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DISCUSSION ON PAPER 9111 STRUCTURAL ENGINEERING GROUP

Influence of wall superstructure on the foundation interaction analysis of a circular raft

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The problem investigated by the Author is very similar to one studied by me about 30 years ago. This was the analysis of a circular plate on an elastic foundation with elastic rotational restraint at the plate edges.[22] The cases of simply-supported and clamped edges had previously been analysed by Miller[23] and Gardner.[24] In references 22–24, the application was to the design of tube sheets in heat-exchangers or reactors.

57. The elastic rotational restraint at the edges of the plate was included in the formulation because of the plate's interaction with the supporting cylindrical wall of the pressurized container. It might be thought that the elastic restraint case could be solved by interpolating between the simply-supported and the clamped edge solutions. However, this is not always the case and, in fact, optimum circular plate designs can be obtained which are considerably thinner than the simply supported cases (see reference 22).

58. The analysis in reference 22 was applied to some 3 m diameter ethylene oxide reactors which were built for Shell Chemical at Partington, Cheshire. In order to check the unusual conclusion about rotational edge restraint, one of the reactors was strain-gauged and tested by Lloyd's. The test was successful; some of the results were reported in reference 25.

59. The French pressure vessel authorities have incorporated the elastic rotational restraint concept in the latest update of their Code CODAP.[26] Other national codes may follow the French lead in due course.

60. I would like to ask Dr Hemsley whether he found any raft designs which were substantially thinner than the simply-supported cases, or did he not investigate this aspect of the problem?

Dr Hemsley

There are countless papers in the literature dealing with various aspects of elastic plates on Winkler springs; those concerned with the more difficult problem of a plate on an elastic continuum are far less abundant. Much theoretical work on circular plates on springs was carried out during the early part of the century, and is summarized by Schleicher.[27] Methods of coupling an end-plate to a cylinder are described by Flügge[3] and others. Linear interpolation between solutions for simply-supported and clamped edges emerges naturally from the elastic formulation of the problem.

62. Closed-form solutions can be derived fairly readily for circular plates of

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uniform thickness founded on Winkler springs. On encountering specific problems of this type, it is frequently quicker and more reliable to obtain solutions from first principles, rather than to spend considerable periods of time searching for published solutions which, more often than not, contain typographical errors, and give limited or specialized results in a problem-orientated format.

63. *Professor Galletly* draws attention to the analysis and design of heat exchanger tube-plates, where Winkler springs represent the tube bundle and where the perforated plate attached to the end of a cylindrical shell is assumed to be homogeneous and of uniform thickness. This is one of several interesting examples of related problems from other industrial applications, and has been referred to elsewhere[28] in the context of foundation engineering. Despite certain similarities, however, they are mostly too far removed from civil engineering analysis to be of much practical use in design.

64. The essential question in any particular analysis is the relevance or otherwise of the Winkler spring representation. Whereas, for example, such modelling may be adequate in the tube-plate analysis, it is likely to lead to poor results for the flexure of a raft on a solid continuum. This is shown in the Paper, and it explains the emphasis on continuum modelling of the ground.

65. The method of optimizing the design of the tube plate by balancing maximum positive and negative bending moments is generally inappropriate to the structural design of foundation structures. In the case of large diameter concrete storage tanks, for example, the raft thickness is governed by other factors and is usually reduced beyond a short distance from the edge; for small tanks, the wall thickness is determined principally by the need to resist lateral loading rather than to provide rotational restraint to the base slab.

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