On the room acoustics of two reactivated Hypar shell buildings at Magdeburg and Templin

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Introduction

Two monument protected buildings from around 1970 with double-curved roof shells shaped as hyperbolic paraboloids (abbreviated Hypar) by the Rügen based structural engineer Ulrich Müther (1934-2007) have been reactivated in recent years and restored to life with fascinating architecture after around 30 years of vacancy and decay.

The Hyparschale Magdeburg is a former exhibition and event hall with a column-free floor space of over 2,300 m². The roof is made up of 4 Hypar shells, resulting in a volume of over 23,000 m³, in which room acoustics suitable for congress and culture for a maximum of 500 guests were to be created.

The Hyparschale Templin is a former dining hall of a typical GDR vacation home. The Hypar shell roof spans a usable area of approx. 480 m² without columns. The hall is part of a partly new building complex with a children's daycare center, administration and restaurant and will be used for cultural events and seasonally as an ice-skating rink with suitable multi purpose room acoustics.

The paper deals with the history, architecture and room acoustic concept as well as the achieved acoustic quality of both building projects.

Benefits of hyperbolic paraboloid shells as roof constructions

Hypar shells have been well introduced in the architectural world. Essential benefit besides a certain architectural 'swing' are the advantageous structural properties as being a self-carrying areal load, so the thickness of many shells by U. Müther is typically only 7 cm of steel reinforced concrete, covering a column free area of typically approx. 500 m². Another important benefit is the geometrical specialty that a hyperbolic paraboloid can be created out of only straight lines. This allows for the use of only straight wooden battens as temporary formwork on the construction site to shape the reinforced concrete. These benefits made Hypar shells (as well funnel and free form shaped shells) interesting as roof construction for public solitary buildings in the former GDR, where U. Müther created a remarkable number of them.

The largest one, the so-called Ahornblatt in Berlin, had been demolished in the year 2000, unfortunately.

Architectural concepts

In both projects, one of the initial steps was the restoration of the Hypar shell roofs using a special carbon fiber-reinforced membrane coating on the exterior. Additionally, the soffits of the roof shells and the glazed façades were restored.

The 'Hyparschale Magdeburg' in its original state only contains a rectangular structure along one of the façades to house building services, facilities and a small grandstand on top.

Figures 1+2: Hyparschale Magdeburg before revitalization. The scaffolding tower in the center of the hall is a temporary item only for thermal expansion investigations before restoration, no load carrying.

For the building's revitalization, the selected architects (gmp Architekten, Berlin Office) developed a concept centered on demolishing the existing wing and replacing it with four newly constructed cuboids, one in each corner. These cuboids do not extend to the roof and are connected by four bridges at their top-floor level.

Two of the cuboids primarily house seminar rooms, while the other two accommodate bathroom facilities and a café. The building services are integrated into the ceiling void beneath the upper floor. Additionally, the narrow, angled gaps between the four Hypar shells have been reopened and glazed, allowing more natural daylight to enter the expansive space.

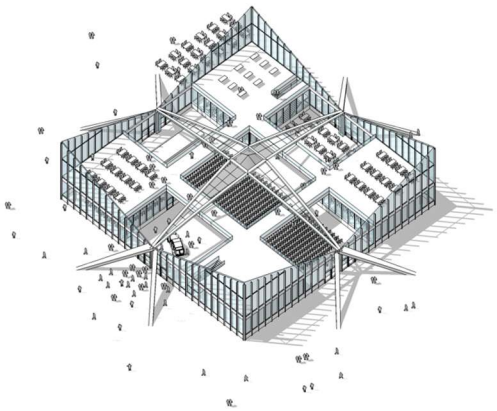

Figure 3: New architectural layout of the Hyparschale Magdeburg © gmp Architekten

Figure 4: Architectural rendering of the Hyparschale Magdeburg © gmp Architekten

Figure 5: Architectural interior rendering of the Hyparschale Magdeburg © gmp Architekten

The 'Hyparschale Templin' in contrast is a puristic hall covered by a single quadratic Hypar shell roof, without any internal structure. The selected architects immer.gut Architektur beckert + grabowski (Prenzlau) developed a revitalization concept for the Hyparschale and its adjoining building. Their plan focuses on restoring the hall for use as a venue for festivities and cultural events with a capacity of up to 200 guests, while also allowing for seasonal use as an ice-skating rink. Additionally, the adjoining building has been expanded to accommodate new functionalities.

Figure 6: Hyparschale Templin before revitalization © immer.gut Architektur

Figure 7: Architectural rendering of the Hyparschale Templin © immer.gut Architektur

Figure 8: Architectural interior rendering of the Hyparschale Templin, with seasonal ice-skating rink © immer.gut Architektur

Room acoustical planning concepts

For the Hyparschale Magdeburg, the architectural requirement was to leave the ceiling soffit untouched by any room acoustic treatment. Given the remaining hall volume of 17,000 m³ and a maximum seating capacity of 500, the specific volume per seat is 34 m³ - clearly indicating the need for substantial absorption.

The goal was to limit the worst-case reverberation time to a maximum of 2.5 seconds, with typical occupied mid-frequency values not exceeding 2 seconds. While this is higher than the target for a hall of similar volume with a conventional architectural shape, it accounts for the unique sound field characteristics under the double-curved Hypar shell roof. A reverberation time of 2 seconds still allows a high-quality, steerable electroacoustic system to deliver excellent sound quality and speech intelligibility. To address the acoustic challenges, a comprehensive room acoustics concept was developed, ensuring that nearly all newly created surfaces function as efficient broadband absorbers. These include the walls of the cuboids, the sides and soffits of the bridges, an openable partition wall to the foyer, and the lower, non-glazed sections of the façades. All these surfaces are constructed from perforated or stretched metal panels with porous absorption behind them.

Additionally, retractable curtain systems are installed beneath the bridges. These feature a five-layer construction that provides some sound insulation while incorporating a reflective layer facing the main event area to support lateral reflections. For thermal protection during the daytime, automatic sun blinds are integrated on the inner side of the façade glazing. While these blinds offer some additional absorption, they are not factored into the acoustic design, as they are not permanently deployed.

For the Hyparschale Templin, a room acoustic concept was developed featuring a sound-absorptive architectural membrane system suspended from the roof's soffit. This solution, agreed upon with both the architects and monument protection authorities, also integrates into the overall lighting concept. Notably, when properly fixed at its edges, the membrane naturally conforms to the geometric shape of a hyperbolic paraboloid.

The goal was to limit the worst-case reverberation time to a maximum of 1.5 seconds, with mid-frequency values around 1.25 seconds under typical occupancy conditions. While this

exceeds the target for a hall of similar volume (2,400 m³) with a conventional architectural shape, it accounts for the unique sound field characteristics beneath a double-curved Hypar shell roof.

To validate the acoustic concepts, repeated iterative simulations were conducted in EASE AURA based on the following models, displayed as EASE wire frame illustrations:

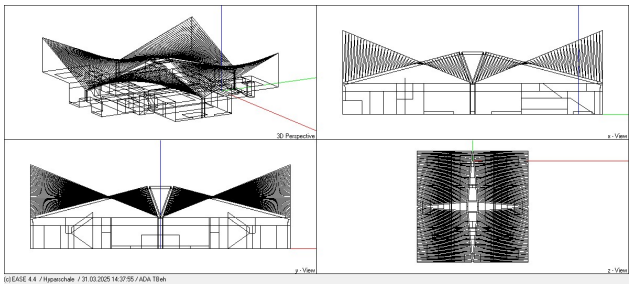

Figure 9: EASE wire frame model views of the Hyparschale Magdeburg

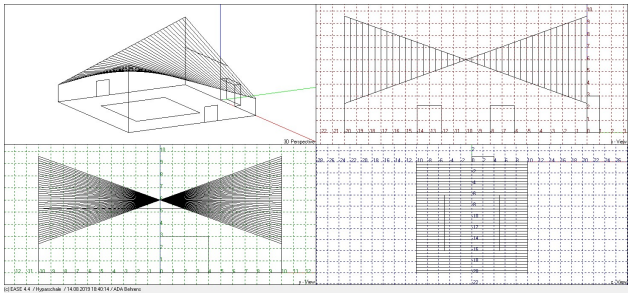

Figure 10: EASE wire frame model views of the Hyparschale Templin

Results

Both buildings now stand as impressive examples of architecttural restoration following the completion of construction.

Figure 11: Hyparschale Magdeburg, revitalized

Figure 12: Hyparschale Magdeburg from the inside, revitalized

At Hyparschale Magdeburg, the reverberation time was measured in June 2024 using sweep excitation in the unoccupied but furnished hall, with approximately 50% of the sun blinds deployed. Conducted just before the opening ceremony, the measurement showed a mid-frequency reverberation time of 1.7 seconds, as illustrated in the following figure:

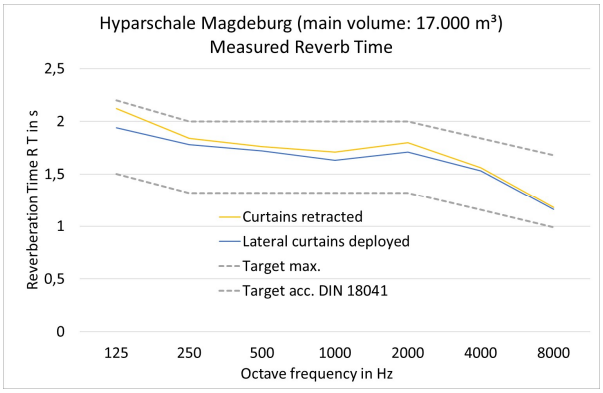

Figure 13: Measured reverberation time in the revitalized Hyparschale Magdeburg

Figure 14: Hyparschale Templin, revitalized
© immer.gut Architektur

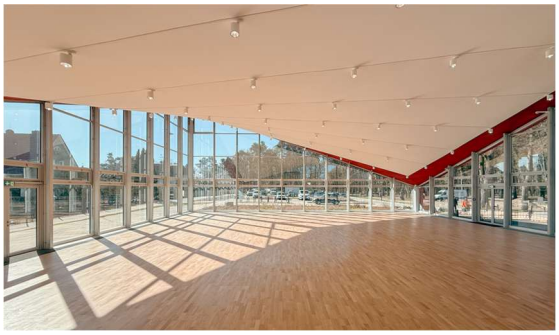

Figure 15: Hyparschale Templin from the inside, revitalized with retractable parquet flooring © immer.gut Architektur

At Hyparschale Templin, the reverberation time yet could only be roughly estimated at approximately 1 second in the mid-frequency range. This was derived from natural decays observed in a speech recording during a festivity in the highly occupied hall.

Both clients and the visitors have expressed their satisfaction with the acoustic properties of the Hypar shell halls, which successfully support their intended events and uses. Gratitude and respect are extended to the clients and all involved parties for their dedication in preserving and revitalizing these two remarkable Hypar shell structures, originally designed by Ulrich Müther.