element

BRIDGE BEARING TESTING

AN OVERVIEW OF THE ONTARIO PROVINCIAL STANDARD SPECIFICATIONS - OPSS 1202

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BACKGROUND

Elastomeric bearings play a critical part in bridge structure. Their regulation and testing is critical to bridge safety.

In recent years, a number of bridge failures have occurred throughout the country, some during construction, others after the bridge was in use for some time. Poor design and quality of materials, magnified by severe weather, were at fault.

Design and construct bridges that perform greatly under all conditions is a major tenet of civil engineers and construction companies. The bridge structure must be able to withstand unavoidable external forces and torques resulting from heavy traffic loads and environmental factors, which provoke movements and contribute to the aging and degradation of the bridge.

Typically comprised of steel cable and concrete, with temperature difference, such as increase in temperature, the bridge expands along its length, producing movements. Vice versa, decrease in temperature causes the bridge structure to reduce in length. During seismic activities, like earthquakes and earth tremors, the bridge foundations take up forces and transfer to the entire bridge structure causing rigorous vibrations.

The bridge structure also vibrates and moves in reaction to forces from trains and vehicles, and because of creep and shrinkage.

Bridge bearings are key structural elements in bridges, able to accommodate these movements and reduce the stresses involved. Their efficiency highly influences the stiffness and stability of a bridge. Thus, a bridge will not be effective if the supporting bearings are faulty.

Preventing collapse is not the only function of bearings for bridges. They also extend the life of a bridge by reducing wear and tear on bridge materials; hence, they help save cost by delaying the replacement of bridges.

Testing bridge bearings for their physical characteristics is fundamental to ensure quality performance and structural integrity of a bridge.

ELASTOMERIC BRIDGE BEARINGS: REGULATION AND TESTING

Bearings can be termed as the mechanical part of a bridge structure. Precisely, they are connections that transfer forces between the bridge superstructure (deck) and the substructure (pier, viaduct, or abutment).

The most common type of structural bearing used on bridges is the elastomeric bearing. The “elastomer” is a compound containing virgin natural polyisoprene (natural rubber) or virgin polychloroprene (neoprene), which demonstrates considerable deformation at low load and which returns to its initial size and shape when this load is removed.

According to design and use, elastomeric bearings can be either plain, consisting of rubber only, or laminated, consisting of alternating individual layers of elastomer and thin horizontal steel plates, which are embedded at specific intervals within the elastomer to prevent the rubber layers from bulging.

Thanks to their low natural stiffness, elastomeric bearings function primarily as an elastic, load transmitting link between construction elements that need to be connected in such a way as to allow a degree of movement. Their structural composition also permits them to perform at extreme temperatures throughout the design life of the bearing.

Because elastomeric bearings for bridges are crucial to the safe and cost-effective bridge design, they must be designed and manufactured to meet standardized requirements.

In the United States, bridge bearings must meet the requirements of the American Association of State Highway and Transportation Officials (AASHTO). Both our US and Canadian labs conduct testing to this requirement. In Canada, the performance requirements of elastomeric bearings for bridges are governed by the provincial and territorial governments. In Ontario, the Ministry of Transportation set out the Ontario Provincial Standard Specification (OPSS 1202), which specifies the requirements for materials, design and fabrication of plain and steel laminated elastomeric bridge bearings for use in provincial and municipal contracts.

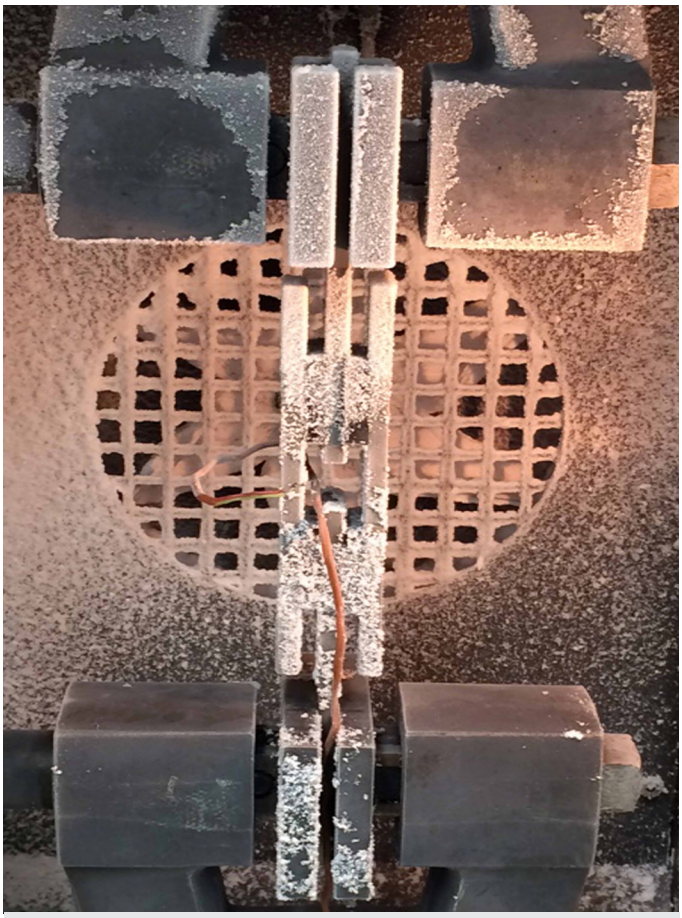
To ensure that the performance of bearings meets the requirements of the bridge design and the Ontario environmental conditions, the OPSS 1202 includes a comprehensive range of tests on the bearings’ physical properties and their elastomer material. Here we examine these tests.

TESTING ELASTOMERS

SHEAR MODULUS TEST

It is well recognized that the shear modulus is the most important physical property that directly enters into the design of elastomeric bearings, affecting their performance. Lateral and longitudinal movements of bridges are in fact accommodated by the pad's ability to deform in shear.

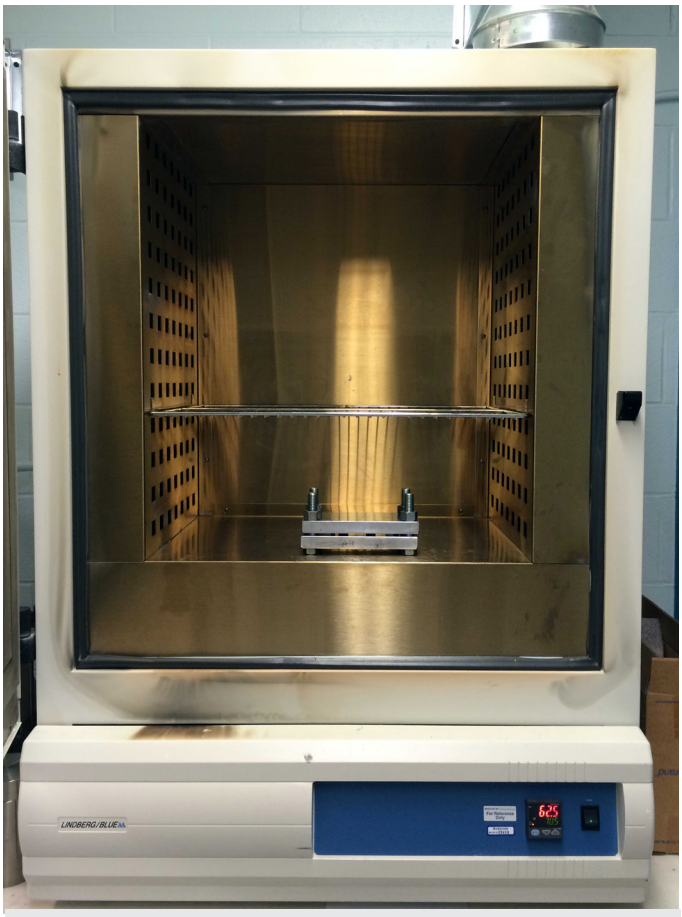
The shear modulus test assesses the stiffness of the elastomeric compound at 20°C and -40°C. Rubber of specified dimensions is bonded to a steel plate and repeatedly pulled in tension to obtain shear modulus data.



Bridge Bearing tested at -40°C using an Instron Load Frame.

COMPRESSION SET TEST

The compression set test is intended to measure the ability of rubber compounds to retain their elastic properties after prolonged exposure to compressive stresses. To conduct this test, the rubber specimen is compressed, placed into an oven at a specified temperature, and held at that compression for a fixed length of time (e.g. natural rubber bearings exposed to 70°C for 22 hours while compressed by 25%).



Compressing rubber using a Lindberg Blue Convection Oven.

TESTING ELASTOMERS

HEAT RESISTANCE TEST

Aging of elastomers involves a progressive change in their physical and chemical properties, usually marked by deterioration. Heat is among the factors that most contribute to the deterioration of elastomers. With the heat resistance test, small specimens of rubber are exposed to the deteriorating influence of air at specified temperatures for known periods (e.g. 70 hours at 70°C for natural rubber bearings), after which the physical properties of the specimens are determined.

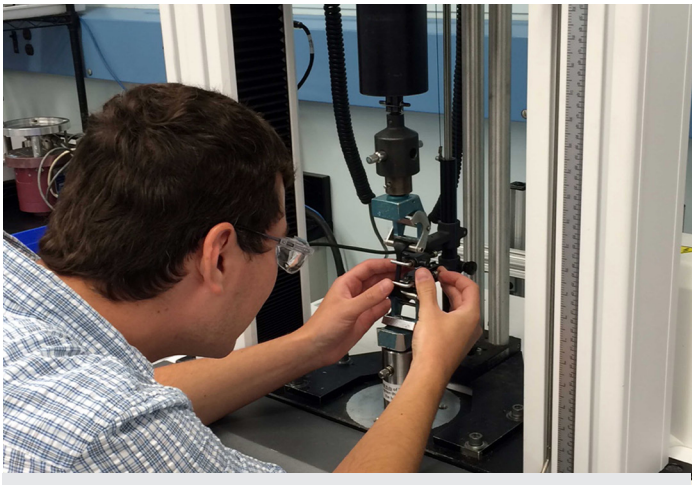
Tensile strength, ultimate elongation and hardness are tested before and after the exposure, so that changes in the rubber's physical properties can be assessed.

Tensile strength is defined as the maximum tensile stress applied in stretching a specimen to rupture. A tensile test is probably the most fundamental type of mechanical test that can be performed on materials. By pulling on something, it is possible to quickly determine how the material will react to forces being applied in tension. As the material is being pulled, its strength along with how much it will elongate is assessed. Tensile strength and elongation are in fact obtained from the same tested specimen.

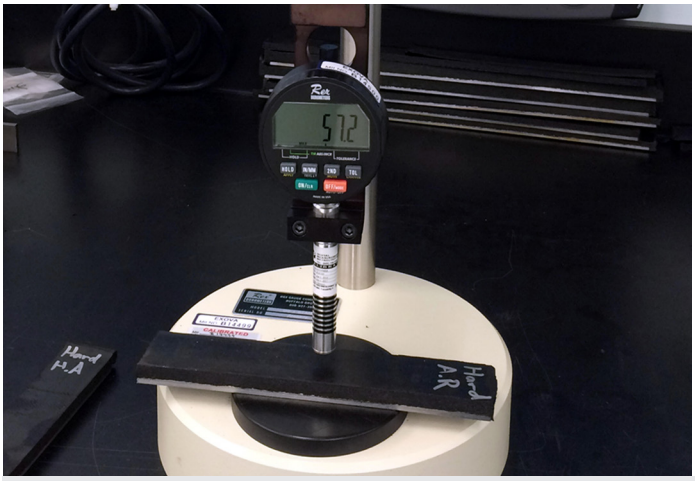
Ultimate elongation is the change in length of the specimen at rupture due to the continuous stress applied to the specimen.

The hardness test measures the resistance of the elastomer by means of a durometer. Type A durometer has a specific geometry indenter that is pressed into the rubber to provide the hardness indication based on the indenter penetration into the rubber. The higher the number, the greater the resistance.

Sample preparation



Tensile strength and ultimate elongation test



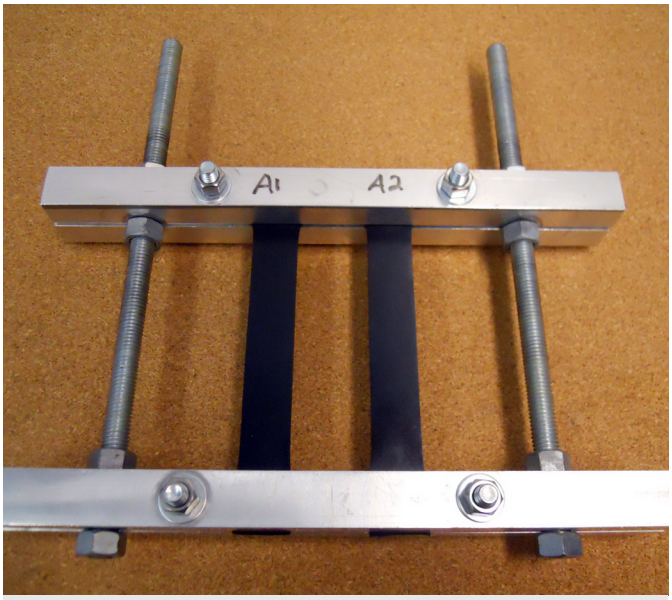
Hardness test

TESTING ELASTOMERS

OZONE RESISTANCE TEST

Ozone attack is another factor that heavily contributes to the deterioration of elastomers. Rubber under tensile strain is susceptible to ozone cracking, a phenomenon caused by ground-level ozone, produced by emissions from heavy vehicle traffic. As a result, protective compounds are incorporated to the rubber to give bearings ozone resistance properties and prevent degradation.

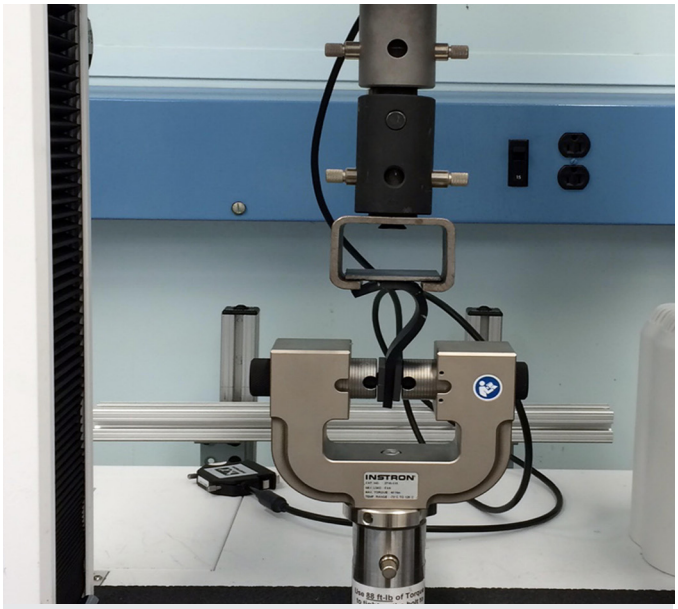
An ozone resistance test is conducted in an ozone generating cabinet where the bearing is exposed to a specified concentration of ozone for known periods (e.g. 25 pphm ozone for 48 hours for natural rubber bearings).



Assessing the rubber resistance after ozone exposure in a SUGA Ozone Weather-Ometer Model OMS-HVCR

BOND STRENGTH TEST

It tests the bond strength between the rubber and the laminated steel plates in reinforced bearings. Poor bonding between rubber and steel can result in bulging of rubber out of the sides of the bearing.



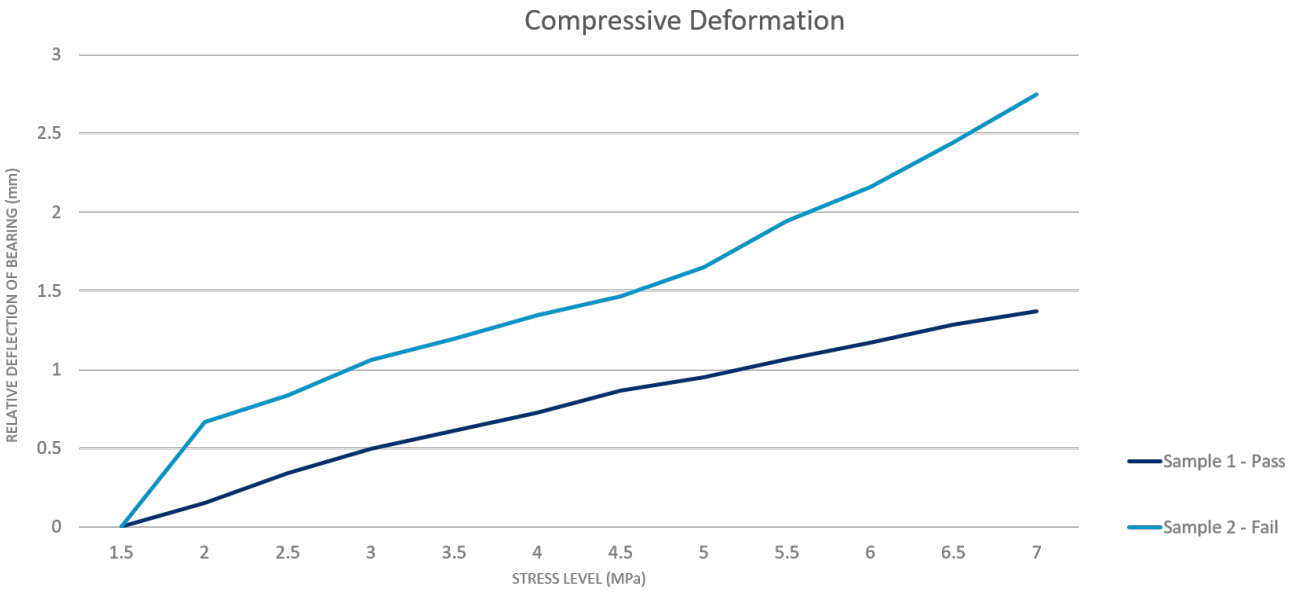
Testing bond strength using an Instron Load Frame in a peeling mode according to ASTM D429 Method B.

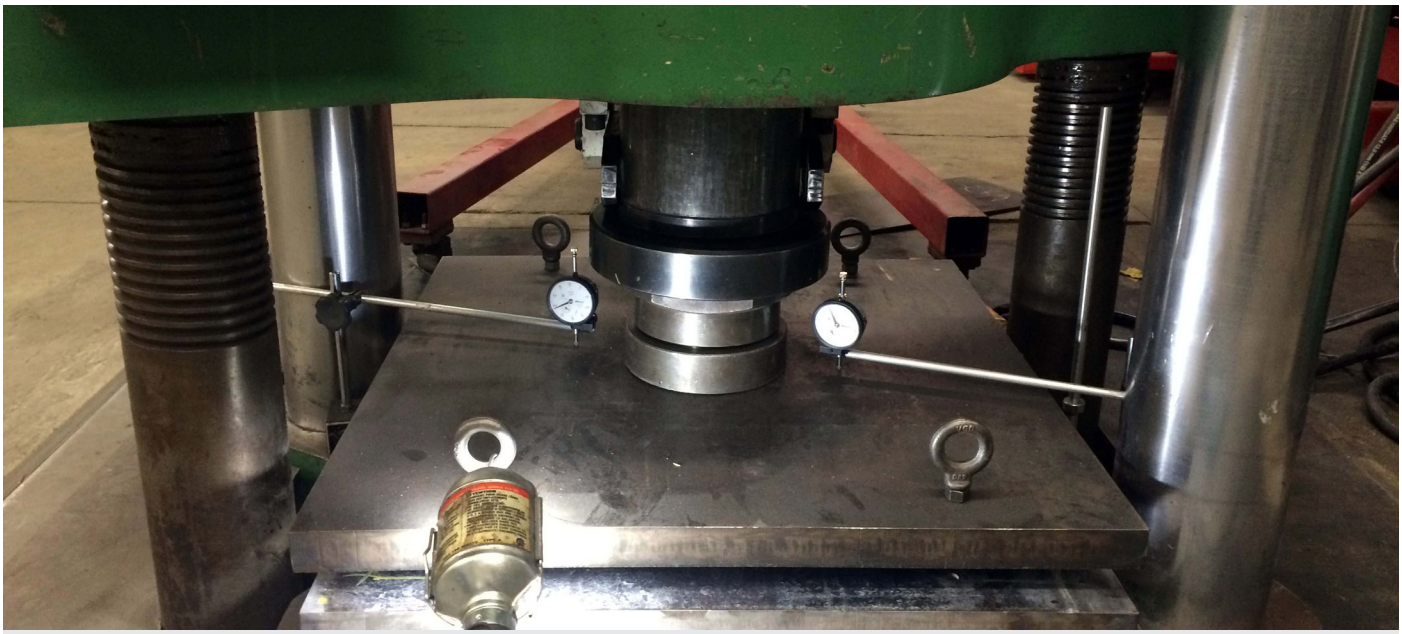
TESTING PERFORMANCE

Compressive Deformation Test

Elastomeric bearings have no movable parts. They accommodate movement and rotation by deformation of an elastomeric pad, which can be neoprene or natural rubber.

During the compressive deformation test, the complete bearing is placed in compression to determine compressive deformation characteristics, that is the deformation at the Maximum Average Pressure (7.0 MP a) expressed as a percentage of the effective elastomeric thickness.





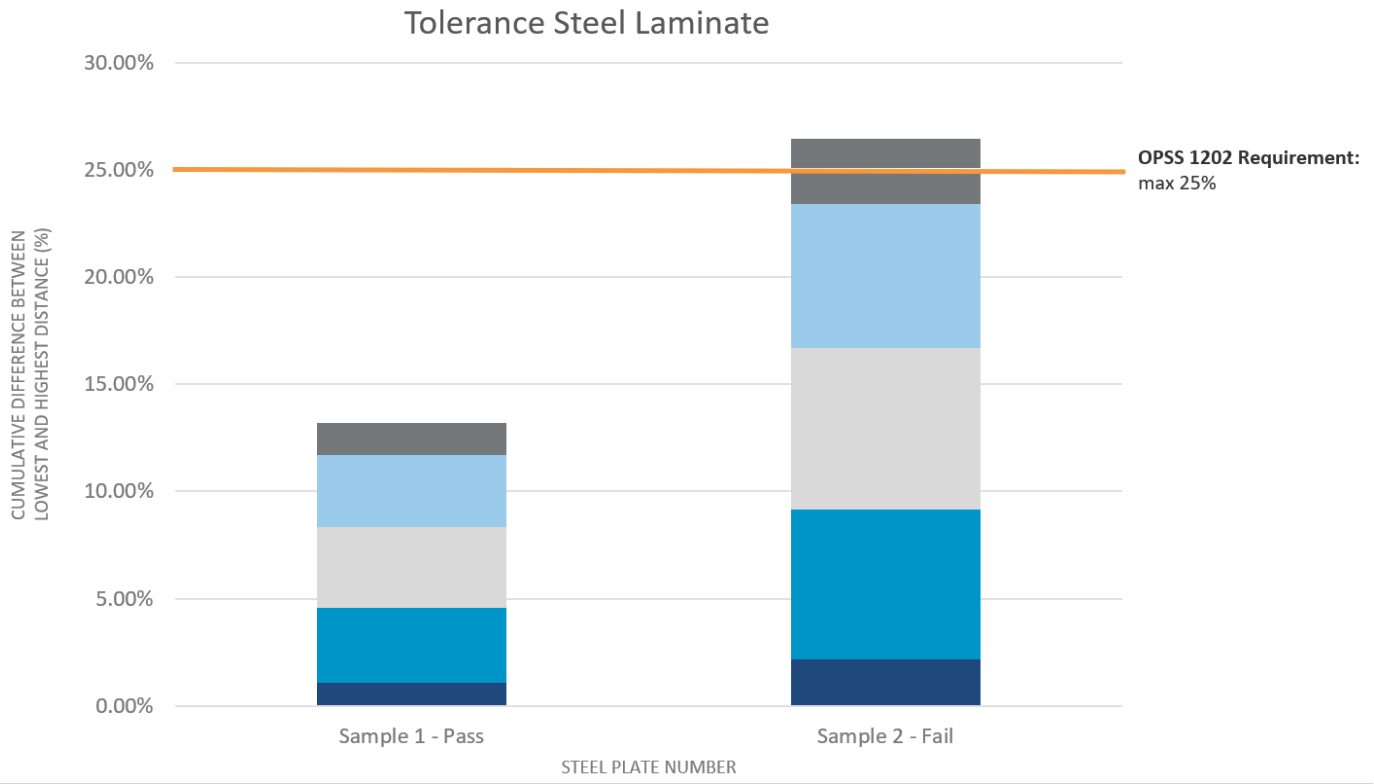
Testing the elastomer deformation using an Instron machine with a 400,000 lbs. capacity.

TESTING TOLERANCES

Bearings must not only comply with testing requirements but also with fabrication tolerances.

Tolerances ensure that the actual bearing dimensions match that of the original design. Tolerance of steel plates in laminated bearings is used to confirm that the steel plates in a laminated bearing are parallel. This testing ensures that the manufacturer has proper control of their manufacturing process with respect to the dimensional requirements of the bearing.

Failure to satisfy the fabrication tolerances related to the position of the internal steel laminates is one of the most frequent reasons for bearings rejection.



CONCLUSION

Performed to evaluate the effectiveness of particular rubber compounds, these tests determine the bearings' ability to meet specified original and aged properties, according to the Ontario Provincial Standard Specification.

They help catch defects before they get into the final product, assuring quality of bearings and safety of the bridge structure, and minimize the costs of bearings' replacement.

Elastomeric bearings play a crucial role in bridge safety, dependability, and longevity. Undoubtedly, carrying out bridge bearing testing is a key asset in this role.

Element Materials Technology is an international provider of testing, advisory and certification services. We are trusted by many of the world's best organizations to test and advise on the safety, quality and performance of their products and operations. Our capabilities help extend asset life, bring predictability to applications and shorten the time to market for our customers' products, processes and materials.

Our polymer laboratory in Mississauga, Ontario has been testing plain and steel laminated elastomeric bearings for bridges for over a decade. We have the capability to perform all testing in-house and the expertise to prepare elastomer specimens from sample bearings.

REFERENCE

Ontario Provincial Standard Specification OPSS 1202: "Material Specification for Bearings - Elastomeric Plain and Steel Laminated". Ontario Ministry of Transportation, Toronto, ON, 2016.

National Cooperative Highway Research Program (NCHRP), Report 449: "Elastomeric bridge bearings: recommended test methods". Transportation Research Board. National Research Council.

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