R = resistance
DL = dead load effect
LL = live load effect, including dynamic load allowance

Based on these calibrations and reliability indices, a higher load factor or lesser resistance factor is applied to loads and materials whose behavior is less-well known and cannot be as accurately predicted. In this manner, greater knowledge of some resistances and loadings can be accounted for, allowing more efficient designs while still applying appropriate levels of safety to those resistances and loads which are more ambiguous. As research is conducted and the knowledge base increases, load and resistance factors can be altered to account for the greater certainty, or in some cases, greater uncertainty of loads or resistances.

1.2.3.1 Original Calibration Work

In 1999, the original calibration work by Dr. Andrzej S. Nowak was published in NCHRP Report 368 (Nowak, 1999). Much of the work for this report was actually completed prior to 1991, prior to the final selection of load and resistance factors used in *AASHTO LRFD*. NCHRP Report 368 provides the background information and the calibration procedure for *AASHTO LRFD*. The original calibration was for the strength limit state, and calculations were carried out for beam- and slab-type bridges. For the original calibration work, it was assumed that resistance would not change over time (assuming that maintenance would be adequate to preserve the original strength) and that the weight of legal loads would not increase over time.

For the original calibration work that served as the basis for the 1994 *AASHTO LRFD*, the reliability index, β, was set at a target of 3.5. The inherent reliability indices of previous specifications ranged from as low as 2.0 to as high as 4.5. A target reliability index of 3.5 was considered appropriate, as it was slightly higher than an average of previous specifications and design philosophies (Nowak, 1999; Kulicki, et al., 2007).

1.2.3.2 Latest Calibration Work from SHRP 2

In December 2013, new calibration work specific to the service limit state was completed as part of the second Strategic Highway Research Program (SHRP 2), administered by the Transportation Research Board. A project team consisting of Modjeski and Masters, University of Nebraska at Lincoln, University of Delaware, and NCS Consultants documented their work in a final report entitled “Bridges for Service Life Beyond 100 Years: Service Limit State Design” (Modjeski and Masters, et al., 2013). The primary objectives of this project (SHRP 2 Project R-19B) were to develop design and detailing guidance to provide 100-year bridge life, to develop calibrated service limit states to provide 100-year bridge life, and to develop a framework for further development of calibrated service limit states.

2.3.1 Safety

The primary responsibility of a bridge engineer is to ensure the safety of the traveling public. This objective is fulfilled primarily by designing the bridge such that it fully satisfies the design requirements of *AASHTO LRFD*, as well as any other governing design requirements.

To ensure that this responsibility is fulfilled, bridge design projects should include a comprehensive check of all calculations and drawings, as well as an independent Quality Control review after the work is completed by an Engineer not associated with the specific work.

2.3.2 Serviceability

Another design objective is serviceability of the bridge, or its ability to provide service to the traveling public as intended.

Serviceability includes many different criteria, such as durability, maintainability, rideability, and deformations. These criteria are generally based on past practices, but they are not necessarily based on scientific evidence or research. However, in December 2013, new calibration work specific to serviceability was completed as part of the second Strategic Highway Research Program (SHRP 2), administered by the Transportation Research Board. Serviceability criteria are intended to ensure that the bridge can provide 75 years of service life.

2.3.2.1 Durability

The single most significant design decision that can enhance bridge durability is the elimination or reduction of the number of deck joints. When road de-icing agents are used on bridges with deck joints, deterioration is common for the structural components immediately below and in the vicinity of the joint. Experience has shown that the best way to prevent this deterioration is to eliminate deck joints as much as possible.

Where deck joints cannot be eliminated, careful attention should be given to making the joint as leak-proof as possible, as well as providing for the protection of bridge components beneath the joint. As shown in Figure 2.3.2.1-1, damage from snow plows, traffic, and debris can cause joint seals to be torn, pulled out of the anchorage, or removed altogether.