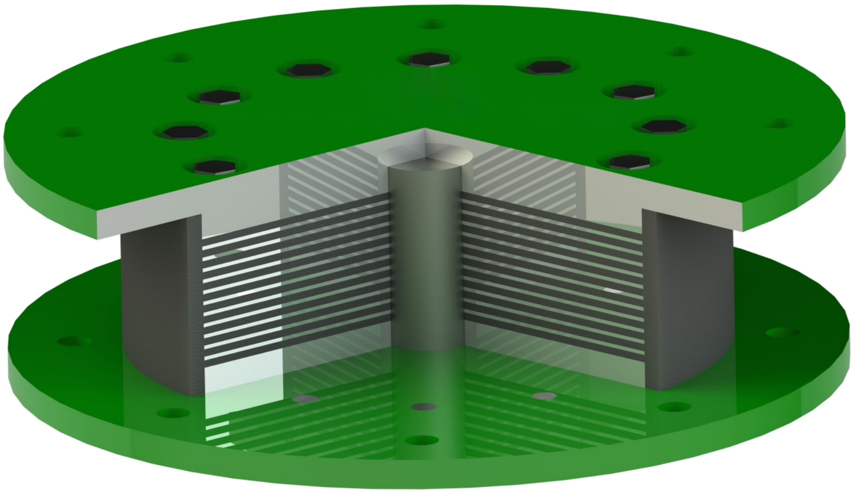
LEAD RUBBER BEARINGS

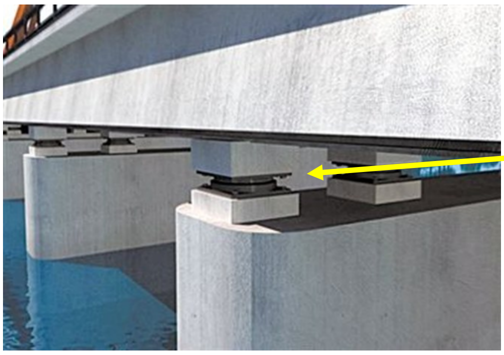


LEAD RUBBER BEARINGS

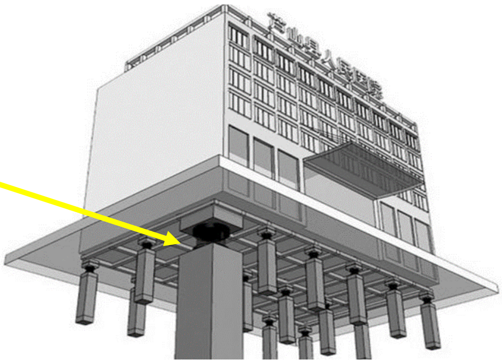
INTRODUCTION:

The Carpenter & Paterson Asia Ltd (CPA) Lead Rubber Bearing (LRB) is a type of seismic isolation device used in the construction of industrial structures, buildings and bridges to protect them from the damaging effects of earthquakes. The LRB is designed to absorb and dissipate seismic energy, reducing the lateral forces transmitted to the structure during an earthquake, thereby minimizing structural damage and enhancing safety.

In the LNG sector, LRB's are often used in order to provide seismic isolation or vibration reduction of LNG storage tanks, LNG processing equipment and LNG terminals and facilities.



CPA LEAD RUBBER BEARING



COMPONENTS AND FUNCTIONING OF THE LEAD RUBBER BEARING:

The CPA Lead Rubber Bearing seismic isolation device consists of several key components, each designed to perform specific functions that collectively help to isolate a structure from ground motions during an earthquake. Here is a detailed description of the components of an LRB:

1. Rubber Layers (elastomeric layers):

The LRB consists of multiple layers of natural rubber (or synthetic rubber) sandwiched between thin steel plates. These rubber layers provide flexibility and elasticity, allowing the bearing to deform laterally (sideways) during an earthquake.

2. Steel reinforcing plates (shims):

Steel reinforcing plates are placed between the rubber layers to provide vertical stiffness, ensuring that the bearing can support the weight of the structure (vertical loads) without significant deformation. The steel plates prevent the rubber layers from bulging outward under compression.

3. Vertical Lead Core:

At the center of the LRB is a lead core. The lead core provides the key feature of the bearing - energy dissipation. Lead, being a soft metal, deforms plastically under stress, which means it can absorb and dissipate a significant amount of energy as it deforms during an earthquake. This helps to dampen the seismic forces acting on the structure.

4. Top and Bottom Steel Plates:

The top and bottom steel plates serve as load transfer elements that distribute the weight of the structure and any additional loads (such as traffic or occupants) evenly across the LRB. They also provide a connection point

5. Bonding layer:

The bonding layer ensures a strong and durable bond between the rubber layers and the steel plates. This prevents delamination or separation under stress, maintaining the integrity and performance of the LRB.

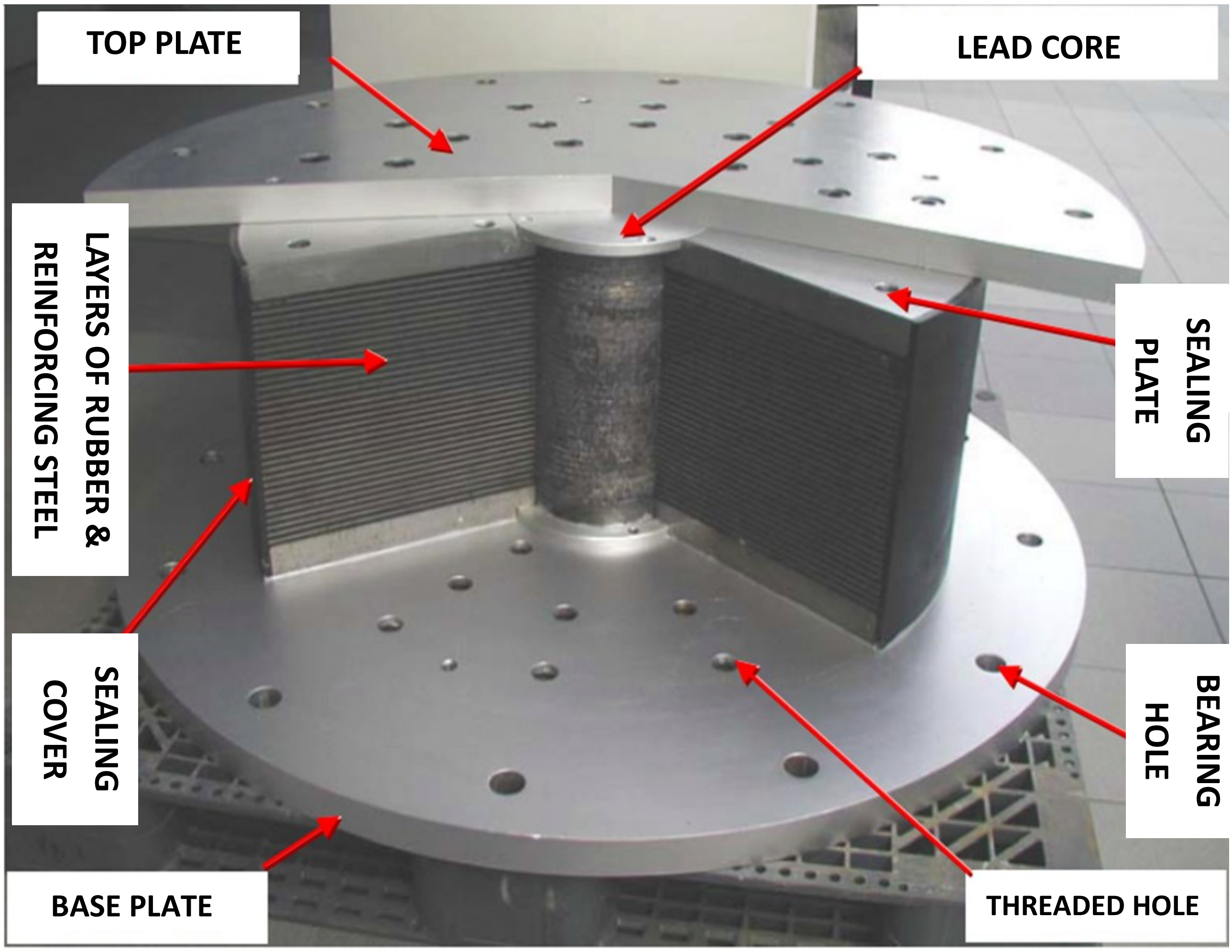
6. Sealing Components:

Sealing components are used to protect the internal components of the LRB (particularly the rubber layers and lead core) from environmental degradation, such as moisture, ozone, UV radiation, and chemical exposure.

7. Base Plate:

The base plate is the lower part of the LRB, which is fixed to the foundation or substructure. It provides a stable platform for the bearing and ensures a secure connection to the foundation.

CROSS-SECTIONAL IMAGE OF THE LEAD RUBBER BEARING:



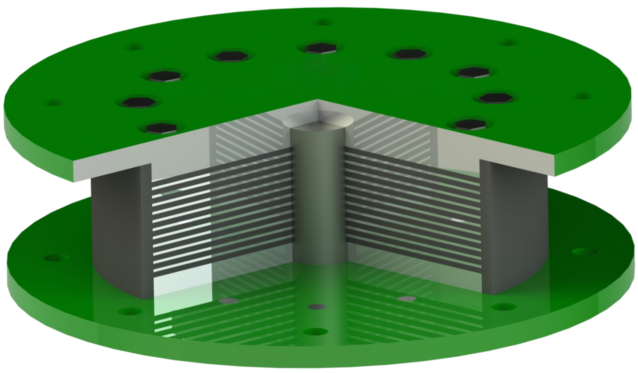
LEAD RUBBER BEARINGS

HOW THE CPA LEAD RUBBER BEARING WORKS:

Flexibility and Movement: During an earthquake, the ground shakes, causing lateral (horizontal) movement. The rubber layers in the LRB allow the bearing to move laterally with the ground motion. This movement helps to decouple the building or bridge from the ground motion, reducing the forces transmitted to the structure.

Energy Dissipation: As the rubber layers stretch and the lead core deforms, energy from the seismic motion is absorbed and dissipated. The lead core undergoes plastic deformation, absorbing a portion of the seismic energy and converting it into heat. This energy dissipation reduces the amount of energy transferred to the building or bridge.

Restoring Force: After the earthquake motion subsides, the elastic properties of the rubber layers provide a restoring force that helps return the structure to its original position.



BENEFITS OF THE CPA LEAD RUBBER BEARING:

Reduces Seismic Forces: By decoupling the structure from ground motion, LRBs significantly reduce the seismic forces transmitted to the industrial structure, building or bridge.

Enhances Structural Safety: Minimizes structural damage during an earthquake, reducing the risk of collapse and enhancing safety.

Long-term Durability and Corrosion Resistance: The CPA Lead Rubber Bearing possesses excellent corrosion resistance as well as strong resistance to fatigue, fire, water, ozone and chemicals. Life span is 60+ years - often larger than the design life the structure itself. The flange plates can be supplied with a hot dip galvanized or painted finish depending on customer requirements.

Quality Assurance and Individual Product Testing: All LRB devices are designed, manufactured and tested in accordance with applicable standards. Each LRB is individually tested using state of the art material testing equipment and isolator testing equipment.

Compact Design and Low Maintenance : Easy to install, maintain and replace. No repair is required after an earthquake has taken place.

Proven Technology: Widely used and proven effective in many earthquake-prone regions around the world.

LEAD RUBBER BEARINGS

KEY PARAMETERS IN THE DESIGN & SELECTION OF LEAD RUBBER BEARINGS:

The design parameters of Lead Rubber Bearings (LRBs) are critical to ensure their effective performance in isolating structures from seismic forces. These parameters are determined based on the specific requirements of the building or bridge, the seismic hazard of the location, and the desired level of isolation. Key design parameters of LRBs include:

1. Horizontal Stiffness (K_horizontal):

Defintion: Horizontal stiffness refers to the resistance of the LRB to lateral (horizontal) movement. It is a measure of how much the bearing deforms horizontally under a given horizontal load.

Importance: Lower horizontal stiffness allows more lateral movement, which reduces the seismic forces transmitted to the structure. However, too much flexibility could lead to excessive displacements.

Determination: Horizontal stiffness is influenced by the rubber compound properties, the thickness of the rubber layers, and the number of rubber-steel laminate layers.

2. Vertical Stiffness (K_vertical):

Definition: Vertical stiffness is the resistance of the LRB to vertical loads (the weight of the structure).

Importance: High vertical stiffness is required to support the weight of the structure without significant vertical deformation, ensuring the building or bridge remains stable.

Determination: Vertical stiffness is primarily provided by the steel plates embedded within the rubber layers. The thickness and number of these steel plates influence the vertical stiffness.

3. Damping Ratio:

Definition: The damping ratio represents the ability of the LRB to dissipate energy. It is a measure of how much of the seismic energy is absorbed by the bearing as opposed to being transmitted to the structure.

Importance: Higher damping ratios lead to better energy dissipation, reducing the seismic forces acting on the structure. LRBs typically achieve this through the lead core, which provides hysteretic damping by deforming plastically under seismic loading.

Determination: The damping ratio depends on the properties of the lead core (such as its diameter and yield strength) and the amount of rubber deformation allowed.

4. Lead Core Size and Yield Strength:

Definition: The size (diameter) and yield strength of the lead core are crucial design parameters that determine the energy dissipation characteristics of the LRB.

Importance: The lead core deforms plastically during an earthquake, providing hysteretic damping. The yield strength determines at what force the lead will start to deform, and the core size affects the amount of energy that can be dissipated.

Determination: The size and material properties of the lead core are selected based on the required energy dissipation capacity and the expected seismic forces.

5. Rubber Layer Thickness and Shear Modulus:

Definition: The thickness of the rubber layers and their shear modulus (a measure of the material's ability to deform under shear stress) affect the horizontal flexibility and energy absorption characteristics of the LRB.

Importance: Thicker rubber layers and an appropriate shear modulus allow for greater horizontal displacement and better energy absorption, improving seismic isolation.

Determination: Rubber layer thickness and the shear modulus are chosen to achieve the desired horizontal flexibility and energy dissipation, depending on the building's seismic isolation requirements.

6. Total Height of the Bearing:

Definition: The total height of the bearing includes all rubber and steel layers as well as the lead core.

Importance: The height affects both vertical and horizontal stiffness and the overall stability of the bearing. A taller bearing may allow for more lateral displacement, while a shorter bearing may provide more vertical stability.

Determination: The total height is designed considering the desired level of flexibility and the vertical load-carrying capacity.

7. Axial Load Capacity:

Definition: The axial load capacity is the maximum vertical load the LRB can support without undergoing significant vertical deformation or failure.

Importance: It ensures that the bearing can safely support the weight of the structure and any additional loads (such as traffic, occupants, etc.) without compromising performance.

Determination: Axial load capacity is a function of the vertical stiffness, the total area of the bearing, and the material properties of the rubber and steel components.

8. Allowable Lateral Displacement:

Definition: This parameter defines the maximum lateral movement the bearing can accommodate during an earthquake without losing stability or experiencing excessive deformation.

Importance: It determines the isolation performance of the LRB and ensures that the structure can withstand expected seismic displacements without failure.

Determination: Allowable lateral displacement is influenced by the rubber layer thickness, lead core properties, and overall design configuration.

9. Shear Strain Capacity:

Definition: Shear strain capacity is the maximum allowable shear deformation (lateral displacement relative to its height) of the rubber layers.

Importance: It ensures that the rubber does not exceed its deformation limits, which could lead to damage or reduced effectiveness of the isolation system.

Determination: This is typically controlled by the properties of the rubber compound and the design thickness of the rubber layers.

10. Temperature and Environmental Considerations:

Definition: The behavior of rubber and lead can change with temperature and exposure to environmental conditions (such as UV radiation, ozone, and chemicals).

Importance: Design must account for temperature effects on rubber elasticity and lead deformation characteristics, ensuring performance in all expected environmental conditions.

Determination: The materials used in the LRBs are selected and treated to ensure long-term durability and performance under varying temperature and environmental conditions.

SUMMARY:

CPA Lead rubber bearings are a vital technology in modern structural engineering, especially in areas vulnerable to earthquakes. Their ability to isolate structures from ground motion, dissipate seismic energy, provide durability, and protect both structural and non-structural elements makes them an essential component in designing resilient and safe buildings and infrastructure. The use of CPA LRBs contributes significantly to safeguarding human lives, reducing economic losses, and ensuring the continuity of essential services during and after seismic events.

For more information on CPA Lead Rubber Bearings and how they can benefit your project, please do not hesitate to contact us.

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