THE USE OF GROUND ANCHORAGES IN WATERFRONT STRUCTURES

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Presented at the International Shipping and Marine Technology Market with Congress, Hamburg, 29 September to 3 October 1992

Ground anchorages have, in the United Kingdom, been used extensively for the retention of waterfront structures for well in excess of twenty years. They have been incorporated in completely new berths, to retain sheet piles, diaphragm walls, and other retaining structures. (see cover photographs of new tanker berth on Manchester Ship Canal (1975) and of Newcastle-on-Tyne (1989). They have been installed through numerous existing walls of masonry, of concrete or of steel in order to allow increased dredge depth and uprate the wharf shipping capacity. In some locations where the harbours have either become tidal or non-tidal the changes in quay loading have also been accommodated by the tensile capacity of ground anchorages (Aberdeen 1969 to 1974).

Along the eastern coast of Britain in order to compensate for on-going ground settlement and progressive elevation of the levels of astronomical tides, a number of tidal barriers were constructed between 1978 and 1981. These works required the installation of several thousand ground anchorages at the barriers themselves (Hull and Ipswich – see Photo 3) and throughout the downstream areas where the bank levels required raising (London and Ipswich).

The construction of dry docks lends itself particularly to the use of vertical anchorages to resist hydrostatic uplift, the common locations being naval dockyards at Devonport, Faslane and Rosyth. Vertical or off vertical anchorages are also ideal for providing resistance to overturning of off-shore berthing dolphins. Either active or passive ground anchorages installed through the supporting piles have been satisfactorily used in several instances (Heysham, Holyhead and Jarrow - photo 4) and in some cases, replaced after severe ship collision impact.

Whatever the intended purpose of the ground anchorage in waterfront structures they are generally installed in areas which subject any exposed steel to extensive corrosion in the highly aggressive environment (Aberdeen – photo 5). For this reason all steel components of the working anchorages incorporated in the construction must be totally protected such that the corrosive elements cannot make direct contact with the steel (Aberdeen - photo 6). Anchorages installed in the late sixties and early seventies conformed with the state of the art at that time and were generally installed with "single corrosion protection" and have in the majority of cases adequately protected the anchorage steels against corrosion. During the late seventies more and more attention was being given to the potential corrosion of the steel and the draft British Code of Practice (DD81) laid down the requirements of "double corrosion protection" of anchorage steels. A number of alternatives were possible but the author elected to research a system in which the entire fixed length and free length of the steel tendon was surrounded by two layers of plastic in addition to the cementitious anchorage grout in the fixed length and the grease lubricant in the free length. Thus, since 1980 steel anchorage tendons fabricated under factory conditions with two surrounding and overlapping layers of plastic ducting or sheathing have been available in the U.K. civil engineering industry (photo 7 and Figure 1). They are particularly appropriate for use in the aggressive areas of the marine environment and they fully conform with the requirements of
current documents such in BS 8081 (British Code of Practice) and in 4125 (German Code of Practice). The anchorage head areas which are equally vulnerable to corrosion are encapsulated by seals and resins, or contained within grease filled steel or glass reinforced plastic caps (Photos 5 and 6).

With regard to the testing of ground anchorages the normal proof loading requirements of every working anchorage demands the attainment of 150% of working load and the ability to maintain that test load. The elastic behaviour of the tendon throughout this load cycle must conform with that calculated from elastic properties. Furthermore tests are required at working load over an adequate period to ensure that any reduction in load is not indicative of unacceptable long term creep losses which may jeopardise the structural stability. These test requirements make ground anchorages probably the most severely tested component in the civil engineering industry prior to their incorporation in the works. This can ensure complete confidence in their use.

Ground Anchorages for the retention of waterfront structures are economic, safe and well proven. The problems associated with corrosion have been fully addressed and the prefabricated anchorage tendons offer protective measures far outweighing those provided by other alternative tensile members. All anchorages are severely load tested prior to their incorporation in the works to confirm their load carrying capacities and loading characteristics. Many hundreds of safety anchored waterfronts exist in the United Kingdom (photo 8) including several miles of seawall downstream of the London Thames Barrier.

Some Anchored Quay Wall Locations in the United Kingdom

Inverness, Fraserborough, Peterhead, Aberdeen, Montrose, Leith, Newcastle, Sunderland, Hull, Boston, Great Yarmouth, Lowestoft, Ipswich, Felixstowe, Tilbury, Grays, Gravesend, Greenwich, Chatham, Newhaven, Shoreham, Portsmouth, Southampton, Plymouth, Teignmouth, Exmouth, Newquay, Bristol, Gloucester, Newport, Holyhead, Liverpool, Manchester, Glasgow, Oban. (Places such as Aberdeen and Great Yarmouth have more than a dozen anchored wall areas).

Fig 1 Keller Colcrete Double Protected Anchor with Two Layers of Plastic.
Photo 1 New Tanker Berth on Manchester Ship Canal.

Photo 2. Anchored sheet pile wall at Newcastle-upon-Tyne
Photo 3. Installation of permanent Ground Anchorages founded on sands and gravels at Ipswich Tidal Barrier (1978)

Photo 4. Tendon Installation for 30m long 1700kN working load dolpohin anchorages at Jarrow (1983)
Photo 5. A row of ground anchor caps in the mid-tidal range in Aberdeen. They have been exposed to this aggressive marine environment since installation in 1977.

Photo 6. Removal of the protecting grease filled anchor cap exposes fresh, bright steel prestressing components with no sign of corrosion (1991)
Photo 7. Prefabricated anchor tendons with two layers of plastic sheathing or ducting protecting the steel against corrosion (Isle of Dogs 1983)

Photo 8. Permanent anchorages resist lateral loading on a new waterfront structure (1976)