

An Actual proof of Tokushima's Museum of Bridges

Shuichi TAKEICHI¹

¹Fellow of JSCE, Tokushima Prefecture Land Development Public Corporation

This project aims to collect, research and organize various information and literature including bridge design documents, documentary videos, press materials such as newspaper articles and local history books of related municipalities. It also aims to compile “*Tokushima Hashi Monogatari*,” a history book about the bridges across the Yoshino River which includes the bridge construction history, the transition of bridge usage, the culture and industry developed around bridges, and the bridge construction technology.

Various events and promotional activities related to bridges are held. For instance, the Tokushima Marathon, which attracts more than 10 thousand participants every spring incorporates the bridges and river banks into the race course. In order to raise public awareness about the bridges, panel exhibits about the bridges across the Yoshino River are installed on the race course and photo books of the bridges are handed out to the participants.

Furthermore, we're working on creating chances to learn the importance and the history of bridges by hosting bus tours for local residents to visit several bridges along the Yoshino River and bridge clean-up activities by senior high school students.

We would like to pass the technological value of the bridges across the Yoshino River and their cultural value as a civil engineering heritage for generations to come. I believe this shows the greatness of civil engineering which generates historical and cultural value.

Key Words: *Yoshino River, museum of bridges, civil engineering heritage, bridge history, infrastructure tourism*

1. INTRODUCTION

Naruto, which is designated as a Site of National Scenic Beauty, as well as a National Park, is located in the northern part of Tokushima Prefecture. Naruto is also where the Kansai Region and the island of Shikoku are connected. It boasts the Naruto Strait, which has amongst the three most dramatic currents in the world and is widely known for producing some of the largest whirlpools in the world with whirlpools of up to 20 meters in diameter. (Pic. 1)

Both Tokushima and Hyogo Prefecture have launched academic research on the cultural and historical values of the whirlpools, as part of their efforts to have the whirlpools registered as a World Heritage Site.

The Konaruto Channel lies just south of the Naruto Strait and the Konaruto Bridge was built over the channel in 1961. The Konaruto Bridge is one of the few multi-span suspension bridges in the world. It also has various state of the art bridge construction technologies applied to it for wind resistant stability, such as truss girders and a drill on vertical girder.

One of the world's top bridges, the Awa Shirasagi Ohashi Bridge, was completed in 2012 over the mouth of the Yoshino River, which is located to the south of Naruto. This bridge has received recognition by prestigious organizations such as the JSCE (Japan Society of Civil Engineers) and the ISE (Institution of Structural Engineers) for its innovative design and technology.



Pic.1 Whirlpools of Naruto



Pic.2 Awa indigo fashion show Pic.3 Awa Odori (Awa Dance)

The Yoshino River is regarded as one of Japan's top three rivers with the strongest currents, alongside the Tone River in the Kanto area and the Chikugo River in Kyushu, nicknamed Shikoku Saburo, Bando Taro and Tsukushi Jiro, respectively. Running through all four prefectures of Shikoku, the Yoshino River is a very important river in terms of both flood control and irrigation. Tokushima Prefecture is frequently hit by typhoons and has experienced flood damage countless times.

The upper streams of the Yoshino River are known for their beautiful natural surroundings, and the Oboke area will host the World Rafting Championship in 2017.

Furthermore, the past rulers of the area chose not to build levees along the river for various reasons such as natural indigo dye which brought in more money than rice (more than twice as much) and the indigo plant which unlike rice could be planted in May and harvested before the typhoon season, meaning levees were not necessary. Another reason being, fertile soil flowed down from the upper streams and this would be hindered by the presence of a levee.

The Yoshino River played an important role in the transportation of natural indigo, rice and fertilizer up until the development of both land transportation, such as railway and automobiles, and artificial dye. We are very fortunate in that the Awa indigo dye has been brought back into the spotlight as "Japan Blue" and the fact that it is appreciated just as much as one of the top three dance festivals in the world, Awa Odori (Awa Dance). (Pic. 2, 3)

Shikoku has another piece of historic heritage:



Pic.4 Tairyuji, 21st temple of Shikoku Pilgrimage



Pic.5 Jizoji, 5th temple of Shikoku Pilgrimage



Pic.6 Awa Shirasagi Ohashi Bridge



Pic.7 Bridge railing lights

cultural the Shikoku 88 Temple Pilgrimage, which is a 1,400km long pilgrimage. 150,000 people, regardless of their religion, annually visit the historic and cultural sites of the 88 temples on this pilgrimage route. (Pic. 4, 5)

The pilgrimage and the warm hospitality given by the local people (*osettai*) has been handed down through generations for over 1,000 years, just like the Route of Santiago de Compostela in Spain. Currently we are in the midst of preparations for including this traditional culture in Japan's tentative World Heritage list.

Tokushima Prefecture is home to 500 rivers that run through the prefecture and bridges of various styles are built across these rivers. The group of bridges built across the large Yoshino River is dubbed the Museum of Bridges as each of the bridges were built at varying times in various styles that reflect the construction technology of that time.

The Awa Shirasagi Ohashi Bridge (Pic. 6, Fig. 1) was completed in 2012, and the part of the bridge built over the extensive stretch of tidal flats has no piers in order to protect and preserve this natural area. The "cable-egret" style was adopted for the first time in the world which makes the main towers lower by placing horizontal cables under the girders.

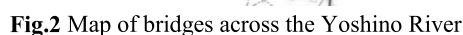
The style at the bridge applies parallel cables for

The Awa Shirasagi Ohashi Bridge, built with this world-unprecedented state of the art technology, received recognition from many organizations such as; the Tanaka Award from the Japan Society of Civil Engineers, the Land, Infrastructure, Transport;

In commemoration of this prestigious recognition from home and abroad, the Tokushima Prefectural Government hosted a bridge symposium on August

Following this statement, academic experts with wide and comprehensive knowledge formed an organization and projects for the “Tokushima-Museum of Bridges” were launched.

There are 46 bridges built across the Yoshino River in Tokushima Prefecture, from the Oboke Bridge situated over the upper streams of the river to the Awa Shirasagi Ohashi Bridge situated over the mouth of the river (Fig. 2, Pic. 8-11). As seen in Table 1, most of the bridges built from the late 1920s to the 1950s were suspension bridges or truss bridges. As the Yoshino River is very wide, the bridges that were built across it had to be long enough, so the Miyoshi Bridge (suspension bridge) and the Yoshinogawa Bridge (truss bridge) were the longest in the East at the time. In 1963, the Nada Bridge was



completed as the second bridge adopting the Dywidag method in Japan. At 800m, it was Japan's longest pre-cast bridge at the time. Construction of arch bridges and steel girder bridges started between the late 1960s to the early 1970s and the box girder became common for steel girder bridges in the late 1970s to the early 1980s.

A cable-stayed bridge, known for its beautiful design, was built for the first time in Tokushima in 1993, and an inverted Langer style PC bridge built using the latest earthquake-resistant design was completed in 1999, after the Great Hanshin-Awaji earthquake. Furthermore, the Awa Shirasagi Ohashi Bridge, which was the world's first cable-egret style bridge, was built over the mouth of the Yoshino River in 2012.



Pic.8 Awa Shirasagi Ohashi Bridge



Pic.9 Yoshinogawa Bridge



Pic.10 Nada Bridge



Pic.11 Awa Chuo Bridge

3. The Beginning of Bridge Construction Across the Yoshino River

The Yoshino River has 46 bridges built across it in Tokushima Prefecture alone, and with a basin area of 3,750km² and at a length of 194km, is one of the largest rivers in Japan. The river originates from the center of Shikoku and pours out into the Kii Channel in Tokushima City. The sheer size of the river makes transportation across it difficult; therefore, smooth and safe transportation between the two sides was a longtime desire for people living along the river.

During the Edo (1603-1868), Meiji (1868-1912) and Taisho (1912-1926) periods, the only way across the Yoshino River was via a “*watashi-bune*” (ferry service). The service was often suspended because of floods and many children lost their lives due to tragic accidents involving these ferries.

To provide more transportation options, several

bridges were built, including toll bridges and those built by military engineer corps. However, as they were all built with wood, they were easily destroyed by floods and every time they were damaged, they had to be rebuilt.

During the Taisho period, Tokushima Prefecture saw much improvement on road construction and maintenance work. With the enactment of the Road Act in 1919, which allowed for the national budget to be utilized for the construction of permanent bridges, the Tokushima Prefectural Government came up with a construction plan to build 11 major bridges. In accordance to this plan, three bridges (the Miyoshi Bridge, the Anabuki Bridge and the Yoshinogawa Bridge) were built across the Yoshino River during the beginning of the Showa period (1926-1989). The people of Tokushima hoped for permanent bridges to be built instead of water crossings (*sensuikyo*), which were originally built as an alternative for wooden bridges. This is how the bridge construction across the Yoshino River started and not only did such road constructions affect the lives of the locals by providing them with better roads to travel on, but it also led to the development of bus services (Pic. 12) including the establishment of the Tokushima City Bus, and eventually led to the further development of railway services. Furthermore, these bridges played an important role in economic activities including transportation of local products such as raw silk and the Awa indigo dye. (Table.1)



Pic.12 Yoshinogawa Bridge at the time of completion
(Photo by Tokushima Shimbun)

Table.1 Bridges across the Yoshino River in Tokushima Prefecture (Chronological order)

Name	Type	Length (m)	Completed
Miyoshi Bridge	Suspension Bridge→Deck-type 2-hinged Lohse bridge + Non-composite girder bridge	244	1927,1989
(old) Anabuki Bridge	Suspension-style cantilever Warren Truss bridge + Steel plate girder bridge	416	1928
Yoshinogawa Bridge	Single-span curved-chord Warren Truss bridge	1,071	1928
Yoshinogawa Railway Bridge (JR Dosan Line)	Steel plate girder bridge + Steel Warren Truss bridge	571	1929
Yoshinogawa Railway Bridge (JR Kotoku Line)	Steel plate girder bridge + Steel Warren Truss bridge	949	1934
Okawa Bridge	Suspension bridge	150	1934
Yoshinogawa No.1 Railway Bridge (JR)	Steel plate girder bridge + Steel Warren Truss bridge	172	1935
Yoshinogawa No.2 Railway Bridge (JR)	Steel plate girder bridge + Steel Warren Truss bridge	249	1935
Awa Chuo Bridge	Single-span steel Warren Truss bridge	821	1953
Miyoshi Ohashi Bridge	Cantilever Warren Truss bridge	236	1958
Mima Bridge	Langer truss bridge + Deck-type truss bridge	418	1958
Minoda Ohashi Bridge	2-hinged stiffening steel truss suspension bridge	184	1959
Nada Bridge	Hinged PC continuous rigid-frame box girder bridge	800	1963
Sezume Ohashi Bridge	(Continuous + Single span) Composite reverse trapezoidal steel box girder bridge	589	1966
Higashi Miyoshi Bridge	Continuous Warren Truss bridge	374	1970
Rokujo Ohashi Bridge	Continuous non-composite steel girder bridge	680	1970
Yoshinogawa Ohashi Bridge	Continuous steel-slab box girder bridge	1,137	1972,1986
Oboke Bridge	Half-through type 2-hinged steel arch bridge	165	1973
Iya-guchi Bridge	Nielsen-Lohse bridge	230	1973
Shiki-no-ue Bridge	2-hinged non-stiffening suspension bridge	195	1975
Akawaga Bridge	Suspension bridge	109	1975
Kunimasa Bridge	Suspension bridge	100	1976
Ikeda Ohashi Bridge	Steel truss bridge + Steel box girder bridge + Steel plate girder bridge + PC I-girder bridge	294	1976
Awa Oe Ohashi Bridge	Through type continuous parallel chord steel Warren Truss bridge	1,084	1979
Aoishi Bridge	Continuous PC box girder bridge	520	1983
Mima Chuo Bridge	Continuous PC box girder bridge + Post-tensioning PC T-girder bridge	657	1988
Kunimiyama Bridge	Steel-slab box girder bridge	152	1989
Sansan Ohashi	Continuous steel box girder bridge + PC T-girder bridge + PC hollow girder bridge	560	1990
Anabuki Bridge	Continuous steel box girder bridge	533	1991
Fureai Bridge	T-type rigid frame PC box girder bridge + Hinged PC continuous box girder bridge	500	1992
Kojima Bridge	Continuous steel box girder bridge	436	1992
Iwazu Bridge	Single span steel-slab box girder cable-stayed bridge	175	1993
Shikoku Saburo Bridge	Continuous steel-slab box girder bridge + Cable-stayed bridge	911	1998
Yoshinogawa Bridge (Expressway)	Continuous steel plate girder bridge + Continuous steel box girder bridge	853	1999
Ikeda Hesokko Ohashi Bridge (Expressway)	Balanced arch bridge	705	2000
Shikoku Chuo Bridge	Continuous steel plate girder bridge + Continuous steel box girder bridge + Continuous PC hollow slab bridge	548	2003
Suminoura Ohashi Bridge	Through type steel Lohse girder bridge + Continuous steel box girder bridge	445	2004
Saijo Ohashi Bridge	Through type steel Lohse girder bridge + Continuous steel girder bridge	734	2004
Awa Shirasagi Ohashi Bridge	Cable-egret bridge + Continuous rigid frame plate girder bridge	1,291	2012
Wakimachi Bridge and 8 other bridges	Sensuikyo (Low water crossing)	36-522	1952-1963

4. History & Culture Involving the Bridges Over the Yoshino River

(1) The History of the Bridges

During the time when land transportation was not yet fully developed, waterway transportation by boat service on the Yoshino River was used to carry people and goods (indigo, rice and fertile). Pic. 13 depicts an idyllic image of a *Hirata-bune* (Hirata boat) taking passengers to and from the opposite sides of the Yoshino River. Hirata boats were one of the major forms of transportation across this river during this time.

Pic. 14 is a *Hakuchi-watashi* (Hakuchi ferry) transporting cars and carriages across the Yoshino River. Such boat services were found at more than 100 locations along the Yoshino River and they remained in service for quite a while even after permanent bridges were built.

Pic. 15 is an *Iwade-watashi* (Iwade ferry) crossing the Yoshino River on the downstream side of the old Anabuki Bridge. You can see teachers and students commuting from the southern bank to the northern bank toward a girls' high school via this ferry.

As you can see the old Anabuki Bridge, built in 1928, in the background of the picture, you can see the *Iwade-watashi* in its last years, as it was replaced by the bridge shortly after. There is nothing left of these ferry services today, and the Miyoshi Bridge and Fureai Bridge (pedestrian bridge) has taken the place of the *Hakuchi-watashi* and the *Iwade-watashi* respectively.

Pic. 16 shows a part of the old Anabuki Bridge that was preserved after its demolition in 1992, following the construction of a new bridge.



Pic.13 Hirata-bune
(City History of Tokushima)



Pic.14 Hakuchi-watashi
(Photo by Tokushima Press)



Pic.15 Iwade-watashi
(Photo by Tokushima
Shimbun)



Pic.16 Preserved old Anabuki
Bridge

Since the old Anabuki Bridge was built at the linkage point of the railway and national route to Takamatsu City, Kagawa Prefecture, it played an important role for the economy and culture in the western region of Tokushima Prefecture.

(2) Cultural Value of the Bridges

The Yoshinogawa Bridge (Pic. 9) has been designated as a piece of Tokushima Citizens Heritage in the following two categories; “Nature & Land scape” and “Townscape & Life”, and is regarded as a symbol of Tokushima City.

The Awa Chuo (Central) Bridge, which crosses the middle basin of the Yoshino River, was the first long-span bridge built in Japan after World War II. Construction of the bridge began after receiving approval from the GHQ. A pair of statues of a boy and girl were erected near the bridge by world-renowned sculptor, Mr. Isamu Noguchi, who sculpted this work with the hopes of promoting a more peaceful world. (Pic. 17)

Pic. 18 & 19 are of the Kawashima Bridge and the Iya Vine Bridge, respectively.



Pic.17 Awa Chuo Bridge



Pic.18 Kawashima Bridge



Pic.19 Iya Vine Bridge

Both of these bridges are still used today by tourists and by the local residents in their day to day lives. The Kawashima Bridge is a *sensuikyo*, or a low water crossing, and as they blend in with the natural landscape, they preserve an untouched landscape of Japan.

The Iya Vine Bridge is built over the Iya River, which is a tributary of the Yoshino River, located in the upper streams. It appears in a traditional folk song “*Iya no Kohiki-uta* (a song for milling grain)”. It was built by defeated warriors of the Heike clan with vine that grows wild in the mountain, so that they could cut it whenever they needed to flee from the enemy. Some consider this bridge to be the origin of suspension bridges.

5. Technologies Applied to the Bridges Across the Yoshino River

The Yoshino River is referred to as “a place to visit when studying about bridges” because of the sheer number and types of the bridges built across it.

The Yoshinogawa Bridge is the third bridge counting from the mouth of the Yoshino River, and at 1,071m in length, was the longest bridge in the East when it was completed in 1928. It survived the war and the Nankai Earthquake which occurred in the Showa period, and was a symbol of Tokushima, a prefecture of bridge engineering.

In order to build a truss bridge of 17 spans across the Yoshino River, which is more than 1,000m in width, a traveling crane was installed on wooden falsework. (Pic. 20, 21)

Located in the upper Yoshino River basin, the Miyoshi Bridge was built for the old National

as a suspension bridge, but had to undergo serious Route 32 in 1927 (Pic. 22). It was originally built reconstruction twice due to damage from use over time and from damage coming from the traffic increase over the bridge. Although it went through two major repair projects, parts of the wires in the main cable was found broken in 1987, which caused the bridge to be renovated from a suspension bridge to a deck-type Lohse bridge.

After considering various designs for this remodeling, it became clear that the stiffening truss and the floor slab was firm and the basement of main towers were covered by solid bedrock. Therefore, a two-pinned arch rib style was adopted to support the stiffening truss by using the bedrock as the pivot point. This is one of the bridges representing the “Tokushima -Museum of Bridges” because it shows how the technological advancement enabled the bridge, which could only be built by suspension-bridge style at the time of construction, to be renovated into a beautiful, yet economically efficient arch-style bridge.

Of the 10 longest bridges in Tokushima Prefecture, the Onaruto Bridge is the longest. The 1,629m bridge connects Naruto City in Tokushima Prefecture with Hyogo Prefecture. The second longest bridge, the Awa Shirasagi (white heron) Ohashi Bridge is 1,291m and even the tenth longest bridge, the Nada Bridge, is 800m. The top 10 longest bridges, except for the Onaruto Bridge, are built across the Yoshino River.



Pic.20 Yoshinogawa Bridge
Yoshinogawa Bridge for
Opening ceremony (1928)



Pic.21 Yoshinogawa Bridge



Pic.22 Miyoshi Bridge
(Completed: 1927)



Pic.23 Miyoshi Bridge
(Renewed: 1990)

Table.2 Top 10 Longest Bridges in Tokushima Prefecture

Rank	Bridge Name	Route	Length
1	Onaruto Bridge	Kobe-Awaji-Naruto Expressway	1,629m
2	Awa Shirasagi Ohashi Bridge	Tokushima Loop	1,291m
3	Yoshinogawa Ohashi Bridge	National Route 11	1,137m
4	Awa Oe Ohashi Bridge	Pref. Route Ichiba-Gaku Teishajo Line	1,084m
5	Yoshinogawa Bridge	Pref. Route Tokushima-Naruto Line	1,071m
6	Shikoku Saburo Bridge	Pref. Route Tokushima-Kitanada Line	910.5m
7	Yoshinogawa Bridge	Tokushima Expressway	852.5m
8	Awa Chuo Bridge	National Route 318	820.6m
9	Nada Bridge	Pref. Route Tokushima-Hiketa Line	800m
10	Saijo Ohashi Bridge	Pref. Route Miyagochi-Ushinoshima Teishajo Line	734m

The Yoshino River goes upstream from east to west to Miyoshi City, then bends at a right angle toward the Sameura Dam. Along the south bank, National Route 192 and Tokushima Line (operated by JR Shikoku, or the Shikoku Railway Company) run side by side. And along the north bank, you will find the Tokushima Expressway, built and managed by NEXCO Nishi Nippon, or the West Nippon Expressway Company. Each bridge is categorized by color, where yellow bridges are road bridges, green are railway bridges and blue are sensuikyo, or low water crossings, which are low bridges that will sink under the water during floods. (Fig.2)

The Yoshino River was originally used as a waterway to transport goods and materials by boat, but eventually grew to include ferry services to connect the south and north banks. But due to the many accidents and the cancellation of services as a result of the typhoons, the people of Tokushima hoped to build bridges, first starting with the sensuikyo over low-water channels, then building permanent bridges, which is standing high above the waters. As the bridges were built in the most suitable way to each building site, various styles were used, including girder, I-girder, box girder, truss, arch, rigid-frame, cable-stayed and suspension.

The Awa Shirasagi Ohashi Bridge is a 1,291m long road bridge that crosses over the mouth of the Yoshino River. It is a central part of the Tokushima Loop (East), an urban planning road which functions as a bypass for National Route 11 and 55. This bridge consists of a 4-span continuous cable-egret bridge (L=575m), which is the first bridge in the world with this style, and two 5-span continuous plate girder bridges (L=350m, 366m).

Extensive tidal flats lie at the mouth of the Yoshino River and is populated by valuable benthic plants and creatures such as fiddler crabs. The area also functions as a stopping point, as well as a wintering spot, for various migratory birds such as snipes and plovers. In order to minimize the effect on this valuable zone, the bridge is designed to have no piers on the tidal flat (approx. 200m) and was built by only using single plane diagonally hanging cables in consideration of wild birds flying. As the bridge resembles the prefectural

bird, shirasagi (an egret/white heron) flapping its wings when viewed from the side, this style is named the cable-egret style.

4-span continuous cable-egret bridge, which is the first bridge in the world. This bridge is designed to have no piers on the tidal flat in order to minimize the effect on this valuable zone and was built by only using single plane diagonally hanging cables in consideration of wild birds flying around. (pic.6, Table.3)

The Yoshinogawa (Yoshino River) Ohashi Bridge, just upstream from the Awa Shirasagi Ohashi Bridge, is on National Route 11. It consists of two separate bridges, which are 1,137m in length and have three lanes each. They were built in 1972 and 1986. The substructures were constructed by the open caisson method and the superstructures were one of the early examples of large scale block construction.

Two bridges stand right next to each other. One is used for northbound and the other for south-bound. They were completed in two different years. Two bridges were built in a same style but the shape of girders and the structure of sidewalks are different. (Pic.24, Table.4)

The Yoshinogawa Bridge, further upstream from the Yoshinogawa Ohashi Bridge, was completed in December 1928. The Warren truss bridge and the silhouette of Mt. Bizan, even mentioned in the Manyoshu, Japan's oldest anthology of poems, are said to have a nostalgic air. This bridge was designed during the Taisho Period (1912-1926) by Mr. Jun Masuda. After studying about bridges in the US, he returned to Japan to set up a consulting business. He designed many Japanese bridges in the rural areas. This bridge was one of the three bridges built across the Yoshino River during the time of the reconstruction efforts of Tokyo after the Great Kanto Earthquake (1923).



Pic.24 Yoshinogawa Ohashi Bridge

Table.3 Awa Shirasagi Ohashi Bridge

Route : Main Regional Route Tokushima Load (East)
Length : 1,291m
Width : 25.5~29.5m
Type of superstructure : Continuous cable-egret bridge + Continuous plate girder bridge
Completed : April 2012

Table.4 Yoshinogawa Ohashi Bridge

Route : National Route 11
Length : 1,137m
Width : 12.3m×2
Type of superstructure : Continuous steel-deck box girder bridge
Completed : 1972 & 1986

Table.5 Yoshinogawa Bridge

Route : Main Regional Route Tokushima-Naruto Line
 Length : 1,071m
 Width : 10.1m
 Type of superstructure : Single-span curved-chord Warren truss bridge
 Completed : December 1928

Symbolic bridge of Tokushima and was the longest bridge in the East when it was built. Designed by Mr. Jun Masuda and took only 3 years to be completed. (Pic.9, Table.5)

The Yoshinogawa Railway Bridge, with a length of 949m, was built for the JR Kotoku Line. This bridge is a steel Warren truss bridge consisting of 3 consecutive spans. As a fully designed and constructed truss bridge with consecutive spans this was a first of its kind in Japan. The pneumatic caisson method was used for the basement of substructure, making this the first time this method was used in railway construction.

Japan's first 3-span continuous truss bridge. The pneumatic caisson method was used for the basement of substructure, making this the first time this method was used in railway construction. (Pic.39, Table.6)

The Shikoku Saburo Bridge is a typical cable-stayed bridge completed in 1998.

Cable-stayed bridge style was used because the only rowboat site in the prefecture is located between the bridge towers. (Pic.25, Table.7)

The Nada Bridge is located about 10km upstream from the river mouth. It is 800m in length and was completed in 1963. This Pre-cast bridge,

Table.6 Yoshinogawa Railway Bridge

Route : JR Kotoku Line
 Length : 949m
 Type of superstructure : 3-span continuous steel Warren truss bridge
 Completed : 1935

**Pic.25 Shikoku Saburo Bridge****Table.7 Shikoku Saburo Bridge**

Route : Main Regional Route Tokushima-Kitanada Line
 Length : 910.5m
 Width : 14.0m
 Type of superstructure : Continuous steel-deck box girder bridge + cable-stayed bridge
 Completed : March 1998

Table.8 Nada Bridge

Route : Main Regional Route Tokushima-Hiketa Line
 Length : 800m
 Width : 8.0m
 Type of superstructure : Hinged PC continuous rigid-frame box girder bridge
 Completed : February 1963

Table.9 Awa Chuo Bridge

Route : National Route 318
 Length : 821m
 Width : 10.0m
 Type of superstructure : Single-span steel Warren truss bridge
 Completed : March 1953

constructed by the cantilever method was the longest of its kind in Japan when it was built. This was about the time when T-girder bridges by post-tensioning method were starting to be used and this one was designed by Dywidag method with full pre-stressing.

Second oldest PC bridge in Japan and the longest when it was built. (Pic.10, Table.8)

The Awa Chuo (Central) Bridge was completed in 1953 and is located about 25km upstream from the river mouth. It was the first long-span bridge built in Japan after World War II. Though the Ministry of Construction budgeted for this bridge in 1947, GHQ banned the construction work because of the shortage of steel. They were finally able to resume construction in 1950, when the Ministry of Construction provided necessary materials. The Oya-bashira (main pillar) of this bridge was designed by the famous sculptor Mr. Isamu Noguchi.

Japan's first long-span bridge built after WWII. Oyabashira (main pillar) was designed by Mr. Isamu Noguchi. (Pic.11.17, Table.9)

The Iwazu Bridge is built at the narrowest point in the middle reaches of the Yoshino River, which is about 40km upstream from the river mouth. It is a single-span steel deck cable-stayed bridge that is 175m in length.

**Pic.26 Iwazu Bridge****Table.10 Iwazu Bridge**

Route : General Pref. Route Funado-Kirihata-Kamiita Line
 Length : 175m
 Width : 9.8m
 Type of superstructure : Single-span steel deck box girder cable-stayed bridge
 Completed : September 1993

Used rare cable-stayed cantilever style due to the topographical restriction. (Pic.26, Table.10)

The Anabuki Bridge used to be a Gerber type Warren truss bridge. Mr. Jun Masuda designed this bridge and the units of measurement used in his designs were feet and inches. It was completed in April 1928 and part of the bridge still remains as a monument. The current bridge adopted the pneumatic caisson method for its substructure and box girder for its superstructure.

South oyabashira (main pillars) were relocated from the old Anabuki Bridge and udatu, or high-winged wall structures are used for north oyabashira. The old Anabuki Bridge, known as a beautiful bridge, can be seen as a monument. (Pic.27, Table.11)

The Wakimachi Bridge is a sensuikyo bridge located over a low-water channel and designed so that it does not obstruct water flow in times of flooding, by letting water flow over the girder. This bridge was completed in 1961 and local residents have expressed a strong desire to rebuild it high above the water.



Pic.27 Anabuki Bridge

Table.11 Anabuki Bridge

Route : National Route 193	Length : 533m
Width : 10.3m	
Type of superstructure : Continuous steel box girder bridge	
Completed : March 1991	



Pic.28 Wakimachi Bridge

Table.12 Wakimachi Bridge

Route : General Pref. Route Waki-Mitani Line
Length : 207m
Width : 3.6m
Type of superstructure : RC deck bridge+PC deck bridge
Completed : March 1961



Pic.29 Mima Chuo Bridge

Table.13 Mima Chuo Bridge

Route : General Pref. Route Mima-Sadamitsu Line
Length : 657m
Width : 9.2m
Type of superstructure : Continuous PC girder bridge + Post-tensioning PC T-girder bridge
Completed : February 1988

It was featured in a movie for its last scene and also functions as a school commute route for senior high school students to this day.

Typical sensuikyo, or low water crossing along the Yoshino River. Featured in a movie for its last scene. (Pic.28, Table.12)

The Mima Chuo Bridge is a PC long-span bridge consisting of 8 consecutive spans and was completed in 1988. It was one of the longest consecutive PC bridges in Japan when it was built. They had much difficulties with controlling the tension using the Freyssinet system.

8-span continuous PC girder bridge, 3rd oldest bridge across the Yoshino River. Used to be one of the longest continuous bridges in Japan when it was built. (Pic.29, Table.13)

The Minoda Ohashi Bridge is located at about 71km from the river mouth. It is a stiffening truss suspension bridge and was completed in 1959. Here on upstream, there are several bridges of the same style. This suspension bridge consists of stretching the storm cables from either above or below the bridge by making the height of the stiffening girder a little higher.



Pic.30 Minoda Ohashi Bridge

Table.14 Minoda Ohashi Bridge

Route : General Pref. Route Hiruma-Tsuji Line
Length : 184m
Width : 7.0m
Type of superstructure : 2-hinged stiffening steel truss suspension bridge
Completed : February 1959

Only suspension bridge built for cars across the Yoshino River. (Pic.30, Table.14)

The Ikeda Hesokko Ohashi Bridge was built by NEXCO Nishi Nippon and is Japan's greatest Langer girder arch bridge with spans of 200m each in length.

Largest class bridge in Japan as an inverted Langer style concrete arch bridge. Won Tanaka Award by Japan Society of Civil Engineers in FY 1999. (Pic.31, Table.15)

The Miyoshi Bridge was designed by Mr. Jun Masuda and was the first long-span bridge to be built over the Yoshino River. It was originally built as a suspension bridge, but the original stiffening girder is reinforced from underneath by a Lohse girder now, a very creative technique used for repair work.

The first bridge built across the Yoshino River not to be under the water during flood. Designed by Mr. Jun Masuda, the same person as the Yoshinogawa Bridge. Used to be the longest suspension bridge in the East, but renovated into an arch bridge due to aging. (Pic.32, Table.16)

The Oboke Bridge is situated over the Oboke Gorge at the entrance toward the Iya Vine Bridge area. It is a half-through type steel arch bridge with an asymmetrical structure. The surrounding area is well known for its boat cruise and rafting spots.

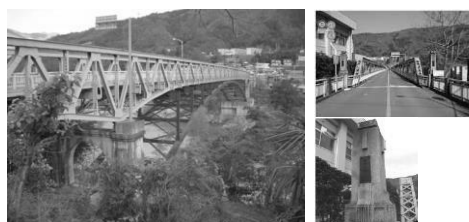
Half-through type arch bridge of interesting left-right asymmetry. (Pic.33, Table.17)



Pic.31 Ikeda Hesokko Ohashi Bridge

Table.15 Ikeda Hesokko Ohashi Bridge

Route : Shikoku Jukan Expressway (Tokushima Expressway)
Length : 705m
Width : 10.4m
Type of superstructure : Balanced arch bridge
Completed : March 2000



Pic.32 Miyoshi Bridge

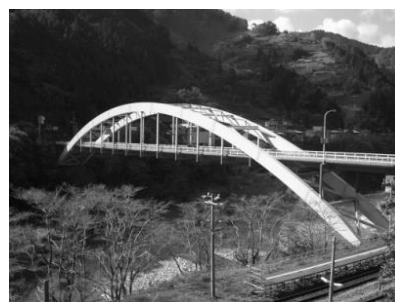
Route : General Pref. Route Norouchi-Minawa Teishajo Line
Length : 244m
Width : 6.1m
Type of superstructure : Deck-type 2-hinged Lohse Bridge
Completed : May 1927 (Renovated in August 1989)

Table.16 Miyoshi Bridge

Diverting from the Yoshino River, there are a few rare bridges located by its tributaries.

The Iya Vine Bridge is built over the Iya River. It is a 45m long suspension bridge, which is said to have been built by defeated warriors of the Heike clan, after a battle against Genji in the late 12th century. They built the bridge with natural vine so that they could cut it to flee from the enemy. Research by Tokushima University revealed that the tension of the vine used for this bridge decreases by half within 3 years, thus the reason why it needs to be reconstructed every 3 years.

Used to be the only type of transportation facility in deep valley area, but were all taken away after iron cable suspension bridges were built. Current bridge was rebuilt in early Showa period (1926-1989) as a tourism spot. (Pic.34, Table.18)



Pic.33 Oboke Bridge

Table.17 Oboke Bridge

Route : Main Regional Route Nishi Iyayama-Yamashiro Line
Length : 165m
Width : 8.8m
Type of superstructure : Half-through type 2-hinged steel arch bridge
Completed : August 1973



Pic.34 Iya Vine Bridge

Table.18 Iya Vine Bridge

Length : 45m
Width : 2m
Type of superstructure : Suspension bridge

The Suehiro Ohashi Bridge was built in the early stages of the cable-stayed bridges. The center span is 250m long and it was at the time, considered to be the longest span in the East. We demonstrated its wind resistance stability under the guidance of the Civil Engineering Research Institute of the Ministry of Construction and we placed 10-degree baffle blades of 1m width and 14 cm sill. Now we see bridges of the same kind, with the length of 1,000m, such as the Stonecutters Bridge in Hong Kong.

8th oldest cable-stayed bridge in Japan and had the longest span when it was built. Flaps added to the railing has an apparent effect against strong wind and was the first countermeasure for wind in Japan. (Pic.35, Table.19)

Lastly, the Konaruto Bridge stands over the Konaruto Channel. It is a multi-span suspension bridge and often appears in university textbooks. The design was created based on results from a wind tunnel test run by Tokyo University and was completed in 1961.

Rare 4 span suspension bridge with an A shaped tower in the middle. Because there were salt manufacturing business in operation in the area back then, anti-rust treatment was added such as cable wrapping and center tower cover. (Pic.36, Table.20)



Pic.35 Suehiro Ohashi Bridge

Table.19 Suehiro Ohashi Bridge

Route : Main Regional Route Tokushima Loop Length : 470m Width : 17.5m Type of superstructure : 3-span continuous steel cable-stayed bridge Completed : 1975
--



Pic.36 Konaruto Bridge

Table.20 Konaruto Bridge

Route : Main Regional Route Naruto Park Line Length : 441.4m Width : 7.0m Type of superstructure : 4-span continuous 2-hinged stiffening truss suspension bridge Completed : July 1961
--

As just described, bridges in Tokushima Prefecture have been built in various ways according to the locations and with the technologies of the era. This explains exactly why it is a "Museum of Bridges."

6. Promoting “Tokushima -Museum of Bridges”

The following are some examples of the projects that are part of the initiative to promote “Tokushima –Museum of Bridges.”

(1) Compiling the “Tokushima Hashi Monogatari (Tale of Bridges)”

“Tokushima Hashi Monogatari” is a history book about the bridges across the Yoshino River and includes the bridge construction history, the transition of bridge usage, the culture and industry developed around bridges, and the bridge construction technology. Bridge design documents and construction related information will also soon be added as references.

“Tokushima Hashi Monogatari” will be compiled with a focus on the bridges across the Yoshino River, such as the Yoshinogawa Bridge (Pic. 9), the Nada Bridge (Pic. 10), the Awa Chuo Bridge (Pic. 11), the Miyoshi Bridge (Pic. 32) and Japan’s first railway bridge of consecutive truss, the Yoshinogawa Railway Bridge (Pic. 39).

(2) Collecting Information to Construct Digital Archives

An expert study group composed of bridge administrators, academic experts, media outlets and cultural history experts will be searching and collecting information regarding bridges across the Yoshino River, such as design documents, documentary videos, newspaper articles and other press materials, local history books, and materials from academic societies. Collected information will be organized and compiled as digital archives.

(3) Holding Bridge-Related Events

Various events and promotional activities related to bridges are planned. For instance, the Tokushima Marathon (Pic. 40), which attracts more than 10 thousand participants every spring, incorporates the bridges and river banks into the race course. Participants can see eight bridges in the lower reaches of the Yoshino River. In order to publicize the bridges, panel exhibits about the

bridges across the Yoshino River are installed on the race course and photo books of the bridges are handed out to the participants.

Furthermore, a bus tour for local residents to visit several bridges along the Yoshino River is planned (Pic. 41). A detailed explanation, history and culture about each bridge is provided while traveling around major bridges along the Yoshino River. In 2014, a tour group visited some major bridges built along the Yoshino River, from those built over the lower reaches of the river such as the Awa Shirasagi Ohashi Bridge, to those built over the upper reaches such as the Miyoshi Bridge. The Civil Engineering Society supported the event in commemoration of the society's centennial anniversary.

Two years ago, will be hold an event similar to *Hashi-arai* (bridge clean-up) in Osaka or at the Nippon-bashi Bridge in Tokyo. In addition, we are going to hold events collaborating with local events such as *Asa-chakai* (morning tea party) which is held on the 15th of each month. Local residents and high school students participate in the event held at the site of old Anabuki Bridge (in front of the Anabuki Station). We believe these events will be a good chance to learn about the importance and the history of bridges by cooperating with local residents. (Pic.37)



Pic.37 Anabuki Bridge (Holding Bridge)



Pic.38 Yoshinogawa Railway Bridge



Pic.40 Tokushima Marathon
(at Awa Shirasagi Ohashi
Bridge) [Tokushima Marathon
Executive Committee]

Pic.41 Bus tour
(at Miyoshi Ohashi Bridge)

7. Conclusion

The opening ceremony of the Yoshinogawa Bridge in 1928 (Pic. 20), saw many cars forming a long line to go across and as many as 40 thousand People gathering to celebrate the completion of this long-wanted magnificent bridge of the time.

In 2012, three generations of couples made the first crossing at the opening ceremony of the Awa Shirasagi Ohashi Bridge, which adopted a new design for the first time in the world. Even to this day, we hope that this bridge will last for many generations just like the three generation of couples.

High expectation and passion for the bridges from the people celebrating can be seen from both of these opening ceremonies.

We would like to pass these valuable assets for generations to come. They have a technological and cultural value as civil engineering heritage.

I believe this shows the greatness of civil engineering which generates historical and cultural value.

These study stated above shows the importance of civil engineering which involves rich regional history and culture. For example, the local residents' longing for bridges has resulted in community activities such as *Hashi-arai* (bridge clean-up).

As seen in the examples of the Tokushima Marathon in which participants can enjoy the view of various bridges and the bus tours which people of all ages can participate and enjoy, the bridges and the civil engineering structures along the Yoshino River has been playing an important role for the increasing number of visitors looking for entertainment.

Infrastructure tourism, a concept of utilizing civil engineering structures for regional tourism can be a powerful card as a countermeasure for depopulating society as well as for regional revitalization.

Civil engineering history and civil engineering heritage which is functionally connected to tourism will be ever more important in the future.

[Reference]

- 1) Tokushima Prefectural Government. *Hashi no Hakubutsukan, Tokushima* (Tokushima - Museum of Bridges). <<http://www.pref.tokushima.jp/bridge/>> [Accessed 11 September 2015]
- 2) Tokushima Prefecture Construction Technology Center. "Bridge Symposium" –*Hashi no Hakubutsukan! Yoshinogawa* (The Yoshino River -Museum of Bridges) –. November 2013
- 3) Tokushima City Office. *Shimin Isan* (Citizens Heritage). <http://www.city.tokushima.tokushima.jp/kankou/shimin_isan/> [Accessed 11 September 2015]
- 4) Tokushima City Office. *Tokushima-shi Shi* (The History

of Tokushima City) <3rd Volume>. 31 March 1983. p.690

- 5) Ikeda Town Office. *Ikeda-cho Shi* (The History of Ikeda Town) <2nd Volume>. 31 March 1983. p.821
- 6) Yoshimi Sakamoto. *Awa no Hashi-meguri* (Bridge Tour in Tokushima). 17 October 1999. pp.26 and 86
- 7) Shuichi Takeichi. “*Bridges and Urban Development in London.*” *The Bulletin of Tokushima Society of Professional Engineers*, 19. 1 December 2011
- 8) Shuichi Takeichi. Museum of Bridges Tokushima Kyoryō Kiso August 2015

[Figures and pictures cited]

- 1) Tokushima Prefectural Government. *Hashi no Haku-butsukan, Tokushima* (Tokushima -Museum of Bridges). <<http://www.pref.tokushima.jp/bridge/>> [Accessed 11 September 2015]
- 2) Technological Committee for the Awa Shirasagi Ohashi Bridge (Design sub-committee and Construction sub-committee)
- 3) Tokushima Shimbun (Tokushima Press)
- 4) Tokushima City Office. *Tokushima-shi Shi* (The History of Tokushima City) <3rd Volume>. 31 March 1983. p.690