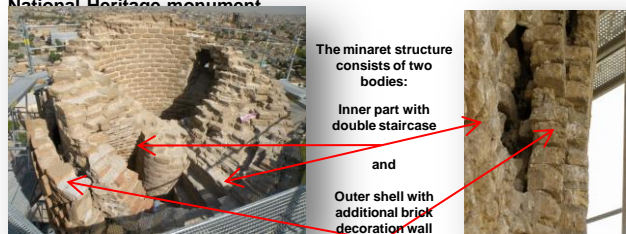


Conservation of Minaret Choli in Erbil, Iraq

Minaret Choli /known also as al Muzaffariya / situated 900 m West from the Southern gate of the Erbil Citadel, is the 36m high leaning structure with double spiral staircase, octagonal base, gallery and broken 24m high cylindrical part. It is a relic of an older mosque, probably originating from late Umayyad or early Abbasid period. The construction was ascribed to Muzaffar Al-Din Abu Sa'eed Al-Kawkaboori (1190 – 1232 AD). It is Kurdish National Heritage monument

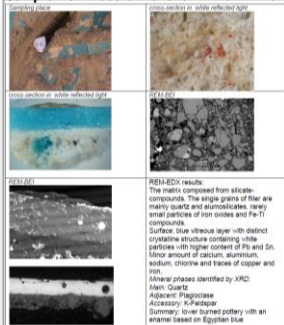


SCIENTIFIC RESEARCH

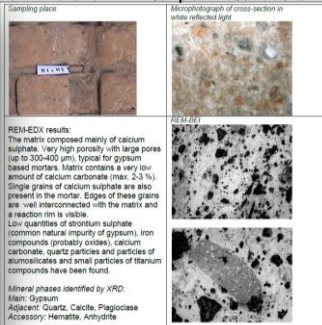
The research covered photogrammetry documentation, 3D visualization, comprehensive geo-physical survey, comprehensive material research, geological survey, mechanical and physical characteristics of the walls and structural measurements. General seismic study was carried out to identify the origin of inclination and reasons of the historic loss of the upper part of the minaret. As the seismic models confirmed, the minaret was proved to be stable and resistant to the seismic movements that have occurred in the past. Additional damage was caused by separation of external wall from the core.

As a result of inclination, tilting moment occurs in the place of location. Under adverse base conditions (flooding of the area), this moment can cause increase of inclination. With regard to the stated facts, it was decided to drain thoroughly the rain water from the area surrounding the minaret. An independent project was prepared for drainage of rain water and implemented in the course of subsequent works. Complete load of water was drained outside the area.

Sample M6 – Decorative relief in the NE niche; brick with enamel

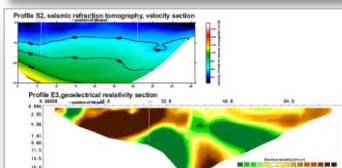


Sample M2 – Joint mortar

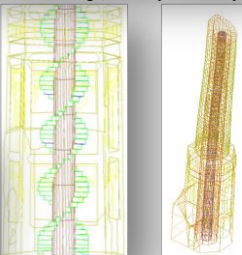


Geophysical methods

Shallow refractive seismology
Seismic 3D/2D tomography
Microgravimetry in rectangular system
Conductivity measurements
Geological studies



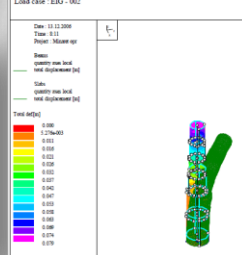
CAD drawings; 3D study of the body



Stability and seismic study modeling

Stat. vibration, mode 1, $\Omega = 1.393$ Hz
Load case: EGO - 002

Photogrammetry of octagonal part before conservation



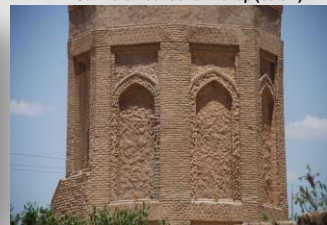
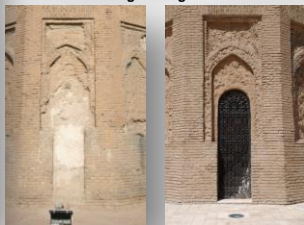
PHILOSOPHY OF INTERVENTION

The intervention was kept in terms of pure conservation. The stabilization of the whole structure and conservation treatment of all surfaces was carried out without the tendency of any reconstruction of missing and/or unknown parts of the decoration. The only exception was the inner area of all niches where pure conservation would be confusing from the architectural point of view. The inside area of all niches has been covered by mortar imitating the underlayer for ceramic tiles. All remaining original parts were carefully consolidated, retouched and incorporated into the system. The inner vaults of niches were reconstructed to its original shape (see below) to make the architectural frame better identified.



Reconstruction of architectural shape and conservation of wall and original fragments of lower niches

Conservation of original fragments (above)
Sunk drained roof at the top (below)



STABILIZATION AND CONSERVATION

The main task of the project was to implement the entire static masonry reinforcement of all walls and then to re-connect the detached internal body with external shell. The principal components of the system used Helibeam system by Helifix (UK) – spiral stainless steel rods – were implemented both radially and horizontally. Structural stabilization of both staircases followed from inside.

The conservation treatment of masonry covered complete repointing of all joints in the entire brick structure, consolidation and restoration of fragments of both ceramic and gypsum decorations including color and plastic retouching. The interior of both staircases has been rehabilitated. Heavily deteriorated bricks were replaced by hand made bricks produced according to the historic technology in local workshop. All refilling materials followed the results of the research of ancient materials and were based on modified alpha-gypsum system with silica sand as a main aggregate. Last remaining original stuccos were re-attached back to the core of the minaret. Subsequently, all open spaces, crevices and cracks were thoroughly filled in with the modified gypsum based filling material. The drained circle around the minaret was paved by replicas of historic low burnt brick tiles called "farshi", additionally consolidated.

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