Discussion of "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes" by Jonathan D. Bray and Jorge Macedo

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The corpus of work led by Dr. Bray, including Bray et al. (1995, 1998), Bray (2007), Bray and Travasarou (2007), Bray et al. (2018), and the paper under discussion, form a landmark series that has greatly contributed to the ability of engineers to rapidly perform pragmatic evaluations of the range of expected seismically induced slope displacements. The discussers are primarily interested in the relevance of these works as related to lined municipal and other solid waste landfills, although these comments are germane to cut slopes and earth embankments as well.

Important parameters included in the evolving simplified methodologies proposed by the authors are the initial fundamental period of the sliding mass, T_s, as calculated from the equivalent slope height, H, and average shear wave velocity, V_s. For purposes of the methodology developed over the past 25 years, the fundamental period of waste fills and cut slopes, as shown in Figs. 1(a and c), using the shear beam theory, is the well-known equation

$$T_s = \frac{4H}{V_s}$$

In Bray et al. (1995), H was simply defined as the "height of the waste fill." Bray et al. (1998) used the same definition but indicated, at least once, that the fundamental period under discussion might be related to the *sliding mass* rather than the whole waste fill. Bray (2007) summarized Bray et al. (1998) and clarified that T_s indeed refers to the fundamental period of the *potential sliding mass* and further defines H as the "average" height of the potential sliding mass. Bray (2007) provided some additional definition of the relationship between T_s, H, and V_s in Fig. 14.4 from that paper (reproduced here as Fig. 1).

Of special note in Fig. 1, and in the text of Bray (2007) and Bray and Travasarou (2007), is the mention of the triangle-shaped sliding mass depicted in Fig. 1(b) that is stated to have a "largely two-dimensional (2D) response" and for which the expression commonly used to evaluate the fundamental period of an embankment dam, $T_s = 2.6H/V_s$, should be used.

Bray and Travasarou (2009) provided much the same definitions as given above, but slightly modified the definition of H as the "representative" height. While the definitions may seem clear, especially to those who regularly run one- and two-dimensional (1D and 2D) site response evaluations, the discussers have noticed while reviewing multiple projects that the evaluation of an appropriate representative height, H, has not been uniform and consistent between different practitioners and agency staff. The most common shape of the sliding mass where clarification is required is shown here in Fig. 2(a), but other variations such as shown in Fig. 2(b or c), as well as others, may exist.

The shape of the failure surface in Fig. 2(a), which typifies the most common geometry encountered in landfills (i.e., interim waste fill placed over a composite liner system), is similar to its embankment dam counterpart in Fig. 1(b). However, the dynamic response of a trapezoidal dam and that of a wedge-shaped interim waste fill are different. Therefore, while the representative height, H [Fig. 1(b)], may represent an embankment dam, it may not represent a wedge-shaped interim waste fill as shown in Fig. 2(a).

For a wedge fill, the discussers compared calculations using the authors' method for $T_s = 4.0H/V_s$ (which corresponds to a 1D column) and for $T_s = 2.6H/V_s$ (which corresponds to an embankment dam) against the results of (2D) site response/seismic

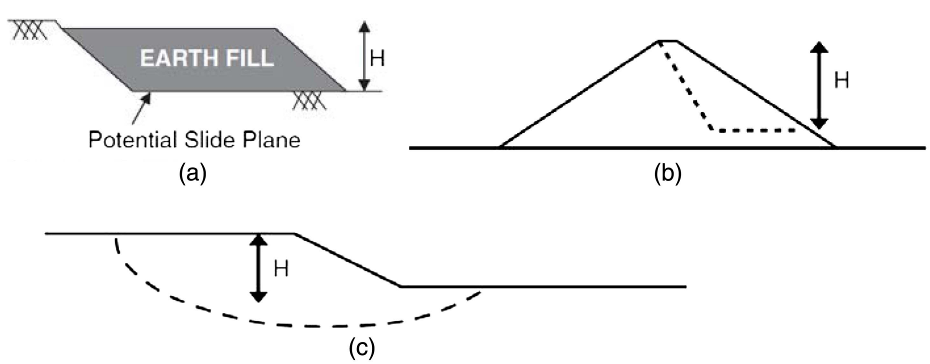

Fig. 1. Estimating the initial fundamental period of potential sliding blocks: (a) earthfill sliding block; (b) embankment dam; and (c) earth slope with deep seated circular failure. (Adapted by permission from Springer Nature: Springer, *Proc., Earthquake Geotechnical Engineering, 4th Int. Conf. on Earthquake Geotechnical Engineering—Invited Lectures*, "Chapter 14: Simplified seismic slope displacement procedures," Jonathan D. Bray, © 2007.)

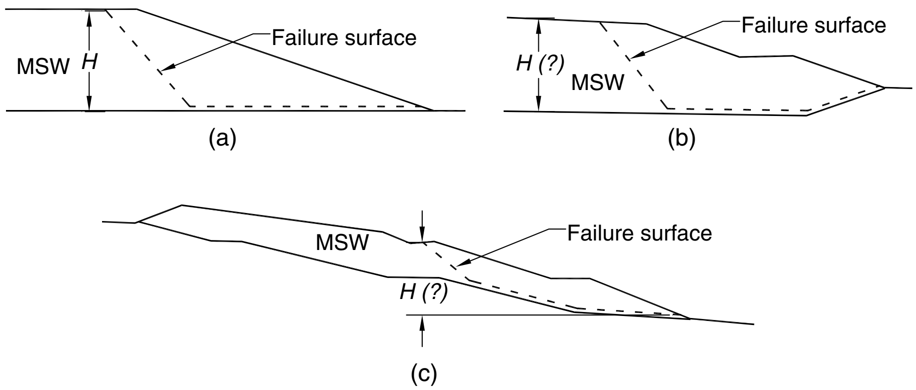

Fig. 2. Representative failure surfaces within lined municipal solid waste (MSW) landfill configurations: (a) typical MSW wedge fill geometry; (b) MSW wedge fill with toe buttress; and (c) MSW sidehill fill.

deformation analyses "correct results." While these calculations bracketed the "correct results," the best agreement was achieved with $T_s \approx 3.3H/V_s$. The equivalent height, H_{eqv}—that is, the equivalent fill height within the failure surface was thus 100% H for 1D analysis [Figs. 1(a and c), which can represent1D analysis], approximately 80% for a wedge fill [Fig. 2(a)], and 65% for an embankment dam [Fig. 1(b)].

Going even further, the discussers find it valuable, and consider it worthwhile guidance to the industry, if the authors would share their experience with wedge fills [Fig. 2(a)] and also provide suggestions for estimating the "representative height," H, for other potential sliding mass geometries [Figs. 2(b and c)] and in general.

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