The costs of replacing bearings are far more substantial than those for initial supply and installation

BEARING FRUIT

The life-cycle cost of bridge bearings is typically many times higher than the initial cost of supply and installation, and must not be neglected in bearing selection and specification, argue **Thomas Spuler** and **Niculin Meng**

That life-cycle costs should be considered when constructing bridges, like other structures, is today widely accepted. What is not granted the same recognition, or demonstrated in practice, perhaps, is that the same applies independently to the bridge's individual key components. It has previously been discussed in relation to expansion joints *(Bd&e issue no 67)*, but consideration of the life-cycle costs relating to a bridge's bearings is no less important.

A great deal has been written to assist engineers and owners in the as-sessment of life-cycle issues, and the field of bridges is no exception – for example the 2003 NCHRP *Report 483* by the US Transportation Research Board Bridge life-cycle cost analysis defines life-cycle cost for a bridge in terms of its constituent parts, being the sum of the design cost, construction cost, maintenance cost, rehabilitation cost and user cost, minus its salvage value.

Life-cycle cost analysis for bridges thus represents a great improvement on the often-used traditional approach, which only the initial direct costs of design and construction.

In applying life-cycle cost analysis to an individual subsection of the bridge – in this case its bearings – a key point to recognise is that the life-cycle considered should be that of the bridge, not that of a particular set of bearings such as those initially installed.

Only then will the cost of bearing replacements during the bridge's life be included – replacements which are inevitable in the vast majority of cases. Bearings are generally much less robust than the main structure, yet are subjected to far greater demands – for example, in accommodating rotations and sliding movements.

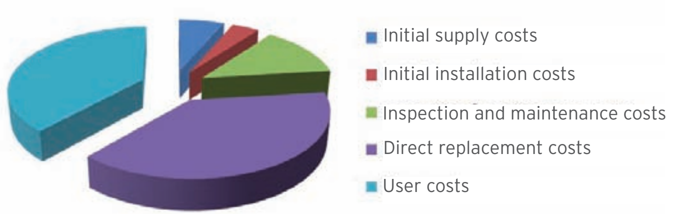
Adapting the above definition for use in relation to bridge bearings, the life-cycle cost is defined as the sum of the initial supply cost, the initial installation cost (at time of bridge construction), the inspection and maintenance cost, the direct replacement cost, and the user cost. Due to the likely need for multiple bearing replacements, these costs are largely cyclical in nature.

The costs relating to bearing replacement are far more substantial than the initial supply and installation costs for the first set of bridge bearings. While the supply cost of replacement bearings is likely to be comparable with the initial supply costs, allowing for inflation, the installation costs will be much higher, generally requiring lifting of the bridge deck, traffic management and so on. And the costs to bridge users resulting from traffic congestion and diversions, can be higher still. The environmental impacts associated with bearing replacement works can also be very significant, considering, for example, materials and energy requirements and increased vehicle exhaust emissions due to congestion. Since all of these associated costs are likely to arise several times during a bridge's typical life of 100 years or more, it is critical to minimise the number of times the bearings need to be replaced.

Due to the cyclical nature of the far more substantial costs relating to replacement – both direct costs and user costs – it is also clear that the initial supply and installation costs are quite negligible by comparison. Despite this, unfortunately the relatively insignificant supply costs still often play a dominant role in the selection process, because a lower-cost, low end product may fulfil short-term needs.

These are important points to be aware of, but awareness of what life-cycle costs entail is

Total life-cycle costs of a bridge's expansion joints during full life of bridge (typical)



of little value unless effectively applied to the goal of minimising them. The life-cycle costs of a bridge's bearings can be minimised in a number of ways, with reference to their constituent parts as defined above.

First of all, the suitability, durability and quality of the bearings selected for use should always be maximised – for example by clear specification of the demands to be satisfied by the bearings; by selection of the optimal bearing type; by verification of long-term bearing performance; by evaluation of the needs of the preferred bearing type; by designing bearings to maximise durability and extend service life; by designing measures which will protect bearings and extend their life-span; and by ensuring the quality of design and manufacture.

Correct installation is also critical for long-term performance. This requires, for example, that the sliding surfaces of sliding bearings are parallel to each other and to the direction of deck movement, and that the bearings are installed with the correct preset, considering the prevailing structure temperature at time of installation. It is also important that the transport fittings of the bearing, which are intended to hold it together until fully installed, are cut at the correct time to avoid damaging constraint forces. The likelihood of a bearing being installed correctly can also be enhanced by the provision of proper access, and by limiting the size of each bearing for improved constructability – for example by the use of spherical bearings with UHMWPE sliding surfaces, which are typically roughly twice as strong as other steel bearings containing PTFE or elastomer.

A further contribution to good long-term performance can be made by ensuring the adequacy of inspection and maintenance activities, for example by providing adequate resources, ensuring proper access, and promoting technical understanding among staff. Proper inspection and maintenance can also be supported by the provision of type plates and

Bearings should be designed with replacement in mind

movement scales, and the keeping and consultation of proper records of previous installation, inspection and maintenance work. Often, automated structural health monitoring systems can also assist greatly. Finally, considering the significant impact that bearing replacement has on life-cycle costs, bearings and bridges should be designed with bearing replacements in mind – for example, by the provision of separate anchor plates in concrete structures.

Consideration of the life-cycle costs of a bridge's bearings, including costs of maintenance and replacement throughout the bridge's life, and related user costs, thus demonstrates the importance of devoting adequate attention and expenditure to the procurement, installation and maintenance of high-quality, well-detailed bearings.

In particular, it also highlights the importance of devising bridge construction contracts in such a way that the party selecting the bearings has a real incentive to ensure their long-term performance. Recognition of these key issues, and consideration of measures that can assist in implementing a long-term strategy, can thus help minimise the life-cycle costs of a bridge's bearings

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