New approach to seismic isolation for Asyaport

The BASIS crane isolation system is designed to offer earthquake protection for a crane structure at a reasonable cost and without affecting the stiffness of the crane in normal operations

US-based Structural and Mechanical Engineering consultancy Casper, Phillips & Associates (CP&A) designed its crane base anti-seismic isolation system (BASIS) for use on two STS cranes at Asyaport in Turkey. BASIS was designed using non-linear time history analysis (NLTHA) to protect the main crane structure from damage in seismic events. The Asyaport cranes were designed using three sets of ground acceleration records (D3 level) provided by Asyaport. A D3 level earthquake is a maximum considered earthquake that is expected to occur once in approximately every 2,500 years – that is a 2% probability of being exceeded in 50 years.

Installation

"BASIS is installed between the sill beam and main equaliser beam, about 13ft (4m) to 16ft from ground level, depending on the crane's size. It includes two friction damper assemblies, two energy restoring device assemblies, a guiding device and two friction damper locking devices," explained CP&A.

BASIS has now been installed in two large units manufactured by Dalian Huarui Heavy Industries in China. They have a 100ft (30.48m) gantry span, 223ft (68m) outreach, 66ft (20m) backreach, and 152ft (46.3m) lifting height above the gantry rail.

BASIS is designed to dampen movement in the trolley travel direction only, explained Mike Zhang, head mechanical engineer at CPA. "The initial container crane isolation system that we developed included dampers in both gantry travel and trolley travel directions," he said.

"NLTHA revealed that the base shear in the gantry travel direction varied within only 5% between a crane with a seismic isolation system and a crane without it. However, in the trolley travel direction, the base shear is significantly reduced by incorporating our seismic isolation system. Therefore, to reduce costs while maintaining a high level of effectiveness, our final seismic isolation system is designed to operate only in the trolley travel direction."

BASIS uses friction dampers manufactured by the Canadian company Quaketek, which has developed this technology over 20 years. It is used extensively in hospitals and public buildings in Quebec, as well as in large aircraft assembly structures in Washington State. The other components in BASIS include restoring devices based on a Conductix-Wampfler buffer, while the mounting base and system assembly are provided by the crane manufacturers. BASIS received a Chinese patent in 2018 and can be installed on new or existing cranes.

"There are alternative crane seismic systems on the market, but BASIS outperforms them," said Zhang. "The friction damper does not slip under normal operations, so the structure maintains the same dynamic and static stiffness as a crane without the seismic device. During a hurricane, when the tie-downs are engaged, the seismic system can be locked to prevent the dampers from slipping.

"We have also developed a special stowage pin assembly that can accommodate the crane movement during an earthquake, even during a microburst or storm wind when there are no tie-downs engaged. Also, the same profile damper can be set at a different sliding force to accommodate various cranes and seismic zones."

The crane BASIS is installed in the saddle bracket between the sill beam and main equaliser beam

Asyaport has a different seismic isolation system on its existing STS cranes, which were manufactured by Anupam-MHI Industries, the joint venture established by Anupam and Mitsubishi Heavy Industries (MHI) in 2011. MHI had earlier designed and patented a seismic isolation system that isolates the crane at the sill beam, using a system of hydraulic cylinders to restrain the motion of the crane during an earthquake. Crane operators complained that hydraulic-based seismic isolation systems affect the operation of the cranes, and the port wanted an alternative.

Controlling the slip

Richard Phillips, mechanical engineer at CP&A, said: "The friction damper system in BASIS is designed to slip at a certain force, and to not slip during regular operation and the more common overload events such as trolley emergency stops. Also, the friction damper system requires little to no maintenance, while hydraulic systems require a moderate level of maintenance."

Asyaport's decision to invest in crane seismic isolation systems has to be seen in the context of Turkey's proactive national effort to improve earthquake risk reduction after the 1999 Marmara earthquake, which killed around 18,000 people and levelled over 100,000 buildings and structures. There are plenty of other ports in high seismic risk zones, especially those on the Pacific Ring of Fire around the Pacific Ocean, but seismic isolation on cranes is rare.

CP&A believes that the increasing size of cranes means this should be reconsidered. "STS cranes have historically been designed for 0.2G static horizontal acceleration in major seismic areas. This is adequate for lighter Panamax or post-Panamax container cranes with a gantry rail gauge less than 80ft. However, for super post-Panamax size or larger cranes with a 100ft or wider gantry rail gauge, the crane may be seriously damaged or even collapse in a major earthquake. These cranes can be subjected to more than 0.6G lateral acceleration in the trolley direction even during a moderate earthquake."

Another reason seismic isolation is not more common is that ports take a narrow approach to the risk of a seismic event. CP&A noted that ports typically specify the seismic requirements, and the crane manufacturers propose a design, which the customer then considers. Phillips added that many ports focus only on whether the structure can withstand a large earthquake, but they should be considering seismic isolation from a wider risk management perspective.

"The idea is that the people on or around the crane are safe, but the crane is allowed to be damaged as long as it doesn't collapse. The cranes can be significantly damaged and will likely require repair before being put back into service. So the risk is that after a major earthquake, the port's cranes cannot be operated for months. The seismic isolation system allows cranes to be put back into service quickly after a major earthquake. Ports are a critical element of the supply chain and after a major earthquake emergency, supplies need to be able to come through the ports as soon as possible," Phillips concluded. ❑

New cabs and gearbox

Some of the cranes being upgraded are 23 years old

The Port of Houston is replacing the operating cabs on four STS cranes with new units from Italy's Brieda.

Some of the units that the four new cabins will be replacing are 23 years old. Houston already has Brieda cabins on some of its newer STS cranes and their ergonomics and the fingertip controls in Brieda's Dynamic Control Station system have been very well received by the port's crane operators from the International Longshoremen's Association.

The Port of Houston has also taken the decision to purchase a spare main hoist gearbox (reducer) for the four Konecranes STS cranes it operates at Barbours Cut Terminal. The cranes were commissioned in 2015, and the port currently does not have a spare unit.

This is an interesting decision for a terminal to make. A main hoist gearbox typically operates for many years, and they are not a regular maintenance item. They are also very expensive, costing around US$105,000 in this instance, and lead times for replacement are much longer than for most other items. Considering the potential downtime in the event of a failure, ports regularly employ gearbox monitoring systems and/or take the decision to stock a spare.