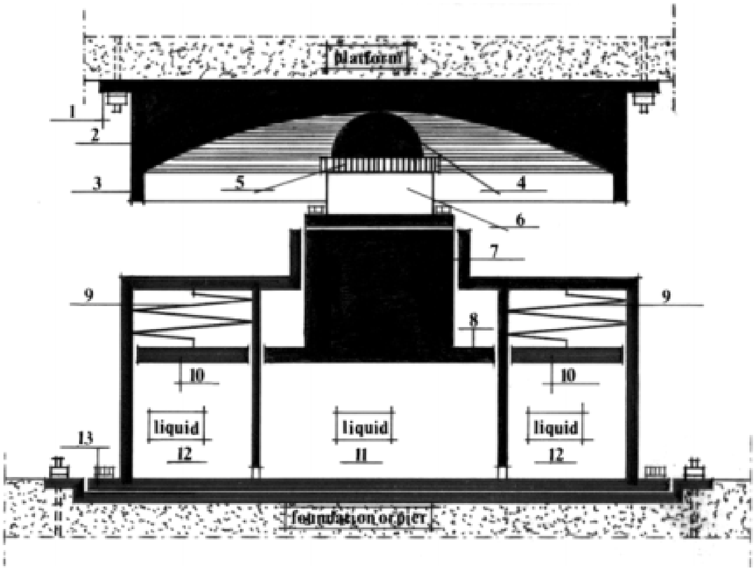
Aseismic Hydraulic Bearing

Figure



Constitution

The bearing consists of: a) steel plate (1) for connecting of the sliding spherical bowl (2) to the platform; b) steel sliding spherical bowl (2); c) safety perimetric spandrel (3); d) movable steel ball (4) in contact with the overhanging spherical bowl (2). Alternatively, the ball (4) can be fixed and surfaced with Teflon (contact with sliding friction); e) rubber elastic protection belt (5); f) body (6) for the ball housing (4); g) movable cylindrical piston (7) coaxial with the body (6). It widens at the base with the steel plate (8); h) central hydraulic chamber (11), where the piston (7) is housed; i) lateral hydraulic chambers (12), separated from the central chamber (11) by vertical baffles, but linked to it by means of special holes made on the base of these baffles; j) movable pistons (10), housed in the lateral chambers (12) and connected to the top by pre-stressed springs (9); k) steel base plate (13), connected to the foundation or the pillar.

Operating principle

When the soil is in a state of rest, the bearing is subjected to a balanced system of loads consisting of the load P_i, transmitted from the building, and from the elastic reactions of the pre-stressed springs (9). Because of the horizontal displacement of the foundation-soil complex, due to the undulatory shock, the increase in the thickness of the sliding spherical bowl (2) forces the movable piston (7) to sink, forcing a part of the liquid of the central chamber (11) to pass through the holes, in equal amounts, into the lateral chambers (12).

The consequent increase of the liquid volume in the lateral chambers forces the pistons (10) to move upward compressing the springs (9). In this situation the building remains motionless , because, due to the thickness variation of the bowl, the rigid deflection is perfectly offset by the lowering of the level of the liquid in the central chamber and by the raising of the level of the liquid in the lateral chambers. In the return phase, that is during contrary horizontal displacement of the foundation-soil complex, because of the decrease in the thickness of the bowl, the elastic reactions of the springs (9) force the movable pistons (10) to sink.

The liquid in the lateral chambers (12) passes into the central chamber, increases the liquid volume of this chamber and forces the piston (7) to move upward, offsetting the thickness variation of the bowl. In this situation the building still remains motionless. Actually, however, the rest state of the building is disturbed by the vertical displacement of the piston (7), due to the load variation $\div P_i$ on the bearing due, always, to the horizontal displacement of the foundation-soil complex.

This variation induces a pendulous effect in the building whose size is determined by the size of the horizontal displacement; the smaller the horizontal displacement, the smaller the pendulous effect. Since the displacement varies from a few millimetres to some centimetres, the pendulous effect is negligible. The horizontal seismic energy in the building is:

$$F_{i,h} = P_i^* \cos^2 \Psi \mathrm{arcsin}\ (S_h / R) \beta c_a \qquad 1)$$

where: P_i^* = load on the bearing after the horizontal displacement; S_h = horizontal displacement; R = curvature radius of the sliding spherical bowl; c_a = friction coefficient between the building and the bearing.
The total inertial force is:

$$F_{i,h,t} = P_b \cos^2 \Psi \mathrm{arcsin}\ (S_h / R) \beta c_a \qquad 2)$$

where P_b = total weight of the building. Owing to the vertical displacement S_v of the foundation-soil complex, the piston (8) of the central chamber undergoes the displacement S_b and, consequently, the pistons (10) of the lateral chambers move vertically by S_m because of the variation in the liquid contained in the relative chambers. In the hypothesis of forced harmonic vibration with damping , the correlation between the vertical displacement of the building S_b and vertical one of the foundation-soil complex S_v is:

$$S_b = S_v / \cdot \ \Psi 1 - (f^2 / f'^{\,2}_n) \beta^2 + \Psi (2\, c / c_{cr})\ (f / f'_n) \beta^2 \qquad 3)$$

where: f = seismic frequency; c = damping characteristic; c_{cr} = critical damping characteristic; f'_n = natural building frequency with damping; f_n = building natural frequency without damping.

N.B. The bearing needs accurate experimental tests