THE DESIGN AND CONSTRUCTION OF A TEMPORARY STORE FOR RADIOACTIVE WASTE

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ABSTRACT

The paper describes the practical aspect of the design and construction of a temporary store for 12 Half Height ISO (HHISO) containers filled with radioactive waste destined for ultimate disposal sometime in the future. This installation has recently been completed at a nuclear power station site in the UK. Included are descriptions and the comparisons of the different shielding arrangements available to the authors, together with the final choice based on the need for a safe but temporary storage and radiation protection solution, which could be easily dismantled and moved to another location, with the minimum production of secondary wastes. Another important feature was the reduction of worker exposure to radiation to as low as practical.

Also described are the detail descriptions of the hollow, interlocking polyethylene block form of shielding employed, the method of production of the blocks as well as the installation of the system to the original design layouts employing labour unfamiliar with the block system. The installation descriptions demonstrate the speed at which the 3.75 metre high walls were constructed and filled with water, as the shielding medium, progressively as the installation proceeded.

Finally, the paper will deal with a number of difficulties encountered during the installation phase and the methods employed to overcome these problem areas. To illustrate the subject, the authors include the original design concept and photographs of the store during and on completion of the construction.

INTRODUCTION

The Hunterston A Magnox Power Station is currently being decommissioned and as a result, is producing large quantities of low-level solid radioactive waste. This waste is mainly sludge arisings encapsulated in 200 litre drums and is stored in a number of half height ISO containers. To ensure efficient disposal operations these HHISO containers require temporary storage in a shielded area before being sent for disposal. The following describes the process of providing a suitable temporary storage facility for these HHISO containers.

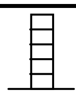
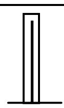
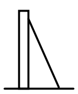
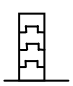
CONSTRUCTION CHOICE

Although the Hunterston Site Engineers came to their own conclusion regarding the type of shielding construction that should be employed for storing 12 HHISO containers, the authors had already undertaken a study [1] to compare the principle features of concrete block (250 mm thick), poured dense concrete (200 mm thick), steel (70 mm thick) and interlocking polyethylene block systems (500 mm thick filled with water). The comparisons were based upon a 6 metre long wall, which was 3 metres high, and with a return at each end which was 2 metres long. In each case, it was assumed that after dismantling sometime in the future, the waste arising could either go as a) LLW or b) non-active waste, for disposal, to an appropriate site. The construction costs calculated include design element, on-site labour, manufacturing, installation, contamination precautions, demolition, decontamination, disposal and recycling operations.

The comparison indicated some interesting factors. For example, the design elements of the steel wall and poured concrete wall were considerably higher than the other two candidates. The clean-up and disposal costs for the dismantled concrete block and the poured concrete walls were much more than in the other two examples. The initial cost of the polyethylene block wall [2] compared very favourably with the steel wall although more expensive than either of the concrete based walls. It is obvious from the summary in Table 1 below that the short construction time associated with the interlocking block system leads to a reduced operator radiation dose uptake during booth installation and decommissioning periods, and that the majority of the same blocks will be re-usable. This re-use factor also leads to a diminution of the waste disposal factor. Although the reduced disposal costs have been taken into account in all cases reviewed, it was impossible to put a cost saving on the reduced or increased dose uptake aspect.

From the detailed cost review, the authors reached the firm conclusion that the interlocking

Table I. Summary of Comparison of Construction Costs.

Construction Type	Cost with LLW	Cost with no LLW	Cost of 2nd wall with no LLW	Time on site (weeks)	Reuse value	Notes
Concrete Blocks 	£20,397[1]	£13,647[3]	£13,647	4	Nil	
Poured Dense Re-enforced Concrete 	£25,159[1]	£19,759[3]	£19,759	6	Nil	
Steel Wall & Support Structure 	£52,895[1]	£32,435[3]	£32,435	6	£1,860	Scrap value
Interlocking Polythene Blocks 	£29,692[2]	£26,081[4]	£7,761	2	£18,320	All blocks re-usable

Note 1 – Assumes all materials resulting from decommissioning are disposed of as LLW
Note 2 – Assumes a small number of blocks need disposing of and replacing
Note 3 – Assumes all waste is eligible for disposal as industrial material
Note 4 – Includes a credit for 1% replacement of damaged blocks

Polyethylene blocks filled with water was the system to be recommended, particularly as the higher initial cost would be recouped over a number of additional applications. Although the site engineers responsible for the decommissioning programme at Hunterston A Decommissioning Site undertook an independent review of the available construction systems, they reached the same conclusion as the authors of this paper. As a result BNFL Environmental services at Hunterston placed an order on the suppliers of the interlocking polyethylene blocks [3] to design and construct a temporary store for 12 HHISO containers. The principle features of the blocks and the store itself are detailed in the following section.

THE MRP INTERLOCKING BLOCK SYSTEM

Designed and developed in the late 1990's, the interlocking, hollow plastic block was intended to obviate the need for labour intensive concrete structures and the inherent high cost of disposal of such structures, for shielding radioactive processes. The largest module of the block system, the Full Wall Block, measuring 1000 mm long x 750 mm high x 500 mm thick weighs some 33 kgs and can, therefore, be lifted by two people. Other designs of block are available based on the Full Wall Block dimensions. Holes are provided in the side faces of the blocks to permit them to be fixed together with 4, 3 or 2 hole plates, depending on the combination of blocks used in the construction. Figure 1 shows Full Wall, ½ Wall and Full Corner units.

The block system adopted by Hunterston A Decommissioning Site engineers has been subjected to numerous test programmes prior to being put into practical use. For example, an empty block has been vertically loaded to 5 tonnes, the equivalent of a base block of a wall some 8 blocks high (6 metres) each filled with concrete. The empty block was also loaded to 5 times this design load and although

Fig. 1 Full Wall, ½ Wall and Corner Blocks

somewhat distorted, the block did not rupture and recovered most of its original shape on relaxing of the load. Horizontal stability tests have been done on a stack equal to 6 blocks high. The block interlocking joints have also been tested with a radioactive source, and proved to be highly efficient. Other tests undertaken on the blocks during the construction programme include low temperature exposure to see the effect of freezing water within the block structure and lifting of water filled blocks with a specifically designed single point lift grab. The effect of accidental collision impacts has also been researched, which could occur, particularly as the Hunterston HHISO containers were to be loaded into the shielded area after construction had been completed.

STORE CONSTRUCTION

BNFL specified that the HHISO container store should be constructed within the redundant Charge Machine Maintenance Building and that where possible, the existing exterior south concrete wall of the CMMB should be utilised to provide part of the overall shielded enclosure. The thickness of shielding required around the HHISO containers was stipulated to be the equivalent of 900 mm of water.

The author's calculations indicated that when, employing water filled interlocking blocks, then a double layer of blocks would be required within the CMMB. But on the external south wall, the existing concrete wall, augmented by a single layer of water filled blocks would be adequate to meet the BNFL specification. It was also proposed to use a traditional labyrinth opening for the personnel access into the shielded facility. For security, the labyrinth was to be closed with a simple, lockable door assembly.

As the interlocking, water filled blocks were to be built 5 units high, vertical structures were provided both inside and outside the block form, tied at the bottom through the existing concrete floor and connected at the top with a substantial screwed rod and nut system. The positioning of the complete shielded structure was determined by placing the west wall against an existing wall within the CMMB. To supplement the vertical structures, fixing plates were to be used at numerous locations to stabilise the structure in the event of an accidental collision when loading the HHISO containers into the store. These plates employed M16 screws directly into the polyethylene blocks employing Helicoil inserts.

During this design phase of the work, a number of investigations were carried out. For example, as the water filled blocks exterior to the CMMB might conceivably be subject to frost, a review of the extreme local weather conditions revealed that -10^0 Celsius was the lowest recorded temperature in the Hunterston area. This discovery led to two more relevant investigations. Firstly, if an anti freeze solution was to be used, employing a chemical additive, this could prove to an environmental problem when emptying the blocks and secondly, what degree of frost would the blocks sustain successfully? Using salt as the antifreeze additive would have solved the first problem, but it does take a considerable quantity of salt up to 20% by weight. Freezing tests carried out in a cold store showed that the water within the blocks eventually froze after at least 5 days at a temperature of -25^0 Celsius and, it was concluded that additives would not be required as the local freezing temperatures would only last for a few hours and would not cause damage to the blocks. The insulation of the block materials provides sufficient protection from freezing in normal UK weather conditions. Collision tests indicated that the water filled block was capable of withstanding over 1000J impact force.

The finalised design of the HHISO Container Store is shown in Fig. 2 below.

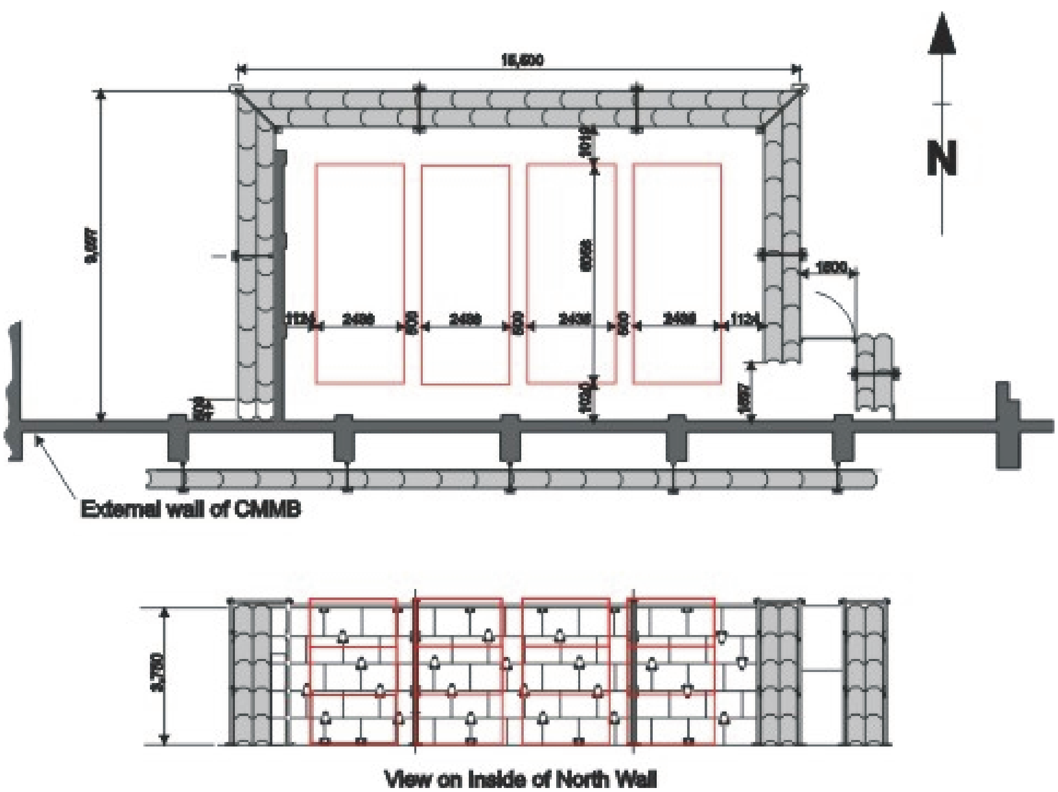


Fig. 2 Design Layout of HHISO Container Store

STORE CONSTRUCTION PROGRAMME

The original programme was based on allowing time for the site induction and checking the floor layouts so that installation work could proceed smoothly using a small team of installers. The typical installation team anticipated: One engineer to direct proceedings; One supervisor/foreman; Two technicians; One forklift truck/crane driver. Finally a period of installation of the peripheral doors and fixings was allowed. The installation period was based on the placing of one layer of blocks, filling them with water and then moving on to the next layer. As the design included for a total of up to 500 blocks, the intention was to layout empty blocks, approximately 20 blocks at a time in the appropriate position connected together before filling with water and moving on to the next 20 blocks. The time to place and fill 20 blocks was based on trials which showed that the main time constraint was the water filling and this could take up to 15 minutes for each large block. Thus 20 blocks could consume up to 5 hours to fill utilising 2 feed pipes for the water supply. It was anticipated that with a 6 hour effective working hours per day, within the radioactive supervised areas, then a rate of 20 blocks per day it would take up to 25 working days (5 weeks) to install the 500 blocks.

In the event, there were site issues unrelated to the store construction, which held up progress and extended the full construction programme. From the date of delivery of the blocks to final completion took over 10 weeks.

Other issues directly related to the store block construction arose which had to be resolved and led to improvement to the designs and experience for future dismantling/construction programmes. These issues included:

- Levelling of the floor and stabilisation of the outer wall
- Leaks from the Helicoil insert positions
- Leaks from a small number of faulty mouldings

These are described in more detail below:

Levels

The inner wall was being assembled on the floor previously used by the Charge Machine and this was extremely flat and solid. The external wall was constructed on a concrete area where there had been signs of a palletised store and this looked level. On closer inspection, the external floor had a slight incline, which needed packers under the bottom layer of blocks to level the base layer. In previous walls of 2 or 3 blocks high any minor discrepancy in the levels could easily accommodate any assembly tolerances, but it was found that at 5 units high the tolerances appeared to multiply. Additional bracing jacks were used to level up the external block wall and jack back out against the steel support struts.

Helicoil Leaks

The blind holes in the blocks were tapped to accept 16mm Helicoil inserts that can then be used to attach plates, etc. with M16 set screws. It was found that during the tapping and insertion process the Helicoils could penetrate the 5mm solid polyethylene layer, thus providing an unacceptable leak path. Some initial problems were experienced using 40mm long Helicoil inserts in 40mm deep hole and this was resolved by reducing the Helicoil lengths to 32mm. Later it was found that if the Helicoil was not inserted with the coils closely packed, then even the 32mm long unit could extend and penetrate the 5mm layer at the bottom of the moulded holes. Further investigations of these issues are continuing.

Faulty Blocks

Some 6 blocks out of the 500 supplied, leaked from a base seam. When traced back to the manufacturers record, there appeared to an initial batch where there were problems with a vent from the rotational mould, which then led to high pressure in the mould cooling air, resulting in a gap in the lower block seam. This resulted in an ongoing investigation of a suitable pressure test of all blocks before despatch.

During the construction the installation team had to disassemble parts of the wall and reassemble to ensure a correct build with sound blocks. The single point lifting grab and forklift truck were used to carry out this work without emptying the blocks. The installation team became very experienced in handling the blocks being able to construct walls at a rate of about 50 blocks per hour.

An illustration of the completed Temporary Store for Half Height ISO Containers is shown in Fig. 3.

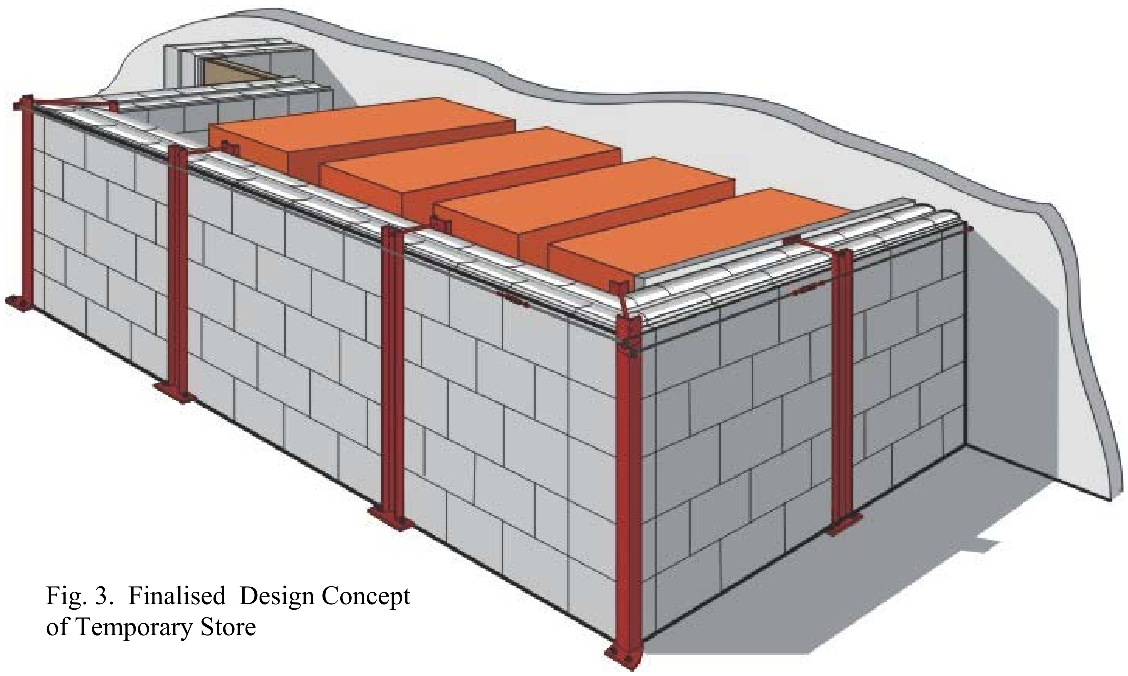


Fig. 3. Finalised Design Concept of Temporary Store

The photographs in Fig. 4 show the finally installed facility.

Internal View of North and East Walls External View of North and West Walls

Fig. 4. Completed Installation of Temporary Store Constructed from MRP Interlocking Blocks

CONCLUSION

This large, practical construction project for a shielded store for a number of HHISO containers has been successfully completed at the Hunterston A Decommissioning Site, employing the MRP modular block system. Many lessons have been learnt in the construction, handling and quality testing of this product. These include: Construction times are dependent on the time taken to fill end block with water and this can be reduced to approximately 3 minutes. The helicoil problems have led to the development of a moulded in thread, eliminating the additional thread cutting. The steel setscrews and fixing plates have been replaced by nylon and polyethylene to reduce the manhandling issues of the large plates. The early leak failures have been eliminated by the development of an accurate leak tests after manufacture.

In addition, the installation team at Hunterston has had valuable construction experience, which will lead to efficient dismantling of the store and the subsequent reconstruction programme at a new location sometime in the future.

ACKNOWLEDGEMENTS

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REFERENCES

1 Report - Mobile Waste Solidification Plant for BNFL Magnox Generation, June 2001.

2 A Mobile Radiological Protection System by J. Sims presented at the Waste Management Conference WM’01 in Tucson, Arizona, February 2001.

3 MRP Systems Ltd, PO Box 71, Marple, SK6 5XB, UK.