Case Study: Using Geofoam on a school project in Encinitas, CA.

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This paper is a case study that identifies why Geofoam was used as in-fill material for a construction project located at a high school in Encinitas, CA. The Geofoam was installed under a stairway that connects to a structural retaining wall. The concrete formwork was connected directly to the foam and the stairs were poured in place onsite. The foam acted as the on-grade material, so the concrete stairs did not have to be self-supporting. The purpose of this study is to understand the benefits of using Geofoam, as the in-fill material, as opposed to other traditional materials. An analysis of various factors, given by the structural engineer, architect, inspector, and superintendent involved in this project, was conducted to compare alternate materials. The Geofoam was used because it alleviated concerns about cost, weight, limited access, and time. The material had neither positive nor negative effects on cost and environmental concerns.

Key words: Geofoam, Foam, Structural Fill, EPS 39, Backfill

Background

Construction began on San Dieguito High School's English and Arts building in winter of 2017. The project was slow moving from the start and quickly became behind schedule. Therefore, faster methods of construction were sought out. One example of the faster method was deciding what type of in-fill material would save the most time when installing the concrete stairs on the north end of the building. Prior to these concrete stairs being poured, the stairs were already surrounding retaining and structural walls in place. The walls on all three sides of where the stairs were installed created a problem due to the limited space for equipment used with traditional soil backfill. This limited space prevented contractors from being able to use large equipment when installing the backfill material.

The focus of this paper will be a case study of the foam that was used as structural fill under a stairway which connects to a structural retaining wall. The forms for the concrete stairs were directly connected to the foam and poured in place. The research performed will provide a better understanding of the benefits for using geofoam as an in-fill material and why this specific material was used for this project.

Geofoam EPS uses in Industry

Expanded polystyrene or better known as geofoam is an extremely lightweight material used as fill material. Geofoam can be used as fill material on a variety of construction projects. It can easily be a faster way to backfill than traditional soil material. This is because when the foam is installed the foam is stacked on top of one another, whereas, soil needs to be compacted and built up layer by layer. In addition to a lightweight structural fill material, geofoam is used for lateral load reduction on structures, soft soil remediation, slope stabilization, and lateral and dead load reductions over buried utilities (Geofoam, 2014). This material has many uses because of its lightweight properties and its ease of manual installation. "After nearly 30 years in a variety of subsurface applications, geofoam has proved itself both a strong, lightweight fill material and a superior geotechnical insulator. In the future, geofoam will certainly be used in more applications as engineers gain greater familiarity with its capabilities" (Negussey, 1998). Geofoam is a quality material with many useful applications in the construction industry.

Methodology

The objectives of this case study are as follows:

- To report on the specific use of geofoam
- To report on why this material was used
- To report on possible environmental concerns.

The methodology used for this project was a case study, primarily relying on qualitative research gathered from structured interviews with the superintendent, structural engineer, architect, and inspector. In addition to these interviews, review of the product submittal and additional online research was conducted. As well as, first-hand information was gathered from personally working on the project as a project engineering intern over the Summer in 2018.

Project Specifics

- Project Cost: $23.5 Million dollars
- Project Timeline: Winter 2017 - Summer 2019
- Architect: SVA Architects
- Structural Engineer: Thornton Tomasetti
- General Contractor: Erickson-Hall Construction Co.
- Concrete Prime Contractor: Rocky Coast Builders
- Project Limits: The project site is located east of the 5 Freeway along Santa Fe Drive, City of Encinitas, CA
- Building Square Footage: 53,000 square-feet

Results and Discussion

The following information was gathered through structured interviews with key parties of this construction project. These parties included the structural engineer, architect, superintendent, and inspector. The goal of this study was to simply gather and present the information as to why geofoam was used on this project.

Cost

The cost of the material and the cost of labor installing these materials were key factors when deciding to use this product. Along with these costs, there would have been additional costs for equipment if soil was used as the backfill material. “Recent cost estimates of geofoam vary from $55 to $100 per cubic yard, depending on a project’s required physical properties” (Geofoam, 2014). According to the structural engineer, “EPS is typically more expensive than [concrete] slurry or soil” (Schoenberg, 2019). The cost was one of the negative characteristics of this foam material. However, the cost of labor for soil in-fill would have been more expensive than Geofoam EPS. This is the case, if there was soil on site that could have been used as backfill. On this project, Geofoam EPS 39 was installed in one 8-hour work day, compared to soil in-fill which would have taken at least three days to compact the soil. In terms of prevailing wage, the cost of labor to compact the soil in-fill would have been similar to the cost of the foam material. This translates to the cost of both the material and the labor would have been approximately the same. The concerns with the weight of the material was a more important deciding factor than the overall cost.

Weight

This Geofoam EPS 39 is a lightweight alternative material to traditional backfill materials. The lightweight property of the geofoam was one of the reasons why this material was used as a fill material. According to the structural engineer, “The additional weight from a more typical backfill solution would add significantly more weight to the foundation which could lead to overstressing the soil.” In table 1 below it shows that Geofoam EPS 39 is the lightest fill material in the table per cubic foot. In comparison, geofoam is typically 2 percent the weight of soil.

Fill Material	Typical Weight (lb/ft^3)
Geofoam EPS	0.7-2.85
Geofoam EPS 39	**2.40**
Soil	110-120
Cellular Concrete	35-100
Wood Chips	15-30
Shredded Tires	38-56
Pumice	40

Table 1: Fill Material Typical Weight comparison
Source: White, Light, and Out of Sight

Table 2 explains the typical tested physical properties of Geofoam EPS 39. According to the structural engineer, “The material provides very efficient stiffness-to-weight ratio. This can reduce weight, and can also reduce required reinforcement as the concrete above does not need to be self-supporting.” Given that this foam material is exponentially lighter than other materials in consideration, it was the perfect application for this project.

Type - ASTM D6817	Units	EPS39
Density (nomical pcf)	lb/ft³ (kg/m³)	2.40 (38.4)
Compressive Resistance ** min. @ 1% deformation	psi (kPa)	15.0 (103)
Compressive Resistance ** min. @ 5% deformation	psi (kPa)	35.0 (241)
Compressive Strength (psi, 10% deformation)	psi (kPa)	40.0 (276)
Flexural Strength (min. psi)	psi (kPa)	60.0 (414)
Oxygen Index, min.	Volume %	24.0
Dimensional Stability	max. %	< 2%
Buoyancy Force	lb/ft³ (kg/m³)	60.0 (960)
Poisson's Ratio	--	.05
Coefficient of Friction	--	.6
Absorption	Volume %	< 4.0
Elastic Modulus, min.	psi (kPa)	1500 (10300)

*Properties are based on data provided by resin manufacturers, independent test agencies and Insulfoam.
** For InsulFoam GF applications the design load stresses should not exceed 1% strain for combined live and dead loads.

Table 2: Fill Material Typical Weight comparison
Source: Insulfoam Geofoam EPS 39

Limited Access

The Geofoam EPS 39 material was installed in the area where the concrete stairs were to be placed. This location is surrounded by concrete walls on three of the four sides, as seen below in figure 1 and figure 2. The benefits of installing

Geofoam EPS 39 is that it just requires the installer to stack the foam like blocks. When the size of the foam blocks needed to be adjusted, the contractor could cut the blocks using a hot wire outside of the installation area. This prevented the area where the Geofoam blocks were being installed from worker congestion because of the limited space. If traditional soil backfill would have been used, it would have been difficult to move full sized equipment in this area to compact the soil. The contractor would have had to use smaller compacting equipment to compact the soil which ultimately would have taken more time to complete and ultimately delaying the completion and adding to the overall cost of this project.

Figure 1: Location where Geofoam EPS 39 was installed
Source: Courtesy of Superintendent

Time

Another big challenge this project faced was time, finishing the project so the school district could utilize the building at the beginning of the 2019 school year. Installing the Geofoam EPS 39 required no equipment; the contractor manually placed the blocks into position. If soil was used instead of foam, there would have been time added to the schedule because the soil would have been compacted using a plate compactor. Also, there would have been soil testing done if soil was used as the backfill material. However, since Geofoam EPS 39 was installed instead, there were no additional inspections required according to the inspector. This material was a great option where time was a factor.

Figure 2: Location where Geofoam EPS 39 was installed
Source: Courtesy of Superintendent

Environmental Concerns

Since the material being used is expanded polystyrene, some might have concerns about environmental impacts. According to the structural engineer on this project, "expanded polystyrene is a non-biodegradable material and studies do not appear to show adverse effects to the soil or surrounding environment" (Schoenberg, 2019). The main concern would be how the material is prepared before insulation. According to the superintendent, "if you cut it with a saw it releases small foam particulates all over the place." To avoid making a mess on the construction site the contractor used a hot wire to cut this material. This is a heated wire that melts through the material, cutting it easily. According to the Geofoam product data, "Insulfoam GF contains no ozone depleting CFCs, HCFCs, or formaldehyde. It is an inert and highly stable product that will not decompose, decay or produce undesirable gasses or leachates. Insulfoam GF is recyclable and safe for waste-to-energy (WTE) systems and landfills" (Insulfoam, n.d.). Geofoam is a safe material that can be used for multiple applications when lightweight fill material is required.

Conclusion

This case study worked well because the fill material needed to be lightweight in order to prevent stress on the soil. The use of Geofoam EPS 39 alleviated concerns about cost, weight, limited access, and time. After reviewing the five key factors which helped determine what material would be used, the characteristics of Geofoam EPS compared to other materials were advantageous in terms of weight, access, and time. The other two factors, cost and the environment were neutral when comparing Geofoam EPS to other in-fill materials. This denotes, the cost and the environment were the only two deciding factors for choosing a material, the characteristics of Geofoam EPS would have neither been an advantage nor a disadvantage. However, because the determining factors were all five components, the best material to use was Geofoam EPS 39. As we continue to encounter conflicts on the construction site, there is always a solution to the problem. This geofoam material may be used as an example of how a lightweight material may be utilized to fill large voids. Moving forward, this material should be utilized for applications similar to the use studied in this case study. There should be further research to compare different materials that have similar applications for in-fill.

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