Eminent Structural Engineer: Dr Atsushi Hirai (1908–1993)

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Brief CV

1908	Born on August 4, in Kyoto
1936	Graduated from The University of Tokyo
1936–1939	Bridge Engineer, Osaka City government
1941–1943	Associate Professor, Keijoh Imperial University
1943–1948	Associate Professor, The University of Tokyo
1945	Dr of Engineering from The University of Tokyo
1948–1969	Professor of Civil Engineering, The University of Tokyo
1966–1972	Member, Science Council of Japan (concurrent appointment)
1969	Retired from the University of Tokyo (Professor Emeritus)
1973–1980	Vice President of IABSE
1976	Honorary member, IABSE
1978–1982	Vice Rector, Nagaoka University of Technology
1979	Honorary member, Japan Society of Civil Engineers
1982	Decorated with the Second Order of the Sacred Treasure
1985	Award of Merit, Japan Society of Civil Engineers
1993	Passed away on June 10, in Tokyo

Before the War

Atsushi Hirai (*Fig. 1*) was born in Kyoto in 1908. However, he spent most of his boyhood in Sapporo, Hokkaido—the northern island of Japan. His father was a civil engineer working for railways. Probably influenced by his father's profession and the bridge construction scenario near his home, Hirai went on to the Department of Civil Engineering of the University of Tokyo, where he spent a few extra years due to his illness. After graduating in 1936, he started to work at the bridge design department of the Osaka municipal office.

Fig. 1: Dr Atsushi Hirai

Facing tiresome design calculations of statically indeterminate structures in those days, Hirai developed the matrix formulation for the analysis of a stiffened arch bridge and derived its approximate solution by defining the distribution rate of bending moment and thrust to the upper and lower chords of the structure. This achievement was published in two papers in the Journal of Japan Society of Civil Engineers (JSCE) in 1940, which were his first papers accepted by academic journals.

Inspired by the Tacoma Accident

With the escalation of the war, bridge construction declined and Hirai came back to his alma mater as a research associate. In 1941, he was appointed associate professor of the newly established Keijoh Imperial University in Korea, annexed to Japan at that time. Around the end of 1940, he happened to see the news film of the collapse of the old Tacoma Narrows Bridge due to wind, in the movie theater. He was spurred on by this dramatic scene and immediately started the theoretical research concerned. Incidentally, when he came back from Osaka to Tokyo, his supervisor, Professor Yutaka Tanaka had suggested that he study a text book of bridge engineering, in contrast with the usual way, backwards from the last chapter, so that Hirai was just studying suspension bridges at that time.

As early as 1942, his first paper on the stability of torsional oscillation of suspension bridge under wind appeared in the Journal of JSCE, and a series of several papers on this topic were successively published. The kernels of this series of research were first the derivation of the critical wind speed for lateral/torsional buckling of a suspension bridge due to wind force, which corresponds to one of the aerodynamic instability phenomena and secondly the definition of reduced bending and torsional rigidity of a suspension bridge. In the latter, he pointed out the significant contribution of self weight to the rigidities of a suspension bridge.

Richard Scott wrote, in his book titled "In the Wake of Tacoma" (2001, ASCE), that *"an early but relatively unknown contributor was Japanese engineer Atsushi Hirai, who in 1942 sought to explain the Tacoma Narrows Collapse in terms of lateral and torsional buckling under static wind forces, a concern for long and slender spans. Hirai's work, which remained virtually unknown because of Japan's isolation during World War II, entered the mainstream only with its English-language publication in 1956. It was considered to offer the first theoretical explanation of the Tacoma Narrows Bridge collapse and was later expanded to include the role of aerodynamic torsion."* Yes, Hirai's pioneering work was completely independent from those of American and European researchers and was purely original. The English language publication mentioned above was that in the Preliminary Publication of the 5th Congress of IABSE. On his way to this congress, Hirai visited Professor F.B. Farquharson of the University of Washington, a main researcher of the Tacoma bridge collapse, and was taken

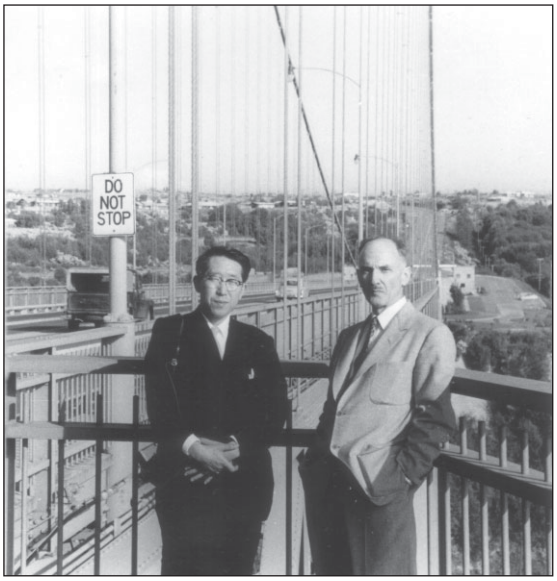

Fig. 2: At the new Tacoma Narrows Bridge, with Prof. F.B. Farquharson (1956)

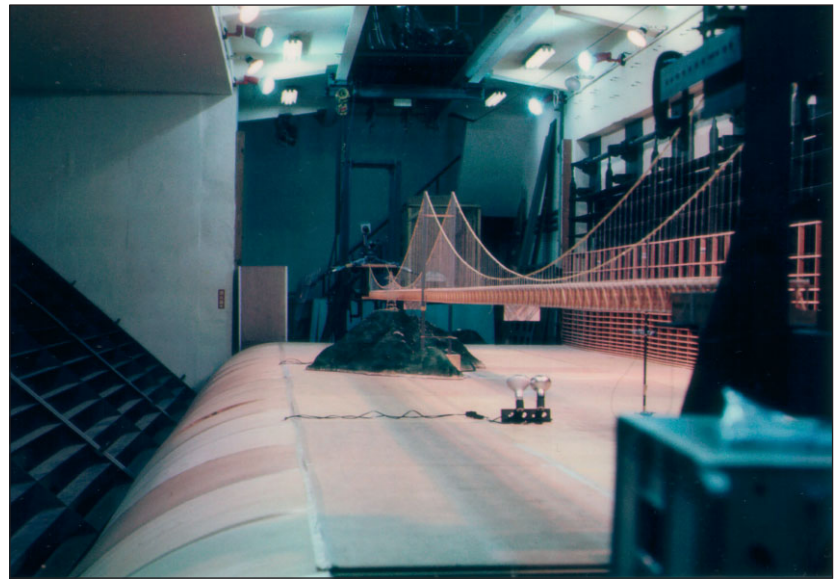

Fig. 3: Wind Tunnel of Civil Engineering Department, the University of Tokyo

to the rebuilt Tacoma Narrows Bridge site (*Fig. 2*).

Leader of Japanese Suspension Bridges

In 1955, studies on Japan's first long suspension bridge, the Wakato Bridge connecting the cities of Wakamatsu and Tobata in northern Kyushu, began and the investigation to select the shape of stiffening frame in view of aerodynamic stability was commissioned to Hirai. During a series of research in the 1940s, he had already recognized the necessity of an experimental study with wind tunnel models. But, since his laboratory did not have the facility at that time, his research group conducted a series of sectional model tests in the old Goettingen-type wind tunnel of the Aeronautics Department of the University of Tokyo. Nevertheless, their study on the Wakato Bridge in the late 1950s could be said to also pioneer the study of aerodynamic forces on bridge models. Although its main span is only 367 m, the Wakato Bridge was a benchmark in Japanese suspension bridge engineering and, upon opening in 1962 it was the largest suspension bridge in the Orient.

As previously mentioned, Hirai had found the contribution of dead weight to the rigidities of a suspension bridge. On the basis of this finding, he proposed the construction of an aerodynamically stable suspension bridge with intentionally heavy concrete deck without a stiffening girder. Several relatively short span bridges of this type were economically built in local areas, such as over the dam reservoir, of the country around 1960 under his advice.

Hirai was very enthusiastic for building a large wind tunnel to test full aeroelastic models of suspension bridges. On submitting the budget to the Ministry of Education, it was realized in 1964 at the University of Tokyo (*Fig. 3*). The tunnel had a test section 16 m wide and was the first, permanent facility of this kind since the early postwar investigations for the Severn Bridge.

Entering the 1960s, the feasibility study of the Honshu–Shikoku linking bridge project started. This project was to connect the main island of Japan with Shikoku, another large island, by building bridges along small islands in the inland sea with three separate routes, containing ten suspension and five cable-stayed bridges. Hirai chaired the committee on wind-resistant design, which published the first edition of design guidelines in 1967. This was the world's first systematic wind-resistant design code for large bridges. Including other technical issues, Hirai continued to be deeply involved in this huge bridge project.

International Activities

Although Hirai did not have a chance to study abroad, opportunities to attend international meetings gradually increased after the 1950s. At the same time, the Japanese engineer's interest in large bridges also increased. At the 1966 International Symposium on Suspension Bridges held in Lisbon, Japanese engineers led by Hirai formed the second largest national contingent and delivered many of the symposium's papers.

In 1969, Hirai, who now became an internationally prominent expert in suspension bridges, was invited to the advisory panel for the Bosporus Strait crossing scheme. In the same year, Italian State Road and Rail Agencies conducted the Design Idea Competition for the Messina Strait Crossing and he was invited to be one of three referees from abroad.

In the specific field of wind engineering, Hirai served as the Chair of the Organizing Committee of the 3rd International Conference on Wind Effects on Buildings and Structures (later, Wind Engineering) held in Tokyo in 1971. Hirai was also very enthusiastic about the activities of the IABSE. Responding to his encouragement, the number of Japanese IABSE members had significantly increased and he became Vice President of the IABSE in 1973. During his term as Vice President, the 1976 Congress of IABSE was successfully held in Tokyo, where he was nominated to become the honorary member of IABSE. His association with foreign engineers continued well into his later years (*Fig. 4*) and his successors at the University of Tokyo have close collaboration with IABSE (*Fig. 5*).

As a university teacher, his methods might be pretty different from that of the present day. He often cited the legend that a lion let his/her cubs fall into a deep ravine and then gave those who climbed out abundant affection, to raise them vigorously. This shows that he was a teacher with unique insight, while he seemed to scarcely force his

Fig. 4: Visit to Steinman's office in NY: from left, Messrs. Ulstrup, Hirai, Birdsall and Gronquist (1984; courtesy of Dr T. Kawada)

Fig. 5: Three generations of Bridge Engineering Chair of the University of Tokyo; from left, Hirai, Y. Fujino and M. Ito (1991)

way on others. Although I succeeded his chair at the university, I could act rather differently from his way.

His Later Years and Epilog

After his retirement from the University of Tokyo in 1969 at the age of 60, Hirai became his own master except for the occasional duties with the IABSE and came back to his own theoretical world, which had attracted his interest in the early 1940s but had been suspended for long. He tried to construct the new theoretical system of the mechanics of deformable bodies, discarding the conventional viewpoints, on the basis of analogy to electromagnetic theory. He presented two papers on this topic at the Proceedings of JSCE in 1971 and 1980 but, to his regret, could not attract the concern of other researchers because of the difficulty based on unique hypothesis.

In 1978, Hirai was called back to the educational community and served as the Vice Rector of the Nagaoka University of Technology for 4 years as the Ministry of Education had asked for advice in establishing this new university. Except for this case, however, he had scarcely been involved in the managerial services. Hirai was a person of individuality by nature. The matrix analysis of the stiffened arch preceding the electronic computer age and the innovative wind study on suspension bridges, far ahead of large bridge schemes in Japan, show his farsighted ability and innovative mind. Hirai seemed to have had a sense of inspiration and originality.

Hirai was, however, not a man confined to his study. When three routes of the Honshu–Shikoku bridges competed for priority, he firmly had his own belief about this issue and showed a very active and balanced attitude. He did not hesitate to express his engineering faith to even the politicians concerned. In private life, he liked to drink, especially whisky and *sa-ke*, and to converse with close friends and young people.