CASE STUDY

Farrat
Engineering Excellence

Queen Mary University Graduate Centre

Main Contractor: Bouygues UK

Acoustic Consultant: Bickerdike Allen & Partners

Structural Engineer: BDP

Challenge

As part of a major redevelopment of one of the UK's largest and leading research-focused higher education institutions, Farrat undertook a £27m project to provide Queen Mary University with a new graduate facility.

The eight-storey facility is constructed with a 750 tonne steel frame and concrete cores, a brick facade and curtain wall system. It is located in very close proximity to a particularly shallow section of the Central Line which has train movements every few minutes throughout the day. In the interest of ensuring the best environment for users, the university decided to invest in vibration mitigation measures to eliminate disruptions.

Solution

Early on (RIBA Stage D), Farrat collaborated with the client's concept design team to provide advice and guidance on the vibration isolation strategy in order to achieve the acoustic requirements set out by the acoustic consultant Bickerdike Allen Partners (BAP) and the clients structural engineer. The building was to be a 8 storey steel structure, with no basement so the ground floor slab was supported directly by the pile caps.

BAP recommended that for buildings on piled foundations, an allowance had to be made to account for the assumed coupling loss that can arise between the ground and the pile of between 4 dB and 7 dB. Amplification factors of 6 dB were included in the calculations to account for the fact that steel frame building elements such as floors and ceilings will tend to amplify vibrations at their fundamental frequency as compared to those present in the building foundations.

> **"Farrat has been very helpful during the design stage and very reliable on product delivery, which was critical for the progress of the project."**
>
> **Fabien Roca**
> Civil Works Manager
> Bouygues UK

Design

The design incorporates cast in-situ ground beams with the ground floor slab constructed using 250mm pre-cast planks and a 50mm topping. Farrat worked with BDP to develop and refine the structural and vibration isolation system design.

The process began with BDP issuing all the column and core loads to Farrat as un-factored dead and live loads (un-factored loads are important because the performance of the isolation system is dependent on the typical in-use loadings). Farrat then applied its precise performance prediction tools to design **acoustic bearings** for each location and returned a Bearing Performance Schedule (BPS) to BDP who converted their pin connection details into springs using the spring constants given in Farrat's BPS.

Although the overall load of the building remained the same, in some locations this led to some re-distribution of loads within the structure. These loads were returned to Farrat to update the BPS and issue back to BDP.

In some locations the design team had to consider horizontal forces resulting from rotation within the ground beams originating from the positioning of the column above and the pile cap below. Initially this rotation was to be resisted using lateral restraints but BDP and Farrat established that they could overcome the effect through strategic placement of the bearings and in some cases splitting a single bearing into 2, 3 or 4 bearings to give rotational resistance.

The building included seven external V columns which spanned from pile cap level up to the underside of level 2. In these cases, the V shape of the column meant that the vertical load included a horizontal component in line with the V shape which had to be resisted using **acoustic lateral restraints.**

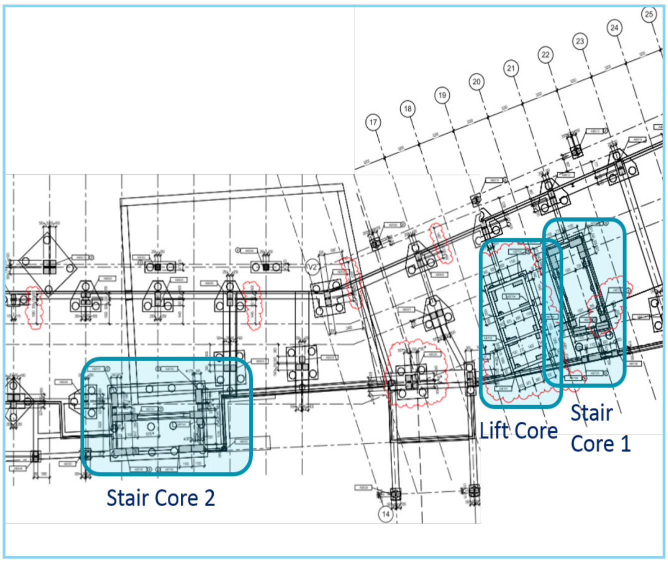

Fig. 1
Plan view GA of the foundations showing the position of the 3 stability cores.

In the other axis the columns had to be designed to resist the potential for a vehicle impact. The design of the cores was similar but required a more in-depth analysis to design the bearings in order to eradicate tension and incorporate appropriate lateral restraints to resist wind and other notional horizontal loads.

This was then followed by a coordinated process between Farrat and BDP to finalise the design and layout of the core vertical and lateral isolation systems as well as the structural design of the pile caps and isolated raft slabs.

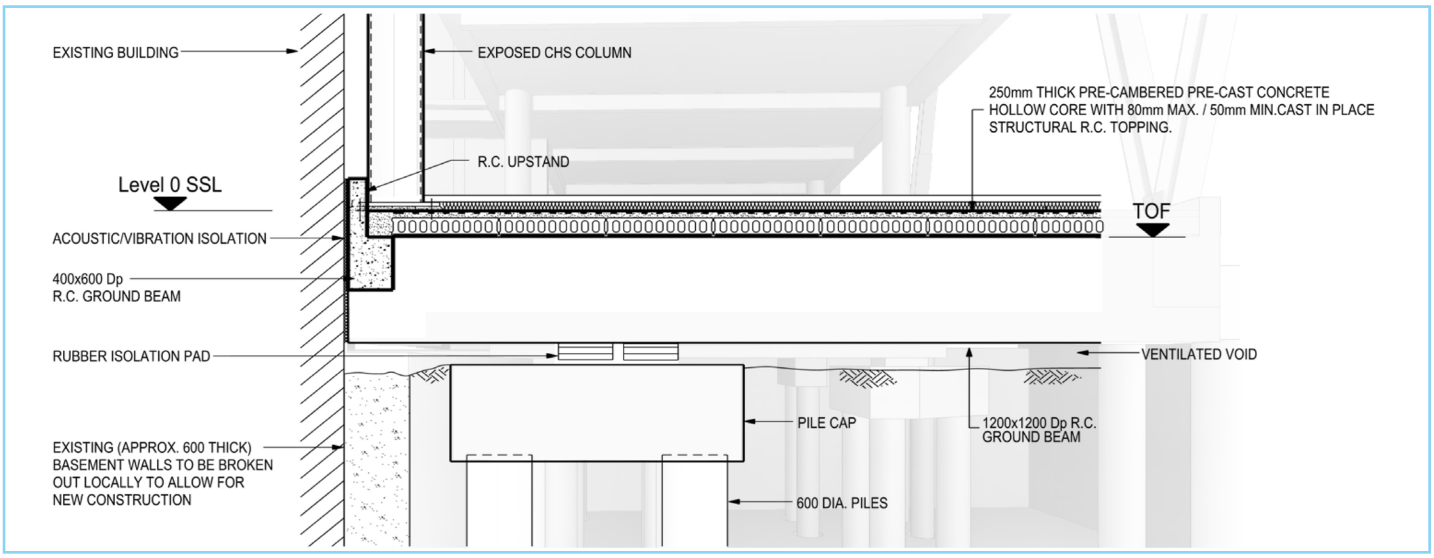

Image courtesy of BDP.

Fig. 2
Typical section of the building, isolation system and foundations.

Fig. 3

The lateral restraint bearing assembly during installation. Care was taken throughout grouting process to avoid air pockets within the grout bed.

For the lift core, which was set at a lower level, where access was restricted once the upper isolated slab was cast, Farrat provided an **Isomat Acoustic Floating Floor system** to be constructed between the bearings to enable a flat slab to be cast where no access was feasible thereafter.

The final stage of the process was for Farrat to provide BDP with all the bearing assembly dimensions and details for them to input into their foundation and structural drawings to ensure accurate setting out.

The majority of the subterranean outer perimeter of the building was in contact with existing, rigid structures either where ground beams were cast up against them or where the ground was back-filled up against it. In order to maintain the isolation performance of the building, **Farrat's Isofoam** perimeter isolation material was used as a resilient acoustic barrier.

Fig. 4

Farrat Natural Rubber Laminated Acoustic Bearing grouted in place with galvanised levelling plate below and galvanised formwork plate above ready for the RC ground beam formwork to be constructed around it.

> "A key principle of the entire design was to optimise the vibration isolation performance and make every detail easy and quick to construct with minimal risk."
>
> **Oliver Farrell**
> CEO & Technical Director, Structural Building Vibration Isolation Systems
> Farrat Isolevel

Fig. 5

Farrat Natural Rubber Laminated Acoustic Bearing supporting and isolating the RC ground beam and the pre-cast concrete ground floor slab.

Fig. 6

Bearing assembly supporting an external V column. Integrated lateral restraints withstand lateral forces from the V column as well as a 150kN force from a potential vehicle impact.

In total Farrat manufactured and supplied **113 Natural Rubber Laminated Acoustic bearings** each with a natural frequencyof 8Hz at working loads.

Every bearing was designed, manufactured and tested up to full SLS load and in accordance with the applicable standard for building isolation bearings BS EN 1337-3 and a test certificate was issued for each bearing. Schedules were provided identifying which bearing, shear key or lateral restraint assembly was to be placed in each location.

Farrat supplied **galvanised steel levelling plates** and **upper formwork plates** enabling the pile caps to be cast with a ±35mm tolerance. Once the bearings were in position they were grouted using a high flow, non-shrink cementitious grout. The high capacity lateral restraint shear keys were also installed in the cores in the same way.

This process enabled Bouygues to construct the bearing installation into the flowing construction process, working from one end of the building to another with pile caps still being cast at one end whilst at the other the pre-cast ground floor was already being installed. Farrat visited the site once per week during the construction process to undertake detailed inspections as well as provide support and advice to the site team.

Fig. 7

50mm thick Farrat Isofoam IS12 was used to laterally separate the isolated building from any surrounding, non-isolated structures.

Key Facts

- Total Buiding SLS Load: 129,400 kN
- 113 Natural Rubber Laminated Acoustic bearings
- Natural frequency of 8Hz at working loads
- Each bearing was tested upto full ULS loads
- Test Certificates issued for each bearing
- Installation schedule for each bearing, shear key and lateral restraint assembly

> **On a quality side, Farrat regularly came to site for reporting, which was instrumental in gaining the client's acceptance.**
>
> **Fabien Roca**
> Civil Works Manager, Bouygues UK

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