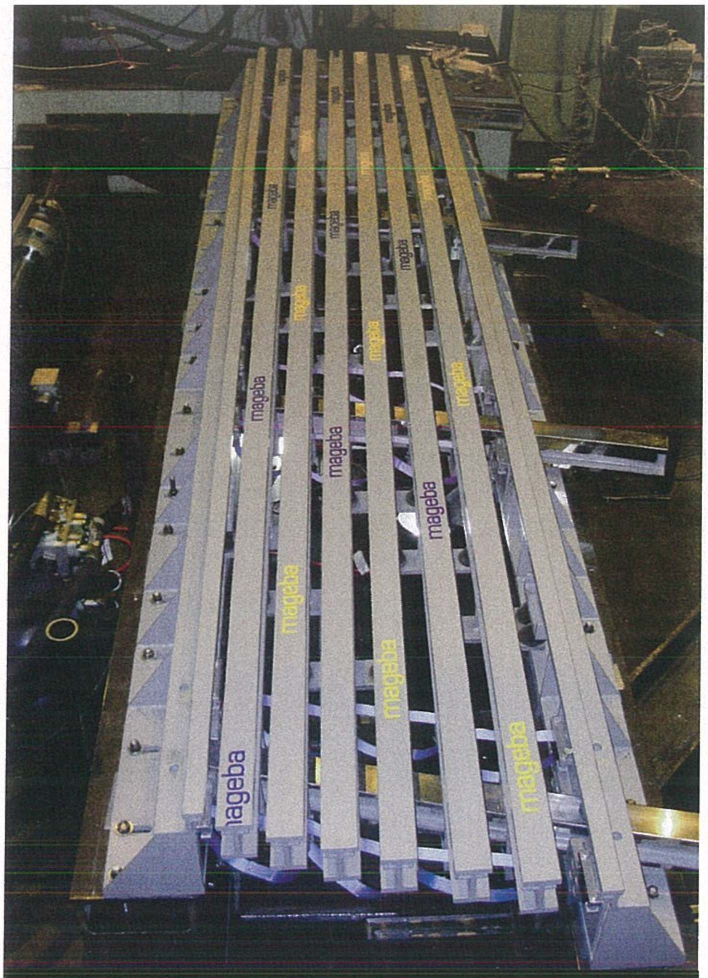
PUT TO THE TEST

Testing of modular joints in accordance with current American standards illustrates diverse and demanding requirements. **Gianni Moor**, **Simon Hoffmann** and **Colm O'Suilleabhain** report.



View of the seismic test in progress.

Use of modular expansion joints on North American bridges has increased substantially over recent years, and this has been reflected in the advance of national standards relating to them. In this market, such joints are now commonly required to have successfully passed a range of demanding tests designed to determine a product's suitability in a number of key areas.

Significant advances have been made in modular expansion joint technology since this type of joint was first invented, and the use of such joints, especially on very large bridges, has increased steadily. This has led to an increasing focus on performance standards and testing requirements for such joints by authorities around the world.

In Europe, where the modular joint originated and where the design and manufacturing of such joints is most established, testing is generally limited to proving the durability and other characteristics of individual components and processes. This is true, for instance, of the influential German standard TL/TP-Fü, first released in 1992, which applies where demands are unparalleled in certain respects - on the country's extensive motorway network, on many parts of which no speed limit applies, and where modular joints are used almost exclusively.

In North America, standards promoted and published by official bodies such as the American Association of State Highway & Transportation Officials have a leading role in terms of testing requirements for modular joints in particular. Testing is often used to determine the suitability of an expansion joint in key areas including fatigue performance, daily movements, traffic vibrations, elastomeric seal strength, and performance during a seismic event.

The report *Performance testing for modular bridge joint systems,* which was published in 2002 as Report 467 of the National Cooperative Highway Research Programme, was based on research sponsored by AASHTO in cooperation with the Federal Highway Administration, and hence carries great weight in the industry. This report defines performance requirements, and presents performance test specifications and guidelines relating to materials, fabrication and construction which are recommended for use in the prequalification and acceptance of such systems to meet these requirements.

Two types of test are defined, both of which are recommended for prequalification for use on a project: the opening movement vibration (OMV) test and the seal push-out (SPO) test. The tests are carried out on a full-scale section of the modular joint type which seeks prequalification. The OMV test simulates the opening and closing movements due to daily thermal cycles that are predicted for a 75-year lifetime - ie one of each movement per day - which is a total of 27,400 cycles. At the same time, the test simulates the vibrations caused by traffic, with a 33kN force being applied to a lamella beam at high frequency for the entire duration of the test. Inspection of the expansion joint after completion of the test allows the ability of the joint to withstand these principal impacts to be fully evaluated.

Once the opening movement vibration test has been carried out and the evaluations have taken place, the seal push-out test is recommended as a follow-up. This test assesses the strength of the connection between the elastomeric seals and the lamella beams which support them, and thus indirectly tests the ability of the joint to remain watertight.

The failure mechanism identified and tested is the pushing out of an elastomeric seal under wheel loading, which is transferred directly to the seal as result of the collection and compaction of debris between the lamella beams above the seal. The SPO test is carried out on the same joint which has been subjected to the opening movement vibration test, and thus simulates the weakened condition that an elastomeric seal may suffer after years of service.

The influence of AASHTO's LRFD Bridge Construction Specifications, which include requirements for these tests, is demonstrated by the fact that the OMV and SPO tests were specified for products seeking prequalification for recent projects outside of the United States. The first such example was the testing of a joint for the Gateway Bridge in Brisbane, Australia, which involves the supply of 27m-long, eight-gap joints capable of accommodating movements of up to 640mm. The second example, earlier this year, was for the testing of an 11-gap joint featuring noise-reducing 'sinus plates' bolted to its surface. This joint is required for the Port Mann Bridge currently being built in Vancouver, Canada, involving supply of joints for eight bridge axes with an average length of 46m, which includes joints with up to 11 gaps for 880mm movements, some with sinus plates.

While these tests are designed to assess many aspects of a modular joint's performance, the significant exception is fatigue. This is covered by the 1997 report *Fatigue design of modular bridge expansion joints,* also issued by the NCHRP as its Report 402. It presents a practical test procedure which enables the fatigue resistance of critical details of modular joints to be assessed. The onerous testing required by this report, and consequently by AASHTO's LRFD Bridge Construction Specifications, simulates the fatigue-inducing movements and stresses of a service life on a full-scale section of a joint which contains all critical members and connections.

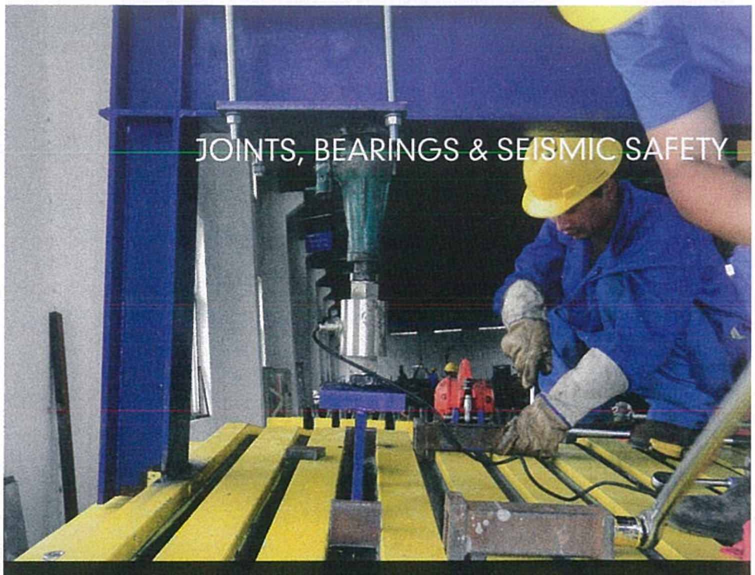
Ten data points are required, gained from a series of tests, to determine the number of load cycles to which the joint can be subjected without failure. Using these data points, a curve is plotted, correlating stress, S, to number of load cycles withstood, N, on a logarithmic scale. This enables the fatigue performance of the joint during an extended lifetime to be determined.

The testing needed to establish these data points is extensive - the test regime being prepared by manufacturer Mageba, for example, will be carried out on four expansion joint samples, each with three lamella beams - each beam providing one data point.

With individual tests consisting of up to six million cycles, testing is expected to require several months of continuous use of specialised pulsator equipment at an independent laboratory. By comparison, fatigue testing by the same manufacturer to the principal European standards involved testing individual components, such as sliding bearings (six million load cycles at loads of up to 160kN), sliding springs (sliding material tested at a pressure of 30N/mm^2 over a sliding distance of 20km), control springs (one million load cycles at maximum displacement) and on-site butt-welds (two million load cycles at a stress of 165N/mm^2).

It is not surprising that the state of California, with its history of destructive and sometimes devastating earthquakes, plays a leading role in the development of seismic protection technology, with bridge components such as expansion joints falling under the remit of Caltrans, the California department of transportation.

The level of testing required to gain approval of certain DOTs in US seismic zones was recently applied during testing at the Center for Advanced Technology for Large Structural Systems at Lehigh University in Pennsylvania. A full-scale modular joint with seven gaps and four support bars was connected to powerful actuators which imposed large, rapid longitudinal and transverse movements. A series of 17 tests was carried out, with varying conditions and requirements. Test 14, for instance, consisted of ten movement



The Seal Pushout Test being carried out.

cycles with a velocity of 1m/s, with longitudinal movements or 450mm and transverse movements of ±250mm arising, and with rotations about every axis. These factors varied for the other tests, allowing the performance of the joint during a range of seismic events to be assessed.

Once the testing was completed and the expansion joint had been dismantled and examined to establish that it had not suffered any significant damage, it was confirmed that this expansion joint type meets seismic testing requirements as currently proposed.

The international impact of these testing standards has also been demonstrated by the fact that this test was conducted in relation to the construction of the Kishon Bridge in Israel, where seven-gap joints for movements of up to 820mm were delivered this year ■

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