

9 FOUNDATIONS

9.1 GENERAL

This section considers only the effects of external forces on foundations. The effects of deterioration of materials are dealt with in the relevant sections of those materials.

9.2 SETTLEMENT

Detecting settlement of foundations is not difficult because it will normally be self evident. The superstructure will be out of line and expansion joints may have opened or closed. If differential settlement has occurred at a support, the superstructure may also be warped, and the pier or abutment may show other distress such as cracking, particularly in piles.

If settlement has been observed, it is desirable to determine whether it is continuing, and at what rate. Precision levelling over a period may be required for this.

Some causes of settlement are:

(a) Compressible Layer

Settlement is often caused by a compressible layer such as clay or peat beneath the foundation or adjacent embankment. Increase in pressure in this layer due to the weight of the bridge and approaches causes consolidation of the material, and settlement of the structure. If this is suspected, it can be verified by drilling and determination of the material properties.

(b) Downdrag

If settlement due to a compressible layer occurs as described above, and if a pile group penetrates the compressible layer, the settlement will induce downdrag forces on the lengths of piles above the layer. On end-bearing piles this may be sufficient to cause crushing of the base material or buckling of the piles. On friction piles the forces may lead to settlement by additional penetration.

(c) Scour or Bed Degradation

Scour during a specific flood or floods induces settlement by reducing the foundation embedment for a short time. Bed degradation over a period of years may have had the same

effect. In either case, the overall safety factor of the foundation is likely to be unacceptably low.

Scour to a critical level during major floods may be suspected even though there may be no visible permanent effects. Verification of this by direct measurements during floods is difficult, as this involves being there at the right time with the necessary equipment, but there are methods of installing instrumentation to record scour automatically.

A frequent problem where critical scour is suspected is that the exact pile lengths may not be known, so that even if scour can be measured, the margin of safety is not known. Some success has been achieved in deducing pile lengths by measuring the ground resistivity between the pile and an electrode at various levels in a hole drilled alongside it. Knowing the pile length and characteristics of the bed material, the safety margin can then be estimated.

If a pier or abutment has settled, it is unlikely that it can be re-levelled, but the superstructure can probably be restored by jacking up and packing under the bearings. Before this is done, the settlement should be halted, and obviously it is necessary to determine why it is happening. The usual remedy is to underpin the structure by driving extra piles and enlarging the pile cap to accommodate them.

See also Sections 6, 10 and 11.

9.3 PILE DEFORMATION

Abutment piles may deform because of horizontal movement accompanying loading of the ground beneath an embankment. In an extreme case this can result in plastic hinging in the piles. Such movement is most likely where there is a single row of piles in a line. It will probably show up as displacement and rotation of the abutment, and closing up of the expansion joint.

If piles are seriously deformed by ground movements, further movement can be prevented by tying back to a deadman anchor or by underpinning using raking piles, but it is unlikely the structure can be restored to its original position. It may also be possible to reduce the load from the embankment by replacing some of the fill with lightweight

material. If this is placed behind the abutment backwall, and a settlement slab is placed above it, there may be some minor relaxation of the displaced abutment back towards its original position.

See also Section 11.

9.4 ABRASION OF PILES OR CYLINDERS

Foundations in gravel-bedded rivers with high-velocity flow may be subject to abrasion at bed level and below. Detection may require divers or remote TV, but should be carried out during a Detailed Inspection. If abrasion is significant, the effective cover remaining should be verified by measurement or by use of a covermeter.

A remedy for abrasion is to jacket the piles with reinforced concrete. There are proprietary sleeves available to use as formwork, and the recommended method of placing the concrete is to use pre-placed aggregate and then grout it.



Figure 9.1: Abrasion of concrete pile cap.

9.5 BIBLIOGRAPHY

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