NATIONAL WINNER

$100M OR GREATER

Kimmel Center for the Performing Arts
PHILADELPHIA, PA

JUROR COMMENTS:

A very strong solution—supports the architectural concept clearly and directly. A striking design that meshes structure with glass.

The Kimmel Center in Philadelphia, PA, contains a 2,500-seat concert hall and a multi-use recital theatre that will accommodate 650 patrons. These two spaces have been designed for a zero noise transmittance. This requires that both be completely isolated from the support and adjacent structure to eliminate any vibration transmittance.

The surrounding spaces are used for offices, classrooms and warm-up spaces. The entire building is covered with a transparent roof and end walls. This transparency invites patrons to feel a part of not only the performance they attend but also the experience of Philadelphia.

The entire structure is built atop a parking basement and mechanical service rooms that require column free spaces to accommodate a dense layout of mechanical equipment.

The Kimmel Center may be split into five engineering design challenges.

CONCERT HALL

The concert hall provides 2,500 seats, cantilevered balconies and member-free reverberation chambers. The superstructure of the concert hall has been developed as a series of trussed-arch shapes springing from a point at the base to provide stiffness to cantilever the balcony support members. This system provided an internal shell that supports all of the loads from the ceiling. The adjacent reverberation chamber is free of structural members passing through it.

RECITAL THEATRE

The recital theatre offers 650 seats and a multipurpose revolving stage. The recital theatre is a conventionally framed box supported away from the sides and the corners creating a difficult transfer path. This accommodates parking underneath and circulation concerns. The theatre also includes a fly gallery and a revolving stage with stage-fixed balcony seating to switch between theatre and recital modes quickly.

GENERAL BUILDING

The general building creates atrium and theatre support and consists of a reinforced concrete basement, parking level and mechanical spaces supported on conventional spread foundations. Large spans are designed for open spaces in both mechanical areas and parking areas, 50′ in most cases.

The reinforced concrete basement forms the support structure for the isolation pads and a shell around the halls, providing additional layers of resistance to sound transmission. The depth of excavation was limited to above the height of the groundwater level, approximately 30′ below the sidewalk grade. The depth of the acoustic isolation space had to be minimized. Upturned beams were used with multiple access points to the space created by the beam pattern.

All concrete areas consist of multiple geometry changes and large accommodations for multiple openings. A plenum structure was used within the concert hall for air distribution.

At grade level the building becomes

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STEEL FABRICATOR
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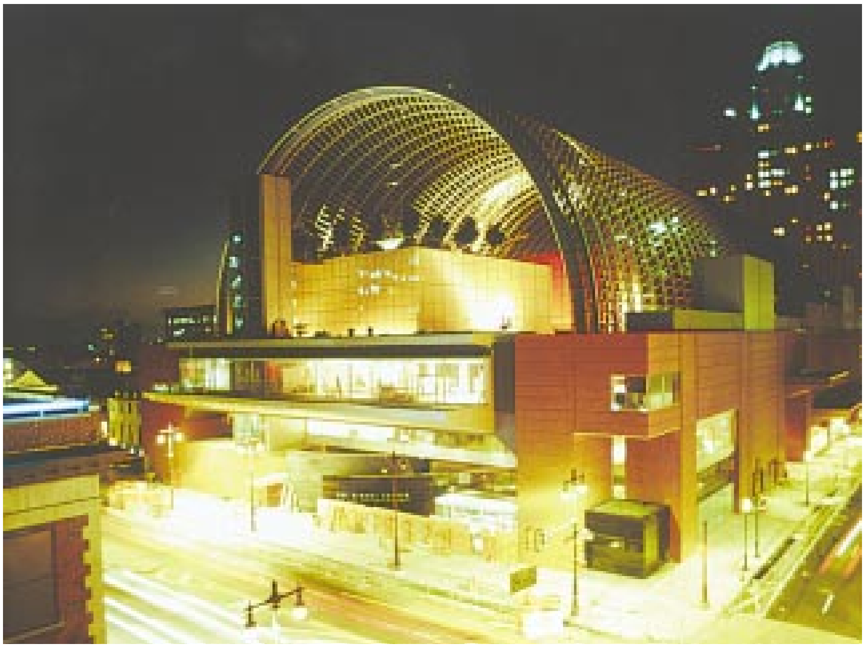
STEEL DETAILER
Base Line Drafting Services, Concorde, Ontario, Canada (NISD member)

GENERAL CONTRACTOR
LF Driscoll, Philadelphia, PA

SOFTWARE
QSE, ROBOT Millenium



steel. The surrounding building structure is composed of 16 main framed "box-columns" that support each floor as a cantilever. This structure includes a 100′ span bridge framed by vierendeel trusses. At the fourth floor level the cantilevered floor plate supports the load from the vaulted roof.

VAULT

The vault roof provides a transparent atrium roof and spans between cantilevered steel frames above the two theatres. It covers the full length of the building, measuring in plan 350′ by 174′.

The roof structure utilizes the depth of the vaulted section to create Vierendeel trusses that arch across the atrium space and provide vertical and lateral support. Each truss is propped against each other to provide folded plate action to resist longitudinal wind loads. Higher value steel stress material was used to minimize the member size. The spacing of the truss members was modulated to suit an optimal glass panel dimension.

END WALLS

Providing transparent closure for the atrium space, the end walls enclose the vault structure. To maximize transparency, a cable structure was utilized. Typical cable net walls rely on very stiff elements to secure the cable. This calls for a pretension load to be applied to the cable to give it initial stiffness and resist lateral wind loads.

The cable wall resists wind loads by creating a catenary shape. The cable is required to be in a catenary mode before it resists loads, hence the pre-tension to restrict initial movement. The base building has long-span members directly under the wall plan, thus providing little in the way of anything stiff enough to anchor the cables to. Additionally, there is a transparency requirement between the base of the wall and the adjacent support structure. The most significant challenge was to provide a technically stable and financially viable solution.

The arch shape naturally provides stiffness; however, the vault structure moves under wind loads, untensioning the cables. The spanning members under the wall also move under load, affecting the cable geometry and loading.

The cable must maintain stiffness throughout the loading cycle. Since the deflection movement of the vault was problematic, a slip joint was introduced to completely isolate the wall from the roof under considerations of lateral movement. It was resolved that the way to maintain constant loads on a deflecting cable was to provide a weight at the bottom end.

Grey iron, the heaviest material economically available, was used. This allowed the smallest possible profile to be created. Due to the different lengths of each cable and its location on the elevation, each weight is required to be different. To maintain cost effectiveness, the dimensions of the weights were designed to be the same. The weight differentials were obtained by using fixed dimensioned castings with varying sized internal hollow cores.

Each weight was calculated to provide a curvature of the wall deflection such that the edges of the glazed surface deflect very little and can be captured in a simple channel detail.

The concept for the total structure is very simple: the box that creates the space of the vestibule carries lateral loads through diaphragm/bracing behavior of the walls and roof. When the box becomes too long to provide diaphragm action, vertical columns provide propped cantilever action. These columns also support horizontal beams that carry the gravity load of the barrel vault trusses.