



**Potential Uses of Bottom Ash for
Underground Pipe Coverings in Water,
Sewage, Drainage and Communications
Infrastructures**

Presented to the Coal Ash Board

By

**Professor Emeritus Naftali Galili
Faculty of Civil and Environmental Engineering
Technion – Israel Institute of Technology**



Expanded abstract

A comprehensive survey to examine the potential use of bottom ash as a covering for underground pipes was carried out. The purpose of the survey was to examine the potential use of bottom ash as filling material for the laying of underground pipes in water, sewage, drainage and communications infrastructures, taking advantage of the relative advantages resulting from the unique composition of the material, leading to savings in the natural and energy resources required for the infrastructures and in development work. To this end, the function of filling material used in the laying of pipes, the place of bottom ash in the international standards, its characteristics as a structural substance, and the conditions for laying stipulated by the standards, as well as the extent to which bottom ash meets these standards were surveyed. The survey culminated with a calculation example of the deflections obtained in the pipes at varying levels of stiffness, with the bottom ash serving as padding for the pipe and as filling to cover it, at the compaction levels defined in the standards. The main findings follow.

1. General properties of bottom ash

Bottom ash, a product of coal combustion in power stations, is composed mainly of silica and alumina. The grey, sand-like substance contains 10-25 percent fines. Coal ash in its various forms can serve as an effective engineering filling material. The grading of coal ash as an engineering substance is subject to the uniform classification system of the various soils. The application of bottom ash is carried out based on appropriate planning and testing methods, adapted to the corresponding soil types, and is strongly grounded in engineering standards and practices. The classification of bottom ash using the uniform classification system is SM – aggregate-granular containing more than 12 percent fines, and sometimes SP-SM, SW-SM, SW-SC, all of which are suitable for use as standard filling material for the laying of underground pipes.

2. Standards for the laying of underground pipes

During the survey, the standards for the laying of concrete, steel, fiberglass, PVC and polyethylene pipes were reviewed. Despite the enormous differences in the types of pipes and their properties, all the standards reviewed required similar laying conditions: deepening of the trench and preparation of an infrastructure for the laying of the pipe (if needed), the preparation of a layer of bedding, and compaction of the pipe socket, additional compacted filling up to the pipe axis and for semi-stiff and flexible piping, controlled filling to above the pipe head. The conditions for the laying of the pipe and classification of filling material are similar in the various standards, as is the case for the special conditions for the covering material: to prevent concentration of stress in the area of the pipe, to protect the pipe covering and as needed, to prevent the erosion of fines in the pipe area.

3. Adapting bottom ash to the standards

Bottom ash of various types is classified as a fine granular substance with fines, which can be found at the center of the recommendations for filling materials as defined by the standards. Bottom ash is consequently suitable as a filling material for the laying of pipes of all the types that were examined, as the primary bedding layer, as filling material for the pipe socket, as additional filling material up to the pipe axis in stiff pipes and as filling material up to the pipe head and above it in flexible and semi-stiff



pipes at compaction levels as determined in the specific standards for the various pipes. Bottom ash is also suitable for the unique demands of the standards because it has the right particle size and distribution, is free of hard masses and foreign bodies, it can provide uniform support and can protect the pipe from harm by foreign bodies, and as required, also minimize the movement of fines to and from the filling material during floods and near groundwater.

4. Prevention of pipe distortion with bottom ash fill

One of the main roles of the filling material in laying flexible and semi-stiff piping is to prevent distortion or ring deflection beyond the permitted levels for these pipes over time: 3 percent of the pipe diameter in steel pipes and pipes with internal steel coating, or 5 percent in fiberglass and plastic pipes of various types.

In order to examine the performance of the bottom ash, a calculation example of the pipe distortion under various conditions of laying and load were carried out, using bottom ash as a filling material. By way of exemplification, the given pipe distortion was calculated at a light to medium external load, for a steel pipe coated internally with cement coating, and also for typical fiberglass (GRP) and polyethylene (PE80) piping, at four levels of compaction of filling material.

It was found that at the mid-level compaction level, the level proposed in the standard for bottom ash (PSD 85-90%), all the pipes examined met the criterion of permitted distortion with an earth load at 3.0 meters, with considerable surplus; at a lighter load (with a covering of 0.9 meters, which is suitable for numerous projects), the various pipes met the permitted distortion criterion even at compaction levels lower than the level recommended in the standard.

The deflection calculation was carried out using the classic, conservative method, which does not include the contribution made by the stiffness of the earth at the site and by the depth of laying, to reinforce the support of the filling material of the pipe included in the new standards. These calculations, which were done according to the data in the literature, must undergo control tests, according to the standardization, before and during the laying of the pipes, unrelated to the type of filling material, in order to verify the planning data.

5. Advantages of using bottom ash to lay underground pipes

The main advantages of bottom ash as a covering material for underground pipes lies in its basic properties, which are documented in the surveyed standards:

- Bottom ash is a lightweight, granular structural substance that is stable and has drainage properties, which can serve as a suitable filling material for application at the required compaction level and provide structural support for the buried pipe as required by the standards;
- Because it is a well-defined industrial product, bottom ash should be able to serve as a bedding layer that prevents the concentration of force on the bottom of the pipe, and as a covering layer protecting the pipe and its coating from stones, masses and foreign bodies found in the soil, and in the materials used to complete the pipe covering;
- Because it has a wide particle distribution (granular substance with fines), bottom ash should meet the criteria for preventing the fines from being eroded from the natural soil to the pipe environs, making the geotechnical fabric that is required when using coarser filling materials unnecessary;



- The use of coal ash as an engineering substance also encourages the preservation of the soil and natural resources, saves energy and reduces the pollutant emissions involved in energy use.

All these aspects demonstrate that bottom ash, subject to the accepted standardization tests, is a preferred engineering material for underground pipes.

In conclusion: In light of the survey and computational test carried out, bottom ash was found suitable to serve as a preferred filling material for the laying of various types of underground pipes, from stiff concrete pipes to flexible plastic pipes, under varying soil and load conditions. As with any other filling material, the use of bottom ash is subject to the laying conditions and laboratory and field tests, in accordance with the appropriate standard for the pipe used.

Keywords: Coal combustion products, bottom ash, structural fill, pipe installation; concrete pipe, steel pipe, fiberglass (GRP) pipe, thermoplastic pipes, PVC pipe, PE pipe.