

## Design Memorandum

TO: All Design Section Staff

FROM: Bijan Khaleghi

DATE: September 12, 2008

SUBJECT: Deep Foundation Program Options and Design force Demand

This memorandum supersedes design memorandum issued on June 18, 2008.

The applicability of DFSAP program for liquefiable soils has recently raised concerns among Bridge Office and Consultant Designers. As a result, the Bridge Design Office and the Geotechnical Division have decided to temporarily place the following limitations on the use of DFSAP program:

- For static soil structural analysis cases, the DFSAP Program may be used for pile and shaft foundations.
- DFSAP program shall not be used for pile or Shaft foundations in the liquefied structural analysis case whether or not the liquefaction option in DFSAP program is turned on or off. The seismic analysis using static non-liquefied soil properties may utilize either the DFSAP or L-Pile program. The liquefied structural analysis case of a shaft or pile foundation shall use LPILE with static soil properties reduced by Geotechnical Division recommended p-y multiplier factors.
- The design of pile or shaft foundations for SDC B shall be based on forces determined by capacity design principles or elastic seismic forces, whichever is smaller. The design of pile foundations for SDC C or D shall be based on forces determined by capacity design principles, except for pile groups designed with the simplified foundation model may be sized to resist the plastic moment of the column,  $M_p$  in lieu of  $M_{p0}$  specified in Article 8.5.
- The design of oversized shafts shall be based on flexural expected nominal capacity equal to 1.25 times the moment demand generated by the overstrength moment of the embedded column. The requirements of capacity-protected members of Article 8.9 apply to all members adjacent to plastic hinge locations.

Pile or shaft foundation group effect efficiency shall be taken as recommended in the project Geotechnical Report.

### Background:

The adequacy of the DFSAP program for all foundation types and all soils profiles has been recently questioned by the Bridge Office and Consultant engineers. When the liquefaction option is selected in DFSAP, bridge designers have had difficulty getting the program to converge on a solution. Comparison of the P-Y curves generated by DFSAP when the liquefaction option in the program is used to other methods of generating P-Y curves (e.g., L-Pile) appears to indicate that the liquefied DFSAP P-Y curves are overly conservative. However, using the convex (i.e., strain softening shape inherent in static p-y curves reduced to a liquefied strength using a p-multiplier approach (DFSAP and L-Pile) may possibly result in an under-prediction of foundation deformation depending on the magnitude of the foundation lateral loads. After a joint meeting between the Bridge Design Office and the Geotechnical Division, it has been decided to use a simplified elastic-plastic liquefied p-y curve that represents a compromise between the strain softening and strain hardening curve shapes used to represent liquefied p-y behavior. This curve shape will avoid the computational difficulties currently caused by other curve shapes, and is also sufficiently accurate considering the lack of knowledge the engineering community has on how to characterize the liquefied behavior of soil for lateral load analysis. At present, DFSAP does not have the ability to use an elastic-plastic p-y curve, whereas L-Pile does have this ability. Furthermore, it has been decided to place limitations on the use of the DFSAP program regarding liquefied soils until further notice. Meanwhile the Bridge Design Office and the Geotechnical Division will be communicating with the developers of the DFSAP program to address these issues and to make necessary revisions to the program, if feasible.

The intent of this memorandum is not to revert to former practice of using L-Pile program for all deep foundations. This is intended as a temporary measure until the issues with the DFSAP program are completely resolved and all the modeling problems are taken away. Upon resolution of these concerns, the DFSAP program then will be returned to use as the recommended program for deep foundation analysis as appropriate.

If you have any questions regarding these issues, please contact Tony Allen at 709-5450, Patrick Clarke at 705-7220 or Bijan Khaleghi at 705-7181.

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