# CHAPTER 1
# INTRODUCTION

The purpose of this document is to provide engineering guidelines for ground improvement for the U.S. Army Corps of Engineers' structures and facilities. It includes essential elements needed for (1) general evaluation of site and soil conditions, (2) selection of improvement methods, (3) preliminary cost estimating, (4) design, (5) construction and (6) performance evaluation for ground improvement. The facilities covered include dams and their appurtenant structures, levees, locks, waterways, structures and tanks, dredged material containment structures, airfields, roadways, buildings, and other special-purpose structures.

The focus of the document is on practical application of recent and rapidly developing methods of ground improvement. Ground improvement for both new and existing structures and facilities is considered. Ground modification for seismic remediation and for correction of hydraulic deficiencies of existing dams and levees are major considerations because of the current COE emphasis on these projects.

There is special focus on how to select, design, specify, and evaluate ground improvement for specific purposes. Guidelines are given for determination if ground improvement is necessary, the level of improvement needed, the magnitude of improvement attainable by different methods, the required depth and areal extent of treatment, configuration of treatment zones, and methods for assessing the effectiveness of treatment. Methods for analysis of stability and deformation under static and dynamic loading are outlined.

Many potential applications of ground improvement for structures are given in Table 1. The table is organized according to types of facilities and their components. Levees are included as a separate category because, while they are similar in some ways to dams, many levees have been constructed of poor quality materials, without careful design or construction control, and in stages over long periods of time.

Although this document contains recommendations, flow charts, and suggested procedures, it is not intended to be a design manual. Rather, its purposes are to identify key considerations for use of ground improvement, to suggest logical paths forward in a project, to provide guidance for design and construction, and to identify sources of useful information.

**Table 1 - Potential Applications Of Ground Improvement Methods In Structures**

| Type Of Facility | Component | Potential Application |
|---|---|---|
| Embankment Dams | Dam | • Increase resistance to liquefaction, cracking, deformation and/or differential settlement<br>• Mitigate effects of excess deformation or differential settlement<br>• Improve seepage barriers<br>• Reduce settlement<br>• Strengthen and/or seal interface between embankment and foundation or abutments<br>• Stabilize dispersive clays<br>• Increase erosion resistance to overtopping |
| | Abutments | • Reduce movements due to seismic activity<br>• Reduce or eliminate seepage through joints or cracks in abutments<br>• Strengthen and/or seal interface between abutment and embankment |
| | Foundation | • Increase resistance to liquefaction<br>• Reduce movements due to settlement, solution cavities or seismic activity<br>• Reduce settlement<br>• Improve seepage barriers<br>• Stabilize collapsing or expansive soils<br>• Strengthen and/or seal interface between embankment and foundation |
| Levees | Levee | • Increase resistance to liquefaction, cracking, deformation and/or differential settlement<br>• Improve seepage barriers<br>• Reduce settlement<br>• Stabilize dispersive clays |
| | Foundation | • Increase resistance to liquefaction<br>• Reduce settlement<br>• Improve seepage barriers<br>• Stabilize dispersive, collapsing, or expansive soils |

Table 1 (cont.) - **Potential Applications Of Ground Improvement Methods In Structures**

| Type Of Facility | Component | Potential Application |
|---|---|---|
| Concrete or Masonry Dams | Abutments | • Reduce movements due to seismic activity<br>• Reduce leakage through joints or cracks |
| | Foundation | • Increase liquefaction resistance<br>• Reduce movements due to consolidation settlement, solution cavities or seismic activity<br>• Improve seepage barriers<br>• Stabilize dispersive, collapsing, or expansive soils |
| Appurtenant Structures to Dams | Spillway | • Improving erosion resistance of dam to overtopping<br>• Increase resistance to erosion or undermining of spillway |
| | Outlet Works | • Stabilize the foundation for gates, valves or hoists that have experienced differential settlement<br>• Seal leaking conduits, reduce piping along conduits |
| | Stilling Basin | • Increase erosion resistance |
| | Piping | • Limit differential settlement to prevent joint separation, structural cracking and/or piping |
| Locks | Chamber | • Increase resistance to liquefaction, cracking, deformation and/or differential settlement<br>• In support of reducing leakage through cracks<br>• In support of reducing seepage to decrease water losses during periods of low water<br>• Reduce movement due to settlement, solution cavities or seismic activity |
| | Foundation | • Increase resistance to liquefaction<br>• Reduce movement due to settlement, solution cavities or seismic activity<br>• Reduce settlement<br>• Reduce leakage through cracks |

**Table 1 (cont.) - Potential Applications Of Ground Improvement Methods In Structures**

| Type Of Facility | Component | Potential Application |
|---|---|---|
| Locks | Gates and Valves | • Stabilize the foundation for gates, valves or hoists that have experienced differential settlement<br>• In support of sealing leaking conduits, reducing piping along conduits |
| Waterways | Canals, Lock Approach or Flood Control Channels | • Stabilize expansive soils, collapsing soils or dispersive clays<br>• Disposal and containment of dredged material<br>• Improve stability of slopes<br>• Linings of stabilized soil |
| | Harbors | • Disposal and containment of dredged material<br>• Improve stability of underwater slopes<br>• Provide support and stability for quay walls<br>• Prevent lateral spreading<br>• Improve stability of breakwaters and their foundations |
| Other Structures (Buildings, Walls, Tanks) | Shallow Foundations (Footings, Mats) | • Increase resistance to liquefaction<br>• Increase resistance to cracking, deformation and/or differential settlement<br>• Reduce movement due to settlement, solution cavities or seismic activity<br>• Stabilization of collapsing or expansive soils |
| | Deep Foundations (Piles, Piers, Caissons) | • Increase resistance to liquefaction to prevent loss of lateral support during seismic activity |
| | Underground Tanks | • Increase resistance to liquefaction to minimize loss of support or flotation of tanks |
| Dredged Material Disposal | Containment Structure | • Consolidation of compressible strata beneath containment area<br>• Improve properties of poor foundation materials<br>• Reduce settlement of containment dikes<br>• Provide containment barriers for pollutants |