Title: AKTII commentary on the 120FS neighbours presentation
Project: 4820 120 Fleet Street
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This document has been prepared by AKTII in their capacity as consulting structural engineers for the above-named project. It is intended to be read in conjunction with the slides entitled *120 Fleet Street Building Movement Monitoring*, which were presented at the Daily Express Building on 17th August 2022.

This commentary provides further explanation and background information to supplement the content of the slides and substitutes for the spoken component of the presentation. Each slide is addressed in turn.

Front cover - introduction:

The presentation has been prepared in response to requests made to have further information on the technical aspects of the building movement monitoring. The presentation covers two distinct forms of *movement* that can be summarised as follows:

Ground movements

These are the long-lasting changes in the movement of the ground. These movements cannot be felt by people but can impact the surrounding infrastructure and buildings. In the case of this project the ground movements predicted are small and so the potential for impact is similarly low. Further detail is provided in the commentary to the slides that follow.

There are two principal sources of ground movements from building work such as this:

- Predominantly vertical movement resulting from the removal and addition of building loads
- Both vertical and horizontal movement resulting from movements in the retaining wall as the soil behind the wall moves in a complementary manner

Vibration

These are the dynamic effects that may result from many sources, including construction activity. These effects can be felt by people if they are of a significant magnitude. At higher levels of intensity vibrations may have the potential to cause cosmetic damage (eg cracking of finishing) and in extreme cases may even cause structural damage.

In the case of this project, threshold levels have been set corresponding to human comfort, which are generally much lower than the levels at which cosmetic damage may occur. Further detail is provided in the commentary to the slides that follow.

It is important to note that noise is not considered to be a structural concern, since it cannot generally pose a risk of damage to primary structure. As such it is covered by separate guidelines related to human comfort. It is not covered further in this structural design note.

Illustrations:

The central image shows the proposed structure viewed from the south-west. The colours are not realistic and only the primary structure is illustrated.

We can see the new steel-framed superstructure and the substructure as if the ground plane were removed. We can see the retained Daily Express Building in the south-west corner of the site.

The existing retaining walls can be seen maintained in place. The existing foundation is largely retained with additional small diameter piles added to provide capacity for the new building massing. More detail is provided in the slides that follow.

Slide 1: Sources of ground movement

This slide is concerned with ground movements as distinct from vibration. It identifies the two major sources of ground movement namely:

- Upward vertical movement from the removal of the existing building loads during demolition and subsequent downward movement due to the new building loads once constructed.
- Vertical and horizontal ground movement resulting from movements in the retaining wall.

Illustrations:

The image on the left shows the existing building profile in grey and the proposed massing outline in red. South is towards the left of the page. We can see that in the south near Poppin's Court, the proposed building massing is similar to the existing. With loads largely balanced, the net vertical ground movement beyond the site will be small, with the initial upward movement from demolition balanced by the subsequent downward movement due to the weight of the new building. In the south the existing raft can be re-used, with only a few small diameter (c.450mm) piles being added to support the increased load under the south core.

As the building rises to the north the existing foundation can no longer support the new, increased building loads and piles are added to control settlements. We can see these piles in the cover image (they are not shown on this illustrative section).

The image on the right shows a diagrammatic section cut east-west through the northern portion of the building. We can see that the existing retaining wall retained. In the temporary condition the wall is propped by stiff raking props to control movement and in the proposed condition new structure is added to largely replicate the existing support condition. The floors are demolished and rebuilt to allow the levels to be subtly altered to suit the use of the space. Only very small retaining wall movements are predicted and so the resulting ground movements behind the wall are also predicted to be small.

Slide 2: Geotechnical analysis

Ground movement assessments have been undertaken by AKTII using finite element analysis. This has allowed us to predict anticipated ground movements resulting from the change in building loads and retaining wall movement.

Illustrations:

The three sections on the left show a typical basement retaining wall in the existing, temporary (demolition) phase and proposed condition. We can see that the propping arrangement, which largely determines the ground movement, remains similar throughout. Note the blue arrows indicate propping locations in the temporary condition.

The image top right shows one stage within our finite element analysis. The image bottom right shows the field of predicted ground movements behind the retaining wall on plan, with these being generally less than 5mm towards the south of the site. This degree of movement is very small.

Slide 3: Monitoring methodology

Having undertaken analysis to predict movements, a system of monitoring is then implemented to check that the measured movements correspond with expectations. A series of reflective *targets* are attached to the surrounding buildings, which can then be monitored using a *total station* to record movements about three axes. These targets are located over the height of the building façade in a regular pattern, which allows vertical & horizontal movements to be determined in addition to tilt.

The retaining wall itself is also monitored for movement using a similar system. Further to this, the level of the basement raft is monitored throughout construction. The three sets of movements can be checked for correspondence. It is worth noting that buildings will experience movement due to effects beyond ground movement, most notably thermal expansion and contraction. These will be independent from any ground movement and will need to be corrected for.

Measurements are initially taken over a 4-week period prior to works commencing in order to set a *baseline*. Thereafter movements are measured weekly, with the option to increase frequency if necessary. Movements are checked against pre-defined *trigger levels* based on predictions, which are explained further in the slide that follows. A report is produced by the surveyor to present the data, which is then reviewed by AKTII and the Contractor.

Accuracy of the surveying equipment is +/-1mm. Depending on the specific method of surveying there may also be transfer errors that need to be considered. In practice, an assumed overall accuracy of +/-2mm is typically reasonable. We should therefore expect to see some *noise* in the movement monitoring week to week. The baseline data helps set expectations in this regard.

Illustrations:

The image far left shows an example of targets on one portion of the surrounding buildings. The adjacent image shows a typical *total station*.

The image top right shows monitoring locations through the height of the retaining wall. These arrays are located at multiple positions all around the perimeter.

The image bottom right shows the locations of monitoring target arrays on the surrounding buildings. Note that at each location multiple targets are positioned throughout the height of the façade.

Slide 4: Anticipated movements, data collection and trigger levels

This slide describes the general pattern of predicted ground movement together with an example of monitoring output and a description of the *trigger levels*. It must be noted that the movements indicated in the images are drastically exaggerated for clarity of illustration.

Illustrations:

The images across the top of the slide show diagrammatically the general pattern of ground movement expected from each source in an exaggerated manner.

The first two images show predominantly vertical movement from the unloading and reloading of the ground due to demolition and construction of the new building. These movements are largest under the new building itself and reduce rapidly as we move away. Given the nature of the proposals as described above, these components of movement are anticipated to be very small.

The image top right shows the more complicated pattern from retaining wall movement. Here there is both vertical and horizontal movement. Again, movements generally reduce with distance away from the site but given the profile of the retaining wall movement, there can be a *trough* of maximum movement a little distance behind the wall.

The graph bottom left shows typical monitoring output for one array of targets. Note the initial noise during the baseline period due to the inherent accuracy of measurement and thermal effects.

The table bottom left describes the actions related to different *trigger* levels. It is worth noting that even at the red trigger level no structural damage to surrounding buildings is predicted. These limits are set to correspond with predicted movements in this instance.

Slide 5: Vibration levels

This slide moves on to consider vibration as distinct from ground movement.

There are a number of construction activities that have the potential to cause vibration. The level of vibration generated will generally be determined by the specific method of construction activity that is adopted. In contrast to ground movements, it is more difficult to make explicit predictions relating to vibration based on calculations. More reliance is therefore placed on following best practice, with monitoring undertaken to ensure that the method adopted conforms to limits.

Various aspects of this particular project help to mitigate the risk of vibration as summarised below:

- **Demolition of the superstructure:** In general, steel framed buildings such as this permit demolition with a lower risk of vibration. The methods employed by the Contractor will follow best practice to minimise vibration from demolition arisings.
- **Demolition in the basement:** In the basement, low vibration demolition methods are being used as far as possible including diamond-tipped coring to form the openings through the basement structure required to construct the new piles and specialist hydro-demolition to remove portions of the raft and prepare interfaces between new and existing.
- **Piling activities:** The piles for the project are anticipated to be constructed using a continuous flight auger (CFA) technique. This reduces the potential for vibration compared with conventional bored piling technique. Conventional rigs need to *clear* the segmental auger of soil when they are withdrawn, which often results in a knocking of the rig to shake the material free. CFA rigs do not require this operation and so inherently generate less vibration and indeed less noise. The rigs that will be used here are at the smaller end of the available range.
- **Vehicle movements:** These will be carefully controlled by the Contractor.

On this project we are using a series of vibration measuring devices (called transducers or accelerometers), with three located immediately adjacent to the site near the *source* and one within the basement of the neighbouring buildings across Poppin's Court.

In general, people are much more sensitive to vibration than building structures. The *trigger levels* for vibration are set to levels aligned with human comfort in accordance with local authority recommendations. It is noted that according to even the most conservative guidance documents, the level of vibration considered to pose a risk of cosmetic damage to building fabric is at least five times than the red trigger level set on this project. The level at which structural damage may occur is much higher still.

Illustrations:

The image on the left of the slide explains diagrammatically the typical path of vibration transmission in the case of typical building works. Being conducted through the ground, this type of vibration is known as *ground-borne* vibration. These ground-borne vibrations travel as waves of different sorts.

In general, the strength of vibrations will reduce as we move away from the source, as a result of the energy in the vibration being absorbed by the ground. There is however the potential for *resonance* effects to occur, when the frequency of the vibration matches the natural frequency of the structure being affected. In such instances a limited amplification effect can occur. The orange circles show indicatively the location within this pathway that vibration is being monitored on this project.

The charts on the right-hand side show the red trigger level based on human comfort compared with the much higher levels of vibration (shown in green) that are considered to represent a conservative threshold for cosmetic damage of building fabric. Intermittent and continuous vibration are considered separately, with continuous vibration generally adopting lower threshold values.