Structural Engineering Guidance No. 12-02

Date: January 31, 2012

Distribution: Internal Bridge Designers Only

SUBJECT: IN-HOUSE NEW LRFD SPREAD AND PILE CAP FOOTING ANALYSIS PROGRAM

VERSION 1.0 TRIALS

Contact: Gregory Sanders/Suresh Patel

EPG Status: NA

Effective Date: Immediately

Expiration/Duration: Upon Completing Trials

Background and Purpose:

The in-house spread and pile cap footing analysis program has been used for designing foundations since 1999/2000 when created by Jeffrey Ger of Development Section with the intent to improve footing analysis accuracy and efficiency. With the advent of the AASHTO LRFD Specifications for bridge design and procurement of the RCPIER substructure analysis and design software program, use of the in-house analysis program naturally may have diminished.

Due to limitations of RCPIER specifically regarding spread footing analysis and the fact that a decision had to be made regarding in-house software retention and conversion, it was decided to retain and convert the in-house footing analysis program using newer programming code and incorporating AASHTO LRFD Specifications.

RCPIER substructure/foundation analysis and design program does not correctly analyze spread footing pressures for the case when the eccentricity (length and/or width) ratio is > 1/6, i.e. when part of the footing is in tension and triangular bearing pressure distribution is in effect for both or either principal directions. It is possible that spread footings could be sized on unreliable results, but more likely oversized unnecessarily.

*(This is not meant to cause unease that under designed spread footings have been produced, but rather to inform those both familiar and unfamiliar with the limitations of RCPIER, that these possibilities are recognized and action is being undertaken to rectify. Designers should be familiar with what has been informed and may be supplementing their designs and checks with spreadsheet analysis or in rare instances, the original in-house program V 3.0 with manipulated input data to produce LRFD results.)*

For example, RCPIER could give the impression that it is using a triangular bearing pressure distribution by returning negative bearing pressure values; but, these values should be considered suspect. Designing with these values could produce unreliable results, especially with large eccentric loadings.

On the other hand and more likely, RCPIER will be used as it was intended and that is to produce larger footing sizes for all load cases based on satisfying that only trapezoidal bearing pressure distribution is in effect, i.e. when eccentricity ≤ 1/6 of footing length and/or width or alternatively no part of footing is allowed to be in tension. In dismissing negative bearing pressure values as erroneous, footings are unnecessarily enlarged until all values are positive rejecting those eccentricities greater than 1/6 that are allowed by AASHTO LRFD Specifications. This analysis shortcoming or shortcut, in either case over conservatism, could become wasteful for large lateral loadings and/or large bending moments where other than an eccentricity ratio < 1/6 would otherwise be allowed by AASHTO LRFD Specifications.

RCPIER pile cap footing analysis is reported as not having problems like what we have discovered with the spread footing analysis. Negative values (indicating tension on pile) are still possible and should be considered correct; however the tension (uplift) values could be overstated if pile is to be seated on rock. This is related to the improbability of rigid pile cap rotating with piles supported on rock reducing the likelihood of tension on pile. For friction piles, this physical limitation does not exist and rigid cap is free to rotate.

Bentley/RCPIER has been contacted regarding this matter and they are reviewing. However, they may not be changing their program any time soon.

The original in-house ASD/LFD (AASHTO 17th Ed.) spread and pile cap footing analysis program could analyze spread footings for larger eccentricity (length and/or width) ratios. IS has converted the original program using C-Sharp (#) programming language (was Visual Basic) and revised some algorithms under our direction utilizing AASHTO LRFD Specifications. All limit cases are represented and may be used when allowed; hence, the title modifier “New” and re-initializing the version number to 1.0.

The original program was proven and this next level of revision will provide indefinite years of service.

Guidance for Trials/Implementation Plan:

Designers are requested to use the new program and compare it with RCPIER trapezoidal bearing pressure distribution case for same sized spread footings under similar loading conditions. Original files (LFD version 3.0) cannot be used in the new program because input file configuration is designed to read RCPIER output file; also, the new in-house interface user screen and manual input has been modified from the original version. Therefore, new files will need to be created. File name extensions for both input and output are also changed for the new version.

The new program does not compute footing loads other than self weight and soil weight above the footing. This is unchanged from the original program. Therefore, RCPIER must be used to develop all other limit state loadings; new in-house program is not a substitute for RCPIER at this time specifically for footing analysis. In fact, the new in-house program is designed to use imported RCPIER output. It can also run loadings independent of RCPIER.

Alternatively, designers can use personal spreadsheets in corroborating results if limit state loadings are known.

New in-house program should produce smaller spread footing sizes and compute correct bearing pressures for triangular distribution case; uplift force on bearing pile (pile on rock) could be reduced for some foundations. There is an option available in this program that will adjust pile/soil stiffness for a pile on rock.

Another option available is load transfer; the new program will transfer top of footing loads to any depth down to bottom of footing. This option was installed since RCPIER cannot compute results at bottom of footing. The decision to add this feature was based on older in-house design practice but is optional for practice at this time. Consult with the Structural Project Manager if you have questions on using this option. This has also been addressed with Bentley.

Trial program link will be installed in Structural Software on the Development Section Web Page and will be noted as “LRFD Footing (Trial)” with a corresponding link to the help file and examples separately listed.

Please report findings to Suresh Patel of Development Section for review.

Under Review at this time:

*EPG 751.38 Spread Footings* for service limit load requirements

*EPG 751.36 Driven Piles* for allowable tension on piles at strength limit state for pile cap footings

Questions, comments, suggestions and recommendations concerning this guidance or procedure should be directed to the Development Section for review.