese plaster was used for laying bricks fired by Japanese craftsmen. This culminated in works of architecture in which Western and Japanese technologies were cleverly integrated.

Production facilities including a huge silk-reeling plant, over 100 meters long, and warehouses for cocoons were set up on a vast site. Steam power generated by boilers was used as both a motive power to run reeling equipment and as a heat source for boiling cocoons.[4] In addition, residences for directors, dormitories for female workers, and a clinic were constructed, and there were efforts to introduce Western-style working environments including working regulations such as labor hours and non-working days according to a seven-day week calendar.

4 As the first step in raw silk production, cocoons are soaked in hot water to remove gum to loosen threads for reeling.

After 20 years of operation under the Meiji government, the mill ownership was transferred to the private sector and managed by a succession of private enterprises; the Mitsui family from 1893, Hara Partnership Corporation from 1902, and Katakura Silk Reeling and Spinning Co., Ltd from 1939. Regardless of changes in management, it continued to be used as a reeling factory for 115 years until its operation ceased in 1987.

During the years of operation, the mill was a model factory, a forerunner in advanced silk-reeling which made use of the cutting-edge technology then available in Japan. The most advanced automatic silk-reeling machines were used here until 1987 and remain as they were when operation ceased. The same styles of reeling machines are still used globally, supporting raw silk production today. In addition, to ensure high quality cocoons, the premises of the factory was expanded to build a silkworm egg production laboratory in 1908 and efforts were made to put into practice ways to cultivate an excellent breed of silkworm in cooperation with influential silkworm-raising farmers.

The original buildings built between 1872 and 1875, such as the silk-reeling plant, east and west cocoon warehouses remain intact. Furthermore, leading-edge factory facilities built at various periods by different managers, as well as facilities for workers and managers, are well preserved.

The building plan of the mill is shown in the Figures 2-2 through 2-4. Table 2-1 exhibits the list of existing buildings. Detailed explanations on notable buildings that depict interchange and innovation in technology will follow. Throughout this nomination dossier, names of buildings from the government management period will follow the names used at the time of establishment.

Photo 2-2 S1 Exterior of east cocoon warehouse, Tomioka Silk Mill

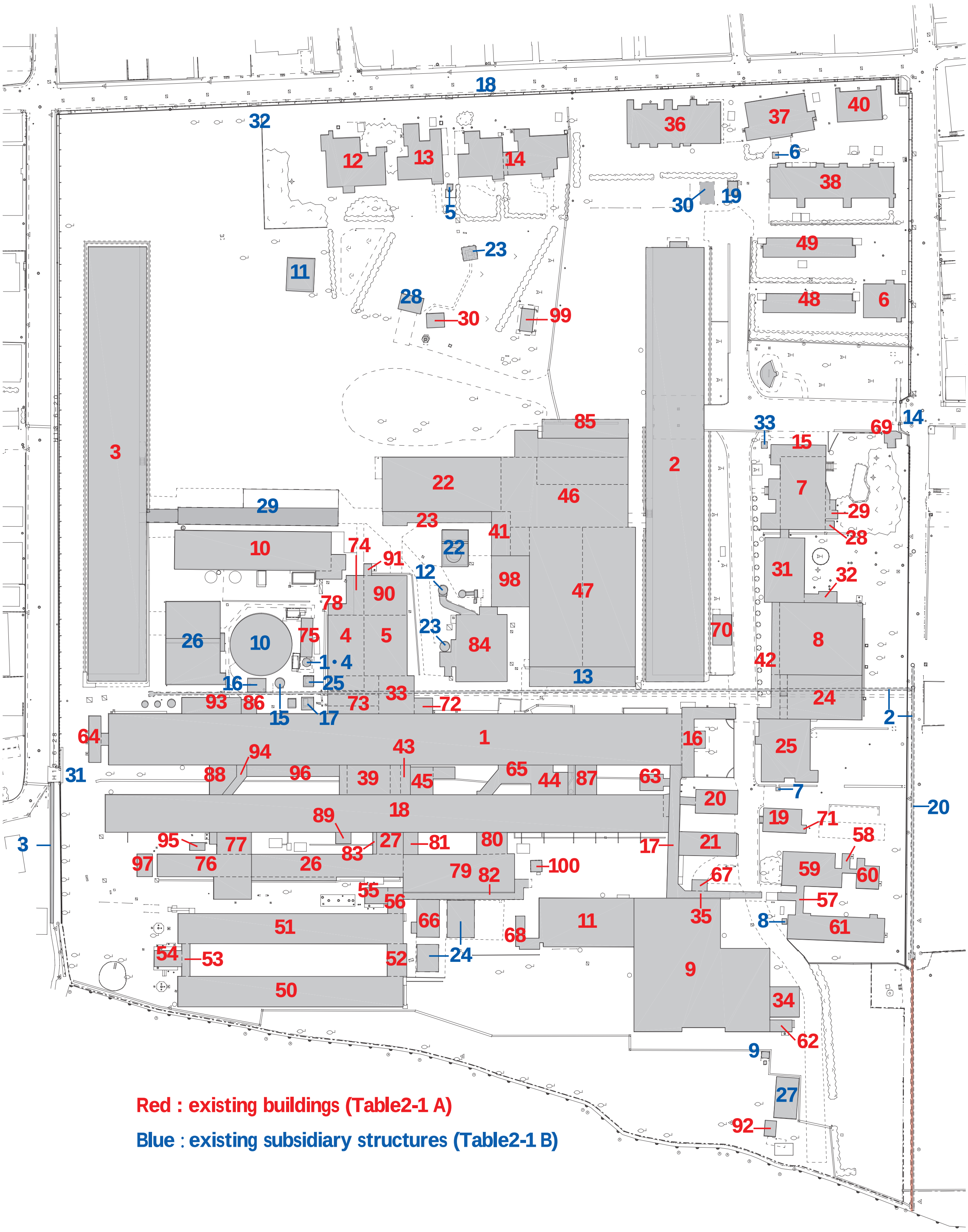


Figure 2-2 S1 Site plan, Tomioka Silk Mill

Table 2-1 S1 The list of existing buildings and subsidiary structures of Tomioka Silk Mill

List of Abbreviations

Structure

TRBM	Timber reinforced brick masonry
TF	Timber frame
BM	Brick masonry
IF	Iron frame
S	Steel

Roofing Material

Tile	Japanese pan tile
CI	Corrugated iron
I	Iron
CA	Corrugated asbestos
IBS	Iron batten seam
CT	Cement roof tile

Ohters

CS	Cobble stone
P	Pebbles
CB	Concrete blocks
PS	Prefabricated structure

A. The list of existing buildings

No.	Period	Name of structure (name of structure at the time when ceased operation)	Year of construction	Structure	No. of stories	Roofing material	Beam span (m)	Longtitudinal beam span (m)	Floor area (sq. m)
1	Government Management Period	Silk-reeling plant	1872	TRBM	1	Tile	12.3	140.4	1,726.9
2		East cocoon warehouse		TRBM	2	Tile	12.3	104.4	1,493.1
3		West cocoon warehouse		TRBM	2	Tile	12.3	104.4	1,486.6
4		Steam boiler plant (Cocoon boiling room)		TRBM	1	Tile	8.6	22.2	190.6
5		Steam boiler plant (Cocoon sorting room)		TF formerly TRBM	1	CI	14.4	10.8	155.5
6		Guard house (Company residence)		TF	1	Tile partially CI	7.3	9.1	87.2
7		Inspector's house	1873	TRBM	2	Tile	8.6	18.6	224.7
8		Dormitory for female instructors		TRBM	2	Tile	17.4	20.1	383.4
9		Director's house: Brunat house		TRBM	1	Tile	West: 17.0 East: 16.0	28.0 27.1	916.8
10	Mitsui Period	Second silk-reeling plant (Warehouse and workroom of by-products)	1896	TF	1	CI	9.1	38.2	393.8
11		Dormitory for female workers: Haruna dormitory		TF	2	Tile	10.8	21.6	252.4
12		Company residence no. 71	c. 1896	TF	2	Tile	11.7	14.2	150.6
13		Company residence no. 72	1896	TF	1	Tile partially CI	13.5	10.9	115.8
14		Company residence no. 73, 74		TF	1	Tile partially IBS	10.9	23.0	229.7
15	Hara Period	Extension to inspector's house	North wing: c. 1910s West wing: c. 1920s	TF	1	Tile			35.6 35.3
16		Entrance hall	c. 1910s	TF	1	IBS	2.9	17.0	60.6
17		Corridor	c. 1910s	TF	1	CI	2.6	26.6	108.7
18		Re-reeling plant and Packing room	1919	TF	1	Tile	9.1	136.4	1,242.8
19		Silk thread warehouse (Grain warehouse)		TF	1	Tile	5.5	9.1	52.0
20		Silk thread warehouse		TF	1	Tile	5.5	10.0	61.8
21		Accounting office (Room for flower arrangement classes)		TF	1	Tile	5.5	12.7	69.4
22		Cocoon drying area	c. 1922	TF	1 partially 2	CI	13.2	28.9	379.7
23		Corridor	c. 1922	TF partially IF	1	CI	2.8	26.2	73.5
24		Dining hall	1923	TF	1	CI	10.9	18.2	218.4
25		Kitchen		TF	1	IBS	13.7	15.4	216.4
26		Reeling plant (Re-reeling plant)	c. 1924	TF	1	I	5.5	37.5	223.8
27		Corridor		TF	1	CI	5.5	5.5	29.9
28		Toilet	c. 1926	TF	2	Tile	2.0	2.6	4.6
29		Washroom and toilet	1926	TF	1	Tile I (wash room)			15.2
30		Oil shed	c. 1910s	BM	1	Tile	3.5	4.4	15.2
31		Dormitory for male workers		TF	2	Tile	9.7	15.6	151.8
32		Toilet		TF	1	Tile	2.5	4.4	18.2
33		Machine maintenance room		TF	1	CI	9.8	12.5	121.3
34		Educational facility for mill workers		TF	1	Tile	7.3	7.3	52.8
35		Corridor	c. 1910s partially 1940	TF	1	CI partially Tile	1.8	15.3	33.7

36	Hara Period	Company residence no. 76	c. 1920s	TF	1	Tile partially, CI	8.2	22.7	219.5
37		Company residence no. 79	c. 1920s	TF	1	Tile	9.1	16.7	141.5
38		Company residence no. 83	c. 1920s	TF	1	Tile partially I, IBS	7.5	30.1	242.4
39	Early Katakura Period	Seriplane room (Reel moistening room)	1938	TF	1	CI	7.2	12.6	90.0
40		Company residence no. 82	1938	TF	1	Tile partially I, IBS	8.2	10.9	81.0
41		Drying machine operator's room	c. 1931 c. 1942	TF	2	Tile	6.8	9.1	62.1
42		Corridor	c. 1939	TF	1	CI	2.8	10.3	28.4
43		Corridor		TF	1	CI	2.4	7.2	17.4
44		Corridor / reel stockroom	c. 1939	TF	1	CI	7.3	9.1	66.8
45		Workroom	c. 1939 1981	TF	1	CI	6.1	7.8	65.2
46		Cocoon handling area	1939	TF	2	CI	17.1	33.1	529.3
47		Cocoon drying area	East:1939 West:1942	TF	1 partially 2	CI partially slate	25.8	34.1	East:439.3 West:439.3
48		Company residence no. 85	1940	TF	1	Tile	4.5	20.9	99.2
49		Company residence no. 86		TF	1	Tile	4.5	20.9	99.2
50		Dormitory for female workers: Myogi dormitory		TF	2	Tile	7.3	55.0	399.9
51		Dormitory for female workers: Asama dormitory		TF	1	Tile	7.3	55.0	399.9
52		Washroom		TF	1	Tile	4.5	8.2	37.2
53		Corridor		TF	1	Tile	1.8	8.2	14.9
54		Toilet		TF	1	Tile	3.8	6.8	25.9
55		Toilet		TF	1	Tile	3.8	5.6	21.4
56		Corridor		TF	1	Tile	3.6	6.3	23.0
57		Corridor		TF	1	CI	1.8	14.5	26.4
58		Corridor and toilet		TF	1	Tile	1.8	3.6	9.9
59		Infirmary		TF	1	Tile	8.2	14.5	112.4
60		Special ward		TF	1	Tile	5.5	5.5	33.1
61		Sickrooms		TF	1	Tile	5.8	23.6	137.7
62		Toilet	c.1941	TF	1	Tile	2.8	5.5	15.3
63		Toilet	c. 1942	TF	1	Tile	3.8	5.7	24.8
64		Toilet	1942	TF	1	Tile	2.8	11.2	37.2
65		Power room	1942 1962	TF	1	I	4.4	7.3	49.0
66		Laundry room	c. 1942	TF	1	CI	5.5	9.1	49.6
67		Entrance hall	1944	TF	1	I	3.7	2.7	9.9
68	Late Katakura Period	Toilet	c. 1945	TF	1	Tile, CI	2.1	5.5	26.4
69		Guard house	1947	TF	1	Tile	2.8	2.8	11.1
70		High-voltage substation	1948	TF	1	Tile	4.6	7.3	33.1
71		Toilet	1951						
72		Corridor	1952	TF	1	CI	3.9	4.6	23.0
73		Corridor	1952	TF	1	CI	2.0	8.6	17.2
74		Corridor	1953	TF	1	CI	2.4	9.8	23.5
75		Pumping house	1955, 1980	TF	1	CI	2.7	9.4	34.5
76		Re-reeling plant	1956 , 1981	TF	1	CT	5.5	22.9	174.3
77		Corridor	1956	TF	1	CI	5.5	8.1	44.1
78		Corridor	1961	TF	1	I	6.2	9.8	30.0
79		Re-reeling plant	1962	TF	1	CT	9.1	27.3	247.9
80		Corridor and reel stockroom	1962	TF	1	CT	5.3	7.3	38.9
81		Reel stockroom	1962	TF	1	IBS	3.6	5.3	19.4
82		Corridor	1962	S	1	CI	1.8	31.3	63.0
83		Corridor	1963	TF	1	CI	1.8	5.5	10.0
84		Boiler house	1966	S	1	CA	12.4	16.0	227.6
85		Extention eaves attached to coccoon drying area and cocoon handling area	1970	TF	2 (NA)	IBS partially PVC	6.4	27.3	175.8
86		Cocoon supplying machine cleansing room	1970	TF	1	CI	3.3	3.7	12.0
87		East employee's lounge	1972	TF	1	CI	5.5	7.3	39.7
88		West employee's lounge	1972	TF	1	IBS	5.5	7.3	31.3
89		Power room for water sprinklers	1973	S	1	CI	2.7	3.6	9.9
90		Cocoon storeroom	1974	TF	1	CI	9.8	10.7	104.9

91	Late Katakura Period	Toilet	1974	TF	1	CI	1.8	2.7	5.0
92		Pump house for industrial water drawn from the Kabura-gawa River	1975	IF, PS	1	CI	3.6	2.7	9.9
93		Room for water-cooling machine for reeling	1977	IF	1	CI	3.6	14.4	51.8
94		Corridor	1979	TF	1	IBS Partially PVC	3.7	7.3	29.5
95		Humidifier room	c. 1979	TF	1	I	1.8	3.6	6.6
96		Passage for carrying reeled silk	1980	TF	1	I	2.7	22.5	58.8
97		Shed	1981	TF	1	CI	3.6	5.5	19.8
98		Woodchip fuel storage	1984	TF	1	CI	7.1	8.9	63.1
99		Toilet	unknown	RC	1	CH	3.1	5.5	17.0
100		Charcoal-powered fire room	unknown	CB	1		2.9	2.9	8.2

B. The list of subsidiary structures

No.	Period	Name of structure	Year of Construction	Structure	No. of stories	Roofing material	Size (sq. m)	Notes
1	Management under Government Period	Chimney base	1872	S			5.6	
2		Brick drain within the premises/ Brick drain outside the premises		BM side: CS				Total length: 322.1m
3		Drain		P				length: 34.3m a part of southwest of Drain remained
4		Well		CS				ϕ2.3m Horizontal well/ a cave to the side of Cocoon boiling area remains A portion of the drain remains at the southwest corner
5		Well		CS				Steel cover
6		Well		CS				Concrete cover
7		Well		CS				Concrete cover
8		Well		CS				Oya stone well cover
9		Well		CS				Concrete cover, pump
10		Iron water tank	1875	Steel with stone foundation			176.2	
11	Hara Period	Filter basin	c.1920s	BM			54.5	
12	Early Katakura Period	Chimney	1939	RC				ϕ2.5m Height: 37.5m
13		Garage	c. 1942	TF	1	CI	95.9	
14		Main entrance	c. 1943	CB, BM				Openings width: 5.23m
15	Late Katakura Period	Water tower	1952	RC		CI		ϕ2.4m
16		Reservoir	1952/1977	RC		I	15.6	Manhole
17		Hot water tank	1952	S		CI	9.0	One tank lost
18		Concrete block wall	1960 /1961/1966	CB				
19		Water tank	1962	RC			8.3	
20		Concrete wall	1965-1966					
21		Demineralized water tank	1966	S				ϕ2.2m
22		Heavy oil tank/ Oil weir	1965/1980	I, CB			57.7	ϕ3.4m
23		Fukutoku Shrine	1968	TF		Copper	0.059	
24		Drying area	1970	S	1	Corrugated PVC	98.2	
25		Pupa waste water regenerating tank	1971	S		CI	6.6	ϕ1.8m Iron tank
26		Wastewater treatment lagoon tank	1974	RC		I	282.5	Steel cover, manhole
27		River water settlement tank	1975	RC			55.0	
28		Ash storage	1984	RC	1		21.9	
29		Corridor/ roof	unknown					
30		Bicycle park	unknown					
31		West gate	unknown					
32		North gate	unknown					
33		Well	unknown					Concrete cover

Management under government period

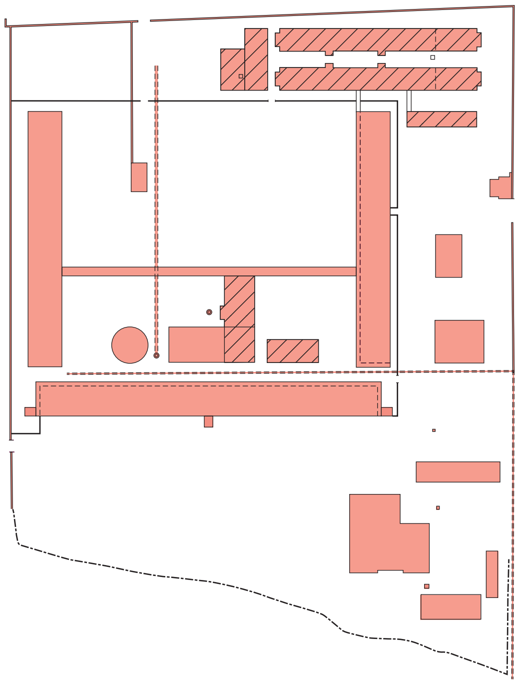
Mitsui period

Hara period

Early Katakura period

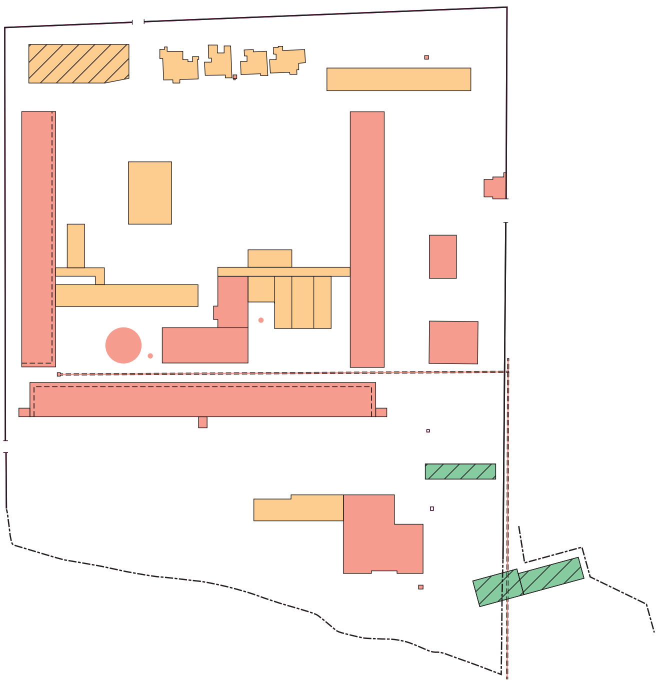
Late Katakura period

Period unknown



Building no longer exists: dormitory and subisidiary facilities, cocoon drying area, steam boiler plant east building, east brick pool

1. Time original construction was completed (1875)



Building no longer exists: silkworm egg production laboratory, cistern

2. Late Mitsui period through early Hara period (1908)

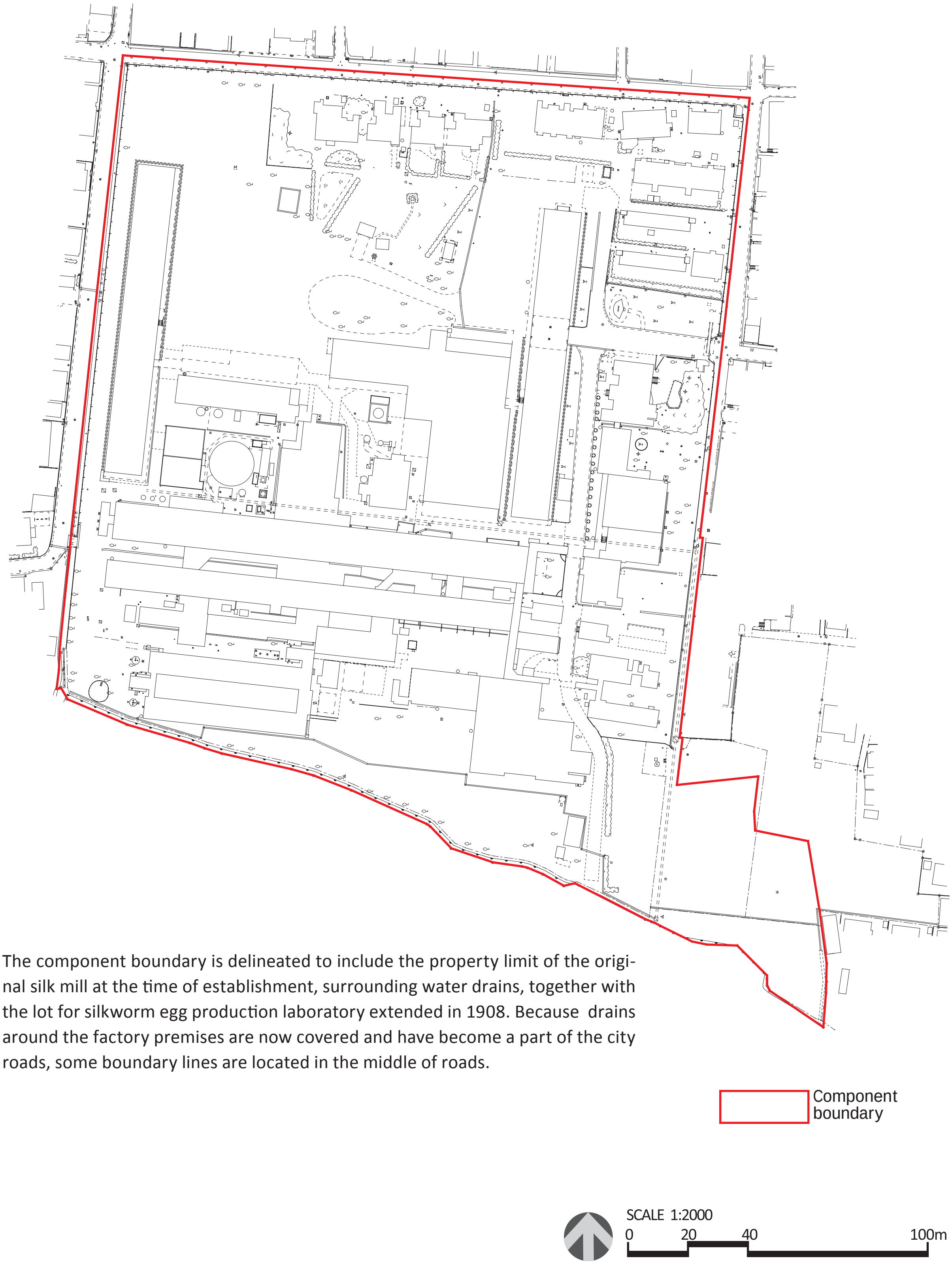
Building no longer exists: silkworm egg production laboratory, dormitory, cistern

3. Late Hara period through early Katakura period (1939)

Building no longer exists: silkworm egg production laboratory, dormitory, bath house

4. Immediately before cease of operation (1986)

Figure 2-3 S1 Site plan over time, Tomioka Silk Mill



The component boundary is delineated to include the property limit of the original silk mill at the time of establishment, surrounding water drains, together with the lot for silkworm egg production laboratory extended in 1908. Because drains around the factory premises are now covered and have become a part of the city roads, some boundary lines are located in the middle of roads.

Figure 2-4 S1 Detailed boundary of component, Tomioka Silk Mill

[Buildings constructed during the government management period (1872 – 1893)]

The original buildings built in 1872 were laid out centering on the silk-reeling mill. The plant was built with the ridge beam running in east-west direction to let sunlight into the work space. The east cocoon warehouse and west cocoon warehouse were built on both sides of the plant in a U shape. The steam boiler plant contained a boiler engine that was built to the north of the central part of the silk reeling plant. A cocoon drying area (no longer exists) was built to the northeast, and the iron chimney was placed to the north of the steam boiler plant.[5]

5 Refer to Appendix 3a and b for details about the production lines

A brick water pool (east reservoir), constructed to the east of the steam boiler plant leaked. Therefore, an iron water tank was installed in 1875 to replace the east reservoir. The underground drain conduit was made from the north side of reeling plant toward east side, draining sewer and rainwater into the Kabura-gawa River.

The four dormitories for female workers and its attached building were constructed in this period but demolished in 1893. Construction of the Director's house (Brunat house), Inspector's house, and the dormitory for female instructors followed soon after operations began, and construction is believed to have been completed sometime around 1873 to 1874. These buildings built during the government management period display both characters of Western and Japanese construction technologies.

Silk reeling plant

Built in 1872, the silk reeling plant is the main component of the mill, where raw silk was reeled from cocoons. At the time of establishment, the massive plant was equipped with mechanical reeling machines made in France with 300 basins.[6] The building was continuously used for silk reeling for 115 years.

6 Typical reeling plants in Europe at that time are about the size of 50-150 basins.

It is a one-story timber-framed brick-masonry structure measuring 140.4 meters long. The tile roof incorporates a raised ridge to vent steam. A section of the roof ridge is raised to vent steam. The wooden frame is constructed of 30 centimeter-square continuous posts supporting a king post truss.[7] Brick walls are laid, mainly in stretcher bond, between posts.

7 A truss is a structure composed of a combination of members in a triangular arrangement to support loads over wide spans enabling the provision of column-free space. This type of structure was new to traditional Japanese architecture. It was an imported technology at the time of Tomioka Silk Mill's establishment.

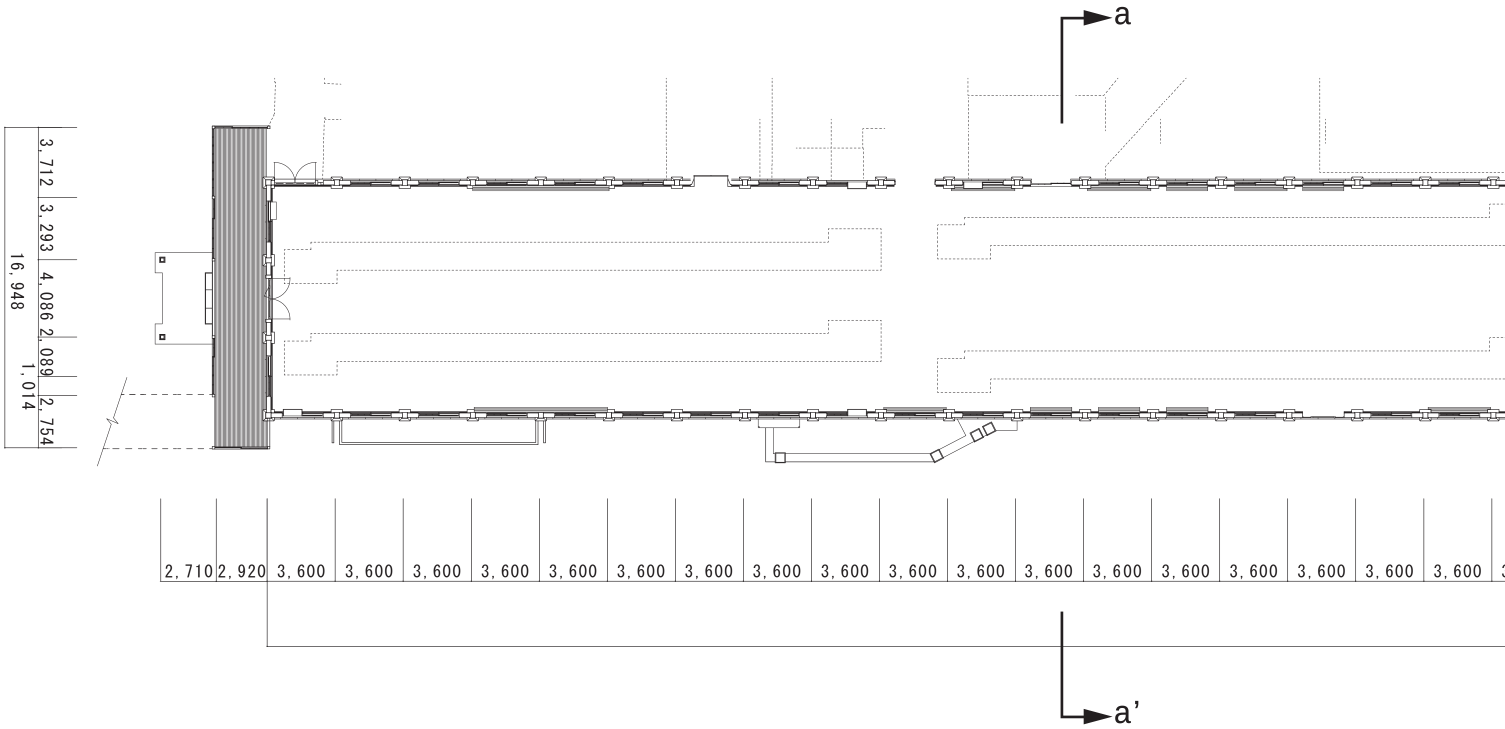
The plant features multiple large windows that illuminate the workspace for silk reeling. Originally, there were iron sash pivoted windows, but the lower part of those have changed into double sliding windows. The glass used for the windows was imported from France.

Photo 2-3 S1 East facade of silk-reeling plant, Tomioka Silk Mill

Although there has been some remodeling, such as window renovation (from pivoted windows to side-by-side sliding windows), and additions of subsidiary structures, the original basic 1872 structure has been kept intact in excellent condition. Automatic silk-reeling machines that were used until the closing of the mill have been kept inside the plant.

Photo 2-4 S1 view from northwest, silk-reeling plant, Tomioka Silk Mill

Photo 2-5 S1 Interior of silk-reeling plant, Tomioka Silk Mill



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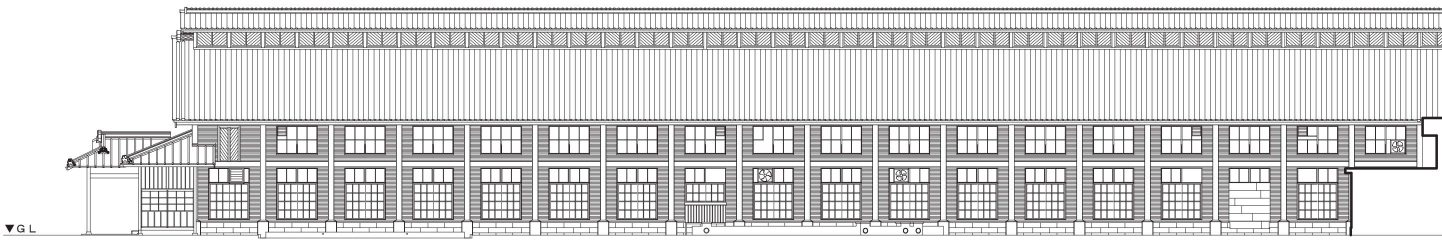

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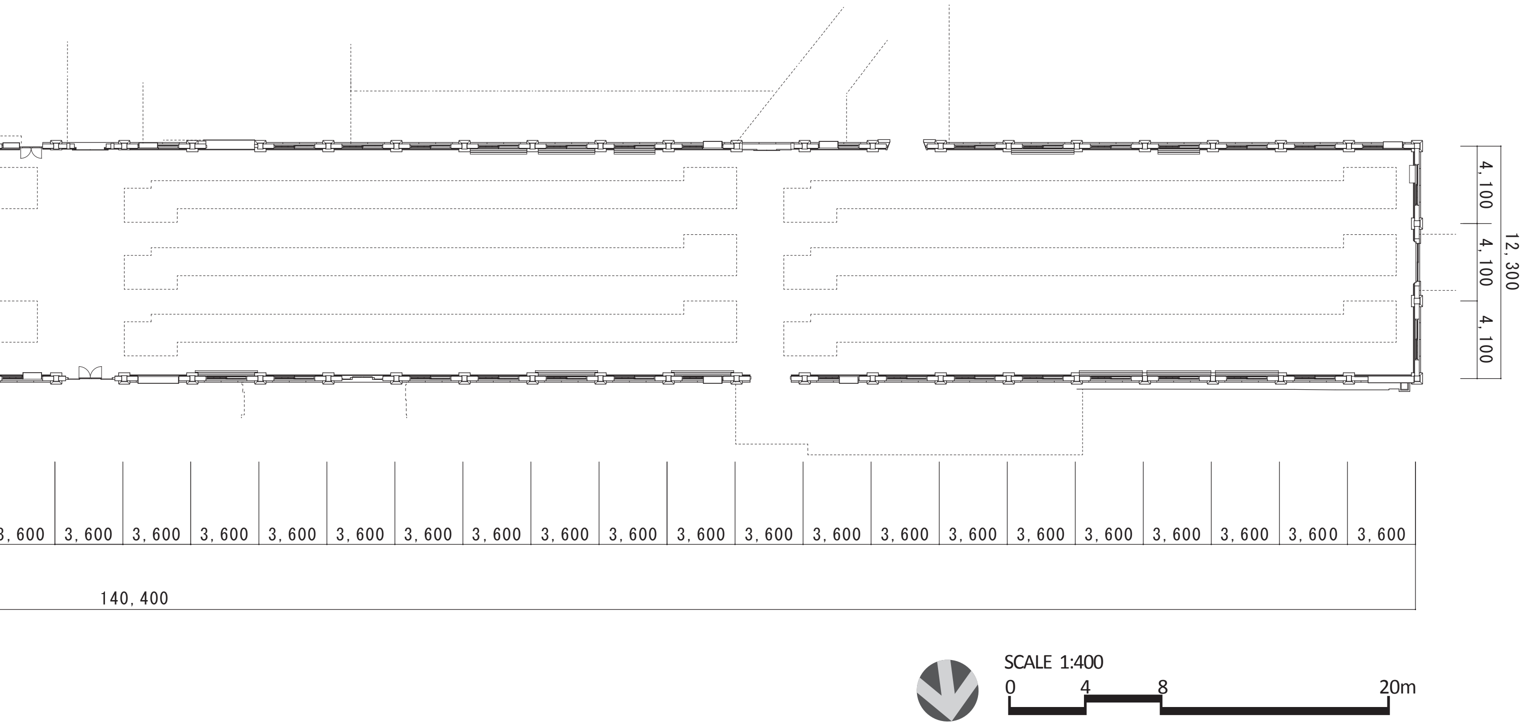

Figure 2-5 S1 Floor plan, silk-reeling plant, Tomioka Silk Mill

Figure 2-6 S1 North elevation, silk-reeling plant, Tomioka Silk Mill

Figure 2-7 S1 East elevation, silk-reeling plant, Tomioka Silk Mill

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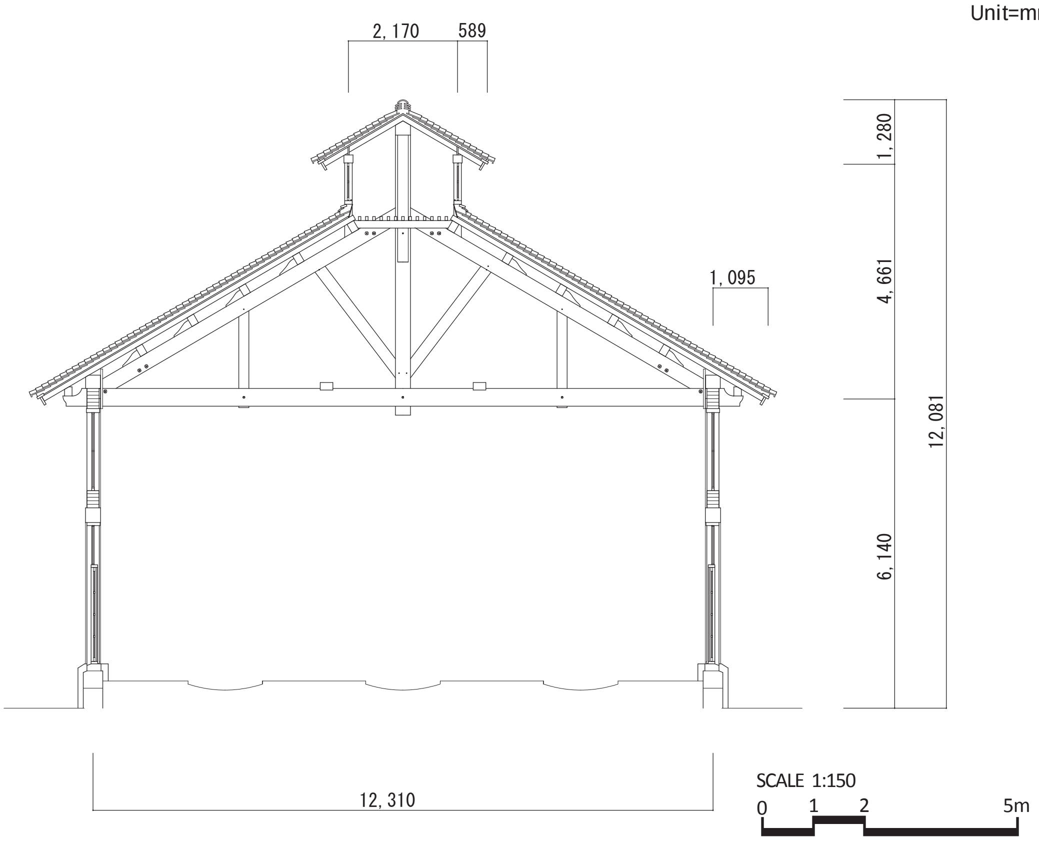


Figure 2-8 S1 Section (a-a'), silk-reeling plant, Tomioka Silk Mill

East cocoon warehouse

Built in 1872, the east cocoon warehouse was used for storage of dried cocoons. At the time, the rearing cycle of silkworms in Japan was once a year, therefore, a large storage area was needed to keep a sufficient supply of cocoons to run the machine operation all year long.

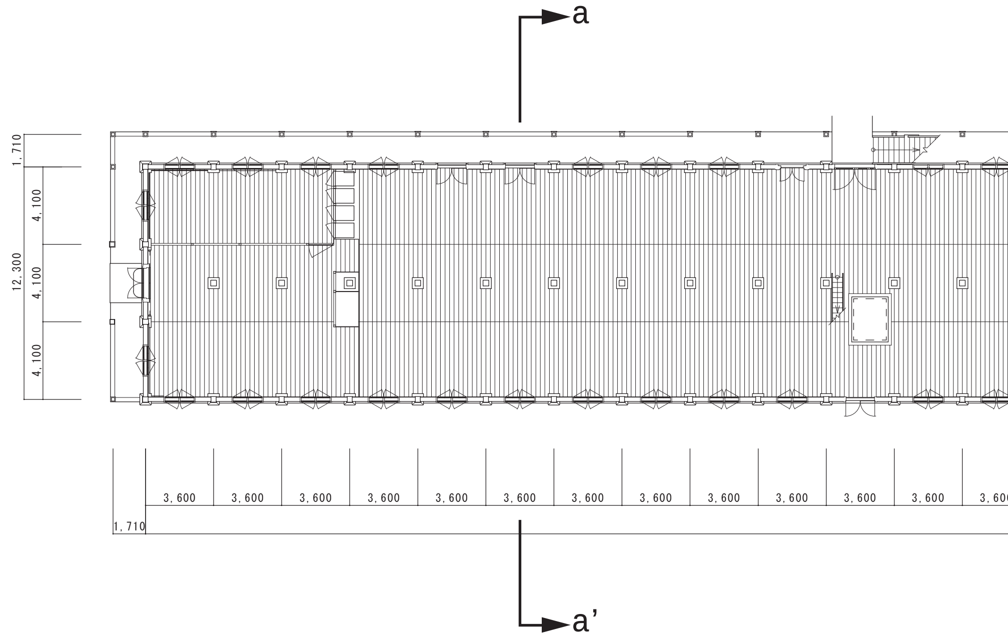
The building is of timber-frame brick masonry and measures 104.4 meters long, 12.3 meters wide, and 14.8 meters high. The gabled roof is made of king post trusses and sheathed with Japanese pan tiles. Aisles run under the eaves along the south and west sides of the building.

Since it was the Japanese carpenters' first attempt to construct a Western-style truss, it is believed that they had doubts on the reliability of such construction being able to support the weight of the roof. In the east cocoon warehouse, built ahead of the silk-reeling plant, 30 centimeter-square posts were installed, penetrating the trusses to directly support the ridge beam; diagonal connecting members were added to the trusses to form an umbrella-like structure. The brick masonry walls were laid in Flemish bond. There is also an arched passageway of brick construction, located north of the center of the ground floor, with a keystone inscribed with the construction year, "the fifth year of the Meiji period" or 1872.

Many windows are installed on both ground and upper floor levels. Originally, some of them were wooden doors, although most were glazed.

Some replacements have been made to preserve fittings, and small changes have been made to the staircase; however, the building has been kept in excellent condition and reflects the time when it was built.

Photo 2-6 S1 Interior of east cocoon warehouse, Tomioka Silk Mill



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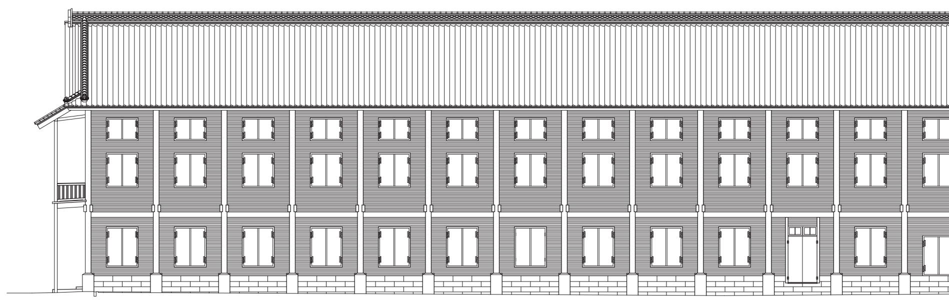

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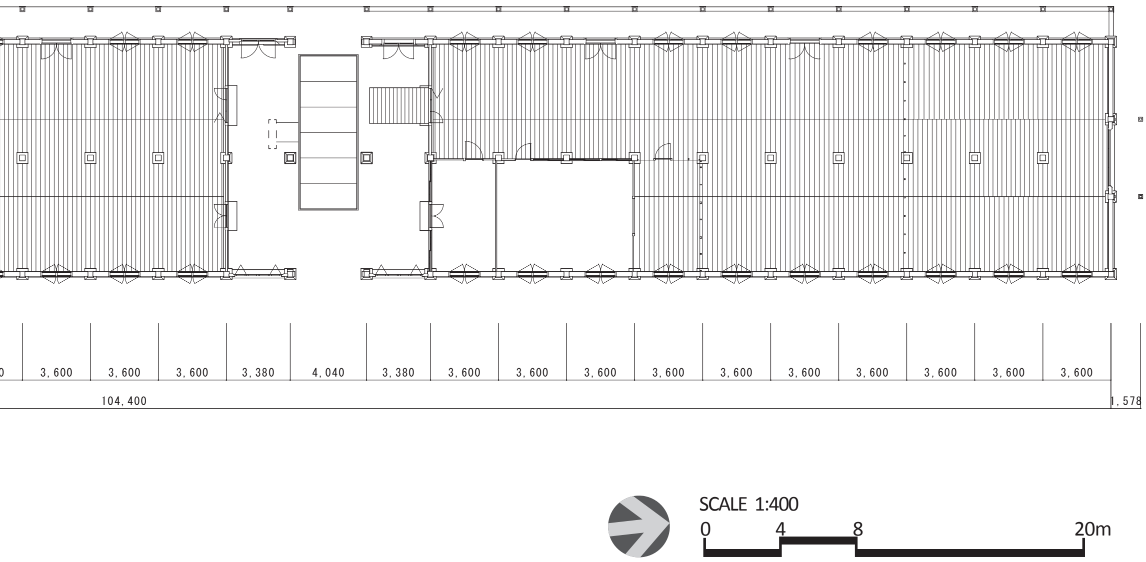

Figure 2-9 S1 Ground floor plan, east cocoon warehouse, Tomioka Silk Mil

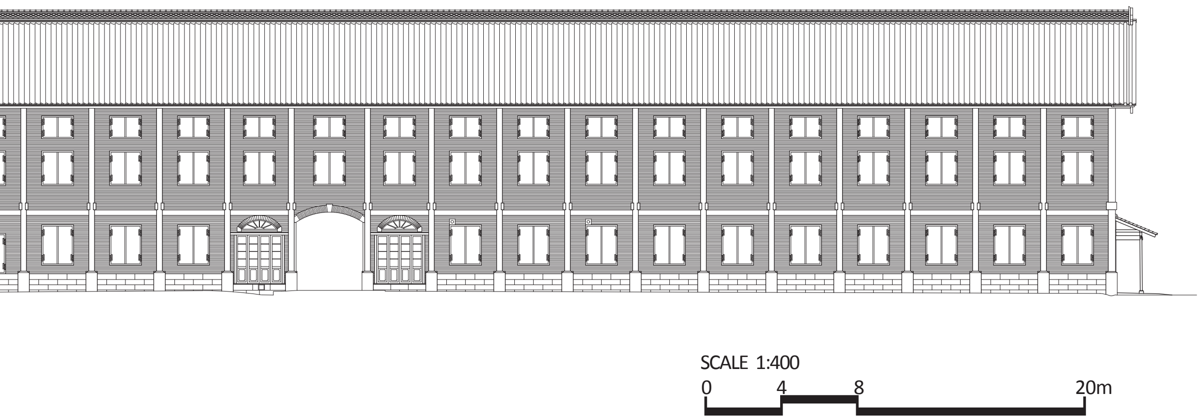

Figure 2-10 S1 East elevation, east cocoon warehouse, Tomioka Silk Mill

Figure 2-11 S1 North elevation, east cocoon warehouse, Tomioka Silk Mill

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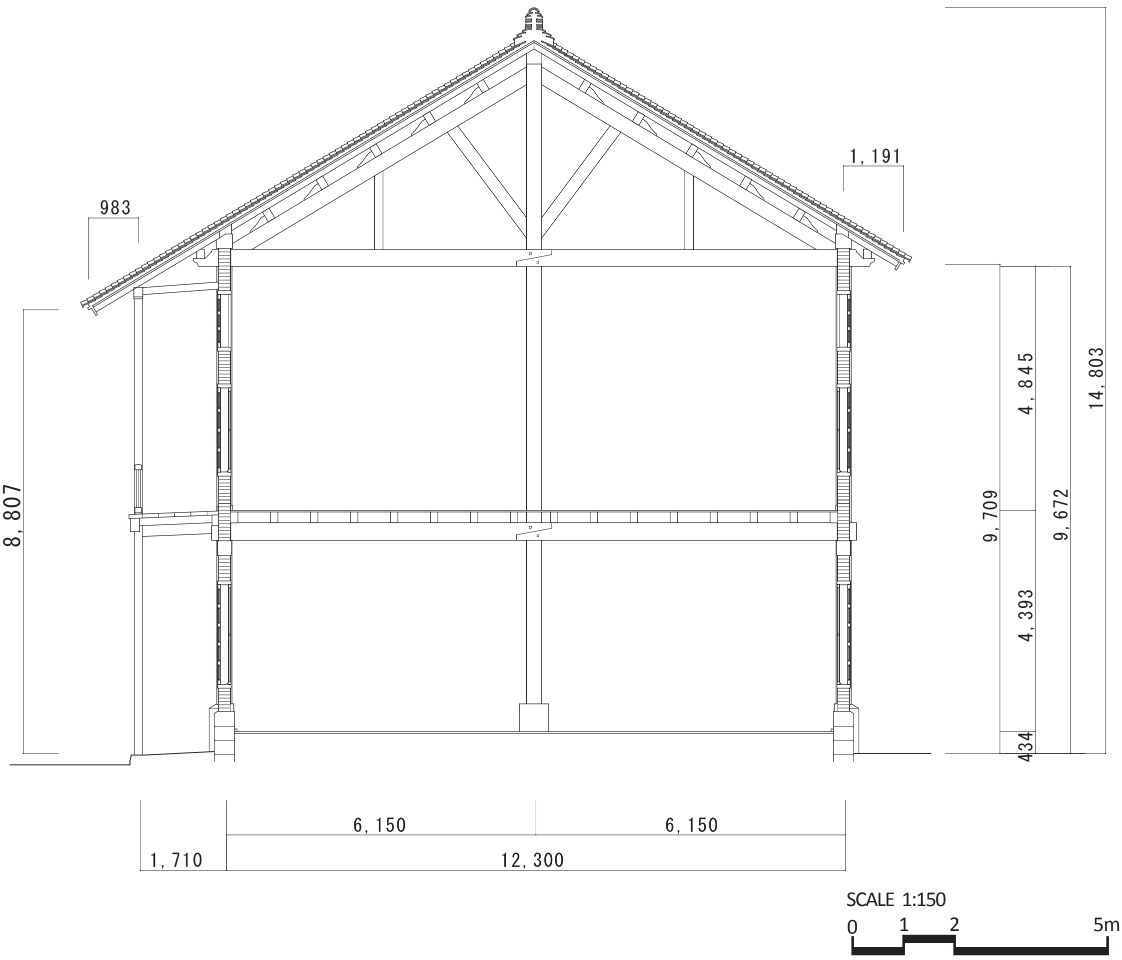

Figure 2-12 S1 Section (a-a'), east cocoon warehouse, Tomioka Silk Mill

8. See Figure 2-13

West cocoon warehouse

West cocoon warehouse, constructed in 1872 of timber-frame brick masonry, measures 104.4 meters long, 12.3 meters wide, and 14.8 meters high. The warehouse is similar to the east cocoon warehouse. The roof is gabled, and aisles under the eaves run along the south and east sides of the building. There originally was no east wall on the northern portion of the ground floor, an area used to store coal.[8] In 1896, a wooden floor was installed when this section of the building was converted to a cocoon selection area, and a brick wall was installed in 1981. Apart from that, most of the structure has been preserved in excellent condition, much like when it was built in 1872.

Photo 2-7 S1 View from southwest, west cocoon warehouse, Tomioka Silk Mill

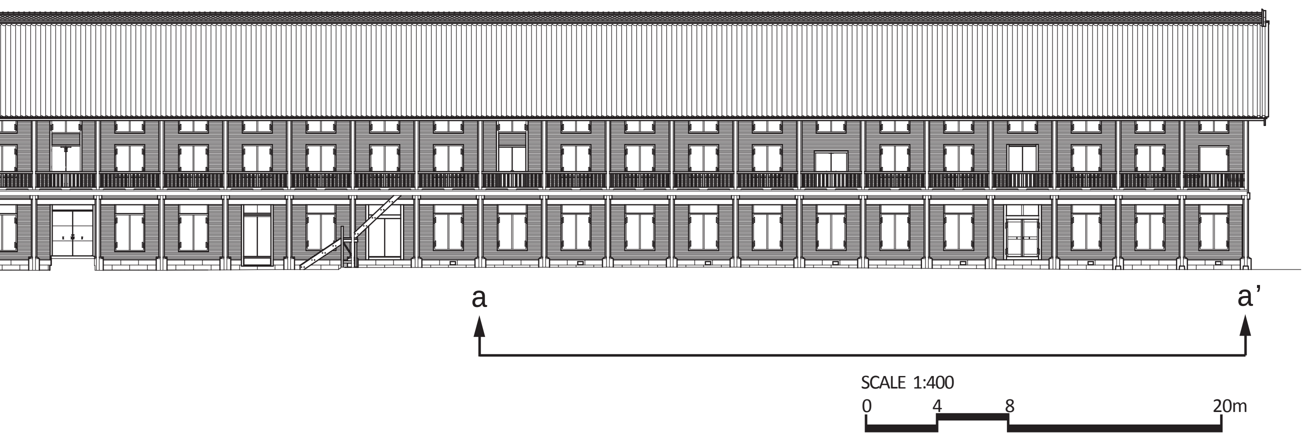

Figure 2-13 S1 East elevation, west cocoon warehouse, Tomioka Silk Mill
There originally was no east wall on the ground floor in the span indicated a-a'.

Steam boiler plant

The steam boiler plant was constructed in 1872 to house six steam boilers (five for the heat source for boiling cocoons and one for the power source) and a steam engine.[9] The one-story structure was originally of timber-frame brick masonry. It was structurally divided into three sections; west building with the steam engine, central building with the steam boiler, and east building used to store coal. As the building underwent renovations as reeling systems were renewed and motive powers changed, the east building was lost. Today, the west building used for boiling cocoons and the central building for cocoon sorting at the time of the factory's closing remain.

9 This engine, also known as the Brunat engine, was originally imported from France. It was removed in 1952 and is now housed in Museum Meiji-mura in Aichi Prefecture.

Photo 2-8 View from northeast, Steam boiler plant, Tomioka Silk Mill

Figure 2-14 S1 North elevation, steam boiler plant, Tomioka Silk Mill

Director's house (Brunat house)

Built in 1873. It is the house where Paul Brunat, the first director of Tomioka Silk Mill, lived with his family. After Brunat left Japan in 1876, the building was used as a school and dormitory for female workers.

The house is a one-story timber frame brick building measuring 917.0 square meters. It is very large for private quarters. The verandas on all four sides are distinctive of the so-called "veranda colonial" style, referring to European colonial architecture in Asia by which early Western-style architecture in Japan was influenced. The king post truss roof structure features a crossbeam that is the largest in the mill complex. The cellar made of brick was once used to store silkworm eggs after the egg production laboratory was built on the premises in 1908.

Renovations to the interior of the house have been made several times to accommodate subsequent use as school and dormitory. Triangular dormers were added to the attic around 1940.

Photo 2-9 S1 View from southwest, Director's house (Brunat house) , Tomioka Silk Mill

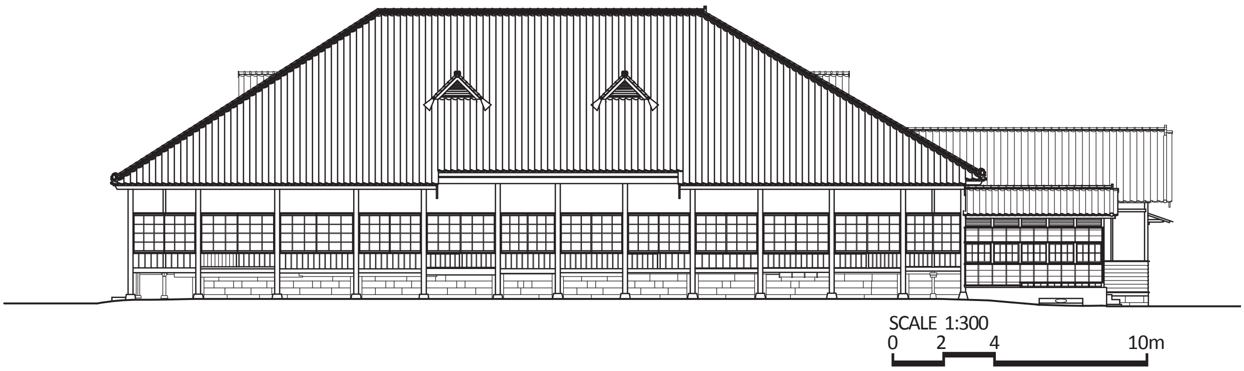

Figure 2-15 S1 South elevation, director's house, Tomioka Silk Mil

Dormitory for female instructors

Built in 1873, the dormitory for female instructors was established as a residence for French female instructors who instructed Japanese workers in machine-reeling.[10] The dormitory is a two-story building, constructed of timber reinforced brick masonry. Verandas adjoin on three sides, east, south, and west, on both stories. Partition walls were partly removed when the building was remodeled for use as a dining room in 1923; however, the appearance and structure have been maintained in good condition.

10 All French female instructors left Japan by March of 1874.

Photo 2-10 S1 View from west, Dormitory for female instructors, Tomioka Silk Mill

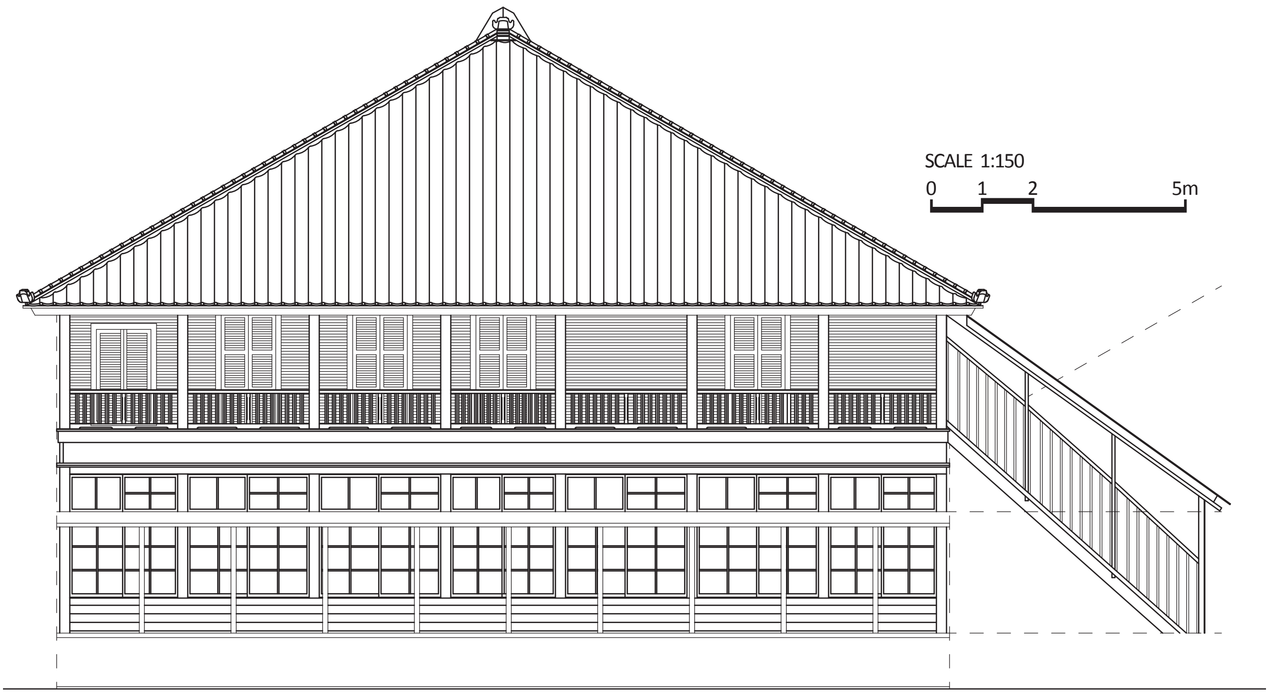

Figure 2-16 S1 West elevation, dormitory for female instructors, Tomioka Silk Mill

Inspector's house

The inspector's house was built in 1873 as a residence for French male engineers.[11] After they left Japan, the house was used as an administrative office. It is a two-story building, constructed of timber-framed reinforced brick. Verandas adjoin on three sides; north, east, and south. The entrance, lean-to roof, and toilet added for use as an administration building do not detract from the original appearance of the building.

11 French male engineers left before the house was completed. They never lived in this inspector's house.

Photo 2-11 S1 View from northeast, Inspector's house, Tomioka Silk Mill

Figure 2-17 S1 East elevation, inspector's house, Tomioka Silk Mill

12 For illustration, see Appendix 3-c

Iron water tank

The iron water tank was built in 1875, replacing the original leaking brick pool, in order to pool and maintain a secure supply of water for boilers and silk reeling. Water stored for several days was softened and made suitable for silk reeling. It is 15 meters in diameter and 2.4 meters in depth (at the deepest point).

Prefabricated iron plates of two different sizes, 1.2 by 3.0 meters and 1.2 by 2.4 meters, both in thickness of 5 millimeters, were riveted together. This tank was manufactured at Yokohama Seizou-jo Steel Mill. The tank is a precious relic as one of the earliest iron facilities constructed in Japan. Its foundation is composed of numerous stone pillars laid along the perimeter and in a grid under the tank.[12]

Originally, the stones were laid in two courses, but later, three more courses of stones were added to each pillar to raise the tank in order to increase water pressure. This tank was used until the mill operation ceased, conveying the history of the water supply system which is indispensable for silk-reeling.

Photo 2-12 S1 View from northwest, Iron water tank, Tomioka Silk Mill

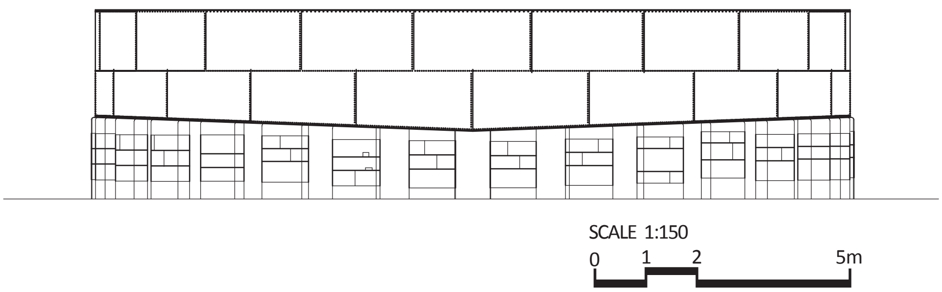

Figure 2-18 S1 West elevation, iron water tank, Tomioka Silk Mill

Brick drain

Built in 1872, this covered brick drain was used not only for rain water runoff from the buildings, but also for discharge of water used for silk-reeling.

The drain runs eastward along the north side of the silk-reeling plant, starting from the northwest corner between the plant and the West cocoon warehouse. This section of the drain is called *gesuito* (within premises), while the other section from the east end of *gesuito* that runs about south straight along the boundary of the site to the Kabura-gawa River bank is called *gaito* (outside premises).

The side walls of *gesuito*, 186 meters in length, are made of brick and those of *gaito*, 135 meters in length, of stone. The drain is covered by a vaulted brick ceiling, barely high enough for one to pass through in crouching position. For waterproofing, a coating cement imported from France was applied to the wall and bottom surfaces. It was used until the Mill operation ceased in 1987 and it continues to serve as a rainwater drainage system.

Photo 2-13 S1 Brick drain, Tomioka Silk Mill

13 The Mitsui family was a business magnate since the Edo period and in 1909 established Japan's first holding company, Mitsui Unlimited Company

14 It is said that timber used for the earlier female workers' dormitory from the time of establishment was dismantled that year and used for construction of this plant.

[Building constructed during Mitsui period (1893 – 1902)]

The mill was transferred to Mitsui[13] in 1893. As for buildings, the second silk-reeling plant (present warehouse and workroom of by-products) was founded along with the expansion of reeling machines in 1896.[14]

A new female workers' dormitory was constructed and three company residences including the company residence for the mill manager were built to the west side of the former female workers' dormitory.

Photo 2-14 S1 View from south, Dormitory for female workers (Haruna dormitory), Tomioka Silk Mill

[Building constructed during Hara Partnership Corporation period (1902 – 1938)]

In 1902, Mitsui withdrew from the reeling business and the Hara Partnership Corporation took control over the mill. It is during this period that many improvements were made to the system including introduction of multi-end reeling machines, establishing of cocoon boiling section with the separation of boiling process from reeling, converting from steam engine power to electric motors, and developing drying machines.

The mill sought to improve raw silk quality by widening its premises onto the adjoining land southeast of the plant, where built a silkworm egg production laboratory in 1908. It also collaborated with silkworm-raising farmers to unify silkworms for producing cocoons into a higher quality breed.

In 1918, the eastern half of the old second plant was converted into a cocoon boiling area to employ a different method of cocoon boiling.[15] In 1919, Re-reeling plant and packing room was built to the south of the silk-reeling plant. Around this time, the basic flow of silk-reeling processes from cocoon boiling, reeling, and re-reeling to finishing was established. Furthermore, in 1924 another silk-reeling plant (present re-reeling plant) was newly built to the south of the re-reeling plant and packing room and 48 sets of Minorikawa-style reeling machines were installed.[15]

15 See p.100 for further detail of Minorikawa-style reeling machines

In 1923 the ground floor of dormitory for female instructors was changed into a dining hall and was adjoined to the newly built dining hall to the south.

Re-reeling plant and packing room

Built in 1919, the building was used for re-reeling and finishing silk into products. The re-reeling process consists of rewinding thread from a small reel onto which it was first reeled from cocoons, to a larger reel to make skeins. Skeins were then removed from the larger reel for bundling into finished products, ready to be shipped. The building was constructed to house re-reeling equipment, which was initially installed at the Silk reeling plant. The equipment needed to be moved to make a room for the newly introduced multi-end reeling machine.

1. Re-reeling plant and packing room
2. Reeling plant (Re-reeling plant)
3. Cocoon drying area

The one-story timber-frame building of 136.4 meters in length is located to the south of the Silk reeling plant and is the second largest structure within the premises. The gabled roof covered with tiles is partially raised for ventilation. Though the roof structure employs the king-post truss, its members are thin and include many reused from other buildings. Such simple construction was commonly seen in ordinary reeling plants throughout Japan, built during the late Meiji and Taisho periods. Originally, the entire side walls were installed with papered *shoji* screen windows; they have been replaced by transom and aluminum sash windows. Buttresses on the south side were later addition. The roof tiles were reroofed from 2002 to 2003.

Photo 2-15 S1 View from southwest, Re-reeling plant and packing room

Reeling plant (Re-reeling plant)

Considered to have been built in 1924, the plant was originally called the Minorikawa-style reeling plant due to installation of the latest multi-end Minorikawa-style reeling machine. Later, it became a re-reeling plant. The building represents technological innovation in silk-reeling. The 37.5 meter-long central area which retains the single-story timber-frame structure from the time of establishment used to extend further to the east. The plant was extended to the east and west in 1956 and 1962 respectively. It was used as a thread-winding factory until 1987.

Cocoon drying area

The cocoon drying area is located on the west side of the east cocoon warehouses. This area was devoted to the drying and killing of pupas. The cocoon drying area is divided into two parts, south and west, with the handling area in the middle. The facility represents the technological innovations regarding procedures from processing to storing of cocoons that occurred during the Taisho period. It was in use at the time when operation ceased.

The west drying area, built in 1922, is constructed of timber-frame with a gabled corrugated-steel roof. A part of the roof is raised to vent hot-air. Two Imamura-style dryers were installed inside of this area. Now, two Yamato-style dryers are installed.[16]

In the south drying area, the western and eastern portions of the building were constructed different times. This timber-frame building equipped with four dryers was built in two sections: the eastern portion in 1939 of king-post truss, and the western part in 1942 of queen-post truss. The gabled roof is raised to vent humidity.

16 This automatic dryer dries cocoons with hot air of about 50-120 degrees Celsius carried by air ducts. Cocoons are circulated on eight layered conveyer belts for about 6 to 8 hours to be dried completely. Remarkable improvement was made from the steam-powered dryer introduced earlier at the time when operation began.

Site of silkworm egg production laboratory

The silkworm egg production laboratory was built in 1908 and has been demolished. It was built on the expanded site at the southeastern corner as a research facility for production of high quality standardized eggs necessary for producing high quality raw silk. It was based on the idea that cooperation between sericultural farmers and factory production must be maintained.

The laboratory had become rundown after the mill's closure in 1987 and was demolished in 1991. Underground remains of the laboratory are preserved on site.

Photo 2-16 S1
Archaeological survey, site of silkworm egg production laboratory, Tomioka Silk Mill

[Buildings constructed during early Katakura period (1938-1945)]

In 1938, the management of Tomioka Silk Mill was transferred from Hara to the Katakura Silk Reeling and Spinning Co., Ltd. In the following year of 1939, Tomioka Silk Mill merged with the Katakura company.

In regard to buildings, the seriplane room (currently the reel moistening room) for testing evenness of raw silk was built in 1938. In 1939, a single concrete chimney was constructed. Meanwhile, the mill became involved in improving working environments. In 1940, company residences were constructed, as were two dormitories for female workers [Photo 2-17] that were built together with a clinic [Photo 2-18].

[Buildings constructed during the late Katakura period (1946-1987)]

The development of automatic reeling machines which had just begun before the Second World War was soon accelerated. The K8-type machine was introduced in 1952 and small improvements were made one after another; the current Nissan HR-type was used in production from 1966.

In addition, after the Second World War, following innovations in reeling technology, facilities for motive powers and factory water as well as those for improving working conditions became necessary. While a high-voltage substation plant and wastewater treatment lagoon tank were newly constructed, and additions were made to many other buildings were added onto, they were all small in scale.

Photo 2-17 S1 View from east, Dormitory for female workers (Myogi dormitory and Asama dormitory), Tomioka Silk Mill

Photo 2-18 S1 View from west, Clinic, Tomioka Silk Mill

S2 Tajima Yahei Sericulture Farm

-Developed an innovative silkworm-raising room structure utilizing a ventilation system (Prototype of modern sericulture farmhouses)
- Yahei Tajima perfected the modern method of sericulture called *seiryo-iku* and set the major trend in Japanese sericulture early in the Meiji period
- Participated in international interchange through direct sales of silkworm eggs to Italy
- Cooperated with Tomioka Silk Mill in development and dissemination of improved species of silkworms

Tajima Yahei Sericulture Farm is located just to the south of the Tone-gawa River in southern Isesaki City. The area is called Shimamura, literally island-village, due to its setting on the sandbank of the river. As a result of changing river-flow, the sandbank developed gradually over time until the beginning of the 20th century. Although not suitable for rice farming, the sandy soil of Shimamura sufficed for cultivation of mulberry, and from late Edo period and the area was well known for silkworm egg production.

Yahei Tajima[17] perfected the modern method of sericulture called *seiryo-iku*[18] through research on effective methods for sericulture, and publicized it in his important sericulture treatise, “Yosan Shinron (New Theory of Sericulture)” in 1872. He also published “Yosan Shinron, Sequel” in 1879 and accepted students from all over Japan, disseminating his skills in sericulture. As the birthplace of *seiryo-iku*,the Tajima Yahei Sericulture Farm became the prototype for modern sericulture farmhouses characterized by the two-story structure with a gabled tile-roof and a *koshiyane* raised section at the ridge with windows for ventilation.[19]

17 Yahei Tajima (1822-1898)

18 For more details on *seiryo-iku*, see p.86

19 This raised roof for ventilation are called by a number of names, such as *koshiyane*, *tenso*, or *kinuki-yagura*. In this document we will use the term *koshiyane*.

Photo 2-19 S2 Aerial view of Tajima Yahei Sericulture Farm

Photo 2-20 S2 View from east, Tajima Yahei Sericulture Farm

Furthermore, Shimamura's silkworm-egg production farmers such as Yahei Tajima actively engaged in exporting silkworm eggs. Soon after export of silkworm eggs from Japan was permitted in 1864, farmers were given the chance to export their eggs to Europe, where pebrine damage had devastated the European silk industry.

Once the cure for pebrine was found by Luis Pasteur, the farmers shifted their marketing strategy to include direct sale of eggs to Italy by transporting the commodity themselves. Yahei Tajima observed Italian sericulture conditions at the time of his visit in 1879. He carried out research on silkworm diseases and testing of mother moths by using a microscope after the person in charge of the fourth direct exportation of silkworm eggs brought German microscopes back to Japan from Italy.

The farmhouse for sericulture built in 1863 is conserved in good condition. Other facilities such as a storage area for mulberry leaves and a storeroom for silkworm eggs are also conserved in the site.

The main building used for sericulture

Built in 1863, this main building with a ventilation system is an innovative architecture for sericulture. It was originally designed and built specifically for practicing the *seiryo-iku* method. This two-story house with a tiled roof and raised roof section for ventilation became the origin of modern sericulture farmhouse architecture in Japan.

The timber-frame building, measuring 28.2 by 12.2 meters, stands facing southeast to take advantage of the timely wind during the sericulture season (spring-summer). Large openings are provided in the northwest-southeast direction, while the raised roof and windows for ventilation stretches across the whole ridge. The ground floor was used as living quarters and the upper floor for raising silkworms; catwalks of the attic space were where mature silkworms spun cocoons. Furthermore, the farmhouse was constructed on a mound for protection from inundation.

Yahei Tajima used the microscopes to carry out research on silkworm diseases and added a room to the northern corner of the building for this purpose. This unique feature could be found in only one other house in neighborhood. In the 20th century, when the Tajimas engaged themselves in test-rearing of foreign bred silkworms and further research on the F1 hybrid, the upper floor was subdivided into six rooms in order to breed specific silkworm species and to safeguard from accidental cross-breeding. Recent minor alterations to the buildings both in interior and exterior are evident, but they are not crucial to the main structure. It is possible to restore it back to its original condition. The projecting front entrance depicted in an illustration[20] in "Yosan Shinron (New Theory of Sericulture)" was demolished in 1952.

20 See p.106 photo 2-46

Other buildings

Other buildings at the site include a storage area for mulberry leaves called *kuwaba*; a former silkworm-raising room called *besso*; a storehouse for silkworm eggs called *tanegura*; and a well building where water was collected for daily consumption and sericultural purposes; a building for storing documents called *bunkogura*; a house shrine; and *torii* gate (Shinto shrine archway) donated by customers outside Gunma prefecture.

There is also a monument commemorating Empress Teimei's visit in 1948, demonstrating the farm's link to the royal family. The foundation of a room exclusively for sericulture called *shin-sanshitsu* built on the east side of the main building and the foundation of a barn, which may have been the experimental reform of a silkworm-raising room by Yahei Tajima, also remain.

Photo 2-21 S2 Interior of attic space under the raised roof, main building, Tajima Yahei Sericulture Farm

Photo 2-22 S2 View from northwest, *Besso* (left) and *kuwaba* (right), Tajima Yahei Sericulture Farm

Photo 2-23 S2 View from north, Exterior of the microscope room (tiled-roofed projection in the center), Tajima Yahei Sericulture Farm

1 Main building
2 Well building
3 *Besso* (former silk-worm raising room)
4 *Kuwaba* (storage area for mulberry leaves)
5 Empress Teimei monument
6 House shrine and *torii* gate (*Shinto* shirine archway)
7 *Bunkogura* (building storing documents)
8 *Tanegura* (storehouse for silkworm eggs)
9 *Sangu okiba* (tool shed for sericulture)

a Foundation for *shin-sanshitsu* (building exclusively used for sericulture)
b Foundation for a barn (*Kogetsuro*)
c Foundation for *kokugura* (storage area for crops)

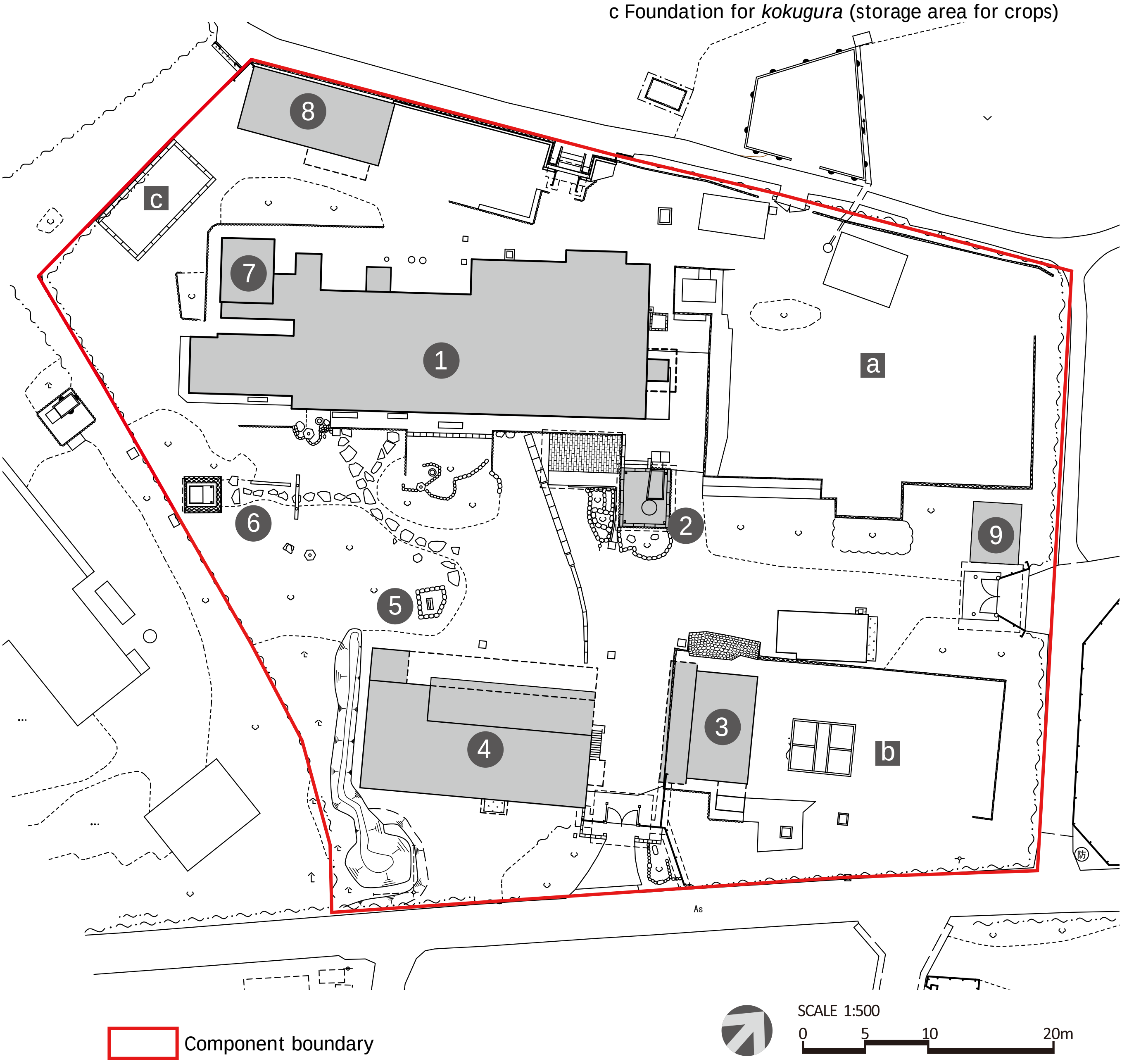

Figure 2-19 S2 Site plan, Tajima Yahei Sericulture Farm

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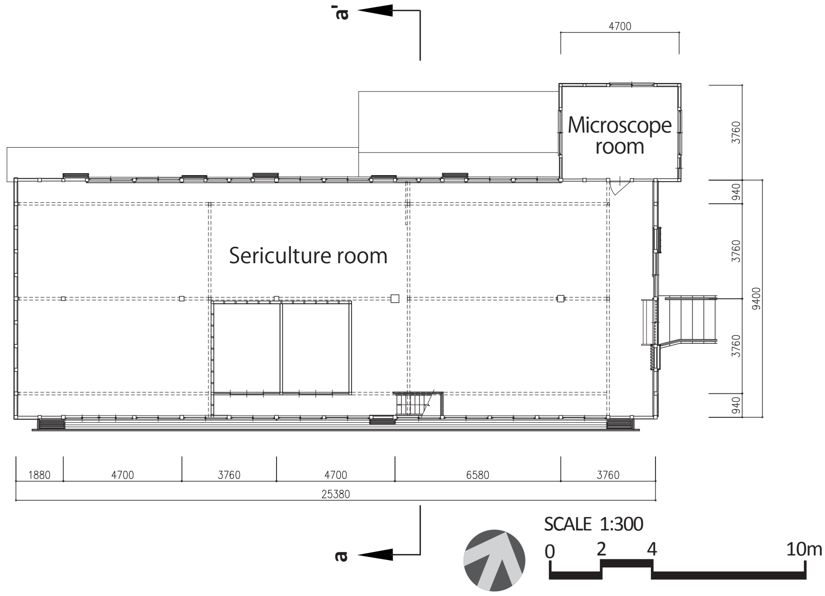
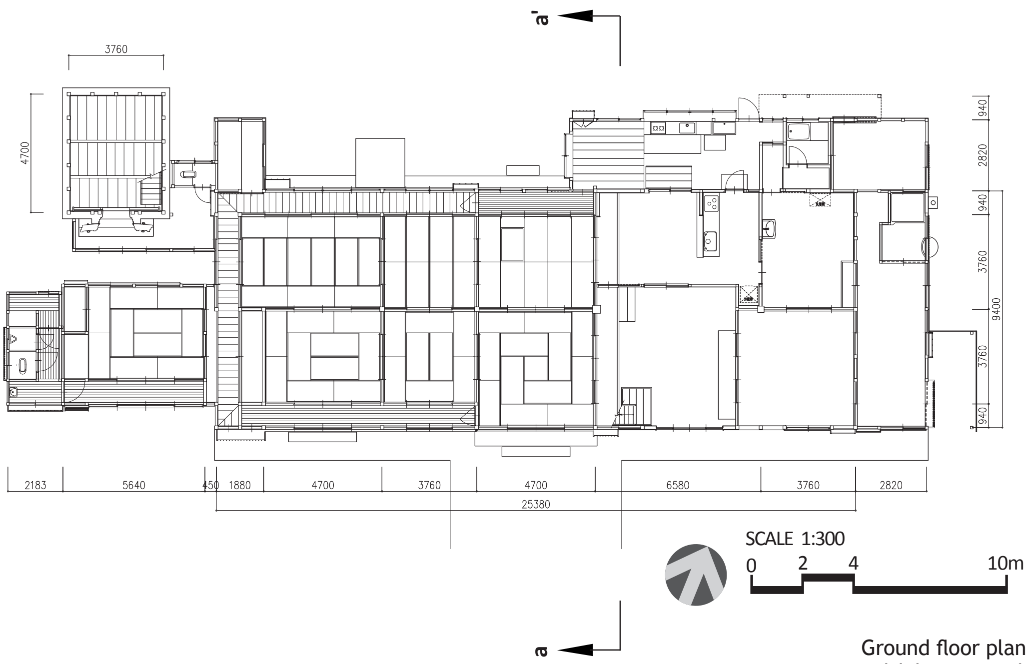


Upper floor plan



Ground floor plan
(Living quarter)

Figure 2-20 S2 Ground and upper floor plans, main building, Tajima Yahei Sericulture Farm

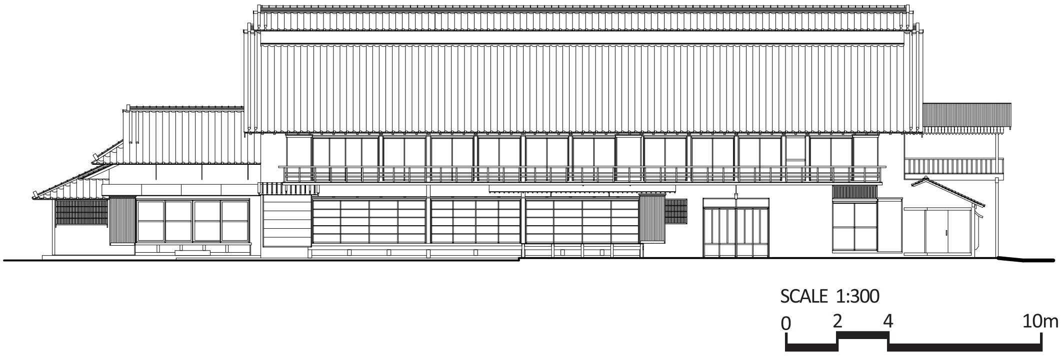


Figure 2-21 S2 Southeast elevation, Tajima Yahei Sericulture Farm

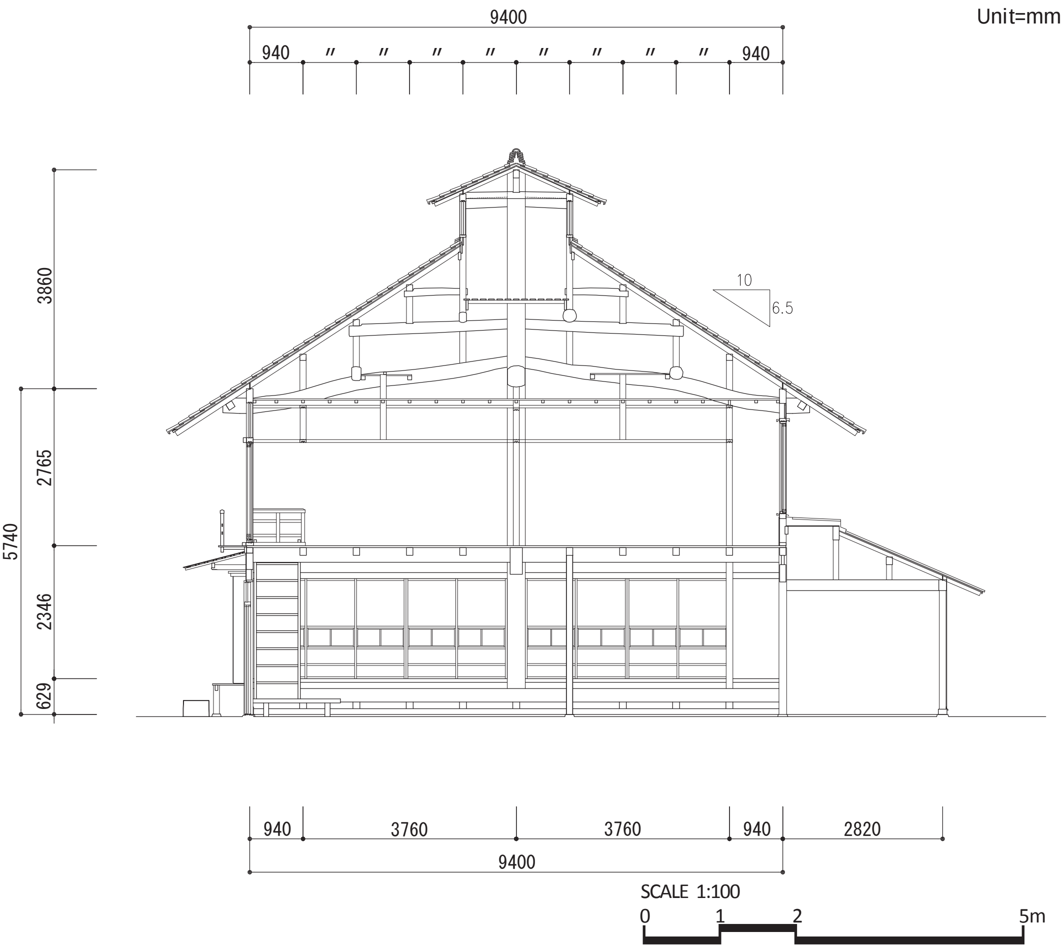


Figure 2-22 S2 Section (a-a'), main building, Tajima Yahei Sericulture Farm

S3 Takayama-sha Sericulture School

- Birthplace of *seion-iku* method, which became the standard in modern Japanese sericultural technology.
- Developed an innovative silkworm-raising room structure used to practice *seion-iku*.
- Established a specialized school for sericulture and successfully spread modern technology throughout Japan and overseas.
- Cooperated with Tomioka Silk Mill in development and dissemination of an improved species of silkworms.

Takayama-sha Sericulture School is located in the outskirts of Fujioka City, on the fluvial terrace at a small valley formed by the Sanna-gawa River. Sericulture had begun in this region in by Edo period.

After Japan opened its doors to the world, raw silk became a major export item and prominent silkworm-raising farms in each region worked on improving cocoon quality and increasing production of cocoons. Takayama-sha was a sericulture school established by Chogoro Takayama,[21] one of the most successful sericulture specialists at the time, to teach *seion-iku*,[22] a method he devised for raising silkworms, which involved careful control of ventilation and temperature. Chogoro Takayama also organized a private sericulture school in 1884. Takayama-sha's students came not only from inside Japan but also from China and the Korean Peninsula. As a result, *seion-iku* became the standard method of sericulture in Japan.

21 Chogoro Takayama (1830-1886)

22 See p.86

Photo 2-24 S3 Takayama-sha Sericulture School

The Takayama-sha Sericulture School includes the farmhouse where Chogoro Takayama lived and also the birthplace of the Takayama-sha. The main building was built by Bujuro,[23] the son of Chogoro and the third president of Takayama-sha, in 1891 as an ideal farmhouse with sericulture rooms specially designed for the *seion-iku* method. From 1887 to 1927 the site was also used as a practical school of Takayama-sha, and featured equipment necessary to implement the *seion-iku* method, embodying the development of modern sericultural technology.

23 Bujuro Takayama (1860-1951) the third president of Takayama-sha Sericulture School

The main building used for sericulture

This farmhouse consists of 2 section, single-story section built in c. 1875, and two-story section added to the east in 1891. The ground floor was used as living quarters and the upper floor for raising silkworms. The construction of the farmhouse with a raised roof for ventilation was derived from Yahei Tajima's teachings. The difference between the Tajima Yahei Sericulture Farm is that there are features, conceived the use of heating devices at the time of construction, to enable the precise management of temperature and ventilation throughout the structure.

This two-story section is of wood frame construction measuring 17.0 meters long, and 7.7 meters wide. It was roofed with wooden boards, but now with tiles. The upper floor was allocated for sericulture rooms facing the south to make good use of the timely winds of the sericulture season (spring-summer). The upper floor was partitioned into six rooms by detachable fittings, and attached by a corridor on the south side that also has detachable fittings.

In order to enhance airflow, the ground floor is elevated and large windows are provided on each floor both in the north and south directions. There are transoms above the full-height windows of the upper floor and three raised roofs structures[24] and windows for ventilation above the ridge of the main roof. Innovative structures can also be seen on the floor and ceiling. There are ventilation openings in the floors where silkworm shelves were set and the ceiling of the upper floor called *komagaeshi* is latticed [Photo 2-27]. The attic was used for mounting of silkworms for cocooning. Furthermore to control temperature, two rooms on the ground floor have floor hearths, and each room on the upper floor has one or two places for situating a brazier, enabling the individual adjustment of temperatures.

24 It is the same facilities as the *koshiyane* at Tajima Yahei Sericulture Farm, but it was called *tenso* at Takayama-sha.

Recent minor alterations to the building in both the interior and exterior are evident, but they do not affect the main structure. It is possible to bring it back to its original condition.

Other buildings

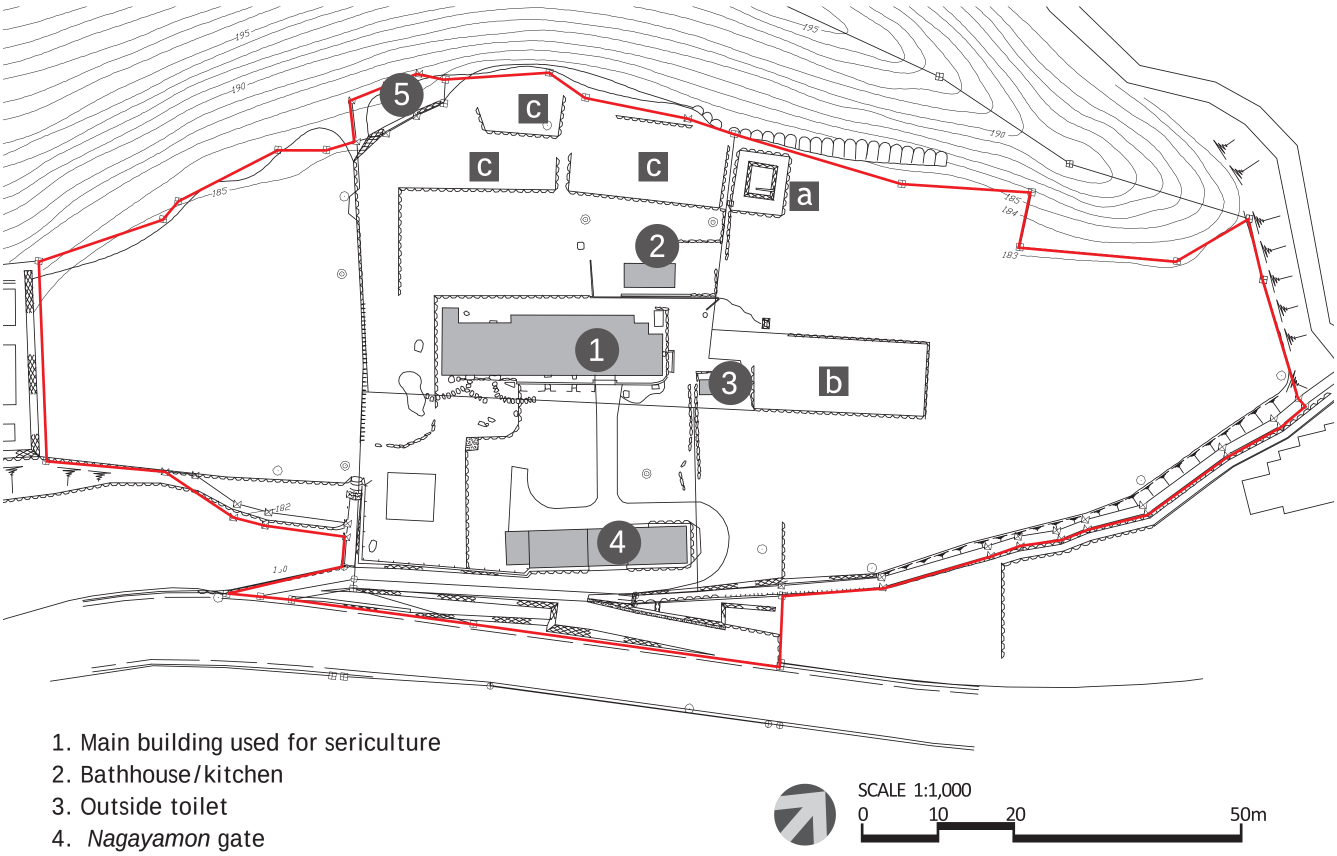
Aside from the main building, the *nagaya-mon* gate, the bath house/kitchen, and the outside toilet remain at Takayama-sha to this day. Furthermore, foundations of lost buildings such as an exclusive sericulture building, and mulberry-leaf storage area and the site of the former mulberry field remain. Locations and scales of structures related to the practical school have been identified through investigation of building foundations and historic documents such as a divination plan and illustrations.

Photo 2-25 S3 View from east, Takayama-sha Sericulture School

Photo 2-26 S3 Interior detail of silkworm shelves and brazier facilities, Takayama-sha Sericulture School

Photo 2-27 S3 Interior detail of latticed ceiling, Takayama-sha Sericulture School

Photo 2-28 S3 Aerial view of Takayama-sha Sericulture School



1. Main building used for sericulture
2. Bathhouse/kitchen
3. Outside toilet
4. *Nagayamon* gate
5. House shrine

a Mulberry leaves storage area
b Foundation for sericulture building
c The remains of the other buildings at the time of practical school

Component boundary

Figure 2-23 S3 Site plan, Takayama-sha Sericulture School

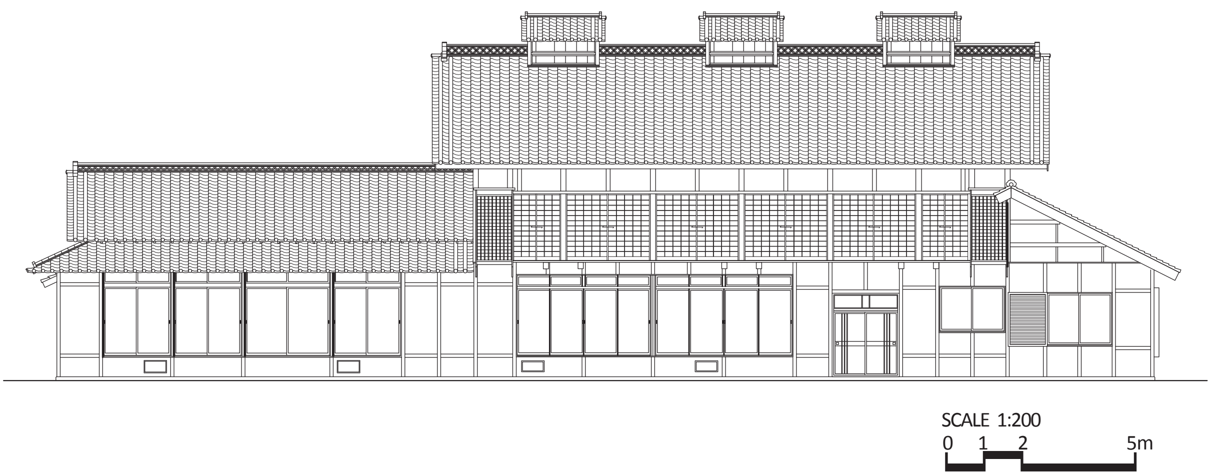


Figure 2-24 S3 South elevation, main building, Takayama-sha Sericulture School

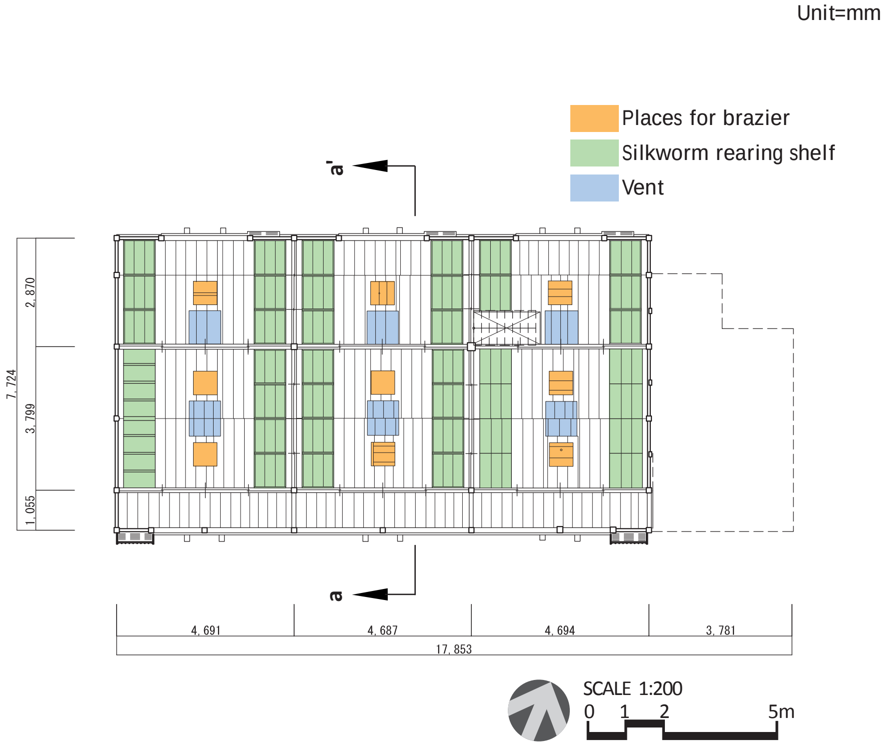


Figure 2-25 S3 Upper floor plan, main building, Takayama-sha Sericulture School

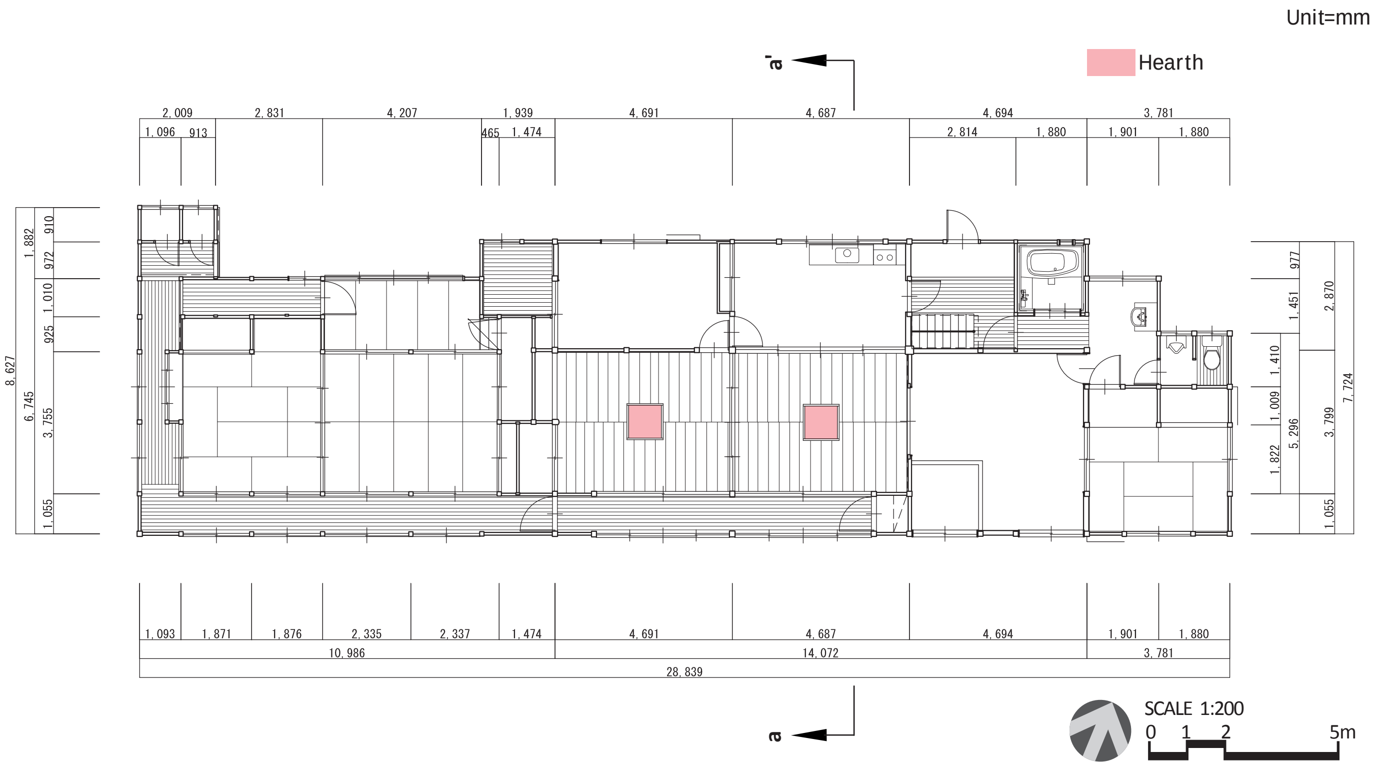


Figure 2-26 S3 Ground floor plan, main building, Takayama-sha Sericulture School

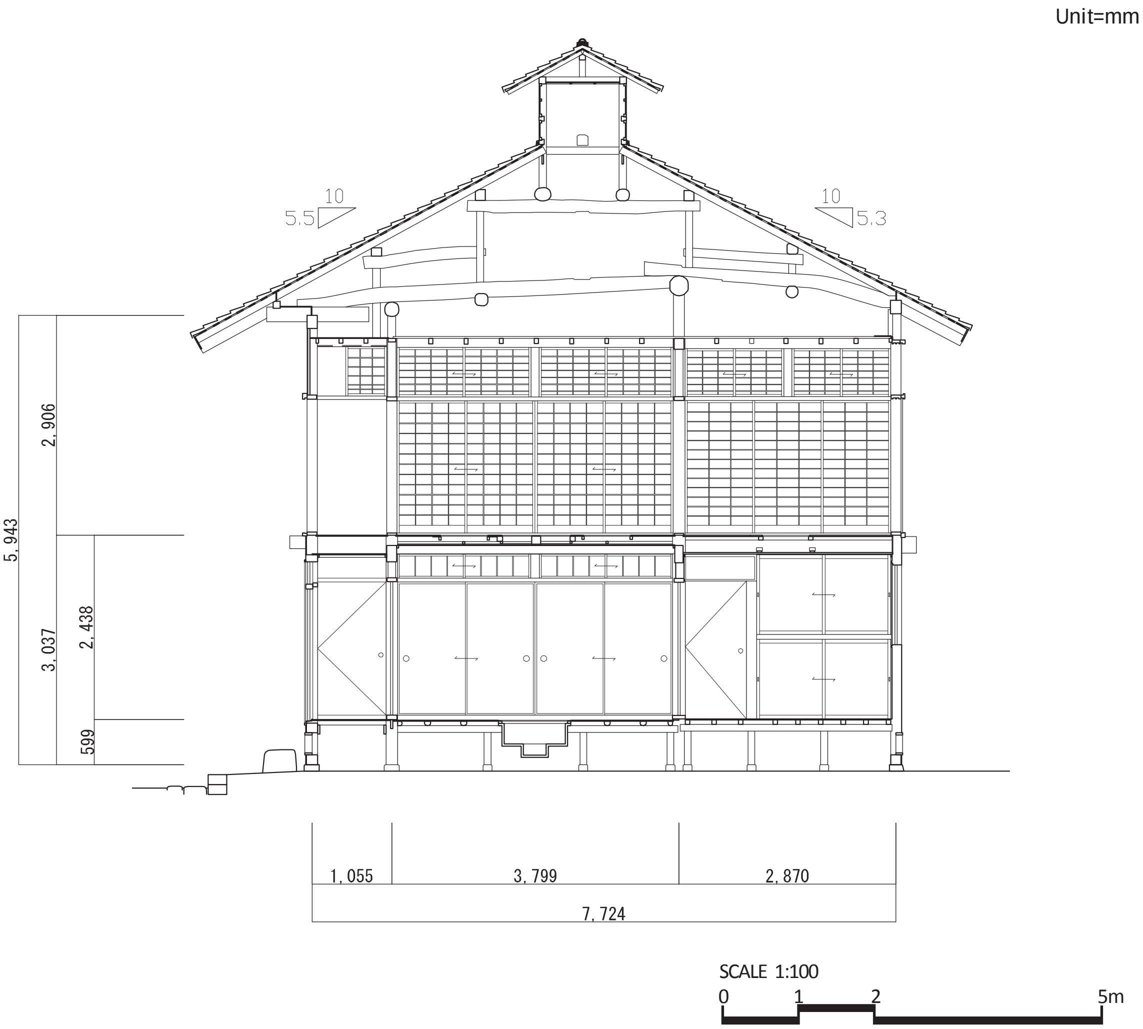


Figure 2-27 S3 Section (a-a'), main building, Takayama-sha Sericulture School

S4 Arafune Cold Storage

- The largest known commercial cold storage facility for silkworm eggs, making use of natural cold airflow
- Representative example of modern storage facilities for silkworm eggs that enabled multiple rearing cycles for increased production
- Cooperated with Tomioka Silk Mill in development and dissemination of improved species of silkworms

Arafune Cold Storage is located 840 meters above sea level in a mountainous region in western Shimonita Town, near the Nagano Prefecture border. This area is topographically formed with exposed plutonic rocks from the Tertiary period. Its masses of rocks collapsed and filled a valley. A leading theory suggests that the cold airflow travels through gaps between rocks and ice stratum that is chilled during the winter season. Arafune Cold Storage employs cold airflow for storing silkworm eggs.

From ancient times, silkworm rearing in Japan has been customarily carried out once a year in spring. By the late 19th century, people learned to control the number of annual rearing cycles by storing silkworm eggs in cold storage where a constant low temperature was naturally maintained, even in the summer, to manage the timing of hatching.

Arafune Cold Storage was the largest silkworm egg storage facility[25] in Japan, capable of storing a volume of 1.1 million sheets of paper on to which silkworm eggs were tightly laid. Originally, there were three cold storage buildings. Foundation walls built along the mountain slope, utilizing stones that had been deposited, formed cellars that supported the wooden-framed upper structures and their heavy earthen walls.

25 See Appendix 5-h

Arafune's founder established this cold storage by first visiting other cold storage facilities already in operation and by cooperating with experts from the fields of meteorology, sericulture, as well as architecture. This brought about success in maintaining constant temperatures in the storage spaces. Methods were devised to alleviate an abrupt change of temperature when eggs were carried out, resulting in a favorable hatching rate.

With clients in 40 prefectures throughout Japan, and even on the Korean Peninsula, Arafune Cold Storage contributed to an escalated production of raw silk by increasing the number of silkworm rearing cycles, particularly to increase summer and autumn yield of cocoons.[26]

26 See p.116, Figure2-43

Photo 2-29 S4 View from northwest, Arafune Cold Storage

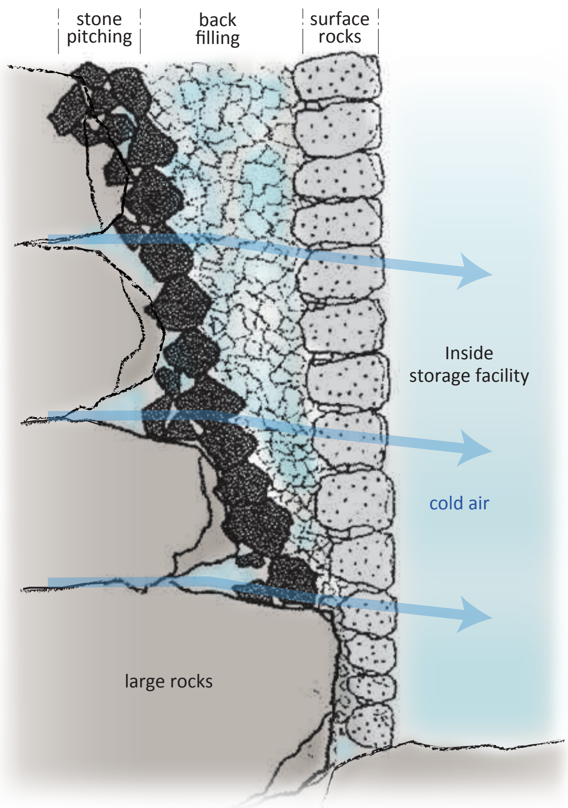
Structure of cold storage

In order the create a sturdy structure and secure passageways for cold airflow, firstly stones about 50 centimeters in diameter (stone pitching) were roughly piled on a mountain slope made of large natural rocks. Then, spaces between those pitching stones on mountain side and stone masonry (surface rocks) that made up the storage facilities were filled with stones of 20 to 30 centimeter diameter (Figure 2-28). Joints in stone masonry facing the valley were sealed from the exterior of the foundation walls to avoid leaks of cold air. Joints in between three storage buildings are not sealed so that cold air can flow. The original buildings consisted of two stories below and one above ground.

In response to the condition of each season, they chose the placement of eggs according to when the eggs were to be shipped out. For example, in the summer and autumn seasons, when there were great temperature differences between the interior and exterior, eggs were first stored at the bottom level, and then eggs were gradually moved to upper floors to adapt to external temperatures in order to maintain favorable hatching rates.

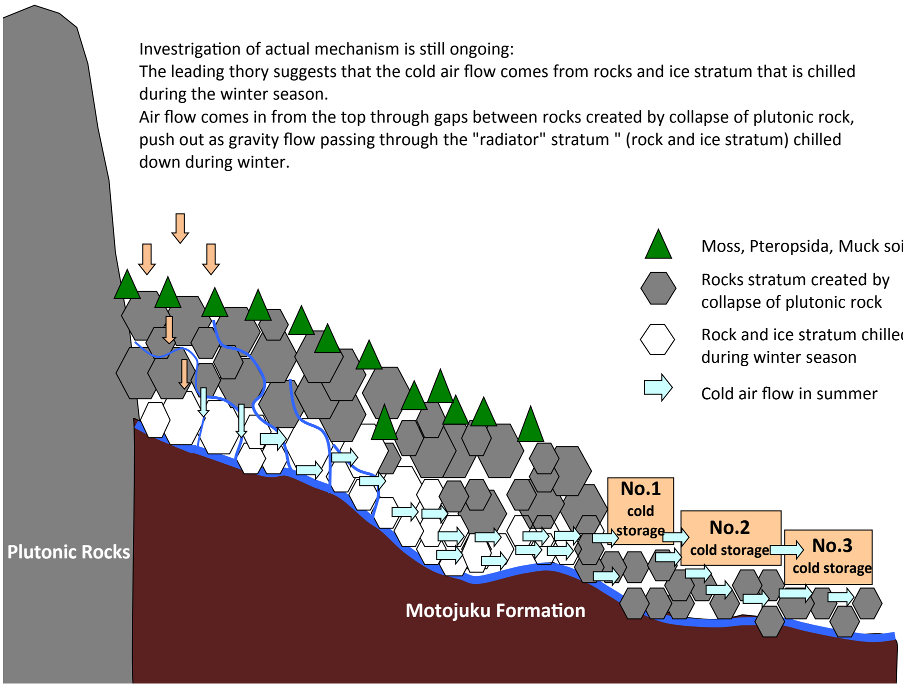
Silkworm eggs were no longer stored from around 1935, and later after World War II, upper structures were torn down, but fortunately the stone foundations were left intact as well as the natural mechanism of circulating cold air that sustains the temperature of two to three degrees Celsius, the same as when Arafune storage was in operation, even during summer to this day (Figure 2-30). The area of the designated Historic Site was delineated in consideration of landform for maintaining this natural mechanism.

Stone foundations of an administrative building next to these cold storage facilities and a passageway linking the buildings are also included within the site boundary.



Section model of masonry structure

Figure 2-28 S4 Section model of masonry structure

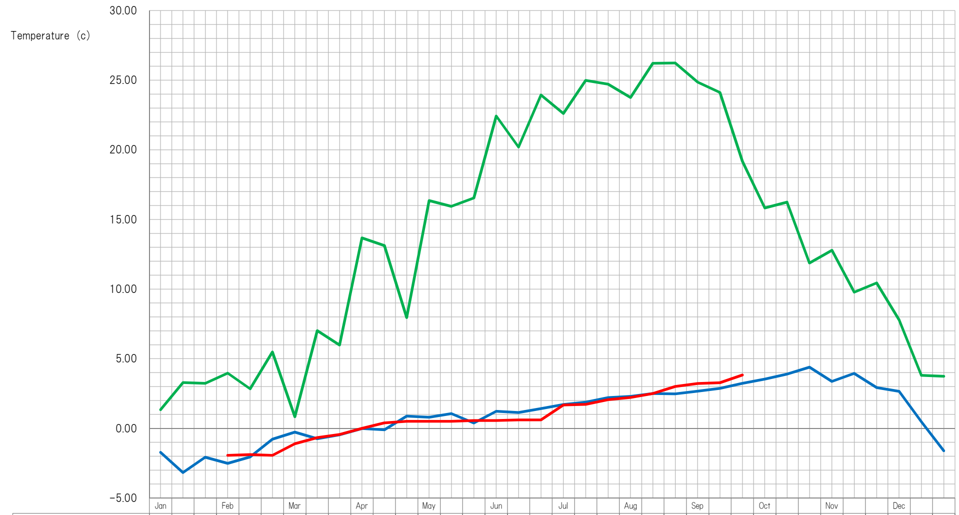


Division of cultural property protection, Shimonita Town Board of Education
Briefing material of cold storage (created in September 21st, 2012)

Figure 2-29 S4 Mechanism of natural cold airflow

Photo 2-30 S4 Reconstruction model of Arafune Cold Storage

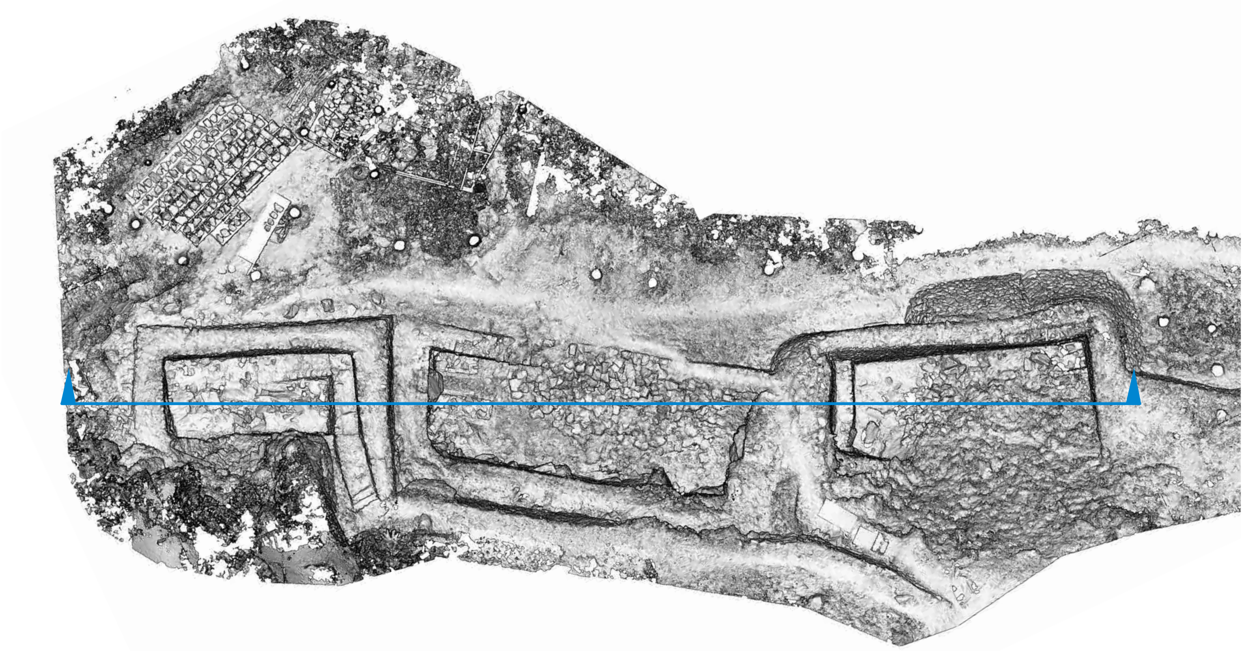
Figure 2-30 S4 Change of temperature throughout the year



	Jan			Feb			Mar			Apr			May			Jun		
Cold Airflow Temp Adjacent area Average 2009-2011	-1.73	-3.18	-2.08	-2.52	-2.05	-0.78	-0.27	-0.75	-0.46	-0.02	-0.11	0.88	0.80	1.06	0.38	1.22	1.13	1.42
Outside air temp. Storage No. 1 Average 2009-2011	1.34	3.29	3.23	3.96	2.84	5.48	0.83	7.01	5.98	13.67	13.12	7.95	16.35	15.94	16.54	22.43	20.20	23.94
Room temp. Storage No. Record 1911				-1.94	-1.89	-1.94	-1.11	-0.67	-0.44	0.00	0.39	0.50	0.50	0.50	0.56	0.56	0.61	0.61

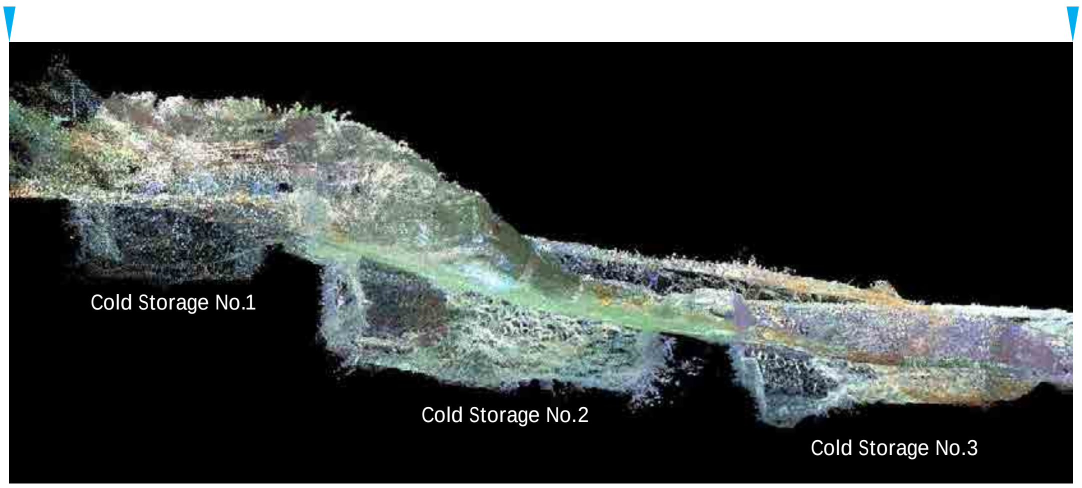
	Jul			Aug			Sep			Oct			Nov			Dec		
Cold Airflow Temp Adjacent area Average 2009-2011	1.71	1.88	2.21	2.30	2.50	2.47	2.67	2.87	3.23	3.53	3.89	4.39	3.37	3.94	2.93	2.65	0.47	-1.61
Outside air temp. Storage No. 1 Average 2009-2011	22.61	24.98	24.71	23.76	26.21	26.24	24.86	24.12	19.18	15.83	16.24	11.87	12.78	9.78	10.44	7.79	3.81	3.74
Room temp. Storage No. Record 1911	1.67	1.72	2.06	2.22	2.50	3.00	3.22	3.28	3.83									

Photo 2-31 S4 Cold airflow at Arafune Cold Storage, No. 1, June 21, 2011



Plan : Orthographic image
Post–processed orthographic image showing a plan of three foundation stone walls of the Cold Storage.

Figure 2-31 S4 Plan, Arafue Cold Storage



Profile: Point-cloud-data image
Point cloud data acquired by a laser scanner showing longitudinal section of the cold storage. The processed image displays all cloud points acquired from the profile line.

Figure 2-32 S4 Profile, Arafune Cold Storage

Cold storage No.1

Cold storage No. 1, constructed from 1905 and operational from winter of 1906, is 9.7 meters long, 4.1 meters wide, and 3.4 meters high at the northern stone wall. A loading slope approximately 1.2 meters wide, is set against the inside of the eastern stone wall that connects to another slope along the northern stone wall. The southern side of the stone wall partially collapsed in 2010. Investigation for restoration is underway. The eastern, northern, and western stone walls are in good condition.

Cold storage No.2

Cold storage No.2, completed by 1908, is 15.9 meters long, 5.6 meters wide and 4.5 meter high and the northern stone wall. The western stone wall from which cold air emanates is connected to the bottom of the eastern stone wall of cold storage No.1 (Figure 2-32). The east, south, and west stone walls are in good condition, while the center of the north wall is collapsed inward.

Cold storage No.3

Cold storage No.3, which was built by 1914, is 13.2 meters long, 5.0 meters wide, and 4.5 meters high at the northern stone wall. The east and west stone walls are in good condition. Two-thirds of the eastern section of north wall was reinforced sometime before 1920. The south wall is partially collapsed, but other parts of the wall are in good condition.

Site of the administrative building (*bansha*)

The administrative building was built on flat land to the south of cold storage No.3. It was a single-story wooden building with dimensions of 9 meters wide and 4.5 meters long. In establishing cold storage No.1, a private telephone line was laid between the "*Shunju-kan*" office, located approximately 7 kilometers away, and this administrative building.

Despite being rebuilt, the final building was demolished in the 1950s. The masonry and a reservoir for storing water for this building are all that remain now.

2.b. History and Development

(i) Background of the Tomioka Silk Mill and Related Sites

(i)-1 Development of the global silk industry

The origin of silk production

Silkworm breeding and silk production started in China around B.C. 3,000. Chinese raw silk and silk fabric were introduced to Europe via the Silk Road, and the most remarkable trade relation was the one between the Roman Empire and the Han Dynasty from around the time of the birth of Christ. Silk was highly esteemed in the Roman Empire, accelerating trade with China. The name of the Silk Road is derived from such history.[27]

Sericulture and silk-reeling technology were introduced to Japan around the time of the birth of Christ. They were introduced to the Byzantine Empire around 6th century B.C., but this did not lead to the establishment of industries including mulberry leaf cultivation or silkworm breeding. The full-scale dissemination of sericulture and silk-reeling techniques took place from the 8th century onwards by a route via the Islamic Empire, which covered Central Asia to North Africa. This route played a role in spreading sericulture and silk-reeling technique to Sicily in the 10th century and then southern Italy. It spread slowly in the Italian peninsula during the 13th-14th centuries. On the other hand, silk production technology was brought to Spain, then to Portugal through North Africa in the 13th century, and became a major industry of the country.

27 or details on history described in (i)-1, refer to the report by Koinetwork in Appendix 5-d

In the medieval period, the demand for silk among kings, feudal lords and clergymen became great. Sericulture and silk-reeling techniques spread from south to north together with the development of agricultural technology. Consequently, it spread to France in the 15th-16th century and by the 17th century an industrial center of sericulture and silk-reeling had formed in France and Italy.

The appearance of silk-mills in Europe

Along with sericulture, silk-reeling techniques introduced from China to Europe were firstly hand reeling and then foot-operated reeling equipment developed in China around the 13th century. Mid-16th century Europe saw the development of the division of labor in the silk-reeling industry, and a new production model known as silk mills developed in the 18th century. Furthermore, at the beginning of the 19th century, steam powered silk-reeling factories appeared and spread into various parts of Europe from France and Italy. A notable shift in the silk-reeling industry from small-scale production in farming households and farming villages to mass-production through factory system occurred. The trade of raw silk produced in Europe in the international markets flourished.

Factory production of raw silk in Europe required an increase in cocoon production, so silk farmers in Europe were forced to raise large amounts of silkworms in limited spaces. However, along with the use of home-propagated silkworm eggs, this resulted in the diffusion of various silkworm diseases and particularly pebrine in the

1850s. The demand for silk fabric in Europe had been increasing steadily since the industrial revolution, but the diffusion of pebrine forced the industry to rely on importing raw silk from Asia to make up for damage to production. Even though Italy recovered from pebrine after Pasteur developed a way to eradicate this disease in 1870, sericulture in France remained on the decline. Therefore the volume of raw silk imported from Asia had continued to increase.

Return of silk-reeling technology to Asia

To cope with demand in the late 19th century, Europe sought to increase raw silk production by introducing machine silk-reeling technology and the factory system to China, India, and Japan, the major raw silk production countries in Asia. With this, Asia, which had brought silk-reeling manual to Europe, was now receiving it in the form of mechanized silk-reeling technology. [Figure 2-33]

The East India Company began building modern silk-reeling factories in India in the late 18th century, and by the late 19th century, many silk-reeling factories had been established in the Bengal region. However, the quality of locally-produced cocoons made them difficult to use with machine-reeling, and eventually there was an outbreak of pebrine. As a consequence, machine-reeling factories were unsuccessful in India.

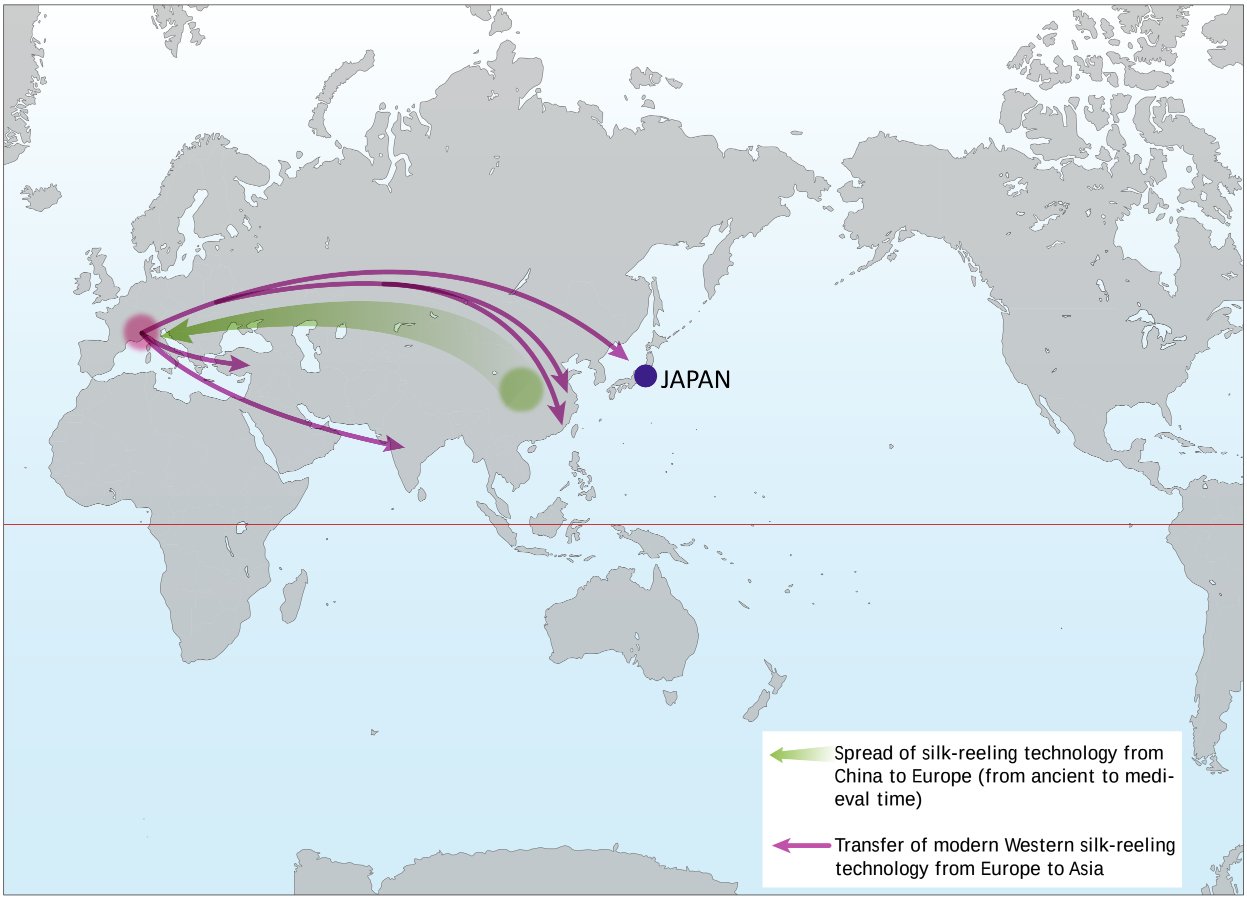


Figure 2-33 Map indicating technology transfer from Europe to Asia (modern Western silk-reeling technology)

In China, a British company established a silk-reeling mill in Shanghai in 1861, and by the 1870s, factories had been built by the British, Germans, and French in Shanghai and Guangdong. The majority of factories in China were foreign owned and even if they were Chinese owned businesses, management of the factory was often outsourced to operators and those contracts were renewed annually. These circumstances worked to prevent Chinese operators from developing modern machine-reeling techniques imported from Europe in their own way. Under the circumstances, the first factory in Shanghai was closed down in a short time, and subsequent factories did not develop smoothly.[28]

28 Kiyokawa 2009

In Japan, on the other hand, silk-reeling and sericulture expanded greatly. For details on the expansion of the Japanese industry, refer to (i)-3 of this chapter.

(i)-2 The silk industry in Japan to modern times

Start of silk production in Japan

Sericulture was first introduced to Japan around the time of the birth of Christ. A Chinese history scroll notes[29] the receipt of Japanese silk fabric as a gift from Japan's king in 239, showing that silk production in Japan had already started in the 3rd century.

29 "Sangokushi (Annals of the Three Kingdoms) Gisho"

In the Nara period (710-784) and Heian period (794-1192), the Imperial Court encouraged the sericulture industry to pay tax in silk yarn and fabric. Consequently, sericulture, silk-reeling, and silk textile production spread in Japan during the 8th to 12th centuries, and the present day, Fujioka City and Kiryu City area became known as a silk-producing region in Gunma Prefecture. However, the quality of domestically-produced silk was not particularly high and high-quality raw silk and silk fabric had to be imported from China.

Silk started to become popular among the new ruling classes including samurai and wealthy classes such as affluent merchants in the Kamakura period (1192-1333) and Muromachi period (1392-1573), and large amounts of raw silk and silk fabric from China were brought to Japan by European trading ships when trade with Europe started in the 16th century.

High-quality silk from China called *shira-ito* or white thread occupied 75% of the total amount of imports during the early Edo period (1603-1867), putting a strain on the balance of trade. This caused the shogunate[30] to limit imports of *shira-ito* from 1685. Taking this as an opportunity, the production of raw silk in Japan increased and the sericulture industry expanded from the Kinki region to the Kanto and Tohoku regions to form a sericulture region on Japan's main island after the shogunate used domestically-produced silk and set forth sericulture promotion measures in 1713.

30 The regime that governed Japan during the Edo period

Tomioka Silk Mill was later built in Gunma Prefecture, where two-thirds of the land is mountainous and volcanic ash land is abundant, making many areas unsuit-

able for rice farming. As a result, many farmers took advantage of the shogunate’s incentive to produce raw silk domestically and expanded into sericulture and silk reeling as a side job for some extra cash income.

Improving sericulture methods

As sericulture flourished throughout Japan, sericultural methods which had previously bred silkworms in a natural state were improved and many sericulture treatises were published to provide instructions on rearing methods. Rearing methods using heating power started at the beginning of the 18th century, when in *Kaiko Yoiku Tekagami* [The Sericulture Manual], by Shigehisa Baba of Gunma Prefecture recommended ways of keeping silkworm rooms warm by using heat in conjunction with paper partition,[31] particularly on cold days. In the mid-18th century several rearing methods were developed from experience to accommodate climates in each region such as methods called *tennen-iku* that make use of natural environment, methods that vigorously warm silkworm rooms, and methods that warm up silkworm rooms only on cold days called *setchu-iku*.

31 A partition made of paper placed inside a silkworm room like a curtain to keep the room warm

Scientific knowledge had been used for sericulture by the late Edo period. In 1849, Zen’uemon Nakamura authored *San-tokei Hiketsu* [Treatise Using Thermometer for Sericulture], and developed modern temperature management methods using a *san-tokei* (silkworm thermometer). Following that, a method called *ondan-iku* to breed silkworms at a warm temperature using a thermometer and heating devices became popular in the Tohoku region which has cold climate.

As the practice of using part of the upper floor of farmhouse as a silkworm rearing room in order to expand sericulture management began, so did the emergence of two-story farmhouses built specifically with the entire upper floor devoted to silkworm rearing.

Furthermore, in regard to silk-reeling technology, the Joshu hand-reeling device using gear wheels and the Oshu hand-reeling device using belts were invented in the latter half of the Edo period, leading to improvements in the quality of silk and the speed of silk-reeling.

By the late 19th century, the time immediately before Japan opened its doors to trade with the outside world, sericulture and silk-reeling techniques had developed to an advanced level, owing to these technological innovations that began in the 18th century. This resulted in high-quality silk fabric production areas, such as Nishijin in Kyoto and Kiryu in Gunma, as well as general-use silk fabric production areas appearing in various regions. The Japanese silk industry had reached the level at which its cocoons, raw silk, and silk fabric were widely distributed.

(i)-3 Development of the modern silk industry through mutual exchange between Japan and other countries

Opening of Japanese ports

Japan emerged from self-imposed isolation and began trading with other countries in 1859. The country's exports were mainly raw silk, accounting for 65% of total export value of Yokohama Port in 1860, a year after ports were opened. Yokohama was the predominant outport of Japan at the time. This increased to 80% or more after 1862. At that time, an outbreak of pebrine spread throughout Europe, devastating sericulture on the continent and resulting in a high demand for Japanese raw silk.

On the other hand, the export of silkworm eggs had been prohibited soon after the ports were opened, but this prohibition was lifted in 1864, and exports to Europe soared. However, they dropped dramatically from 1877 after Pasteur developed a way to eradicate pebrine in 1870.

Introduction of silk-reeling machine

As raw silk exports dramatically increased after the ports were opened, the overall low standard of Japanese raw silk was noticed overseas due to the large quantities of inferior products that had been rushed to export. Because of this, it became necessary for the Meiji government, which had taken over from the Shogunate in 1868, to gain the trust of its export partners by improving the quality of raw silk, Japan's principal export product. The new government refused offers from various foreign countries to construct silk-reeling factories with foreign capital. To protect its economic independence, constructing modern silk-reeling factories with domestic capital became an urgent task for the government. The Maebashi clan[32] invited experts from Switzerland to construct Japan's first hydraulic-powered machine-reeling factory in present day Maebashi, after which several small-scale machine-reeling factories were constructed. Maebashi in Gunma Prefecture had been a silk-producing region from the Edo period. However, these silk-reeling factories were all small-scale, insufficient as modern factories. Therefore, the Meiji government constructed Tomioka Silk Mill (S1) as a large-scale, national model with state-of-the-art facilities in 1872.

32 The local government that governed the area around present day Maebashi City, Gunma. The government transferred to Gunma Prefecture in 1871.

The Meiji government expected factories modeled after Tomioka Silk Mill to be built one after another across Japan and technicians and female workers who trained at Tomioka to return to their respective regions as instructors in machine-reeling techniques. This aim was widely accepted by entrepreneurs and small and mid-scale factories were established nationwide.

In Nagano Prefecture, which later became one of the central sericulture regions, numerous reeling mills were built concentrating mainly in the Suwa region. Here, French reeling technology from Tomioka Silk Mill was adopted as the base and Italian techniques were adopted in part, developing a new method that enabled building construction and facilities installation at low costs. This method spread throughout Japan as Suwa-style mechanical reeling. Factories in each region were

built by local governments or entrepreneurs, and adaptations were made to the original model of Tomioka Silk Mill through unique approaches. They simplified the architecture, motive power, and machinery in line with Japanese technical standards and added some ingenious alterations.

Though private mechanical reeling factories were mostly small-scale at the time of establishment, after having experienced rise and fall of the industry, rapidly developed and giant companies such as Katakura Reeling made their appearance in the 20th century.

Meanwhile, there were farmers engaged in traditional *zaguri* manual-reeling that formed filature cooperatives and succeeded in improving product quality by adopting a broad range of modern techniques, in addition to those for silk-reeling itself, such as processing and preservation of cocoons or methods for sorting and finishing raw silk.

Establishment of modern silkworm-raising methods

The increased demand for raw silk after the opening of the ports meant that sericulture farmers had to improve the quality while increasing the quantity of cocoon production. The most famous example being Tajima Yahei Sericulture Farm (S2) , built in 1863.

This silkworm-raising farmhouse designed by Yahei boasted an innovative structure incorporating a ventilation system that made use of natural wind to facilitate the new *seiryo-iku* sericulture technique aimed at stabilizing cocoon production. This farmhouse became the prototype for modern silkworm-raising farmhouses.

Yahei Tajima authored *Yosan Shinron* [New Theory of Sericulture] in 1872 to help spread the use of *seiryo-iku* by silkworm-raising farmhouses. When the construction of the silk mills and mass-production of raw silk led to a shortage of cocoons, farmers responded to this by introducing modern silkworm-raising farmhouses modeled after Tajima Yahei Sericulture Farm and the modern *seiryo-iku* sericulture method making use of silkworm-raising rooms in an attempt to increase production and improve the quality of cocoons.

Seiryo-iku was the first modern sericulture method to spread throughout Japan based on a publication.

However, there was a limit when it came to improving ventilation in less windier regions or colder regions where temperature control was needed. Thus, in the 1880s Chogoro Takayama developed the innovative *seion-iku* sericulture method. This method combined the strengths of the *ondan-iku* method, which uses a thermometer and heating devices to control temperature thermally, and the *seiryo-iku* method, which controls humidity by a ventilation system.

To diffuse the method, he established Takayama-sha in 1884 as the first specialized school for sericulture in Japan. In 1891, Chogoro's son built a model silkworm-raising farmhouse for effectively implementing the *seion-iku* method and used this for practical training at Takayama-sha(S3). More than 20,000 students from Japan studied at Takayama-sha and international students from China, and the Korean Peninsula also enrolled. As a result, *seion-iku* spread throughout Japan and became the standard sericulture method in Japan at the end of the 19th century.

Increasing the number of annual rearing cycles

Together with the advances of sericulture technology, research on techniques in using natural cool wind to store silkworm eggs in cold storage and adjust the incubation period was carried out to achieve multiple rearing cycles.

In 1904, when Senju Niwaya, who studied at Takayama-sha, focused on cold air-flowing out in the vicinity of his residence in Shimonita Town, his father, Seitaro Niwaya, decided to build a silkworm egg storage facility and in 1905, assembled the latest sericulture, meteorological and architectural technologies in building the Arafune Cold Storage (S4).

The hatching rate of eggs stored at Arafune Cold Storage was excellent because of its structure which ensured that there were little changes in temperature throughout the year and moderated temperature changes in the silkworm eggs when entering and exiting the facility. Arafune Cold Storage had the largest storage capacity of silkworm eggs in Japan and made use of modern communications and transport technologies, such as railway and telecommunications to take orders for silkworm egg storage from 40 prefectures in Japan and the Korean peninsula. Accordingly, it enabled the expansion of sericultural production in the summer and autumn and ensured, a large supply of cocoons in Japan.

World’s top exporter of raw silk

Due to the efforts of those involved in Japanese sericulture and silk reeling and the promotion of silk production by the new government, Japanese raw silk production increased steadily over half a century and, by 1909, Japan was the world’s top exporter of raw silk.

When trends in silk fabric production shifted from figured fabric to plain fabric from the late 19th century, production by power loom increased. Consequently, by the end of the 19th century the bulk of silk fabric production shifted to the United States which had built a mass production system by power looms, and Japan found itself exporting more than 80% of its raw silk trade volume to the United States.

By the end of World War I, silk manufacturing in the United States expanded rapidly and brought silk products within the reach of working class people. Notably, the increased demand for silk products was not only due to the booming economic conditions, but also to the fact that a greater number of women had taken jobs outside the home after the war. Traditional long dresses became outmoded, in favor of simpler, easy-to-wear silk clothing. Shortened skirt and silk stockings were in demand.

Thus, raw silk exported from Japan to the U.S. significantly contributed to the diversification of fashion culture changing silk from a material for garments worn by the affluent class to garments worn by the masses.

Sales of Japanese raw silk grew to occupy 80% of the world market by the 1930s. Therefore, the distribution of influence in the global export of raw silk, which had previously been a competition between Japan, China, and Italy, shifted exclusively to Japan.[Figure 2-34, 35]

Column

<<Excerpts from Articles describing Popularization of Silk>>

“What I heard from an upper-class American lady on my visit to the country seven years ago (note: refers to 1899) was that they wear woolen under-shirts before putting on another under garment, something like what we call juban, usually made of thin woven cotton. However, today (note: refers to 1906), most people wear thin silk underclothing made of either Japanese habutae silk fabric or a similar material woven with raw silk imported from Japan and then wear underwear called “skirt.” Thicker silk fabric for outer garments used to come from Lyon, but is now produced in the United States. Silk textiles, whether thick or thin, all use Japanese silk as warp.”

Kentaro Kaneko “On the Silk Reeling Industry,” from Dainihon Sanshi Kaiho (Great Japan Silk Journal), Vol. 167, April 20, 1906, p4

“By the early twentieth century, Japan dominated U.S. silk imports, selling most of her output to America. Without this enormous, dependable source of raw silk, American industrial-scale silk manufacturing would never have been possible.”

“American silk manufacturing expanded rapidly and brought voluminous quantities of silk goods within the reach of more middle- and moderate-income consumers than ever before in history.”

Jacqueline Field et al, “American Silk 1830-1930,” Texas Tech University Press, 2007, ppXXI-XXII (Introduction)

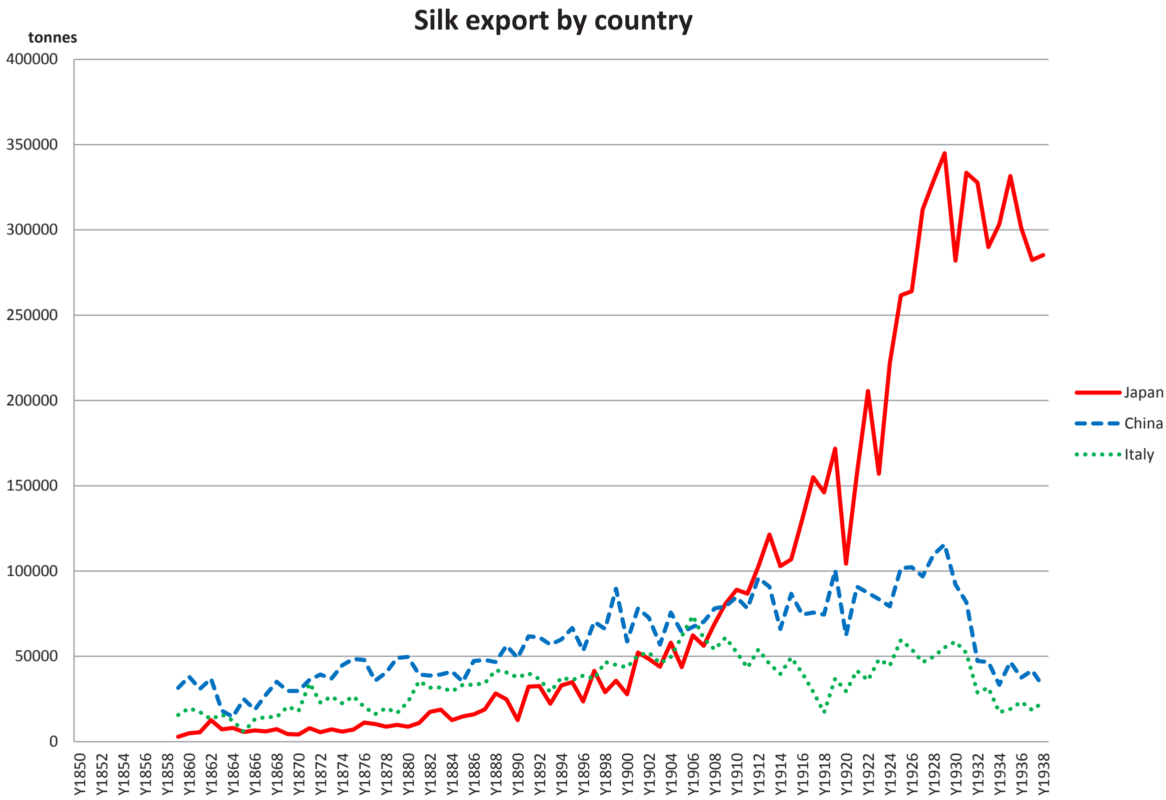


Figure 2-34 Comparison of raw silk exports, Japan, China, Italy (1850-1940)

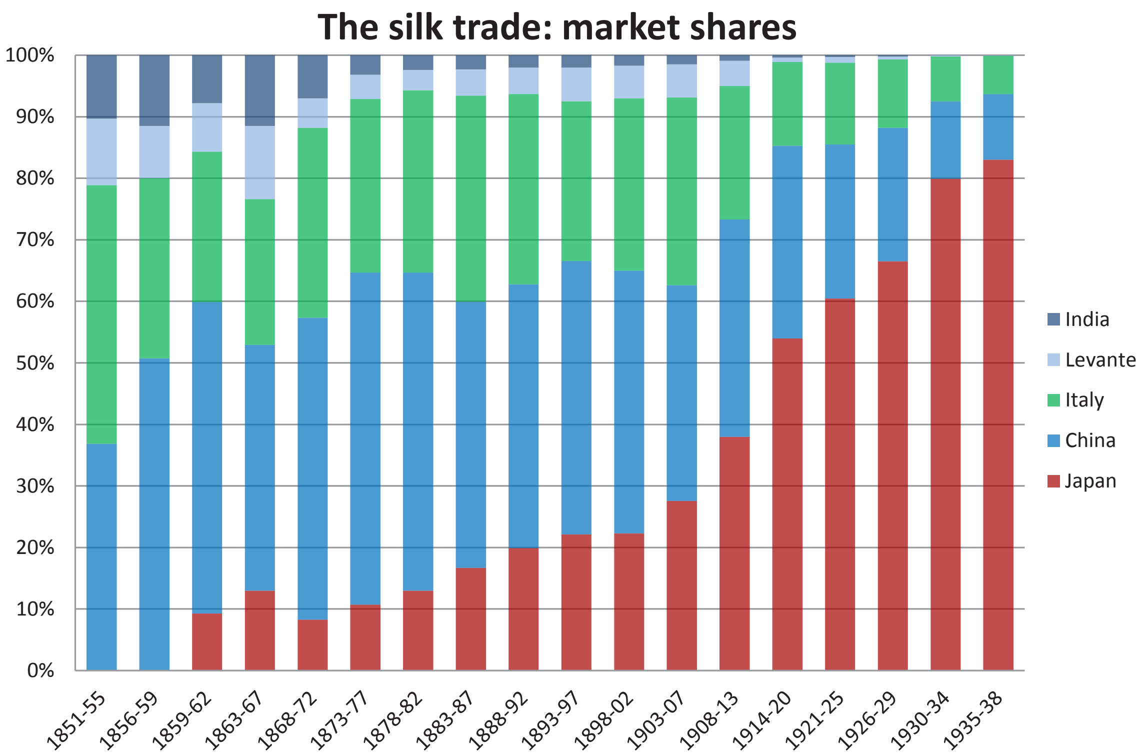


Figure 2-35 The silk trade: market shares (1851-1938)

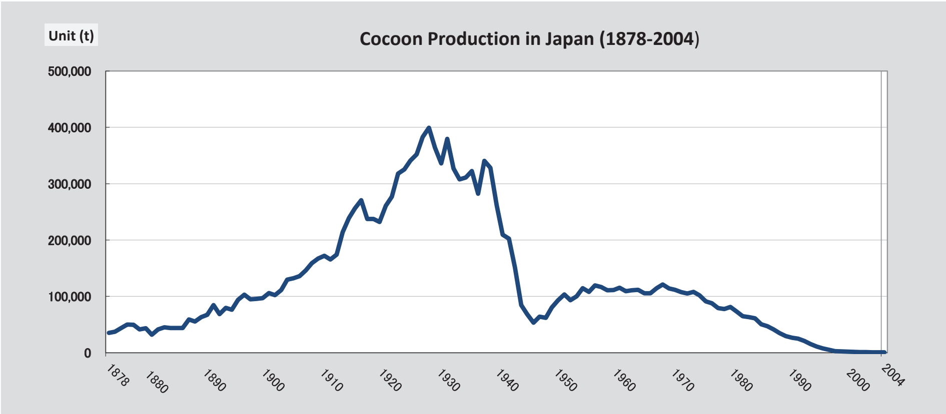


Figure 2-36 Cocoon production in Japan (1878-2004)

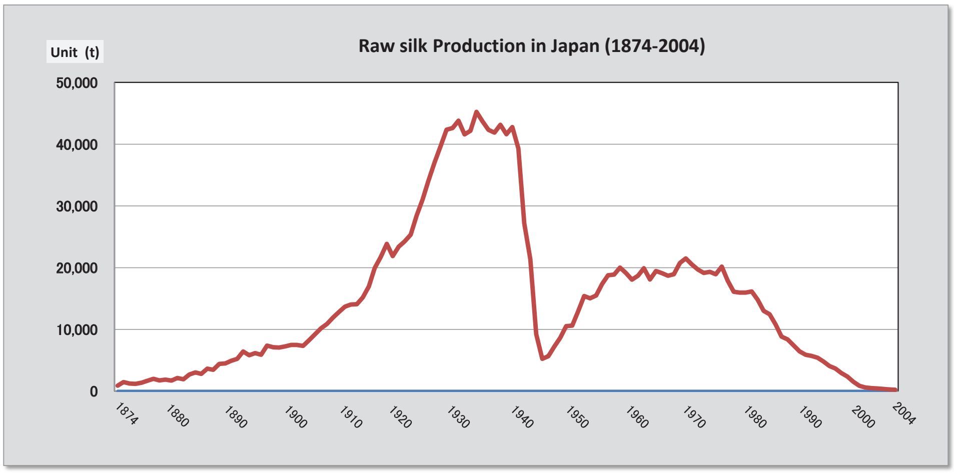
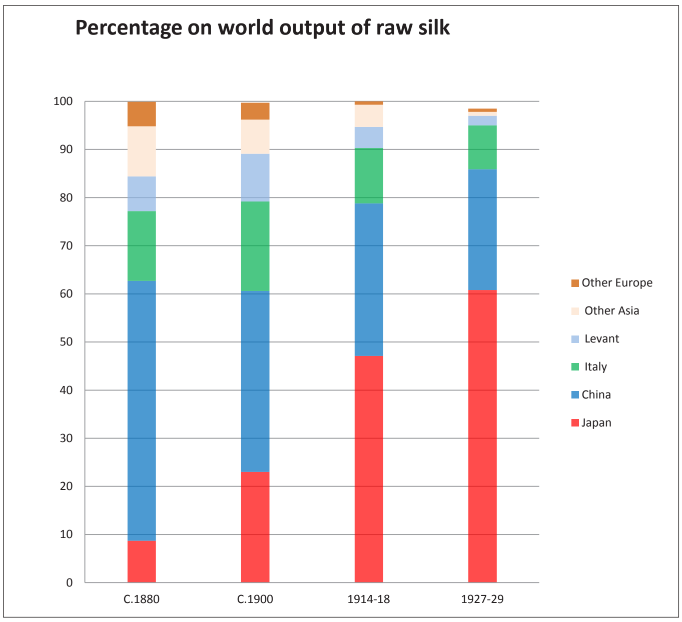


Figure 2-37 Raw silk production in Japan (1874-2004)



Charts (Figure 34, 35, and 38) are produced using the data made available in the monograph "An economic history of the silk industry, 1830-1930." [Fedelico 1997]

Figure 2-38 Percentage on world output of raw silk (c. 1880-1929)

Technological innovation in sericulture and silk-reeling

Such Japanese success was brought by achievements in technological innovation for efficient production with low-cost facilities through the improvement of machine-reeling technology introduced from Europe. It was also the result of innovating sericultural technology to materialize the mass-production of high-quality cocoons at a low price. The most typical example of collaboration between sericulture and silk-reeling is one centered on Tomioka Silk Mill with sericultural farmers, that is, the nominated property.

Tomioka Silk Mill, established in 1872 by the government, was privatized and transferred its business to the Mitsui in 1893. It was transferred again to the Hara Partnership Corporation in 1902. The Hara Partnership led efforts in Japan to standardize cocoons and develop the F1 hybrid as a quality improvement measure. Hara entered into contracts with influential silkworm-raising farms such as Takayama-sha and the Tajima farm to deliver particular varieties of silkworm eggs and buy cocoons in bulk. Until then farmers had less direct relationship with plants. Hara also endeavored to improve the quality of cocoons by entrusting the experimental raising of foreign breeds to Takayama-sha and the Tajima family. Arafune Cold Storage was used as the facility to store such silkworm eggs.[33]

33 According to Dainihon Sanshi Kaiho published on April 1st, 1917, collaborative efforts made by Hara-Tomioka Silk Mill sericulture improvement department together with Yahei Tajima, Chogoro Takayama of Takayama-sha and Seitaro Niwaya of Arafune Cold Storage were regarded highly for making a substantial contribution to the practical application of F1-hybrid technology of genetic improvement on silkworms.

In addition to taking initiative to improve silkworm-raising, Tomioka Silk Mill contributed in technological advancement to produce high-quality raw silk systematically by introducing the automatic cocoon dryer and the Minorikawa-style multi-end reeling machine developed in the 1920s. The mill once again became the model for silk mills throughout Japan.

Raw silk exports stopped with the outbreak of World War II, and the production, distribution, and pricing of raw silk became subject to control by the "Sericulture Industry Control Law." As the war prolonged, silk mills were converted to ammunition factories one after another, and mulberry fields were used to produce food. Tomioka Silk Mill became one of the last two silk reeling mills in the country at that time. Therefore, raw silk production in Japan shrunk to about one-tenth of pre-war output in 1945.

At the end of World War II, the sericulture and silk-reeling industries sought a speedy recovery based on hopes for exports. The silk-reeling industry succeeded in practical use of automatic reeling machines and automatic cocoon boiling machines. Those innovations contributed to improve productivity greatly, and responded to competition with raw silk imported from overseas and synthetic fiber such as nylon. It also helped the industry to cope with rising labor costs due to Japanese economic growth. The Katakura Silk Reeling and Spinning Co., Ltd., which managed Tomioka Silk Mill from 1938, started the practical operation of automatic reeling machines at Tomioka Silk Mill in 1952 and became one of the pioneers of automatic reeling.

In the sericulture industry, on the other hand, agricultural cooperatives played important roles after the war. The cooperative rearing of young silkworm and exclusive silkworm-rearing buildings in line with the popularization of an efficient feeding method[34] were spread via such the cooperatives. These enabled silkworm-raising farmers to stably produce large quantities of cocoons at a low cost.

34 The method called *Joso-iku*: A method of feeding silkworms mulberry leaves on branches. Compared to the traditional method of picking leaves off branches and chopping into small pieces before feeding, much less labor was required of the silkworm farmers.

COLUMN

<<Development of the F1 Hybrid Silkworm>>

The Japanese natural scientist, Kametaro Toyama (1867-1918), was the first scientist in the world to prove the advantage of F1 hybrids in the animal kingdom as well as plant kingdom: only F1 hybrids inherited the superior traits of parents. Toyama announced in a 1906 paper the results of experiments proving that Mendel's laws of heredity applied also to silkworms, and this research was highly acclaimed all over the world. It was proven that thread made with cocoons produced by F1 silkworms is better in quality and quantity. The Japanese government established a National Silkworm Egg Production Laboratory in 1911 and attempted to breed F1 hybrids by hybridizing imported European or Chinese silkworms with the Japanese silkworm based on Toyama's theory.

In accordance with the government policy, influential silk mills such as Tomioka Silk Mill, produced the F1 hybrids themselves and distributed them to silkworm-raising farmers to purchase all cocoons made; This resulted in the F1 hybrids becoming rapidly disseminated throughout the country. Japan succeeded in the application of F1 hybrids through close collaboration among the academic world, government, silk mills, and silkworm-raising farmers. Factories were thus able to procure a sufficient amount of superior unified cocoons, which resulted in quality improvement of raw silk itself.

Photo 2-32 Comparison of cocoon size

Left: Native species *Koishimaru*
Right: F1 hybrid *Shin-koishimaru*

Transferring technology to countries all over the world

As a result of aforementioned innovations, Japanese sericulture and reeling techniques became the world's best and most advanced in the 1960s and Japan regained its monopolistic position in the world silk market. Consequently, Japan received many requests from around the world for technology transfer related to sericulture. Japan responded with the dispatch of instructors and export of automatic silk-reeling plants overseas [Figure 2-39].

Silk is still an extremely popular fiber across the world. Although China and India constitute the mainstream of modern producers, it is the technological basis of sericulture and silk-reeling developed in Japan after World War II that these industries in all regions of the world rely on to this day. Though the amount of produced silk was greatly surpassed by the amount of produced synthetic fibers such as rayon and nylon, the development and spread of these low-price new fibers is based on the background of the world having once experienced the popularization of silk.

The silk-reeling techniques that Asia had introduced to Europe from ancient times to the Middle Ages had returned to Asia as machine silk-reeling technologies in the late 19th century. These were then improved in Japan and reintroduced to the world as state-of-the-art automatic reeling machines in the latter half of the 20th century, 100 years later. At the same time, innovative sericulture techniques which enabled the mass-production of cocoons resulting in mass production of raw silk were also introduced from Japan to the world.

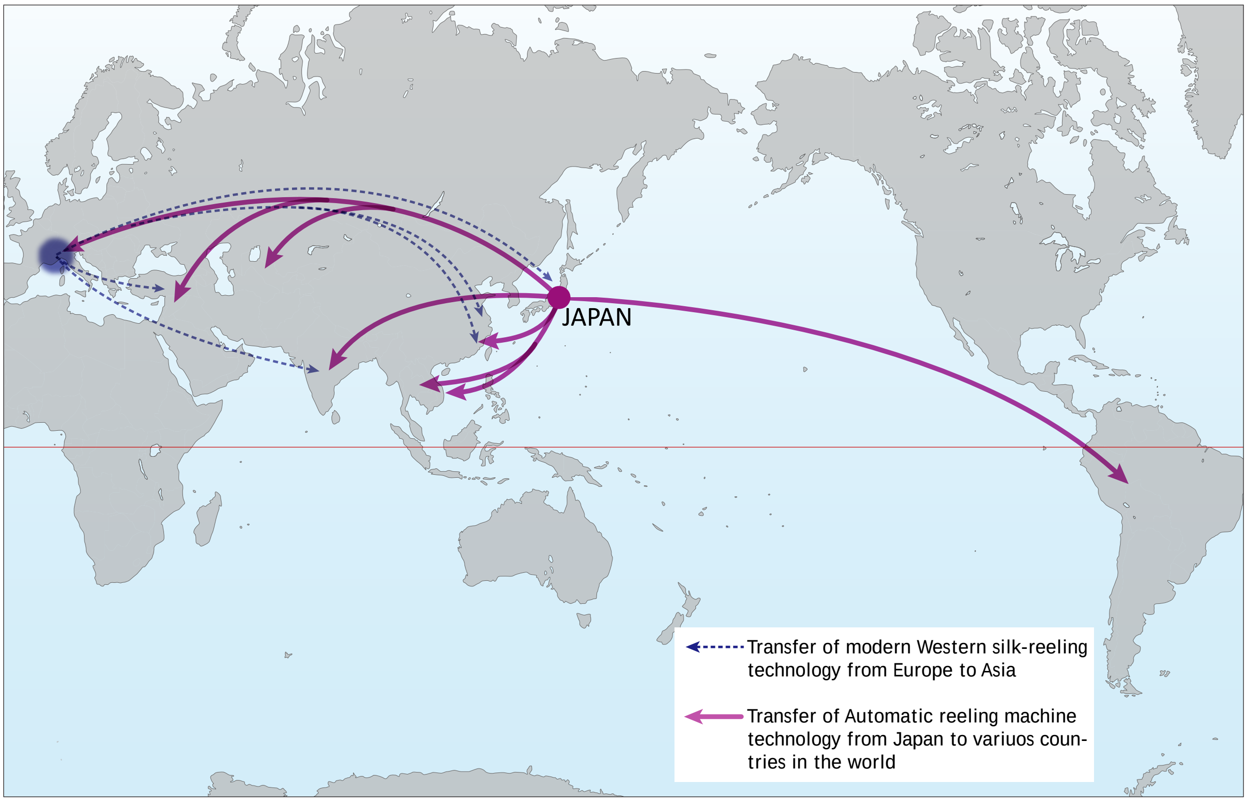


Figure 2-39 Map indicating technology transfer from Japan to numerous countries (multi-end and automatic silk-reeling machines)

Photo 2-33 Examples of automatic reeling machines exported by Japan
Nembri Ind., Iseo, Brescia, Italy 1961

Photo 2-34 Examples of automatic reeling machines exported by Japan
Gilan Silk Ind., Gilan, Iran 1978

(ii) History of individual components

S1 Tomioka Silk Mill

Tomioka Silk Mill is a machine-reeling factory that was built in 1872 by the Japanese government as part of the modernization policy, asking French raw silk expert Paul Brunat for advice. The Mill is the core component of the nominated property, which exhibits international interchange and technological innovation in the fields of sericulture and silk-reeling. At this site, machine-reeling technology transferred from Western Europe was further developed through Japan's unique ingenuity into an automatic machine-reeling technology that eventually spread throughout the world. It also played a key role in driving the innovation of sericultural technology including the standardization and mass-production of high-quality cocoons and the application of F1 hybrid technology, in cooperation with leading sericultural farmers in Gunma Prefecture, who had individually developed sericultural technology.

The Meiji government, whose primary concern was to build a modern nation by nurturing industrial development planned to introduce the machine-reeling factory to increase production and raise the quality of raw silk which was Japan's main export item since opening its ports at the end of the Edo period. In order to avoid interference from various foreign countries that were eager to introduce machine filatures into Japan, the Japanese government chose to establish Tomioka Silk Mill on its own.

Photo 2-35 Woodblock print of Tomioka Silk Mill, circa 1873

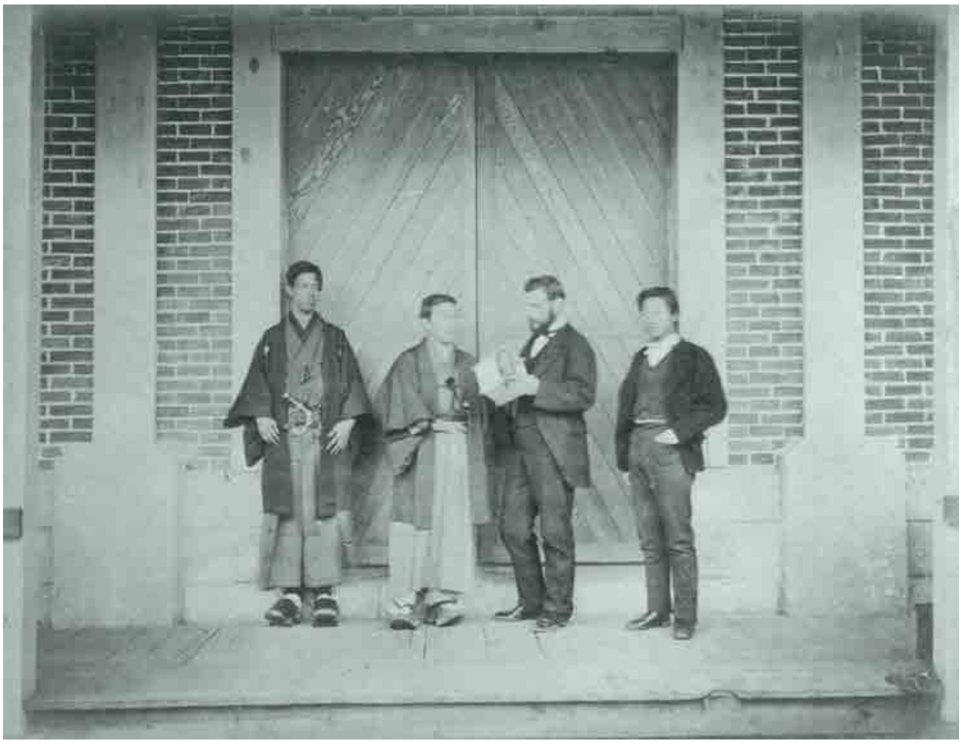


Photo 2-36 Paul Brunat standing, second from right

Photo 2-37 A scene during the time of original construction, east cocoon warehouse

Photo 2-38 Interior of the silk-reeling plant at the time of establishment

Photo 2-39 Silkworm egg production laboratory of Hara company, sericulture improvement division (demolished)

Paul Brunat, a French raw silk inspector hired to undertake this work, constructed the factory employing Western architectural techniques such as the truss system, timber-frame masonry construction, and glass; and introduced Western reeling technology such as steam-power, French-style reeling machines, and product management systems. In order to arrange modern working conditions, houses for directors and instructors, dormitories for workers and a clinic were built, the seven-day week calendar was employed, and work regulations were made.

The more than 400 female workers gathered nationwide mastered mechanical reeling technology and, after returning to their homelands, became responsible for disseminating this technology

When operations got underway, those aiming to enter the silk-reeling industry visited Tomioka. Machine-reeling factories modeled on Tomioka Silk Mill were constructed all over Japan.

By the end of the 19th century, the bulk of silk fabric production shifted to which had built a mass production system by power looms. Thus, Japanese raw silk exports from the 1880s onwards went mainly to the U.S. American textile manufacturers. They requested the supply of slightly thick threads of uniform thickness in raw silk suitable for production by power looms, and after World War I there was increased demand for thinner raw silk with less streaky threads[35] for manufacturing silk stockings.

35 Uneven thickness of thread and burl of thread

To meet these demands, Tomioka Silk Mill worked towards innovating silk reeling technology and the stable production of high-quality cocoons.

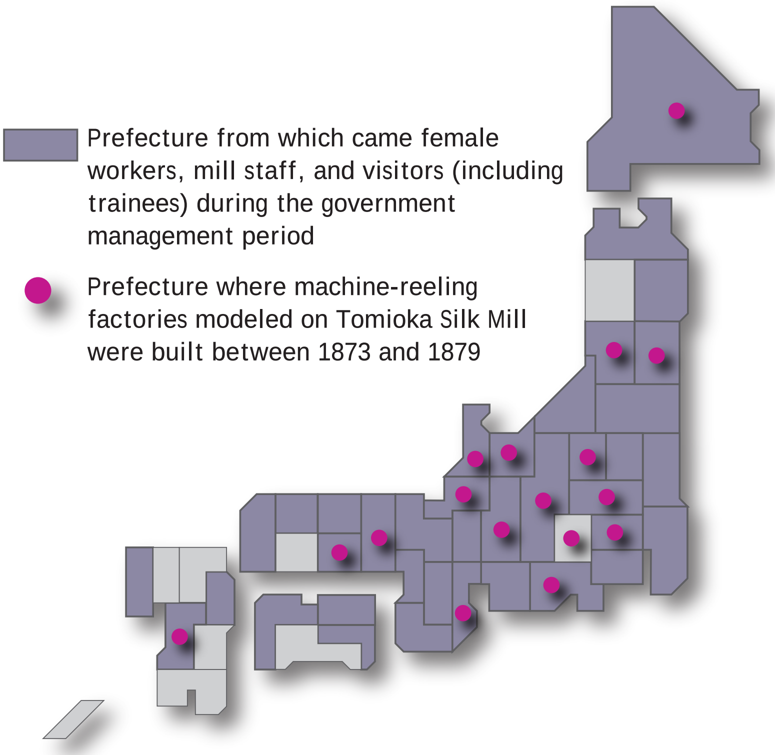


Figure 2-40 Tomioka Silk Mill: Influence of the mill throughout Japan

Tomioka Silk Mill, established in 1872 by the government, was privatized and transferred its business to the private enterprise, Mitsui, in 1893. It was transferred again to the Hara Partnership Corporation in 1902 and then to the Katakura Silk Reeling and Spinning Co., Ltd. in 1938.

The Hara Partnership Corporation, which ran Tomioka Silk Mill from 1902, recognized the importance of producing high quality cocoons for high quality raw silk. To achieve this, a sericulture improvement division was established in 1905, and in 1908, a silkworm egg production laboratory was built on the expanded site at the south-east corner of the mill to improve silkworm eggs [Photo2-39]. From 1906, Hara entered into cocoon-supply contracts with silkworm-raising farmers in various regions. The corporation distributed a specific species of silkworm eggs free-of-charge to those farmers, and promised to purchase the cocoons produced by that Takayama-sha that was commissioned to dispatch instructors to contracted farmers to give guidance on sericultural techniques. Competitive juried shows were organized to encourage silkworm-raising farmers to improve the quality of cocoons.

Furthermore, since 1911, the mill cooperated with influential sericulture farms in Gunma, Nagano, and Saitama for improving and standardizing silkworm species and putting the F1 hybrid into practical use. Collaborative partners included Seitaro Niwaya, manager of Arafune Cold Storage; Kikujiro Machida, president; and Bujuro Takayama, vice-president of Takayama-sha; and Sadayasu Tajima, a grandson of Yahei, the large-scale silkworm egg producer.

In addition, the mill worked on innovations in silk reeling such as the introduction of electric power and construction of the re-reeling plant. They also attempted to introduce domestically-made automatic cocoon dryers and led the way in the mass introduction of the “non-cutting slow speed low temperature multi-end reeling machine” developed by Naosaburo Minorikawa in 1924.

This reeling machine slowly reeled raw silk at the uniform thickness demanded by American textile manufacturers. It was designed for a large number of reels to be operated by a single worker to raise efficiency.

In that way, Tomioka Silk Mill succeeded in mass-producing high-quality raw silk by introducing the latest manufacturing technology as well as improving raw material. As a result, it once again became the model for silk mills throughout Japan. Consequently, most of the mechanical equipment initially imported from France had been replaced by that time.

Even though the production of raw silk in Japan decreased dramatically during World War II, sericulture and silk reeling were positioned as industries for the acquisition of foreign currencies after the war. Silk reeling companies accelerated the development of the so-called “dream” automatic reeling machine that started before the war in order to improve product quality and realization of mass production of raw silk.

Katakura Company began management of Tomioka Silk Mill from 1938 and developed the automatic reeling machine in 1952. Tomioka Silk Mill became a model factory of automatic silk production and it continued to introduce leading-edge automatic reeling machines. Katakura merged its research division with Prince Jidosha (later merged with NISSAN MOTOR CO., LTD.) and it continued to introduce leading-edge automatic reeling machines. Tomioka Silk Mill used the most advanced automatic reeling machines in the world while in operation. Machines similar to these models were exported all over the world and still support raw silk production today.

The Japanese silk reeling industry gradually deteriorated due to the emergence of synthetic fibers and imports of low-price raw silk from abroad, and Tomioka Silk Mill ceased operation in March 1987, 115 years after it opened in 1872.

Katakura kept possession of the mill after it ceased operating, and managed the entire premises to maintain its appearance from the time of closing to the acquisition in 2005 by the City of Tomioka. The timber-framed brick building of the silk-reeling plant, the east and west cocoon warehouses, steam boiler plant, director's house, dormitory for female instructors, inspector's house, and iron water tank, that were built when the mill was opened in 1872 and soon after, still maintain their original appearance. In addition, leading-edge factory facilities built at various periods by different managers, as well as facilities for workers and managers, are well preserved to fulfill the integrity of the historic site.

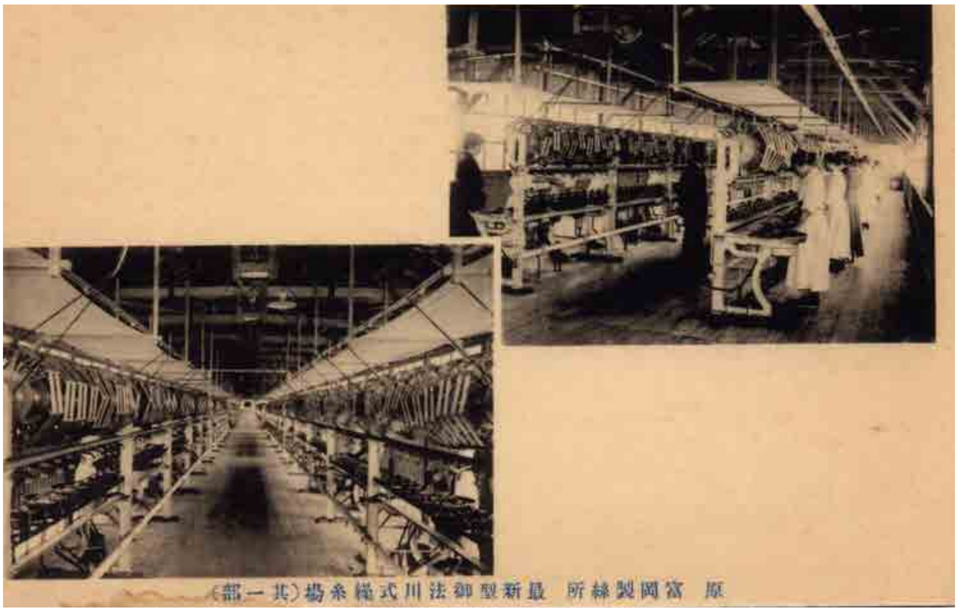


Photo 2-40 Minorikawa-style multi-end silk-reeling machines

Photo 2-41 Yamato-style cocoon dryer

Photo 2-42 Aerial view of Tomioka Silk Mill in the 1940s-50s

Photo 2-43 Interior of the Katakura mill (Tomioka Silk Mill) before closing

【History of conservation, repair, and maintenance】

This table covers the period of time after the mill's operation ceased.

1987	Katakura Industries Co., Ltd. managed Tomioka Silk Mill after operation ceased
1991	Silkworm egg-production laboratory, a part of the dormitory, and bathroom for female workers were demolished.
2002 -2003	The tiles of re-reeling plant and packing room were reroofed.
2004	Tomioka City Board of Education carried out a brief investigation of Tomioka Silk Mill and a report was published.
2005	• Its historic value was admitted and it was designated a national Historic Site. • The Tomioka City Board of Education set up the Tomioka Silk Mill Investigation Examination Committee and carried out a survey of old buildings based on the committee's instructions and advice.
2006	• Tomioka City acquired the land and buildings on the site from Katakura Industries Co., Ltd. • Nine properties (including two subsidiary structures) built in the government control period were designated as Important Cultural Properties. • Emergency roof repairs of the Myogi dormitory and Asama dormitory were carried out.
2008	• "Historic Site and Important Cultural Property of the Former Tomioka Silk Mill Preservation and Management Plan" was drawn up by Tomioka City. • Emergency roof repairs of the steam boiler plant as well as iron water tank preservation repairs were carried out.
2009-2010	A seismic capacity evaluation of the west cocoon warehouse was carried out.
2011	Anti-seismic reinforcement of the east cocoon warehouse and archaeological survey of the west cocoon warehouse and the site of silkworm-eggs production laboratory were completed.

S2 Tajima Yahei Sericulture Farm

Tajima Yahei Sericulture Farm is where the modern *seiryo-iku* method was developed by Yahei Tajima. The main house became the prototype of the two-story farmhouse designed for sericulture. Its silkworm room equipped with a raised roof (*koshiyane*) for ventilation demonstrates technological innovations in sericulture and the spread of this structure made a significant contribution to the stable production of high-quality cocoons.

The Sakai-shimamura district of Isesaki City, where the Tajima Yahei Sericulture Farm is located, was an active silkworm egg production region from the middle of the Edo period (around the 18th century), and the Tajima family was the most influential silkworm egg-producing farmer here. Silkworm rearing was difficult at that time because of silkworm disease and parasites and there were significant differences in annual yields. Yahei Tajima, born in 1822, researched *tennen-iku* (natural rearing), *ondan-iku* (warmed rearing), and *setchu-iku* (mixed rearing) in various regions, leading him to develop the *seiryo-iku* method and its emphasis on the use of natural airflow and ventilation based on the *tennen-iku* method. Yahei believed that it was necessary to select silkworm room structures that were appropriate for *seiryo-iku* in order to accurately practice the method, so he started to work on the improvement of silkworm rooms from 1857. Increased demand for raw silk after the ports opened in 1859 stimulated Yahei's efforts towards technological development, and in 1863 he completed the *seiryo-iku* method by devising and building a silkworm room with large openings and tiled-roof with ventilation facilities (*koshiyane*) on its whole ridge, to contribute to the stable production of cocoons.

Incorporating a ventilation system for silkworm breeding purposes was the first example of technological innovation in such architecture. Yahei wrote *Yosan Shinron* [New Theory of Sericulture] in 1872 and *Yosan Shinron, Sequel* in 1879 and endeavored to spread the *seiryo-iku* method. As a result, this method became the major trend in Japanese sericulture up to 1880, until it was replaced by the method developed at Takayama-sha. The residential structure with silkworm rearing rooms on the upper floor which he designed and was illustrated in his first book (Photo 2-46), became the standard for modern silk farmhouses.

Shimamura, including the Tajima Yahei Sericulture Farm, received praise from abroad as an excellent silkworm egg production site soon after the commencement of silkworm egg exports, and there were countless visitors from abroad to research new sericulture techniques.

Photo 2-44 Portrait of Yahei Tajima
This portrait was drawn in Milan, Italy.

Photo 2-45 Divination plan, Tajima Yahei Sericulture Farm, 1863

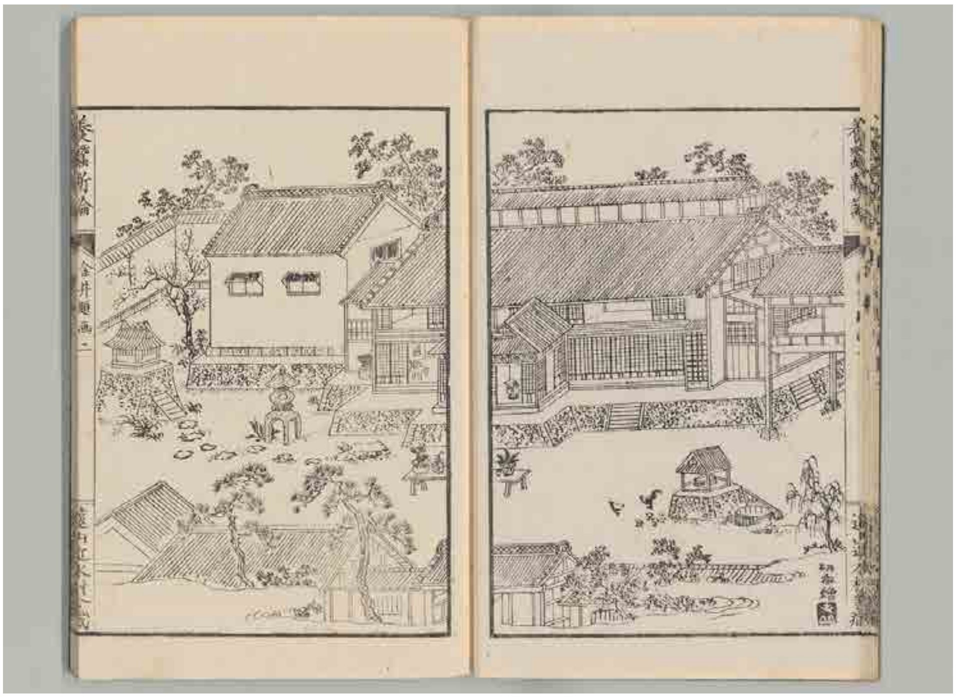


Photo 2-46 Woodblock print of Tajima Yahei Sericulture Farm *Yosan Shinron* [New Theory of Sericulture] by Yahei Tajima, 1872

Photo 2-47 Tajima Yahei Sericulture Farm in the early 20th century

The British minister to Japan, Sir Harry S. Parkes, ordered the clerical officer, F. O. Adams, to conduct a survey on the Japanese sericultural industry in 1869 and 1870. Adams' survey[36] report was submitted in four parts. Especially in part three of the survey report it is written that Yahei Tajima made the first silkworm room with an attached ventilation system and the silkworm room is introduced with an illustration. Paul Brunat, who was an advisor when Tomioka Silk Mill was established, participated in the first survey and in a report created separately from Adams' report, he argued that Shimamura silkworm rooms are comparable to those found in Europe.

36 A report on sericulture in Japan written by Adams who was a secretary in the British Legation (Tomioka City Board of Education, 2011)

In addition, many silkworm egg traders from Italy including Italian Ambassador, Comte Sallier de La Tour, visited Tajima Yahei Sericulture Farm. In 1869, they determined Tajima Yahei Sericulture Farm to be the most effective silkworm-raising farm in Japan. It was highly praised for the exceptionally high quality of its silkworm eggs and for the revolutionary sericulture manual, "Yosan Shinron (New Theory of Sericulture)."[37]

37 "Domestic Travel in Japan," a travelogue by a silkworm-egg trader named Cesare Breciani in 1880. A description of his visit to Tajima Yahei Sericulture Farm in 1872 can be found.

During the early Meiji period, in response to the success of raw silk exports, there were movements to newly establish sericultural and reeling industries throughout Japan. The most popular place for observation tours was to study silk-reeling at Tomioka Silk Mill and sericultural techniques at the Tajima Yahei Sericulture Farm. The names of observers from 25 prefectures across Japan are written in the visitors' log books of the Tajima family from 1873 to 1874. Silkworm-raising rooms built at the Matsugaoka Land Reclamation Site in Yamagata Prefecture are an example of sericulture structures modeled after those at the Tajima farm; 17 trainees were sent to Shimamura in 1874 to acquire knowledge for launching sericulture and reeling businesses. In addition, Yahei Tajima was invited as a sericulture leader to the Imperial Palace in 1871, and he was in charge of design when a silkworm-raising room was built in the Aoyama Imperial Palace in 1879. Thus, Yahei Tajima was seen to be an advanced instructor of sericultural techniques by both the public and private sec-

Photo 2-48 Sericulture buildings at Matsugaoka Land Reclamation Site in Yamagata

tors that led modern Japanese sericulture.
Shimamura sericultural farmers such as Yahei worked proactively towards exporting its silkworm eggs to Europe, where pebrine had devastated European silk production, and the Shimamura Kangyo (Commerce Promotion) Company was established to produce and sell silkworm eggs in 1872.

However, once the pebrine problem was solved in 1870, silkworm egg exports to Europe dropped to a low level. Between 1879 and 1882, the Shimamura Kangyo Company sought to improve the situation by transporting its silkworm eggs to Italy and shifting to direct sales. Yahei Tajima was a member of the first silkworm egg direct export mission to Italy. Keitaro Tajima,[38] who was a member of the fourth mission in 1882, brought back a microscope from Italy, and Yahei Tajima built an addition of a microscope room to the north side of the main building to perform inspections and study pebrine.

38 A relative of Yahei Tajima

This microscope room was devised to properly control the lighting based on many years experience of using microscopes. Such facility cannot be found elsewhere except for one example located near Yahei Tajima's sericulture farm. Although European sales of silkworm eggs from the Shimamura district including Tajima Yahei Sericulture Farm ceased, eggs aimed at the domestic market continued to be produced in abundance.

When Arafune Cold Storage started operations in 1905, this was actively used for the consignment of silkworm egg storage. It also contributed to experimental breeding of foreign silkworm eggs as requested by Tomioka Silk Mill, as well as to the development of an F1 hybrid and unifying cocoons into a higher quality breed from 1911.

Descendants of Yahei Tajima used the main building for sericulture until the 1960s and live at the farm today. Some buildings of the farm have been dismantled with decline of sericulture, and some alterations were made to the main building after sericulture operation ceased. However, the two-story tiled-roof house used for silkworm-raising, together with the ventilation system demonstrating innovations in sericultural techniques, have been kept in good condition. In addition, the building that was used to store mulberry leaves, well, and foundation of the silkworm-raising room remain, and the locations of the lost buildings of the silkworm egg production farm can be identified.

[History of conservation, repair, and maintenance]

1952	A silkworm-raising room called *shin-sanshitsu* dismantled; main building entrance refurbished; roof retiled.
1958	A Barn (a former silkworm-raising room) was dismantled.
1967	The printing woodblock of "Yosan Shinron (New Theory of Sericulture) ," is designated a tangible cultural property by Isesaki City.
1983	The Yokohama Port Museum in Yokohama City has organized and catalogued approximately 4,000 documents on sericultural techniques and silkworm egg producers.
1989	Sakai Town conducted a survey and "Sakai Town History Data No.5 ： Private Residences and Western-style Architecture in Sakai" published.
1992	Gunma Prefecture Board of Education conducted "Comprehensive Survey on Heritage Structures related to Japanese Modernization" and published the "Comprehensive Survey Report on Heritage Structures related to Japanese Modernization."
1996	Re-roofing was completed.
2007	Gunma Prefecture conducted "a survey of modern-times sericulture farmhouse in Sakai-shimamura."
2011	"Report of Research on Sakai-shimamura Sericulture farms" was published by Isesaki City Board of Education.
2012	"Report of Reserch on Tajima Yahei Sericulture Farm" was published by Isesaki City Board of Education.

S3 Takayama-sha Sericulture School

Takayama-sha accomplished several innovations in Japanese sericulture, and spread *seion-iku* inside and outside Japan through their educational activities. The buildings for raising silkworms at Takayama-sha Sericulture School depict technological innovations in rearing methods.

Chogoro Takayama, who was born in 1830, believed that sericulture would be effective for enriching villages and worked to improve sericultural methods from the end of the Edo period. When trade with foreign countries began and raw silk attracted attention as an export item, he organized the Takayama Group for Sericultural Improvement in 1873 and began full-scale improvements in sericultural methods and its dissemination.

Silkworm rearing methods from the mid-Edo period included *tennen-iku* (natural rearing), *ondan-iku* (warmed rearing) and *setchu-iku* (mixed rearing) to meet the various climates of each region. At first, Chogoro tried to improve rearing methods based on *ondan-iku*, which was used in cold regions. However, in 1882 he learned the strong points of *seiryo-iku* from Yahei Tajima and the effectiveness of installing a *koshiyane* to silkworm rooms. Chogoro then completed the *seion-iku* method which carefully controls breeding methods by regulating ventilation and heat, incorporating the strengths of both *ondan-iku* and *seiryo-iku*. This site is where technological innovation in the silkworm-rearing method, called *seion-iku*, was developed. Bujyuro, the son of Chogoro and Takayama-sha's third president, built the still remaining combined-use farmhouse used for sericulture in 1891 as the ideal silkworm room to practice *seion-iku*.

When Chogoro Takayama developed this *seion-iku* method, he strengthened the educational aspect of Takayama Group for Sericultural Improvement and organized "Sericulture Improvement Takayama-sha Company" to provide sericultural education in 1884 and diffuse the method. Kikujiro Machida, who became the second president in 1886, decided to move the company's head office and training center to the middle of Fujioka City in 1887 to accommodate the large number of entrance applicants. After that, this birth place of Takayama-sha was used as a practical school for sericulture training. Takayama-sha further established "the first grade sericulture school of Takayama-sha," where a student could obtain a certification equivalent to a middle school in 1901. Students entered these training facilities and the school from all 47 prefectures as well as China, and the Korean peninsula

Photo 2-49 Chogoro Takayama

Photo 2-50 Historic photo (data unknown) of Takayama-sha Sericulture School when it was as a practical school for sericulture training

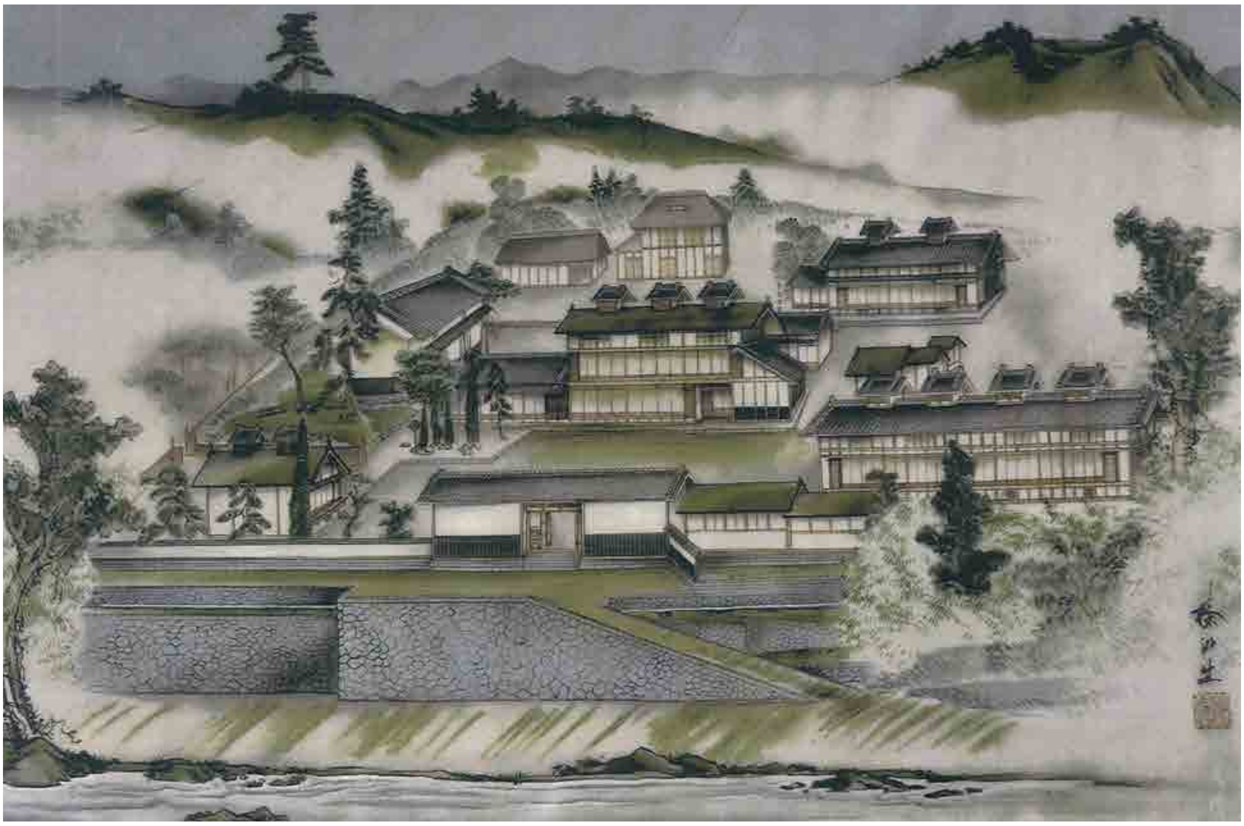


Photo 2-51 Illustration of Takayama-sha Sericulture School

between establishment of the company in 1884 and closure of the school in 1927, and their number totaled more than 20,000 people. In addition, sericulture instructors were dispatched to all prefectures in Japan, as well as China, and the Korean peninsula, and the *seion-iku* method was spread inside and outside Japan from the mid-Meiji period as the standard Japanese sericultural method.

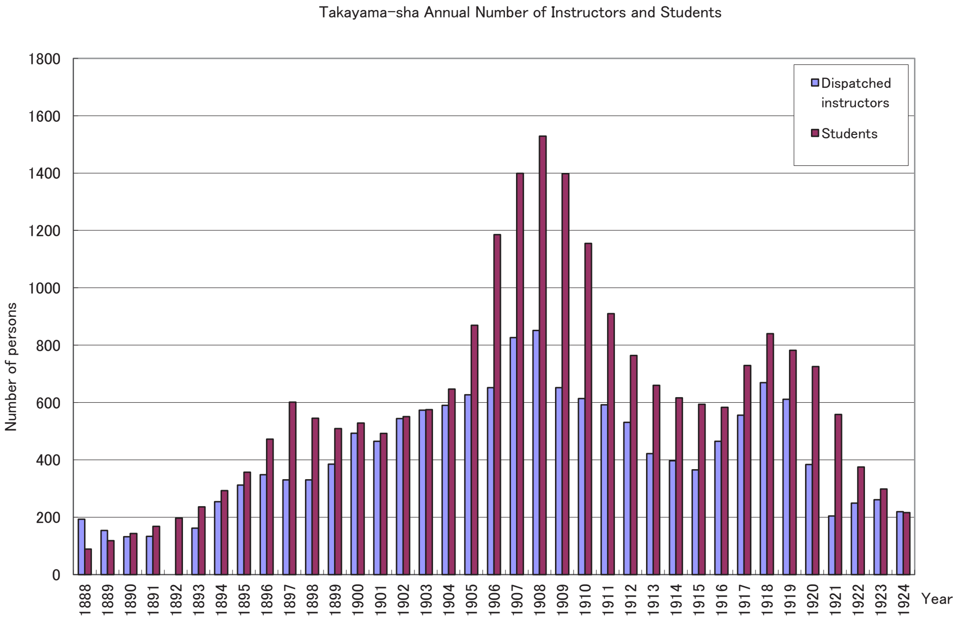
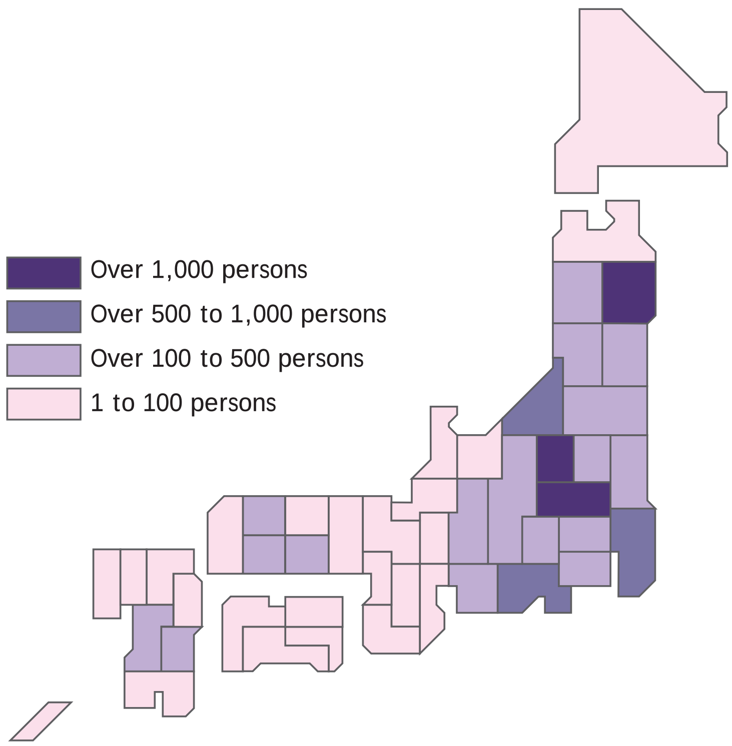


Figure 2-41 Annual number of instructors and students in Takayama-sha Sericulture School (1888-1924)



Takayama-sha Sericultural School：Total number of students in years 1888-1924

Figure 2-42 Takayama-sha Sericulture School: Influence throughout Japan

As the 20th century began, the Takayama-sha strengthened its relationship with Seitaro Niwaya who ran one of the district stations and used Arafune Cold Storage to raise silkworms in the summer and the fall. It also strengthened cooperation with Tomioka Silk Mill and entered into an exclusive contract for cocoons and cooperated in the exhibition of articles at fairs, and was entrusted by Tomioka Silk Mill to examine foreign breeds of silkworms to contribute to cocoon standardization and the practical use of the F1 hybrid cross-breeding.

As the sericulture industry developed, the number of public and partnership-run agricultural schools providing sericultural education increased in the Taisho period. As a result, the number of students entering the sericulture school of Takayama-sha rapidly decreased and the school closed in 1927.

The main building, as well as the stone walls used to form the site, the *nagaya-mon* gate, the outside toilet, the bath house/ kitchen, and the stone walls of the mulberry leaves storage area are the structures included in the site. Furthermore, the stone masonry that sectioned the buildings at the time of the practical school of Takayama-sha has now been confirmed, and we are certain of the building footprint at the time of the practical school was in operation.

In addition, a descendant of Chogoro and Bujuro Takayama lived in the main farmhouse of this site until Fujioka City acquired the land and buildings in 2010. They ran the sericulture business until the early 1960s and interior and exterior elements of the main farmhouse were partially altered to secure residential space and to maintain the house in the latter half of the 1960s. However, the silkworm-raising room structure that enabled the fine adjustment of temperature-humidity demonstrating the innovation of sericultural techniques has been kept intact.

[History of conservation, repair, and maintenance]

1947	Silkworm-raising room, dormitory, and mulberry leaves storage were demolished by this time.
2004	Gunma Prefectural Museum of History organized approximately 13,000 documents and published “Catalogue of the Takayama Family Historic Documents.”
2009	• “Brief report on overall reserch of Takayama-sha Sericultuer school” was published by Fujioka City Board of Education. • Takayama-sha Sericulture School was designated as a national Historic Site based on the Law for the Protection of Cultural Properties.
2010	Fujioka City acquired the land and the buildings. A tentative covering structure was installed for bath house/ kitchen
2011	A survey by the Fujioka City Board of Education to confirm the extent of remains was carried out. Also a survey of existing buildings such as main building, bathhouse/ kitchen, and outside toilet was carried out.
2012	A preservation and management plan was devised.
2013	Investigation for initial construction and previous intervention was carried out on south and east facade of the main building and temporary remedy was made until restoration decisions can be made when the conservation and utilization plan scheduled in 2013.

S4 Arafune Cold Storage

During the Meiji period when there was increased demand for raw silk production, stable sericulture production in the summer and autumn was enabled by adopting silkworm egg storage technology that utilized the natural cold air. Arafune Cold Storage was the largest silkworm egg storage facility in Japan that stored silkworm eggs from all over Japan and contributed to the increase of cocoon production in Japan, making use of modern systems such as railway, communication, and postal services.

Due to the start of overseas trading at the end of the Edo period, there was demand for the increased production of cocoons as raw silk exports flourished. Typically, sericulture in Japan was limited to once a year in spring (May-June), and rearing of multivoltine silkworms was at one time prohibited by the Meiji government because the quality of its cocoons deteriorated in summer and autumn and rearing was difficult. However, when demands to increase cocoon production heightened in the late 19th century, research on the stable rearing of silkworms in summer and fall progressed, and efforts became underway to store silkworm eggs in natural cold storage facilities called *fu-ketsu*, that use naturally cold air, in order to adjust the hatching timing. However, as it was difficult to maintain a constant temperature inside the storage facility, the rate of successful hatching of stored silkworm eggs varied. In order to overcome this problem, in late 19th century knowledge of sericulture, geology, and meteorology was utilized to explore for solutions in the selection of a location for the storage system, an ideal structure for the storehouse, and construction of a cold storage system with a scientific temperature control system.

When Senju Niwaya, a silkworm-raising farmer in Shimonita Town who studied at Takayama-sha in 1904, discovered that the cool wind there could be utilized for storing silkworm eggs, his father Seitaro decided to build a silkworm egg storage facility.

Photo 2-52 Seitaro Niwaya (1862-1936)

In addition to studying cold storage systems in Nagano Prefecture, he gained the support of engineers from various fields including governmental engineers, Gunma Agricultural Society engineers, and Maebashi Meteorological Station engineers in the building of the No.1 cold storage. Following that, the No.2 cold storage was built by 1908 and the No.3 cold storage in 1914 with technical cooperation from Kikujiro Machida, the second president of Takayama-sha, the Tokyo Sericulture School, and the Gunma Agricultural Experiment Station. Some cold storage facilities used the cold conditions of natural caves, but Arafune Cold Storage was built on the

Photo 2-53 Arafune Cold Storage in the 1910’s

Photo 2-54 Historic photo, silkworm eggs were kept in the Arafune Cold Storage, 1909

mountain slopes where cold air gushed, with stone wall foundations. Above this structure was a cellar shed with plastered earthen walls. The buildings consisted of two stories below and one above ground. The three cold storages facilities altogether were capable of storing 1.1 million sheets of paper at one time onto which silkworm eggs were tightly laid, making them the largest in Japan.

No records have been found on storing silkworm eggs in cold storage or caves in China or in Europe. Although such facilities were utilized in the Italian-French Alps, it did not spread widely.[39] Therefore, Arafune Cold Storage was the largest silkworm egg storage at the time in the world.

39 See p.153 Compalative Analysis

Following completion, Gunma Agricultural Society and Maebashi Meteorological Station employees controlled the storage environment by the use of automatic temperature-humidity measuring instruments. Thus, Arafune Cold Storage was built and operated using the essence of technologies from various fields to maintain ideal storage environments and demonstrates technological innovations in silkworm egg storage.

An administrative office was built adjacent to the cold storage, and business headquarters called *Shunju-kan* was set up in the house of Seitaro Niwaya, which was located approximately seven kilometers east of the storage. *Shunjyu-kan* also served as a district station of Takayama-sha. Modern communications and transport sys-

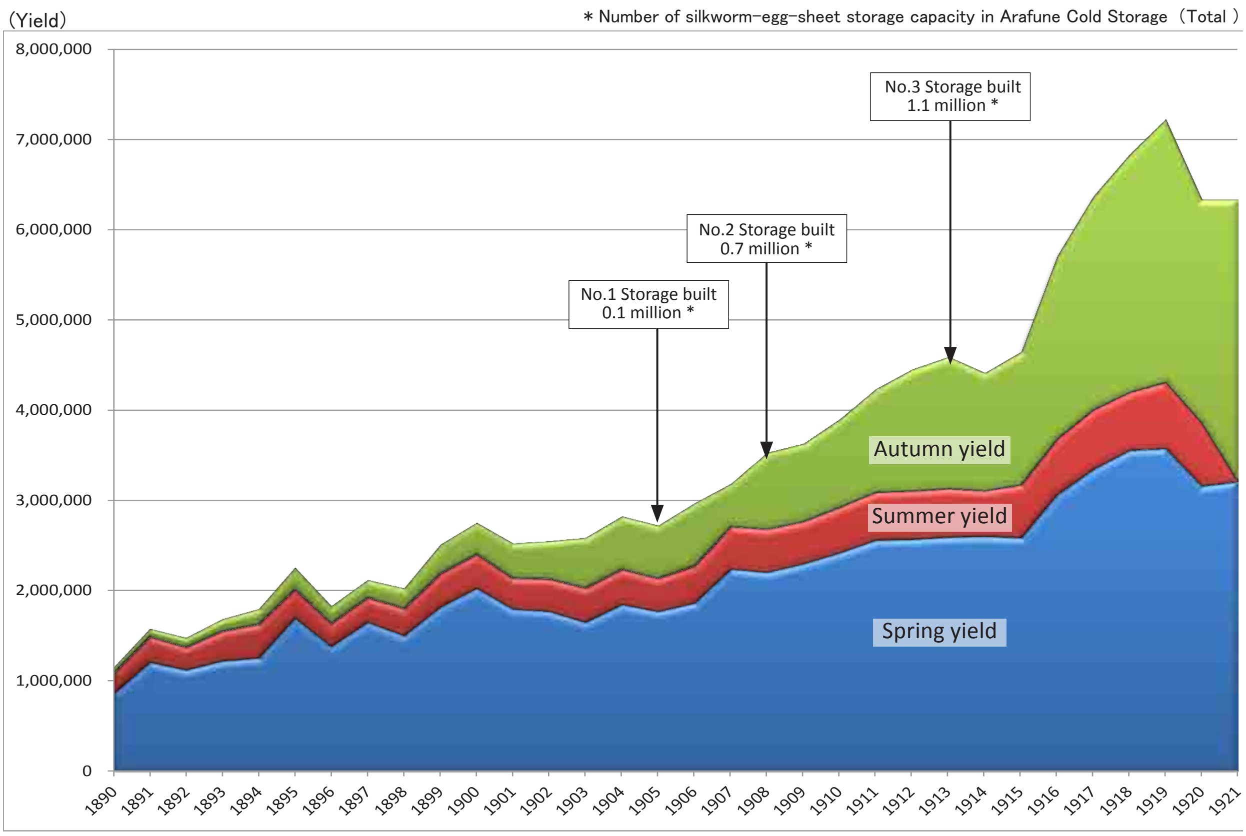


Figure 2-43 Seasonal cocoon production ratio in Japan (1890-1923)

tems such as the postal service, telephone, telegraph, and parcel delivery trains were used, and systems to accept silkworm eggs for storage from anywhere in Japan were created. With such systems distribution of clientele became widespread to 40 prefectures, contributing to the development of multiple silkworm-rearing seasons and increasing summer-autumn crops.

In addition, Arafune Cold Storage strengthened cooperation with Tomioka Silk Mill from 1907 and stored silkworm eggs commissioned by the mill. From 1912, it was entrusted with the test breeding of foreign eggs and contributed to cocoon standardization and the practical use of the first filial generation.

From around 1935, due to the spread of electric refrigerators, natural cold storage was no longer necessary for storing the silkworm eggs and local residents continued to use the facilities for storing food. All upper structures were removed by circa 1955. Shimonita Town made the land a public domain and the three sets of foundation stone walls are all that is left, but the cold air gushing mechanism, connecting passage ways, and the structure devised to seal the seams of the stone walls still remain today in good condition.

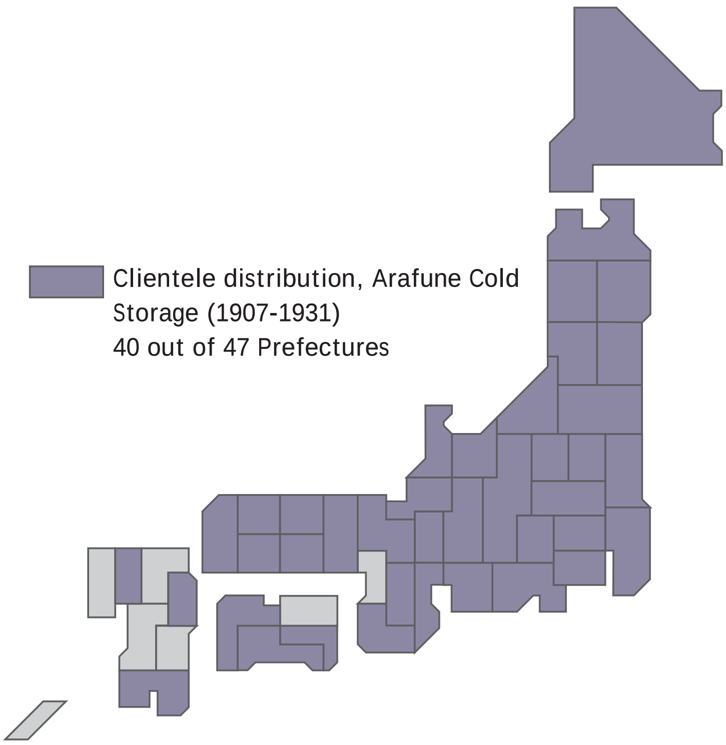


Figure 2-44 Arafune Cold Storage: Clientele distribution throughout Japan

Photo 2-55 Entry log book for Arafune Cold Storage, 1912 Photo

(Left) Photo 2-56 Silkworm egg card, on which moths laid eggs

(Right) Photo 2-57 Advertisement for Arafune Cold Storage, 1922

[History of conservation, repair, and maintenance]

c. 1955	All upper structures of cold storage were demolished.
1992	Gunma Prefecture Board of Education listed the results of survey for Arafune Cold Storage in “Gunma Prefecture Comprehensive Survey Report on Heritage Structures related Japanese Modernization”
2006	Shimonita Town designated the Cold Storage as a Historic Site.
2007	Gunma Prefecture completed a survey of the site.
2008	Shimonita Town conducted a survey of historical documentation while Gunma Prefecture surveyed cold storage across the whole of Japan.
2010	• Arafune Cold Storage was designated as a national Historic Site. • Shimonita Town made the site a public domain. • A part of stone wall of cold storage No.1 collapsed.
2011	A three dimensional survey to stone wall condition is of cold storage No. 1 and a local office remains confirm was completed.
2012	Preservation and management plan was devised. Structural survey for the restoration of the cold storage No.1.