

## Introduction

This document has been created to provide an insight into the design and selection of our materials in order to assist in the understanding of technical datasheets and in the selection of an appropriate material for a particular application. Farrat are manufacturers of acoustic and vibration isolation bearings rather than traditional bridge bearings (for road bridges etc) but we have summarised the principles behind bridge bearings to explain the distinctions.

Farrat elastomeric (rubber) isolation materials are high quality, easy to use and economical. Produced in the UK by Farrat using high quality compounds they provide excellent tuned frequency vibration, acoustic and shock isolation as well as predictable, low long term creep performance and have been used globally in industrial and structural applications.

The most common applications for elastomeric structural bearings are either as bridge bearings or acoustic and vibration isolation bearings. Although similar in appearance and design the two applications require the bearings to perform different functions and different design considerations apply to each case.



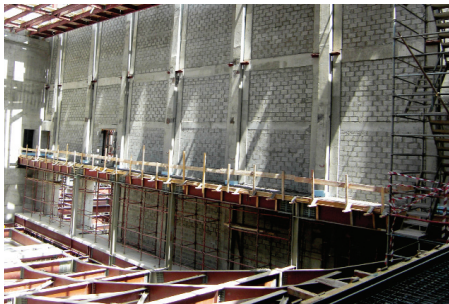
*Low frequency acoustic  
& slide bearings for floor  
& roof structure of  
QECC project.*



Low frequency acoustic & slide bearings for floor & roof structure of QECCC project.



Far right, Low frequency acoustic structural bearings for seating, stage, interior wall & roof (box in box) structure of QECCC project.



Above; acoustic bearings and washers for cinema raked seating. Right; Acoustic bearings pads for a 7 storey office and residential building.



### Bridge bearings

Used to support bridge or structural beams.

Bridge bearings are required to:-

- Carry high permanent compression loads with minimum compressive deflection.
- To accommodate horizontal movement by shear deflection with low shear stiffness to prevent excessive loads on the bridge piers due to thermal expansion and contraction.
- To accommodate rotational deflections due to the beams hogging and sagging.
- To accommodate live loads with minimal additional compressive deflection.

### Acoustic & Vibration Isolation Bearings

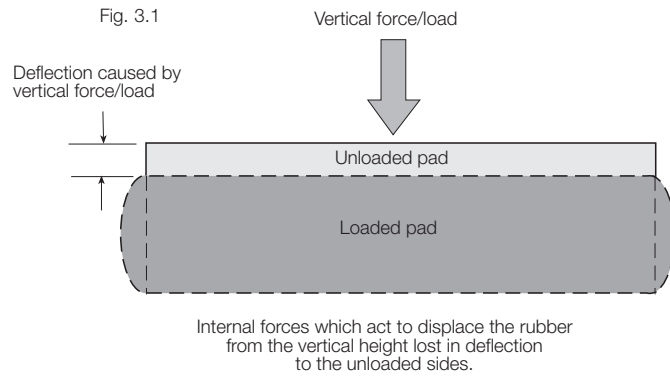
Used to isolate structures from external noise and vibration or to prevent the migration of noise and vibration within a structure. Structural bearings for noise and vibration isolation are required to:-

- Carry permanent compression loads with minimum compressive deflection.
- To accommodate live loads with minimal additional compressive deflection.
- To have a natural frequency particular to the application.
- In some cases the acoustic bearing must also be designed to accommodate:
  - Rotational deflections due to the beams hogging and sagging.
  - Horizontal thermal expansion and contraction. This is achieved by incorporating PTFE slide bearing slip faces to the acoustic bearing and load bearing structural element.

Both types of bearing are required to have low long term creep rates and neither type is to be subjected to tensile strains.

### Resilient Seatings

Elastomeric Vibration Isolation materials can also be used as Resilient Seatings in the construction of concrete and steel structures to provide full area seatings and prevent structural damage from stress concentrations caused by rotation and settlement.



### Elastomeric Bearing Design

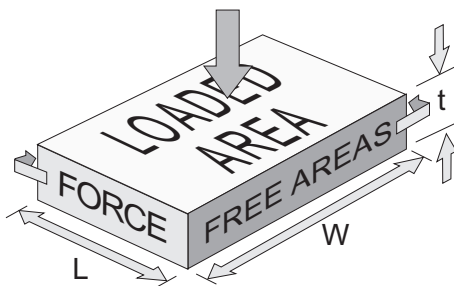
Rubber compounds are in practical terms incompressible. When a vertical compression load is applied to a rubber bearing pad the volume of rubber is displaced around the edges of the bearing resulting in a bulging at the edges.

The compressive stiffness of a rubber pad i.e. the amount of compressive deflection per unit of compressive load (kN/mm) is therefore dependent upon the ease with which the rubber can bulge i.e. the "Shape Factor" and the shear modulus of the rubber compound.

Introducing unfilled holes and slots into the pad increases the force free area and consequently reduces the shape factor.

Fig. 3.2

For a rubber bearing the Shape Factor =  $\frac{\text{Loaded Area}}{\text{Force Free area}}$



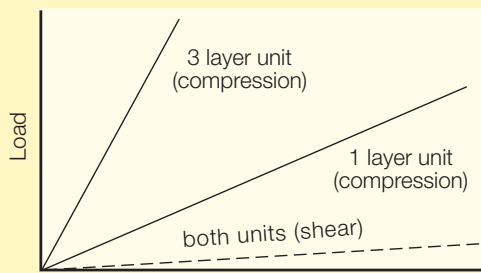
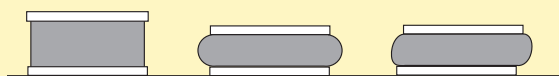
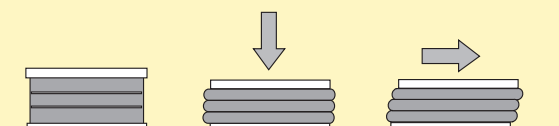
For rubber bearing of length = L  
width = W  
thickness = t  
the Shape Factor =  $\frac{LW}{2t(L+W)}$

The compression modulus of a rubber bearing is proportional the shape factor squared which means that changes in pad dimensions (length, width or thickness) will result in differing pressure carrying capabilities.

The shear stiffness of a rubber bearing is unaffected by the shape factor.

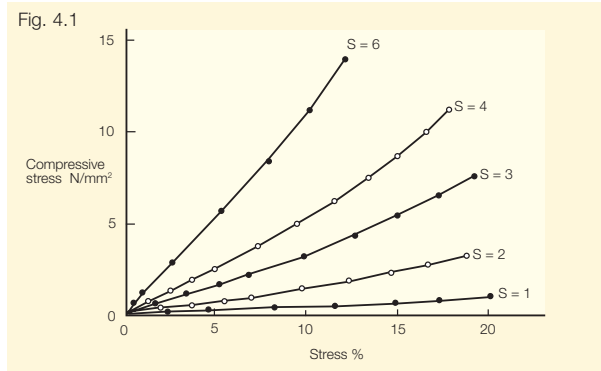
In order for low frequency structural bearings for noise and vibration isolation to achieve an appropriate natural frequency they need to achieve a certain deflection. The obvious solution is to make the bearing thicker but in practical terms an individual elastomeric layer thicknesses should usually not be more than 25mm (in some cases up to 30mm may be possible) as beyond that the shape factor becomes too small which can result in a low load bearing capability and excessive bulging of the elastomer.

In order to overcome this within bridge and vibration isolation bearings, horizontal reinforcing plates are moulded into the rubber to reduce the shape factor relative to the overall height of the bearing which increases the compressive stiffness of the bearing.



To maximise their compressive stiffness bridge bearings may typically have 6 - 8 reinforcing plates with the shape factor for each rubber layer possibly being 6 -12.

By reducing the freedom of the rubber to bulge, the shape factor not only increases the compressive stiffness it also alters the curve of the load vs deflection characteristic.



Excluding the initial low stiffness at very small compressive strains elastomeric bearings are generally considered to have linear load vs deflection characteristics up to around 10% compressive strain. As the compressive strain increases beyond 10% the curve in the load vs deflection characteristic increases so increasing the tangential stiffness at the design load. Whilst this effect can be useful in bridge bearings to limit live load deflections and movements at the bridge to road joint it is undesirable in acoustic and vibration isolation bearings which are required to have a substantially linear characteristic over a range of +/- 25 % of the design load.

Bridge bearings can be safely designed to operate with a permanent compressive strain of 15%; however it is common practice to limit the permanent compressive strain on acoustic and vibration isolation bearings to 10%. To achieve a satisfactory load vs deflection characteristic for acoustic and vibration isolation bearings the geometry of the bearing should be limited to give a shape factor around 3.

In addition to considering the compressive strain limits when designing bearings it is also important to consider the resultant compressive stress acting on the bearing and onto the supporting structure.

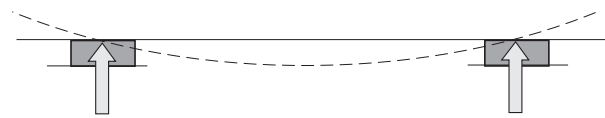
For both bridge bearings and acoustic and vibration isolation bearings the bearing stress should be not greater than 15 Mpa.

The pad performance is reliant on the compressive load being spread evenly across the entire bearing area and where the bearings are placed on concrete supports (columns, corbels etc) the bearings must be placed within the area covered by the steel reinforcement to eliminate the risk of cracking in the concrete support.

### Rotation

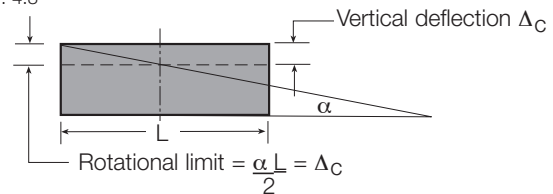
Rotation usually results from hogging and sagging of the beams / trusses which are being supported by the bearings.

Fig. 4.2



This means that the pivot point of rotation is usually at the centre of the bearing. A rotational limit must be applied to ensure no tension or lift off at the 'rear' of the bearing i.e. upward movement must not exceed compressive deflection under static vertical load.

Fig. 4.3



$$\text{Rotational limit} = \frac{\Delta_c \times 2}{L} = \frac{1 \times 2}{Kc \times L}$$

If  $Kc = \text{kN/mm}$  and  $L = \text{mm}$

$$\text{Rotational Capacity} = \frac{\Delta_c \times 2}{L} = \frac{1 \times 2}{Kc \times L}$$

$$\text{Rotational Capacity} = \frac{2}{Kc \times L} = \text{RADIANS/ kN}$$

Farrat manufacture a wide range of elastomeric materials and laminated Acoustic & Vibration Isolation Bearings and are always happy to discuss specific project requirements and offer specific design specification calculations and advice. Please contact Farrat for more information.