Engineering Ethics Cases with Numerical Problems

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Mechanical Engineering Case 8

Mount Dioxin

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Suggested Courses:

Fluid Mechanics & Statics

Level:

Junior

I. Narrative

ETC was a former wood-treating company. The facility occupies 26 acres in an industrial area, but three African-American residential neighborhoods are in the immediate vicinity of ETC. The site was first developed for creosote wood preserving in 1941. Penta-chlorophenol (PCP) has been used as a preservative at the site since 1963 and was the only preservative used after 1970. Manufacturing activities have not taken place at the facility since October 1982, and the site was officially abandoned through bankruptcy proceedings in February 1991.

The RCRA (Resource Conservation & Recovery Act) inspection report in February, 1981 showed that ETC was cited for numerous non-compliances, including no inspection logs, no personnel training records, no groundwater monitoring, no protective cover and inspections of surface impoundments, and no inspection-data/inspection-schedules, etc.

In June, 1990, during a remedial investigation and feasibility study (RI/FS) of a Superfund site (the ACE Chemical site) located 3,000 feet to the northeast of ETC, groundwater contamination from the ETC location was detected at the ACE facility.

In September, 1991, preliminary assessment began at the ETC site to determine the extent of contamination. Soil sampling showed that at one sampling location, PCP was detected at a concentration of 170 ppm (parts per million) at 4 feet below the surface, of 160 ppm at 8 feet below the surface, of 170 ppm at 5 feet below the surface and of 170 ppm at 6 feet below the surface at another sampling location. Sampling results also showed 180 ppm and 160 ppm, respectively, at 8 feet below the surface at two different sampling locations, and 150 ppm and 160 ppm, respectively, at five feet below the surface at two other different locations. High concentrations of creosote, dioxin, benzene, lead, and arsenic were also detected on site. No samples were collected below 8 feet. Based on this sampling study, EPA began soil excavation under the Emergency Removal provision of the Superfund law; this means that work can begin without publishing a public notice.

According to an Action Memo to EPA dated April, 1991, the EPA manager for the ETC site requested $1.3 million, of which $1 million was for contractor's fee. Work to be performed included soil excavation and additional sampling. In January 1992, the ETC site manager wrote another action memo and requested that funding be increased to $2 million with $1.4 million allotted for the contractor. The action memo also pointed out that approximately 54,000 cubic yards of waste sludge and soil had been excavated so far, but acknowledged that the volume of waste material had been greatly underestimated. The memo said waste sludge could go as deep as 40 feet and estimated the total volume of waste sludge and contaminated soil to be over 100,000 cubic yards.

Four months later, in May, 1992, the site manager wrote another action memo to the regional office of EPA to increase the amount of requested fund to $4.4 million, with $3.3 million for the contractor. The memo also stated that approximately 180,000 cubic yards had been excavated and stockpiled on site and that the depth of contamination is almost four times deeper, covering a 50 percent larger area than originally suspected. Based on the amount of soil excavated so far, the site manager estimated that it would cost an additional $43 million to treat the contaminated soil. Since $43 million is more that twice the yearly budget for the Regional Removal Program, the site manager suggested that a suitable vinyl cover for the stockpiled soil that would last five years be designed.

The last action memo for the ETC site was dated January 6, 1993. The site manager increased the requested amount to $5 million with $4.3 million allotted for the contractor. The memo stated that a total of 255,000 cubic yards of PCP, creosote, and dioxin-contaminated soil were removed and stockpiled on site, and that severe weather conditions led to problems in installing a stormwater drainage/erosion control system as well as the vinyl tarp which covered the stockpiled soil. In addition, the memo stated that a November 1992 storm destroyed the temporary cover, and that the installed portion of the permanent cover was damaged by wind gusts of up to 60 miles per hour. Soil excavation was finally completed by Spring, 1993, and the stockpiled soil was covered by a 60 mil thick, UV-resistant vinyl tarp. The ETC site was not placed on the Superfund National Priority List (NPL) for cleanup until December, 1994.

Creosote, PCP, and dioxin compounds have a number of toxicological effects on humans and will adversely affect human health. Acute effects include severe eye, skin, and respiratory irritation, chloracne, burning of exposed skin, erythema, anorexia, acute nausea, and dyspnea. The chronic health threats range from carcinogenicity, mutagenicity, teratogenicity, and long-term respiratory impairment to death.

During soil excavation, neighboring residents complained of respiratory problems as well as other health problems, such as skin rash, caused by the contaminated dust. Former ETC workers who lived in the neighboring communities reported additional contaminated locations to the site manager, but he refused to listen

to them. Security around the ETC site was lax, and the local newspaper reported that kids were discovered using the vinyl-covered pile of contaminated soil, "Mount Dioxin," as a giant slide.

II. Numerical Problems

1. Due to aerodynamics, there is a concern that the vinyl tarp might be blown away by wind. Calculate the lift on the vinyl tarp caused by a 75 mph wind gust, stating any assumption you make.

2. Determine the anchoring force needed for the vinyl tarp.

III. Ethics Problems

For the EPA site manager:

The EPA site manager is under organizational pressure to begin cleanup, but he is also concerned about the health impact of soil excavation on the surrounding communities. Furthermore, he is constrained by budget and incomplete sampling data. Soil sampling showed the same degree of contamination (150 to 180 ppm PCP) at 8 feet and 5 feet.

1. There are a number of ways to test the ethical permissibility of actions. Here are three:

> The Golden Rule Test asks whether we would be willing to exchange places with those affected by our actions.
>
> The Rights Tests asks whether our actions violate the rights of others, including the right to free and informed consent, to life, and to health.
>
> The Utility Test asks what action would produce the most well-being for the most people, even if some individuals are harmed.

The site manager knows a number of former ETC workers living in adjacent neighborhoods who can help him identify additional contaminated locations, but he is under pressure from the EPA regional office to move quickly. Based on the three tests how should the EPA site manager respond to not notifying the affected communities?

2. There is an apparent conflict between informed consent and utility (as measured by quick action). Which consideration should be given priority here? Explain.

3. The site manager knows that the ETC site has resulted in groundwater contamination but he also knows that funds are insufficient to immediately treat the excavated soil. Experience shows him that it generally takes about ten years to clean up a Superfund site. What is the ethically justifiable course of action to take during the intervening ten years? Explain.

For the Contractor:

An engineer working for the contractor to excavate the contaminated soil found out that only $1 million was initially budgeted for the ETC site. He also knows from soil sampling, which was performed by another contractor, that contamination goes deeper than 8 feet and covers a larger area.

1. Should this engineer recommend additional soil sampling before excavation begins, which would decrease

the amount of funds available to his company for soil excavation? Analyze his decision from the standpoint of the three tests for ethical action mentioned above.
2. Is there a creative middle way between more sampling and recommending immediate soil excavation to the EPA site manager?

For the Regional Manager of EPA:

Funding priority for cleanup depends on a site's being placed on the National Priority List (NPL), and the ETC site had not been placed on the NPL.

1. Justify his approval for funding request from the ETC site manager under the Emergency Removal provision of Superfund law based on the three tests mentioned earlier.
2. What considerations should he have taken prior to approving the soil excavation plan, even though sampling data is incomplete?
3. How would he justify his approving soil excavation and stockpiling with no plan for cleanup?

IV. Solutions To Numerical Problems

1. Determine the lift force on the vinyl tarp

Given: volume of contaminated soil = 255,000 cubic yards

Assume a half-cylindrical shape: $\pi R^2 L$ = 255,000 cu.yd with L = 450 ft

therefore, radius R = 40 yards = 120 ft

Assume a 75 mph wind velocity from a minimal hurricane, velocity V = 110 ft/sec

Reynold's No.. $R_e = \rho VD / \mu$

where ρ = density of air = 1.23 kg/m^3 at standard conditions = 0.0934 lb$_m$/ft^3

μ = viscosity of air = 1.78 x 10^{-5} kg/m-sec at standard conditions

D= diameter

Substituting, R_e = 5.5 x 10^8; and for a half cylinder, table gives a lift coefficient C_L = 0.5

The relationship between lift force, F_L, and lift coefficient, C_L is given by:

$C_L = F_L / (1/2) \rho V^2 A_p$

or, $F_L = (1/2) C_L P V^2 A_p$

where, for a half cylinder, the planform area $A_p = (2R)L$ = 108,000 ft^2

$F_L = (1/2) (0.5) (0.0934 \text{ lb}_m / \text{ft}^3) (1 \text{ lb}_f\text{-sec}^2 / 32.1 \text{ lb}_m\text{-ft}) (110 \text{ ft / sec})^2 (108{,}000 \text{ ft}^2)$

$= 9.53 \times 10^5$ lb_f

This is the total upward lift force on the vinyl from aerodynamic forces due to a 75 mph wind gust from a hurricane.

2. To determine the anchoring force for vinyl tarp

Based on free-body diagram of vinyl tarp, for equilibrium

$\Sigma F = 0: F_L = W + F_A$

where W = weight of vinyl tarp = mg

F_A = anchoring force

m = mass of vinyl tarp = density x volume

density $\rho = 1.40$ g/cc = 87.33 lb_m/ft^3

dimension of tarp: 60 mil thick with a width of 2R = 240 ft and a length of L = 450 ft

volume of tarp = Area x thickness = 540 ft^3

$W = (87.33 \text{ LBM} / ft^3)(540\ ft^3)(1 \text{ lbf-sec}^2 / \text{LBM } 32.1\text{-ft})(32.1 \text{ ft} / \text{sec}^2) = 47{,}160\ lb_f$

Therefore, $F_A = F_L - W = 9.53 \times 10^5 - 47\ 160)\ lb_f = 905{,}840\ lb_f$

Assuming 1 anchor bolt per foot around the perimeter of vinyl tarp,
perimeter = 2D + 2L = 1,140 ft

Therefore, 1,140 bolts are needed.

Force on each bolt = 905,840 lb_f/1,140 = 795 lb_f

This is the force on each anchor bolt to counter the aerodynamic lift of a minimal hurricane.

1. **Ethical Solutions**

   1. In order to apply the Golden Rule Test, the EPA site manager would have to ask whether he would be willing to exchange places with those living near the site. The narrative states that "chronic health threats range from carcinogenicity, mutangenicity, teratogenecity, and long-term respiratory impairment to death." It is doubtful if he would be willing to accept these consequences, certainly not without informed consent. So by the Golden Rule Test, he should notify the affected communities of the danger. The Rights Test would come to a similar conclusion. Not telling those who live nearby about the danger certainly violates the right to free and informed consent and possibly the rights to life and health as well. The results of the Utility Test might be somewhat more open to question. There might be some arguments that the public at large would not be affected by

the chemicals, and they would benefit from not having the tax dollars spent to clean up the site. However, a general policy of subjecting some citizens to unnecessary risk can produce social unrest and result in other consequences that do not promote the welfare of the majority, even if they are not directly affected by the toxins. In any case, the strong and clear conclusions of the first two tests probably justify informing those affected of the dangers, and cleaning up the mess as well.

2. As the last question indicates, considerations of general welfare should probably be overridden by considerations of the rights of individuals who can potentially be harmed and at the very least denied the right of free and informed consent. Besides, whether there is greater utility in refusing to inform the residents is not clear.

3. The site manager faces the fact that it may be ten years before the toxins are removed. In the meantime, the residents in the area could be exposed to various health problems. His first obligation is to inform the residents of the danger. He should certainly take steps to prevent the most obvious kinds of exposure. For example, he should prevent children from playing on "Mt. Dioxin." He may also be able to get some emergency funding to move the residents from the area. He should also arrange to have the health of the residents who chose to remain in the area constantly monitored. Students may be able to think of other creative ways to make the best of a bad situation.