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A tale of two phases

PCS Structural Solutions' team — Brian Wiens; Craig D. Stauffer, S.E.; and Steve Farvour, S.E. — delivers an effective two-part modernization to Woodinville High School

Also inside:

Professional development series

Differential shortening of tall steel building columns

page PDH1

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A TALE OF TWO PHASES

The replacement and modernization of Woodinville High School

By Craig D. Stauffer, S.E.

The unified high school consists of five new buildings and three existing buildings, totaling nearly 240,000 square feet. The reconnected campus reduces travel time between classes and provides enhanced security and supervision.

studio Meng Strazzara

Woodinville High School

Owner
Northshore School District, Bothell, Wash.

Structural engineer
PCS Structural Solutions, Seattle

Design architect
studio Meng Strazzara, Seattle

General contractor/Construction manager
Cornerstone General Contractors, Bothell, Wash.

Set in the forested suburbs ringing Seattle, the Woodinville High School replacement and modernization, located in Woodinville, Wash., exemplifies not only a distinctive design, but a creative strategy and construction approach that gave the school district the facility it desired despite the reality of unsure funding and multiple phases of construction. Additionally, the project illustrates the dramatic growth of building information modeling (BIM) use — even in a low bid environment — and the significant advantages with its use in phased design.

Originally constructed in the early 1980s, the campus consisted of several buildings on a sloping 37-acre site, with several ball fields and on-site parking. One of three high schools in the Northshore School District, there are 1,400 students and 140 staff members on campus. In 2006, the district challenged the design team to reconnect the campus, better support current educational approaches, reduce travel time for students and faculty, and provide enhanced security and supervision.

Additionally, because of scheduling and funding parameters and the need to remain operational throughout the modernization, the design and construction schedule needed to be at least five years long and depend on the success of two voter-supported construction bonds.

After extensive programming and existing facility evaluations, the design team proposed a two-phased construction process with the second phase containing multiple construction "stages." New buildings would be built adjacent to the existing gymnasium, which was originally located at the eastern edge of the complex. As new buildings were constructed, existing structures to the west were demolished to make way for later stages of construction. This approach focused the majority of construction to occur without impacting the existing campus or sacrificing teaching spaces. Once complete, the renovated and new buildings will create a unified campus.

To add early expertise, because of the complexity of the multi-phased project, the district selected the general contractor/construction manager (GC/CM) process. GC/CM allowed the owner to select a general contractor that assumes a risk for construction at a guaranteed price, and provides consultation during design to assist with scheduling and sequencing recommendations, alternative design concepts, and cost estimating. At the end of design, the GC/CM then competitively bid the work in a series of subcontracts. The

Phase 2 of the high school was designed so that the existing facilities would remain fully operational throughout construction. *www.vitopalmisano.com*

Spotlight: PCS Structural Solutions

Q&A with the structural engineer

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PCS Structural Solutions' Craig Stauffer, S.E. (CS), discussed the Woodinville High School project with **Structural Engineering & Design** Editor Jennifer Goupil, P.E. (JG).

JG: What was most interesting thing about this project that inspired you during the design process?

CS: It was an enjoyable challenge to design the Phase 1 structure without knowing exactly when, or even if, the latter stages of construction would occur. We provided a design that functioned well on its own, but was also able to accommodate future construction with minimal impact to the Phase 1 structure. It simply wasn't feasible to design a Phase 1 building that may need to be partially shut down for upgrades during Phase 2.

JG: What was the first task you needed to do to get started on the design?

CS: The existing gymnasium was built on a hillside, and the foundations on the east end of the structure were two stories lower than the west end. To meet programming requirements, it was necessary to build directly up against the gymnasium but without matching the existing foundation grades. To reduce the impact – and the upgrade cost – to the gymnasium foundations we developed a Phase 1 foundation scheme that used the existing foundations where possible, and pulled the new foundations away from the existing bearing lines where necessary.

JG: What types and how many structural systems did you and your team evaluate for this project?

CS: When considering the structural systems, we reviewed cost, flexibility, fire-rating requirements, and function. For the horizontal floor plates, a composite floor beam system was selected as it met building-type requirement, was cost efficient, and provided flexibility for future modifications. The lateral systems vary throughout the buildings, ranging from structural steel braced frames to masonry and concrete shear walls – interior braced frames to increase allowable glazing areas, and shear walls where acoustical or fire separation requirements also came into play.

JG: What software did the design team use for the project design?

CS: We used Revit as our primary production platform in Phase 2. We utilized RAM Steel to analyze the structural steel frame and for lateral load distribution.

JG: Was building information modeling process used on this project? If so, to what extent?

CS: Building information modeling was used extensively. A model of every structure was developed and utilized for coordination and the production of construction documents.

JG: How was building information modeling process used on this project to benefit the structural engineering team? The whole project team?

CS: The model was used to produce the production documents, but it was also used to coordination the interaction between the different buildings framing systems and foundations. Three dimensional views were exported to PDFs or jpeg to facilitate coordination with other disciplines not utilizing BIM.

JG: Was the project peer reviewed? What benefits did your team realize from this process? Was this an owner requirement?

CS: A value analysis and constructability review was performed on both phases of the project. The reviews – which were desired by the owner and design team – helped confirm many of our decisions, as well as start discussions that ultimately led to better designs.

Firm Facts

Established in 1965, PCS Structural Solutions specializes in new building construction, historical renovation/building preservation, seismic retrofits, structural evaluations, and peer reviews. The firm — which has offices in Seattle and Tacoma, Wash. — serves several industries, including K-12 and higher education, health care, institutional, commercial, historic-building presearvation, and residential.

project team agrees that the cooperative process between the district, design team, and general contractor has been invaluable for the successes to date.

Phase 1

Because of the layout and use of the existing buildings, the first phase of construction needed to occur without sacrificing teaching or support space. To accommodate this, a parking lot adjacent to the gymnasium was regraded to make way for a two-story commons, library, and kitchen facility. A steel-framed system — using composite steel beams at the floor and steel beam/open-web steel joists at the roof — was selected. Located in a seismically active area, a steel concentrically braced system resists lateral forces. The former exterior wall of the gymnasium was resurfaced and is now an interior wall adjacent to the new commons. The support columns and frames for the new structure are positioned several feet away from the existing building, thereby significantly reducing foundation modifications to the existing gym.

Perhaps the most significant challenge during Phase 1 was designing a building with the intent — but not a guarantee — of a second construction phase. The two phases were funded independently by voter-approved construction bonds, and although Phase 1 was approved, the Phase 2 capital projects bond would not go before voters until after Phase 1 construction was in process.

To address this complexity, the design team jointly detailed a system to function well on its own, and, if necessary, serve the school independently for years. Ideally, it also was ready to accept the second phase of construction if and when it occurred, even though the second phase was only conceptually designed. Additionally, it was important to seismically separate the Phase 2 buildings to avoid triggering an upgrade on the Phase 1 structure due to increased seismic loading.

Three-story full height columns — designed for both the gravity system and lateral force resisting frames — were detailed to speed up structural steel erection in the new classroom building.

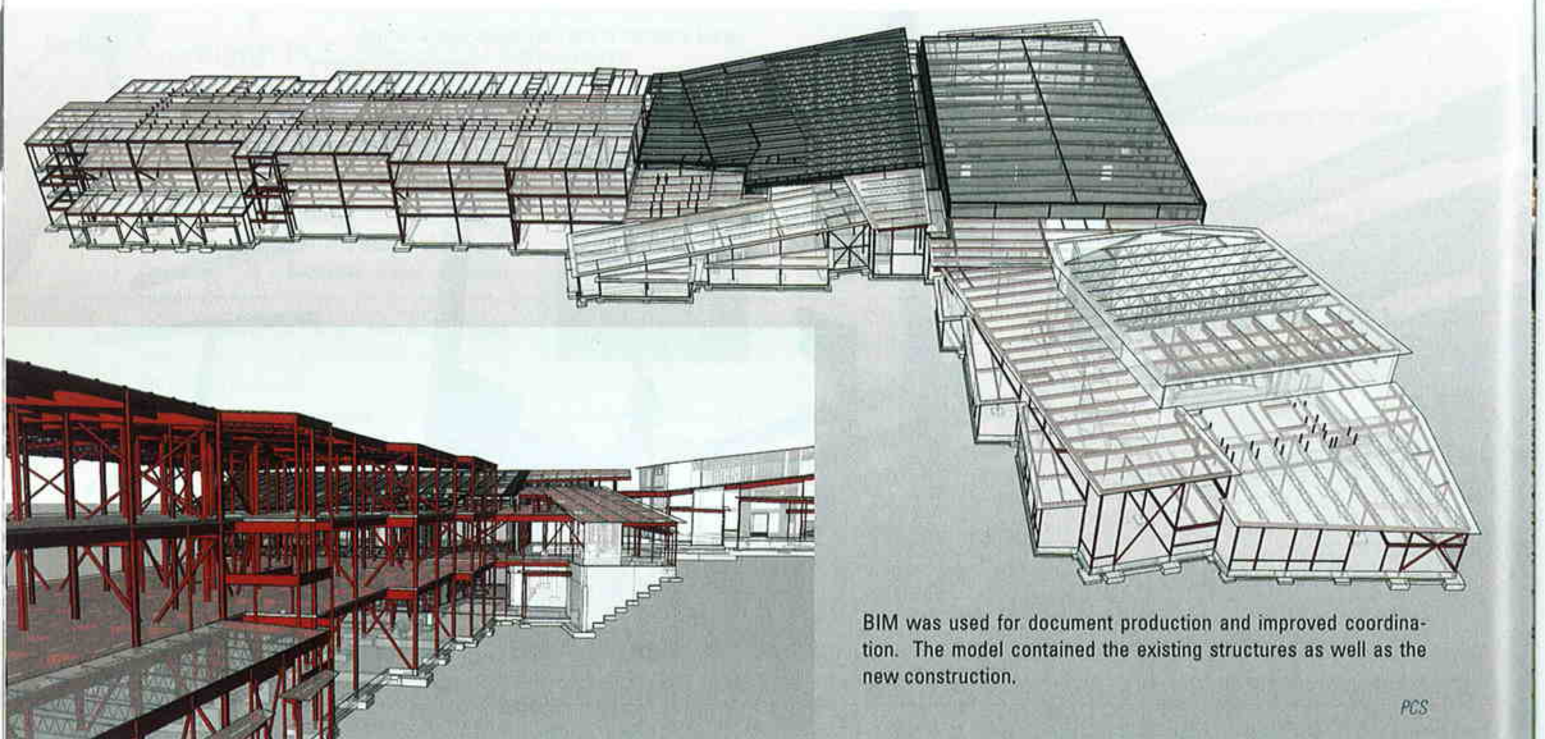
studio Meng Strazzara

One solution to this challenge was to provide oversized matt foundations on two sides of the building to support future columns and frames. On the uphill side of the building, the basement wall was constructed to act as a self-supporting retaining wall during Phase 1. While it retained soil, it did not provide vertical or lateral support for the building. However, the wall also was reinforced to act as a basement and lateral shear wall for the planned upper-level Phase 2 building. With this, the construction of Phase 2 could occur without disrupting the use of the commons, library, or kitchen.

Since the construction timeline for Phase 1 was aggressive, the design team worked closely with the GC/CM to produce early structural-bid packages for the steel, metal deck, and the critical foundations. These early bid packages were released several weeks before the other disciplines' bid documents. Since coordination was still occurring in many areas during the early bid process, the design team worked at developing details that contained flexibility for minor changes later in the design process, or clearly delineated which secondary elements were not to be bid in the early package. The secondary elements — such as the grand staircase — were then detailed and bid in subsequent bid packages. This process allowed production to occur on the majority of the shop drawings prior to "final" design completion.

Shortly after the construction of Phase 1 was completed, the district successfully passed its second bond campaign, launching the extensive Phase 2 design and construction. This phase is four new buildings totaling 140,000 square feet for classrooms, administrative functions, athletics, and performing arts.

Similar to Phase 1, the construction is staged to allow classes to continue. With Phase 1 completed, an adjacent 30,000-square-foot building was partially demolished to make way for Phase 2 construction. The design team



BIM was used for document production and improved coordination. The model contained the existing structures as well as the new construction.

PCS

analyzed the building closely to confirm that vertical and lateral systems were minimally affected by the partial demolition. Otherwise, it might have been necessary to upgrade the remaining facility to current code, even though it would be used for just the year to construct replacement space. Together, the design and construction team found a way to demolish the northern half, performing minimal seismic upgrades for the one year needed.

After this partial demolition, construction of the three-story classroom building and the new administration wing commenced, followed by the three-story gym annex, and finally, the performing arts wing. New and expanded parking lots, bus loops, street front improvements, and landscaping upgrades also are included.

Together, the design and construction team agreed that keeping the Phase 2 structural systems similar to the Phase 1 systems wherever possible would improve the design and construction process, since the teams were familiar with the details and could apply "lessons learned" from Phase 1. Accordingly, the primary horizontal framing system consists of composite steel floor beams and steel beams/open-web joists for the roof system. The lateral systems vary depending on the function of the proposed spaces and the proximity to adjacent buildings. For instance, the three-story classroom facility is laterally supported by internally located special concentrically braced frames. This allows a high level of external glazing and natural lighting, and also provides future interior flexibility between classrooms.

On the other hand, the performing arts center is laterally supported by masonry and concrete shear walls that also provide acoustical separation from adjacent spaces. Masonry shear walls also are utilized where a fire separation/shear/bearing line is required adjacent to existing construction.

To address the different configurations of new construction of Phases 1 and 2, and their proximity to the original gymnasium, several seismic joints are provided. In total, six buildings are tied together and yet seismically independent. Four of the buildings tie together in one localized, complex area which is also the new main entry to the performing arts center and gymnasium. This area required close coordination not only with the structural elements, but the architectural requirements, mechanical configuration, and fire-separation doors.

BIM

BIM is the primary production platform for the Phase 2 design. Although the complexity of each building in this phase was reason enough for the commitment to BIM, the design team agreed that we would better understand the entire complex if all the buildings — existing, Phase 1, and Phase 2 — were modeled. As the existing buildings were added, the team leveraged the power of BIM to provide clarity in the layout and design of the last phase.

By accurately modeling each structure, it became clear how the six buildings came together. For example, the sloping site dictated that the main level of the administrative wing and the performing arts center was at the second floor level of the other commons and classroom buildings. Foundations from elevated structures, as well as the foundations around the dropped seating in the performing arts wing, were coordinated to ensure no loading conflicts with existing foundation and basement walls. BIM fostered this coordination by using visualization tools that are not available in 2D plans.

Another aspect of the project where BIM clarified the detailing was where the new buildings met the existing gymnasium. Geometric complexity was modeled in 3D to better reflect the intricacy of framing systems at seismic joints and foundation configurations. We found that when the design was based off of 2D plans only, team members assumed different configurations, but BIM took the guesswork out of the equation.

Shop-drawing review

In Phase 1, the majority of the shop-drawing review was performed by the typical process: several hard-copy sets delivered to the first member of the design team (often by hand truck) were reviewed, marked-up, and forwarded to the next team member. The majority of Phase 2 submittals are being reviewed and returned in digital format, significantly speeding up review process, reducing delivery times from days to minutes, and fostering concurrent reviewing. With less paper and transportation, efficiency here also means sustainability.

Conclusion

The highly integrated design and construction of Woodinville High School has proven successful on account of the great teamwork among the owner, design team, and contractor. A high-quality, cost-efficient, and sustainable facility is provided while minimizing disruption to an active campus during several years of construction. ▼

Craig D. Stauffer, S.E., is a principal and president of PCS Structural Solutions, a single-disciplinary structural engineering firm with offices in Seattle and Tacoma, Wash. Since beginning his career with PCS in 1993, he has worked on both private and public projects, including new construction and renovations to primary-, secondary-, and higher-education facilities. Stauffer can be reached at cstauffer@pcs-structural.com.

Q&A with the architect

As the architect of record for Woodinville High School, Eric Meng, AIA (EM), of studio Meng Strazzara, shared the following information about the project.

JG: How was the most unique problem on the project solved?

EM: The most unique problem for this project was the tight steep site and the need to add a new school while maintaining existing facilities. This Rubik's Cube problem was solved by consolidating a previously spread out, multiple-building campus into a single, internally-circulated building placed through the center of the site.

JG: What challenges were solved with direct collaboration with the structural engineering team that would have been difficult otherwise?

EM: The difficult site constraints dictated some unusual skewed geometry; as well as challenging connections to those existing building components that were to remain.

JG: What new design innovations were employed by the design team?

EM: The building envelope employs highly-efficient components such as rain screen siding systems and large format windows — well placed for optimum day lighting. These technologies were afforded with common materials such as metal siding and concrete masonry veneer, selected with an interesting mix of colors and textures.

JG: How did this project's owner-required sustainable design goals affect the structural systems selection?

EM: This project was required to meet the Washington State Sustainable Schools Protocol — similar to USGBC LEED goals. The design team members all had experience with this protocol and it was an important selection criteria. The requirements supported the selection of efficient steel structural systems.

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The two phases of the Woodinville High School modernization project remain seismically separate to avoid triggering an upgrade to the existing structure due to increased seismic loading.