

ENTRY FORM



DVASE 2019 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	X	Other Structures Over \$1M	
Buildings \$40M - \$100M		Single Family Home	

Approximate construction cost of facility submitted:	Building Cost = \$37M
Name of Project:	Villanova University - Performing Arts Center
Location of Project:	Villanova, Pennsylvania
Date construction was completed (M/Y):	Early 2020
Structural Design Firm:	O'Donnell & Naccarato, Inc.
Affiliation:	All entries must be submitted by DVASE member firms or members.
Architect:	Voith & MacTavish/Robert AM Stern Architect (Joint Venture)
General Contractor:	L.F. Driscoll Co.

Company Logo (insert .jpg in box below)



Important Notes:

- Please .pdf your completed entry form and email to bsagusti@barrhorstman.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.

The Villanova University - Performing Arts Center (PAC) is both the new home of Villanova's Department of Theatre and Studio Art but also will be the venue for Broadway-caliber shows brought to the Main Line. The PAC is a three story, 83,700 square feet steel-framed building featuring two theaters; a 400-seat proscenium theater with a full gridiron/fly loft, and a 200-seat courtyard (black-box) theater. The building also has a grand two-story lobby, production shops, rehearsal spaces including a dance studio and choral room, a roof terrace, green roofs, classrooms and office spaces. This description however is oversimplified as the PAC is the proverbial 10 pounds of potatoes in a 5-pound sack.

The structural design challenges for the PAC are as varied as the program. A listing of some of the greater challenges is shown below:

1. The first challenge of the PAC is the "program centric" structural layout. The column layout for the PAC is both non-regular and discontinuous such that there are more than 30 column grids in each direction over an approximately 180 feet x 240 feet footprint. The vertically discontinuous nature of these grids led to post-up columns throughout all levels of the structure. Additionally, beyond the three "main" floors of the building; stepped balconies, stage rigging and tech levels translate into 27 distinct framing levels for the building. These levels precluded the economical use of formed concrete construction. With the choice of a steel frame structure in-hand, these layout challenges were met with intensive BIM modeling and creative steel detailing.

2. The challenges in the proscenium seating balcony area include the double-curved layout, the multi-stepped seating configuration and limitations for both the clearance and column-free sight lines below. These challenges are met with a radial structural layout using stacked built-up sections that cantilever out as much as 14 feet from column supports. Portions of the built-up section drop off as the balcony extends to create the steps. Further, to minimize structure depth a steel plate decking under the concrete slab is used and welded to all structural members to increase stiffness. At the sides of the balconies, the back-span for the cantilever is cut off by stairs. A box girder made up of a 40" deep girder and heavy side plates is used to resist the torsion and plated column members are used as vertical outriggers to engage the adjacent floor levels and minimize torsional rotation. 3D analysis was used for a "system" approach to this challenge.

3. The challenges of the courtyard theater balcony are similar to that in the Proscenium theater but more pronounce in terms of structural depth restriction. A 12-foot, column-free projection of the balcony from the sides of the theater, where no other floor level exists, is required to be achieved with a 10" total structure depth. To accomplish this a propped cantilever configuration is adopted with fixed torsional restraints along the outer edge of the balcony and hangers that extended up to the long-span roof construction at strategic points of the balcony. The shallow profile is achieved using 5" deep structural members with a bottom plate-supported deck. This steel is embedded in a 10" reinforced concrete slab creating a composite system adequate for stiffness, strength and vibration while maintaining the desired shallow profile.

4. Discontinuous floor plates and varying framing levels cut off the floor diaphragm. This makes both the choice and analysis of lateral force-resisting system a challenge. With load path issues and frame discontinuities, a combined lateral system was chosen. The center Proscenium Theater stage house was constructed of solid reinforced CMU and augmented with strategically placed irregular moment frames. Drag struts, girts and shear-transfer connections were used throughout the structure. The stage-house "core" was further complicated by embedded steel columns needed for support of backstage operating and loading galleries and balconies. Embedment details were designed to provide continuity of the CMU shear walls.

5. Structural loading requirements for professional level theaters are extensive, heavy, dynamic and varied. While magnitude of loading for a three-story building is not generally a structural challenge; the vast number of heavy loading requirements, combinations and multi-directional applications provided for a complexity of analysis and accounting not typical for the size of building. The building used almost 1,000 tons of steel which is about 24 psf.

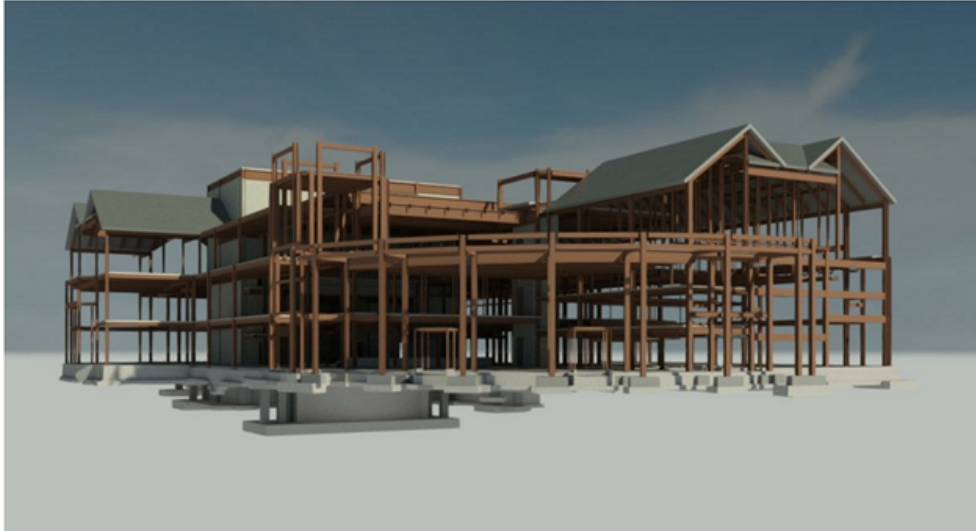
6. Other features of the PAC structure include:

- long span roofs over the theater spaces using deep fabricated steel plate girders
- A 17-foot-deep orchestra pit with a moving pit floor
- Strict vibration and acoustic requirements necessary for proper function of a theater with simultaneous use of program spaces, including dance studio and choral room
- Gabled/Mansard roof construction with "bent" beams over column free rehearsal spaces
- Large rooftop mechanical wells
- Removable trap floor areas on the stage
- Heavy terrace and green roof loading over long-span, column-free grand lobby space with designed mechanical openings in the structure
- 10 foot high perforated/discontinuous parapet walls at feature "turret"
- Precast concrete wall panels with inlaid stone

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



Front Architectural Rendering



Front Rendering - Structural Revit Model



Front Photo (from Ithan Ave) - Steel Complete



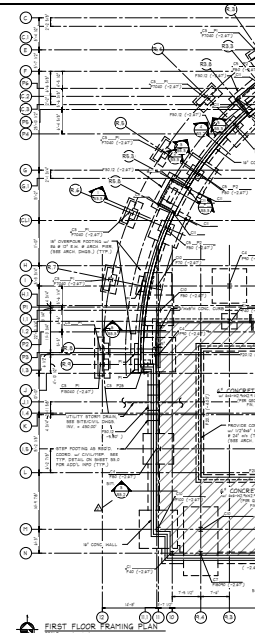
Front Photo (from Ithan Ave) - Skin Complete



Rear Architectural Rendering and Photo (from Lancaster Ave)



Proscenium Theater Curved, Cantilevered, Stepped Balcony Construction



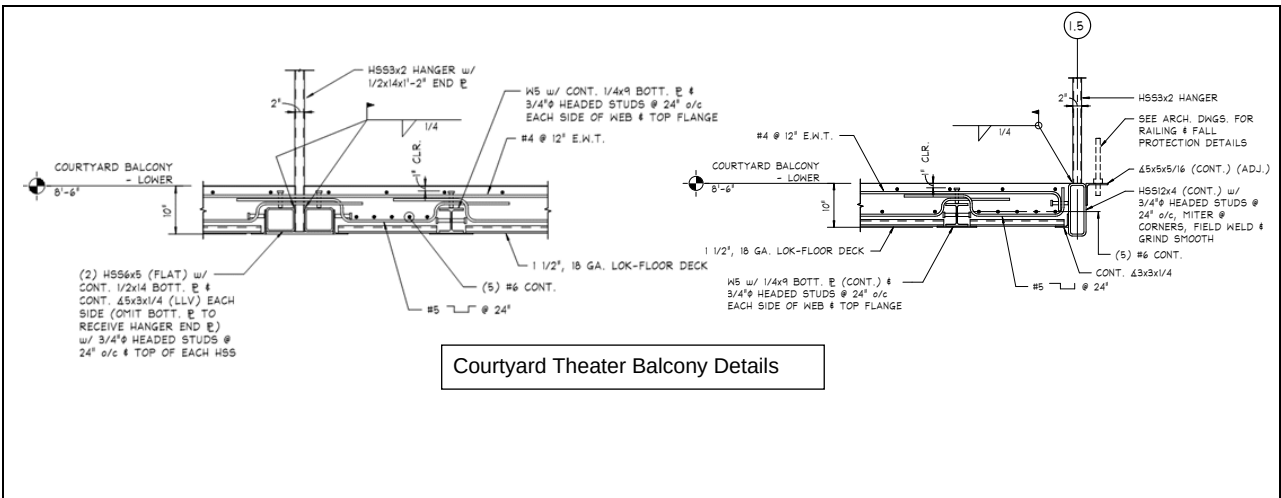
Plan Snapshot Showing Irregular Column Grid



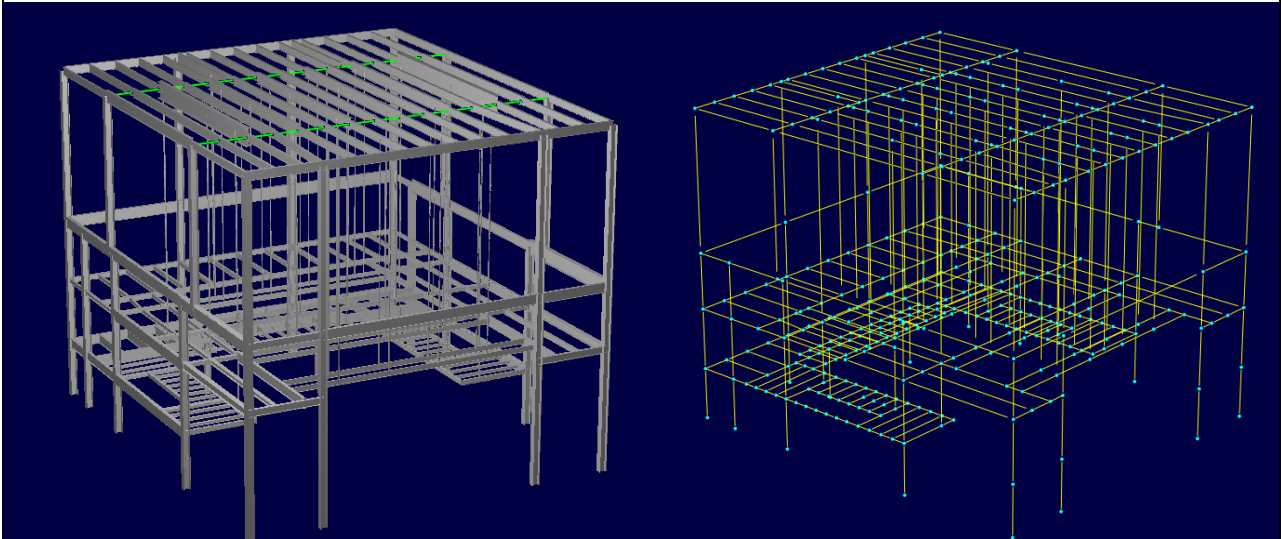
Proscenium Theater Balcony Revit Model Images

Proscenium Theater Architectural Rendering from Balcony

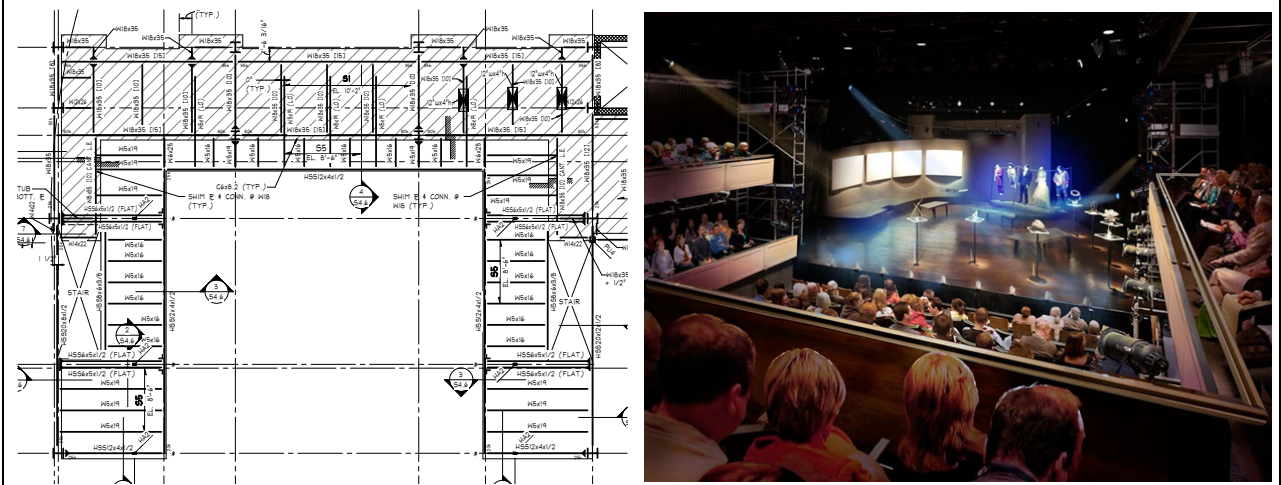




Courtyard Theater Balcony Details



Courtyard Theater 3D Analytical & Revit Models



Courtyard Theater Balcony Plan & Rendering



Aerial Photo During Construction



Architectural Rendering of Grand Lobby

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.

If selected as an award winner, you may be offered the opportunity to present your project at a DVASE breakfast seminar. Would you be willing to present to your colleagues? ☒ **YES** ☐ **NO**

Submitted by:

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