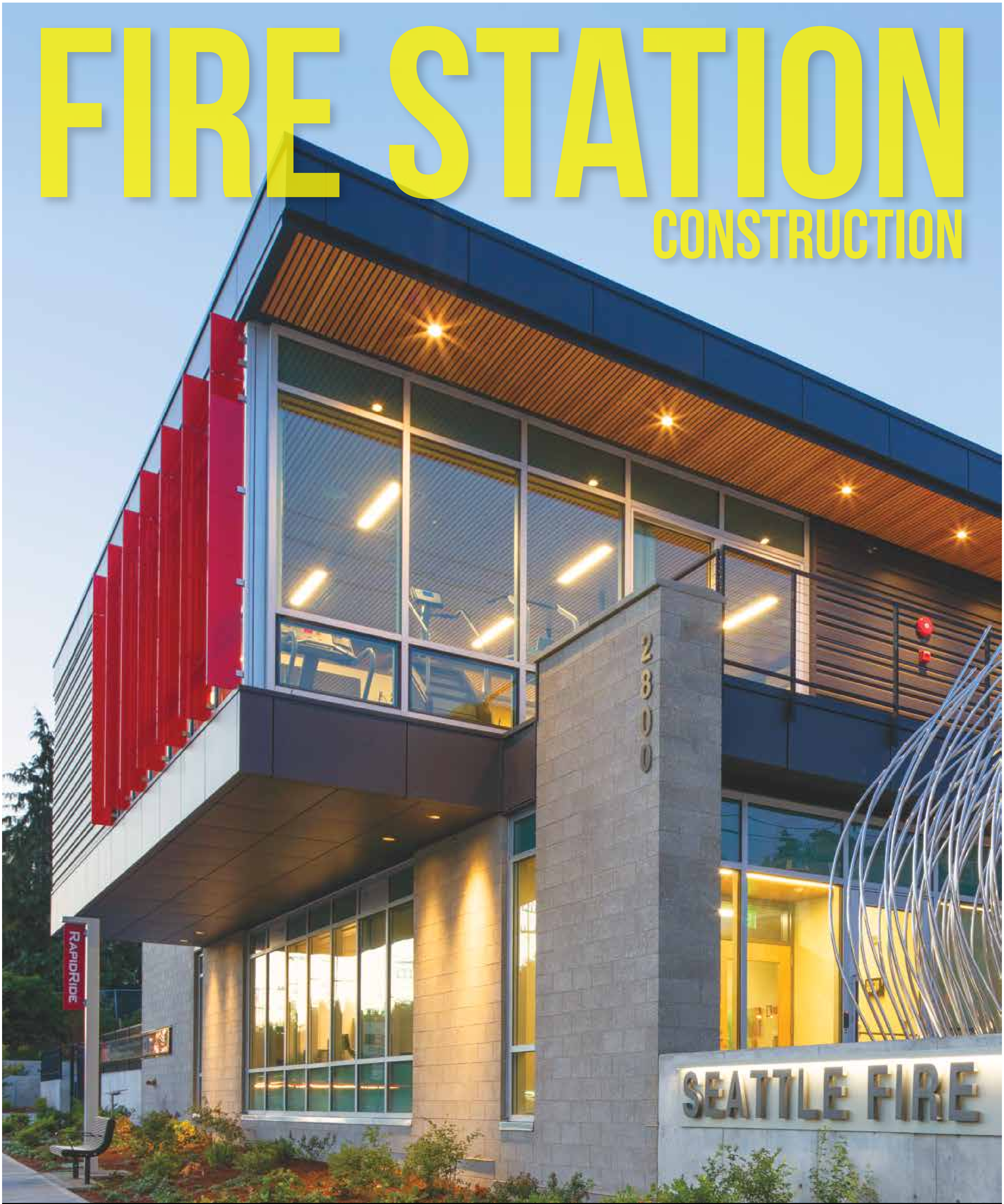
FIRE STATION CONSTRUCTION



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WILL YOUR FIRE STATION BE OPEN AFTER THE BIG ONE HITS?

Building codes provide minimum requirements, but sometimes that is not enough.


BY DAVID SWANSON & CORBIN HAMMER

REID MIDDLETON

This fire station in Chile was damaged in 2010 during the Bio Bio earthquake. The weak first story damaged columns and shattered apparatus bay doors.

PHOTO BY DAVID SWANSON

The seismic design of fire stations and essential facilities demands that the structural engineer clearly understand the importance of these facilities and the role they play in the disaster resilience of our communities.

Engineering for resilience

Fire stations house apparatus such as engines, ladder trucks, hazmat response and paramedic vehicles, along with their most important asset: the firefighters, paramedics and rescue personnel who live and work there. Consequently, these facilities need to be robustly designed to keep them operational and functional after a severe earthquake.

Our building codes provide minimum force-level and structural detailing requirements, but sometimes the minimum is not good enough.

Engineering for performance

Performance-based seismic design standards have been available to engineers for over 20 years. These standards allow the structural engineer to select a specific level of earthquake shaking and determine the seismic performance of the structure with varying levels of analysis complexity.

The performance-based seismic design standards were initially designed to evaluate and upgrade existing buildings seismically, but they can also be applied to the design of new buildings as a check on the expected level of seismic performance for the building-code level design. Performance-based seismic design standards were originally intended to evolve into the codes for new building design, and their development is moving in this direction.

Essential community facilities, such as fire stations, police stations, emergency services facilities, hospitals, schools and critical infrastructure deserve this level of design analysis for reliability and community resilience.

Learning from failure

Designing fire stations and emergency services facilities to better withstand the effects of extreme events like earthquakes, tsunamis and hurricanes requires that we pay particular attention to how our designs perform in these extreme events. By studying failure, we learn what worked well and what didn't work so well and how to apply those lessons learned to our designs.

Earthquake reconnaissance is one such tool that allows structural engineers to investigate damage to buildings, bridges and essential facilities, such as fire stations, to determine how to better design these facilities to be reliable and resilient to extreme events.

Communities struck by these extreme events provide a real world example of disaster performance that must be observed and studied to help our profession improve our design capabilities. This firsthand experience then becomes a useful tool to better understand how to design these facilities for better performance.

Collaboration is key

Resilient design is all about effective collaboration among the owner, user, architect and engineers. Fire station programming leads to determination of the type, size, shape and siting of the facility. Station size and shape leads to selection of structural systems that are integral to the architecture and building function. Other building systems — such as HVAC, electrical and fire protection — play a central role in a fire station designed to continue performing immediately after a significant earthquake. This design for resilience is a collaborative process.

Collaboration also requires effective communication among these multidisciplinary design teams to meet design objectives for the overall facility design and its various systems and components. Over the last decade, building-information modeling (BIM) has provided an excellent tool for the design team to collaborate visually on the design. BIM allows designers to see detail long before it is constructed. As structural engineers, BIM can help us see where other building systems will need to penetrate our structural systems so we can plan for their effects on the performance of the structural systems.

Be prepared

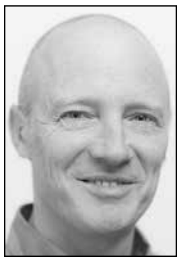
The overarching goal of all of this work is to make our communities more disaster resilient. When fire station and essential facility design teams understand the importance of these facilities and the role they play in the disaster resilience of our communities, we can be more prepared to address their unique seismic design needs.

David Swanson is director of structural engineering at Reid Middleton. Corbin Hammer is a structural engineer at Reid Middleton specializing in the design of essential facilities.

HERE'S HOW WE SLASHED ONE STATION'S ENERGY USE BY 75 PERCENT

Issaquah's Fire Station 72 is empty much of the time, so mechanical systems were designed to use less energy when firefighters are away.

Fire stations in our region are typically very energy-intensive facilities for the following reasons: they are operated 24 hours a day, 365 days a year; they are home to six or more firefighters at a time — doing all their cooking, cleaning and washing; they serve as an office and training facility; and they contain a great deal of equipment that must be kept ready at all times in case of emergency.



BY JONATHAN HELLER
ECOTOPE

Washington state has committed to reducing energy use in buildings by 70 percent by the year 2030. This is a challenging goal, but recent success stories of low-energy buildings demonstrate that it is an attainable goal. By carefully focusing on where all of the energy is going we can dramatically reduce the energy use in new fire stations to about one-fourth of the typical.

Typical fire stations in the region use about 100 kilo-British thermal units (kBtu) per square foot a year of energy. Ecotope worked with TCA Architecture to design Issaquah Fire Station 72 for Eastside Fire and Rescue to use only 28 KBtu per square foot a year. With solar panels installed, the total net energy use of the station is only 22 KBtu per square foot a year.

To figure out how to do this we started by carefully studying a similar nearby fire station. What we saw was that although these are 24/7 facilities, they are mostly empty for much of the day. The firefighters are not sitting around in the station waiting for something to happen. They are out answering calls, performing testing of fire-protection systems or fixing equipment.

However, the mechanical systems typically function as if all parts of the station are fully occupied at all times. To reduce energy use, the systems must be designed to respond to the actual demands of the firefighters.

Reducing demand

At Station 72 we focused on reducing energy demand wherever possible. The heating loads were reduced by providing the building with high levels of wall, roof and floor insulation, as well as triple-glazed windows.

Since the station is always open, fresh air must be provided at all times. This requires a large amount of energy to heat up the ventilation air. An important component of the mechanical system at Station 72 is a heat recovery ventilator that strips the heat from the exhaust air and uses it to warm the incoming air, dramatically reducing heating energy use.

By super-insulating and providing heat recovery ventilation, we reduced the required size of the heating system to about

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The building is heavy insulated and has triple-glazed windows.

PHOTO COURTESY OF ECOTOPE

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ON THE COVER

Fire Station 20 opened in 2014 in Seattle's Interbay neighborhood. Schacht Aslani Architects was the designer and Forma Construction Co. was the general contractor. PHOTO BY LARA SWIMMER

DJC TEAM

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WEB DESIGN: LISA LANNIGAN • ADVERTISING: MATT BROWN

FIRE TRAINING CENTERS TODAY ARE MORE LIKE THE REAL WORLD

Adding obstacles like parked cars and cul-de-sacs matches the dangers emergency reponders actually face.

The changes in the fire service industry over the last 50 years have been unmistakable. They include better protective equipment, the entry of more women, larger and more sophisticated apparatus, recognition of presumptive cancers in firefighters, and the advent of fire-based emergency medical services. The list goes on.

BY DAVID FERGUS
RICE FERGUS MILLER

The fires we fight are different as well. With furniture and everyday household products containing more plastics and petroleum-based materials, fires are burning hotter and faster, and the dangers of flashover occur substantially earlier.

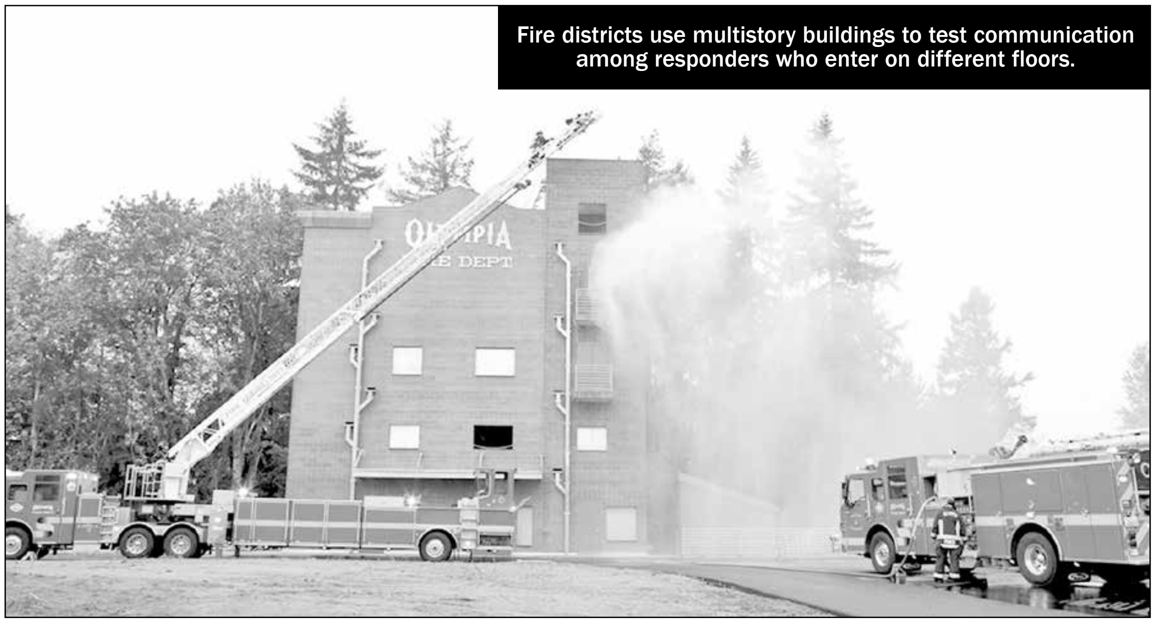
Training has changed, too, in large part as a result of these changes in the industry. More importantly, we have become much better teachers.

We have learned how we can provide more effective training and how the training environment itself can better support how the training is delivered. Here are a few notable trends:

Focusing on objectives

The approach to planning and designing fire training facilities today begins with a detailed look at training objectives. This requires gaining an understanding of the specific skills that need to be taught. These skills are derived from the broader context of the particular community.

A community risk assessment identifies the potential natural and man-made disasters that emergency responders in that particular region could face. A review of the agency's response data further reveals the most common types of responses their personnel are called upon. Tailoring the training environment specifically to that community, the risks existing there, and preparing those firefighters for those situations ensures they are as prepared as they can be.



Fire districts use multistory buildings to test communication among responders who enter on different floors.

PHOTO COURTESY OF RICE FERGUS MILLER

Realistic scenarios

Today's training centers focus more heavily on creating greater realism for the trainee. It is not often that a fire department responds to a concrete building on fire in the middle of a parking lot. Although that has been the standard design practice for decades, it doesn't match the risks and dangers emergency responders face in the real world today.

Giving thought to intervening roads, cul-de-sacs, spaces between buildings, and obstacles like parked cars enhances the training experience. Locating fire hydrants where they are likely found in the real world, as opposed to where it's convenient, adds dimension and challenge to the drill.

Using a variable pump on the hydrant system can simulate a loss of pressure, again mimicking what could occur on an actual call.

Roadways

Roads within a training campus are being viewed as more than just a means to get to a particular prop — they can be integral to driver training. Roads designed with pavement markings and actual traffic signs can further enhance the realism of the training experience.

Water bodies

Whether a natural lake, wetland or storm pond, opportunities abound for learning proper techniques for drafting water and a variety of water rescue scenarios. Placing vehicles so they are partially or fully submerged adds other training opportunities. A natural ravine is good for swift-water rescue training, which involves using ropes and technical rescue equipment.

Topography

Topography has many benefits in a training campus environment. Many fire districts have found the advantages of creating multistory training structures with on-grade access to different floors on different sides of the building.

In a simulated residential structure, it's a daylight basement. In a simulated commercial structure, it tests communication between responders entering from opposite sides of the building.

Topography is also beneficial for driver training, as well as extrication from a car over an embankment.

Working with neighbors

Regardless of whether the adjoining property is farmland or a residential development, neighbors care about what gets built next to them. They will have concerns about lights and noise, night operations and smoke drifting in their direction.

Fire departments that proactively address these potential impacts with nearby property owners at the onset (and mitigating them to the best of their ability) ensure a more positive

TRAINING CENTERS — PAGE 7

INTERBAY FIRE STATION IS ONE OF THE NATION'S GREENEST

Energy modeling helped push the project to meet LEED platinum and 2030 Challenge standards.

The new Fire Station 20 is located at the western base of Queen Anne Hill on the heavily trafficked 15th Avenue West and serves a rapidly growing Interbay neighborhood.

Given the highly visible site, the city of Seattle identified the project as an opportunity to create a civic presence for the Fire Department while setting a new high-performance design standard for its facilities.

BY ERIC AMAN
SCHACHT ASLANI ARCHITECTS

The Fire Facilities and Emergency Response Levy passed in 2003 identified the then-55-year-old Station 20 as one of the smallest stations in the system, insufficient to meet the neighborhood's needs.

The building was in poor condition and had reached the end of its useful building life, not meeting the emergency response operational requirements of the Seattle Fire Department or current earthquake safety standards.

In 2009, the Seattle City Council authorized the purchase of two vacant parcels and two small properties along the east side of 15th Avenue West, a major arterial that runs through the Interbay industrial zone connecting downtown with the Queen Anne and Ballard neighborhoods. Schacht Aslani Architects was selected to design the new, modern two-engine-bay station.

From 2010 to 2014, the station's emergency response calls increased by nearly 13 percent. The design for the new station accounts for the rapidly growing Interbay community and considerable redevelopment within its service areas of Queen Anne and Magnolia.

Siting challenge

Fire Station 20 addresses a number of interrelated challenges: differentiating the building from its industrial and commercial neighbors, many with large garage doors; cutting through the steep topography to create a drive-through apparatus bay; creating privacy for the firefighters' living quarters adjacent to the busy thoroughfare; and carrying out an ambitious sustainable design agenda.

A series of parallel concrete and masonry walls in the north-south direction retain the hillside, organize the site, contain green infrastructure, and provide lateral resistance for the building.

Steel-framed volumes that contain the program run over and between the masonry walls in the east-west direction. Their major openings are perpendicular to the walls and the street, maximizing daylight and views, reducing solar gain and shielding the living quarters from acoustic impacts.

Earning LEED platinum

The city of Seattle has utilized the U.S. Green Building Council's LEED rating system for city-owned facilities since 2000. Over the years, the city has continually raised the bar for high-performance buildings, resulting in an increasing number of LEED gold-certified facilities.

For Fire Station 20, the city chose to exceed its own standards, and challenged the design team to create a building that met the criteria for LEED platinum certification. Through an ambitious sustainable design agenda, the project achieved 98 points and LEED platinum status, making it the highest-scoring fire station in the country.

The project also follows the guidelines set in the Architecture 2030 Challenge. The challenge is designed to significantly reduce carbon emissions and fossil fuel consumption, with long-term goals to have all new buildings be carbon-neutral. Ultimately the steps taken in the design for Fire Station 20 meet the 2015 targets for the Architecture 2030 Challenge.

Bioretention planters and green roofs contain plants, soil and gravel, which manage stormwater, cool the site, and integrate the masonry building walls with the hillside retaining walls. Native, drought-tolerant plants are used to buffer the station from the street and require very little water once established.

Energy-reduction strategies

The design team took an aggressive approach to energy conservation. The energy modeling of the station was completed by Hargis Engineers, simulating the building's energy consumption throughout the design process. The final system selections were evaluated through a customized energy model to simulate the 30-year performance of the ground source heat pump, as well as standalone simulations of HVAC coils that directly utilize ground source water for cooling during swing seasons.

Heating and cooling is provided by a ground source water-to-water heat pump system. A flat-plate heat exchanger recovers energy from the relief air stream to the fresh outside air stream. The 35-kilovolt photovoltaic array on the roof provides 27 percent of the energy used by the station. LED fixtures, occupancy sensors and daylight harvesting further increase the electrical energy savings.

Seattle's Fire Station 20 is heated and cooled by a ground source heat pump system.

PHOTO BY LARA SWIMMER

Energy performance in any fire station is a primary design challenge due to the demands of the apparatus bay and the nature of large bay doors that open frequently. To mitigate the heat loss that occurs during frequent crew deployment, the apparatus bay contains a radiant floor heating system, which, together with the thermal mass of the concrete walls and floor, allows the indoor temperature to rebound efficiently.

Meanwhile, the residential portion of the building is served by a central heat recovery air-handling unit with dedicated variable air volume units and temperature sensors that allow for individual zone control. The ground source water-to-water heat pump system provides an opportunity to create a variety of zones that support a firefighter's daily routine of work, training and rest or sleep.

Fire Station 20 attempts to educate the community on how public buildings can employ sustainable strategies without sacrificing program space. Strategically located site signage invites the public on a self-guided tour of the station's sustainable systems. A low-energy flip-dot sign along the 15th Avenue West arte-

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HOW TO KEEP FIRE CREWS MOVING AS THE CITY GROWS

Designers are finding ways to decrease "turnout time" in the station and using GIS to help navigate congested streets.

BY BRIAN HARRIS
TCA ARCHITECTURE PLANNING

At its simplest level, a fire station is a sophisticated “cog in the wheel” that programmatically supports emergency operations with the continually evolving task of defining what there is to protect and how best to do it.

Over the last 25 years, the Puget Sound area has seen significant changes in the design of fire stations as older facilities have been remodeled and replaced.

As technology and the workforce have changed, fire station designs have also responded to these new circumstances. Terms that have become commonplace include urban responsibility, neighborhood oriented, seismically resilient, gender inclusive, energy use index and sustainable.

The Puget Sound area has been a leader in redefining next-generation facilities. Not only does the area boast the first LEED-certified fire station in the country (city of Issaquah, 2003), it also is home to the first LEED platinum fire station (city of Issaquah, 2011) and the first LEED training facility in the country (city of Seattle, 2009).

These facilities have pushed the envelope of what an emergency facility can become from a sustainability perspective. As a result, these facilities have provided insight to other communities around the country: the city of Portland recently completed a LEED gold waterfront fire facility with input from our area, and Salt Lake City has two net-zero fire stations in design that take guidance from local projects as well.

As we fine-tune the lessons learned from stations built over the last decade, a significant fire station design consideration will gain new attention as a direct result of our explosive regional growth.

Growth means more people, more congestion, and an increase in emergency and nonemergency calls. If not addressed, response times will increase and eventually impact service levels.

The design for this new LEED gold fire station in Portland drew inspiration from several LEED fire stations in the Puget Sound area.

PHOTO BY TOM BONNER

Turnout time

While effectively tackling increased call load may require additional funding for staffing and apparatus (impacting facility needs), it also requires leveraging existing resources effectively. Understanding changing density, traffic patterns and demographics through sophisticated GIS modeling and real time and projected traffic data will help determine areas of increased demand.

Since staffing, equipment and facilities come at a significant cost, we are seeing “turnout time” getting significant attention. Turnout time can be defined as when the emergency response facility and the emergency response unit’s notification process begins by either an audible or visual annunciation (or both) and ends at the beginning point of travel time. It’s the “call receipt at the station to wheels rolling.”

National Fire Protection Association Standards stress speed of response with specific time lines for fire versus emergency medical response calls. Depending on the type of call, turnout time within a facility accounts for approximately 20 percent of the targeted time after call receipt within a facility to arrival on scene.

Cutting seconds off a call within a facility can help offset this increased demand as our community continues to grow.

Snohomish County Fire District 1, protecting nearly 200,000 citizens in 45.6 square miles, is tackling this issue head on. The district will soon start a study to evaluate the impact of growth in its service area relative to response, as well as turnout times within all of its stations. Taking an inside-out/outside-in approach, the district will be able to understand the most effective way to address this emerging issue.

What contributes to reducing turnout time within a facility?

A 2009 study of several departments — including Puget Sound’s Eastside Fire & Rescue — by Michael Dell’Orfano of South Metro Fire Rescue Authority found behavioral factors such as motivation, station call load, daytime versus nighttime response and station familiarity have an impact on turnout time. Additionally, technical factors such as data transfer, travel distance, clear paths of travel, support space location and bay door speed impacted turnout time.

Both behavioral and technical aspects affect the ability of an organization to have a positive impact on the outcome of an emergency based on how quickly appropriate resources are deployed to an event.

An underlying philosophy in fire station design is to provide direct and unobstructed paths of travel to the apparatus being deployed such that all paths of travel flow efficiently with minimal turns towards the bays. Generally the closer to the apparatus is to the responder the quicker the turnout time.

Firefighter health

As regional response continues to be addressed for the sake of saving lives and protecting property, increased attention is also being placed on the health and safety of the responders that provide this service.

Recently the National Institute for Occupational Safety, with funding from the U.S. Fire Administration, undertook a detailed study of almost 20,000 firefighters to understand cancer rates in the profession. Findings suggest that firefighters are at a higher risk of cancers of the digestive, oral, respiratory and urinary systems compared to the general population due to job-related exposure.

A recent Firehouse magazine article notes, “while scientific studies connecting what firefighters do with their health consequences is still in their infancy, common-sense observations and actions can be made about exposure to carcinogens, transport of the cancer-causing agents back to the fire station and control measures to limit their impact.”

As this and like studies continue to gain attention, we are increasingly seeing departments take a stronger and more proactive position to understand and better mitigate exposure to cancer-causing agents both outside and inside the fire station.

Previously, facility testing has not been common due to cost, however we are seeing more interest in doing such testing to better understand risk. Additionally, there has been increased sensitivity to clearly identify “hot zones” within the facility, where potentially carcinogen-contaminated equipment is transported back to a facility from a call and stored, decontamination and cleaning occurs, potentially contaminated turnout gear is hung and apparatus is parked.

In addition to carcinogens, this same equipment can carry contagious bacteria that also pose a risk to responders.

Ironically, current codes that focus on energy conservation (allowing for decreased ventilation) are becoming increasingly at odds with typical air capture, dilution and filtration strategies. This will be the next nut to crack. As a starting point, better definition of transition areas between high- and low-hazard areas within stations will be a big step forward.

As new facilities are designed and renovated, fire stations will continue to become more specialized relative to performance

KEEP MOVING — PAGE 7

ENERGY USE

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one-third to one-half the size of a typical station, so we were able to shift money from the mechanical system budget to help pay for the extra insulation.

The primary heating and cooling at Station 72 is provided by a ground source heat pump system through hydronic radiant slabs. The building includes three small residential-scale heat pumps: one for heating, one for cooling, and one for hot water, with the ability to back each other up.

Using radiant slabs for heating and cooling creates a constant, even temperature in the station and eliminates the large amount of energy use associated with the fan systems used in a typical fire station. Only the sleeping rooms included small individual fan systems that can be adjusted by the firefighters so they can each have fast-responding control over the environment in their own room.

With a super-insulated building and ground source heat pumps for heating and cooling, domestic hot water heating became the largest single end use in the building. This is driven by three shifts of six people living in the building continuously, cooking, laundering clothes and showering two to three times per day each. To reduce the high domestic hot water load, low-flow plumbing fixtures and six large solar thermal preheat panels were used. The ground source heat pump system finishes heating the hot water.

To reduce energy use associated with lights and equipment we installed automatic controls. When there is an emergency call every second is critical, so firefighters do not stop to turn off lights and equipment. All nonessential equipment and lights at Station 72 are turned off automatically on vacancy sensors when the room is unoccupied.

Finally, solar electric panels on the roof provide about 20 percent of the total annual electrical energy demand of the station.

Setting an example

If this fire station were built to typical standards it would use over three times as much energy annually. This translates to a reduction of over 150,000 pounds of carbon dioxide per year that is not released into the atmosphere.

Direct reduction of water, materials and energy use are very important. However, perhaps the most important environmental impact is the example this station sets for the entire community.

Station 72 has a mission of maximum resource efficiency and minimum energy expenditure, given its critical role if the community should be in crisis. The station, which opened in 2011, is located in downtown Issaquah and abuts a busy transit center. Station 72 provides community education and a high level of visibility for energy efficiency and sustainable buildings.

Firefighters are a traditionally conservative group and are almost universally respected by the community. To have the firefighters visibly embrace sustainable buildings and practices helps to further convince the community that high-performance buildings are an appropriate response to climate change and dwindling resources that will impact future generations.

Jonathan Heller leads the Ecotope Design Team and has over 25 years of experience providing design, research, and consulting on energy and resource efficiency in the built environment.

INTERBAY

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rial is connected to the building's control system and displays real-time information on energy, water and carbon savings.

Operational since last December, Fire Station 20 serves as a symbol of the city's commitment to improving the performance of its buildings while creating a civic structure that contributes to the character of its rapidly growing service area.

Eric Aman is a principal with Schacht Aslani Architects, with 20 years of experience in the planning and design of public sector facilities.

KEEP MOVING

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from both response and safety perspectives. Both the fire service and design community will need to continue to shift their mindset in terms of performance-based ends rather than means through better definition of objectives, data gathering, modeling, evaluation and measuring results.

Brian Harris is a principal with TCA Architecture Planning and has specialized in fire facility design for over 25 years. TCA has been involved with the planning of more than 250 fire facilities nationwide.

TRAINING CENTERS

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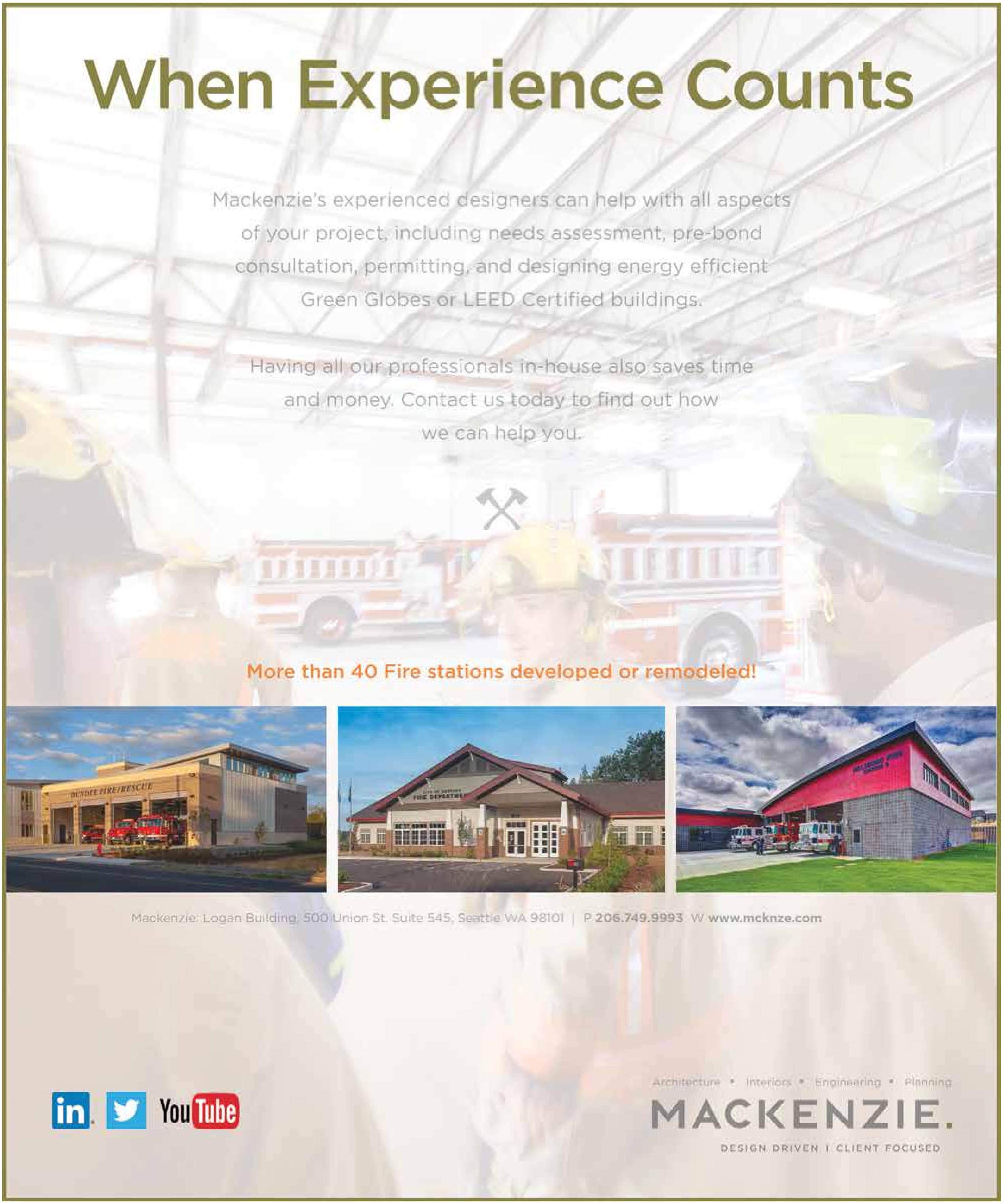
relationship with them for years to come.

When thinking about replacing or adding to your current training facilities, value can be found in a thoughtful process that confirms your most pressing training objectives, how they are taught, and the environment that fosters that education. Without question, the results can be invaluable.

Rice Fergus Miller Principal Dave Fergus is an expert at programming, planning, and designing fire and emergency services facilities. He has completed more than 200 civic projects over the last 25 years and regularly consults with public agencies on project feasibility, service locations, capital project funding and other strategic issues.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