Ancient buildings in Japan were intuitively engineered to dissipate seismic forces. Out of approximately 500 wooden pagodas only two have collapsed in the past 1400 years. In these ancient structures, joints were 'kept loose to avoid the extreme build-up of forces that can lead to catastrophic failure'. For example, the columns at the lowest storey are not bound to the ground, enabling them to lift up when the earthquake-induced tension force exceeds the gravity loads.' This 'stepping column' was inspiration for a contemporary stepping column in the new build Maison Hermès in Tokyo (See [Fig 16]). This structure as used in Maison Hermès is a half-cycle damper without a steady state, 'unique and innovative even by Japan's seismic engineering standards.' The reason it was used was because the building is very slender in plan and section. In a severe earthquake a slender building such as would suffer from an overturning moment which would result in high tensile forces in columns. This is usually ameliorated by heavy foundations as counterweights or tension-resisting piles. [xxv]

This relatively light connection with the ground might suggest a system for the prototype as the prototype would likely to be composed of slender units for which heavy foundations as counterweights or tension-resisting piles are unlikely to be suitable or viable.

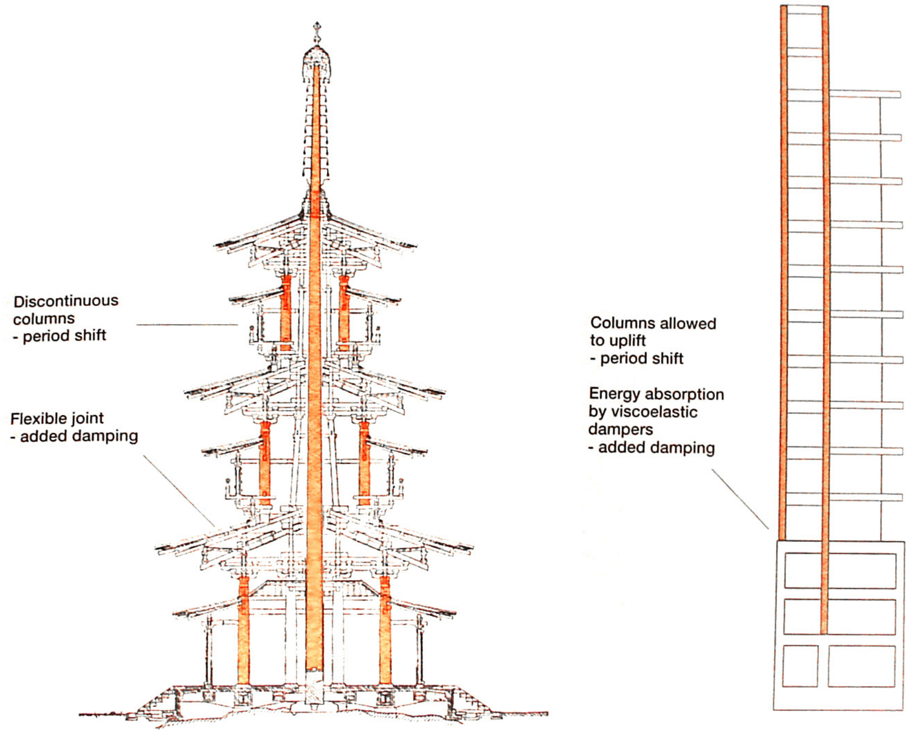

Fig 16. The 'stepping column' of ancient Japnanese pagodas inspired a contemporary system in Maison Hermès

Fig 17. Maison Hermès, Tokyo; architect: Renzo Piano Building Workshop, engineer: Arup

The construction of the Nicolas G Hayek Center saw the implementation of a new type of mass damper passive control system. Real estate values for the site in Ginza, Tokyo were among the highest in the world, therefore the 1 meter clearance zone that would be required around the perimeter of the building for base isolation was considered unacceptable. Nonetheless the client desired a very high level of seismic resistance (structure to remain elastic under level2 - 500 year return / collapse prevented under level 3 - 1000 year return). A new 'Self Mass Damper' (SMD) system was developed for the building. The SMD consisted of isolating floors 9,10, 12 and 13 of the 15-storey building (See [Fig 18]). This system uses the mass of these four floorplates to dampen seismic forces. Initially it was proposed to hang these floorplates to create a 'swinging pendulum', apparently inspired by the swinging pendulum of an antique clock. However this would have led to problematic vertical displacements of the floors due to the rocking movement. Instead the floorplates were to be isolated laterally and supported vertically by corbels, and also connected to the main structure by special spring and damper devices. Existing base isolator bearings were found to be too large and stiff. 'High-damping rubbers in typical isolator bearings are initially very stiff but subsequently softer beyond a certain applied shear force. This bi-linear stiffness can be adjusted by varying the hieght and area of the high-damping rubber material. Typically to prevent crushing under the building's weight, multiple steel plates are sandwhiched between rubber layers, which also makes the bearing extremely stiff laterally. For the SMD system an innovative alternative was taken: to use the layers of rubber without the sheets of steel, to prevent the rubber from being crushed the weight of the floorplates was held by slider bearings with extremely low friction coeffieient. Each of the floorplates weighs approximatelly 100 tons.[xxv] For the proposal at the end of this report the principles behind the SMD system are to be appropriated on a much smaller scale.

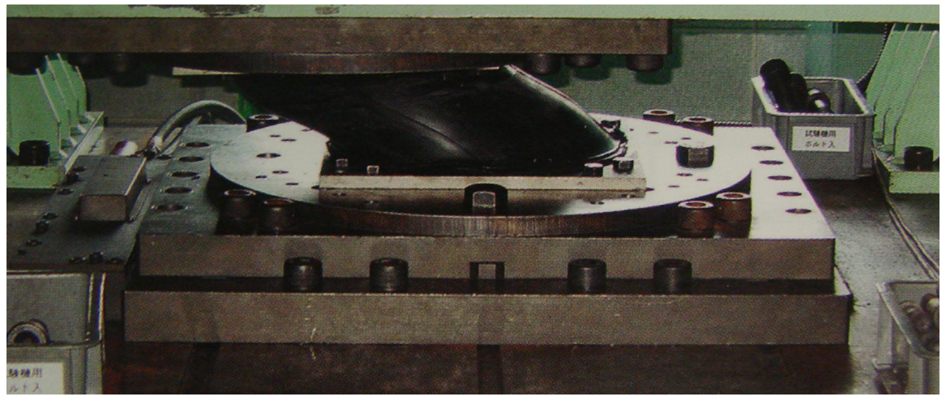

Fig 19. Testing rubber dampers for the SMD system for the Nicolas G Hayek Center

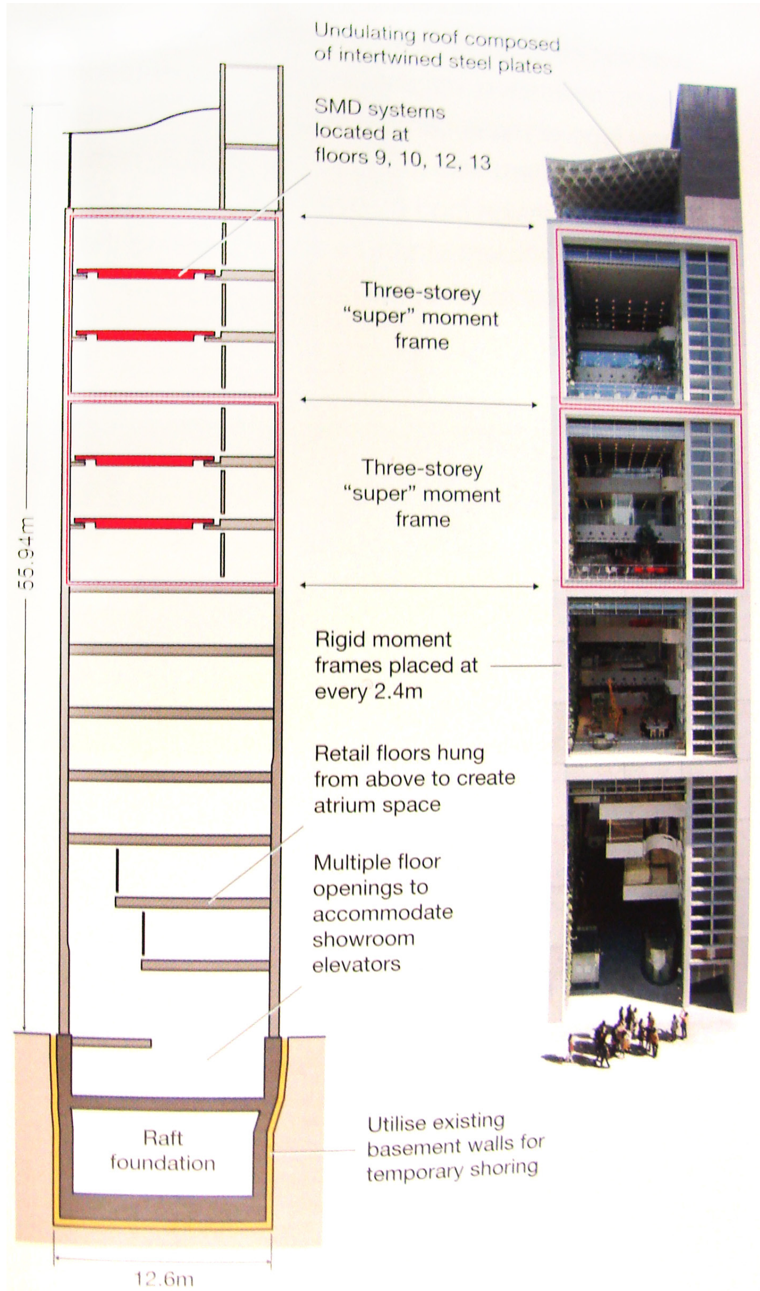

Fig 18. SMD system in Nicolas G Hayek Center; architect: Shigeru Ban, engineer: Arup