

# ENTRY FORM



## DVASE 2018 Excellence in Structural Engineering Awards Program

### PROJECT CATEGORY (check one):

|                          |   |                             |  |
|--------------------------|---|-----------------------------|--|
| Buildings under \$5M     |   | Buildings Over \$100M       |  |
| Buildings \$5M - \$15M   |   | Other Structures Under \$1M |  |
| Buildings \$15M - \$40M  |   | Other Structures Over \$1M  |  |
| Buildings \$40M - \$100M | x | Single Family Home          |  |

|  |  |
|--|--|
| Approximate construction cost of facility submitted: | <b>\$60 million</b>  |
| Entry Fee:   | <b>FREE</b>  |
| Name of Project:                                     | <b>Museum of the American Revolution</b>                               |
| Location of Project:                                 | <b>Philadelphia, PA</b>  |
| Date construction was completed (M/Y):               | <b>April 2017</b>  |
| Structural Design Firm:                              | <b>Keast &amp; Hood Structural Engineers<br/>Philadelphia, PA</b>      |
| Affiliation:   | <b>All entries must be submitted by DVASE member firms or members.</b> |
| Architect:   | <b>Robert A.M. Stern Architects</b>                                    |
| General Contractor:                                  | <b>Intech Construction</b>   |

Company Logo (insert .jpg in box below)



### Important Notes:

- Please .pdf your completed entry form and email to [bkoroncai@barrpino.com](mailto:bkoroncai@barrpino.com).
- Please also email separately 2-3 of the best .jpg images of your project, for the slide presentation at the May dinner and for the DVASE website. Include a brief (approx. 4 sentences) summary of the project for the DVASE Awards Presentation with this separate email.
- Provide a concise project description in the following box (one page maximum). Include the significant aspects of the project and their relationship to the judging criteria.

## **Museum of the American Revolution | Philadelphia, PA**

The new Museum of the American Revolution is the first museum dedicated to preserving the history of the American Revolution. The 4-story structural steel framed building is 120,000 square feet and sits on slightly less than an acre of land. Exhibit and theater spaces occupy portions of the ground floor and much of the second floor. Offices, event space, and mechanical equipment are located on the third and fourth floors. Keast & Hood provided structural engineering for the building as well as design for support of the feature exhibit, George Washington's headquarters tent. 1300 tons of structural steel was used in the design of this project.

### Key Design Challenges

**Construction on a tight urban sight:** The tight urban setting required complex construction coordination. In order to make room for the museum, a portion of the existing NPS Visitor Center had to be demolished while the remaining portion stayed open and occupied. A center tower crane was removed after the building was erected around it and the feature stair was then constructed in its place.

**Groundwater & soft soil spot during foundation construction:** The site required retention on all sides and the northeast corner was inundated with water. Dewatering pumps were needed to control water infiltration and prepare the subgrade for construction of foundations. Soils were stabilized with crushed stone and foundations placed. The first footing took 440 yards of concrete.

**Support larger than usual floor loads while limiting deflections and floor vibration:** The building consists of steel frame supporting concrete slabs on metal deck and partially restrained moment frame lateral system. Complex intermediate layered framing was necessary to accommodate interstitial support spaces and building setbacks. The framing system accommodates heavy exhibit loading and long spans. In the exhibit spaces, W27 & W30 members span over 45ft and more closely spaced W24 & W27 members span almost 48ft over a second floor marquee theater space. All members mentioned are topped with shear studs to create composite action with the 7 ½ inch slab on steel deck floor structure. Primary steel members with large depths were carefully located to provide floor depressions for exhibits and minimize the potential for conflicts should the exhibit spaces move or change.

**Support heavy precast panel exterior walls:** Large concrete encased cantilevered framing was necessary to support the south precast panel façade and avoid the foundations of adjacent buildings. Along the east elevation the design incorporates a concrete haunch that projects beyond the face of the foundation wall to support the precast panels and a stone water table. The largest panels on the north and west elevations to be supported from cantilevered steel weighed nearly 60,000 pounds. Along the remaining elevations, a concrete stem wall occurred above the foundation walls easily accommodating the returns and variations in the panel face. Early collaboration with the precast supplier resulted in no major conflicts or field corrections for the structural connections during construction.

**Monumental elliptical stair:** The signature Court space contains a 50ft tall clerestory public area for circulation. The main feature of the Court is an expressive elliptical stair with hidden hanger supports. To achieve this, box stringers made up of welded plates were designed to span from the ground floor to the second floor with steel hanger rods discretely placed within the full height balustrade extending from the landing level to the second floor. To control the tendency of the stair to sway under load, the ends of the welded plate box stringers had to be rigidly connected to the floor levels and the magnitude of these stringer reactions had to be resolved into the floor framing. Horizontal steel trusses were designed integral with the ground and second floor framing and plates and stiffeners added to receive the stringer connections.

**Provide additional exhibit support:** An important aspect of the firm's involvement in this project was the extensive exhibit support which included the need for collaboration beyond that of traditional building construction. Keast & Hood designed a structure to support the museum's feature exhibit, George Washington's Headquarters Tent. The resulting structure successfully supports the artifact without being seen or projecting through the object.

- The following 5 pages (maximum) can be used to portray your project to the awards committee through photos, renderings, sketches, plans, etc...



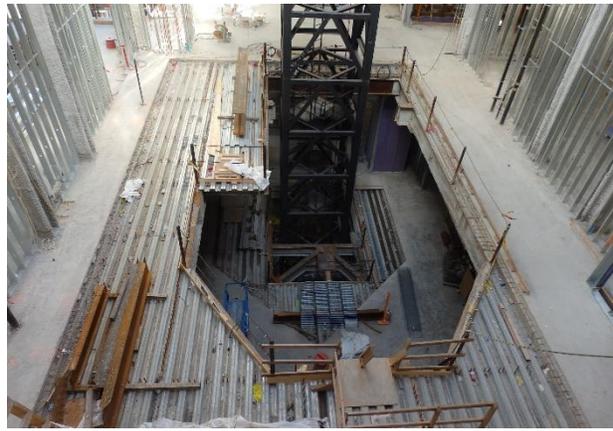
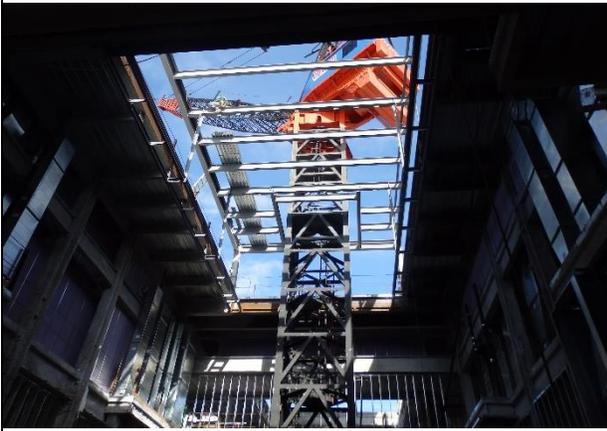
The new Museum of the American Revolution. The four story building is designed to amplify and contribute to the surrounding historical context of the Independence National Historic Park. (Final © Peter AaronOTTO for Robert A.M. Stern Architects)

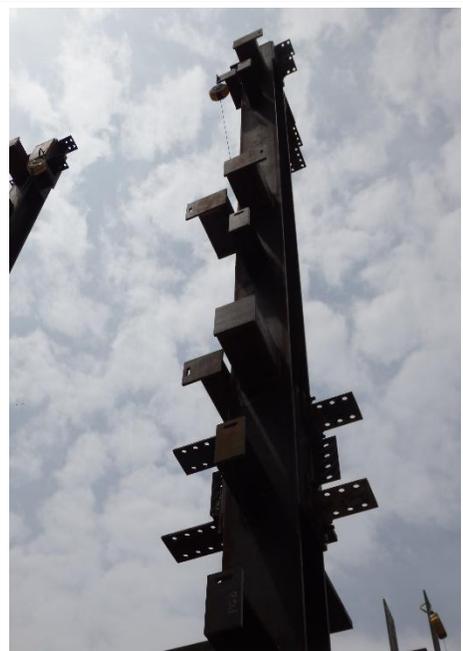


In construction photo showing the articulated panels. The Largest panels occur on north and west elevations at approximately 58,000 lbs. Connections had to reach out almost 3ft to support panels. (photo © Jeffrey Totaro)



The site required retention on all sides. Groundwater issues were pervasive, especially in the northwest corner during foundation construction (above left). The foundation of the existing NPS building to the south was XXX inches from the building's new footings (above right). The tight site necessitated erection of the tower crane in the center of the structure (below). (Construction photos © Keast & Hood)





Above, structural connections for the precast panels. At certain areas connections had to reach out almost 3ft to support panels.

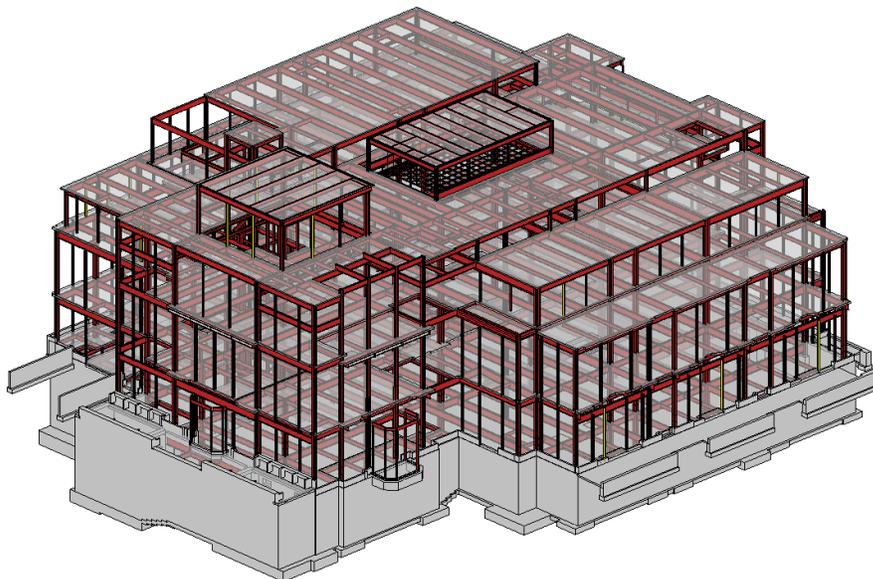
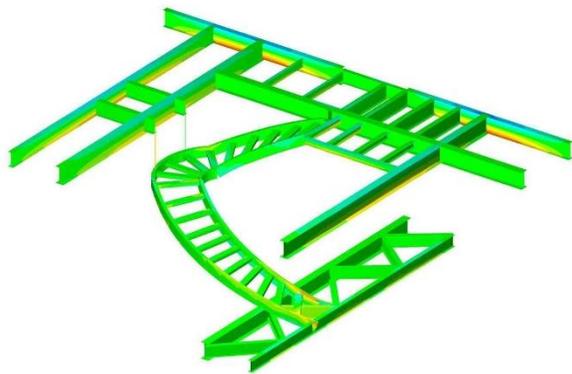
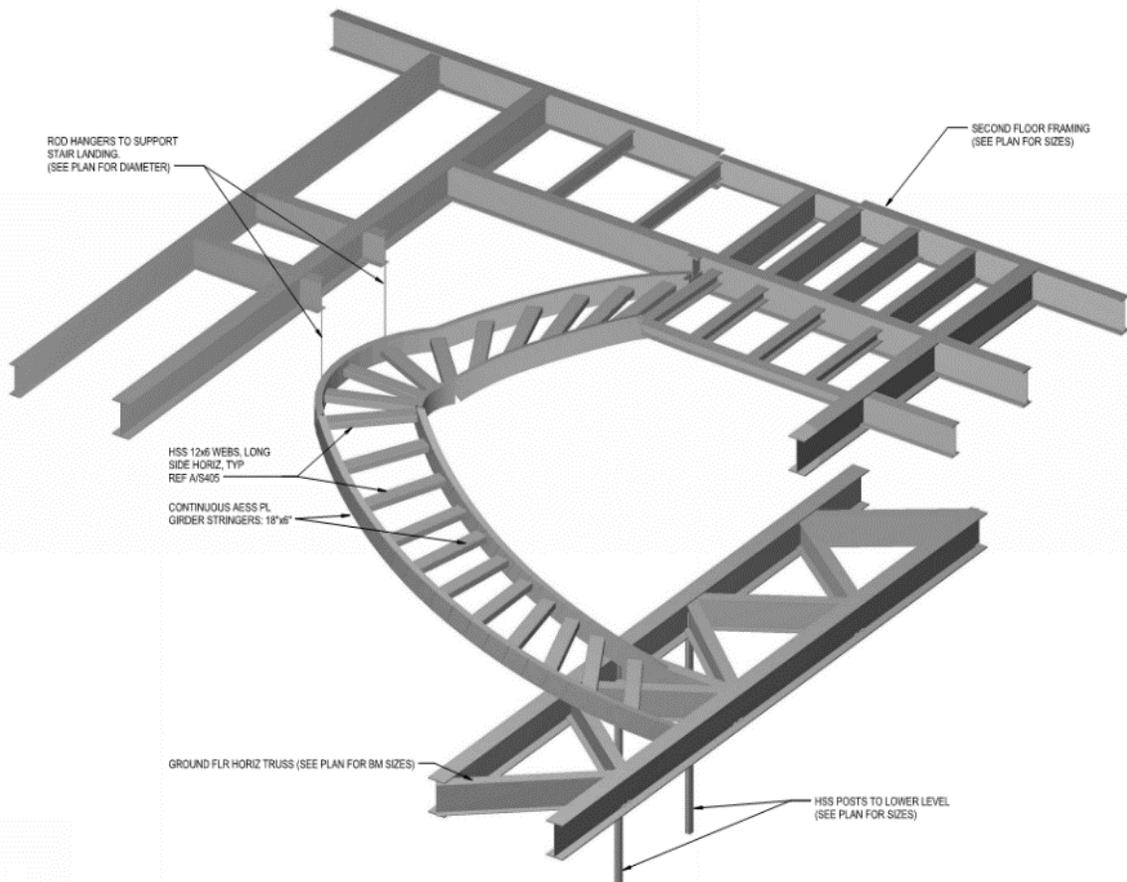


Image of BIM structural model. The 7 1/2" concrete slabs atop steel deck span between beams of depths varying from W24 to W33. Beams topped with shear studs to develop composite action btwn steel and concrete slab. Limiting bm depths helped meet the 16ft +/- clr ht in grd flr & 18ft +/- clr in the 2nd flr. Zoning setbacks req'd tiered roof frmg (7 lvls) done w/ transfer girders and trusses.



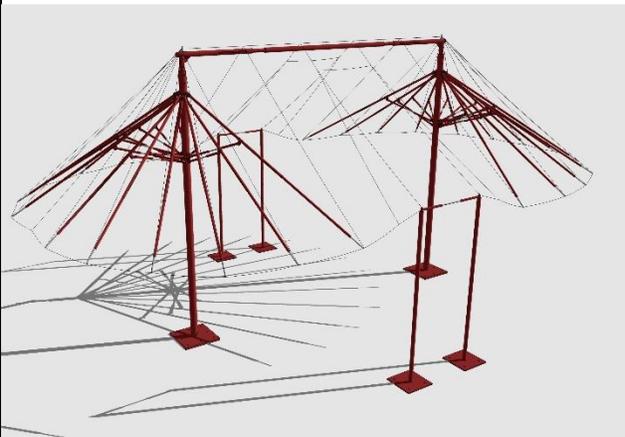
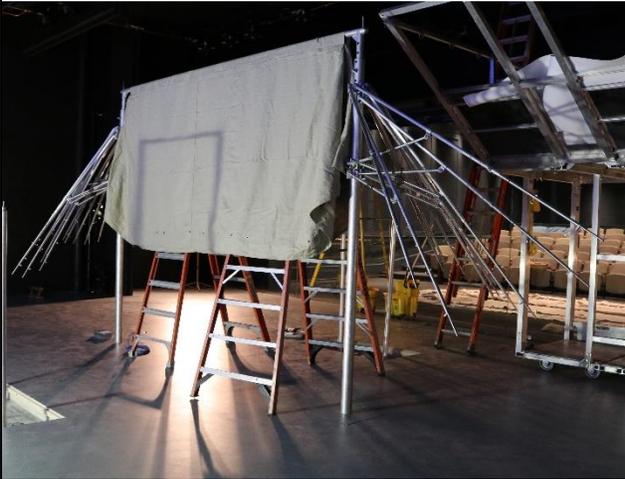
The stair's geometry is a complex assembly of curved parabolic arcs, meant to appear as if it is winding up to the second floor with no intermediate supports. Horizontal steel truss in ground floor receives court stair stringer loads.





Engineers designed large, open column-free spaces for public areas, exhibit spaces and theaters, while minimizing beam depths required to support larger than usual loads with strict deflection criteria.

The firm provided design support for the museum's feature exhibit and worked with fabric consultants, historic tent makers, tailors and architects to design an innovative umbrella-like structure that supports the artifact without inducing stress in the delicate fabric. The sub-tent structure consists of a light aluminum structure topped with a modern, inert fabric membrane that would take the tensile forces the artifact could not. Then the artifact could be draped over the sub-tent structure, much like a tablecloth atop a table.



By signing, signatory agrees to the following and represents that he or she is authorized to sign for the structural design firm of record:

*All entries become the property of DVASE and will not be returned. By entering, the entrant grants a royalty-free license to DVASE to use any copyrighted material submitted.*

Submitted by:

|   |   |  |
|---|---|--|
| <b>Print name:</b><br>Constantine G. Doukakis, PE | <b>Signature:</b><br> | <b>Date:</b><br>April 2, 2018            |
| <b>Submitting Firm:</b>                           | Keast & Hood  |  |
| <b>Mailing address:</b>                           | 400 Market Street<br>Suite 1250<br>Philadelphia, PA 19106   |  |
| <b>Telephone:</b><br>(215) 625-0099               | <b>Fax:</b><br>(215) 625-9408   | <b>Email:</b><br>ddoukakis@keasthood.com |