Fallingwater

30 Years of Structural Conservation

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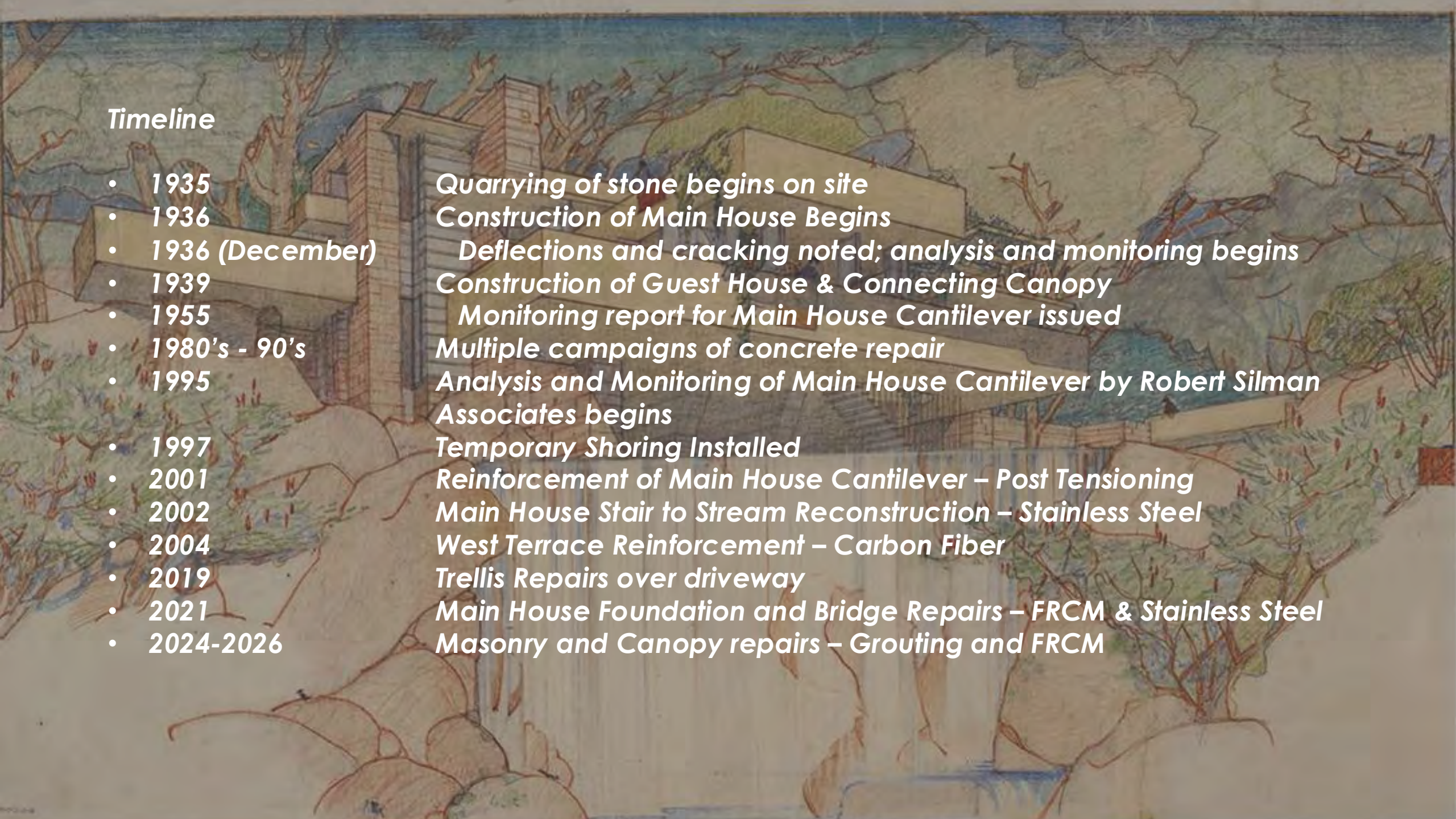
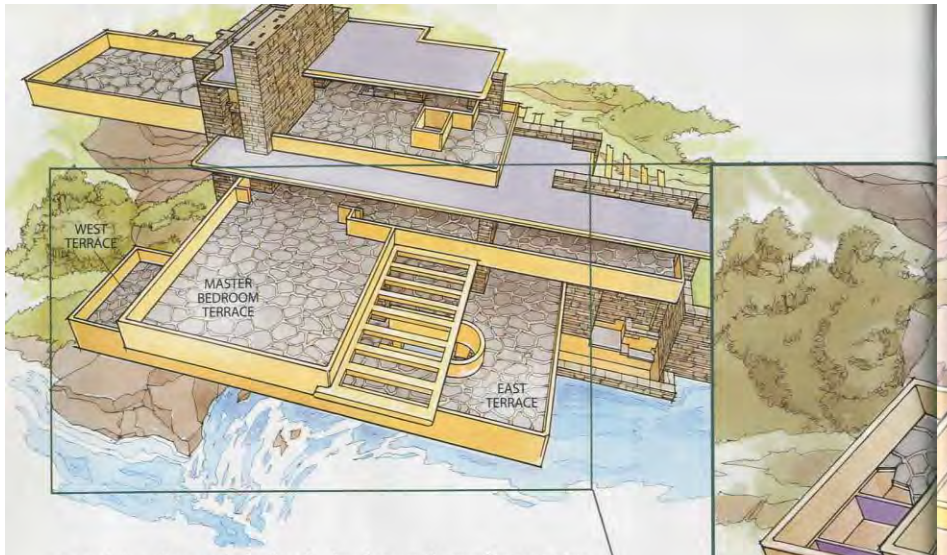
Themes

- *Architecture, Engineering and Conservation*
- *Flow Networks – Water and Force*
- *Reinforced Concrete*



Timeline

- 1935 — Quarrying of stone begins on site
- 1936 — Construction of Main House Begins
- 1936 (December) — Deflections and cracking noted; analysis and monitoring begins
- 1939 — Construction of Guest House & Connecting Canopy
- 1955 — Monitoring report for Main House Cantilever issued
- 1980's - 90's — Multiple campaigns of concrete repair
- 1995 — Analysis and Monitoring of Main House Cantilever by Robert Silman Associates begins
- 1997 — Temporary Shoring Installed
- 2001 — Reinforcement of Main House Cantilever – Post Tensioning
- 2002 — Main House Stair to Stream Reconstruction – Stainless Steel
- 2004 — West Terrace Reinforcement – Carbon Fiber
- 2019 — Trellis Repairs over driveway
- 2021 — Main House Foundation and Bridge Repairs – FRCM & Stainless Steel
- 2024-2026 — Masonry and Canopy repairs – Grouting and FRCM



ed his design. Once again he forced Kaufmann, Sr., to choose between him and Metzger-Richardson. Kaufmann, Sr., decided to go ahead with the house as originally planned.

Still, the house's owner remained concerned about the tilting of the terraces, so he commissioned a surveyor to measure the deflections on a regular basis by recording the elevations of the tops of the parapet walls. This was done from 1941 until 1955, when Kaufmann, Sr., died. In 1963 Kaufmann, jr., presented the house to the Western Pennsylvania Conservancy. Between 1955 and the time our firm was retained in 1995, only one or two random measurements of the terraces' deflections were recorded.

Engineers as Detectives

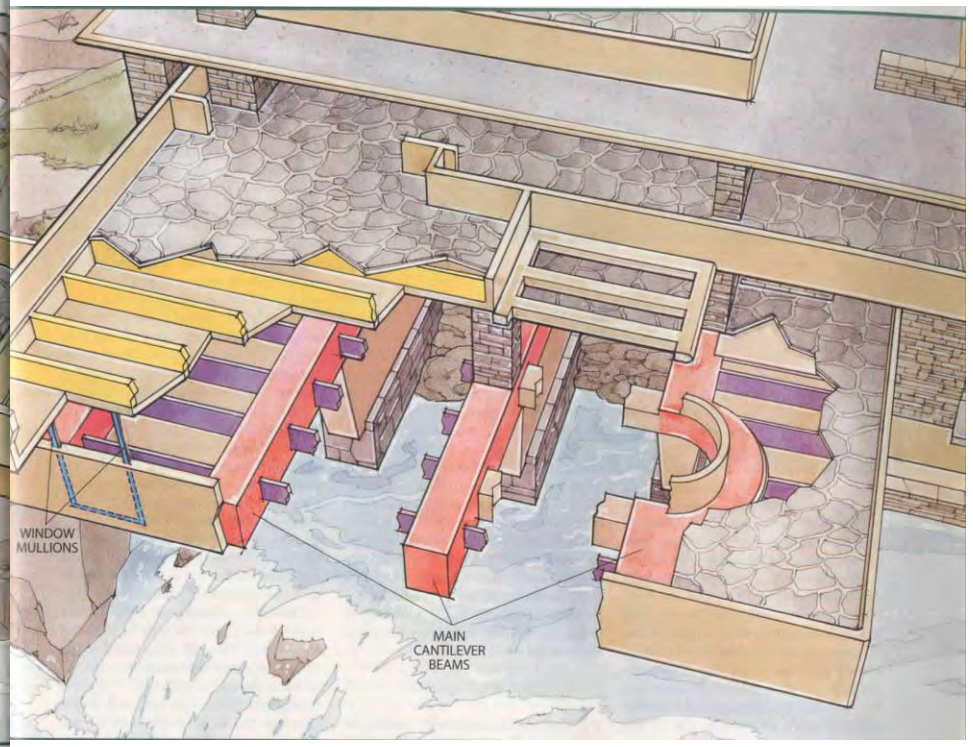
The conservancy initially asked our office to evaluate the structural adequacy of the master bedroom terrace, the part of the house that historically had the most severe visible cracks. Work was ongoing to repair Fallingwater's facade, including the terrace's cracks, and the conservancy wished to know whether it was wise to continue repairing these cracks cosmetically without first performing a structural review and, if necessary, repairs. We soon realized that we had to broaden our investigation to include the living room below, because the two floors are structurally interdependent.

Our first question was, "Have the deflections stopped, or are they still growing?" Using an instrument called a water level, we took height readings at more than 30 locations and attempted to relate them to the survey readings done earlier. Our measurements showed that the edge of the west terrace had sagged by as much as 146 millimeters and the edge of the east terrace by as much as 184 millimeters. The deflection of the south end of the master bedroom terrace was about 114 millimeters. We then installed electronic monitors to measure very small movements of the terraces and changes in the width of the cracks in the terrace's parapets. The results over more than one and a half years, corrected for daily and seasonal temperature variations, confirmed that the cracks were still growing and the terraces sagging ever lower.

The next step was to examine the structure's as-built condition to see how closely it conformed to Wright's plans. In particular, we needed to verify the actual number, size and location of the reinforcing bars in the cantilever beams and other structural elements. We organized a program of nondestructive evaluation, employing instruments that used impulse radar, ultrasonic pulses and high-resolution magnetic detection to plumb the interiors of the beams, floors and parapets. The tests also provided data on the quality of the house's concrete. The work was performed by GB Geotechnics of Cambridge, England. To investigate the main cantilever beams, the technicians had to remove several paving stones from the living room floor so that they could gain access to the hollow space below.

Our engineers then conducted an independent structural analysis of the house. Metzger-Richardson had done such an analysis in 1936 and 1937, but we wanted to make our own determination of how the structure functioned.

BARRY ROSS



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