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Discussion: The effect of ground movements on rigid masonry facades

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ABSTRACT: In a contribution to the symposium, Mr J Standing presented measured displacements of the Treasury Building in London caused by excavation of the Jubilee Line tunnels. He showed that although the structure had rotated significantly, this was solid body movement and distortion and damage were minimal. The writers are concerned that results such as these, on this building or others, may not be wrongly interpreted to mean that the onset of serious damage is remote.

Simpson (1994) published the results of finite element computations of deformation of Britannic House, the headquarters of British Petroleum in London, due to the planned excavation of the Liverpool Street Station of CrossRail. This structure had facades of limestone backed by brick with an internal steel frame. Some of the floors, on some facades, were of modern reinforced concrete construction and were tied into the facades. Greenfield deformations, computed from Gauss curves, were transmitted to the base of the structure through a special layer of elements. This was designed to represent the ground within the zone of influence of the foundations and provided a cushion between the greenfield deformations and the stiff response of the structure.

The computations indicated that the facades would probably rotate without distortion or damage from modest ground movement due to tunnelling. However, as the ground movement became larger, computed damage accelerated very rapidly. Where the facades were tied to reinforced concrete floors, cracks would tend to be numerous and fairly small, but where there was no such reinforcing effect, cracks might be few and large.

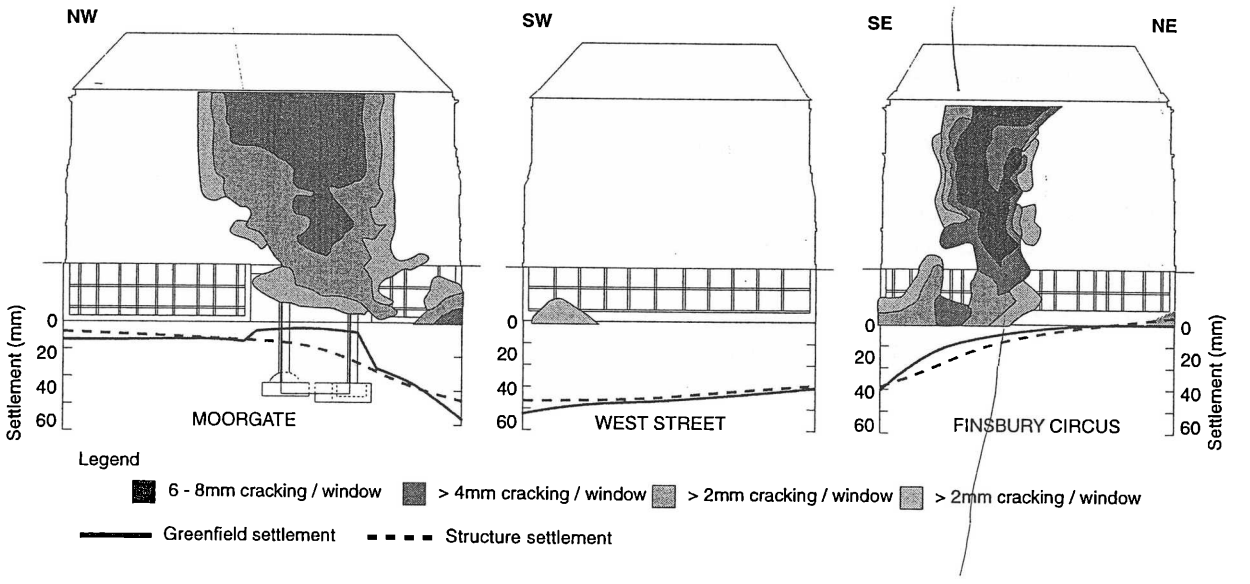

Fig. 1. Computed cracking of the facades

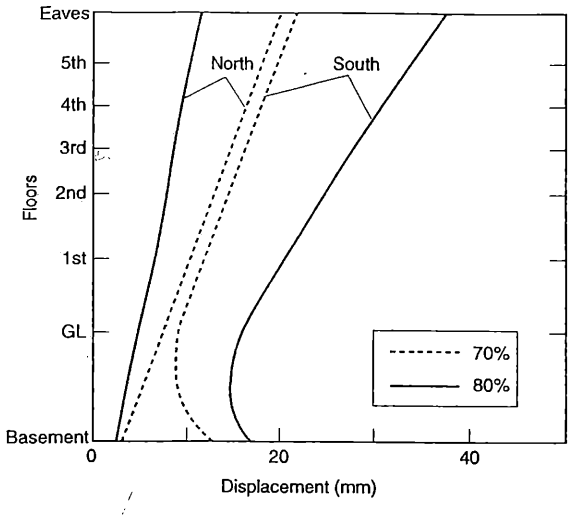

Fig. 2. Horizontal displacements of ends facade

Figure 1 shows the computed displacements and degree of damage for three facades, expressed as crackwidth per window bay. Before cracking, the stiff facades smooth out the greenfield settlements to become linear. However, the stiffnesses of the facades reduce markedly when they have cracked.

Figure 2 shows the development of horizontal displacement and tilt at the north and south ends of the Moorgate facade. When 70% of the ground displacement had been applied, the facade was still behaving in an semi-elastic manner and strains were very small; cracking was computed at the base of the facade but it had not yet extended to the top. Thus the displacements at the ends of the facade were almost identical. However, as the next 10% of ground displacement was imposed, the cracks reached the full height of the facade and it started to move in two distinct sections. This can be seen by the large difference in horizontal displacement and tilt of the north and south ends.

The Moorgate facade was subject to particularly severe ground displacements because of local deep (and stiff) foundations located near its centre. Nevertheless, similar behaviour was predicted for the Finsbury Circus facade, which had the disadvantage of an absence of reinforced floor at high level near its centre.

Although the model of the structure was inevitably simplistic, it gives a warning that comfort cannot necessarily be drawn from measurements which show negligible distortion of masonry facades. Severe damage might occur suddenly in brittle structures. The changes of stiffness which may occur as cracking takes place should be considered when using the results of analyses such as those presented by Potts and Addenbrooke (1996).

References

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