Combined library/classroom space is designed to accommodate future technology

By William Andrews, S.E.

Faced with a growing student body and the need to increase access to new technology, the Davis (CA) Joint Unified School District recently embarked on an ambitious master plan for renovation and expansion. Developed by The Steinberg Group of San Jose, CA, the facilities master plan is designed to carry the 30-year-old high school into the next century.

The centerpiece of the plan is a new steel-framed, $4.1 million Library/Classroom building, with structural engineering provided by DASSE Design, Inc., of San Francisco.

The architect's programming goal was to fulfill the District's philosophy of education, which is to develop in students the knowledge, skills, character, and values of discipline, responsibility, honesty, fairness, and a desire for lifelong learning, in a safe and nurturing environment. The new building creates the main entry into the campus of 1,400 students and responds to the urban elements of the surrounding neighborhood as well as to the quad area. The 33,000-sq.-ft., two-story facility combines 15,000 sq. ft. of library space and 18,000 sq. ft. of classroom space. The library is a media center, with 6,000 sq. ft. for book stacks, electronic card catalog and CD-ROM research stations, plus instructional areas, a computer lab and an audio/visual center.

The library stack area is a 40'-tall, open space with exposed structural steel braced frames and suspended air conditioning ducts. Abundant natural light is provided through a full-height glass and metal curtain wall on the north face and curved ribbons of glazing on other walls. The natural light is supplemented with artificial lighting reflected off a curved ceiling.

Solar aspects are incorporated into the design to respond to the functionality of the building, the locale's climate, and to the environmentally conscious community. Sun control elements are strategically placed along the building's...
south wall to limit heat gain from the afternoon sun and reduce building cooling loads, saving the district money on its utility bills in the spring and fall. The desire to accommodate future changes in classroom technology and teaching methods placed a high priority on creating short and long term space flexibility. Classroom walls are non-load bearing partitions comprised of metal studs and gypsum wall board, which can be easily reconfigured to accommodate future space plans and incorporate electrical and mechanical alternations required by new technologies.

**Framing System**

The building is a Type II N (sprinklered) steel-framed structure designed in accordance with the 1991 Uniform Building Code (UBC), as amended by the Division of the State (CA) Architect for school construction. The building contains 234 tons of A36 wide flange steel and A500 Grade B tube steel, and 31 tons of prefabricated steel open web joists supplied by AISC-member Vulcraft. Columns are typically W8 members, with bays varying from 26’ to 33’.

The main roof construction is a single-ply membrane roofing over rigid insulation and 1½”x18 gage metal deck supported by steel open web joists and wide flange girders. The second floor construction is 3½” of regular weight concrete fill over 1½”x18 gage composite metal deck supported by steel open web joists and wide flange girders. Girder shapes were limited to W18s to permit passage of mechanical ducts in the limited ceiling space underneath. Girders were designed as unshored, composite beams, cambered for deflections due to the weight of the framing and concrete fill. The ground floor is a reinforced concrete slab on grade.

The lateral force resisting system is a steel concentric braced frame, with frame design lateral forces governed by the earthquake provisions for UBC seismic zone 3. The foundation is a system of conventional spread footings and grade beams. The exterior wall system is a combination of cement plaster over light gage steel studs and storefront glazing.

The architectural focal point of the library space is the curved roof and ceiling. The roof framing consists of W16 beams curved to a radius of 132’, covered
### DASSE’s Quality Assurance Checklist

#### Coordination
- Dimensions shown on structural match architectural
- Call-outs are correctly cross-referenced
- A path exists to all details
- State typical and minimum clearance for mechanical systems between ceilings and bottom of structure
- Roof elevations are adequately defined by architect or structural, or both
- Roof elevations provide sufficient slope for the entire roof (1/4”/ft. min.)
- Horizontal dimensional control clearly stated
- Vertical dimension control clearly stated (top of slab, top of steel, etc.)
- Partitions and ceiling bracing adequately detailed by architect
- Mechanical equipment support details provided
- Cladding issues adequately addressed on drawing (who is responsible for detailing; acceptable loadings and loading locations defined)
- What is fire rating classification of building?
- What is required fire separation between floor levels?
- How achieved?
- Framing at all levels, including roof provided to brace elevator rails at maximum of 15’ o.c. (8” for OSHPD)

#### Welded Connections
- All welds prequalified with AISC
- Field welds only where required
- Complete penetration vs. partial penetration welds clearly and efficiently specified

#### Bolted Connections
- If mixing bolt types (i.e. A307 or A325), different sizes used
- Single plate shear tab connections considered rotation
- Block shear conditions checked
- Prying action considered where appropriate
- Combined stresses considered where appropriate

#### Columns
- Transverse loads from cladding connections included in calculations?
- Eccentricity of loads considered at perimeter and at other non-concentrically loaded columns
- Column splices shown at 3’ to 4’ above floor level
- Live load reduction properly utilized (Live load reduction from roof area should not be applied to next lower level if it yields a lower live load than would otherwise be the case)

#### Steel Deck
- Deck depth, gauge, fastening and span adequate for both vertical and lateral loads, including any single span conditions? Shoring called out if required
- Deck designations consistent between plans and schedule
- Vented deck provided at locations with concrete fill covered by a water-proof membrane? (i.e. roofs and decks)
- Deck support at “wet” columns covered?

#### Steel Joists
- Are deck cantilever conditions detailed and supporting calculations (including cladding loads) provided?
- Is a construction joint detail in concrete fill over deck included?
- Typical opening details provided? Larger openings framed in plan? Diagonal trim rebar shown at larger openings?
- Framing notes completely define “marks” used
- Elevated view of framing detailed at all levels

#### Steel Beams
- Stud spacing on beams coordinated with flute layout 70% - 80% composite
- Beams cambered for calculated dead load deflection
- Typical beam connection table checked for project loads
- Typical beam vibration characteristics checked
- Special loading conditions incorporated into design

- All Braced Frames
- Describe lateral load path from baseplate to soil
- Are drag connections completely detailed?
- Do shear lugs clear grade beam reinforcement?
- Oversized holes in baseplate acceptable?
- High strength anchor bolts checked availability?
- Foundation system strength sufficient to ensure yielding occurs in braced frame?
- Is relationship between centerline and column connector plate centerline clearly defined? (particularly at braced frame gusset plates)
- Tube sections b/t less than or equal to 110 over the square root of gy
- Compression elements b/t compactness requirements (AISC Table B5.1).
- Tube steel members should have b/t less than 15
- Bracing checked for l/r per 2710(h)2. For angles use r2
- Bracing connections designed for strength per i. tensile strength of brace or ii. 3(ry/8) seismic force or iii. maximum force transmitted
- Chevron bracing designed for 1.5 times other prescribed forces

#### Framing
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#### Other (list)
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<table>
<thead>
<tr>
<th>Beams cambered for calculated dead load deflection</th>
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Shown at right is the chevron bracing during construction. The bracing consists of 8"x8" hollow structural sections, while the columns are 14"x14" HSS.

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Steel studs and welded angle assemblies cantilevered and suspended from the roof and second floor framing along the south wall. Tapered shapes and changing slopes required careful coordination not only between architect and structural engineer during design, but also continued with the steel detailer, fabricator and general contractor to achieve a successful installation.

**Cost Control**

As with much school construction in California, this project was originally conceived as a wood-framed structure with a minimal amount of structural steel. However, at the completion of the schematic design phase in the spring of 1993, lumber prices were steadily increasing and unstable, while steel prices were flat or dropping. A value engineering session with the design team and the project construction manager, Vanir/3DI, Sacramento, revealed that a steel-framed solution was less costly and more reliable from a construction budget point of view. This was very important to the school district, whose funding source was a recently approved local bond measure and real estate developer fees.

Cost estimates were then performed by the construction manager at three successive milestones prior to the bid to confirm design costs were not straying beyond the budget. Design team members reviewed the estimates relative to their disciplines and reported omissions and overages to the construction manager. This method proved highly successful and the winning bid was $200,000 below budget, allowing the district to set aside a portion of the remaining budgeted money for desperately needed furnishings.

**Quality Assurance**

DASSE Design, Inc., employs an internal quality assurance program in an effort to produce structural drawings that are technically consistent, coordinated with other disciplines, con-
structable and in compliance with applicable design criteria and building codes. This process includes involvement by a firm principal throughout the project, a detached review by a senior structural engineer not involved in the design and completion by the project engineer of a QA checklist for steel buildings—a checklist that includes more than 75 items.

For this project, design team meetings were held roughly twice a month during the height of the construction document phase to resolve coordination issues in this complicated building. Many of the architectural features that give this building its unique character are complex, unconventional geometric shapes that required detailed structural support. Structural coordination with electrical requirements included location of underslab electrical ducts and provisions to thread electrical service through the center of the library tube steel columns and beams for face mounted light fixtures.

Tight ceiling spaces restricted the sizes and locations of air conditioning ducts passing through the open web joists and under flange girders. Sizes and locations of roof mounted HVAC units were pre-selected to define corresponding equipment loadings to the steel joists.

Before a building permit can be issued for a school, the Office of Regulation Services (Division of the State Architect) reviews all construction documents for structural compliance with the governing code. One unique requirement of ORS is that pre-fabricated structural members, such as open web joists, must be included in the structural drawings fully designed and completely detailed. This brought Vulcraft into the process much earlier than would normally occur on a non-school project. Though it required more work up front by DASSE and Vulcraft in the design phase, it ultimately resulted in a shorter lead time for fabrication and delivery of the joists and in fewer field problems.

The intense coordination efforts by the design team and implementation of other quality assurance measures resulted in a project that was completed under budget and within the 13 month construction schedule.

William Andrews, S.E., is project engineer with DASSE Design Inc., a consulting structural engineering firm headquartered in San Francisco with an additional office in Irvine, CA and celebrating its 10th anniversary this year.