DESIGN OF DRYSTORE FOR INTERMEDIATE LEVEL WASTE

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ABSTRACT

A new concept in dry radwaste store design has been developed which makes possible significant reductions in project cost and timescale when compared to existing facilities designed to meet current regulations. This new store design eliminates three of the major cost items normally found in stores of this type; the product support structure, the engineered shield floor and the requirement for a heavy shielded charge crane. By the use of novel structural features, the problem of seismic enhancement within the product storage matrix has also been eliminated.

This paper describes the main features of the store design and shows how the modular concept can be tailored to suit specific requirements. The design parameters and objectives for the study are identified and the chosen configuration and associated structural design philosophy are described. Major areas of cost benefit inherent in the design are considered, and the various advantages offered by the concept over alternative installations are highlighted

INTRODUCTION

Intermediate Level Waste (ILW) from the nuclear industry covers a wide spectrum of waste types, the largest components of which are those arising from fuel reprocessing and decommissioning operations. The storage and disposal of this waste presents difficult political and environmental problems and interim storage facilities will be required whilst decisions on long term policies are formulated and implemented. Costain Engineering and Design Group Partnership have initiated a design study for an ILW store with the aim of providing substantial benefits over known existing designs in terms of cost and construction time, whilst satisfying the integrity required by both UK and international current regulations.

To establish a basis for the design, a definition of ILW was first required. It was apparent from available literature that there was no internationally accepted definition of ILW. That proposed and accepted by the Sizewell 'B' enquiry in the UK is as follows: "ILW: Wastes with levels of activity exceeding the limits for Low Level Waste, but not requiring the heat generated by radioactive decay to be taken into account in the design of storage facilities", (1). The U.K. Department of the Environment instigated an assessment of the Best Practical Environmental Options (BPEO), for the management of conditioned ILW and LLW, and, as part of this study, a survey of waste storage facilities in Europe was conducted (Ref. 2). This report provided an insight into current thinking in store designs and enabled a critical review of existing sites to be made with a view to providing a conceptual design which overcomes present problems and concerns, whilst satisfying the regulations within an economic framework.

BACKGROUND

The present situation in the UK is that ILW is stored unconditioned at source. An encapsulation facility is under construction at Sellafield to condition MAGNOX cladding waste arising from the 'decanning' plants. The cladding waste is encapsulated in a cement matrix within 500 L stainless steel drums. A dry store building, with a capacity of 12,000 product drums is currently being built alongside the encapsulation plant.

Ultimate disposal of conditioned ILW from both operation and decommissioning activities will be provided by NIREX within a deep repository. However, plans for this facility will be subject to political and environmental structures and it is unlikely to be available before 2010. Bearing in mind the current pressure for immobilization of wastes, interim dry storage facilities will therefore be required. In addition, if it is deemed practical to separate out short half-life material, it may be beneficial to store this waste in an interim facility until it can be handled as LLW or it can be handled without restriction, so reducing the quantity of material for final disposal.

A number of important problems require investigation during the design and construction of a store. These are related mainly to seismic categorization, the nature of the product stored, dropped loads, shield floor design and the design of the product support system. The seismic categorization has a significant effect on design and construction. As the specified category becomes more severe, so the reinforcement requirements of the structure become more massive and the design analysis becomes more complex. The potential consequences of a dropped load incident and the requirement for a large number of individual shield plugs have led to the adoption of very complex and expensive shield floor structures in some current radwaste store designs.

The review of European stores (2) suggested that most stores containing LLW or ILW have involved little or no consideration of seismic events, with drums stacked together in large arrays. It is also not clear what, if any, allowance has been made for gas seepage from drums due to internal corrosion or reaction of the encapsulated waste. In addition the identification, isolation, and retrievability of a leaking drum from these stores could be very difficult, and it would appear that most of these facilities have a number of shortcomings, especially in relation to long term integrity.

It is believed that few, if any, of the stores considered in the survey would meet current UK regulatory requirements.

STUDY DESIGN PARAMETERS

The following broad remit was established as a basis for the development of a conceptual design.

- A reduction in project cost, compared with known acceptable alternatives.
- A reduction in overall project time, particularly with respect to that required for construction.
- Increased flexibility of design, notably with regard to store capacity and the provision of services.
- Design integrity in accordance with current UK regulatory authority requirements.
- Minimized and simplified product handling.

A basis of design was formulated recognizing that waste could be sent to a store packed in various shapes, especially those arising from future plant decommissioning. However it was apparent that drummed waste was likely to constitute a major proportion of ILW arisings. The following basis was therefore adopted:

- The waste is received at site in 500 litre drums, packed in returnable NIREX flasks.
- The store to have a capacity of at least 4000 drums stored in air.
- The store to have a minimum design life of 50 years and be capable of withstanding a design basis earthquake.
- The total facility to provide for monitoring, inspection and retrieval of product with minimum radiation dose uptake.
- Reduced costs and construction times whilst providing design flexibility and integrity compatible with regulatory requirements.
- Simple and efficient remote product handling and inspection with the feasibility of handling decommissioning wastes.

DESIGN CONFIGURATION

To reduce seismic effects on the design of the store structure, the center of mass should ideally be as low as possible with no significant structure above the charge floor. The higher the elevation of a large mass, such as a crane, the higher will be the seismically induced acceleration. In addition, large voids within the structure are undesirable since they require the addition of complex steel structures to both support the product and to transfer seismic loadings induced in the product stack, back to the walls. The design concept which has been developed (Fig. 1) overcomes these problems by the use of a relatively low structural profile and by mounting the charging mechanisms and associated shielding on a mobile trolley at charge floor level. The storage space is subdivided in both longitudinal and transverse directions by integral reinforced concrete walls, which also carry the rails for the charge trolley.

The size of store modules selected represent only one possible solution to a given storage requirement. It is not suggested that this is necessarily the optimum configuration for any particular situation but it is put forward as an eminently workable choice with structural thickness of walls and final layout established to suit.

The layout selected for evaluation is based on the construction of a series of rectangular reinforced concrete storage modules. Each module is a rectangular reinforced concrete structure (Fig. 2) and is divided into cells by internal reinforced concrete walls. The total capacity of each module is approximately 4000 drums. The *charge floor* is made up of reinforced concrete slabs each within a mild steel casing. There are 15 slabs per cell, each slab weighing approximately 12 tones. The product drums will be packaged in mild steel simple frame construction stillages, 5 product drums per stillage. Each stillage incorporates seismic restraint buffers, located on the full height continuous corbels, which are integral with and equally spaced along the longitudinal walls of the storage cells.

MECHANICAL SYSTEMS

It was recognized that an important philosophy of store design was the need to keep the handling of drums to a minimum and as simple as possible in order to reduce the risk of accidents or damage. The mechanical systems can be considered in three main groupings:

- Product handling facilities in the receipt and export areas.
- Product handling facilities in the stores area.
- Facilities and services required for the operation and management of the stores complex.

Receipt and Export Areas

The product handling facilities in the receipt and export area can be sub-divided into three facilities comprising a Railbay, a flask preparation room and a product drum handling cave and associated viewing room. The Railbay contains facilities for the receipt, from a railway network, of product drums packaged in standard shield flasks, and for transferring flasks to the flask preparation room. Each flask contains four product drums in a stillage, and whilst in the bay the drums are contained within the shield flask and present no radiation problems. The Flask Preparation Room is equipped with a flask posting port in the room roof forming an access to the railbay and closed by a door. The flask is transferred into the drum handling cave on a power driven bogie, and a shield door separates the drum handling cave from the railbay. A Rail track connects the rooms via the shield door, and equipment and facilities for un-bolting/bolting the shield flask lid and for storing the bolts is incorporated in this area. Whilst in the flask handling room the product drums are still contained within the shield flask and present no radiation risk.

Within the drum handling cave the product drums are removed from the shield flask and re-packaged in stillages

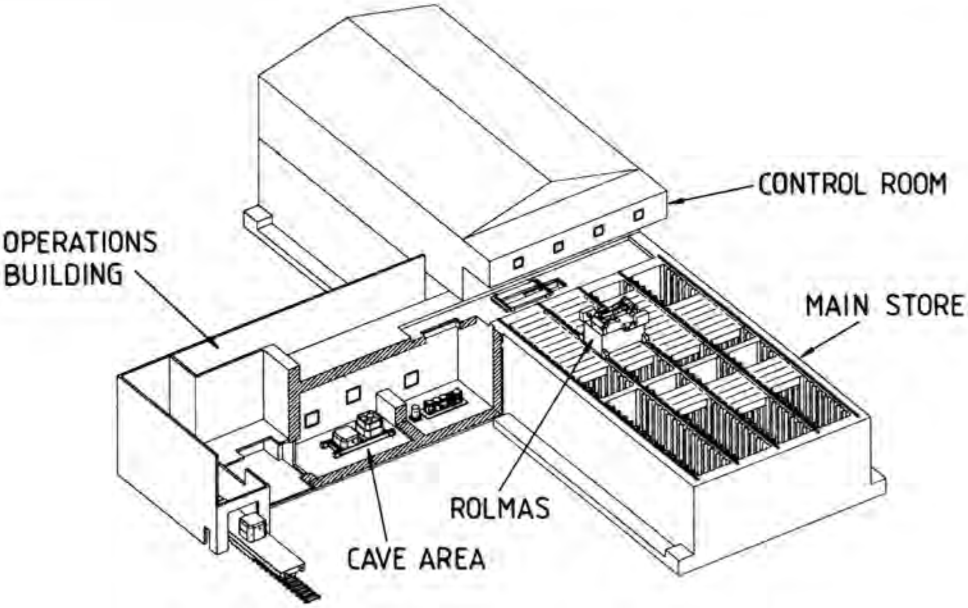

Fig. 1. Drystore For Intermediate Level Radioactive Wastes.

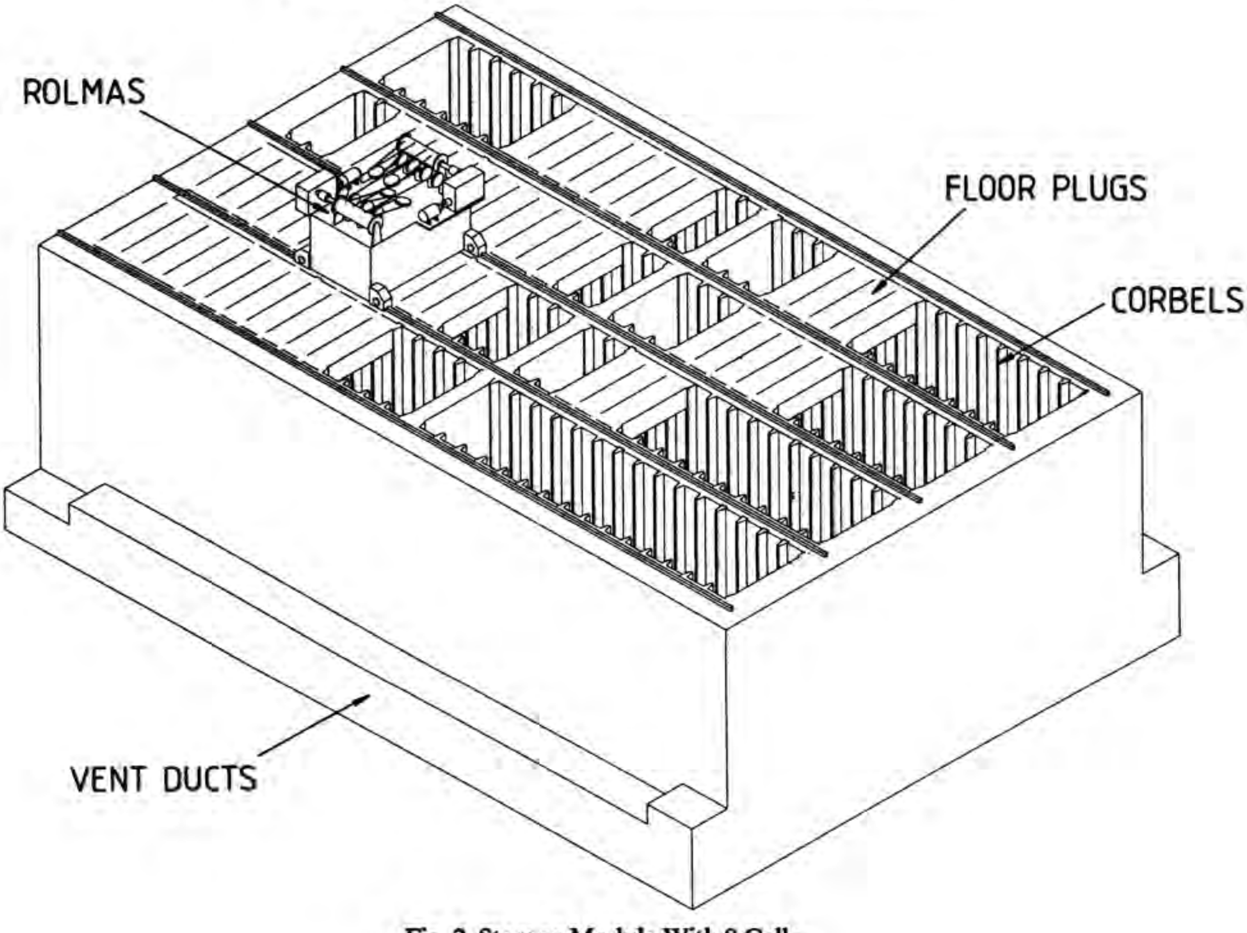

Fig. 2. Storage Module With 8 Cells.

suitable for use in the product store area. These store stillages accept five drums inline. The stillage in which the drums were originally contained remains in the shield flask and is returned with the flask.

The drum handling cave equipment comprises a rail system for the shield flask bogie and a flask de-lidding station. A product drum unload station and associated drum inspection facility are also included. A store stillage posting port in the cave roof directly above the stillage load station provides stillage export access to the store charge floor level and is closed by a port plug. A product drum and store stillage handler transfers drums and stillages to the various positions in the cave area. A viewing facility is situated along one wall of the cave and is equipped with controls for all functions in the cave.

STORES AREA

Handling Facilities in the Stores Area

These facilities comprise two main systems consisting of a ROLMAS (Remotely Operated Lifting Mechanism and Shield) Vehicle and a Cross Travel Vehicle. The ROLMAS is the essence of operations at the charge floor level (Fig. 3) and performs a number of functions. Those specific to product handling include lifting the stillage to the required store position under shielded conditions, and the removal of floor plug and lowering of stillage into the store whilst maintaining the shield. The ROLMAS is essentially a thick steel box providing shielding mounted on wheels and incorporating two lifting frames side by side. It typically covers the area of two floor sections whilst spanning one cell width and travelling on rails mounted on the cell walls.

The ROLMAS is propelled by a variable speed geared drive connected directly to two of the vehicles four rail wheels. Positioning of the vehicle is by local locating sensors. Power and instrument connections to the ROLMAS vehicle are via festoons which are suspended from overhead rail and trolley systems. The festoons are anchored to and fed from the cross travel vehicle. The hoist motors and drives are mounted on top of the ROLMAS shield box with four wire hoist ropes entering the shield box to each lifting frame. The lifting frames themselves incorporate four twistlock lifting attachments that key into the stillages and the floor plugs. The same standard connectors are proposed for both the floor plugs and the store stillages in order to provide flexibility of operation and back up lifting facility.

The ROLMAS is designed to manipulate simultaneously a stillage and a floor plug. During store charging it operates by removing a floor plug with one of the lifting frames whilst the other frame carries the loaded stillage. The ROLMAS then moves across by the pitch of one floor section so that the stillage is positioned over the open channel and is subsequentially lowered into the store. The stillage is then released, the lifting frame retracted back into the ROLMAS which moves back one pitch such that the plug is over the vacant floor space into which it is then replaced.

In addition to the product handling task the ROLMAS will be used to provide remote viewing of the product store stacks by TV camera housed in the stillage hoist portion of the ROLMAS shield box (Fig. 4). The vehicle is used to manipulate the camera over the space between the produce store stacks and under the store shield plug support beam. The camera attachment incorporates camera pod swivelling and horizontal traverse as well as raise/lower traverse of the camera itself.

The cross-travel vehicle is a wheeled carriage which traverses on rails between the adjacent ends of the store modules (Fig 1). It is used to transfer the ROLMAS from the cave stillage port station to the required set of rails for the appropriate line of storage cells. The cross carriage has rails mounted on it which match those feeding the store cells and allow a short longitudinal movement of the ROLMAS. This enables the ROLMAS to lift the cave stillage port plug and then position itself over the access port to lift the stillage to charge floor level. The cross carriage is powered from the festoon cable system feeding the ROLMAS. Both the ROLMAS and the C.T. vehicle are observed and remotely controlled from the stores control room gallery, positioned above the cross carriage track.

Ancillary Services

In the area under the cross travel vehicle railtrack between the store modules, a facility would be provided for the servicing of the lifting frames. These would be lowered from the ROLMAS into a purpose built equipment maintenance area. A second area under this railtrack is utilized for the ventilation equipment and HEPA filters. This gives the cross carriage and ROLMAS another important function since the ROLMAS can be used for filter changing and handling. Access to the filters would be via ports in the floor under the cross carriage using the same principle as for the port area to the cave.

Ventilation

All the enclosed and utilized spaces within the store will be mechanically ventilated and the system will provide the following facilities:

- Maintain containment barrier concept.
- Temperature and humidity control.
- A means of accurate radiological monitoring.
- Provide standardization of design.
- Provide system of purging of off-gas.

Area classification for radiation and contamination zoning has been undertaken and all necessary change rooms embodied into the layout to link the variously classified areas throughout the store complex. In the event of accidental damage to a stillage or drum leading to a release of radionuclides it may be necessary to increase ventilation during clean up. This requirement would be met from the existing vent system which would be suitably rated to cater for the extra load. Each cell would be permanently connected through dampers and ducts to the cave active ventilation system such that any cell could be isolated for clean up as required.

The store module construction, with internal walls, which have high radiation shielding value, sub-dividing the

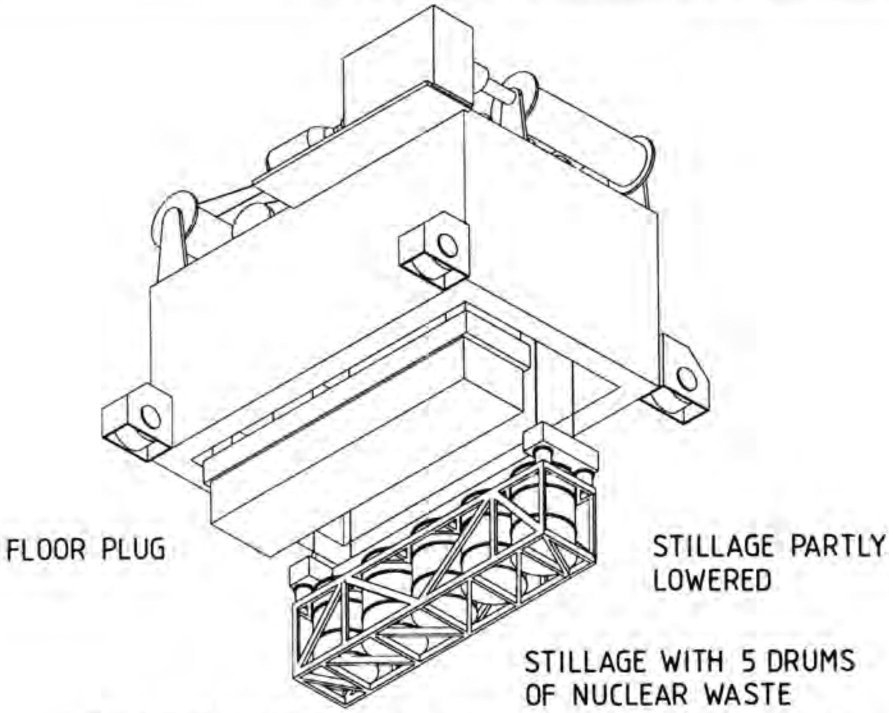

Fig. 3. ROLMAs-Remotedly Operated Lifting Mechanism and Shield.

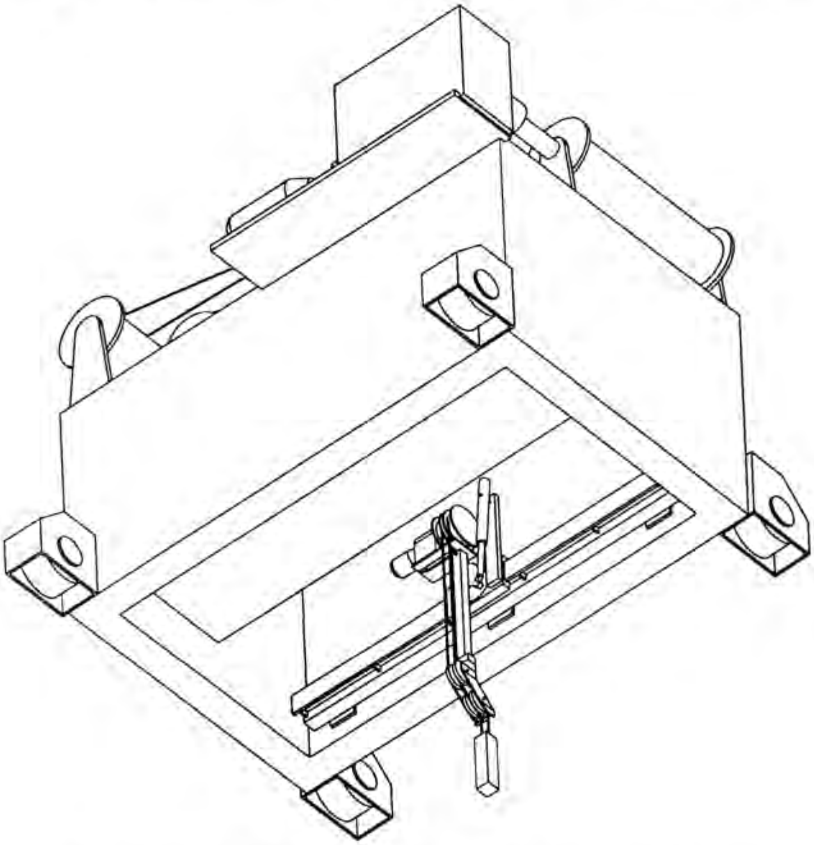

Fig. 4. ROLMAs With Inspection Gear in Unfolded Position.

store space into smaller cells, facilitates the de-contamination of a cell should a handling malfunction create a radiological hazard. Any progressive build-up of contamination from small sources, such as 'breathing' drums or minor accidents in the store space can be controlled in a store of this cellular construction.

Emergency Operations

Successful functioning of the whole facility depends on the reliability of the various items of equipment and although the system has been designed to use only relatively standard units performing simple operations, some failures or difficulties however unlikely, must be considered. Where practical, powered items will be provided with low speed, hand wind, back-up systems. Potentially a most difficult emergency problem would relate to the mishandling of a drum in the cave simultaneous with failure of the cave crane. Duplicated crane drives and retrieval systems are provided but failure of the drum grapple may be more difficult to overcome. For this reason these items are designed as high integrity units with important functions duplicated. Access would be provided for a remotely controlled manipulator. Consideration has also been given to the possible contamination of local areas of the drum handling cave and the storage modules during an emergency.

STRUCTURAL DESIGN AND CONSTRUCTION

The basic design service conditions incorporate dead loading derived from all elements of the structure, and live loading from the ROLMAS rolling loads. Consideration has also been given to extreme environmental and accident conditions that could cause an abnormal structure loading, these include seismic events and dropped load scenarios. The seismic analysis is based on a zero period acceleration for horizontal ground motion equivalent to 0.25g without permanent deformation or loss of shielding to the concrete containment structures. A worst case 0.35g horizontal zero period acceleration analysis ensures that overall shielding integrity is not compromised and retrievability after an event is possible. An accident involving a stillage or drum drop has also been assessed to ensure that structural containment is not affected.

The store foundation can be based on either a raft or piles depending on site soil conditions. The reinforced concrete walls in each store module act as in-plane shear walls, transferring lateral seismic and wind loads to the foundations. Vertical gravity loads of the stillages and product drums are supported directly on the foundation slab. The precast shield floor plugs span between the walls of each storage cell. The horizontal seismic forces from the stillages are transferred via the continuous wall corbels into the store walls, and hence to the foundations. Tests on a sample design have demonstrated that the structure is seismically stable and that the required 'shielding' thicknesses are adequate to provide seismic qualification.

The storage capacity of the plant may be increased by the addition of extra modules. Each additional module will be built with an isolation/movement joint between the existing and new structures. This joint will reduce the effects of structure to structure interaction due to seismic and thermal loadings, and eliminate the generation of torsional forces between the two structures. Connections between the two structures such as roof purlins and charge rails, will be articulated to facilitate long term settlements between the two structures. Hence the structural isolation of each module unit from its neighbor results in a self contained analysis which imposes no restraints on future loading regimes of the individual modules.

CONCLUSIONS

A design of dry radwaste store capable of accepting drummed waste or crates of decommissioning waste, and offering significant cost and technical benefits has been developed. A total remotely operated system of emplacement monitoring and inspection provides radiological protection and contamination containment with minimum risk from accidents or emergency operations. The basic structure provides flexibility of storage with proven construction methods and satisfies current regulatory requirements for high integrity plant.

REFERENCES

1. Layfield Report on Sizewell B, Volume 3, Chapter 41. Categories of Radioactive Waste.
2. Survey of Stores for Conditioned Intermediate and Low Level Wastes in Europe. Radioactive waste management research program 1985/86. DOE Report No. DOE/RW/85/158.