Eminent Structural Engineer: Dr Fritz Leonhardt (1909–1999)

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Prologue

The most difficult part while writing this article was to compile 90 years of an exceptionally creative life into a concise text. The authors apologise the absence of some important names within this text, particularly those who played an important role in Dr Leonhardt's life.

Brief CV

12.07.1907	Born in Stuttgart
1927–1931	Student of Civil Engineering at the Stuttgart University (Emil Mörsch, Otto Graf)
1932–1933	Graduate studies at the Purdue Universtiy
1934–1938	Bridge Engineer for Highway Bridges in Stuttgart, Berlin and Cologne
	Work with Karl Schächterle and Paul Bonatz
1936	Marriage with Liselotte Klein
1938	Doctor of Engineering at the Stuttgart University
1938–1941	Chief Engineer for the suspension bridge Cologne-Rodenkirchen
1939	Consulting Engineer
1954	Consulting Firm Leonhardt und Andrä
1958–1974	Professor at the Stuttgart University, Institute for Concrete Structures
1967–1969	President of the Stuttgart University
12.07.1999	Award of the First Fritz Leonhardt Prize
30.12.1999	Passed away in Stuttgart

The Design Engineer

General

In 1939 Dr Leonhardt (*Fig. 1*) established his design firm, which later became Leonhardt, Andrä und Partner.

Fig. 1: Dr Fritz Leonhardt (1999)

He established – at a time when the word was yet unkown – a management buy out which secured the continuity of the firm.

Bridges

At the age of 28 years, Leonhardt was appointed by the German Highway Administration as Chief Engineer for the construction of a suspension bridge across river Rhine at Cologne with a main span of 378 m, *Fig. 2*. Leonhardt managed to build the bridge within three years and performed – parallel to the construction – tests on the cable clamps, the friction of the abutments, aerodynamic stability etc.

Fig. 2: Suspension Bridge across River Rhine at Köln, Germany (1938–1941), mainspan 378 m

In 1948, Leonhardt designed, again in Cologne, a continuous steel box girder with a main span of 184,5 m and slenderness ratios of L/56 in the span and L/24 over the piers. Also in 1948, Leonhardt designed with Willi Baur his first bridge from prestressed concrete with a span of 30 m, prestressed by concentrated tendons.

In 1964, Leonhardt and Baur designed a 480 m long bridge with spans of 90 m across the Caroni River in Venezuela. The bridge was built completely behind the abutment and than launched, a world novelty for concrete bridges. From this the incremental launching bridges developed, built behind the abutments in length of about 25 m and then launched.

In the 1980s Leonhardt designed with Zellner prestressed concrete bridges for Germany's new high speed railway lines, e.g. two bridges across the Main River.

At this time, Leonhardt and Saul designed record breaking longspan steel composite bridges: a combined highway-railway bridge across the Caroni River, Venezuela (main span 213,75 m) and a railway bridge across the Main River (L = 208 m). Both bridges have haunched continuous girders and a bottom slab from concrete over the piers.

Bridge engineer Fritz Leonhardt is, nevertheless, best known world wide for his theoretical studies and his designs of cable-stayed bridges. Starting in 1955 with the design of the North Bridge across the Rhine River in Düsseldorf, Leonhardt and LAP have worked on more than 140 bridges of this type all over the world, some examples are:

- The Zárate-Brazo Largo Bridges across the Paraná/Argentina, the world's first cable-stayed bridge for highway and full railway.
- The Pasco-Kennewick Bridge across the Columbia River, USA, the

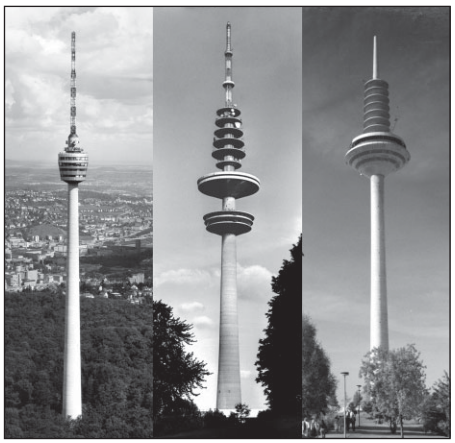

Fig. 3: Television towers, from left to right: Stuttgart 1956, height 216 m, diameter of pulpit 15 m; Hamburg 1967; Frankfurt 1978

world's first cable-stayed bridge with a deck from prestressed precast concrete.

Television Towers

In 1953, the South German Broadcasting Corporation (SDR) planned to build a 200 m high guyed lattice mast on a hill, south of Stuttgart.

Leonhardt developed as an alternative – a concrete mast with lookout platforms, restaurants and broadcasting facilities at its top; and he convinced the Lord Mayor of Stuttgart and the Director of the SDR to build this alternative. Construction started in June 1954 and opening took place in February 1956. This tower *Fig. 3* marked a break-through in the design of television towers – not only in Germany, where every major city asked for its own, tower, but also around the world.

Cable-Net Roofs

In 1967 Behnisch and Partner won the design competition for the Olympics 1972 in Munich. The indoor pool, the gymnasium, the stadium and the connections between them were covered by extremely complex tentlike roofs, *Fig. 4*. Together with experts like Frei Otto, Lingwitz and Argyris, Leonhardt and his team headed by Jörg Schlaich developed since mid 1968 the structural concept and the detailing of the roofs which were tendered a year later and finished one year ahead of the Olympics.

Fig. 4: Tentlike roofs for the Olympic Games in Munich (1968–1971)

The Professor, Inventor and Researcher

The Professor

Leonhardt taught 'Concrete Structures' at the Stuttgart University from 1958 to 1974; his lectures have been condensed, with the aid of Eduard Mönnig, in his famous "Red Books".

The Inventor

Leonhardt was never satisfied with the "State of the Art", but always tried to improve proven design and construction procedures. The most important of these improvements were:

- Aerodynamically stable suspension bridges with mono-cable.
- Neopotand teflon sliding bearings (Wolfhardt Andrä).
- Parallel wire cables with High AM anchorage (Wolfhardt Andrä).
- Perfobond strips (Wolfhardt Andrä + Hans-Peter Andrä).
- Leoba prestressing system and incremental launching of prestressed concrete bridges (Willi Baur).

The Researcher

The research work of Dr Leonhardt was basically related – but not limited – to concrete structures. Some examples are:

- "Stuttgarter Schubversuche" (Stuttgart Shear Tests) together with René Walther which resulted in codes on the dimensioning for shear and torsion.
- Distribution of cracks in concrete under tension with Horst Falkner, which was the basis for jointless structures.
- Stud Shear strips as reinforcement against punching, with Hans-Peter Andrä, which allowed to omit the ceiling joists.

After the collapse of the Tacoma Narrows Bridge Leonhardt started experimental and analytical research on wind induced vibrations of suspension bridges which he presented at the IABSE Conference in Rio de Janeiro in 1964.

Following the design of the roofs for the Olympics 1972 he established an Investigation Group dedicated to all aspects of lightweight structures including comparison with and adaptation of natural structures.

The Author

Dr Leonhardt has written numerous papers and was the author and co-author of 22 books. The most important books were:

- Spannbeton für die Praxis (Prestressed Concrete …). Co-authors – Wolfhardt Andrä and Willi Baur.
- Ingenieurbau – Bauingenieure gestalten die Umwelt (Structural Engineering – Civil Engineers create the environment).
- Vorlesungen über Massivbau (Lectures on Concrete), Volume 1 to 6.
- Bridges – Aesthetics and Design.
- Türme aller Zeiten – aller Kulturen. Co-author – Erwin Heinle (Towers of all times and all cultures).

The homo politicus

Dr Leonhardt never joined a political party but he was always interested in politics and criticised developments which he judged to be wrong.

He was for instance against the rearmament of Germany because he had experienced the horrors of World War II and felt that money might be better spent than by weapons.

He critizised his own profession, architects and investors for their careless treatment of nature; in 1975 he gave a lecture on "Bauen als Umweltzerstörung" (Building as destruction of the environment) which justified his point of view.

Last but not least, he was very active in civil engineering societies like IABSE which he supported in 1976 by a proclamation "Werden Sie Mitglied der Internationalen Vereinigung für Brückenbau und Hochbau" (Become a member of the IABSE).

Dr Leonhardt – Private

Although he never joined a sports club Dr Leonhardt was very sportive, following the wisdom: "Mens sana in corpore sano" (A sound mind in a sound body). In 1929 he crossed the Alps by hiking. This activity was so important to him that he later wrote the article

"Vom Wert des Wanderns und der heilsamen Wirkung der Natur" (On the value of hiking and the salutary effects of nature).

Whenever he visited a site if his schedule permitted, he always travelled a step further. His first and longest travel was in 1957 – a three month 15000 km trip from Buenos Aires to Lima, Peru.

Dr Leonhardt was also an avid music lover. Guided by his wife he attended classical concerts regularly.

Honours and Distinctions

The eminent work of Prof. Leonhardt was recognized by numerous honours and distinctions, some noteworthy accolades include:

- Doctor honoris causa of the universities: Braunschweig, Copenhagen, Purdue, Lüttich, Bath and Pavia.
- Honorary Membership of American Concrete Institute, Chamber of Architects Baden-Württemberg, Comité Euro-International des Béton, IABSE, Heidelberg Academy of Sciences, Finish Concrete Association.
- Medals and Prizes: Paul-Bonatz Prize, City of Stuttgart; Werner-von-Siemens-Ring; Honorary Medal Emil Mörsch; Grashof Memorial Medal, VDI; Freyssinet Medal of FIP; Golden Medal of the Institution of Civil Engineers, UK; Citizen Medal of the City of Stuttgart; Great Prize of the German Association of Architects and Engineers.

Fig. 5: Award of the First Fritz Leonhardt Prize to Dr Michel Virlogeux

The Fritz Leonhardt Prize (FLP)

On the occasion of Dr Leonhardt's 90th anniversary, the Chamber of Engineers of Baden-Württemberg, the German Association of Civil Engineers and Leonhardt, Andrä und Partner established the Fritz Leonhardt Prize (FLP) for outstanding achievements in structural engineering.

The first FLP was awarded on 12th July, 1999 to Dr Michel Virlogeux amidst 500 jubilee-guests from all over the world, *Fig. 5*.

Epilogue

The authors joined Leonhardt, Andrä und Partner between 1968 and 1977 and have worked with Dr Leonhardt for three decades. All who were lucky to spend such a great part of their professional life with him are grateful for the professional lessons and human example he gave.

References

[1] LEONHARDT, F. Baumeister in einer umwälzenden Zeit – Erinnerungen (Masterbuilder in revolutionary times – reminiscences). Deutsche Verlagsanstalt, Stuttgart, 1984.

[2] Stahlbau 68 (1999) Volume 7, with papers of several authors dedicated to Professor Leonhardt on occasion of this 90th anniversary. Ernst & Sohn, Berlin, 1999.

[3] ZELLNER, W. Fritz Leonhardt. Ein Leben als Bauingenieur in der Gesellschaft (Fritz Leonhardt. A life as Civil Engineer in the Society). Ingenieurkammer Baden-Württemberg, 2002.