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Effects of Soil Information on Economics of Jackup Installation

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Abstract

The authors address economic impact of quality and availability of site soil information on safe jackup installation. Preload operations based on sufficient and on limited (or insufficient) soil data are analyzed. Reliability and applicability of a variety of soil information sources are discussed.

Preloading

In order to prevent jackup settlement during drilling or during storm conditions, the jackup unit is preloaded during the initial stages of the installation procedure. The preloading of a three leg unit is normally performed by elevating up to a 3-5 feet air gap. Ballast water is then gradually added to preload tanks until the weight of the unit loads the soil under the spud cans to a level equal to or in excess of the anticipated spud can loads for the design storm conditions. During the preload process, increasing rig weight usually causes the legs to penetrate deeper until the bearing capcity of the soil becomes equal to or greater than the spud cans loads. One of the main potential problems during preloading is a sudden uncontrolled leg penetration caused by (a) a spud can punching through the stronger soil layer into the underlying weaker soil, or (b) by unit leaning instability in uniform soft clays.

The results of uncontrolled penetrations can be disastrous. There are some preloading strategies that can lessen or even eliminate the magnitude of uncontrolled penetrations and reduce the possibility of rig leg damage. One strategy is to preload at zero air gap (also termed "preloading in the water"). As preload is applied and the spud cans penetrate into the soil, the rig draft increases. However, to achieve full preload, the draft of the rig hull typically must be limited to about 2 feet. At drafts greater than this, the buoyancy of the hull will not allow full spud can loading. As shown on the Fig. 1, this procedure can significantly reduce the potential peak value of the soil loading during punch through, and resulting differential leg penetrations.

Another strategy to lessen the magnitude of uncontrolled penetrations is to sequentially preload each leg of the rig. Because the total weight of the rig is reduced, the load during the punch through is also reduced. Also, the other legs, due to lower load can be jacked during a punch through to lessen the out-of-level condition of the rig, and lessen the load increase on the punch through leg. When this procedure is used together with zero air gap, dramatic reductions in spud can loading during punch through can be achieved, as illustrated in Fig. 2.

SUBSURFACE INFORMATION AND MODU SITE ASSESSEMENT

To plan preloading operations, expected rig foundation performance should be evaluated. This information requires subsurface soil data including soil stratigraphy and engineering properties. The following information is typically gathered to assess MODU foundation stability:

- Geological information for the area, to understand physical environment.
- Site bathymetric data, to provide accurate water depth and seabed topography.
- Site high resolution geophysical shallow seismic data, to determine near surface soil stratigraphy and presence of shallow gas. (The geophysical data by themselves do not provide quantitative data on soil strength.)
- Site side scan sonar data, to identify obstructions and seabed features.
- Geotechnical data from the shallow seabed coring (3 to 10 feet cores) in the area.
- Jackup installation data for the area
- Site geotechnical soil boring data at the proposed site, (typically about 100-ft deep).

In most cases, only part of the above data is available for a desktop study. The authors have asked experienced offshore geotechnical engineers from several companies to rate reliability of different data often available for desktop studies. All of these engineers perform assessments of jackup foundation stability on regular basis. Their answers are summarized in Table 1. The table illustrates that different sets of site data are considered to have different degrees of reliability for MODU foundation analysis, and that a site specific geotechnical soil boring provides the most reliable data, especially for assessment of the potential for uncontrolled leg penetrations during preloading.

A typical process of jackup foundation evaluation is presented in Fig. 4. The flowchart illustrates two approaches to planning safe rig preloading: (a) planning based on sufficiently reliable site data where, in the absence of a punch through potential, preloading is typically performed at a 5-ft air gap, and (b) planning based on insufficient soil data which does not rule out the risk of punch through, dicating that preloading should take place in the water with sequential preloading of each leg.

ECONOMICS OF PRELOADING

It is typically accepted in the industry to preload jackups at a 5-foot air gap when no reasonable risk of punch through is deemed to exist. A safe and prudent operator will reduce this air gap to nil if the punch through potential exists or if the subsurface conditions are unknown. At potential punch through locations, when the soil conditions are known, the operator will preload at zero air gap or in the water, only at the critical spud can penetrations, returning to a 5-foot air gap after the dangerous zone has been penetrated.

It could be argued that the simplest approach would be to preload assuming punch through potential at the locations with unknown soil conditions. However, preloading at zero air gap dramatically increases the time to preload due to the necessity of dumping preload ballast more frequently. This significantly increases the number of load and dump preload cycles required to fully preload the rig. For a typical Gulf of Mexico soil, and a typical Marathon Letourneau 116C rig (initial penetration - 60 feet, final penetration – 90 feet), preloading at 5 feet air gap will require about 30 to 45 hours, which is about a third of the time and a third of the preloading cycles required to preload the same unit at zero air gap, assuming ideal weather conditions. Additionally, preloading at zero air gap places tighter limits on allowable wind, tide, and sea conditions under which the MODU can conduct preloading operations.

CONCLUSIONS

Safe preloading in the absence of sufficient site soil information generally results in a lengthy preloading process and therefore higher installation costs. The time to preload can be significantly reduced if sufficient soil information is available.

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Table I COMPARATIVE RELIABILITY OFSOURCES OF GEOTECHNICAL SITE INFORMATION FOR JACK UP MODU STABILITY ASSESSMENT

(Rated 1 to 10, By Experienced Practicing Offshore Geotechnical Engineers)

Sources of Information	DATA RELIABILITY For Assessment of Maximum Leg Penetrations	DATA RELIABILITY For Assessment of Punch Through Potential
Site Specific Soil Boring	10	10
Geophysical High Resolution Site Survey Combined with 1-m to 3-m Cores (Typical in Geohazard Site Surveys)	2 to 4	1 to 2
A Soil Boring (100+ ft) Within 5 miles Radius	2 to 5	1 to 2
Several Soil Borings (100+ ft) Within 5 miles Radius	4 to 6	2 to 5
A Soil Boring (100+ ft) Within 5 miles Radius and High Resolution Site Survey Combined with 1-m to 3-m Cores	4 to 7	3 to 5
Several Reported MODU Penetrations Within 5 Miles Radius	4 to 6	2 to 5
Several Reported MODU Penetrations and Several Soil Borings Within 5 Miles Radius	5 to 7	4 to 6
Reported on site Penetrations For Identical MODU (Workover Site)	9 to 10	6 to 10
Reported On Site Penetrations For Different MODU (Workover Site)	6 to 8	5 to 7

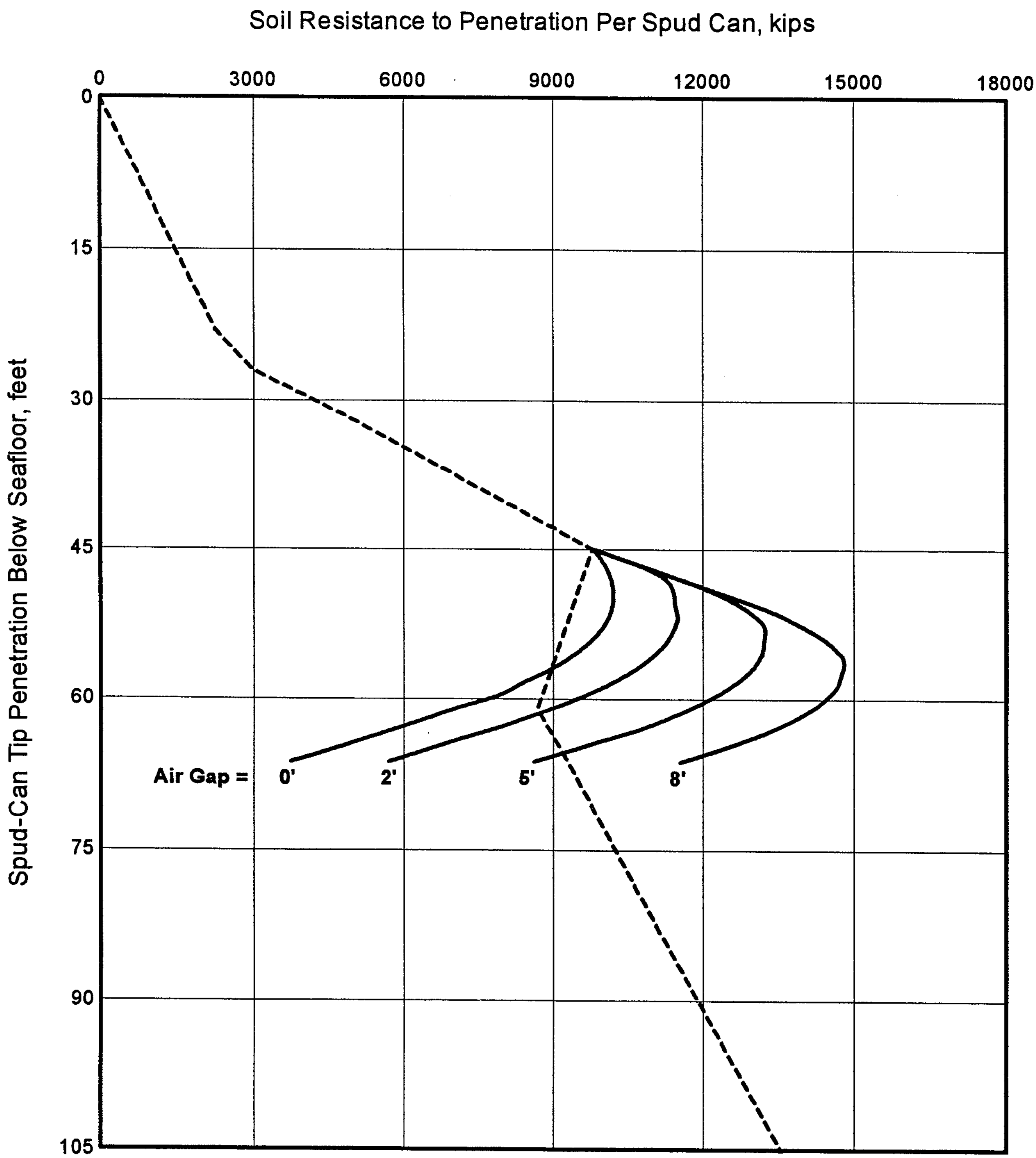

FIGURE 1. LEG PUNCH THROUGH AT DIFFERENT AIR GAP
Water Depth 300 feet
MODU: Marathon LeTourneau Design, Class 116C
Simultaneous Preloading

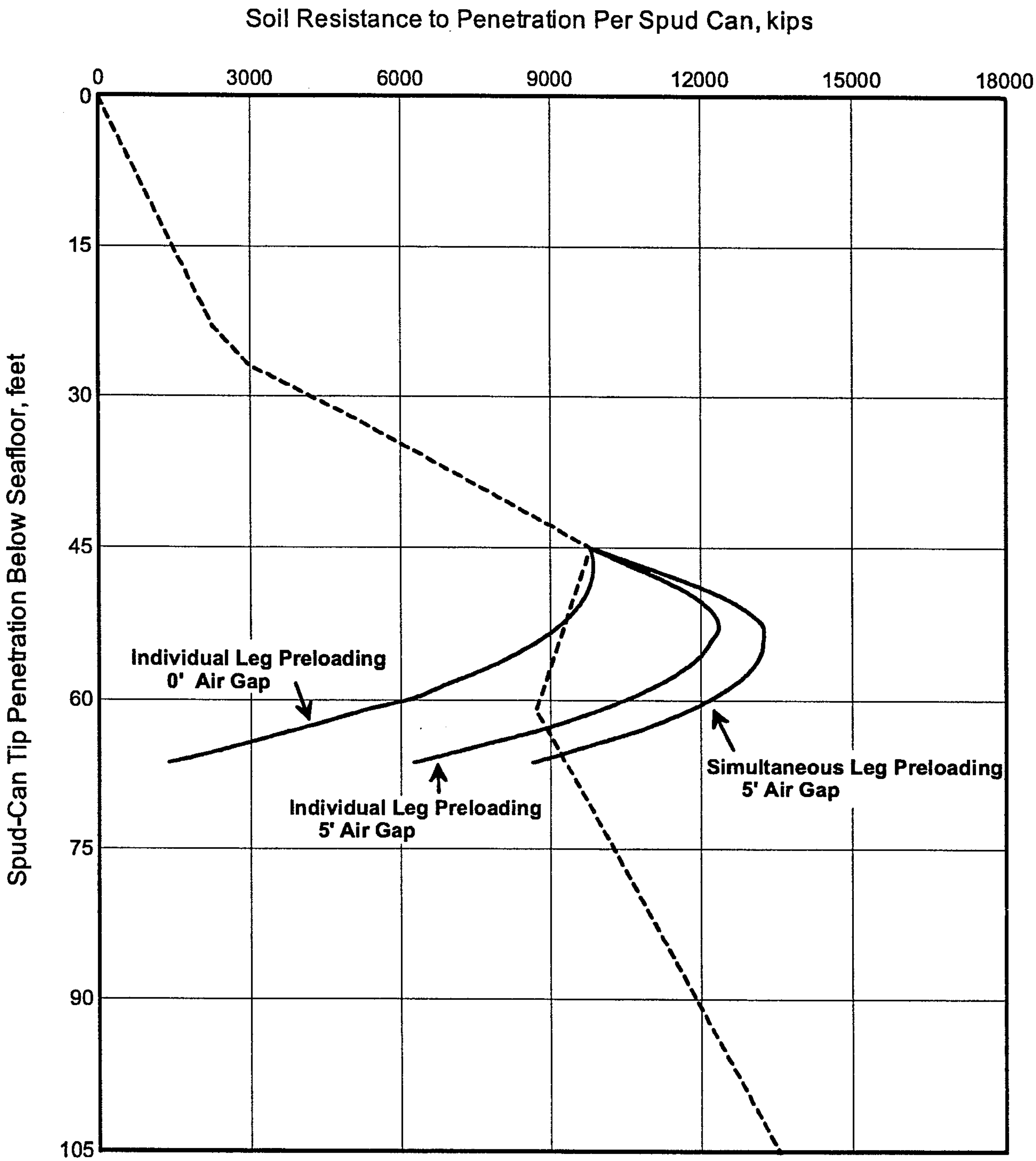

FIGURE 2. LEG PUNCH THROUGH AT SIMULTANEOUS AND INDIVIDUAL LEG PRELOADS
Water Depth 300 feet
MODU: Marathon LeTourneau Design, Class 116C

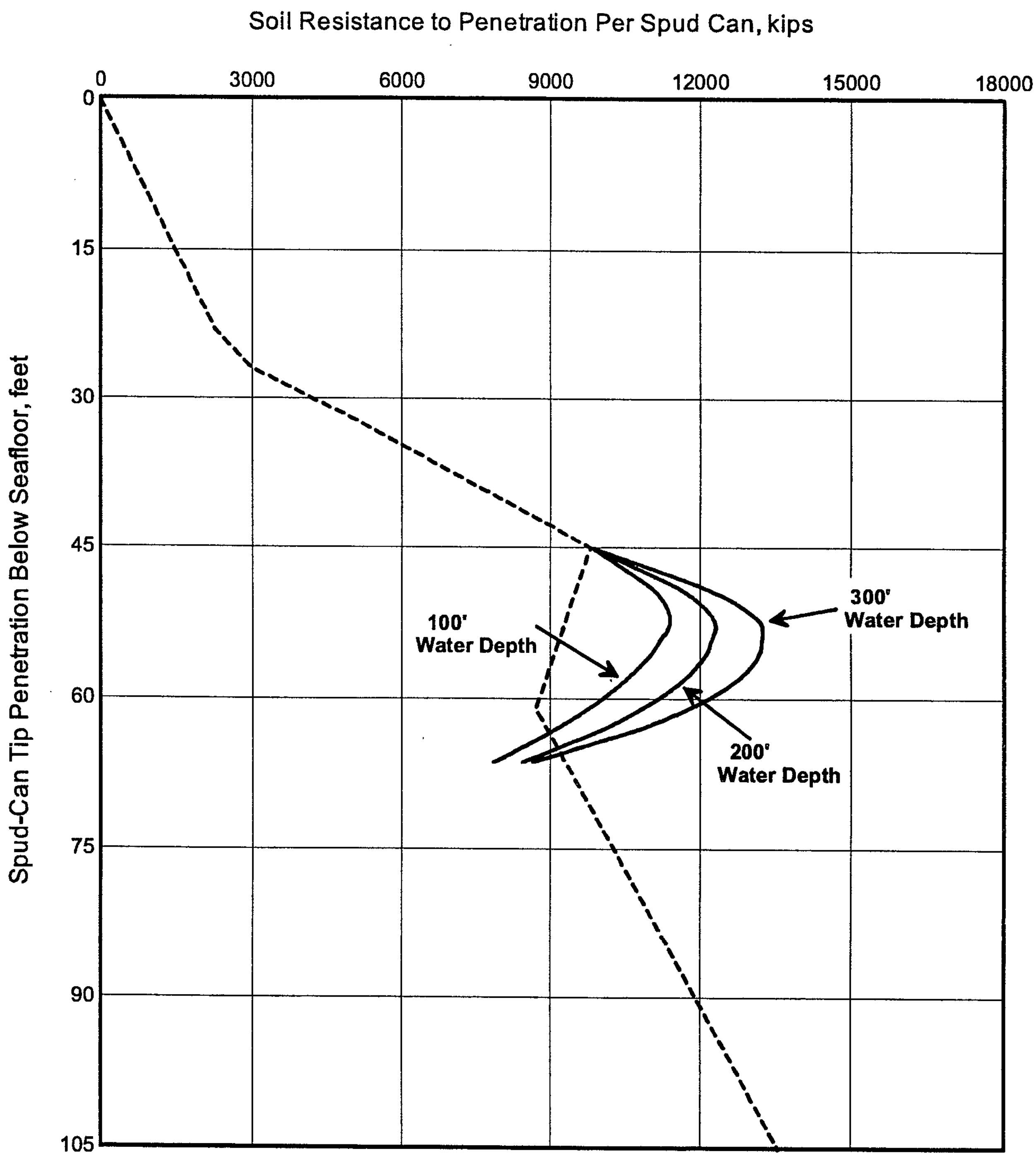

FIGURE 3. LEG PUNCH THROUGH AT DIFFERENT WATER DEPTH
Air Gap 5 feet
MODU: Marathon LeTourneau Design, Class 116C
Simultaneous Preloading

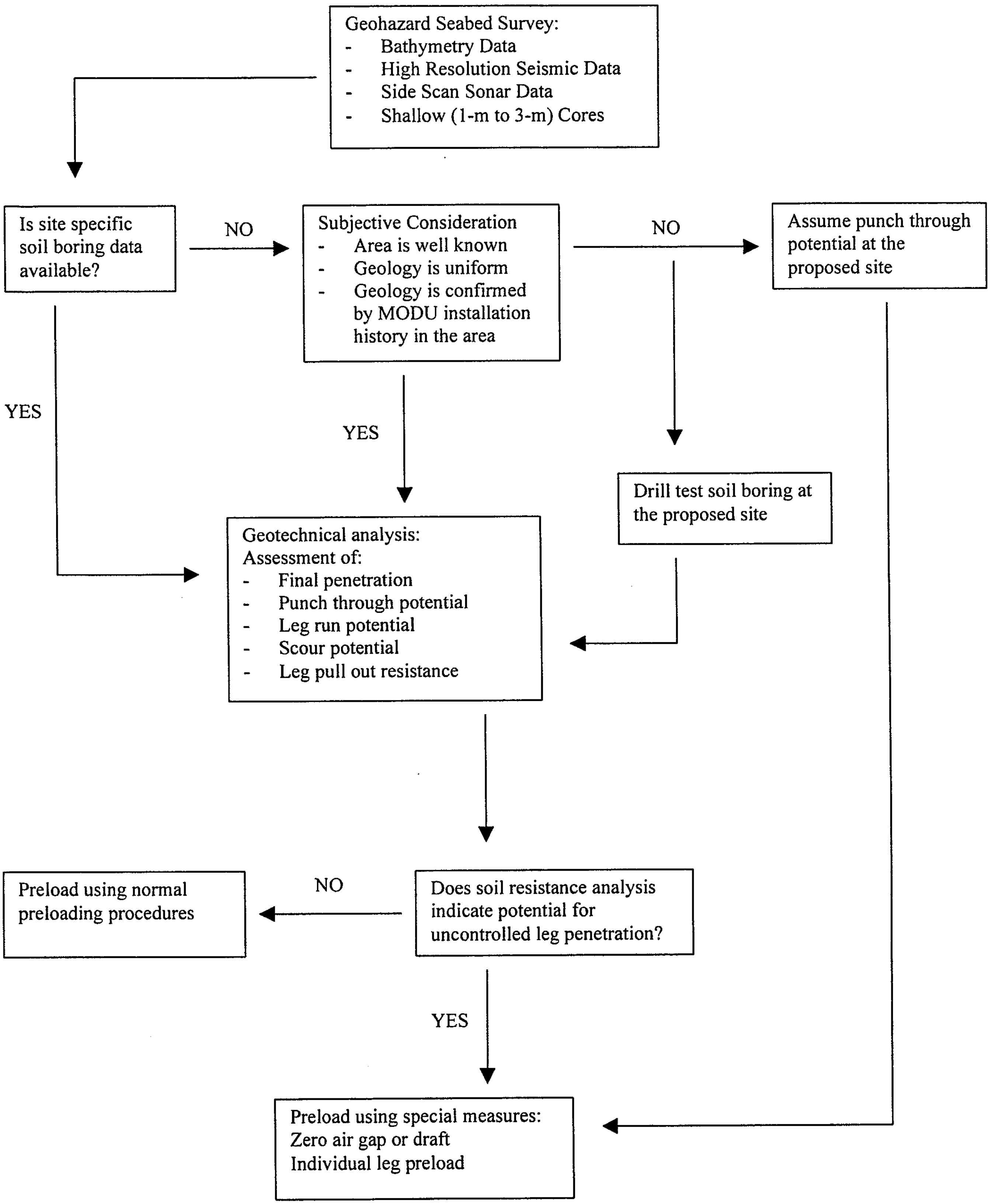

FIGURE 4. MODU FOUNDATION EVALUATION PROCESS