March 17, 1998

Ms. Virginia Fairweather, Editor-in-Chief
Civil Engineering
American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191-4400

Re: Editorial Letter

Dear Ms. Fairweather:

I have been active in the research, development, and technology transfer of what is now referred to generically as geofoam since 1988. Based on my experience with this subject, it is my professional opinion that the article titled "Putting Polystyrene to Work" which appeared on pp. 65-67 of the March 1998 issue of *Civil Engineering* contains a number of technical errors as well as omission of important facts. In the interest of making accurate and complete information available to the many readers of *Civil Engineering* who are potential end users of geofoam technology, I offer the following comments on this article:

1. To begin with, an incorrect definition of geofoam was given. The generic term geofoam has, since the early 1990s, been recognized worldwide as a geosynthetic product category that includes <u>any</u> foam material used in a geotechnical application. Thus geofoam materials include several types of polymeric (plastic) materials, not just the two variations of polystyrene (EPS and XPS) mentioned in the article, as well as cellular glass and various cementitious materials.

2. The published record indicates clearly that geofoam usage dates at least as far back as the 1960s, including in the U.S.A. where, for example, a patent for using geofoam as pavement insulation was granted in 1966 to the late Prof. Gerry A. Leonards of Purdue University. This documented usage is thus a decade older than indicated in the article and indicates how long geofoam technology has been underutilized in the U.S.A. and elsewhere. Actual usage may even be older as the most commonly used geofoam materials, EPS and XPS, were invented circa 1950.

3. Although not directly related to geofoam, it should be noted that the term "reinforced earth" is a registered trademark of a particular type of mechanically stabilized earth (MSE) technology marketed for decades by The Reinforced Earth Company. Therefore, it has long been recognized in practice that this term should not be used in a generic context as it was in this article. As information, MSE is the globally recognized generic term for the use of tensile reinforcement in conjunction with soil.

4. The author chose to state explicitly that a "hydrocarbon gas" (it is pentane) is used as the blowing agent to manufacture EPS. However, he curiously neglected to mention the fact that the blowing agent used traditionally to manufacture XPS is a fluorocarbon (FC) family gas, formerly CFC (now banned) and currently HCFC. Since FC-family gases are thought by many

to contribute to the depletion of the Earth's upper-atmosphere ozone layer, the use of FC-family gases in general is not without controversy and concern to some. The writer takes no position here in this highly contentious issue but simply makes the point that it is important that end users be aware of all the relevant facts and exercise their own professional judgement when making decisions.

5. It is now well accepted in practice that the compressive strength of EPS and XPS is, per se, an irrelevant material parameter for the load-bearing aspects of geofoam analysis and design. Relevant material parameters include the elastic-limit stress, initial tangent Young's modulus, and deterministic creep behavior. Compressive strength has for some time now been relegated to a role as a manufacturing quality control and assurance (MQC/MQA) parameter in modern geofoam practice.

6. Contrary to what was stated in the article, the Poisson's ratio of EPS (the predominant geofoam material worldwide, a fact not made clear in the article) within its elastic stress range is close to zero and, therefore, is significantly less than the Poisson ratio for soil. This is based on research over several decades at a number of different locations worldwide. In the interest of objectivity, the author should have stated clearly that his published research alone is contrary to this otherwise universal observation. It is of relevance to note, for example, that the French national design manual for EPS geofoam as lightweight fill for roads states explicitly that Poisson's ratio be taken to be zero for practical design purposes.

7. It should have been noted that for even greater economy, the trend worldwide for many years now has been to use an EPS-geofoam fill with vertical, not sloped, sides as what the writer terms a "geofoam wall." Such configurations are cost effective because they minimize both the volume of geofoam and right-of-way area required. EPS geofoam is inherently self stable even with a vertical side slope and thus simply needs to have its permanently exposed face(s) covered for architectural and UV-protection purposes.

8. It should have been noted that the use of wood chips beneath an EPS-geofoam fill as suggested in the article is not a typical design detail. As is well known, wood chips undergo anaerobic decomposition to varying extents and at varying rates when buried in the ground above the ground water table. Thus long-term decomposition of the wood chips may cause the entire fill to settle totally and, most likely, differentially. In addition, the heat generated by decomposition of the wood chips has the potential to increase the creep rate of, or even melt, plastic such as EPS. In those cases where EPS and wood chips have been used on the same project for economic reasons, it is the writer's personal experience that the two materials were separated using a layer of gravel which was designed to act as a thermal ventilation layer.

9. Contrary to what was stated in the article, a portland-cement-concrete (PCC) slab is no more required on top of an EPS-geofoam fill than such a slab is required on a soil subgrade of equivalent stiffness (CBR = 2% to 4%). Since the 1970s, there have been countless EPS-geofoam fills constructed around the world that have not used a PCC slab but simply placed the road pavement system directly on the geofoam (a geomembrane or geotextile separator was typically used however). For example, both the British and German national design

manuals for EPS geofoam as lightweight fill for roads explicitly allow the elimination of a PCC slab. The primary function of the PCC slab, if used, is to stiffen the unbound layer(s) in the pavement system and thus allow a thinner/lighter pavement system. If the slab is eliminated, a somewhat thicker/heavier pavement is required. For example, the Norwegian national design guidelines for EPS-geofoam as lightweight fill for roads allow replacement of the PCC slab with soil on a three to one ratio, i.e., 300 mm of soil is structurally equivalent to a 100 mm-thick PCC slab. Thus in modern geofoam practice whether to use a PCC slab or not is based solely on project-specific economics. In terms of trends, in the United Kingdom a PCC slab is rarely used. In the writer's experience in the U.S.A to date, economics typically favor elimination of the PCC slab if the design engineer has been supplied with the correct technical guidance and is aware of the fact that a PCC slab is not "mandatory." Unfortunately, this fact has not been widely disseminated within U.S.A. practice to date so EPS-geofoam fills have tended to be needlessly expensive in the writer's opinion.

10. One of the more contentious issues in the market war that has always existed in the U.S.A. and elsewhere between EPS and XPS (the other contentious issue is blowing agent which was mentioned previously) is the relative amount of water absorbed by the geofoam in applications where thermal insulation is the primary geofoam function. Again curiously, the author cited only water absorption figures for EPS. In the interest of completeness and objectivity, it should have been noted that XPS absorbs water as well and its thermal efficiency is also detrimentally affected by this fact. Therefore, end users are encouraged to always evaluate the most thermally cost effective geofoam material (EPS versus XPS) to use on a project-specific basis.

11. The simplistic statement that "geofoam is combustible" is highly misleading and could needlessly deter potential end users. Although it is a fact that polystyrene is inherently flammable (as are most other plastics), both EPS and XPS can be manufactured to be flame retardant and self extinguishing although they will still melt when exposed to heat above some threshold value. In some countries such as the U.S.A., manufacturers will, by default, tend to supply flame-retardant EPS and XPS for geofoam usage. However, this should not be assumed universally and end users need to be careful to specify flame-retardant EPS or XPS when they feel it is necessary. It is worth noting that the bromine-based flame-retardant additive to EPS changes neither its appearance nor its geotechnically relevant properties (stiffness, thermal conductivity, etc.).

12. Finally, the author failed to mention numerous additional geosynthetic functions for geofoam such as compressible inclusion, noise and vibration damping, drainage, and structural. The compressible-inclusion function in particular is seeing increasing use worldwide for important civil-engineering problems such as seismic loading and expansive soils Readers interested in obtaining more-complete and -detailed information concerning all aspects of geofoam technology can visit *The Geofoam WWW Site* on the Internet at **http://www.geofoam.org** as well as read my monograph *Geofoam Geosynthetic* which is the only book in the world devoted exclusively to all aspects of geofoam geosynthetic technology.

I look forward to having this complete letter published at the earliest possible opportunity for the benefit of readers of *Civil Engineering*. I know that you share my interest in seeing that the readers of this magazine be provided with complete and accurate information at all times and for all subjects.

Very truly yours,

John S. Horvath, Ph.D., P.E.
Professor of Civil Engineering
Member, ASCE