USE OF ELEVATED, CONCRETE BUILDING FOR "SANITARY LANDFILLS", "HAZARDOUS-WASTE LANDFILLS", MONOFILLS, AND COGENERATION FACILITIES

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ABSTRACT

The concept of the use of an elevated, prestressed, concrete building, the WAMASAL HIGHSTORE, was created to satisfy the need for safe and acceptable facilities for the indefinite storage (disposal) of hazardous wastes. The attributes that the buildings were designed to have make it possible to site them in or near almost any geographic location. Initial considerations demonstrated the economic feasibility of the WAMASAL HIGHSTORE system for disposal of hazardous wastes. The further analyses presented herein demonstrate similar feasibility for use of the system for cogeneration facilities and to replace municipal-garbage sanitary landfills and monofills.

INTRODUCTION

The WAMASAL HIGHSTORE was proposed originally for storage (disposal) of hazardous wastes. The building was designed to satisfy concerns regarding the safe management of hazardous wastes. The WAMASAL HIGHSTORE concept involves the use of above-ground, elevated permanent buildings. These buildings, constructed of prestressed concrete, would provide protection against seepage of leachate into soils and groundwaters, prevention of emissions of volatiles, and assurance of no contact of the wastes with precipitation. Even though the WAMASAL HIGHSTORE was designed originally for storage of hazardous wastes, its attributes are such that it could be used also to alleviate the crisis in managing municipal solid wastes in the United States.

People seem less paranoid about health hazards from disposal of municipal solid wastes than about hazardous-waste disposal. However, there is about as much resistance to new sanitary landfills as there is to landfills for hazardous wastes. Moreover, there is resistance to use of incinerators because of concerns that ash from incinerators may be classified as a hazardous waste.

Regardless of one's views of recycling or incineration of municipal solid wastes, there is currently a crisis caused by insufficient garbage-disposal capacity. New incinerators, recycling programs, and sanitary landfills are not being approved and implemented at rates sufficient to accommodate demands for disposal capacity. Currently, at least one third of the nation's landfills have four years or less of remaining capacity. Consequently, there follows an evaluation of the workability and financial feasibility of using the WAMASAL HIGHSTORE buildings for disposal of either municipal solid wastes or the ash that results from incineration of municipal solid wastes.

The greatest advantage in constructing and maintaining the WAMASAL HIGHSTORE buildings is that wastes would be stored almost 10 feet above the land surface. Should any leak occur, it would be readily detectable because the building is designed for sub-floor, walk-through inspections. Such buildings, which could be as large as 250 feet on a side, would hold enough wastes that millions of dollars of return could be realized on the investment in the construction of each building. These buildings could be constructed at virtually any location and thereby would provide for reasonable transportation distances and reduced costs. Such buildings would last for decades or centuries when maintained responsibly.

Because these buildings are inspectable, protect health and the environment, and are economically feasible, they offer an immediate solution to problems associated with current landfilling practices. Materials stored within the buildings also would be available when technology and economics make recycling feasible on a large scale.

In the following presentation, design features of the WAMASAL HIGHSTORE as a hazardous-waste storage facility are considered first. The authors then discuss use of the WAMASAL HIGHSTORE as a monofill, as a "sanitary landfill", and as a cogeneration facility. Finally, the authors address several questions posed at previous conferences and symposia.

DESIGN CONSIDERATIONS FOR DISPOSAL OF HAZARDOUS WASTES

The concept of above-ground storage of hazardous waste is not new. Lough, Gilbertson, and Riner[1] evaluated use of above ground facilities for storage of hazardous wastes for the Waste Management Board of Minnesota. They designed a facility for annual storage of 22,000 drums in a container building and 185,000 gallons in bulk-liquid tanks. The facility would require about 60 acres for an assumed operating life of 10 years. Provisions were made in their design for offices and equipment, treatment of on-site wastewaters, water and sewer systems, and wells for the monitoring of groundwater. Assuming state ownership and no return on investment, the authors determined the price for storage of hazardous wastes at the facility to be about $1,100 per ton.

Graybill[2] reported the potential for use of above-ground, on-site closures for containment of hazardous wastes. Such uses would incorporate civil-engineering concepts for design of above-ground, compacted, and formed shapes using solidified wastes. Waste sludges, for example, could be converted into materials having load-bearing capacities and soil-like consistencies that could be covered with compacted clay, topsoil, and grass which would protect the wastes from stormwater infiltration. A gravity-feed system for detection of leaks would be installed beneath solidified and compacted waste to warn of failure of the top liner. Because the structures would be above ground level, they would provide easy access from the top or sides for remedial work.

Graybill also illustrated use of vaults in which wastes would be enclosed by liners at the top and bottom and would be surrounded, in some instances, by reinforced-concrete walls. Leachate collectors would be located beneath the wastes. Graybill illustrated a hillside adaptation of the vault concept. Costs ranged from $25 to $100 per cubic yard depending on availability of on-site materials and characteristics of materials to be disposed.

Lough, Gilbertson, and Riner designed a facility specifically for storage of hazardous wastes for Minnesota. Graybill provided designs for construction of above-ground storage whereby wastes would become, in essence, a part of the structure. In contrast to their designs, the design proposed herein is for large concrete buildings that could be used to store hazardous wastes at virtually any location. The buildings in essence would be secure, above-ground, inspectable, hazardous-waste landfills.

The WAMASAL HIGHSTORE was designed after a set of building attributes appropriate for disposal of hazardous wastes were developed. The attributes addressed the geotechnical difficulties in siting hazardous-waste landfills, public opposition to such landfills, risks involved in transporting hazardous wastes to distant landfills or incinerators, concerns over threats to underground waters, and concerns for emissions of volatiles from landfills. The following attributes were selected in designing a building composed of modular, prestressed concrete:

- Provide for storage of wastes on an elevated floor to provide for direct inspection for leaks and to separate wastes from soils

- Prevent leaks onto and into soil using a concrete slab that also spreads the loading of the building (onto the supporting soils) so that geology and hydrology may be minimal concerns and thereby minimally restrict siting
- Provide for collection, analysis, treatment, and storage of any leachate—however miniscule—that might occur
- Provide for a structure of great strength that would withstand hurricane-force and reasonable tornadic-force wind loadings, contain large volumes of hazardous wastes, and have an extremely long life
- Provide a structure that could bear 150-pounds-per-cubic-foot loadings through optimal spacing of exterior and interior support walls
- Provide for either bulk or containerized storage of hazardous wastes
- Provide for drains to accommodate rainfall from the roof of the structure
- Size the structure for volumetric equivalence to a very large pit (for example, 500 feet by 500 feet and as high as feasible) such as might be used in existing hazardous waste landfills
- Provide for an almost air-tight structure through appropriate pouring and placement of concrete and through use of tight seams to joint precast, concrete members
- Control miniscule leaks and production of volatiles by maintenance of slight negative pressure within the building with draft blowers followed by activated carbon filtration to collect volatile organics for return to the building

BUILDING DESIGN FOR HAZARDOUS-WASTE MANAGEMENT

The original concept was for a building that would be 500 feet square. However, a maximal longitudinal dimension of 250 feet was selected to accommodate thermal expansion. A maximal gross vertical dimension of 70 feet was selected in response to the lateral loads exerted by 130-mile-per-hour, hurricane-force winds. Nominal, horizontal, module dimensions thus are 250 feet square. The 70-foot overall height provides for a useful storage depth of 60 feet, the depth of the roofing system, and the depth necessary for walk-through inspection below the floor upon which the wastes are deposited. Further, the 250-foot-square buildings can be constructed side to side and end to end thereby providing for a structure that is nominally 500 feet square.

Figure 1 provides a cutaway view of the building. The structure provides for passages for walk-through inspections, a strong double-tee roof, interior support walls, an elevated floor for support and containment of hazardous wastes, and a poured-in-place, concrete slab that spreads the load of the building and contents on soils. The elevated construction and supporting concrete slab preclude undetected migration of leachate onto and into soils.

The floor upon which the wastes are to be placed would be an 8-inch-thick slab that would be poured in place with its surface sloped to floor drains. The channel sections to support that floor would be 8 inches thick. The concrete floor could be sealed with epoxy or similar formulations or microsilica

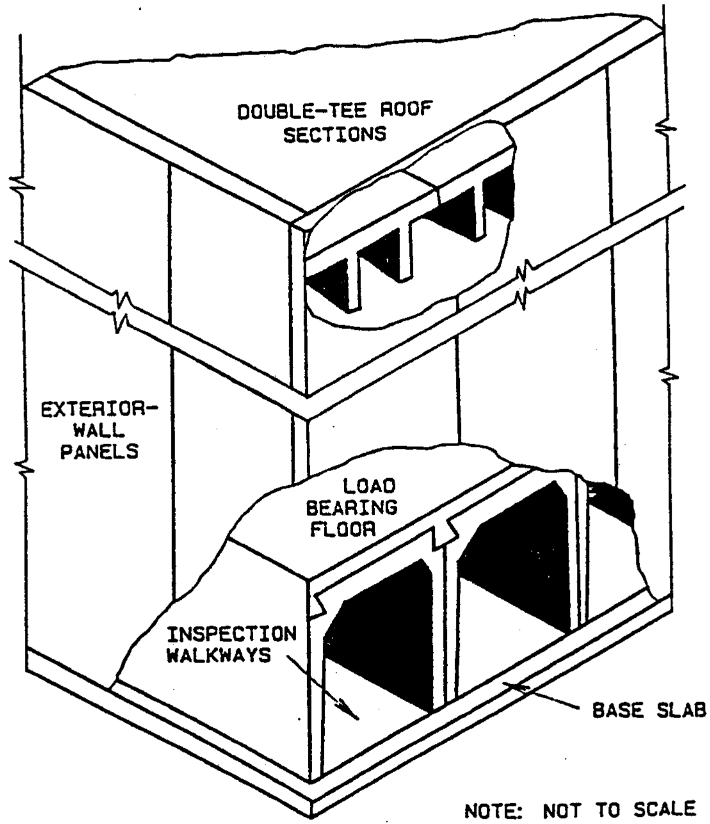

FIGURE 1
Sectional Perspective of Structure Showing Base Slab, Inspection Walkways, and Double-Tee Roof Sections.

could be added to the concrete to maximize resistance to spilled chemicals. Resistant synthetic liners or special containers could be used for storage of wastes that might react with the concrete floor. Trapped floor drains would allow visual inspection and easy sampling of any leachate from each drain and would be piped to a central point for appropriate treatment. Treatment of any leachate may include ion exchange, activated carbon sorption, and solidification for return to storage inside the building.

The foundation for the structure would be a 12-inch thick, post-tensioned, cast-in-place slab that is on grade. A continuous slab foundation would spread the structural loads onto consolidated soils or structural fills. In some locations, to satisfy specific building codes and on some foundation materials, additional enhancements of the foundation system, such as piling support systems that are not a part of the system proposed herein, may be necessary for the satisfactory performance of buildings like those herein proposed. The load- and floor-supporting, prestressed, channel sections and the exterior wall panels are placed and grouted onto the foundation slab.

A flat, membrane roof system with drains for storm runoff would be supported by prestressed, double-tee sections of nominal 50-foot span. The double-tee sections would be supported by special prestressed panels that would be placed side by side to form load-bearing walls. Interior support walls and the roof double-tee sections serve as shear panels to furnish the reactions for prestressed, outside wall panels that are designed to sustain

130-mile-per-hour wind loadings from hurricanes or tornadoes. The walls, which would be 8 inches thick, provide support for the roof while also providing for partitioning of wastes. The subfloor, inspection walkways provide ample room for visual inspection of the floor that supports and contains the hazardous wastes. Support for the load-bearing, storage floor, which is designed to sustain a live loading of 150 pounds per cubic foot of waste stored, is not a trivial structure. Precast channel sections were selected so that the legs of adjacent channels constitute load-bearing walls that support the storage floor, and the interior of the channels provide walk-through passageways for inspections.

DISCUSSION

Disposal of Hazardous Waste in the WaMaSaL Highstore

Wastes that are stored in a building such as the one described above can be fixed or solidified to prevent migration of any appreciable amount of leachate. To further reduce the likelihood of migration, wastes would not be placed directly upon the poured-in-place concrete floor that would support them. Wastes would be deposited upon a layer of a porous material such as geotextile or a layer of pea gravel. Such a medium would allow flow of leachate to the trapped floor drains and piping for collection, inspection, analysis, treatment, and disposal. One possible treatment for leachate is solidification using some sorbent that would be returned to the building for storage.

Runoff would be piped from the roof away from any contact with the stored wastes. The roof, walls, and floor join to provide a tight system for confinement of wastes. Joints and seams are designed for maximizing the sealing of air within the structure and for adding structural strength to the building. As noted above, wastes could be stored in such a structure to a depth of about 60 feet. The design consideration that limits the depth of storage is the hurricane-wind loading on the exterior walls of the structure. The exterior wall panels are designed to withstand those external lateral loads but cannot withstand significant lateral loads from within the building. For this reason, wastes cannot be placed against the exterior walls unless they are in containers and stacked so that they will never exert appreciable lateral loads upon the exterior walls. Beyond this constraint, wastes generally could be deposited in bulk. Bulk waste can be placed directly against the load-bearing walls that support the double-tee sections of the roof. Placement against the opposite sides of a given wall must progress in a balanced manner so that large, unbalanced, lateral loadings will not be exerted against the interior walls.

The foundation slab provides for additional separation of disposed wastes from soils and groundwater. The slab further provides for a spreading of the load of the building and its contents so that geotechnical constraints are minimized. Geology and hydrology are less restrictive factors as compared to siting of hazardous-waste landfills. However, structures should not be built over sinkholes nor over highly compressible soils that would allow large differential settlements.

Security that can be provided with the storage of wastes in such a structure is economical, and its degree is both predictable and high. The strength of the structure and its foundation protect against natural forces. Provisions for leachate collection, treatment, and disposal; visual inspectability of the bottom of the containment systems; and provisions for collection and removal of runoff from the roof will prevent contamination of soils or ground water. The maintenance of sub-atmospheric pressure in the building and the treatment of discharged gas over activated carbon prevent atmospheric contamination. Physical security against vandalism and terrorism would be promoted by the neat physical boundaries of the facility and the susceptibility of such a system to effective video monitoring of building and fencing boundaries.

Disposal of wastes in buildings described herein has many favorable attributes. The most important practical attribute of the WaMaSaL Highstore system is that it will be profitable for those who adopt its use. For many professionals, its most important feature will be that it is "protective of human health and the environment." The collection and removal of all storm water and the collection, monitoring, treatment, and satisfactory disposal of any leachate from the wastes preclude contamination of soils, groundwater, or surfacewater. The ability to walk and inspect beneath the stored material further guarantees that no water pollution will result from the storage of the waste.

Air pollution would be avoided by the system of durable and tight building components, the trapped floor drains, and maintenance of a slight negative pressure within the building. A blower can be used to maintain the building interior at a small negative pressure. Discharge from the blower would pass through an activated-carbon, sorption system to trap volatile organics. The sorbed organics can be incinerated or disposed inside the building. The air-handling system provides for removal of organic constituents from the air so that none escape and cause air pollution.

Control of volatiles and leachate reduce the likelihood of chemical reactions among the disposed wastes. Such reactions are further precluded if wastes are segregated within the compartments created by the walls that support the roof. The compartments can be specially equipped to accommodate wastes that might react with the concrete floor or other physical components within the structure. Compartmentalization of wastes also provides a means for maintaining an inventory of wastes for recovery of future raw materials. Such an inventory also would provide for research inspections to determine effects of wastes on containers, liners, or sorbents.

People inherently distrust invisible mechanisms and processes. From buried waste deposits, people fear that hazardous waste components will leach and flow through the soils to contaminate underground waters. Containment systems and monitoring systems around waste-disposal facilities represent considerable fractions of facility costs. Public concerns and costs make it desirable to prevent contact of wastes with the ground and to provide a demonstrable separation between the ground and wastes. One method of providing this separation is to store wastes on an upper floor in a reinforced concrete building so that an inspector can walk below the floor and inspect for any leakage.

With a working storage depth of 60 feet, each square foot of floor area can store about 2.2 cubic yards. At a ratio of 2 cubic yards per square foot of floor area, a 250-foot-square module can be expected to store about an eighth of a million cubic yards of waste. At a construction cost of about 90 dollars per square foot, that cost represents approximately 45 dollars per cubic yard of stored waste. Currently, average cost for disposal of wastes in a hazardous-waste landfill is about 100 dollars per ton. Although ratios for converting tons to cubic yards vary, a conservative estimate of one ton per cubic yard can be used. This produces a gross profit of 55 dollars per ton of waste disposed in the proposed buildings. Thus, each 250-foot-square building could provide for greater than six million dollars of income above the direct costs for construction of a building. Because disposal can be local, the transportation costs associated with other methods of disposal improve the attractiveness of the proposed method.

The buildings proposed herein may offer solutions to many future waste-storage problems. A most significant use for the buildings may be for disposal of ash from municipal, solid-waste incinerators. These buildings could substitute for monofills, which are being considered for management of ash from municipal incinerators. Because geology need not so stringently control the location of the buildings as it does the locations of underground depositions, the buildings can be located for ease of use and convenience and safety of transportation of wastes. Each state or city could have a building. The buildings could be located to minimize exposure of the public to wastes. A building could reasonably be located in or adjacent to an industrial park. The exteriors of the structures are strong, constitute a well-defined boundary between the waste and the rest of the world, and can be treated architecturally to harmonize well with other industrial buildings.

The accessibility and safety of such buildings provides for many alternatives for management of hazardous wastes. For example, wastes can be segregated and their locations recorded. Maintenance of such records provides for recovery of raw materials and for research regarding effects of wastes on liners, containers, or sorbents, or for research on other aspects of managing hazardous wastes. Wastes within the buildings also could be recovered for incineration, recycling, or other treatment as capacity or technology is developed. Schedules could be developed for use of available mobile incinerators or processes to destroy or treat certain wastes as such processes become available.

The WaMaSaL Highstore as a Monofill

The U.S. Environmental Protection Agency currently is evaluating whether ash from waste-to-energy facilities (incinerators) is a hazardous waste. If the ash is deemed to be hazardous, then it must be disposed in hazardous-waste landfills or possibly in specially designed, single-purpose landfills (for example, a monofill). The WaMaSaL Highstore is ideal for the disposal of ash from incinerators for the same reasons that it is ideal for the disposal of hazardous wastes. For example, ash would be stored 10 feet above grade and would be inspectable and available for recovery and recycling.

Because such buildings can be constructed at almost any location, an ideal situation for managing municipal solid wastes would be to construct a single-purpose facility consisting of an incinerator and a WaMaSaL Highstore. Incineration generally achieves a reduction of 90 to 95 percent of the initial volume of municipal solid wastes. A WaMaSaL Highstore of maximum dimensions of 250 feet by 250 feet by 70 feet (with a depth of storage of wastes of 60 feet) provides for disposal of about 138,000 cubic yards of wastes. The authors, to provide for limited loading of exterior walls and as a conservative economic approach, have assumed a nominal storage capacity of 125,000 cubic yards. Using a 90 percent volumetric reduction, the ash from 1.25 million cubic yards of municipal solid wastes could be disposed in a WaMaSaL Highstore Highstore.

Using the following simplistic, but reasonable, assumptions one can evaluate the economic feasibility of using the WaMaSaL Highstore as a monofill:

- 90-percent-volumetric reduction of 1.25 million cubic yards of solid waste by incineration produces 0.125 million cubic yards of ash to dispose
- density of tipped garbage of 700 pounds per cubic yard (achieved through use of large garbage-hauling trucks with powerful compactors)
- 1.25 million cubic yards of garbage at in-truck densities of about 700 pounds per cubic yard would weigh 875 million pounds or about 437,000 tons
- at $135 per ton the tipping fees for 437,000 tons of garbage would be $59,000,000
- approximate cost of one WaMaSaL Highstore $6,000,000
- difference $53,000,000

The use of the tipping fee of $135 per ton in the preceding computations is to allow those along the eastern seaboard who face such charges to assess the value of the system to them. Others located in areas characterized by lower rates should substitute their costs if they wish to evaluate the system for their use.

Obviously, this does not include the costs associated with construction and operation of an incinerator. However, the tremendous potential gross revenue simply associated with the capability for disposal of the ash, as well as the potential for selling electrical and thermal energy and a reasonable operational life for the incinerator strongly favor use of the buildings. Further, the increased likelihood of siting a building for disposal of the ash when compared to overcoming public opposition to siting a landfill for disposal of the ash favors use of WaMaSaL Highstore buildings. Moreover, the building provides for disposal of the ash at greatly reduced costs compared to disposal of it in a hazardous-waste landfill ($45 per cubic yard instead of $100 per cubic yard).

By using an incinerator to reduce the volume of wastes to be disposed by 90 percent, a WaMaSaL Highstore could accommodate the ash from garbage produced (at 1,000 lbs/person/year) by 87,500 people for 10 years.

The ash from an incinerator sometimes could be heavy because it contains water that becomes mixed with the ash during the scrubbing of exhaust gases. The WAMASAL HIGHSTORE is designed to support loadings of 9,000 pounds per square foot. Thus, there will be no problem in disposing of moist ash from incinerators into the WAMASAL HIGHSTORE. The underdrain system would collect any exudate from the ash.

The WAMASAL HIGHSTORE as a "Sanitary Landfill"

Again, because the buildings can be constructed almost anywhere, an ideal situation for managing municipal solid wastes would be to construct a single-purpose facility consisting of a high-pressure garbage compactor/baler adjacent to a WAMASAL HIGHSTORE. High-pressure balers could achieve densities of a ton per cubic yard of baled garbage. This is equivalent to the estimate used to evaluate the economic feasibility of disposing of hazardous wastes in the WAMASAL HIGHSTORE. Using a density of one ton per cubic yard, the WAMASAL HIGHSTORE could be used to dispose of 125,000 cubic yards of garbage. Thus, the gross economics are as follow:

• Gross revenue from 125,000 yd^3 at $135/ton (where 1 ton = 1 yd^3)	$16,900,000
• Approximate construction cost of one WAMASAL HIGHSTORE	$6,000,000
• Gross Profit	$10,000,000

Operating and maintenance costs are not available for the preceding analysis because no one has operated such a facility to date. If such a building were designed to be filled during 24 months it is estimated that it could be operated for that duration for a total not greater that a million dollars, and once it was filled, maintenance should average no more than fifty thousand to one hundred thousand dollars per year. These costs for operation and maintenance must be subtracted from the gross profit described above with due attention to the temporal value of money in order to make predictions of possible net profit.

Additional attributes, beside economic feasibility are:

- Construction of the compactor and building(s) at the same location
- Minimal binding of bales practicable due to proximity of the disposal building to the baler
- Minimal handling of compacted garbage (bales) due to proximity to the baler
- Baled garbage can be transported to the disposal building using conveyors
- Ease of stacking of the bales in the WAMASAL HIGHSTORE
- One building could serve 25,000 people for 10 years

Obviously, details for control of odor and prevention of explosions due to presence of methane must be considered for any final design. These limitations can be overcome and can be used to advantage as is discussed below.

Cogeneration and the WAMASAL HIGHSTORE

As has been noted previously, the WAMASAL HIGHSTORE was originally designed for control of hazardous wastes. As a consequence, the buildings were designed to be reasonably air tight so that volatile organics could not escape. This "air tightness" of the WAMASAL HIGHSTORE provides an ideal configuration for capture of the methane resulting from decomposition of garbage and for subsequent production of electrical and thermal energy.

Although specific designs require further research, perforated piping for capture of the methane could be attached to the interior walls of the WAMASAL HIGHSTORE. The piping could be placed, vertically, at intervals of, for example, 50 feet for ready capture of the methane. The methane could be conveyed to a header and cleansing system and then be burned to produce electrical and thermal energy. Such a system easily could be installed and would be, obviously, less costly than drilling wells into landfills as commonly is being done today for the capture of methane.

Additional research is needed to develop methods for keeping flammable gases at concentrations well below the lower explosive limit during emplacement of garbage. However, these obstacles should be surmountable.

The possibilities for successful management of municipal solid wastes seem vast. Additional ideas for the use of elevated, concrete buildings for the management of municipal solid wastes include:

- Inoculation of garbage with bacteria to catalyze the breakdown of the garbage and the concomitant production of methane
- Supplying nutrients to enhance bacterial degradation of garbage and production of methane
- Maintenance of ideal moisture conditions to enhance bacterial degradation of the garbage
- Feedback of thermal energy from cogeneration to enhance bacterial breakdown of garbage
- Intermittent inspections of rates and characteristics of degradation through controlled entry into the buildings or through electronic methods of monitoring

RESPONSES TO INQUIRIES ABOUT THE WAMASAL HIGHSTORE

Aesthetics

The authors have received several questions about the aesthetics of 70-foot tall concrete buildings. The architectural treatments available for exterior concrete are limited only by the degree of genius of the improviser. Some may object to the non-uniform color of freshly cast concrete. However, the appearance of the concrete becomes much more uniform with the exposure to weathering.

Form-coating compounds are available that will react with the adjacent cement paste of newly placed concrete. After removal of the forms used to cast the concrete, the paste at the outside surface can be removed with a high-pressure, aqueous washing to expose the aggregate at the treated surface and thereby provide a pleasing texture. Sandblasting of the exterior surfaces of cured concrete panels can provide a similar but different finish. Another textured surface can be provided through bushhammering of the exposed concrete surface. Form liners made of polyvinyl chloride (PVC) can be used to provide textures of greater depth than the surface treatments just described. If textures of extreme depth are desired, the attachment of cast, architectural, concrete panels to the exterior of the walls of the building can be provided. The purpose of the panels is architectural amelioration, and they seldom are used as a structural portion of the building they adorn. Such architectural castings rely upon the use of PVC form liners and can provide surfaces having the shape of any desired brick or stone masonry. Similarly, there are available many patterned form-liner designs that produce abstract textures or imitations of natural textures. Limitless patterns of such different textures on different panels are available to the artful designer.

The costs of texture modifications for the exterior surfaces of the walls should be considerable but not exorbitant. The walls to be modified represent only about 20 percent of the cost of the structure, and a 10-to-20-percent increase of the cost of the walls for the aesthetic improvements would represent a cost increase of less than 5 percent of the cost of the overall structure.

Costs For Site Preparation

The cost of site preparation was included in the $90-per-square-foot, estimated construction cost for a WAMASAL HIGHSTORE store. That preparation cost is about five percent of the cost of the structure. Not included in the estimate was the cost of the detailed engineering design services that would be necessary for matching the overall design to a particular site in the detail that would allow completion of all the permitting that construction of such a facility would require. The estimated construction costs of about $90 per square foot were developed for the market of the southeastern United States that includes the bordering states of Mississippi, Tennessee, and North Carolina. The estimate that was developed for the southeast is applicable for most of the rest of the nation. There are, however, some expensive markets where labor rates are sufficiently higher than those of the southeastern estimate that the estimated cost should be increased by 20 to 30 percent. Another additional cost allowance of from 2 to 5 percent may be prudent in some cases to allow for more-complicated-than-usual access roadways.

Design Alterations

Designs for WAMASAL HIGHSTORE, to date, have been general and of a nature that allowed assessment of feasibility. Some readers have asked questions concerning such details as the possible locations of doors and the nature of doors that would likely be used in a WAMASAL HIGHSTORE. The wall panels are elements that form the entire vertical, confining structure of the building, and embedded steel elements in adjacent panels will be welded to each other to form the vertical, encapsulating structure of integral high strength. With appropriate planning, doors can be located almost anywhere within the structure. The doors can be of almost any design or style. Where a high degree of security is desired, materials such as stainless steel can be used for doors and other exposed metal hardware without significantly affecting the overall cost of such a building.

Catastrophic Damage

Some who have considered the use of a WAMASAL HIGHSTORE have expressed concern about what kinds of catastrophic damage might possibly occur to such a structure and about what means might be available for the repair of that damage. If sufficient damage were suffered by one of the structural elements so that it could not function satisfactorily, the construction techniques are such that the damaged panel(s) or section(s) could be removed and be replaced. Those who have expressed such concerns have been helpful because their apprehensions suggest to future designers that they make special provisions to increase the ease with which such repairs may be made.

In answer to questions about the types of damage and likely causes of damage to such buildings that might be expected, the experience in the southeastern United States, to date, indicates that they will be very damage resistant. Recently, a Cessna, light, private airplane crashed into a condominium located on the gulf coast of Florida. That building was constructed of materials and in a manner very similar to those proposed for the WAMASAL HIGHSTORE. Subsequent examination of the condominium revealed that it had suffered no structural damage as the result of the airplane collision.

Resistance Of Concrete To Chemical Corrosion

The use of microsilica as an additive to the concrete to improve the resistance of the concrete to chemical corrosion was included in the first proposal of the WAMASAL HIGHSTORE. Since that time additional experience, in the United States, with use of the microsilica as an additive to prestressed concrete has indicated that such addition is desirable for improving the resistance of concrete to chemical corrosion and for other reasons. Unconfined, compressive strengths of 12,000 pounds per square inch have been attained with the addition of appropriate amounts of microsilica to the concrete. Addition of the microsilica to the concrete results in a power-of-10 reduction of the permeability of the concrete. These attributes have caused the major producer of prestressed concrete in the southeastern market to use microsilica routinely.

Areal Site Requirements

A practical problem of interest to people considering construction with precast elements of prestressed concrete is the amount of site area that is required for construction and as a materials staging area. With more area available, the construction can be planned to proceed more conveniently. When the site is most extremely constricted, the minimum area acceptable is sufficient room from which the erecting crane can operate and sufficient parking space for a truck from which an element is being unloaded. Usually a clear space of 50 feet around the building is required for the erecting crane. In the tightest sites, as little clear space as 50 feet along the entirety of one outside edge of the building being erected will suffice because the building can be erected from the inside out.

SUMMARY

The 250-foot-square building proposed herein satisfies the required attributes deemed necessary by the authors for environmentally safe, long-term disposal of either hazardous or municipal wastes. The buildings are inspectable, should be acceptable to the public, and are economically feasible. Each building constitutes a module that can be placed at the ends or sides of similar buildings to maximize storage capacity. Wastes can be stored on elevated floors to separate wastes from the supporting soils. Additional separation from soils is provided by the slab foundation, which spreads the loading of the building onto the supporting soils and reduces geotechnical and hydrogeologic constraints on siting. Leachate from the building can be collected, analyzed, and treated. Undetected leaks of leachate are virtually impossible because of the inspection passages beneath the floor upon which wastes would be stored. The building has great structural integrity which insures that it will be immune to the vast majority of natural damaging forces.

The system is not foolproof. A thoughtless operator could allow creation of an explosive mixture in the atmosphere of the building during the storage operations. A careful operator can prevent such an occurrence through the careful practice of ventilation during placement.

The building is practically air tight and provides for control of miniscule leaks of volatiles through use of a system to maintain a slight negative pressure and to capture volatile organics for incineration or storage in the building.

The WAMASAL HIGHSTORE system provides for an environmentally safe yet economically feasible method for disposal of either hazardous or municipal wastes. Interpretation of gross economic estimates indicate that each building could provide a substantial profit to an operator.

In addition to being environmentally safe, inspectable, and economically feasible, the buildings proposed herein could be constructed in a relatively short period of time. Because technologies for massive recycling and minimization require years to develop, these buildings could be the solution to the predicted scarcity of space for both hazardous waste and municipal waste disposal.

Adoption of the subject proposal is likely to require regulatory changes. If the modules are treated as units for extended storage of future raw materials, they may be perceived to be exempt from consideration under current law for the regulation of the disposal of wastes. Whether society decides that such facilities require regulation, the proposed system protects the environment and health, is inspectable, is economically attractive, and offers immediate solution to current problems in hazardous and municipal waste disposal.

DISCLAIMER

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