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Partial collapse of the Berlin Congress Hall on May 21st, 1980

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ABSTRACT

The Berlin Congress Hall was a gift of the United States of America to Germany for the Berlin World Exhibition in 1957. The elegantly double-curved roof was made from an advanced prestressed concrete construction. The construction followed the design by the American architect Hugh Stubbins with special structural modifications to comply with German construction rules. No early indications for failure initiation were detected before a sudden partial collapse. On May 21st, 1980, the Southern external roof overhang collapsed. In December 1980, Jörg Schlaich and his co-authors published a summarizing expert opinion about structural causes of failure. The present paper mainly introduces results of cause analysis made at the Federal Institute for Materials Research and Testing (BAM), mandated by the Public Prosecutor at the Berlin District Court to specify the causes of the sudden failure. This paper refers to BAM-publications about analyses that were performed under this mandate and published – most of them in German language – within the first years after failure. The expert's opinions comprise structural considerations materials investigations, metallographic analyses and corrosion. Nowadays experts have learnt from the failure and built a slightly modified roof in the original shape at the 750th birthday of the city of Berlin and re-opened the former Berlin Congress Hall to the public on May 9th, 1987. The Hall is now serving as the House of the Cultures of the World, following the initial intention of the hall.

1. Introduction

The Berlin Congress Hall is a building that is of importance not only from the architectural, but also from the historical point of view. The gift from the United States of America was of high politic and symbolic relevance after WWII in the period of the cold war between the two international political blocks. The architect of the Berlin Congress Hall, the American architect Hugh Stubbins (1912–2006), started his carrier as an assistant of Walter Gropius (1883–1969). He was working together with other famous architects such as Marcel Breuer (1902–1981) and Alvar Aalto (1898–1976). At the time of erection, only few shell structures existed in the world such as the *Raleigh arena* (now Dorton Hall) in North Carolina, designed by the architect Maciej Nowicki (1910–1950), realized by his colleagues in 1953, and the Kresge-Auditorium of the Massachusetts Institute of Technology in Cambridge built by Eero Saarinen between 1953 and 1956 [1]. Early shell structures in Germany are the Schwarzwaldhalle in Karlsruhe built by Erich Schilling, the master transmitting station Felsberg in Saarland by Jean Francois Guédy – both built in 1954 – and the retirement home Knapsack of the Hoechst AG in Hürth by Karl Hell, which followed in 1956. Most of the previous structures were supported along their roof arches.

The Berlin Congress Hall roof with a new type of very slim prestressed concrete structure and cantilevers forming the external roof, belongs to the most famous international structures of the postwar modernity. The structurally demanding

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and venturing prestressed roof structure provoked special awareness. Great public attention was paid to the construction and finally to the big opening of the Berlin Congress Hall which represents the recent architecture from the fifties until today [1]. A hyperbolic paraboloid (Hypar shell) as a roof erected on only two bearings with a wide brim – as designed by the American architect Hugh Stubbins – has never been built in this manner before. The initial design of a roof with only two supports was sensitive to fulfil stability requirements under extreme load cases such as one-sided wind or snow. To ensure a safe performance of the structure, the structural design of the double-curved roof had a modification of the roof details.

23 Years after the big opening, in May 1980, a considerable external part of the Southern roof suddenly collapsed. One journalist lost his life; several persons were injured [3]. In the end of 1980, Professor Schlaich, Professor Kordina and Professor Engell published the summarizing expert opinion, prepared under the mandate of the owner and operating company Ausstellungs-Messe-Kongress-GmbH (AMK) [2]. The Office of the Public Prosecutor at the Berlin District Court mandated the Federal Institute for Materials Research and Testing (BAM) to carry out an expert opinion with special attention to materials behavior [3] to ascertain the circumstances of the partial collapse in more detail. Under this mandate BAM experts cooperated with the building operating company AMK during inspection of the failure and the dismantling of the remaining roof overhang. The root cause analysis finally resulted in the conclusion that nobody was declared to be exclusively responsible for the partial collapse and the Office of the Public Prosecutor at the Berlin District Court stopped all further investigations.

The coincidence of all subsequent insufficiencies during construction, execution and survey of the structure led to the failure. A single deficit would not have caused this catastrophe [3]. The Office of the Public Prosecutor could not accuse any of the responsible persons for full misconduct. No single acting person was able to foresee that his doing together with the activities of others could result in the partial collapse of the roof. The event was discussed in expert groups; the findings and the lessons learnt from the collapse were published, e.g. in [2–4], and resulted finally in generating new knowledge for the design of prestressed concrete structures and optimization of technical approvals, consequences in standards few years later, for prestressing steel.

Prestressed concrete structures have been a quite young technology based on the ideas and patents of Freysinet between 1928 and 1936. German practical experience with prestressed concrete structures reached back to the first prestressed bridges in Aue (1937–1993) with external prestressing cables, designed by Franz Dischinger. The first prestressed bridge with prestressed tendons embedded in the concrete according to Freysinet was erected in Germany in 1938. As Leonhardt mentioned in his *Prestressed concrete for the practice* (1955) [10], there was a need for developing higher strength steel for reaching a sufficient remaining prestressing force in the structure, high enough to prestress the concrete. That was, at the same time, a demanding requirement for the early application of the high strength steel wires for the erection of the Berlin Congress Hall.

1.1. Historical and political importance

The history of the Berlin Congress Hall began during the preparation for the *Internationale Bauausstellung IBA* (International Exhibition for Construction), which was planned to take place in Berlin in 1956. At the same time, the construction was part of the American initiated economic support in the West German federal states after WWII. The engagement was affected by the relation to the Soviet Union and the confrontation between the two political blocks. Thus, besides the intention to build an exhibition hall and conference venue, the hall gained a prominent symbolic role in the political context.

Fig. 1. Original structure of the congress hall before sudden collapse, photograph in 1960 [3].