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UK ABWR Generic Design Assessment

Generic PCSR Chapter 10 : Civil Works and Structures

Hitachi-GE Nuclear Energy, Ltd.

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Executive Summary

This chapter describes the civil engineering safety case for the main buildings and facilities for the UK ABWR. It lists the high level Safety Functional Claims that are made on these structures together with the Safety Property Claims that demonstrate compliance of the civil engineering design with the Nuclear Safety and Environmental Design Principles.

This chapter describes the main features of the key civil structures that would be required for a single ABWR unit (see PCSR Chapter 9: General Description of the Unit, for general description). The structures included in the GDA process are those where the overall design will be similar for most site specific conditions, and so are appropriate for any of the UK Government's eight candidate nuclear licensed sites.

The structures in the scope of this chapter include the Primary Containment Vessel, main stack and Safety Class 1,2 and 3 buildings. Tank facilities, comprising of foundations and basement structures, and service connections/tunnels are also included.

The information provided for each of the structures includes: system design, including general structure layouts; functionality in normal operation and during faults; safety categorisation and classification; justification of design methodologies; safety case assumptions; Limits and Conditions for Operation; resistance to withstand hazards; and compliance with the ALARP principle.

The designs of the Safety Class 1 structures are well advanced for GDA, being largely based on proven technology from the Japanese ABWR reference design. The design of Safety Class 2 and 3 structures is less advanced, but is sufficient to demonstrate these structures are appropriate in the UK. Additional risk reduction measures have been introduced (with reference to the J-ABWR design) in response to safety assessments undertaken in GDA. These include designing the Reactor Building to be resistant to aircraft impact, and the addition of the Back-up Building for additional resilience from external hazards following learning from the Fukushima Daiichi event.

This chapter concludes that the civil engineering structures of the UK ABWR generic design are sufficiently robust and tolerant to internal hazards and external hazards. The structures will protect the nuclear safety systems, structures and components that they support and provide the required containment safety functions.

The chapter demonstrates that the risks associated with the design and operation of the civil engineering structures for the UK ABWR are ALARP. It is acknowledged that further work will be required post-GDA to develop the design and fully incorporate site specific aspects. This work will be the responsibility of any future licensee.

10.1 Introduction

Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE) has developed the Advanced Boiling Water Reactor (ABWR) and is submitting the UK ABWR design to the UK Regulators under the Generic Design Assessment (GDA) process. The GDA safety case is described within the generic Pre-Construction Safety Report (PCSR). See PCSR Chapter 1: Introduction, for the overview of the generic PCSR.

This chapter of the PCSR describes the safety requirements and the design principles for all the UK ABWR civil works and structures that are within the scope of GDA. This chapter lists the Safety Functional Claims (SFCs) that are made on these structures to maintain the high level safety functions (HLSFs) during normal operational conditions and fault conditions. It also lists the Safety Property Claims (SPCs) that apply to civil structures generally. The SFCs and SPCs have been written in accordance with the “GDA Safety Case Development Manual” [Ref-02], and these are presented in Appendices A and B. This chapter demonstrates compliance of the civil engineering structures with the UK ABWR Nuclear Safety and Environmental Design Principles (NSEDPs) [Ref-03].

Chapter 10 is underpinned by a number of Level 2 documents, the Basis of Safety Cases (BSCs), and there is a BSC for each of the civil structures in the GDA scope [Ref-04 to 18]. See Appendix C for the document map for Chapter 10 and its supporting documents.

The abbreviations and terms without explanations in this chapter are referred from “Abbreviations and Acronyms List” [Ref-19] and “UK ABWR Glossary of Terms” [Ref-20].

10.1.1 Background

This section gives an introduction to the safety requirements and design principles which are described in more detail in the body of this chapter.

10.1.1.1 Safety Requirements Overview

The UK ABWR civil structures are designed according to the safety function categorisation, the classification of the systems, structures and components (SSCs) and the seismic categorisation based on the SSCs housed in the structure [NSEDP Principle BP4.6]. See PCSR Chapter 5: General Design Aspects, Section 5.6 for the categorisation and classification systems for SSCs.

The UK ABWR civil structures are designed for the following conditions. These are described in Section 10.3 for general principles and in Section 10.4 on a building by building basis.

a) For Normal Condition

These are the conditions during normal operating conditions. For variable loading, such as external hazards, normal conditions are defined as having a probability of exceedance of 10^{-2}/y.

- Physical support of the SSCs housed within the civil structure.
- Confinement of radioactive materials.
- Provision of shielding against radioactivity.
- Providing the internal environment conditions appropriate for each SSC, primarily protection from the weather and groundwater ingress and also to provide the conditions required for building ventilation systems.
- Cooling of spent fuel outside the reactor coolant system.
- Limiting the effect of external hazards for normal condition on the SSCs inside the building or supported by the structure.

- Functions required for operational working, including arrangements for workforce, materials and vehicles.

b) For Fault Conditions

These are design basis conditions for the design of civil structures in accordance with Principle BP4.7 [Ref-03].

- Physical support of SSCs which deliver safety functions.
- Confinement of radioactive materials.
- Provision of shielding against radioactivity.
- Providing the internal environment conditions appropriate for SSCs which deliver safety functions.
- Cooling of spent fuel outside the reactor coolant system.
- Limiting the effect of design basis external hazards on the SSCs inside the building or supported by the structure. For fault conditions, the magnitude of external hazards used in design for Class 1 structures is specified in BP4.7 [Ref-03].
- Limiting the effect of design basis internal hazards on the SSCs inside the building or supported by the structure by providing barriers where required.
- Prevention of hazard/fault propagation.
- Supporting functions for on-site emergency preparedness.

10.1.1.2 Overview of Design Principles

The following principles are incorporated in the design of civil structures:

- Applicable UK Regulations and permitting regime [Principle BP11.3].
- Design codes and standards appropriate to the safety category and class of the structures [Principle BP8.3].
- Appropriate design methodologies with justification [Principle BP4.1 and BP8.1].
- Appropriate design conditions and loading for the required safety functions over the lifetime of the plant [Principle BP4.3].
- External hazards as evaluated for normal conditions and for design basis conditions [Principle BP4.7, BP4.10 and BP7.3].
- Internal hazards resulting from design basis fault conditions [Principle BP4.7, BP4.10 and BP7.3].
- Design for Examination Maintenance Inspection and Testing (EMIT) regimes [Principle BP8.8].
- Design items arising from the radioactive waste management safety case [Principle BP8.10].
- Design items arising from the decommissioning safety case [SP5.3.9, BP8.2 and BP8.10].
- Design items arising from the construction plan [BP8.2].

10.1.2 Document Structure

The structure of Chapter 10 is as follows:

10.1: Introduction	This section introduces the safety functions and design principles of the civil structures and how this chapter links to the other chapters in the generic PCSR.
10.2: Purpose and Scope	This section defines the purpose of this generic Chapter 10 and the scope of which civil engineering structures it covers for the GDA. For generic links to GEP (Generic Environment Permit), and CSA (Conceptual Security Arrangements) documentation, please see Generic PCSR Chapter 1. For GEP, where specific references are required, e.g. in Radioactive Waste Management, Radiation Protection, Decommissioning, these will be included in the specific sections within the relevant chapter.
10.3: General Principles for Civil Structures	This section provides an overview of safety claims made for the civil structures. The categorisation of safety functions and safety classification of SSC in this chapter conform to the methodology described in PCSR Chapter 5, Section 5.6. Additionally, the general requirements for Equipment Qualification, Examination Maintenance Inspection and Testing (EMIT) and codes and standards that come from this safety categorisation and classification are also described in Chapter 5、sections 5.7 and 5.9, respectively. Further details can be found in the EMIT section of the corresponding Basis of Safety Case document referred to for the PCSR section. General requirements related to conventional safety aspects are described in PCSR Chapter 4: Safety Management throughout Plant Lifecycle, Sections 4.7 and 4.8.
10.4: Safety Claims and Design Principles for Civil Structures	This section provides more specific description of each of the civil structures included in GDA scope, the safety functions and other design criteria.
10.5: Codes and Standards	This section summarises the design codes and standards and design guidance documents used for the civil engineering structures.
10.6: Beyond Design Basis Condition	This section provides the explanation of the Beyond Design Basis Condition for civil engineering structures.
10.7: Assumptions, Limits and Conditions for Operation	This section gives a summary of the assumptions and the limits on civil structures during operation.
10.8: Summary of ALARP Justification	This section gives a summary of the how the ALARP principle is considered in the civil engineering design.
10.9: Conclusions	
10.10: References	
Appendix A: Safety Functional Claims Table	This appendix provides a table for each civil structure in GDA scope which lists the safety functional claims against each HLSF.

Appendix B:	Safety Property Claims table	This appendix provides a table of the safety property claims for GDA civil structures, which apply across the design. The table of SPCs, shown in Appendix B, were derived for the topic area covered in this chapter based on the 'guide word' approach specified in Hitachi-GE's Safety Case Development Manual [Ref-02]. Having derived the SPCs, a mapping exercise was undertaken to ensure that the SPCs fully cover the relevant NSEDPs applicable to the topic area. More information on the development of SPCs, and the coverage, at the more detailed level in the safety case, to demonstrate full compliance with the relevant NSDEPs is presented in Chapter 5.3.
Appendix C:	Document Map	This appendix illustrates the documents which provide the arguments and evidence to support the claims made in this generic PCSR chapter.
Appendix D:	Internal and External Hazard Mapping	This appendix summarises which hazards are considered in the design of each individual building.

The document map of this chapter is shown in Appendix C.
The civil engineering design must provide the functions required by the plant and equipment and the evaluation of the hazards for design basis loading conditions and beyond design basis assessment. Therefore, Chapter 10 takes input from practically every chapter of the PCSR as follows.

- Chapter 2: Generic Site Envelope for the characteristics of the generic site envelope.
- Chapter 4: Safety Management throughout Plant Lifecycle.
- Chapter 5: General Design Aspects for approach and method for safety categorisation and classification and for seismic categorisation.
- Chapter 6: External Hazards withstand requirements for normal conditions and fault conditions.
- Chapter 7: Internal Hazards withstand requirements for design basis.
- Chapter 8: Structural Integrity for requirements of major nuclear plant items.
- The Technical Systems Chapters – Chapters 9 to 17, for details (bounding) of the SSCs supported by the building for the purposes of building design and performance under all conditions.
- Chapter 9: General Description of the Unit (Facility).
- Chapter 13: Engineered Safety Features.
- Chapter 18: Radioactive Waste Management, for claims relating to radioactive waste management.
- Chapter 19: Fuel Storage and Handling, for claims on support of mechanical handling equipment.
- Chapter 20: Radiation Protection, for claims related to protection against direct radiation and contamination control.
- Chapter 22: Emergency Preparedness, for claims relating to working conditions and access/egress.
- Chapter 24: Design Basis Analysis, for claims on civil structures related to the fault schedule.
- Chapter 25: Probabilistic Safety Assessment.

- Chapter 26: Beyond Design Basis and Severe Accident Analysis, to provide the criteria for assessing the civil structures performance under these conditions.
- Chapter 27: Human Factors for claims relating to human occupancy and working conditions.
- Chapter 28: ALARP Evaluation.
- Chapter 29: Commissioning for the design and commissioning of major nuclear plant.
- Chapter 30: Operation for building arrangements.
- Chapter 31: Decommissioning, for claims on structures from the decommissioning plan.

General requirements for decommissioning of the systems, structures and components within this chapter scope are described in PCSR Chapter 31: Decommissioning. The related claims are summarised in Chapter 31, Section 31.2.

10.2 Purpose and Scope

10.2.1 Purpose

Detailed design of the civil structures will continue beyond the end of GDA and so the purpose of this chapter is to specify the safety and other requirements and the design principles that have been used in the generic design of the UK ABWR. These requirements can then be taken forward into the detailed design for the site specific ABWR.

These civil engineering requirements are based on the safety information for SSCs as detailed in the systems PCSR chapters. The civil engineering design provides input into the assessment chapters of the PCSR, i.e. for the design basis assessment, the PSA, the beyond design basis assessment and the ALARP evaluation. See Section 10.1.2 for chapter descriptions.

Chapter 10 is underpinned by a number of Level-2 documents, Basis of Safety Cases (BSCs), which support the chapter. There is a BSC that covers each of the civil structures in the GDA scope [Ref-04 to 18]. The BSCs signpost to Level-3 supporting documents which provide the details of the justification of the design during GDA. These supporting reports deal with aspects such as structural design, seismic analysis, concrete reinforcement design, codes and standards, etc.

See Appendix C for the document map of the civil engineering documents supporting this generic PCSR chapter.

10.2.2 Scope

This section describes the scope of UK ABWR civil structures to be assessed in the GDA process. A list of the structures is given in Table 10.2-2, in order of their category and class and grouped according to type of structure. Section 9.4.1 of the PCSR Chapter 9: General Description of the Unit, gives an overview of the conceptual site plan used in the generic design, and of the main buildings included in the scope of GDA. The generic site layout is based on one ABWR unit.

The civil structures to be assessed in the GDA process are those where the design is predominantly independent of the site specific conditions, and so should be appropriate for any of the UK Government candidate sites within the UK. These structures house nuclear safety related plant and equipment (which provide Class A and B functions and generally comprise all Safety Class 1 and 2 structures. The exceptions to this are the Service Building (S/B) and Radwaste Building (Rw/B). However it must be noted that the internal layout of the S/B will be dictated by the future licensee's requirements and that the Rw/B design is still at conceptual design level for GDA.

The plant items given in Table 10-2.1 are included in GDA scope, but the structures (Civil Engineering) associated with them are not. This is because the provision of the plant for the UK ABWR is included in the safety case, but not its location or arrangement of the building housing it since these are more appropriately addressed by a future licensee for the specific site.

Table 10.2-1: List of UK ABWR Civil Structures Excluded from GDA

Plant Item:	Associated Civil Structures:
Suppression Pool Water Surge Tank (SPT)	NOT included • Suppression Pool Water Surge Tank (SPT) Structure • R/B-SPT Connecting Service Tunnel
Diverse Alternative Generator (DAG)	NOT included • Diverse Alternative Generator Foundation • R/B-DAG Connecting service tunnel
Spent Fuel Interim Storage (SFIS) Facility Chapter 32: Spent Fuel Interim Storage, includes a concept design for the operation of this facility.	NOT included • Building or facility for SFIS • Infrastructure to service the SFIS facility from the R/B, i.e. service corridors, roads, etc.
Intermediate Level Waste (ILW) Store	NOT included • Building or facility for ILW • Infrastructure to service the ILW facility from the R/B, i.e. service corridors, roads, etc.
Low Level Waste (LLW) Store	NOT included • Building or facility for LLW • Infrastructure to service the LLW facility from the R/B, i.e. service corridors, roads, etc.

Table 10.2-2: List of UK ABWR Civil Structures Included in GDA

Building No.	Name	Safety Category	Safety Class	Seismic Category
	MAIN BUILDINGS / FACILITIES			
101	Reactor Building (R/B)	A	1	1
(101)	Reinforced Concrete Containment Vessel (RCCV)	A	1	1
102	Control Building (C/B)	A	1	1
103	Heat Exchanger Building (Hx/B)	A	1	1
105	Filter Vent Building (FV/B)	A	1	1
106	Main Stack	A	2	1
110 a,b,c	Emergency Diesel Generator Buildings (EDG/Bs) (three buildings, one for each division)	A	1	1
107	Back-up Building (B/B)	A	2	1
108	Turbine Building (T/B)	B	2	2 /1A*
104	Radwaste Building (Rw/B)	C	3	2 /1A*
109	Service Building (S/B)	C	3	3 /1A*
	TANKS, UNDERGROUND FACILITIES			
502	Light Oil Storage Tank (LOT) Foundation	A	2	1
515	FLSS Water Storage Tank (WST) Foundation	A	2	1
505	Condensate Water Storage Tank (CST) Structure	A	2	2
	SERVICE TUNNELS / CONNECTIONS			
603	Reactor Cooling Water (RCW) Tunnel	A	1	1
601 a,b,c	R/B-EDG/B Connecting Service Tunnels (three tunnels, one for each division)	A	1	1
604	R/B-B/B Connecting Service Tunnel	A	2	1
602	B/B-LOT Connecting Service Tunnel	A	2	1
618	B/B-FLSS Water Storage Tank Connecting Service Tunnel	A	2	1
605	R/B-CST-Rw/B Connecting Service Tunnel	A	2	2

Refer to “List of Safety Category and Class for UK ABWR” [Ref-21] for the summary listing of the safety category and classification for the principal SSCs.

Note*: These buildings are designed for Seismic Category 2/3, but are checked for stability under the Design Basis Earthquake so are also designated Seismic Category 1A.

10.3 General Principles for Civil Structures

10.3.1 Introduction

This section provides an overview of the civil structures safety case. It outlines the general design principles which have been used for all civil structures within GDA (as appropriate to the structure safety class), and may affect not just the structural design but also the arrangements and detailing which may be used for protection. General design principles applied to the UK ABWR design are documented in the NSEDPs [Ref-03]. Since these general principles are not specific to SSCs, the approach to demonstrating compliance with those design principles relevant to civil structures is via the Safety Property Claims (SPCs) given in Appendix B. The Safety Functional Claims, specific for each civil structure are given in Section 10.4 within the relevant sub-section.

The design principles, both general and building specific, have been applied to the GDA design to demonstrate that risks have been reduced to levels that are as low as reasonably practicable (ALARP). This means that further refinement of the civil engineering design would not significantly improve safety, and that so there are no further, reasonably practicable measures that should be implemented. It is important to note the GDA context of the civil structure design; compliance with the ALARP principle will need to be revisited by any site licensee, addressing aspects such as the location of the civil structures on the site. The civil structure design covered in GDA therefore aims not to foreclose additional risk reduction measures which may be appropriately taken by a future licensee. The “GDA ALARP Methodology” [Ref-22] describes the UK ABWR methodology, and Section 10.8 of this chapter describes how it has been applied for civil structures.

10.3.2 Categorisation and Classification of Civil Structures

10.3.2.1 Overview

The categorisation of safety functions and the classification of the structures, systems and components (SSCs) that deliver them, is an important part of the development of safety cases. This section summarises the UK ABWR approach for convenience of this chapter; however see PCSR Chapter 5, Section 5.6 for a full description.

Each civil structure is categorised and classified into Category A, B or C and Class 1, 2 or 3 according to their safety functions and contribution to nuclear safety, see Chapter 5: General Design Aspects, Sections 5.6.3 and 5.6.4. This depends largely on the SSCs housed in the structure, and so the highest category and class of the various SSCs within the structure will govern. The seismic categorisation for the overall civil structure is decided not only on the SSCs within that structure, but also whether the structure could affect an adjacent structure if it were to fail during a seismic event. The definitions of seismic categories 1, 1A, 2 and 3 are given in Chapter 5, Section5.6.6.

10.3.2.2 ABWR Safety Functions

10.3.2.2.1 Hierarchy

The safety case for the UK ABWR is based on multiple layers of key safety functions, developed systematically using international guidance as described in Chapter 5, Section 5.6.2. These are as follows:

I. Fundamental safety functions (FSFs)
   (1) Control of reactivity
   (2) Fuel cooling
   (3) Long term heat removal
   (4) Confinement/Containment of radioactive materials

(5) Others

II. High level safety functions (HLSFs)
These are listed in Table 5.6-1 of Chapter 5. HLSFs are developed from each FSF above.

III. Safety function claims (SFCs) and safety property claims (SPCs)
SFCs are developed for each structure and link the claims for that structure to the HLSFs. SPCs are developed across all civil engineering design and are claims made on integrity, reliability, design principles and relevant good engineering practice.

More information is provided on development of SFCs and SPCs in the "GDA Safety Case Development Manual for the UK ABWR" [Ref-02].

10.3.2.2.2 High Level Safety Functions

The High Level Safety Functions relevant to the civil structures of the GDA are:

- HLSF 5-17, Function to provide structural support to SSCs.
- HLSF 5-18, Function to maintain internal building environment appropriate for SSC.
- HLSF 2-4, Function to cool spent fuel outside the reactor coolant system.
- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release.
- HLSF 4-8, Function to minimise the release of radioactive gases
- HLSF 5-7, Functions to limit the effect of hazard.
- HLSF 5-14, Supporting functions for on-site emergency preparedness

To achieve these HLSFs, the UK ABWR safety philosophy is based upon redundant, diverse and segregated safety systems that deliver the FSFs as described in PCSR Chapter 5, Section 5.6.2.

Not all of these HLSFs are applicable to every civil structure, and may not be required for both normal operating conditions and fault conditions.

10.3.2.3 Determination of Safety Class for Civil Structures

This section describes how the safety class has been determined for each civil structure.

The safety systems for the UK ABWR can be divided into two main groups: the systems that prevent faults in the facilities, and the systems that mitigate the consequences of faults. The structures fulfil the relevant HLSFs as a part of multiple layers of the UK ABWR safety functions to prevent or mitigate a potential accident.

Each structure's class is determined by considering the classification required for each HLSF/SFC as shown in Appendix A, with the resulting overall class as previously shown in Table 10.2-2. This class is then taken forward to the supporting document "List of Safety Category and Class for UK ABWR" which provides the summary of the safety category and classification for the all SSCs [Ref-21]. These principles satisfy the safety property claims below (see Appendix B):

CE SPC 01: Civil engineering structures have been classified in accordance with the safety functional category of the equipment housed within them or supported by them.

CE SPC 02: Civil structures are seismically categorised to ensure either the SSCs contained within them can operate safely following a seismic event or such that a failure of a structure does not have a detrimental impact on adjacent structures containing SSCs.

10.3.3 General Principles for Protection against Internal Hazards

The internal hazards assessment has been carried out for the UK ABWR and is presented in PCSR Chapter 7: Internal Hazards. The general principles for protection against internal hazards (IH) are described in Section 7.3 and this approach is summarised below as relevant to civil structures. The sub-sections of Section 10.4 describe each civil structure within GDA scope and include a Safety Functional Claim where the IH assessments apply for that building/structure. Additionally Appendix D contains a summary of the hazards that are applicable to each building.

Hazards protection is achieved mainly by prevention, mitigation and limitation of severity, which is provided by segregation/separation or by qualification. In some cases a combination of approaches is used. Three mechanical divisions are provided for the principal cooling and support systems and this ensures there are redundant, segregated and diverse SSCs available to deliver all safety functions. The safety divisions are segregated by robust barriers which contain an internal hazard within the affected division and prevent the spread of the hazard to a different division to satisfy HLSF 5-7 by providing the required barrier function and prevention of hazard propagation. These principles satisfy the safety property claim below:

CE SPC 07: Civil engineering structures are designed to be tolerant of internal hazards and provide the required barrier functions as specified in PCSR Chapter 7 Internal Hazards.

There are areas where physical segregation of divisions cannot be achieved by barrier walls. These are areas where the systems from different safety divisions converge and are located within the same space. Protection in these areas is provided by spatial separation and/or qualification of SSCs against any relevant internal hazards. The main areas with exceptions to segregation are the Primary Containment Vessel (PCV), Main Steam Tunnel Room (MSTR) and Main Control Room (MCR). These have been subject to specific assessment as summarised in sub-sections 7.12 to 7.14.

As noted in Chapter 7, the internal hazards considered in the UK ABWR design basis assessment are listed below.

- Internal Fire and Explosion
- Internal Flooding
- Pipe Whip and Jet Impact
- Dropped and Collapsed Loads
- Internal Conventional Missiles
- Turbine disintegration
- Internal Blast
- Electro Magnetic Interference (EMI) and Radio Emitted Interference (RFI)
- Miscellaneous Internal Hazards, e.g. onsite hazardous materials, transport accidents, pipeline accidents and natural gases from the ground
- Combined Internal Hazards
- Combinations of Internal Hazards with External Hazards

It should be noted that some hazards such as EMI and RFI do not lead to structural loads on the civil structures.

Civil structures provide passive barriers with sufficient withstand to maintain their structural integrity against a postulated internal hazard. In areas where there are exceptions to segregation, the civil structures form a robust enclosure around the area to prevent internal hazards propagating to adjacent areas.

Barrier substantiation has been provided by the IH assessment. In areas where it can be demonstrated that certain cases can be used to bound other examples, the general principle was to identify the potential sources of each hazard in each building, and then confirm a threshold level of withstand required which is bounding. However for hazards where the use of bounding cases was deemed infeasible each hazard was individually substantiated with its unique input data.

It should be noted that all structural calculations carried out to substantiate the barrier withstands are documented in the Internal Hazards Barrier Substantiation Report [Ref-102] with input data provided by the relevant IH Topic reports [Ref-30 to 41]. The Internal Hazards Barrier Substantiation Report contains a detailed barrier by barrier assessment of the potential risk and consequences of occurrence for the internal hazards listed above that are applicable to civil structures. Additionally further conservatisms included in the calculations and further proof that options to remove, reduce and mitigate the associated hazards have not been foreclosed in GDA are also included in the Internal Hazards Barrier Substantiation Report. The report describes in detail the methodologies applied and explains why they are suitable and provides relevant references to the calculation documents that provide the evidence for the substantiation of the civil structures against the design basis hazards. Further information on the assessments performed is contained in PCSR Chapter 7: Internal Hazards.

10.3.4 General Principles for Protection against External Hazards

The external hazards assessment has been carried out for the UK ABWR and is presented in PCSR Chapter 6: External Hazards. Chapter 2: Generic Site Envelope, characterises the list of hazards identified in Chapter 6 and evaluates the normal operating values and the design basis values. The general principles for protection against external hazards (EHs) are described in Chapter 6 and these are summarised below as relevant to civil structures. The sub-sections of Section 10.4 describe each civil structure within GDA scope and include Safety Functional Claims where the EH protection applies for that building/structure. The external hazards applicable to normal conditions and fault conditions are as follows:

(a) Normal Conditions These are hazards with a magnitude evaluated for a frequency of occurrence of 10^{-2}/y and correspond with normal operating conditions.

(b) Fault Conditions These are hazards with a magnitude evaluated for a frequency of occurrence according to the safety classification of that structure.

Hazards protection is achieved mainly by the robust nature of the civil structures, which form passive resistance by continued support to SSCs or provide a barrier function. Spatial separation of plant from different safety divisions is also used, such that there are redundant, segregated and diverse SSCs available to deliver all fundamental safety functions. These principles satisfy the safety property claim below:

CE SPC 04: Civil engineering structures are designed to be tolerant of external hazards and provide the protection to the SSCs housed within or supported by the structures. The magnitude of normal operational and design basis external hazards is given in PCSR Chapter 2, Generic Site Envelope.

Chapter 6 identifies the individual external hazards relevant to a UK site. Similar types of hazards are then grouped together where they have common characteristics and so could have the same potential impacts on SSCs. There are 22 hazard groups identified, which describe all the individual hazards (refer to Table 6.3-3). Of these, 14 are applicable to generic sites (see below) and the remaining 8 hazard groups are dependent on the specific site features and so it is not practicable to include these groups in the GDA design. Refer to the “Topic Report on External Hazard Protection” [Ref-42] for further information.

The postulated external hazards groups that can impose design requirements on the UK ABWR, either in design basis or beyond design basis situations, are listed below.

- Air temperature
- Wind
- Rainfall and Ice
- Drought
- Snow
- Electromagnetic interference (EMI)
- Sea or River water temperature
- External flooding
- Seismic activity
- Loss of Off-Site power (LOOP)
- Aircraft impact
- External fire
- External missile
- External explosion

The generic design has used the seismic design spectra from the European Utilitiy Requirements [Ref-43] which is accepted and recognised across Europe. To account for the variation of ground strata at the UK candidate sites, two spectra have been used, for hard and medium sites. The ground characteristics have also been taken from the EUR using lower bound, best estimate and upper bound soil properties and so representing a range of uncertainties. The allowable bearing capacity of the site is not known at GDA stage, however consideration of the bearing pressures calculated in the structural design with typical values has been carried out. Refer to the “Supporting Document on Soil and Seismic Input for Generic Site Envelope” [Ref-44] for more details on this. These principles satisfy the following safety property claim:

CE SPC 06: Civil engineering structures are designed to be tolerant of variations in the ground conditions, since GDA is not based on a specific site. This includes variations in seismic soil parameters and the assumption that the groundwater level is at ground level.

The possible effects on SSCs are shown in Chapter 6, Table 6.3-2, and 8 effects have been identified for GDA. The relationship between the plant effect by External Hazards Groups and Safety Functions are shown in Chapter 6, Table 6.5-1. The plant effects that can impose design requirements on civil structures are listed below:

1. Structural load
5. Plant flooding
6. Thermal load
8. Other direct impact.

The external hazards assessment has also appraised the combinations of external hazard groups to confirm if potential combinations could cause a different plant effect to that caused by a single hazard group. Refer to the “Topic Report on Combined External Hazards” [Ref-45]. Combinations of two hazards will still have an overall probability of exceedance of 10^{-4} to be equivalent to a design basis event. Therefore the magnitude of each will be lower than 10^{-4}. In terms of structural loading it has been demonstrated that design of civil structures for the design basis individual EH provides enough resilience. Protection against combined external hazards is mainly provided by structural details and site layout.

Consideration of beyond design basis external hazards, and the potential effects on civil structures, has been carried out. This is described in Section 10.6 of this chapter. The generic seismic hazard is the governing structural loading and so substantiation that the structures have sufficient margin beyond the design basis is provided by the bounding seismic behaviour. These principles satisfy the following safety property claim:

CE SPC 05: Civil engineering structures designed to Seismic Category 1 requirements have no cliff edge effects for beyond design basis seismic events.

10.3.5 Structural Design Loading

10.3.5.1 General Methodology

The structural design of civil structures for the UK ABWR has been carried out using relevant good practice and sufficiently conservative methods to ensure that the structures fulfil the fundamental safety functions. The design codes used are mainly American codes since these are recognised within the UK as appropriate for nuclear structures. The main design standards are as follows (refer to Section 10.5 for full list).

- ACI 349-13: Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary
- ANSI/AISC N690-12: Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities
- ASME B&PV (Boiler & Pressure Vessel) Code, Sections II, III, V, VII, IX and XI

The principles of the structural design, inputs and finite element analytical methods, and design results are documented for each structure in the relevant structural design reports (see Section 10.4 for building by building list of relevant documents). These documents also include the seismic analysis reports which document the first step of the two-step methodology used for UK ABWR in accordance with American standard ASCE 4-15 (refer to Section 10.5). The Step 1 seismic analysis comprises a soil-structure interaction (SSI) analysis performed using dynamic finite element modelling (FEM) to obtain the seismic response. The Step 2 static stress analysis is performed using FEM where the seismic loads from Step 1 are combined with the other non-seismic structural loads. This results in element force and moment demands which are then used to design the reinforcing steel required for the structure. As described in Section 10.3.6.5, the analyses have been carried out for the buildings defined by the Design Reference Point. It is noted that SSI analyses for main buildings with similar nature such as the R/B, Fv/B and C/B are performed in full design condition to demonstrate the structural integrity. The other main buildings are evaluated to demonstrate the resilience and the stability of the structures by using representative conditions in GDA [Ref-52].

The GDA design includes the design of the primary structural elements which form the main structural load paths and load resisting systems. Main areas of steel and section thicknesses are confirmed; however detailing of local elements and junctions is not within scope. The GDA also includes consideration of structural deflections and movements at joints to ensure that these can be appropriately detailed at site specific stage.

The above general methodology satisfies the safety property claims below:

CE SPC 03: The analysis and design of CE structures has been carried out using conservative methods and input parameters to ensure they are robust and thus achieve the required reliability to meet all relevant accident conditions, including suitable resilience to DBA, BDBA and SA events.

CE SPC 08: CE structures are designed using relevant good practice and complies with the appropriate internationally, recognised codes and standards.

CE SPC 09: Finite element analysis models used in the CE structural analyses have been sufficiently validated to provide confidence in the results. The various computer codes have been sufficiently verified to prove they are used within the limits of applicability.

10.3.5.2 General Loading

The following general building, plant and equipment loads for normal operating and during fault conditions, other than internal and external hazards, are considered in the design of civil structures:

- Dead Loads
- Live loads
- Temperature Effects / loads
- Equipment Loads
- Dynamic and static piping loads
- Disassembled parts loads at the operating deck
- Disassembled parts loads at unloading pathways
- Building crane with lifting loads
- Pool water Loads
- Monorail and lifting loads
- Vibration effect of heavy pumps and motors

Further information concerning specific plant loads is provided in individual building sub-sections in Section 10.4 and in the individual Basis of Safety Case documents referenced in Section 10.10.

The following sections list the design loads included in the main design standards used for the structural design.

10.3.5.3 Civil structures under ACI 349-13 and ANSI/AISC N690-12

Civil structures designed to ACI 349-13 and ANSI/AISC N690-12 include the majority of civil structures, including some internal structures to the RCCV (see Figure 10.4.2-3). The definition of each design load is taken from these codes are listed below. The loads applied to each civil structure are identified in the supporting reports of each civil structure.

D Dead Load

L: Live Load

F: Fluid Load

H: Lateral Soil Loads (Note: This includes vertical loads, i.e. weight of soil, lateral pressure and buoyancy loads)

To: Thermal Loads (normal condition)

Ta: Thermal Loads (fault condition)

Ess: Seismic Loads

W: Wind Load (basic wind)

Wt: Wind Load (extreme wind)

Ro: Pipe reaction loads (normal condition)

Ra: Pipe reaction loads generated by a postulated pipe break

Yj: Jet impingement load on the structure generated by a postulated pipe break

Ym: Missile impact load on the structure generated by a postulated pipe break

Yr: Load on the structure generated by a postulated pipe break

Ccr: Crane load rated capacity – building crane with lifting loads. Monorail and lifting loads are included in this load type

10.3.5.4 Civil structures under ASME BPVC Section III – for RCCV and internal structures

Civil structures designed to ASME B&PV Code include the RCCV concrete structure and liner and the diaphragm floor (refer to Figure 10.4.2-3). The definition of each design load is taken from these codes are as follows:

D: Dead loads, including hydrostatic and permanent equipment loads

L: Live loads, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressures

Pt: Pressure during the structural integrity and leak rate tests

SRV: Loads resulting from relief valve or other high energy device actuation

Pa: Design pressure load within the containment generated by the DBA, based upon the calculated peak pressure with an appropriate margin

Tt: Thermal effects and loads during the test

To: Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition

Ta: Thermal effects and loads generated by the DBA including “To”

Eo: Loads generated by the ½ DBE

Ess: Loads generated by the DBE

W: Loads generated by the design wind specified for the plant site

Wt: Tornado loading including the effects of missile impact

Ro: Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition

Ra: Pipe reaction from thermal conditions generated by the DBA including “Ro”

Rr: The local effects on the containment due to the DBA

Pv: External pressure loads resulting from pressure variation either inside or outside the containment.

Ha: Load on the containment resulting from internal flooding, if such an occurrence is defined in the Design Specification as a design basis event

10.3.6 Other Design Principles

This section describes other design principles used within the GDA civil works and structures design.

10.3.6.1 Safety Management throughout Plant Lifecycle

The generic safety management arrangements put in place by Hitachi-GE for the UK ABWR are described in PCSR Chapter 4. These arrangements ensure that the generic design is of the appropriate quality that it will deliver the required levels of nuclear safety, conventional safety, environmental protection and security throughout the lifetime of the plant. These arrangements will also support future licensees to implement effective safety management post-GDA.

The civil engineering generic design has included provisions for safety in design, construction, operations and decommissioning to reduce risks as far as is reasonably practicable within the scope of GDA. It is acknowledged that further work will be required post-GDA to fully incorporate site specific aspects.

10.3.6.2 Conventional Safety

The management of conventional health and safety risks has been included in the generic design assessment process for the UK ABWR. Normal practice in the UK is to document conventional safety arrangements separately to the nuclear safety case since the regulation of each is carried out by the Office for Nuclear Regulation and the Health and Safety Executive respectively. However, for this GDA the UK regulators requested submissions were included that provide evidence of Hitachi-GE's understanding and implementation of UK health and safety legislation.

Hitachi-GE's approach to management of safety is that conventional safety is considered as an integral part of the design optioneering and design requirements. Indeed, there are many areas where nuclear and conventional health and safety risks converge, e.g. future licensee working areas, internal fire, emergency evacuation, lifting operations and decommissioning. There are other areas where conventional safety takes priority e.g. construction safe systems of working, COSHH, noise and vibration and prevention of legionella.

The Construction (Design & Management) Regulations 2015 (CDM 2015) apply to the whole design and construction process on all construction projects from concept to demolition so that projects are carried out in a way that ensures health and safety risks are mitigated ALARP, communicated and managed. The Hitachi-GE arrangements are defined in the "CDM Regulations 2015 Compliance Plan for Generic Design Activities" [Ref-23] and the approach set out in the "Topic Report on Hitachi-GE Approach to CDM Compliance" [Ref-24]. Hitachi-GE has therefore satisfied its responsibilities within GDA under these regulations.

The Compliance Plan is specifically written giving consideration to the provision of information for ongoing site specific design and construction planning. Design options are not foreclosed, but information is provided, allowing site specific designers and contractors to develop them further. A series of reports looking at specific areas of risk have been submitted during the GDA process to demonstrate understanding and implementation of the Compliance Plan, as described in the "Topic Report of CDM2015 Compliance" [Ref-25]. This information includes designers' hazard logs which record residual risks to be considered by the future licensee. These principles satisfy the following safety property claim:

CE SPC 13: The generic design of CE structures complies with the CDM 2015 Regulations, and includes appropriate health and safety file information for consideration by the future licensee (contractor). Residual risks are recorded in designers' hazard logs.

10.3.6.3 Construction

The generic design for the UK ABWR must ensure that potential construction methods do not adversely affect the nuclear safety functional and design requirements of the finished works. It must also support the establishment of suitable arrangements in order to protect the health and safety of the public and construction workers, and to protect the environment during construction.

The details of the construction methods and sequences are not known at GDA phase. Indeed, GDA will not specify the methods to be used for UK ABWR construction in order to prevent foreclosure of options for the future licensees and constructors. However, the civil engineering design does consider the option to adopt a number of advanced construction techniques which have been successfully implemented on the construction of existing ABWRs in Japan.

Japanese ABWRs have been built via extensive use of modular construction, where items of plant and structure are pre-fabricated off-site in controlled environments. The building structure is constructed using a technique called "open-top construction" which allows these modules to be lifted into place before completing the ceiling slabs. Works progresses from the foundation upwards, level by level.

Modular construction and open-top construction techniques have been continually improved upon during each Hitachi-GE ABWR project in order to optimise the construction process. They provide benefits to the quality of the finished work as well as reductions in construction timescales and conventional health and safety hazards on-site during the construction phase. The personnel safety records are presented in PCSR Chapter 4, Section 4.4 and demonstrate that these techniques have an excellent safety record. The potential use of these techniques has been justified under the CDM 2015 regulations as described in Section 10.3.6.2 and is evaluated in "Topic Report on Option Evaluation of Construction Method" [Ref-26].

The nuclear safety case is primarily concerned with the ability of the constructed plant to fulfil its safety functions. Construction activities that could affect the condition of the civil structures include the following:

- Construction loadings must not overstress the SSCs, and must ensure that their as-built integrity is maintained.
- Pre-fabrication processes and loads during transportation must not overstress the modular SSCs, and must ensure their as-built integrity is maintained.
- Formation ground level must be protected from degradation from the weather or site traffic, such that the bearing capacities claimed in the safety case are not affected (refer to Assumptions 7 and 8 in Section 10.7).
- The potential construction technique has been appropriately considered and will not significantly impact the decommissioning plan (refer to Section 10.3.6.7).

The civil engineering generic design has included appropriate allowance for construction loadings on the building structures, as described in the individual structural design reports (see Section 10.4).

The loads on modular SSCs from lifting and wet concrete pressures have also been appropriately considered in the design. These design principles are suitable to be taken forward for detailed justification during the site specific phase.

The above considerations for construction can be safely managed by the future licensee and a competent contractor. The GDA civil engineering design does not preclude optioneering of construction techniques at site specific stage.

10.3.6.4 Support Brackets and Embedded Parts

Support Brackets

This section describes the considerations taken within GDA to allow for the support brackets for plant and equipment. The detailed design is outside the scope of GDA, and will be finalised by the future licensee and its suppliers. Design for supports within the RCCV has been carried out within GDA, and is discussed in Section 10.4.2.

The civil structures provide the global structural support to all plant and equipment within a building and the services to that plant and equipment, including pipework, electrical cabling and C&I cabling. Local supports to these will be fixed to either concrete or steel structures, and must be designed according to the safety classification of the plant or services they support.

The internal hazards assessment has included assessment of pipe whip and jet impact for high energy pipework. This has confirmed that in some areas additional pipe whip restraints are required, see PCSR Chapter 7: Internal Hazards. This has been demonstrated by the assessment for pipe whip within the Reactor Building main steam tunnel room [Ref-67] where the design methodology for pipe supports/restraints has been justified.

The general civil engineering design principles in GDA for support brackets are that the brackets will be seismically categorised according to the safety class of the plant and services being supported.

Embedded Parts

This section describes the considerations taken within GDA to allow for items embedded within civil structures. The detailed design is outside the scope of GDA, and will be finalised by the future licensee and its suppliers.

Embedded parts within the RCCV structure and internal structures such as the reactor pedestal are discussed in Section 10.4.2. The civil design appropriately considers the interaction of the concrete and embedded parts in terms of seismic, pressure and thermal movements.

The "Topic Report on ALARP Assessment for Embedded Pipework" [Ref-01] describes the approach to embedded pipework, i.e. pipework which transports radioactive liquid and is embedded within concrete walls or floors. The assessment considers the risk presented by this pipework in terms of potential undetected leakage within the concrete and impact it has on decommissioning. It concludes that the use of embedded pipework within the UK ABWR will be minimised so far as is reasonably practicable.

For smaller embedded parts, such as encast plates, then normal UK detailing methods can be suitably used for the UK ABWR at detailed design stage.

10.3.6.5 Building Layouts

The internal building layouts used for the UK ABWR are the result of over 40 years design development of the BWR and ABWR reactors in Japan as described in PCSR Chapter 9, Section 9.1.1. During GDA, UK requirements have been included resulting in the UK ABWR Design Reference Point (DRP) defined at the end of Step 3, to enable the structural design to proceed and be completed within GDA. The DRP layouts are presented in general arrangement drawings [Ref-46].

Improvements made to deal specifically with UK requirements include review of layouts for

- Fire safety management, see "Topic Report on Fire Safety Strategy" [Ref-27]. This included speciation of fire zones and improving space provided such as UK standards for corridor, staircase and landing widths.
- Emergency egress, see "Topic Report on Departures from Conventional Fire Regulation" [Ref-105].
- Space requirements for operations from human factors considerations, see PCSR Chapter 27: Human Factors.

In the later stages of GDA, modifications required after the Design Reference Point were controlled by the Design Change Process (refer to PCSR Chapter 4, Section 4.7.6). The final GDA building layouts are shown in this chapter and are included in [Ref-47]. The structural design is based on the DRP layouts [Ref-46] but it is recognised that the building layouts will be finalised during site specific design and the structural design repeated for the actual site soil characteristics and updated structural form.

These principles satisfy the following safety property claim:

CE SPC 11: The internal layouts of the CE structures and buildings provide suitable space and access in respect of safety requirements during normal operations and emergency response considerations. The layouts are derived from the Japanese ABWR reference plant and are established with relevant operator experience.

10.3.6.6 EMIT Requirements

The GDA design of civil structures includes consideration for the EMIT (Examination, Maintenance, Inspection and Testing to be carried out to ensure that the required safety and reliability will be achieved throughout the Plant Lifecycle. A strategy for surveillance programmes during construction, routine operation, periodic safety reviews and finally for decommissioning are described in the document "Examination, Maintenance, Inspection and Testing for Civil Engineering" [Ref-29]. The surveillance programmes will need to be finalised by the future licensee, once more detail of operating regimes and construction materials become available.

The typical degradation factors and defects that may occur for civil structures have been considered in "Examination, Maintenance, Inspection and Testing for Civil Engineering" [Ref-29]. Requirements have been considered for the various civil structures including requirements of the ASME B&PV Code for the RCCV, ACI349 for concrete structures and ANSI/AISC N690 for steel structures. Relevant good practice from IAEA NS-G-2.6 on the frequency of inspections has also been considered.

The design principles included within GDA for civil structures satisfy the safety property claim below (Appendix B).

CE SPC 10: Civil engineering structures have a design life of 100 years to ensure they are robustly detailed so that they can be maintained appropriately throughout the 60 years operational life, and also for the safe decommissioning of the site.

10.3.6.7 Decommissioning

The generic approach to decommissioning the UK ABWR is described in Chapter 31: and its supporting topic reports. It demonstrates that the UK ABWR may be safely decommissioned using currently available tools and techniques and GDA design does not foreclose future options. Decommissioning is an end of life activity, and additional work is required to develop the strategy and plans throughout the life of the facilities by the future licensee.

During the GDA design some design features have been identified which would enable risk reduction during decommissioning and these have been incorporated into the civil design. These include:

- Type of aggregates to reduce activation PCSR Chapter 31, Section 31.5.2.1.
- This assessment uses concrete of typical UK industry standards. The final concrete material used for site specific stage will need to maintain the validity of the activation study meet either the same chemical makeup as that modelled, or further reduce activation. Concrete cover thickness is also provided to suit removal of potential contamination/activation.
- Design for Decontamination PCSR Chapter 31, Section 31.5.2.2.
- Appropriate concrete surface coatings and drainage pipe details can be used in the final design.
- Design to ensure access/space PCSR Chapter 31, Section 31.5.2.6.
- The layout of buildings has been assessed for access requirements for decommissioning, and has been demonstrated to be suitable.
- Reduction of embedded piping by design PCSR Chapter 31, Section 31.5.2.7.
- Drainage pipework has been minimised within the civil structure.
- Design integrity of structures PCSR Chapter 31, Section 31.5.2.8.
- The design life of the civil structures and the detailing of them will ensure they maintain their integrity into the decommissioning period.
- Design to Minimise Leakage from Containment PCSR Chapter 31, Section 31.5.2.9.
- Barriers to leakage of radioactive liquid e.g. SFP liner, suppression pool liner have been appropriately included in the civil engineering structures. There is also provision of bunded areas around floor drains where there is potential for leakage.
- Design for Construction and Decommissioning PCSR Chapter 31, Section 31.5.2.10.
- An assessment of the impact of construction techniques on decommissioning has been carried out and is described in the "Topic Report on Decommissioning: Impact of Construction Techniques on Decommissioning [Ref-28]. This includes consideration of modularisation of plant and equipment and permanent structures as well as other construction techniques such that there is sufficient access/space for future dismantling.
- Removal of large items PCSR Chapter 31, Section 31.5.2.11.
- Feasibility studies on the removal and export of dismantled components have been carried out and the building layouts have been demonstrated to be suitable. To facilitate and improve the spatial environment in decommissioning, work has also been undertaken during GDA to identify all walls that do not affect structural integrity or that are not required for performance and capabilities of Class 1 systems. The design's ability to

accommodate breakout of those cell walls would facilitate removal of large plant items and has been carried forward to the site specific design where the suitability of this feature will be considered.

The exact requirements will be defined at site specific stage. However the generic design has considered the high level principles in accordance Principles SP5.2.5, and SP8.10.1 and BP10.3 of the NSEDPs. This ensures that the adoption of any such techniques can be easily accommodated into the generic structure during the site specific phase.

The following SPCs capture the above design requirements:

CE SPC 10: Civil engineering structures have a design life of 100 years to ensure they are robustly detailed so that they can be maintained appropriately throughout the 60 years operational life, and also for the safe decommissioning of the site.

CE SPC 11: The internal layouts of the CE structures and buildings provide suitable space and access in respect of safety requirements during normal operations, emergency response and decommissioning considerations. The layouts are derived from the Japanese ABWR reference plant and are established with relevant operator experience.

CE SPC 12: The materials and details used for civil structures are appropriate to reduce the hazard from contamination and activation at the time of decommissioning.

CE SPC 13: The generic design of CE structures complies with the CDM 2015 Regulations, and includes appropriate health and safety file information for consideration by the future licensee (contractor). Residual risks are recorded in designers' hazard logs.

10.4 Safety Claims and Design Principles for Civil Structures

This section describes each civil structure in turn in sub-sections 10.4.1 to 10.4.17. The general principles given in Section 10.3 are used as a basis for the design of all civil structures; therefore the following sub-sections aim to describe the differences required by that particular building.

10.4.1 Overview of the Reactor Building

This section provides the high level safety claims and the design principles of the Reactor Building (R/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Reactor Building Civil Design [Ref-04]
- Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Seismic Analysis Report [Ref-50]
- Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report [Ref-51]

10.4.1.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Reactor Building and safety category and class for that function. Accordingly the R/B is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

The R/B primarily houses the reactor pressure vessel and all its reactor coolant systems, reactivity control systems and associated systems. Chapter 9: General Description of the Unit, of the PCSR provides a general description of the SSCs and the R/B. The key SSCs are as follows:

- The Reactor Pressure Vessel (RPV).
- The Nuclear Steam Supply System (NSSS).
- Reactivity control systems.
- The primary containment vessel (PCV).
- The secondary containment system.
- Emergency core cooling systems (ECCS).
- Main steam lines and feedwater return pipes; both enclosed in the main steam tunnel room.
- New fuel handing and spent fuel handling.
- Spent fuel pool and cooling water systems.
- Radioactive waste management systems.
- C&I, electrical power and HVAC systems.

The R/B is segregated into three plant divisions and the building structure provides the barriers between divisions.

10.4.1.2 Structural Form

The Reactor Building (R/B) is a reinforced concrete building structure with a steel frame supporting the arched reinforced concrete roof. Figures 10.4-1 to 10.4-5 provide general plans and sections of the building. A more detailed description is given in the BSC [Ref-04] and supporting documents.

The UK ABWR primary containment vessel comprises a steel lined reinforced concrete containment vessel (RCCV) which is integrated with, and fully enclosed within the R/B. The RCCV and its internal structures are described in Section 10.4.2. The secondary containment is formed by the R/B reinforced concrete building structure that surrounds the RCCV.

The R/B is 63.0m by 61.0m in plan and the top of the arched roof is 42.6m high above ground level. The building basement is 25.7m deep to formation level. The whole R/B, including the RCCV, is supported on a 5.5m thick square reinforced concrete foundation; this is known as the basemat. The exterior walls rise from the basemat to the roof so that the R/B external envelope is a reinforced concrete box. The secondary containment is formed by a combination of external and internal walls to enclose the RCCV above the basemat. The R/B and the secondary containment therefore share common structural walls and slabs.

The R/B has six reinforced concrete floors which are monolithically connected to the RCCV outer face and to the exterior walls. There are also 18 internal, reinforced concrete columns supporting these floors. The ground floor (known as floor level 1F, refer to Figure 10.4.1-2) is at the generic site datum of 0.000m (known as grade level); the general station ground level is 300mm below this. The operating floor at + 19.4m level (see Figure 10.4.1-3) is one large room which provides access to the top of the RCCV and to the spent fuel pool (SFP). This area is serviced by the R/B crane.

The SFP is constructed monolithically with the RCCV and the R/B. The operating floor slab and the SFP are supported by the fuel pool girders, which are deep, reinforced concrete beams. These span north to south, between the RCCV and the R/B external walls (see Figure 10.4.1-3).

The central roof slab is an arch structure, with flat roofs provided along the east and west sides. The main stack is supported by the flat slab on the west side (refer to Section 10.4.8). A series of arched steel frames are provided to support the arched roof slab. The steel frames are supported by columns above the operating floor. The R/B crane girders run north to south and are supported on the same columns at lower roof level.

The main load transfer structures for the seismic motion are the R/B exterior walls and the RCCV cylindrical wall. Some internal walls also act as seismic shear walls. The loads from the roof structure and floors are transferred into these shear walls and distributed down to the basemat and basement walls.

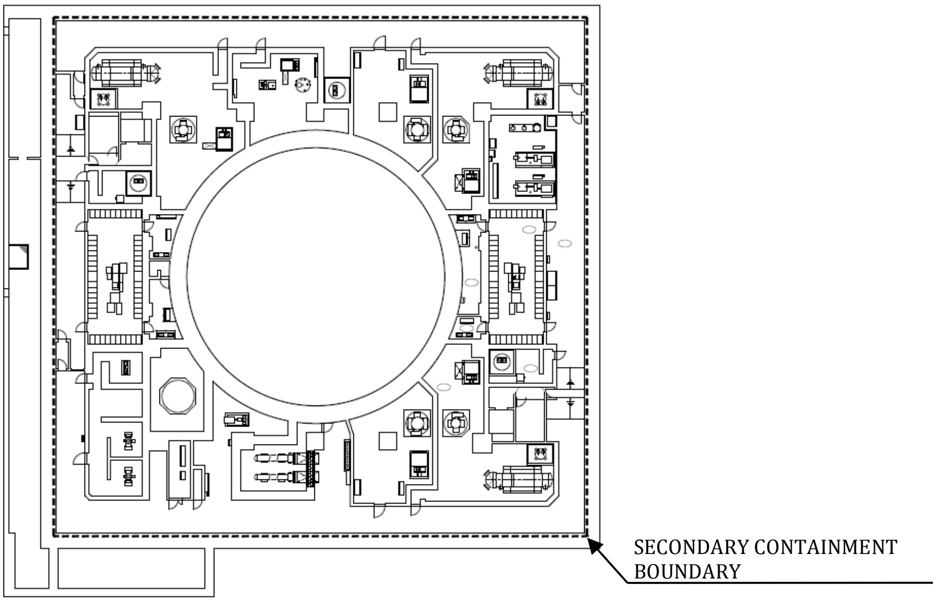

Figure 10.4.1-1: Plan B3F, RB

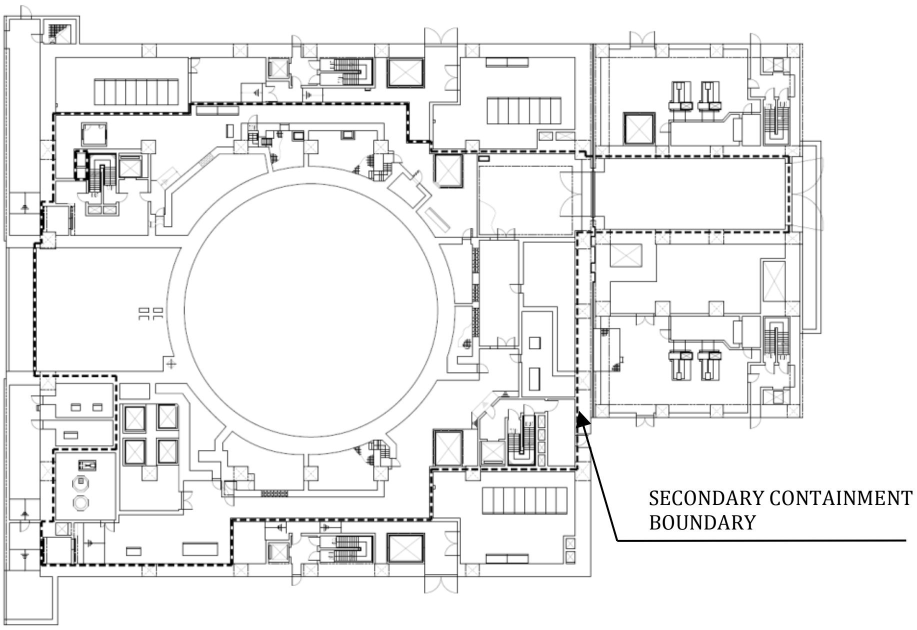

Figure 10.4.1-2: Plan 1F, RB

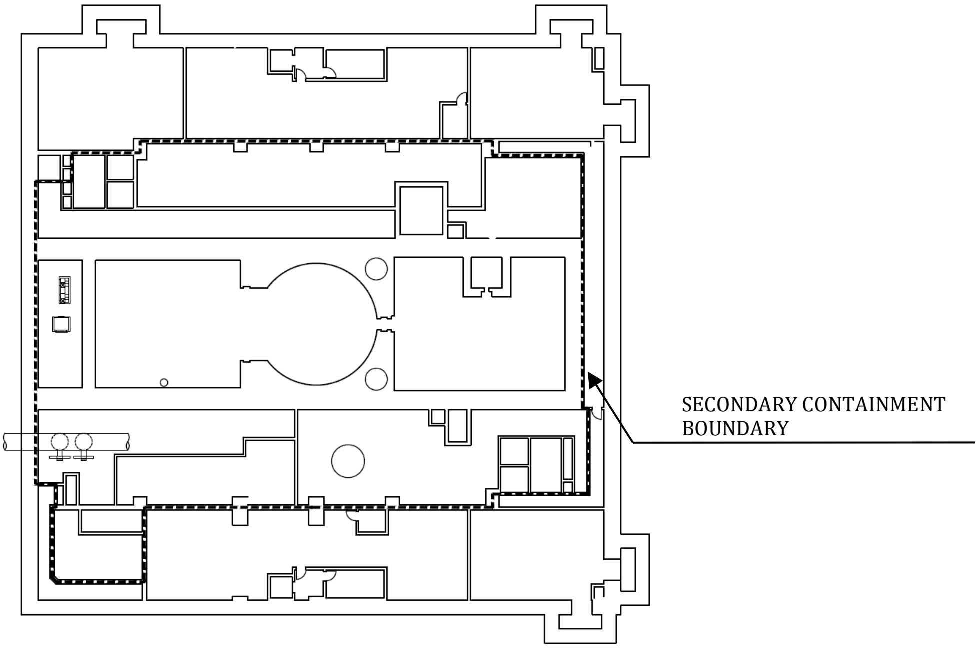

Figure 10.4.1-3: Plan 4F, RB

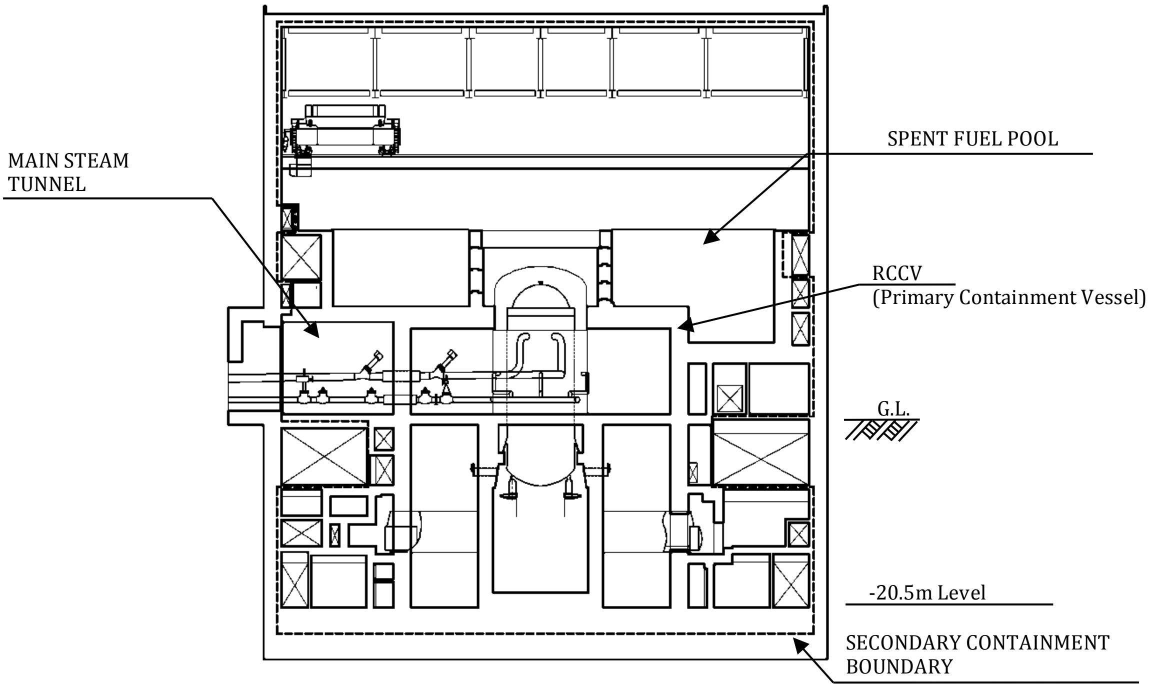

Figure 10.4.1-4: Section, R/B

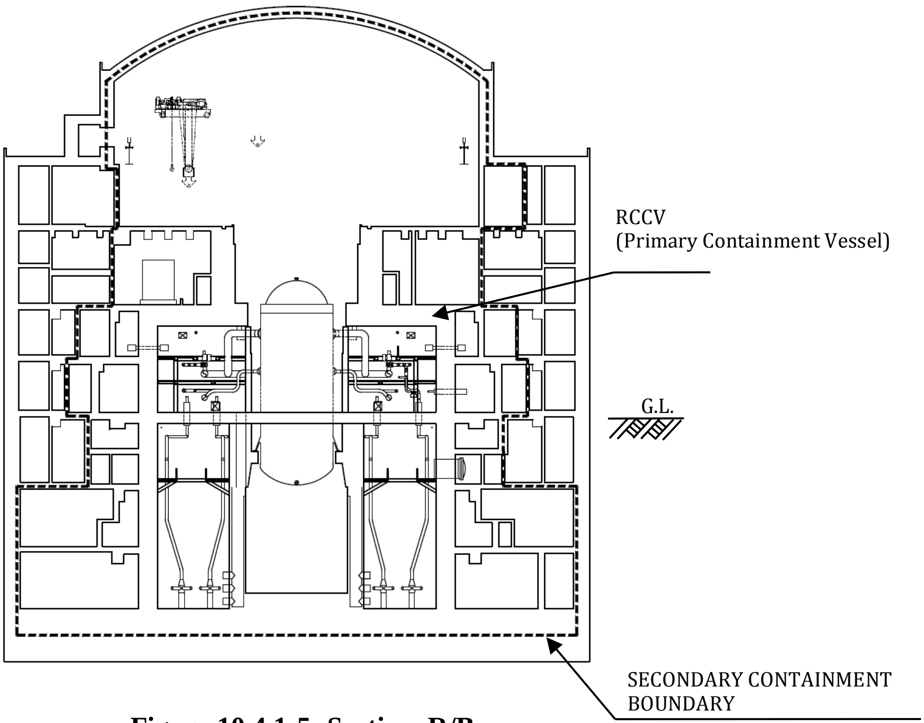

Figure 10.4.1-5: Section, R/B

10.4.1.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the R/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [R/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the spent fuel pool
- Loads associated with the fuel transportation route
- Loads from lifting equipment on the reactor deck level
- Temporary loads from disassembled parts on the reactor deck

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B SFC 5-18.01]

The R/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [R/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16: Auxiliary Systems, Section 16.5.

The R/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [R/B SFC 5-18.01.2]

The R/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [R/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15: Electrical Power Supplies, Section 15.6.5.

- HLSF 2-4, Function to cool spent fuel outside the reactor coolant system

R/B forms SFP together with stainless liner and cooling systems, to enable fuel cooling outside the reactor coolant system. [R/B SFC 2-4.01]

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

R/B forms a part of the RCCV together with several MC components, to shield radiation from the reactor and confine the radioactive substance inside the containment. [R/B SFC 4-7.01]

The R/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary. The HVAC system maintains inside of the secondary containment at negative pressure, so that airflow is always from outside to inside. This negative pressure limits a potential radioactive release to the external environment during the normal condition. [R/B SFC 4-7.02]

The R/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [R/B SFC 4-7.03]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the R/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [R/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B SFC 5-18.02]

The R/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [R/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The R/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [R/B SFC 5-18.02.2]

The R/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [R/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 2-4, Function to cool spent fuel outside the reactor coolant system

R/B forms SFP together with stainless liner and cooling systems, to enable fuel cooling outside the reactor coolant system. [R/B SFC 2-4.02]

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

R/B forms a part of the RCCV together with several MC components, to shield radiation from the reactor and confine radioactive substances inside the containment. [R/B SFC 4-7.04]

The R/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. The Standby Gas Treatment System (SGTS) creates a negative air pressure inside the secondary containment during postulated accidental conditions, so that airflow is always from outside to inside. This negative pressure limits a potential radioactive release to the external environment during the fault condition. [R/B SFC 4-7.05]

- HLSF 5-7, Functions to limit the effect of hazard

The R/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B SFC 5-7.01]

The R/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design basis internal hazards. [R/B SFC 5-7.01.1]

The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.

Specific information relating to the spent fuel Transfer Cask dropped load case is included in Chapter 19. It has been identified that an impact limiter is required for the case of the spent fuel Transfer Cask drop to the ground floor. The design of the impact limiter will be performed at the site specific stage.

The R/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which delivers safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B SFC 5-7.02]

In addition to the design basis external hazards requirements the walls and slabs are designed to provide countermeasures against an aircraft impact and thus prevent or mitigate the physical impact, fire and vibration effects. [R/B SFC 5-7.02.1]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The R/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B SFC 5-14.01]

10.4.1.4 Design Principles

The safety functional claims of the R/B are described in Section 10.4.1.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report, Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report" [Ref-51]. The design method of the R/B is carefully determined to realise those design principles based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the R/B are based on the material standards listed in Section 10.5.6.

- Structural
  - The R/B shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10^{-5}/y for design basis internal hazard condition and 10^{-4}/y for design basis external hazard condition.
  - All structural members of the R/B shall be designed to remain essentially elastic under the envelope of the normal conditions and the design basis internal and external hazards.

- Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
- The thickness of the walls and slabs for which the radiation shielding is required shall be designed to be sufficient to ensure adequate shielding to the public and operational personnel.
- The R/B shall be checked for design basis external hazard loadings, such that it does not adversely interact with adjacent buildings, i.e. the C/B and the FV/B, under these events.
- The R/B shall be checked for beyond design basis resilience as described in Section 10.6.
- The R/B structure shall be considered as defence in depth for the protection of the C/B from aircraft impact.

• Design of External Envelope (External Walls and Roof)

- The external envelope of the R/B shall provide low-leak rate boundaries to maintain internal air negative pressure, during normal conditions and fault conditions.
- The external envelope of the R/B shall provide protection to the SSCs, which deliver the safety functions, from design basis external and internal hazards.
- The external envelope of the R/B shall mitigate the ingress of ground water and egress of liquids from inside the R/B to the external environment.
- The external envelope of the R/B shall be designed to achieve the appropriate fire resistance for the design basis external and internal hazards.
- The external envelope of the R/B shall provide shielding function.

• Design of Internal Walls and Slabs

- All divisional walls and slabs within the R/B shall provide the segregation function for all design basis internal hazards.
- Some part of the internal walls and slabs of the R/B shall provide a radiation shielding function.

• Design of Basemat Slab

- The basemat slab of the R/B must provide an adequate foundation to the R/B, in addition to the RCCV and Reactor Pedestal, which are supported on the same common basemat, under all normal condition and design basis fault conditions.
- The basemat slab of the R/B shall transfer all vertical and lateral forces applied by the R/B superstructure to the ground formation.
- The basemat slab of the R/B shall provide the structural continuity of the RCCV primary containment by providing the structural support to the RCCV liner for normal conditions and fault conditions.
- The basemat slab of the R/B shall provide airtight boundaries as the secondary containment for the normal conditions and the fault conditions to maintain R/B internal air pressure negative.
- The basemat slab of the R/B shall be designed to mitigate the ingress of groundwater and egress of liquids from inside the R/B to the external environment.

• Design of SFP

- The reinforced concrete pool structure is lined internally with a stainless steel liner. This second barrier is entirely within the R/B and so is not the final barrier to the outside environment. Structural inspection can be carried out to parts of the outer face of this second barrier to check for potential leakage. Cracking of concrete will be controlled by reinforcement as required.

The generic design methodology is provided in "Civil Engineering Supporting Report, Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report" [Ref-51].

10.4.2 Overview of the RCCV

This section provides the high level safety claims and the design principles of the Reinforced Concrete Containment Vessel (RCCV) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR. The RCCV is the general term used in the civil engineering topic for the structure which forms the Primary Containment Vessel and includes the internal structures and MC components.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on RCCV [Ref-05]
- Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Seismic Analysis Report [Ref-50]
- Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report [Ref-51]
- RCCV Liner Design Report [Ref-54]
- The design reports for the MC Components, drywell head, airlocks and hatches etc ([Ref-55] to [Ref-64]).

10.4.2.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by RCCV and safety category and class for that function. Accordingly, the RCCV, MC Components and RCCV Internal Structures are classified as:

- Safety Category A, Safety Class 1.
- Seismic Category 1.

The function of the RCCV is to be the primary containment vessel (PCV) to the reactor pressure vessel (RPV). This is described in PCSR Chapter 13 and is summarised here for convenience.

The UK ABWR uses a pressure suppression type of containment. The RPV and its primary systems are housed within the PCV so that there is an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment in the event of an accident.

Figure 10.4.2-1 shows the general arrangement of the RCCV. It is divided into two main areas, the drywell (D/W) which contains the nuclear reactor and its primary systems and the suppression chamber (S/C) that stores water for cooling. The extent of the S/C is shown in Figure 10.4.2-2 and the air space is called the Wetwell (W/W), and the water pool space is called the Suppression Pool (S/P).

During operation, the temperature and pressure inside the RCCV and the water level in the S/P are kept to the limits and conditions of operation listed in Section 10.7.2. In fault conditions, such as a Loss of Coolant Accident (LOCA), the D/W is the release space for coolant from the nuclear reactor where the primary piping may break. The water in the S/P can be condensed into the released steam, and the pressure can be suppressed. The W/W stores non-condensing gas coming from the D/W, to suppress the excessive pressure rise.

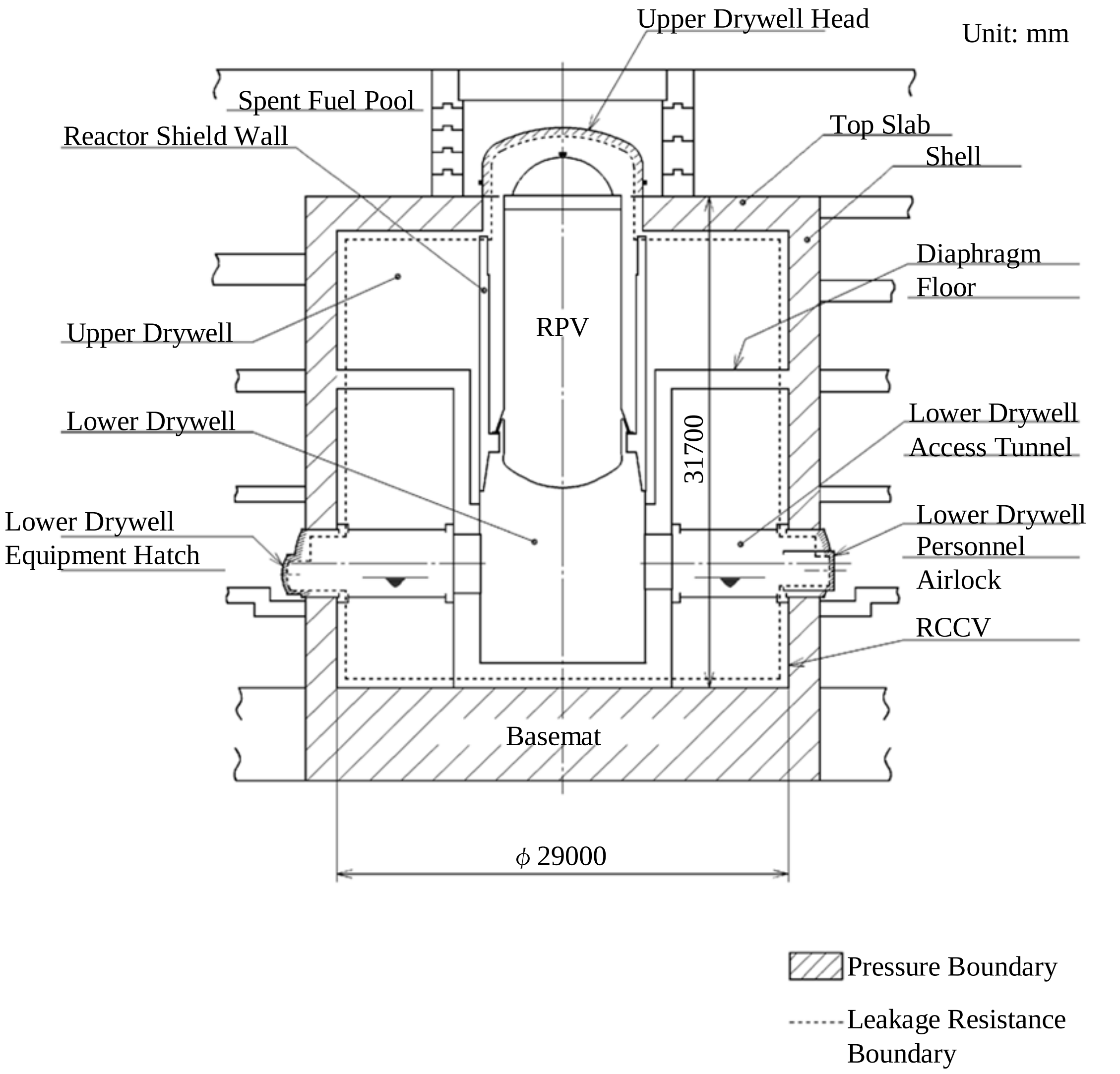

Figure 10.4.2-1: RCCV Arrangement Showing Containment Boundaries

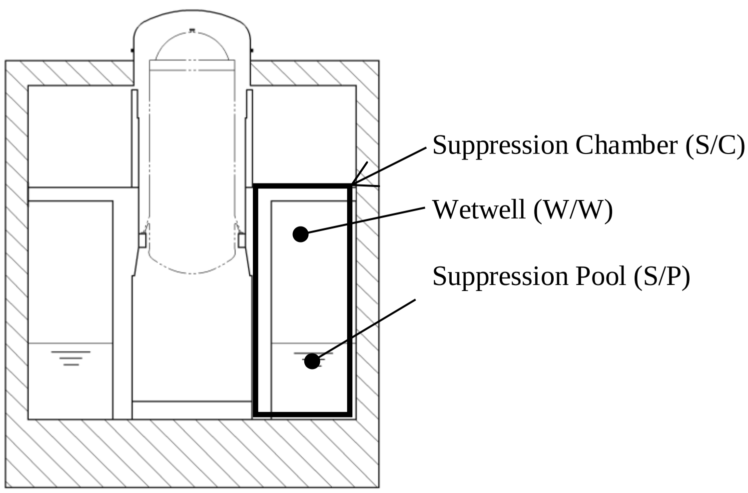

Figure 10.4.2-2: Suppression Chamber

The diaphragm floor (D/F) forms a pressure partition between the Upper Drywell (U/D) and the S/C and the RPV Pedestal is the partition between the Lower Drywell (L/D) and the S/C. Vent Pipes connect the D/W and the S/C are embedded through the RPV Pedestal. There are ten vent pipes and for each one, there are three horizontal pipes. In the event of a LOCA, a mixture of steam and water is discharged in the D/W and is led, via the vent pipes, to the S/P where the steam is cooled and condensed. This can effectively suppress the increase of pressure within the RCCV.

Two personnel access tunnels are provided for workers to gain access into the D/W through the S/C during maintenance outages. Access to the top of the RPV is provided via the upper drywell head which is located in the space above the RCCV top slab.

10.4.2.2 Structural Form

The RCCV consists of a cylindrical reinforced concrete structure with internal diameter of 29m and height of 36m (including Upper Drywell Head) as shown in Figure 10.4.2-1. The RCCV is integrated with the R/B structure such that its base is the R/B basemat and it provides support to the R/B floors, including the operating deck.

The RCCV Internal Structures provide support to the RPV, equipment support, radiation protection, and components for operation of the ABWR pressure suppression containment. RCCV Internal Structures include the RPV Pedestal, Reactor Shield Wall (RSW), Diaphragm Floor (D/F), Lower Drywell Access Tunnels and various equipment hatches.

The general arrangement and jurisdictional boundaries between design codes are shown below in Figure 10.4.2-3.

(a) Reinforced Concrete (RC) and RCCV Liner

The thickness of the RC structural wall is 2m, which includes the steel liner thickness (6.4mm). The primary containment pressure boundary is provided by the RCCV liner. This is continuous over the full inner surface and includes the steel upper drywell head as shown. The RCCV is classified as ASME B&PV Code Section III, Division 2, Concrete Containments.

Stainless steel is used for the liner material, to provide corrosion protection on the normally wetted portion, i.e. for the area that comes into contact with S/P water and immediately above it (‘splash zones’). Carbon steel with a protective coating (paint) is used on the dry portion of the S/C (W/W) and D/W.

(b) MC Components

Penetrations through the containment pressure boundary include the U/D Head, Equipment Hatches into U/D and L/D regions, Personnel Airlocks into U/D and L/D, a combined personnel access and equipment hatch (W/W Hatch) into the S/C, and pipe and electrical penetration sleeves. These Containment Penetrations are steel structures classified as ASME B&PV Code Section III, Division 1, Subsection NE, Class MC Components.

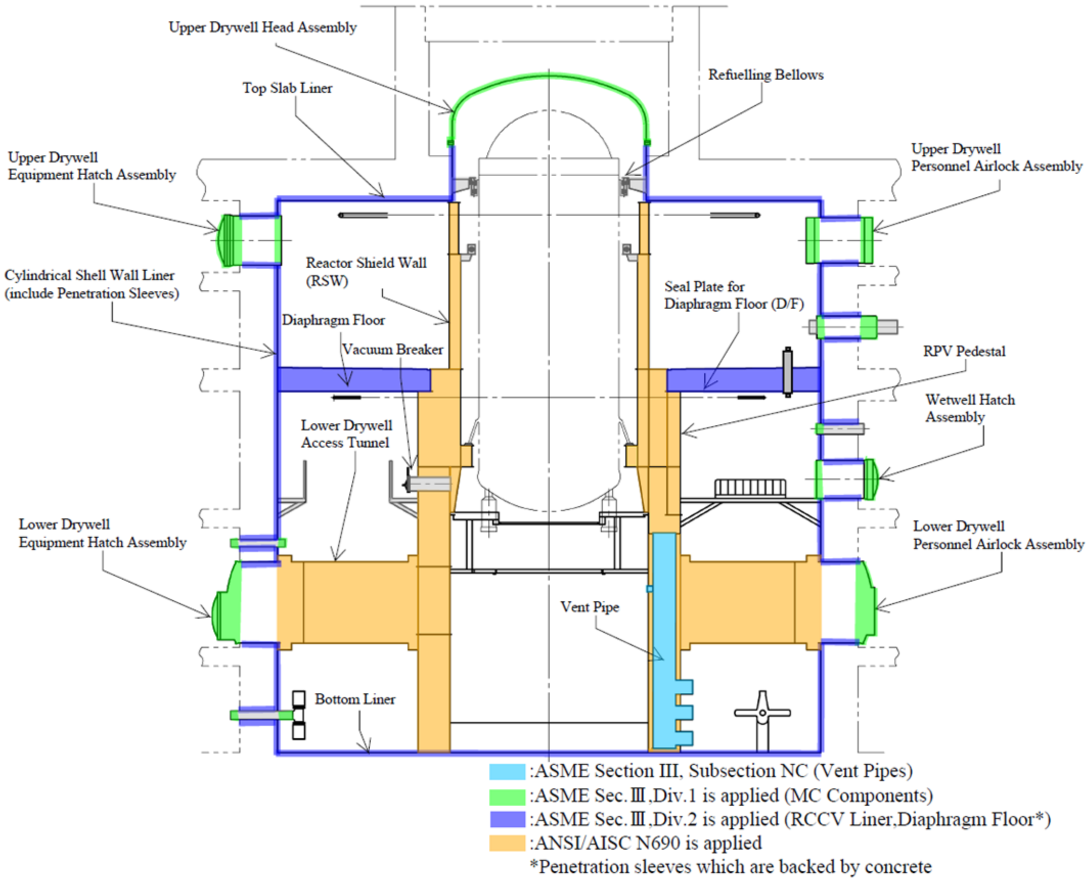

Figure 10.4.2-3: Jurisdictional Boundaries of RCCV, RCCV Internal Structures and MC Components

(c) RCCV Internal Structures

As described above, the RPV Pedestal and the D/F separate the containment volume into D/W and S/C regions.

The RPV Pedestal forms the lower drywell (L/D) region and consists of two to five concentric steel cylinders joined together radially by vertical steel diaphragms and filled with concrete. It is anchored to the basemat slab and supports the RPV through a support ring girder. The RPV Pedestal also supports the RSW. It is designed to ANSI/AISC N690 as a steel structure, and is infilled with concrete to provide shielding and stability.

The pressure suppression venting lines are an integral part of the RPV Pedestal structure. The vent pipes serve as the route for the mixture of coolant and non-condensing gas released to the D/W into the S/P water. Vent pipes are designed in accordance with ASME B&PV Code Section III, Division 1, Subsection NC.

The D/F separates the U/D and the W/W. It is formed from reinforced concrete and has a steel liner plate on the underside (Seal Plate). The Seal Plate prevents the bypass flow of steam from the U/D to the W/W during a potential LOCA condition. The plate also acts as permanent formwork when the concrete is poured.

The RSW is a steel cylindrical structure which surrounds the RPV. It provides lateral supports to the RPV. It is designed to ANSI/AISC N690 as a steel structure, and is infilled with concrete to provide shielding and stability.

Other internal structure includes VBs. The VBs connect the S/C and the D/W to maintain the integrity of the RCCV, by eliminating the negative pressure when the D/W pressure is decreased due to overflow stream caused by injection water in Emergency Core Cooling System (ECCS) or due to water spray in the PCV. VB valves are designed in accordance with ASME B&PV Code Section III, Division 1.

10.4.2.3 Safety Functional Claims

The RCCV provides the pressure suppression Primary Containment System, which comprises the D/W, the S/C and supporting systems The RCCV is designed to have the following functional capabilities and the following conditions shall be satisfied (PCSR Chapter 13: Engineered Safety Features, Section 13.3.2.1.

(a) Normal Conditions

In order to meet the safety functions for the normal operating conditions the following safety functional claims are incorporated in the RCCV design principles.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The air leakage ratio of the RCCV is 0.4 percent per day or less of free volume of the containment at ordinary temperature and with a 90 percent of the maximum design pressure [PCV SFC 4-7.3] (PCSR Chapter 13, Section 13.3.2.1). The testing requirements are specified in the limits and conditions of operation as described in Section 10.7.2.

The RCCV and structures within the RCCV have a structural strength that maintains integrity when assumed static load and dynamic load generated in normal condition are appropriately combined with the relevant seismic load [PCV SFC 4-7.4] (PCSR Chapter 13, Section 13.3.2.1).

As for the steel parts in the RCCV, brittle fracture is prevented by taking the lowest design temperature (10°C) into consideration [PCV SFC 4-7.5] (PCSR Chapter 13, Section 13.3.2.1).

The requirement for biological shielding is included in R/B SFC 4-7.3.

- HLSF 5-17, Function to provide structural support to SSCs

The RCCV has a structural strength that maintains integrity when assumed static load and dynamic load generated in normal condition are appropriately combined with the relevant seismic load to support SSCs within RCCV (and/or to support the RCCV) [PCV SFC 5-17.1] (PCSR Chapter 13, Section 13.3.2.1).

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the RCCV design principles.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

Any steam released into the RCCV from a possible pipe rupture in the primary system will be condensed by the S/P, and will suppress any significant pressure rise [PCV SFC 4-7.1] (PCSR Chapter 13, Section 13.3.2.1).

The RCCV can withstand the maximum excessive pressure and temperature caused by the defined LOCA events including piping break such as instantaneous, complete and double-ended guillotine break of one feedwater piping or one main steam piping [PCV SFC 4-7.2] (PCSR Chapter 13, Section 13.3.2.1).

The air leakage ratio of the RCCV is based on 0.4 percent per day or less of free volume of the containment at ordinary temperature and with a 90 percent of the maximum design pressure [PCV SFC 4-7.3] (PCSR Chapter 13, Section 13.3.2.1). The testing requirements are specified in the limits and conditions of operation as described in Section 10.7.2.

The RCCV and structures within the RCCV have a structural strength that maintains integrity when assumed static load and dynamic load generated in fault conditions are appropriately combined with the relevant seismic load [PCV SFC 4-7.4] (PCSR Chapter 13, Section 13.3.2.1).

As for the steel parts in the RCCV, brittle fracture is prevented by taking the lowest design temperature (10°C) into consideration [PCV SFC 4-7.5] (PCSR Chapter 13, Section 13.3.2.1).

The RCCV and structures within the RCCV have sufficient structural strength to maintain integrity against the following hydrodynamic loads [PCV SFC 4-7.6] (PCSR Chapter 13, Section 13.3.2.1).

- Gas / steam release
- Pool swell
- Steam condensation (oscillation / chugging loads)
- Annulus Pressurisation

- HLSF 5-17, Function to provide structural support to SSCs

The RCCV has a structural strength that maintains integrity when assumed static load and dynamic load generated in fault conditions are appropriately combined with the relevant seismic load to support SSCs within RCCV (and/or to support the RCCV) [PCV SFC 5-17.1] (PCSR Chapter 13, Section 13.3.2.1).

The RCCV and structures within the RCCV have sufficient structural strength to maintain integrity against the following hydrodynamic loads to support SSCs (and/or to support the RCCV) [PCV SFC 5-17.2] (PCSR Chapter 13, Section 13.3.2.1).

- Gas / steam release
- Pool swell
- Steam condensation (oscillation / chugging loads)
- Annulus Pressurisation

HLSF 5-7 is enveloped by HLSF 4-7 and HLSF 5-17 because the functions of HLSF 5-7 are considered as design inputs to achieve the functions of HLSF 4-7 and HLSF 5-17.

The pressure and temperature requirements for severe accident conditions are listed in [Ref-65]

10.4.2.4 Design Principles

The safety functional claims of the RCCV and the RCCV Internal Structures for the normal conditions and the fault conditions are described above as well in Chapter 10.4.1 as it is monolithically connected to the R/B. The RCCV and the RCCV Internal Structures are divided into three main sections, which are "Reinforced Concrete and RCCV Liner", "MC Components" and "RCCV Internal Structures", as described in Section 10.4.2.2. To fulfil these requirements, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report" [Ref-51], "MC Components of Reinforced Concrete Containment Vessel Structural Design Report" [Ref-55] and "Internal Structures of Reinforced Concrete Containment Vessel Structural Design Report" [Ref-60]. The design method of the RCCV and the RCCV Internal Structures is carefully determined to realise those design strategies based on the codes and standards listed in Chapter 10.5, which are internationally recognised as appropriate for the design of nuclear facilities. The structural materials to be used for the RCCV and the Internal Structures are based on the material standards also listed in Section 10.5.6.

- RC and RCCV Liner
- RC Structure
  - The RC shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-5/y for design basis internal hazard condition and 10-4/y for design basis external hazard condition.
  - All structural members of the RC shall be designed to satisfy code requirements under design basis load combinations for the normal conditions and the design basis internal and external hazards.
  - The RC has a function of pressure resistance.
  - The thickness of the shell wall and the top slab of the RCCV shall be designed to be sufficient to ensure adequate shielding to the public and operational personnel.
  - The RC portion of the RCCV shall be designed to achieve the appropriate fire resistance for the design basis external and internal hazards.
  - The R/B Basemat must provide an adequate foundation to the RCCV, in addition to the R/B and the RPV Pedestal, which are supported on the same common basemat, under all normal conditions and design basis fault conditions.
  - The R/B Basemat shall transfer all normal condition and design basis vertical and lateral forces applied to the RCCV to the soil formation below the R/B.

- RCCV Liner
  - All structural members of the RCCV Liner shall be designed to satisfy code requirements under design basis load combinations for the normal conditions and the design basis internal and external hazards.
  - The RCCV Liner shall provide leak-tight boundaries as the containment during the normal conditions and the fault conditions.

- MC components
  - All structural members of the MC components shall be designed to satisfy code requirements under design basis load combinations for the normal conditions and the design basis internal and external hazards.

- The MC components shall provide pressure and leak-tight boundaries as the containment during the normal conditions and the fault conditions.

- RCCV Internal Structures
  - All structural members of the Internal Structures in RCCV shall be designed to satisfy code requirements under design basis load combinations for the normal conditions and the design basis internal and external hazards.

The generic design methodologies of the RC and RCCV Liner, MC Components, and the RCCV Internal Structures are provided in “Civil Engineering Supporting Report Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report” [Ref-51], “MC Components of Reinforced Concrete Containment Vessel Structural Design Report” [Ref-55] and “Internal Structures of Reinforced Concrete Containment Vessel Structural Design Report” [Ref-60] respectively.

10.4.3 Overview of the Control Building

This section provides the high level safety claims and the design principles of the Control Building (C/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Control Building Civil Design [Ref-06]
- Civil Engineering Supporting Report Control Building Seismic Analysis Report [Ref-70]
- Civil Engineering Supporting Report Control Building Structural Design Report [Ref-71]

10.4.3.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Control Building and safety category and class for that function. Accordingly the C/B is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

The Control Building contains the Main Control Room and a significant amount of C&I equipment that is used to control the ABWR.

10.4.3.2 Structural Form

The C/B is constructed of reinforced concrete and structural steel with a steel frame and reinforced concrete roof. The C/B is 43.6 m × 59.4 m reinforced concrete structure that is 16.5 m high above grade (top roof level excluding shafts). The total building embedment is 25.7 m. The foundation basemat is 3.0 m thick. The C/B has four internal floor levels, constructed from reinforced concrete slabs. Inside the C/B, there are 15 columns supporting the floors.

The main steam tunnel runs through the C/B at ground floor level and provides an independent open space between the R/B and the T/B. The tunnel is closed at the R/B end and open at the T/B end. The main steam tunnel is designed to withstand pressurisation effects that occur within it a result of postulated rupture of pipes containing high energy fluid. The tunnel has no penetrations into other areas of the C/B. The concrete thickness of the tunnel walls, floor and ceiling are designed to minimise the potential dose rate to workers.

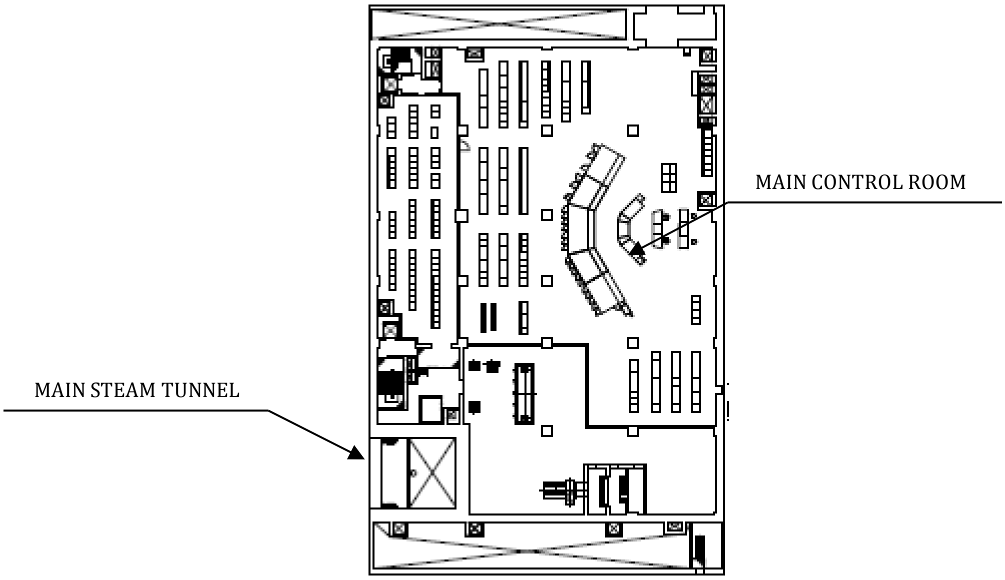

Figure 10.4.3-1: Plan 2F, C/B

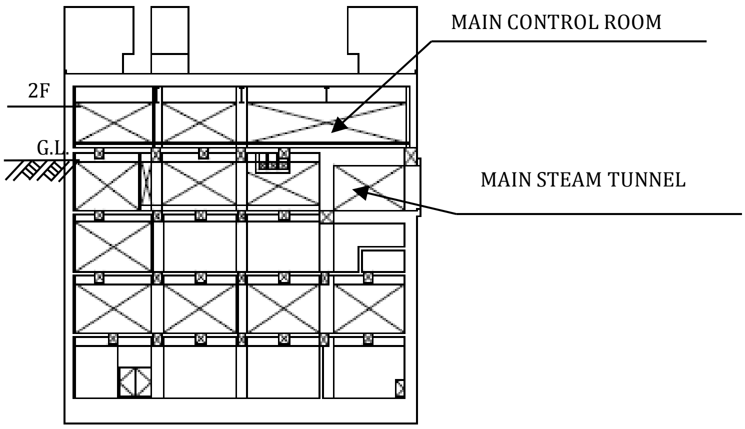

Figure 10.4.3-2: Section, C/B

10.4.3.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the high level safety functions for the normal conditions the following safety functional claims are incorporated in the C/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The C/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [C/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the Main Control Room
- Loads associated with the electrical cabinets
- Loads associated with the piping inside of the MSTR Tunnel which runs through a section of the control building

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The C/B exterior building envelope maintains the internal building environment appropriate for SSCs. [C/B SFC 5-18.01]

The C/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [C/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The C/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [C/B SFC 5-18.01.2]

The C/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [C/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The C/B provides shielding by concrete walls and slabs, to shield radiation from the main steam tunnel. The shielding walls and slabs are arranged around the Main Steam (MS) System and Feedwater (FDW) System piping to reduce worker's exposure within the C/B. The shielding walls and slabs also provide shielding to reduce the potential dose rate at the site boundary. [C/B SFC 4-7.01]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the C/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The C/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [C/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The C/B exterior building envelope maintains the internal building environment appropriate for SSCs. [C/B SFC 5-18.02]

The C/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [C/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The C/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [C/B SFC 5-18.02.2]

The C/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [C/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The C/B provides shielding by concrete walls and slabs, on the perimeter of the MCR, to minimise the received radiation dosage and facilitate accident management activities inside the MCR. The shielding walls and slabs maintain their shielding function against postulated fault conditions. [C/B SFC 4-7.02]

- HLSF 5-7, Functions to limit the effect of hazard

The C/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [C/B SFC 5-7.01]

The C/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design base internal hazards. [SFC C/B 5-7.01.1]

The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.

The C/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design base external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [C/B SFC 5-7.02]

The C/B is shielded by the R/B and T/B on the north / south axis and the Rw/B and S/B on the east / west axis adding defence in depth against postulated external hazards.

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The C/B layout provides safe escape routes from the inside the building to the designated safe mustering point [C/B SFC 5-14.01].

10.4.3.4 Design Principles

The safety functional claims of the C/B are described in Chapter 10.4.3.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Control Building Structural Design Report" [Ref-71]. The design method of the C/B is carefully determined to realise those design principles based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the C/B are based on the material standards listed in Chapter 10.5.6.

- Structural
  - The C/B shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-5/y for design basis internal hazard condition and 10-4/y for design basis external hazard condition.
  - All structural members of the C/B shall be designed to remain essentially elastic under Design Basis load combinations for the normal conditions and the Design Basis internal and external hazards. Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
  - The thickness of the walls and slabs around MS and FDW piping shall be designed to be sufficient to ensure adequate shielding to the public and operational personnel.

- Design of External Envelope (External Walls and Roof)
  - The external envelope of the C/B shall provide protection to the operating personnel and the SSCs, which deliver the safety functions, from Design Basis external and internal hazards.
  - The external envelope of the C/B shall mitigate the ingress of groundwater.
  - The external envelope of the C/B shall be designed to achieve the appropriate fire resistance for the Design Basis external and internal hazards.

- Design of Internal Walls and Slabs
  - All division walls and slabs within the C/B shall provide the segregation function for all Design Basis internal hazards.

- Design of Basemat Slab
  - The basemat slab of the C/B must provide an adequate foundation to the C/B under all normal condition and Design Basis fault conditions.
  - The basemat slab of the C/B shall transfer all normal condition and Design Basis vertical and lateral forces applied by the C/B superstructure to the ground formation.
  - The basemat slab of the C/B shall be designed to prevent ingress of groundwater.

The detailed design methodology is provided in "Civil Engineering Supporting Report Control Building Structural Design Report" [Ref-71].

10.4.4 Overview of the Heat Exchanger Building

This section provides the high level safety claims and the design principles of the Heat Exchanger Building (Hx/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Heat Exchanger Building Civil Design [Ref-07].
- Civil Engineering Supporting Report Heat Exchanger Building Seismic Analysis Report [Ref-72].
- Civil Engineering Supporting Report Heat Exchanger Building Structural Design Report [Ref-73].

10.4.4.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Heat Exchanger Building and safety category and class for that function. Accordingly the Hx/B is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

The Heat Exchanger Building houses portions of the Reactor Building Service Water (RSW) system, the Reactor Cooling Water (RCW) system, the Turbine Building Service Water (TSW) system and the Turbine Building Cooling Water (TCW) system. A detailed description of these systems and their safety functions is provided in PCSR Chapter 16: Auxiliary Systems, Section 16.3. A summary of the main systems is provided below.

The Hx/B receives water from the ultimate heat sink intake structure and via the RSW pumps and pipework supplies the RCW heat exchangers with this cooling water. The RCW system is a closed loop, and circulates cooling water from the RCW heat exchangers to the reactor building systems using the RCW pumps. There are three independent and separated divisions A, B and C of RCW and RSW. The Hx/B houses the following for each division in order of the flow:

- RSW intake pit
- RSW pumps (three per division)
- RCW heat exchangers (three per division)
- RCW Pumps (three per division)
- RCW Pipework to R/B

The Hx/B also uses the Ultimate Heat Sink (UHS) water supply for the TSW which supplies the TCW heat exchangers with this cooling water.

The TCW system is a closed loop, and circulates cooling water from the TCW heat exchangers to the turbine building systems using the TCW pumps.

There is one division of TCW, which is independent and separated from the RCW three divisions.

The Hx/B also houses a maintenance area and emergency electrical equipment and associated HVAC.

10.4.4.2 Structural Form

The Hx/B is a reinforced concrete structure. The general arrangement for GDA is shown in drawings GA12-2002-0015-00001 Rev.3 [Ref-47] and illustrated in Figures 10.4.4-1 and 10.4.4-2 below. The Hx/B is located away from the nuclear island and for GDA it is assumed to be due west of the T/B (see PCSR Chapter 9: General Description of the Unit).

The building is 63m by 51m in plan and 24m high above ground level, with a ground and first floor level. There is one basement floor level, at -11.400m which houses the RCW heat exchangers. At the west side there is the intake chamber, which receives the Ultimate Heat Sink (UHS) intake pipes at -23.800m level. The intake chamber extends outside the building to the west, with its top slab at ground level, thus providing access. The exact size of the intake chamber cannot be confirmed until the site specific UHS is known; therefore the GDA design assumes this intake level.

There is a maintenance room provided above the RSW pumps and this includes an overhead travelling crane. The top slab of the intake chamber is designed for vehicular loads from installation and maintenance of plant.

The Hx/B structure comprises an orthogonal grid of concrete walls. The main lateral load carrying walls in the building part are the perimeter walls and the walls between divisions which run east to west. At first floor level, there is also an internal wall running north to south. The walls to the intake chamber are thick and form a cellular structure to withstand the hydrostatic and ground pressures. There are also internal concrete columns to support the plant floors. The foundation basemat slab is 2.70m thick underneath the building and 3.50m thick underneath the deeper intake chamber with appropriate transition between the two areas [Ref-73].

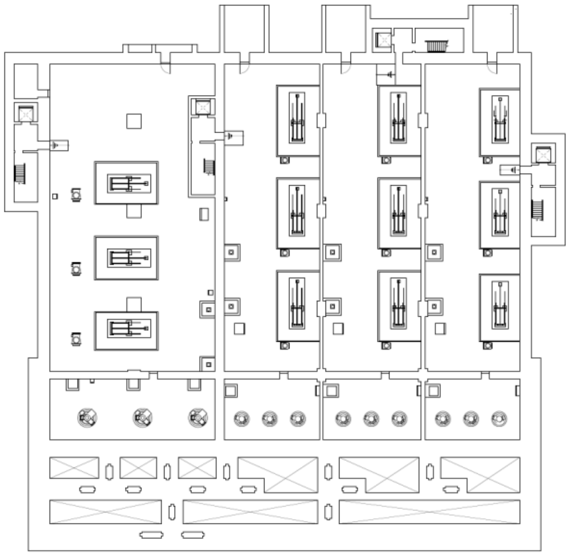

Figure 10.4.4-1: Plan B1F, Hx/B

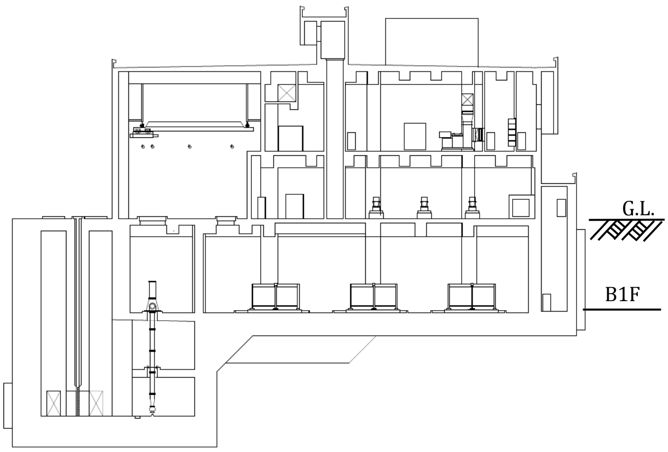

Figure 10.4.4-2: Section, Hx/B

10.4.4.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the Hx/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Hx/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [Hx/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the RCW and TCW heat exchangers and connecting pipework
- Loads associated with the RSW, RCW, TSW and TCW pumps and connecting pipework
- Crane loads and associated loading within the maintenance bay
- Hydrostatic and ground pressures
- Vehicular loads on top slab of intake chamber

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The Hx/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Hx/B SFC 5-18.01]

The Hx/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Hx/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The Hx/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Hx/B SFC 5-18.01.2]

The Hx/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Hx/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the Hx/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Hx/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [Hx/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The Hx/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Hx/B SFC 5-18.02]

The Hx/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Hx/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The Hx/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Hx/B SFC 5-18.02.2]

The Hx/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Hx/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 5-7, Functions to limit the effect of hazard

The Hx/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [Hx/B SFC 5-7.01]

The Hx/B provides divisional separation barriers between the safety trains, to protect SSCs, which deliver safety functions from design base internal hazards. [SFC Hx/B 5-7.01.1]

The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.

The Hx/B provides thick sectioned exterior walls, slabs and roof to protect SSCs inside the building which delivers safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [Hx/B SFC 5-7.02]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The Hx/B layout provides safe escape routes from inside the building to the designated safe mustering point [Hx/B SFC 5-14.01].

10.4.4.4 Design Principles

The safety functional claims of the Hx/B are described in Chapter 10.4.4.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design strategies are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Heat Exchanger Building Structural Design Report” [Ref-73]. The design method of the Hx/B is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the Hx/B are based on the material standards listed in Section 10.5.6.

- Structural
  - The Hx/B shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a

loading evaluated for a frequency of occurrence of 10-5/y for design basis internal hazard condition and 10-4/y for design basis external hazard condition.

- All structural members of the Hx/B shall be designed to remain essentially elastic under the envelope of normal conditions and design basis internal and external hazards.
- Building deflections (including vibration and resonance with pumps and dynamic plant) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
- The Hx/B shall be checked for beyond design basis resilience as described in Section 10.6.

• Design of External Envelope (External Walls and Roof)

- The external envelope of the Hx/B shall provide protection to the SSCs housed within it, which deliver safety functions, from the external environment.
- The external envelope of the Hx/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
- The external envelope of the Hx/B shall mitigate the ingress of groundwater.
- The external envelope of the Hx/B shall be designed to achieve the appropriate resistance for the design basis internal hazards which arise from other buildings or facilities on the site, e.g. missile, fire or explosion. The internal hazards assessment has considered the hazard from turbine blade disintegration across the site Chapter 7: Internal Hazards, Section 7.15, and identified the requirement of impact resistance of the Hx/B external concrete walls. This is discussed in the “Topic Report on Turbine Disintegration Safety Case” [Ref-103].

• Design of Internal Walls and Slabs

- All divisional barrier walls and slabs within the Hx/B shall provide the segregation function for the design basis internal hazards. This is described in the “Internal Hazards Barrier Substantiation Report” [Ref-102].

• Design of Basemat Slab

- The basemat slab of the Hx/B must provide an adequate foundation to the Hx/B under the design loading for normal condition and design basis fault conditions.
- The basemat slab of the Hx/B shall transfer the design vertical and lateral forces applied by the Hx/B superstructure to the ground formation.
- The basemat slab of the Hx/B shall be designed to mitigate the ingress of groundwater.

The generic design methodology is provided in “Civil Engineering Supporting Report Heat Exchanger Building Structural Design Report” [Ref-73].

10.4.5 Overview of the Turbine Building

This section provides the high level safety claims and the design principles of the Turbine Building (T/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Turbine Building Civil Design [Ref-08].
- Civil Engineering Supporting Report Turbine Building Seismic Analysis Report [Ref-74].
- Civil Engineering Supporting Report Turbine Building Structural Design Report [Ref-75].

10.4.5.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Turbine Building and safety category and class for that function. Accordingly the T/B is classified as:

- Safety Category B, Safety Class 2 structure.
- Seismic Category 2 and 1A.

The design is also checked for stability and resilience for the following:

- Seismic Category 1A – it is confirmed that T/B has no interaction with the Control Building.

The T/B houses the steam and power conversion systems. A detailed description of these systems and their safety functions is provided in PCSR Chapter 17: Steam and Power Conversion Systems. A summary of the main systems is provided below.

- Turbine Generator – comprising one high pressure and three low pressure turbines and the electricity generator
- Turbine Main Steam System – this comprises the four main steam lines which supply steam from the reactor
- Condenser – this cools the steam after exiting the turbine, to return to the reactor as feedwater. The off-gas system extracts air and non-condensable gases from the condenser, which are discharged via the R/B main stack after appropriate treatment
- Condensate and Feedwater System – supplies feedwater from the condenser to the reactor feedwater lines
- Auxiliary steam supplies and purification systems
- Circulating water system – provides cooling water to the condenser and the turbine exhaust. The Turbine Cooling Water (TCW) system provides cooling water for the turbine itself

The above systems which contain steam from the reactor, i.e. reactor coolant which is beyond the reactor coolant pressure boundary.

10.4.5.2 Structural Form

The T/B is a reinforced concrete building with and a structural steel roof structure with concrete roof slab and side walls. The general arrangement for GDA is shown in drawings GA12-2002-0008-00001 Rev.2 [Ref-47] and illustrated in Figures 10.4.5-1 and 10.4.5-2 below. The T/B is located to the north of the nuclear island, such that the Control Building is adjacent on its south elevation.

The building is 114m by 70m in plan and 34m high above ground level with four floor levels including the ground floor. Below ground level, there is an annexe to the east, such that the building is 114m by 85m in plan. The basement is 25.5m deep with three floor levels. The turbine generator is located in the turbine hall, central to the building, on a 25.5m high concrete pedestal with top slab level at +9.800m FL. The pedestal is 70m long, in the north to south axis and 16m wide.

There are two overhead travelling cranes in the central turbine hall; a 250te main crane and a 50te sub-crane. Plant rooms are located up to roof level along the east and west sides and have longitudinal runway beam hoists.

Cooling water is provided via three culvert pipes which enter from the west underneath the basemat and exit to the north. This water may be salt water if the ultimate heat sink is provided by the sea.

The structure of the T/B is generally symmetrical and is founded on a 2.5m to 3.0m thick foundation slab known as the basemat. Above ground level the main shear walls are the four perimeter walls and the two longitudinal walls to the east/west of the turbine hall. At and below ground level there are additional cross walls provided giving a robust grid. Plant floors are supported by intermediate columns as required. The pedestal is supported by 12 substantial concrete columns which are founded on the same foundation basemat. The pedestal is structurally separated from the surrounding building structures, above the basemat, so that the turbine vibration load is not transferred to adjacent parts of the structure.

The T/B is structurally separated from adjacent buildings. There is a seismic isolation gap of a minimum of 100mm with the C/B so that there is no interaction of the superstructures [Ref-75, Figure 11.3-4]. At foundation level, the T/B and C/B basemats are in contact to transfer lateral forces to provide sliding resistance.

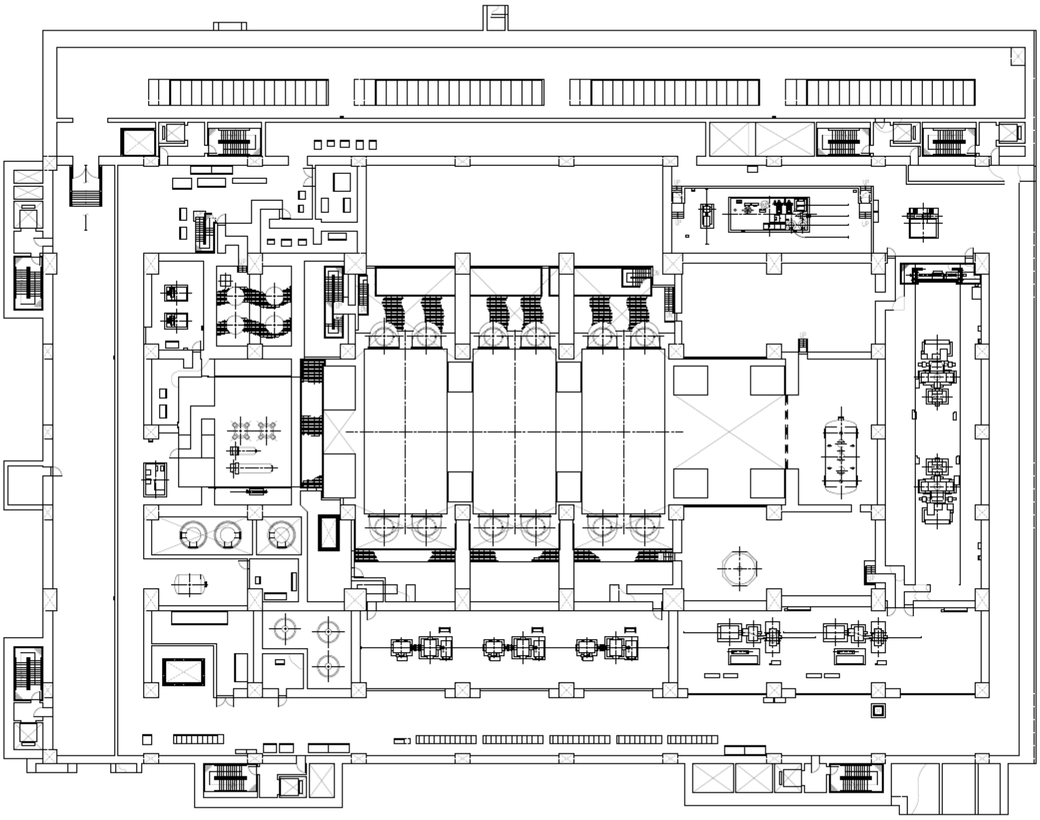

Figure 10.4.5-1: Plan B1F, T/B

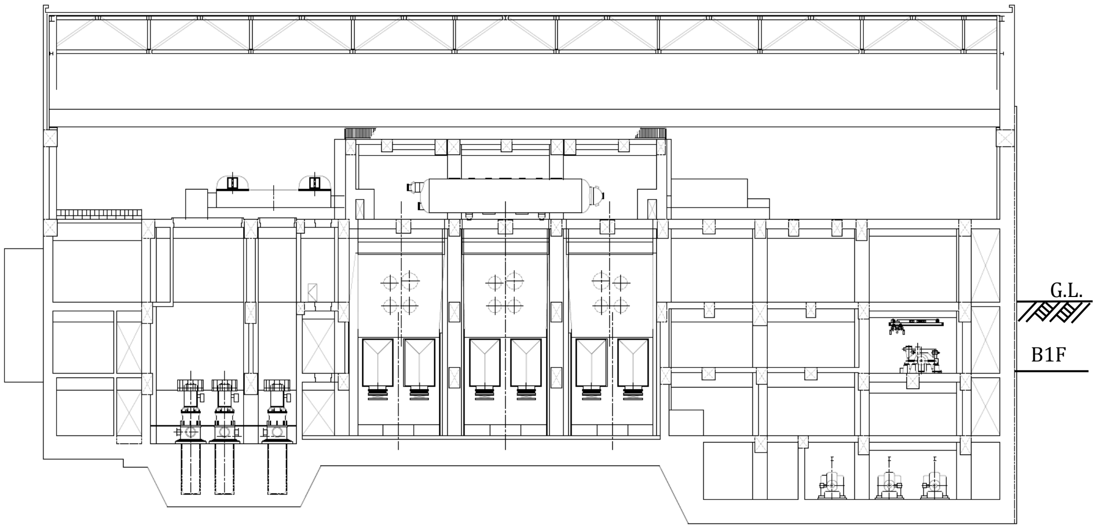

Figure 10.4.5-2: Section, T/B

10.4.5.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the T/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The T/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [T/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the turbine generator and pedestal, including vibration, thermal expansion and condenser vacuum force.
- Loads associated with the piping from the Turbine Main Steam and Condensate and Feedwater Systems.
- Overhead crane and hoist loads.

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The T/B exterior building envelope maintains the internal building environment appropriate for SSCs. [T/B SFC 5-18.01]

The T/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [T/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The T/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [T/B SFC 5-18.01.2]

The T/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [T/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The T/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce the dose rate at the site boundary. [T/B SFC 4-7.01]

This function relates to the shielding functions TG SFC 4-7.1, ES SFC 4-7.1, etc. in Chapter 17 Sections 17.3 to 17.11.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the T/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The T/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [T/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The T/B exterior building envelope maintains the internal building environment appropriate for SSCs. [T/B SFC 5-18.02]

The T/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [T/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The T/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [T/B SFC 5-18.02.2]

The T/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [T/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The T/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. [T/B SFC 4-7.02]

- HLSF 5-7, Functions to limit the effect of hazard

The T/B provides thick sectioned exterior walls, slabs and roof to protect SSCs inside the building which delivers safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [T/B SFC 5-7.01]

The T/B is categorised as Seismic Category 2/1A. Therefore, the T/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [T/B SFC 5-7.01.1]

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The T/B layout provides safe escape routes from inside the building to the designated safe mustering point [T/B SFC 5-14.01].

10.4.5.4 Design Principles

The safety functional claims of the T/B are described in Section 10.4.5.3 for normal conditions and fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Turbine Building Structural Design Report” [Ref-75].

The design method of the T/B is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the T/B are based on the material standards listed in Section 10.5.6.

- Structural
  - The T/B shall be designed to withstand the design basis external hazards as defined for Class 2 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10^{-3}/y for design basis external hazard conditions.
  - There are no internal hazards claims made on the T/B structure since the SSCs housed within it are Class 2 or below. However the internal hazards assessment has considered the hazard from turbine blade disintegration across the site (see Chapter 7, Section 7.15), and noted the additional defence in depth offered by the T/B concrete walls and slabs. This is discussed in the "Topic Report on Turbine Disintegration Safety Case" [Ref-103].
  - All structural members of the T/B shall be designed to remain essentially elastic under the envelope of the normal plant loadcases and design basis loadcases for the fault conditions including external hazards.
  - Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
  - The T/B shall be checked for design basis external hazard loadings, such that it does not adversely interact with adjacent Class 1 buildings, i.e. the C/B, under these events.
  - The T/B structure shall be considered as defence in depth for the protection of the C/B from aircraft impact.

- Design of External Envelope (External Walls and Roof)
  - The external envelope of the T/B shall provide protection to the SSCs housed within it, which deliver safety functions, from the external environment.
  - The external envelope of the T/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
  - The basement of the T/B shall mitigate the ingress of groundwater.

- Design of Basemat Slab
  - The basemat slab of the T/B must provide an adequate foundation to the T/B under the design loading for normal and design basis fault conditions.
  - The basemat slab of the T/B shall transfer the design vertical and lateral forces applied by the T/B superstructure to the ground formation.
  - The basemat slab of the T/B shall be designed to mitigate the ingress of groundwater.

The detailed design methodology is provided in "Civil Engineering Supporting Report Turbine Building Structural Design Report" [Ref-75].

10.4.6 Overview of the Radwaste Building

This section provides the high level safety claims and the design principles of the Radwaste Building (Rw/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Radwaste Building Civil Design [Ref-09].
- Civil Engineering Supporting Report Radwaste Building Seismic Analysis Report [Ref-76].
- Civil Engineering Supporting Report Radwaste Building Structural Design Report [Ref-77].

10.4.6.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Radwaste Building and safety category and class for that function. Accordingly the Rw/B is designed and constructed as:

- Safety Category C, Safety Class 3 structure.
- Seismic Category 2.

The design is also checked for stability and resilience for the following

- Seismic Category 1A – it is confirmed that Rw/B has no interaction with the Control Building.

The Rw/B houses all equipment associated with the collection and processing of solid and liquid waste generated by the plant. The designs of all of the radioactive waste management systems are at concept design which aligns with UK regulatory guidance. The description of the concept design of these systems and their safety functions is provided in PCSR Chapter 18: Radioactive Waste Management. A summary of the main systems is provided below.

- Liquid Radioactive Waste Management System (LWMS) – collects liquid waste generated in the controlled areas of the whole nuclear island, segregates it based on chemical impurity and radioactivity and processes it. Treated water is generally returned to the Condensate Storage Tank for reuse
- Controlled Area Drains (CAD) system – collects water from local air-conditioning drains and floor drains in the controlled areas of the R/B and T/B. The system is comprised of collection tanks, pumps, piping, valves and measuring and control equipment
- Spent Resin and Sludge (SS) system – collects these wastes from the R/B and T/B and stores in tanks in the Rw/B
- Solid Radioactive Waste Management System (SWMS) – wet solid waste that is generated within the above systems is collected in tanks in the Rw/B and then processed

The Rw/B therefore, houses various storage tanks for liquid waste and the associated processing plant to safely treat it. Secondary solid wastes arising from this treatment are appropriately managed as described in PCSR Chapter 18.

10.4.6.2 Structural Form

The Rw/B is a reinforced concrete building including the roof and external elevations. The general arrangement for GDA is shown in drawings GA12-2002-0013-00001 Rev.1 [Ref-47] and illustrated in Figures 10.4.6-1 and 10.4.6-2 below. The Rw/B is located within the main power block of the nuclear island, and is immediately west of the Control Building. Personnel access corridors connect between the two buildings. However, structural independence is maintained through provision of a 100mm wide seismic gap.

The concept layout of the building is an approximate cube, 53m by 44m in plan and a total height of 57.5m. The roof is 28m above ground level and the basement has two levels with a maximum depth of 29.5m on the east side (adjacent to the C/B) and a depth of 20m on the west side [Ref-76].

Above the ground level floor there are two plant floors which house pumps and electrical equipment. The waste storage tanks and processing plant are housed in the basement at the -26.9m and -16.9m floor levels, with an operating floor overall at -5.4m level. There will be a vehicle bay for the building for future export of solid waste flasks; however the location and details of this are not included in the scope of the concept design.

The internal walls of the Rw/B form a symmetrical, regular grid and so provide similar structural load paths for lateral loads in both directions [Ref-76]. Above ground level, the numbers of internal walls decrease and so concrete columns are used to support the floors.

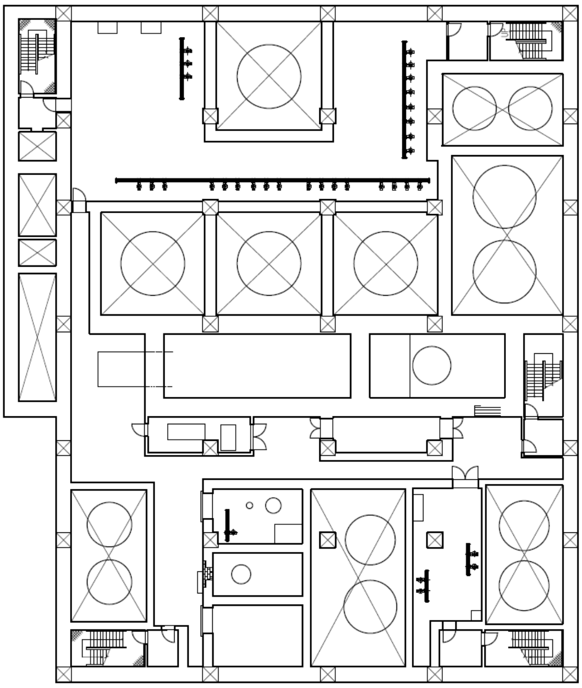

Figure 10.4.6-1: Plan B2F, Rw/B

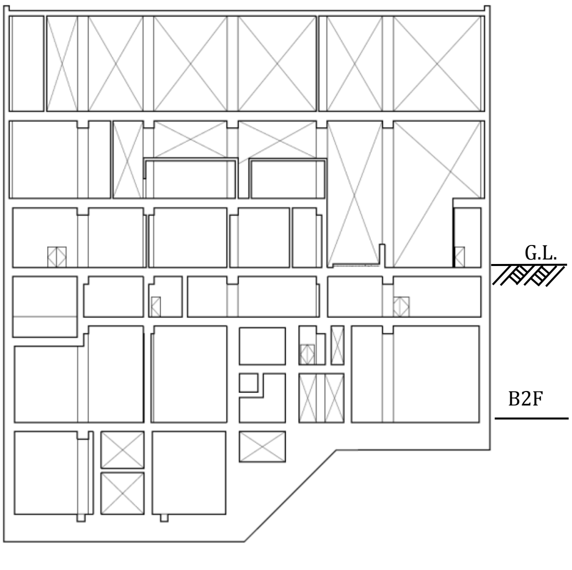

Figure 10.4.6-2: Section, Rw/B

10.4.6.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the Rw/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Rw/B is designed with the loading conditions described in section 10.3.5, to support the SSCs for the normal conditions. [Rw/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the liquid storage tanks on the lower levels of the Rw/B
- Loads associated with process plant and piping where known, otherwise a floor live load is used
- No loads from vehicles have been included for this concept design

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The Rw/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Rw/B SFC 5-18.01]

The Rw/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Rw/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The Rw/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [Rw/B SFC 5-18.01.2]

The Rw/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Rw/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The Rw/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [Rw/B SFC 4-7.01]

This function relates to the dose rate function LWMS SFC 4-12.3 and SWMS SFC 4-13.2 in PCSR Chapter 18, Section 18.3.1.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the Rw/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Rw/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [Rw/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The Rw/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Rw/B SFC 5-18.02]

The Rw/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Rw/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The Rw/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Rw/B SFC 5-18.02.2]

The Rw/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Rw/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The Rw/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. [Rw/B SFC 4-7.02]

- HLSF 5-7, Functions to limit the effect of hazard

The Rw/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [Rw/B SFC 5-7.01]

The Rw/B is categorised as Seismic Category 2/1A. Therefore, the Rw/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [Rw/B SFC 5-7.01.1]

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The Rw/B layout provides safe escape routes from the inside of the building to the designated safe mustering point. [Rw/B SFC 5-14.01]

10.4.6.4 Design Principles

The safety functional claims of the Rw/B are described in Section 10.4.6.3 for normal conditions and fault conditions. To fulfil these claims, following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Radwaste Building Structural Design Report” [Ref-77].

The design method of the Rw/B is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the Rw/B are based on the material standards listed in Section 10.5.6.

- Structural
  - The Rw/B shall be designed to withstand the design basis external hazards as defined for Class 3 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-2/y for design basis external hazard conditions except for seismic category 2 structures where the seismic loading is evaluated for a frequency of occurrence of 10-3/y.
  - There are no internal hazards claims made on the Rw/B structure since the SSCs housed within it are Class 3 or below.
  - All structural members of the Rw/B shall be designed to remain essentially elastic under the envelope of the normal plant loadcases and design basis loadcases for fault conditions including seismic category 2 loading.
  - Building deflections (including vibration and resonance with from pumps and dynamic equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
  - The Rw/B shall be checked for design basis external hazard loadings, such that it does not adversely interact with adjacent Class 1 buildings, i.e. the C/B, under these events.
  - The Rw/B structure shall be considered as defence in depth for the protection of the C/B from aircraft impact.

- Design of External Envelope (External Walls and Roof)
  - The external envelope of the Rw/B shall provide protection to the operating personnel and the SSCs housed within it, which deliver the safety functions, from the external environment.
  - The external envelope of the Rw/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
  - The basement of the Rw/B shall mitigate the ingress of groundwater.
  - The external envelope of the Rw/B shall be designed to achieve the appropriate fire resistance for the Design Basis external and internal hazards.

- Design of Tank Rooms
  - The concrete rooms where storage tanks are located shall be able to receive appropriate surface finishes for containment and decontamination purposes. This is conceptual at GDA stage, and detailed specification will be carried out at site specific stage (refer to Section 10.3.6.7).

- Design of Basemat Slab
  - The basemat slab of the Rw/B must provide an adequate foundation to the Rw/B under the design loading for normal condition and design basis fault conditions.
  - The basemat slab of the Rw/B shall transfer the design vertical and lateral forces applied by the Rw/B superstructure to the ground formation.
  - The basemat slab of the Rw/B shall be designed to mitigate the ingress of groundwater.

The detailed design methodology is provided in "Civil Engineering Supporting Report Radwaste Building Structural Design Report" [Ref-77].

10.4.7 Overview of the Back-up Building

This section provides the high level safety claims and the design principles of the Back-up Building (B/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Back-up Building Civil Design [Ref-10].
- Civil Engineering Supporting Report Back-up Building Seismic Analysis Report [Ref-78].
- Civil Engineering Supporting Report Back-up Building Structural Design Report [Ref-79].

10.4.7.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Back-up Building and safety category and class for that function. Accordingly the B/B is classified as:

- Safety Category A, Safety Class 2 structure.
- Seismic Category 1.

The B/B contains alternative safety management capacity for accident management and diverse provision in the event of Loss Of Off-site Power (LOOP). The plant and equipment housed within the B/B is segregated into two independent divisions as further defence in depth and includes the following:

- Two back-up diesel generators (A and B) with fuel day tanks
- Two battery rooms (A and B)
- Associated electrical panels, HVAC and cooling to the generators
- Emergency control room with two diverse HVAC systems to maintain a habitable indoor environment
- Communications equipment, offices and welfare facilities for emergencies
- Water pumps and associated pipework for the Class 2 Flooder System of Specific Safety Facility (FLSS). Two pumps in each division, giving four pumps in total

10.4.7.2 Structural Form

The B/B is a reinforced concrete structure, including roof and external wall elevations. The general arrangement for GDA is shown in drawings GA12-2002-0012-00001 Rev.2 [Ref-47] and illustrated in Figures 10.4.7-1 and 10.4.7-2 below. The B/B is located away from the nuclear island and for GDA it is assumed to be due south of the R/B (see PCSR Chapter 9). The B/B is also located at a higher elevation than the nuclear island. These spatial separation measures ensure the B/B cannot be affected simultaneously with the nuclear island from hazards such as beyond design basis external flooding, aircraft impact, fire, missile and explosion.

It is basically a cube in shape, being 45m by 45m in plan and 42m overall in height. The roof is 23.2m high above grade and supports the air fin coolers and silencers for the generators. The ground floor houses the diesel generators, electrical and battery rooms arranged in two divisions. There are two floors above ground level; +8.9m level houses the control panels and day fuel tanks and the +15.9m level houses the emergency control room, offices and facilities for emergencies.

The main basement floor at -8.0m level houses the two divisions of cooling fans and water pumps as well as the emergency air tanks. The lower basement at -15.8m level and covers just a quarter of the building plan area; it houses the FLSS water pumps.

The external perimeter walls are thicker than the internal walls, however due to the regular grid most internal walls contribute to the structural load carrying capacity. The B/B basemat is 2.80m thick.

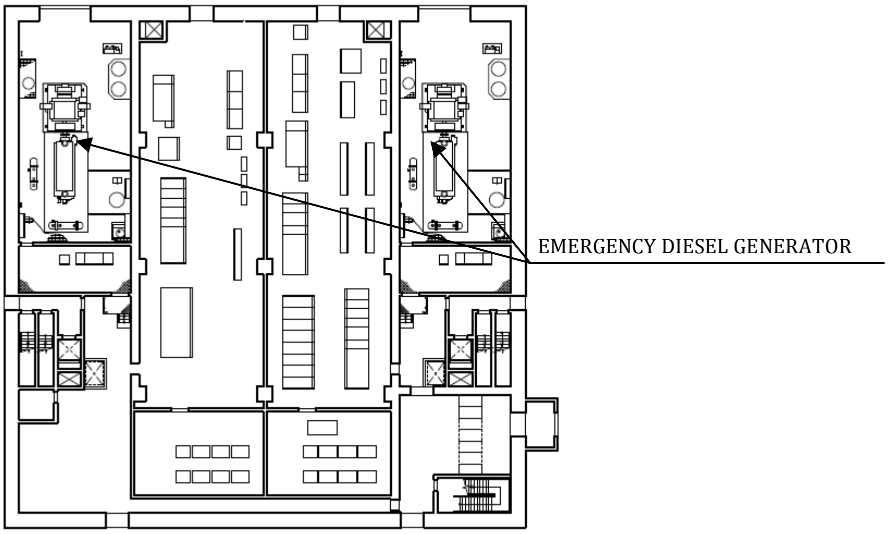

Figure 10.4.7-1: Plan 1F, B/B

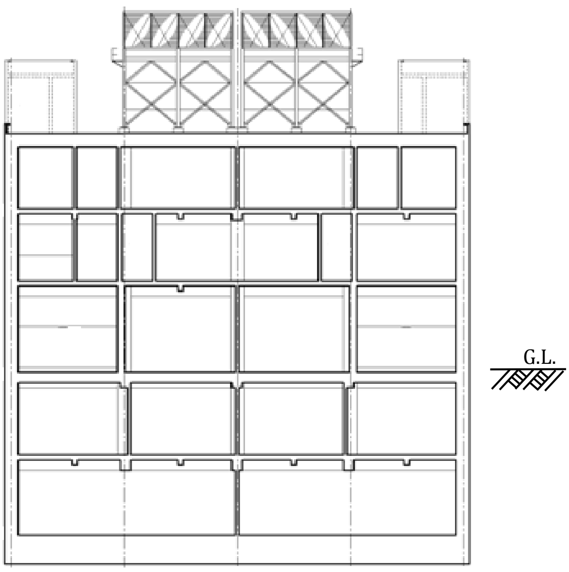

Figure 10.4.7-2: Section, B/B

10.4.7.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the B/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The B/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [B/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the diesel generators including vibration and installation loads
- Loads associated with heavy pumps and motors including vibration
- Loads associated with the cooling water pipework

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B exterior building envelope maintains the internal building environment appropriate for SSCs. [B/B SFC 5-18.01]

The B/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [B/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The B/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater [B/B SFC 5-18.01.2].

The B/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [B/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the B/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The B/B is designed to support SSCs which deliver safety functions for design basis (DB) loads, to support accident management facilities. [B/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B exterior building envelope maintains the internal building environment appropriate for SSCs. [B/B SFC 5-18.02]

The B/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [B/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The B/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [B/B SFC 5-18.02.2]

The B/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [B/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The B/B provides shielding walls and slabs, to shield radiation to lower for accident management activities inside the building. The shielding walls maintain their shielding function against postulated fault conditions. [B/B SFC 4-7.01]

- HLSF 5-7, Functions to limit the effect of hazard

The B/B shall provide thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [B/B SFC 5-7.01]

The B/B is located with adequate separation from the nuclear island to maintain function of the accident management facilities during relevant external hazard conditions which affect the R/B and C/B. [B/B SFC 5-7.01.1]

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The B/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [B/B SFC 5-14.01]

10.4.7.4 Design Principles

The safety functional claims of the B/B are described in Section 10.4.7.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Back-up Building Structural Design Report” [Ref-79].

The design method of the B/B is carefully determined to realise those design strategies based on the codes and standards listed in Section 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the B/B are based on the material standards listed in Section 10.5.6.

- Structural

- The B/B shall be designed to withstand the design basis external hazards as defined for Class 2 structures (refer to PCSR Chapter 5). However, for additional resilience the GDA design includes design to the same design basis external hazard conditions as Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10^{-4}/y for design basis external hazard conditions.
- All structural members of the B/B shall be designed to remain essentially elastic under the envelope of normal conditions and design basis external hazards.
- Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
- The B/B shall be checked for beyond design basis resilience as described in Section 10.6.
- The B/B also provides resilience to the beyond design basis external hazard conditions by its location, particularly external flooding, aircraft impact, fire, explosion and missiles.
- Since the B/B is a Safety Class 2 building, the internal walls are not classed as internal hazards barrier walls.

• Design of External Envelope (External Walls and Roof)

- The external envelope of the B/B shall provide protection to the SSCs housed within it, which deliver the safety functions, from the external environment.
- The external envelope of the B/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
- The external envelope of the B/B shall mitigate the ingress of groundwater.
- The external envelope of the B/B shall be designed to achieve the appropriate resistance for the Class 1 design basis external hazards.

• Design of Basemat Slab

- The basemat slab of the B/B must provide an adequate foundation to the B/B under the design loading for normal condition and design basis fault conditions.
- The basemat slab of the B/B shall transfer the design vertical and lateral forces applied by the B/B superstructure to the ground formation.
- The basemat slab of the B/B shall be designed to mitigate the ingress of groundwater.

The detailed design methodology is provided in "Civil Engineering Supporting Report Back-up Building Structural Design Report" [Ref-79].

10.4.8 Overview of the Main Stack

This section provides the high level safety claims and the design principles of the Main Stack (Stack) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Reactor Building Civil Design [Ref-04].
- Civil Engineering Supporting Report Stack Seismic Analysis Report [Ref-80].
- Civil Engineering Supporting Report Stack Structural Design Report [Ref-81].

10.4.8.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Main Stack and safety category and class for that function. Accordingly the Stack is classified as:

- Safety Category A, Safety Class 2 structure.
- Seismic Category 1.

The function of the stack structure is to support the ventilation discharge ducts exiting from the reactor building. The systems which are ducted to the Stack are as follows:

- The R/B reactor area HVAC which maintains a negative pressure within the reactor area during normal conditions
- The R/B Standby Gas Treatment System (SGTS) which provides HVAC to the secondary containment during fault conditions
- The Filtered Containment Venting System (FCVS) from the PCV during severe accidents
- The T/B HVAC from the controlled area within the T/B, including the off-gas system duct
- The Rw/B HVAC from the controlled area within the Rw/B with local air treatment for airborne contamination as necessary
- All exhaust air through the Stack ducting is treated with HEPA filters before discharge

10.4.8.2 Structural Form

The Stack is a steel lattice structure which provides support to the various ducts described above. The structure is 48m tall and is 8.1m square at the base and 5.5m square at the top. It is located on the roof of the R/B as shown in Figures 10.4.8-1 and 10.4.8-2, such that the top of the exhaust duct, or stack shell, is 75m above ground level.

The Stack is an independent structure from the R/B. The feet of the steel lattice are bolted to the concrete plinths on the R/B roof slab and these are designed as pinned. The steel lattice structure is constructed of hot rolled circular hollow sections and is shown in Figure 10.4.8-3 with simplistic geometry as used in the finite element analysis. A more detailed arrangement is shown in Figure 3 of the "Civil Engineering Supporting Report Stack Structural Design Report" [Ref-81]. Associated pipework and five platforms are supported off the structure, and helical stairs and ladders are supported off the stack shell allowing access up the Stack for inspection, maintenance and monitoring purposes.

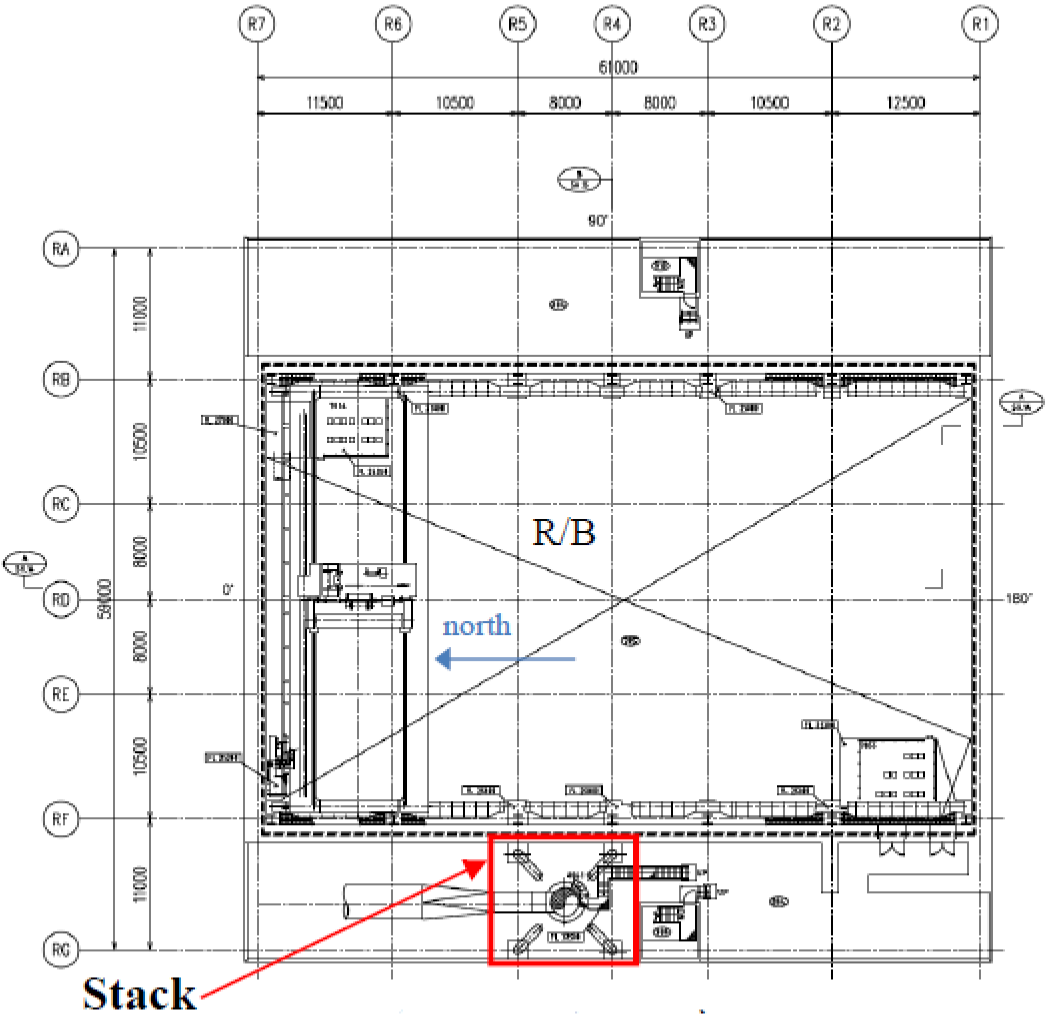

Figure 10.4.8-1: Plan, R/B Roof showing Stack Location

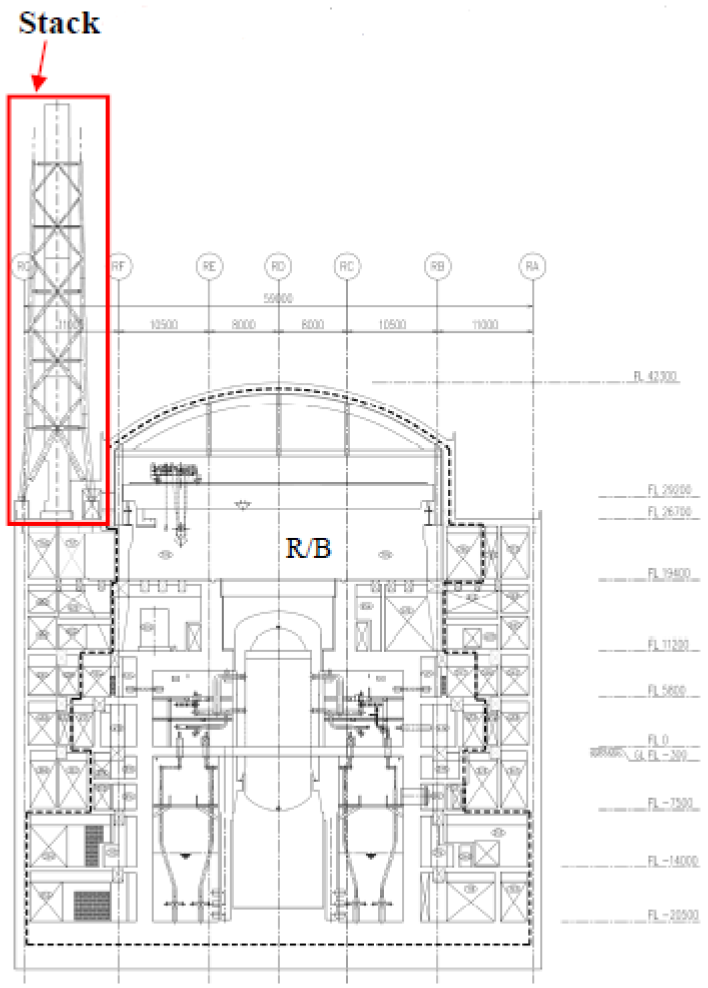

Figure 10.4.8-2: Section, Stack and R/B

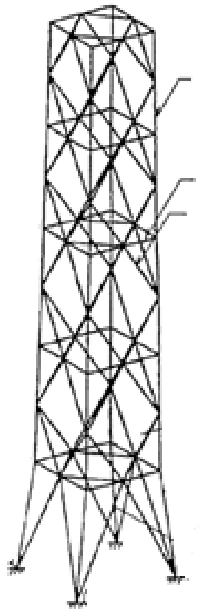

Figure 10.4.8-3: Analysis Model, Main Stack

10.4.8.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the Stack design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Stack is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal conditions. [STACK SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the ducts and equipment supported by the stack.
- Wind loading on the lattice frame and on the stack shell.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the Stack design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The Stack is designed to support SSCs which deliver safety functions for design basis (DB) loads. [STACK SFC 5-17.02]

- HLSF 4-8, Functions to minimise the release of radioactive gases

The stack provides the required height from the dispersion of exhaust gases from the ventilation of the radiation controlled area within the plant. [STACK SFC 4-8.01]

The height of the top of stack duct is determined by air diffusion modelling and for GDA purpose, this is set at 75m above the nominal site ground level. The height for a specific UK site will be reassessed during the site specific stage; however this is not anticipated to vary significantly from the GDA height.

- HLSF 5-7, Functions to limit the effect of hazard

The stack will be designed to protect SSCs connected to the stack which deliver safety functions from design basis external hazards. The structure shall retain its structural integrity and maintain raised vent against the design basis hazards. [STACK SFC 5-7.01]

10.4.8.4 Design Principles

The safety functional claims of the Stack are described in Section 10.4.8.3 for normal conditions and fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Stack Structural Design Report" [Ref-81]. The design method of the Stack is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the Stack are based on the material standards listed in Section 10.5.6.

- Structural
  - The Stack shall be designed to withstand the design basis external hazard conditions as defined for Class 2 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-3/y for design basis external hazard conditions except for seismic category 1 structures where the seismic loading is evaluated for a frequency of occurrence of 10-4/y.
  - All structural members of the Stack shall be designed to remain essentially elastic under the envelope of normal conditions and design basis external hazards.
  - The seismic modelling of the Stack and the R/B shall be appropriately integrated.
  - The Stack deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.

The detailed design methodology is provided in "Civil Engineering Supporting Report Stack Structural Design Report" [Ref-81].

10.4.9 Overview of the Emergency Diesel Generator Building

This section provides the high level safety claims and the design principles of the Emergency Diesel Generator Buildings (EDG/Bs) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR. There are three separate buildings, which are all identical, and so this section in generally written in the singular.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Emergency Diesel Generator Building Civil Design [Ref-11].
- Civil Engineering Supporting Report Emergency Diesel Generator Building Seismic Analysis Report [Ref-82].
- Civil Engineering Supporting Report Emergency Diesel Generator Building Structural Design Report [Ref-83].

10.4.9.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Emergency Diesel Generator Building and safety category and class for that function. Accordingly the EDG/B is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

There are three Emergency Diesel Generators, one supplied for each safety division A, B and C. The safety functions are described in Section 15.5.3 of PCSR Chapter 15: Electrical Power Supplies. This is mainly to supply power needed to shut down and cool the reactor safely if off-site power is lost and in the unlikely scenario of a LOCA occurring simultaneously.

To provide divisional segregation three separate EDG/Bs are provided, each housing one diesel generator. The GDA site plan is shown in the “Overview of UK ABWR Civil Structures” [Ref-104]. The positions of buildings away from the nuclear island are indicative only and so the exact positions of the EDG/Bs are not finalised within GDA. However, a multi-disciplinary, optioneering study was carried out to confirm the locations of the EDGs could be optimised. This considered external hazards, internal hazards, overall nuclear safety, reliability, maintainability, construction and decommissioning and is described in the “Topic Report of the Emergency Diesel Generator locations optioneering study” [Ref-109]. This report justifies that the design change reduces risk to ALARP, as follows:

- Each EDG is segregated both from each other and from other primary and back-up safety systems.
- Each EDG is located in its own substantial concrete building which protects the EDG from relevant internal/external hazards. The EDG/Bs are Seismic Category 1.
- The locations of the EDG/B provided physical separation which reduce the risks from external hazard groups 11 to 14 (aircraft impact, fire, missile, explosion) from simultaneously affecting two or more EDGs.

Each EDG/B is arranged such that the diesel generator is located on the ground floor to allow potential replacement during the 60 years plant life cycle. Two light oil storage tanks are located in the basement and a fuel day tank is located on the floor above the generator. The building has an

HVAC system and dedicated ventilation fans for the diesel generator room. The exhaust to the generator is located on the roof of the building.

10.4.9.2 Structural Form

The EDG/B is a rectangular box, reinforced concrete structure which is 27.5m by 19.5m in plan. The structure has three storeys above ground and one storey below. The roof level is 15.6m above general site datum level (ground level). The basement is 11.6m deep and the foundation slab is 3m thick.

The main structural resisting system is provided by the external perimeter walls and floor slabs. Internally vertical load is transferred mainly through concrete columns. Internal walls do not need to resist internal hazards, but do provide suitable fire compartments. Two staircases are provided for access and emergency egress. Concrete hoods are provided over large openings e.g. air intakes to provide protection from impacts from outside the building.

The basement includes bund walls around the diesel storage tanks. The tunnel connecting the EDG/B to the Reactor Building exits the basement at -4.9m level.

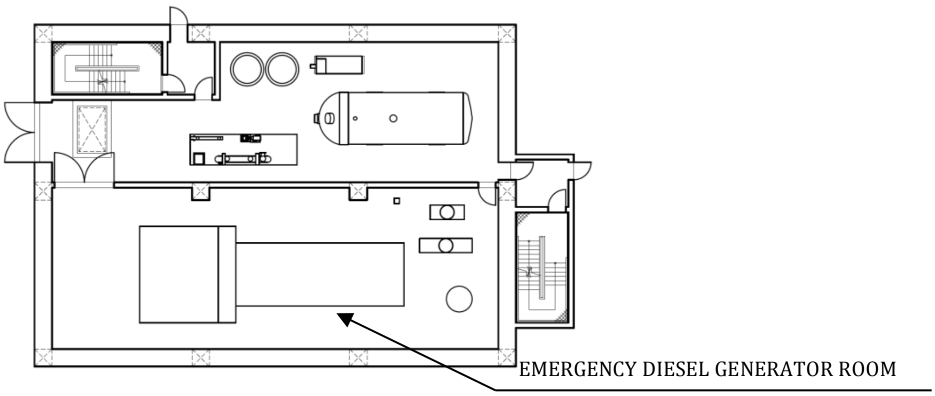

Figure 10.4.9-1: Plan 1F, EDG/B

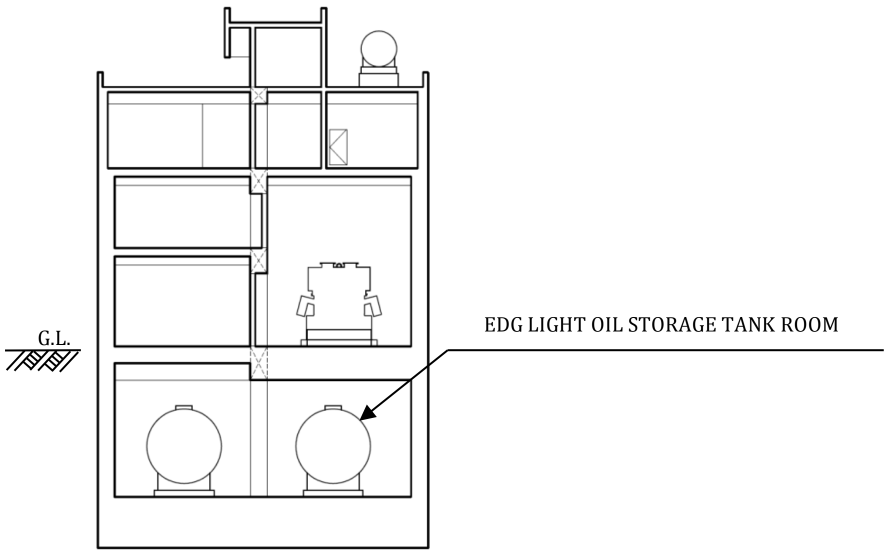

Figure 10.4.9-2: Section, EDG/B

10.4.9.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the EDG/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The EDG/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [EDG/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the diesel generator including vibration.
- Loads associated with the fuel storage tanks including pumps and the fluids stored.
- Installation loads for the generators are also included.

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The EDG/B exterior building envelope maintains the internal building environment appropriate for SSCs. [EDG/B SFC 5-18.01]

The EDG/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [EDG/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The EDG/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [EDG/B SFC 5-18.01.2]

The EDG/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [EDG/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the EDG/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The EDG/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [EDG/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The EDG/B exterior building envelope maintains the internal building environment appropriate for SSCs. [EDG/B SFC 5-18.02]

The EDG/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [EDG/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The EDG/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [EDG/B SFC 5-18.02.2]

The EDG/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [EDG/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 5-7, Functions to limit the effect of hazard

The EDG/B provides sufficiently thick exterior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [EDG/B SFC 5-7.01]

The EDG/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design basis internal hazards. [EDG/B SFC 5-7.01.1]

The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.

Since each EDG/B is one division, there are no IH claims on internal walls. The barrier requirements are given in the “Internal Hazards Barrier Substantiation Report” [Ref-102].

The EDG/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [EDG/B SFC 5-7.02]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The EDG/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [EDG/B SFC 5-14.01]

10.4.9.4 Design Principles

The safety functional claims of the EDG/B are described in Chapter 10.4.9.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Emergency Diesel Generator Building Structural Design Report” [Ref-83]. The design method of the EDG/B is carefully determined to realise those design strategies based on the codes and standards listed in Chapter 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the EDG/B are based on the material standards listed in Chapter 10.5.6.

- Structural

- The EDG/B shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are the hazards with a loading evaluated for a frequency of occurrence of 10^{-5}/y for design basis internal hazard condition and 10^{-4}/y for design basis external hazard conditions.
- All structural members of the EDG/B shall be designed to remain essentially elastic under the envelope of normal conditions and design basis external hazards.
- Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
- The EDG/B shall be checked for beyond design basis resilience as described in Section 10.6.

• Design of External Envelope (External Walls and Roof)

- The external envelope of the EDG/B provides protection to the SSCs, which deliver the safety functions, from design basis external hazards and internal hazards arising elsewhere on the site.
- The external envelope of the EDG/B mitigates against the ingress of groundwater.

• Design of Basemat Slab

- The basemat slab of the EDG/B provides an adequate foundation to the EDG/B under all normal condition and design basis fault conditions.
- The basemat slab of the EDG/B transfers the design vertical and lateral forces applied by the EDG/B superstructure to the ground formation.
- The basemat slab and basement walls of the EDG/B are designed to mitigate the ingress of groundwater. Final details of the waterproofing strategy will need to be confirmed at site specific stage.

The generic design methodology is provided in "Civil Engineering Supporting Report Emergency Diesel Generator Building Structural Design Report" [Ref-83].

10.4.10 Overview of the R/B-EDG/B Connecting Service Tunnel

This section provides the high level safety claims and the design principles adopted for the R/B to EDG/B Connecting Service Tunnel, in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on R/B-EDG/B Connecting Service Tunnel Civil Design [Ref-12].
- Civil Engineering Supporting Report R/B-EDG/B Connecting Service Tunnel Seismic Analysis Report [Ref-84].
- Civil Engineering Supporting Report R/B-EDG/B Connecting Service Tunnel Structural Design Report [Ref-85].

10.4.10.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the R/B-EDG/B Connecting Service Tunnel and safety category and class for that function. Accordingly the R/B-EDG/B Connecting Service Tunnel is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

There are three R/B-EDG/B tunnels, one for each EDG/B (refer to Section 10.4.9). Each R/B-EDG/B Tunnel houses piping and cabling associated with the systems of the EDG/B and connects it to the R/B. The major systems housed by the Tunnel include power cables to supply the R/B and cable trays for instrumentation and station power to the EDG/B, Instrument Air (IA) system piping, HVAC Emergency Cooling Water (HECW) system piping, Reactor Building Cooling Water (RCW) system piping and related components.

10.4.10.2 Structural Form

The R/B-EDG/B Connecting Service Tunnel is an underground reinforced concrete tunnel consisting of a single square cell, 5.4m wide by 4.4m tall. The Tunnel is formed by a number of longitudinal units with each unit isolated by seismic joints to avoid interaction between each unit. Suitable joints are also provided at the buildings at each end. The alignment of the Tunnels may also include bends to facilitate changes in direction of the cable routes. The GDA site plan is shown in the “Overview of UK ABWR Civil Structures” [Ref-104], but is indicative only and so the alignment of the tunnel is not finalised within GDA. The depth of overburden is assumed to be 7.0m maximum.

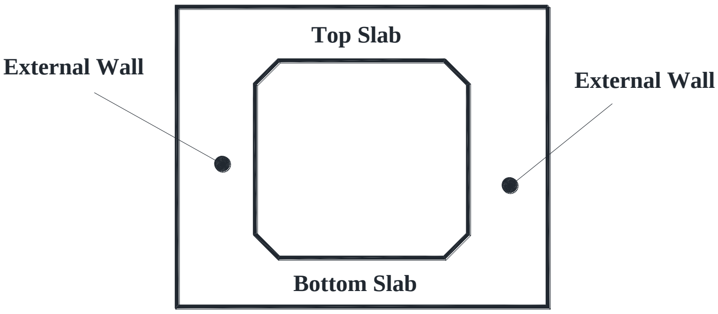

Figure 10.4.10-1: Section, R/B-EDG/B Connecting Service Tunnel

10.4.10.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the R/B-EDG/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B-EDG/B Connecting Service Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [R/B-EDG/B Tunnel SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with piping and cabling
- Loads from the weight of the surrounding ground
- Allowance for surcharge from vehicular loading

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B-EDG/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-EDG/B Tunnel SFC 5-18.01]

R/B-EDG/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-EDG/B Tunnel SFC 5-18.01.1]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the R/B-EDG/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B-EDG/B Connecting Service Tunnel is designed to support SSCs which deliver safety functions for design basis (DB) loads. [R/B-EDG/B Tunnel SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B-EDG/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-EDG/B Tunnel SFC 5-18.02]

The R/B-EDG/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-EDG/B Tunnel SFC 5-18.02.1]

- HLSF 5-7, Functions to limit the effect of hazard

The R/B-EDG/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B-EDG/B Tunnel SFC 5-7.01]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The R/B-EDG/B Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B-EDG/B Tunnel SFC 5-14.01]

10.4.10.4 Design Principles

The safety functional claims of the R/B-EDG/B Connecting Service Tunnel are described in Section 10.4.10.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report R/B-EDG/B Connecting Service Tunnel Structural Design Report” [Ref-85]. The design method of the R/B-EDG/B Connecting Service Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the R/B-EDG/B Connecting Service Tunnel are based on the material standards listed in Section 10.5.6.

- Structural
  - The R/B-EDG/B Connecting Service Tunnel shall be designed to withstand the design basis external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are the hazards with a loading evaluated for a frequency of occurrence of 10^{-5}/y for design basis internal hazard condition and 10^{-4}/y for design basis external hazard conditions.
  - All structural members of the R/B-EDG/B Connecting Service Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and design basis external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
  - The R/B-EDG/B Tunnel, as a Class 1 structure, shall be checked for beyond design basis resilience as described in Section 10.6.

- Design of Walls and Slabs
  - The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards, including adequate foundation to transfer the vertical and lateral forces to the ground formation.

- The external walls and slabs shall mitigate the ingress of groundwater.
- The external walls and slabs shall be designed to achieve the appropriate fire resistance.

The generic design methodology is provided in “Civil Engineering Supporting Report R/B-EDG/B Connecting Service Tunnel Structural Design Report” [Ref-85].

10.4.11 Overview of the Condensate Storage Tank Structure and Connecting Service Tunnel

This section provides the high level safety claims and the design principles adopted for the civil structures associated with Condensate Storage Tank (CST), in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR. These structures are as follows.

- The structure which supports and encloses the tank, water pumps and associated cabling. This is referred to as the CST Structure
- The connecting service tunnel which conveys the CST water supply pipework from the tank to the Reactor Building. This is referred to as the R/B-CST-Rw/B Connecting Service Tunnel

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Condensate Storage Tank Structure and Connecting Service Tunnel Civil Design [Ref-13].
- Civil Engineering Supporting Report Condensate Storage Tank Structure and Connecting Service Tunnel Seismic Analysis Report [Ref-86].
- Civil Engineering Supporting Report Condensate Storage Tank Structure and Connecting Service Tunnel Structural Design Report [Ref-87].

10.4.11.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Condensate Storage Tank Structure and Connecting Service Tunnel and safety category and class for that function. Accordingly the CST Structure and Connecting Service Tunnel are classified as:

- Safety Category A, Safety Class 2 structure.
- Seismic Category 2.

The CST is used as a water storage for the Makeup Water Condensate System (MUWC) which is one of the water sources for makeup water to the RPV via the Reactor Core Isolation Cooling System (RCIC), the High Pressure Core Flooder System (HPCF), the Suppression Pool Clean-up System (SPCU) and the Control Rod Drive System (CRD).

The CST has a nominal capacity of 2,400m^3 and there is a leak detection system in case of leaks from the tank. Since the water could be radioactive, the CST Structure provides shielding. There are three MUWC pumps housed in the CST Structure, however during power operation a single pump is sufficient. Power to the pumps supplied by normal station power supply but also from an EDG/B in case of a LOOP event.

10.4.11.2 Structural Form

The CST Structure consists of two parts: a Tank Room and a Pump Room. These are structurally separated from each other by a seismic isolation joint. The layout is shown in Figures 10.4.11-1 and 10.4.11-2 below.

The CST is a vertical, cylindrical steel tank and is enclosed by the Tank Room for shielding purposes. The structure consists of a 23m diameter circular reinforced concrete top slab, bottom foundation slab (or basemat) and a peripheral external concrete wall. The external shielding wall is constructed monolithically with the Tank Room basemat slab. The structure is 16m high above ground level and is embedded by 5.5m.

The Pump Room is a rectangular box concrete structure, 23m by 17m in plan, 10m above ground level and embedded by 18m in order to reach the level of the tunnel. This houses the three MUWC pumps and associated equipment.

The R/B-CST-Rw/B Connecting Service Tunnel is an underground reinforced concrete tunnel consisting of a single square cell, 5.2m wide by 5.8m tall. The tunnel runs between the CST Pump Room and the Reactor Building, with a branch to the Radwaste Building. The GDA site plan is shown in the "Overview of UK ABWR Civil Structures" [Ref-104]. The positions of buildings away from the nuclear island are indicative only and so the alignment and lengths of the tunnel are not finalised within GDA. It is expected to include bends to facilitate changes in direction of the piping and cable routes.

The GDA design generally considers the tunnel is formed by a number of longitudinal units, with each unit isolated by seismic joints, to accommodate appropriate movement, particularly in a seismic event. Suitable joints are also provided at interfaces with the buildings at each end. The depth of overburden is taken as 11.9m for the GDA design. The design of the structure is based on the cross section resisting lateral forces as a moment frame. Longitudinally the walls act as shear walls between tunnel joints. At bends, joints will be provided either side; the tunnels walls at the bend provide stability in both horizontal directions.

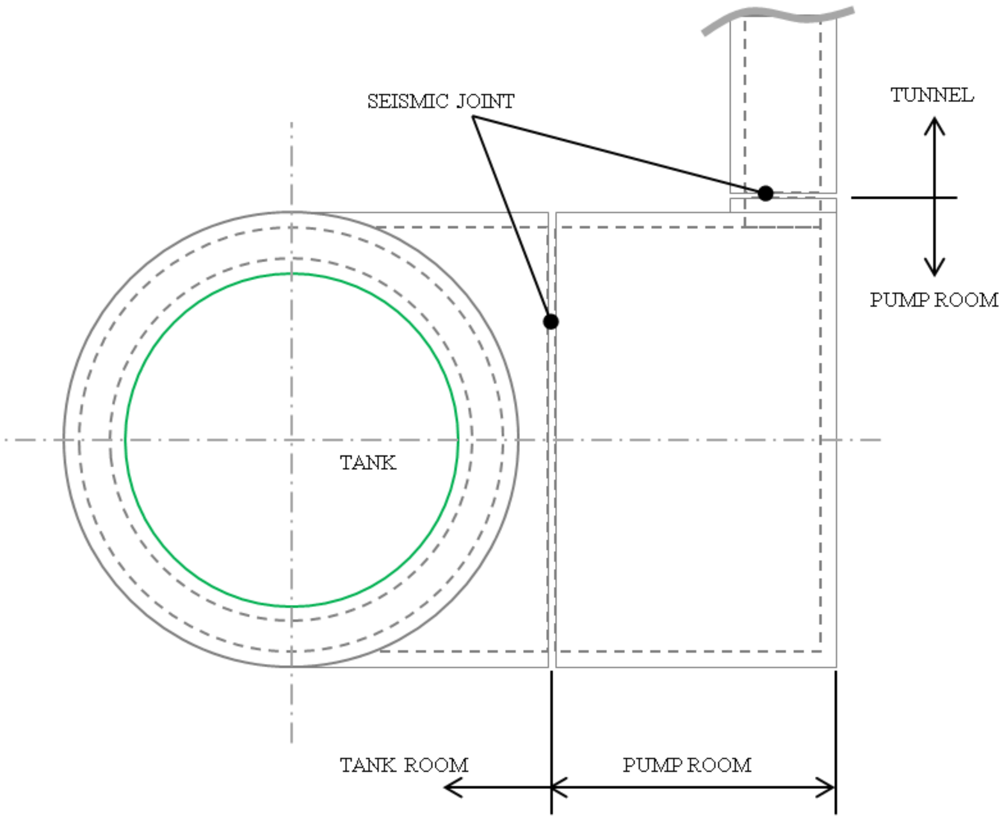

Figure 10.4.11-1: Plan, CST Structure and Tunnel

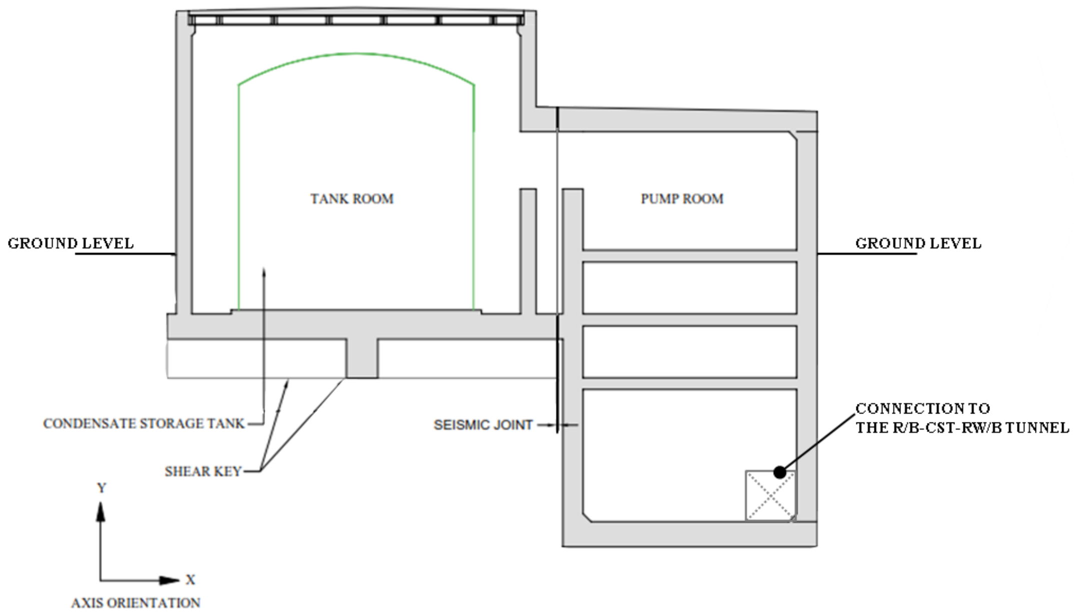

Figure 10.4.11-2: Section, CST Structure and Tunnel

10.4.11.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [CST SFC 5-17.01]

The main specific normal condition loads for the CST Structure include:

- Loads associated with the tank and the fluid it contains
- Loads associated with the weight of the pumps
- Loads associated with water piping

The main specific normal condition loads for the CST Tunnel include:

- Loads associated with the pumped water pipes and cabling between the CST and buildings
- Allowance for surcharge from vehicular loading

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel exterior building envelopes maintain the internal building environment appropriate for SSCs. [CST SFC 5-18.01]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide building envelopes which maintain the airflow into/out of the buildings suitable for the HVAC systems to be able to maintain the building internal environments, for the normal operating and fault conditions. [CST SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel building envelopes protect the building interior from the external meteorological effects e.g. winds, precipitation, snow and are designed to mitigate ingress of groundwater by the concrete walls and slabs. [CST SFC 5-18.01.2]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel buildings have a lightning protection system to protect the SSCs inside the buildings from adverse effects due to lightning strike in normal operating and fault conditions. [CST SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide shielding provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [CST SFC 4-7.01]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are designed to support SSCs which deliver safety functions for design basis (DB) loads. [CST SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel exterior building envelopes maintain the internal building environment appropriate for SSCs. [CST SFC 5-18.02]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide building envelopes which maintain the airflow into/out of the buildings suitable for the HVAC systems to be able to maintain the building internal environments, for the normal operating and fault conditions. [CST SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel building envelopes protect the building interior from the external meteorological effects e.g. winds, precipitation, snow and are designed to mitigate ingress of groundwater by the concrete walls and slabs. [CST SFC 5-18.02.2]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel buildings have a lightning protection system to protect the SSCs inside the buildings from adverse effects due to lightning strike in normal operating and fault conditions. [CST SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 5-7, Functions to limit the effect of hazard

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [CST SFC 5-7.01]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [CST SFC 5-14.01]

10.4.11.4 Design Principles

The safety functional claims of the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are described in Section 10.4.11.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Condensate Storage Tank Structure and Connecting Service Tunnel Structural Design Report" [Ref-87]. The design method of the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are based on the material standards listed in Section 10.5.6.

- Structural
  - The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel shall be designed to withstand the design basis external hazards as defined for Class 2 structures (refer to PCSR Chapter 5). These are the hazards with a loading evaluated for a frequency of occurrence of 10^{-3}/y for design basis external hazard conditions.
  - All structural members of the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and design basis external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.
  - The thickness of the walls and slabs for which radiation shielding is required shall be designed to be sufficient to ensure adequate shielding to the public and operational personnel.

- Design of Walls and Slabs
  - The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards including adequate foundation to transfer the vertical and lateral forces to the ground formation.
  - The external walls and slabs shall mitigate the ingress of groundwater and egress of liquids from inside the CST Structure and R/B-CST-Rw/B Connecting Service Tunnel to the external environment.
  - The external walls and slabs shall be designed to achieve the appropriate fire resistance.
  - The external envelope of the CST Structure shall provide the shielding function.

- Design of Tank Rooms
  - The concrete rooms where storage tanks are located shall be able to receive appropriate surface finishes for containment and decontamination purposes. This is conceptual at GDA stage, and detailed specification will be carried out at site specific stage (refer to Section 10.3.6.7).

The generic design methodology is provided in "Civil Engineering Supporting Report Condensate Storage Tank Structure and Connecting Service Tunnel Structural Design Report" [Ref-87].

10.4.12 Overview of the Reactor Cooling Water Tunnel

This section provides the high level safety claims and the design principles of the Reactor Cooling Water (RCW) Tunnel, in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on RCW Tunnel Civil Design [Ref-14].
- Civil Engineering Supporting Report RCW Tunnel Seismic Analysis Report [Ref-88].
- Civil Engineering Supporting Report RCW Tunnel Structural Design Report [Ref-89].

10.4.12.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the RCW Tunnel and safety category and class for that function. Accordingly the RCW Tunnel is classified as:

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

The RCW Tunnel contains Class 1 pipework and services between the Heat Exchanger Building and the Reactor Building. These comprise three independent and separated divisions A, B and C of RCW systems of cooling water used to cool auxiliaries in the Reactor Building. The RCW Tunnel is therefore divided into three physically segregated and protected cells, which exit the Hx/B separately and then combine to run together towards the Reactor Building. The cells are of suitable size to allow for the installation, operation, maintenance and decommissioning of the SSC's housed therein. The RCW Tunnel is also isolated from the surrounding structures to maintain the intended nuclear safety related functions.

10.4.12.2 Structural Form

The RCW Tunnel is an underground reinforced concrete structure which is rectangular in cross section, as shown in Figure 10.4.12-1. There are two internal walls which divide the tunnel into the segregated three cells. These also provide fire and ventilation compartmentalisation.

The GDA site plan is shown in the "Overview of UK ABWR Civil Structures" [Ref-104]. The positions of buildings away from the nuclear island are indicative only and so the alignment of the tunnel is not finalised within GDA. It is expected to be approximately 150m long and include bends to facilitate changes in direction of the piping and cable routes. The GDA design generally considers the tunnel is formed by a number of longitudinal units, with each unit isolated by seismic joints, to accommodate appropriate movement, particularly in a seismic event. Suitable joints are also provided at interfaces with the buildings at each end.

The longitudinal alignment of the tunnel is also not decided at GDA stage, and so the depth of overburden is taken as 6.5m for the GDA design. However, since the final arrangement of the buildings and the tunnel will not be confirmed until site specific stage, the exact tunnel lengths and bend configurations are not known.

The GDA design analyses the RCW Tunnel cross-section as one, so that there is moment continuity around the junctions and provides lateral stability. Longitudinally, the walls act as shear walls between tunnel section joints. At bends, joints will be provided either side; the tunnels walls at the bend provide stability in both horizontal directions.

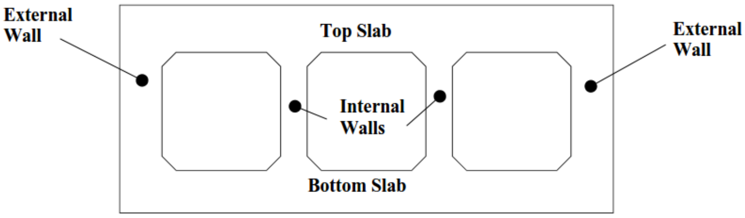

Figure 10.4.12-1: Section, RCW Tunnel

10.4.12.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the RCW Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The RCW Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [RCW Tunnel SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with piping and cabling
- Loads from the weight of the surrounding ground
- Allowance for surcharge from vehicular loading

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The RCW Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [RCW Tunnel SFC 5-18.01]

The RCW Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [RCW Tunnel SFC 5-18.01.1]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the RCW Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The RCW Tunnel is designed to support SSCs which deliver safety functions for design basis (DB) loads. [RCW Tunnel SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The RCW Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [RCW Tunnel SFC 5-18.02]

The RCW Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [RCW Tunnel SFC 5-18.02.1]

- HLSF 5-7, Functions to limit the effect of hazard

The RCW Tunnel provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [RCW Tunnel SFC 5-7.01]

The RCW Tunnel provides divisional separation barriers between the safety trains, to protect SSCs which deliver safety functions from design basis internal hazards. [RCW Tunnel SFC 5-7.01.1]

The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.

The RCW Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [RCW Tunnel SFC 5-7.02]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The RCW Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [RCW Tunnel SFC 5-14.01]

10.4.12.4 Design Principles

The safety functional claims of the RCW Tunnel are described in Section 10.4.12.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report, RCW Tunnel Structural Design Report” [Ref-89]. The design method of the RCW Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the RCW Tunnel are based on the material standards listed in Section 10.5.6.

- Structural
  - The RCW Tunnel shall be designed to withstand the design basis internal and external hazards as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10^{-5}/y for design basis internal hazard condition and 10^{-4}/y for design basis external hazard conditions.
  - All structural members of the RCW Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and design basis internal and external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.

- The RCW Tunnel, as a Class 1 structure, shall be checked for beyond design basis resilience as described in Section 10.6.

• Design of Walls and Slabs

- The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards including adequate foundation to transfer the vertical and lateral forces to the ground formation.
- The external walls and slabs shall mitigate the ingress of groundwater.
- All walls and slabs shall be designed to achieve the appropriate fire resistance for the design basis.
- The internal walls shall provide the segregation function for the design basis internal hazards as described in the "Internal Hazards Barrier Substantiation Report" [Ref-102] in addition to the requirements above.

The generic design methodology is provided in the "Civil Engineering Supporting Report, RCW Tunnel Structural Design Report" [Ref-89].

10.4.13 Overview of the Light Oil Storage Tank Foundation and Connecting Service Tunnel

This section provides the high level safety claims and the design principles for the civil structures associated with the Light Oil Storage Tanks (LOT), in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR. These structures are as follows.

- The foundation slab supporting the LOT. This is referred to as the LOT Foundation.
- The connecting service tunnel which conveys the light oil supply pipework from the LOT to the Back-up Building (B/B). This is referred to as the B/B-LOT Connecting Service Tunnel.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Light Oil Storage Tank (LOT) Foundation and Connecting Service Tunnel Civil Design [Ref-15].
- Civil Engineering Supporting Report Light Oil Storage Tank (LOT) Foundation and Connecting Service Tunnel - Seismic Analysis Report [Ref-90].
- Civil Engineering Supporting Report Light Oil Storage Tank (LOT) Foundation and Connecting Service Tunnel - Structural Design Report [Ref-91].

10.4.13.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the LOT Foundation and safety category and class for that function. Accordingly the LOT Foundation and the B/B-LOT Connecting Service Tunnel are both designed and constructed as:

- Safety Category A, Safety Class 2 structure.
- Seismic Category 1.

The LOT is used to store the light oil that is used as the fuel for the Back-up Building Generator (BBG) as described in Section 16.6.2.2 of Chapter 16: Auxiliary Systems. It provides sufficient oil for seven days operation.

The B/B-LOT Connecting Service Tunnel connects the LOT to the B/B. The major systems housed by the tunnel include the light oil supply pipes, power cables, cables trays and related components.

10.4.13.2 Structural Form

The LOT is a vertical cylindrical steel tank and it is anchored to the LOT Foundation structure. The foundation structure consists of a reinforced concrete bottom slab that supports the tank, and a peripheral bund wall. The bund wall is constructed monolithically with the LOT Foundation.

The B/B-LOT Connecting Service Tunnel is an underground reinforced concrete structure consisting of walls and slabs. The transverse section of the tunnel consists of a single cell. As described in Section 10.4.12 for the RCW Tunnel, the exact layout of this tunnel is not finalised in GDA. Therefore, the GDA design generally considers the Tunnel is formed by a number of longitudinal units with each unit isolated by joints. The alignment of the Tunnel is also expected to include bends to facilitate changes in direction of the piping and cable routes.

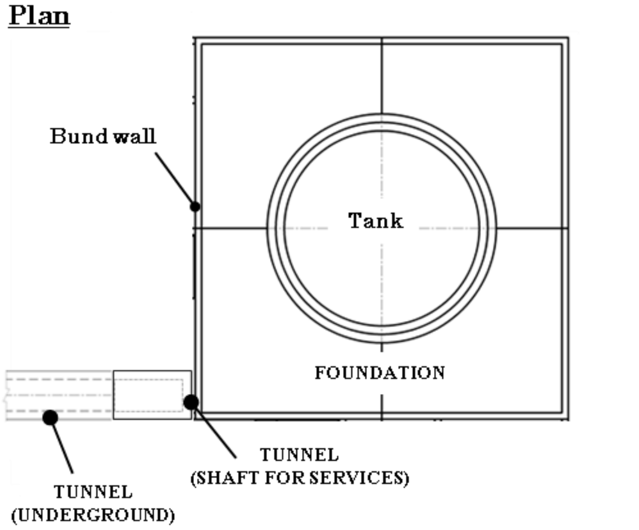

Figure 10.4.13-1: Plan and Section, LOT Foundation

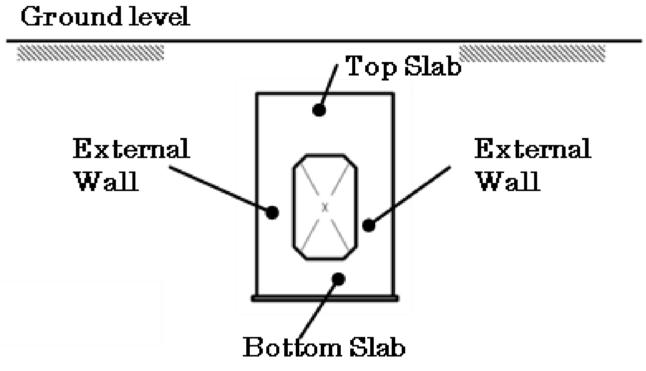

Figure 10.4.13-2: Section, B/B-LOT Connecting Service Tunnel

10.4.13.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the LOT Foundation and Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The LOT Foundation and B/B-LOT Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [LOT SFC 5-17.01]

The main specific normal condition loads for each LOT Foundation include:

- Loads associated with the tank and the fluid it contains

The main specific normal condition loads for the B/B-LOT Connecting Service Tunnel include:

- Loads associated with the piping and cabling between the B/B and LOT
- Loads from the weight of the surrounding ground
- Allowance for surcharge from vehicular loading

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B-LOT Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [LOT SFC 5-18.01]

The B/B-LOT Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [LOT SFC 5-18.01.1]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the LOT Foundation and Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The LOT Foundation and B/B-LOT Connecting Service Tunnel are designed to support SSCs which deliver safety functions for design basis (DB) loads. [LOT SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B-LOT Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [LOT SFC 5-18.02]

The B/B-LOT Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [LOT SFC 5-18.02.1]

- HLSF 5-7, Functions to limit the effect of hazard

The B/B-LOT Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [LOT SFC 5-7.01]

The LOT is located with adequate separation from the R/B and C/B to maintain function of the accident management facilities against a beyond design basis external hazard to the R/B and C/B. [LOT SFC 5-7.01.1]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The B/B-LOT Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [LOT SFC 5-14.01]

10.4.13.4 Design Principles

The safety functional claims of the LOT Foundation and Connecting Service Tunnel are described in Section 10.4.13.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Light Oil Storage Tank Foundation and Connecting Service Tunnel Structural Design Report" [Ref-91]. The design method of the LOT Foundation and Connecting Service Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the LOT Foundation and Connecting Service Tunnel are based on the material standards listed in Section 10.5.6.

- Structural
  - The LOT Foundation and B/B-LOT Connecting Service Tunnel shall be designed to withstand the design basis external hazards as defined for Class 2 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-3/y for design basis external hazard conditions, except for seismic category 1 structures where the seismic loading is evaluated for a frequency of occurrence of 10-4 /y.
  - All structural members of the LOT Foundation and B/B-LOT Connecting Service Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and the design basis external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.

- Design of Walls and Slabs of the Tunnel
  - The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards including adequate foundation to transfer the vertical and lateral forces to the ground formation.
  - The external walls and slabs shall mitigate the ingress of groundwater.

- The external walls and slabs shall be designed to achieve the appropriate fire resistance.

The GDA design methodology and arrangement is provided in “Civil Engineering Supporting Report Light Oil Storage Tank Foundation and Connecting Service Tunnel Structural Design Report” [Ref-91].

10.4.14 Overview of the R/B-B/B Connecting Service Tunnel

This section provides the high level safety claims and the design principles adopted for the R/B-B/B Connecting Service Tunnel, in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on R/B-B/B Connecting Service Tunnel Civil Design [Ref-16].
- Civil Engineering Supporting Report R/B-B/B Connecting Service Tunnel Seismic Analysis Report [Ref-92].
- Civil Engineering Supporting Report R/B-B/B Connecting Service Tunnel Structural Design Report [Ref-93].

10.4.14.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the R/B-B/B Connecting Service Tunnel and safety category and class for that function. Accordingly the R/B-B/B Connecting Service Tunnel is classified as:

- Safety Category A, Safety Class 2 structure.
- Seismic Category 1.

The R/B-B/B Connecting Service Tunnel connects the systems and services between the Back-up Building and the Reactor Building, as described in Section 10.4.7 for the B/B. Some of these services enter the R/B via the Filter Vent Building and so the tunnel splits into two with the western cell carrying services for the R/B and the eastern cell carrying services for the FV/B.

10.4.14.2 Structural Form

The R/B-B/B Connecting Service Tunnel is an underground, reinforced concrete structure which is rectangular in cross section, as shown in Figure 10.4.14-1. There is a central, internal wall which divides the tunnel into two cells.

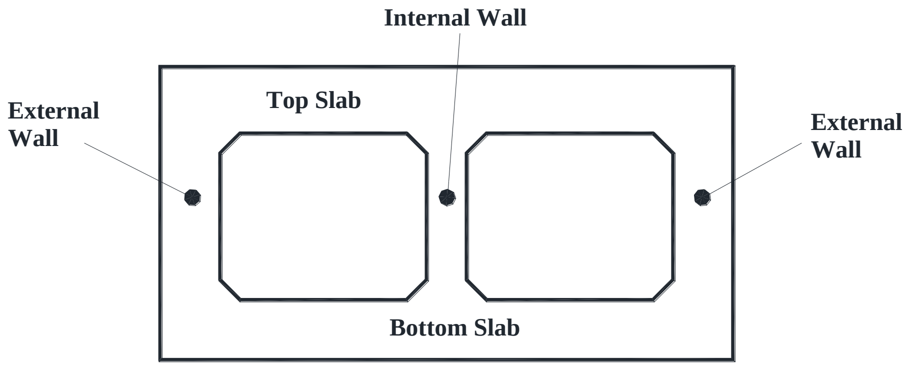

Figure 10.4.14-1: Section, R/B-B/B Connecting Service Tunnel

As described for the RCW Tunnel in Section 10.4.12, the alignment of the tunnel is expected to include bends to facilitate changes in direction of the piping and cable routes. The GDA design generally considers the tunnel is formed by a number of longitudinal units, with each unit isolated by seismic joints, to accommodate movement, particularly in a seismic event. However, since the final arrangement of the tanks and the tunnel will not be confirmed until site specific stage, the exact tunnel lengths are not known.

10.4.14.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for the normal conditions the following safety functional claims are incorporated in the R/B-B/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B-B/B Connecting Service Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [R/B-B/B Tunnel SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with piping and cabling
- Loads from the weight of the surrounding ground
- Allowance for surcharge from vehicular loading

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B-B/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-B/B Tunnel SFC 5-18.01]

The R/B-B/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-B/B Tunnel SFC 5-18.01.1]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the R/B-B/B Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The R/B-B/B Connecting Service Tunnel is designed to support SSCs which deliver safety functions for Design Base (DB) loads. [R/B-B/B Tunnel SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The R/B-B/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-B/B Tunnel SFC 5-18.02]

The R/B-B/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-B/B Tunnel SFC 5-18.02.1]

- HLSF 5-7, Functions to limit the effect of hazard

The R/B-B/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B-B/B Tunnel SFC 5-7.01]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The R/B-B/B Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B-B/B Tunnel SFC 5-14.01]

10.4.14.4 Design Principles

The safety functional claims of the R/B-B/B Connecting Service Tunnel are described in Section 10.4.14.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report, R/B-B/B Connecting Service Tunnel Structural Design Report” [Ref-93]. The design method of the R/B-B/B Connecting Service Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the R/B-B/B Connecting Service Tunnel are based on the material standards listed in Section 10.5.6.

- Structural
  - The R/B-B/B Connecting Service Tunnel shall be designed to withstand the design basis external hazards as defined for Class 2 structure (refer to PCSR Chapter 5). These are the hazards with a loading evaluated for a frequency of occurrence of 10^{-3}/y for design basis external hazard conditions, except for seismic category 1 structures where the seismic loading is evaluated for a frequency of occurrence of 10^{-4} /y.
  - All structural members of the R/B-B/B Connecting Service Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and the design basis external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.

- Design of Walls and Slabs
  - The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards including adequate foundation to transfer the vertical and lateral forces to the ground formation.
  - The external walls and slabs shall mitigate the ingress of groundwater.
  - The external walls and slabs shall be designed to achieve the appropriate fire resistance.

The GDA design methodology and arrangement is provided in “Civil Engineering Supporting Report, R/B-B/B Connecting Service Tunnel Structural Design Report” [Ref-93].

10.4.15 Overview of the Service Building

This section provides the high level safety claims and the design principles of the Service Building (S/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case for Service Building Civil Design [Ref-17].
- Civil Engineering Supporting Report Service Building Seismic Analysis Report [Ref-94].
- Civil Engineering Supporting Report Service Building Structural Design Report [Ref-95].

10.4.15.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Service Building and safety category and class for that function. Accordingly, the S/B is classified as:

- Safety Category C, Safety Class 3 structure.
- Seismic Category 3.

The design is also checked for stability and resilience for the following

- Seismic Category 1A – it is confirmed that S/B has no interaction with the Control Building.

The main function of the S/B is to act as the main controlled access to/from the UK ABWR Radiation Controlled Area (RCA) inside the Power Block and to house the RCA support facilities. It should be noted that the layout of the S/B is largely dependent on the future licensee and its arrangements. However, for GDA the layout has been assumed to include the Active Laundry, Radioactive Showers, Radiochemistry Lab, change rooms and Health Physics monitoring. These facilities generate low level liquid waste which is processed within the Service Building.

10.4.15.2 Structural Form

The S/B is constructed of reinforced concrete (RC) with RC walls and internal columns, beams and RC floor and roof slabs. The S/B is 65.0 m × 43.6 m on plan. The maximum roof height is 21.1m above ground floor slab level, with parts of the roof at 4.9m and 16.0 m. The S/B has five main floors, including one basement level. Refer to Figures 10.4.15-1 and 10.4.15-2 below.

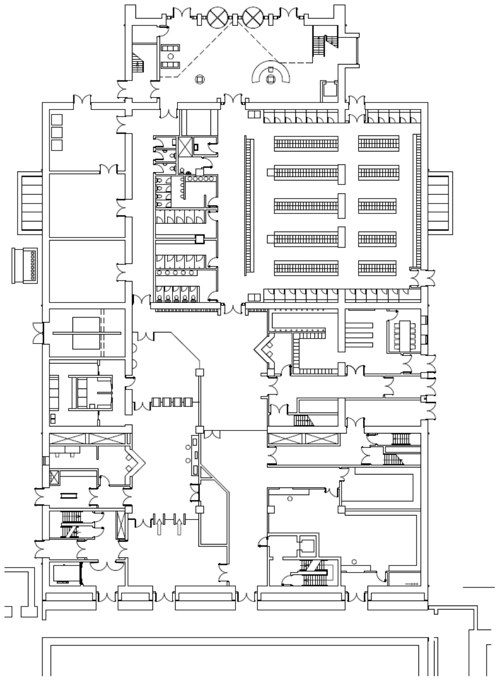

Figure 10.4.15-1: Plan 1F, S/B

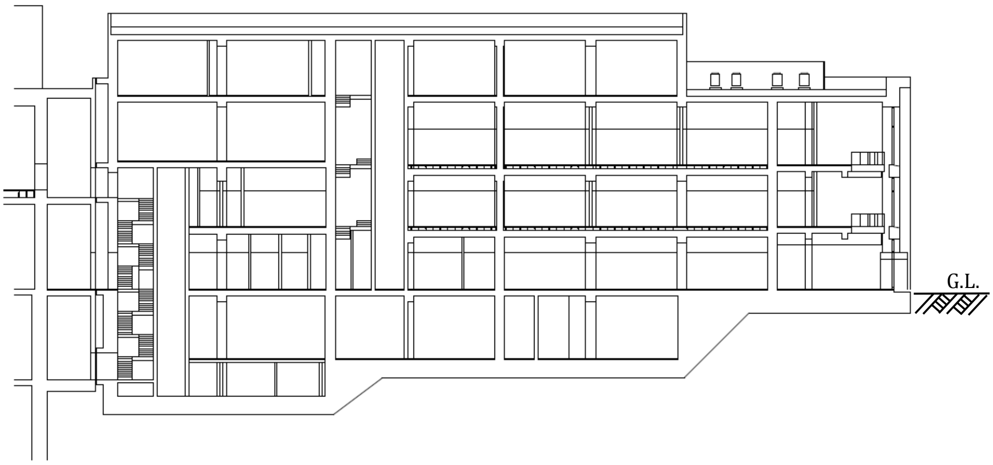

Figure 10.4.15-2: Section, S/B

10.4.15.3 Safety Function Claims

(a) Normal Conditions

In order to meet the high level safety functions for the normal conditions the following safety functional claims are incorporated in the S/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The S/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [S/B SFC 5-17.01]

The main specific normal condition loads include:

- There are no large items of plant inside the S/B so there are no special building specific normal condition loads that are not already included in general live loads given in Section 10.3.5.

- HLSF 5-18, Functions to maintain internal building environment appropriate for SSCs

The S/B exterior building envelope maintains the internal building environment appropriate for SSCs. [S/B SFC 5-18.01]

The S/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [S/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The S/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [S/B SFC 5-18.01.2]

The S/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [S/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The S/B provides a confinement function against radiation from radioactive materials housed within the building under normal operating and fault conditions, by means of concrete walls and slabs. The shielding walls and slabs are arranged around areas housing radioactive materials to reduce worker's exposure. The external walls and slabs also provide shielding to reduce the potential dose rate at the site boundary. [S/B SFC 4-7.01]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the S/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The S/B is designed to support SSCs which deliver safety functions for Design Base (DB) loads. [S/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The S/B exterior building envelope maintains the internal building environment appropriate for SSCs. [S/B SFC 5-18.02]

The S/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating conditions. [S/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The S/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [S/B SFC 5-18.02.2]

The S/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [S/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 5-7, Functions to limit the effect of hazard

The S/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which delivers safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [S/B SFC 5-7.01]

The S/B is also categorised as seismic category 1A. Therefore, the S/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [S/B SFC 5-7.01.1]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The S/B layout provides safe escape routes from the inside the building to the designated safe mustering point [S/B SFC 5-14.01]

The S/B acts as a Forward Control Point (FCP) for Emergency Response; Emergency access to allow future licensees to monitor and control the plant in emergency situations. [S/B SFC 5-14.02]

10.4.15.4 Design Principles

The safety functional claims of the S/B are described in Section 10.4.15.3 for the normal and fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report Service Building Structural Design Report" [Ref-95].

The design method of the S/B is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3 which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the S/B are based on the material standards listed in Section 10.5.6.

- Structural
  - The S/B shall be designed to withstand the design basis internal and external hazards as defined for Class 3 (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-2/y for design basis external hazard conditions.
  - All structural members of the S/B shall be designed to remain essentially elastic under the envelope of the normal conditions and the design basis external hazards.
  - Building deflection (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting values, or the requirement.
  - The S/B shall be checked for design basis external hazard loadings, such that it does not adversely interact with adjacent Class 1 buildings, i.e. the C/B, under these events.
  - The S/B structure shall be considered as defence in depth for the protection of the C/B from aircraft impact.

- Design of External Envelope (External Walls and Roof)
  - The external envelope of the S/B shall provide protection to the operating personnel and the SSCs, which deliver the safety functions, from design basis external hazards.
  - The external envelope of the Rw/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
  - The basement of the S/B shall mitigate the ingress of groundwater.
  - The external envelope of the S/B shall be designed to achieve the appropriate fire resistance.

- Design of Basemat Slab
  - The basemat slab of the S/B must provide an adequate foundation to the S/B under all normal condition and design basis fault conditions.
  - The basemat slab of the S/B shall transfer the design vertical and lateral forces applied by the S/B superstructure to the ground formation.
  - The basemat slab of the S/B shall be designed to mitigate the ingress of groundwater.

The detailed design methodology is provided in "Civil Engineering Supporting Report Service Building Structural Design Report" [Ref-95].

10.4.16 Overview of the Filter Vent Building

This section provides the high level safety claims and the design principles of the Filter Vent Building (FV/B) in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on Reactor Building Civil Design (includes FV/B) [Ref-04].
- Civil Engineering Supporting Report Filter Vent Building Seismic Analysis Report [Ref-96].
- Civil Engineering Supporting Report Filter Vent Building Structural Design Report [Ref-97].

10.4.16.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by the Filter Vent Building and safety category and class for those functions. Accordingly the FV/B is classified as

- Safety Category A, Safety Class 1 structure.
- Seismic Category 1.

The Filter Vent Building houses the major portion of Filtered Containment Venting System (FCVS). The FCVS consists of filter vent devices, nitrogen gas purge facility, rupture disks, I&C devices, valves and connecting piping. The system is intended to prevent damage to the Primary Containment Vessel by overpressure and to avoid releasing a large amount of fission products under a severe accident condition. The control of the FCVS can be changed from the C/B to the B/B if required.

The FV/B also provides ventilation and air conditioning for the FV/B Electrical Equipment Zone, the RIP Control Room and the ASD supply fan room. The FV/B has one independent division. Additional information on the design and operation of the FV/B HVAC along with the specific equipment for the FV/B HVAC is provided in the PCSR Chapter 16.

10.4.16.2 Structural Form

The Filter Vent Building is a reinforced concrete structure including the roof slab and external walls. The general arrangement for GDA is shown in drawings GA12-2002-0007-00001 Rev.2 [Ref-47] and illustrated in Figures 10.4.16-1 and 10.4.16-2 below. The FV/B is located immediately adjacent to the R/B, and for GDA this is assumed to be the south elevation.

The building is a regular, rectangular box shape, being 25m by 43m in plan and 42m in overall height. The roof is at 19m above ground level and the basement is embedded into the ground by 23m.

At ground floor level, the vehicle entry bay passes through the full width of the FV/B to allow fuel delivery and export to the R/B. This bay forms part of the secondary containment boundary. The bay walls are substantial and divide the ground floor thus segregating the A and B ASD Fan Supply Rooms. The second storey extends over only two thirds of the building and houses FV/B HVAC equipment.

The basement has a central full height room, which houses the 12m high filter vent tank. This has thick surrounding walls for shielding purposes and divides the basement thus segregating the RIP Control Panels rooms to the east and west.

The external walls and internal walls are all substantially thick and so provide a very robust structure. The basemat is 2.5m thick and founded at a similar level to the R/B basemat. There is a gap between the two buildings to provide seismic isolation, except at basemat level where the gap is infilled to provide lateral force transfer for overall sliding stability.

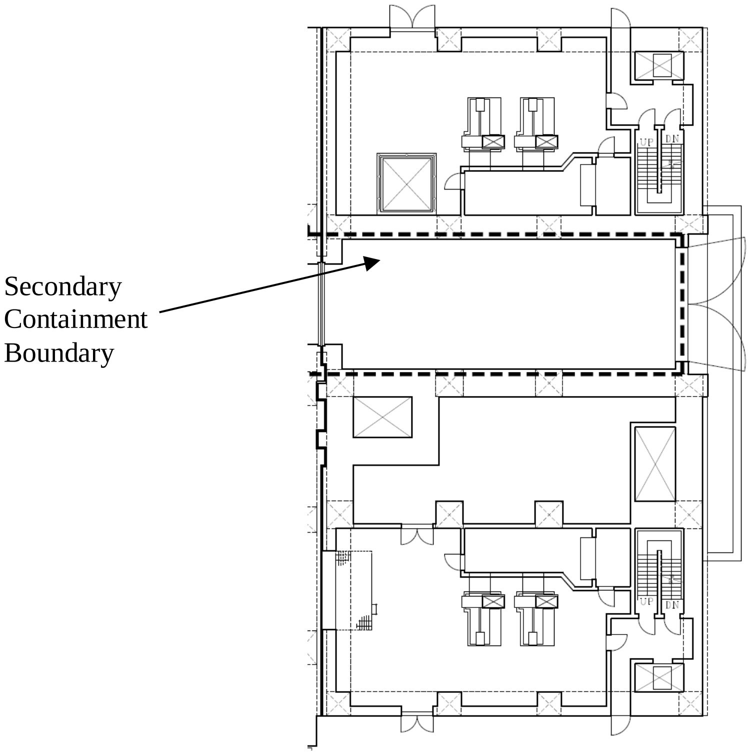

Figure 10.4.16-1: Plan 1F, FV/B

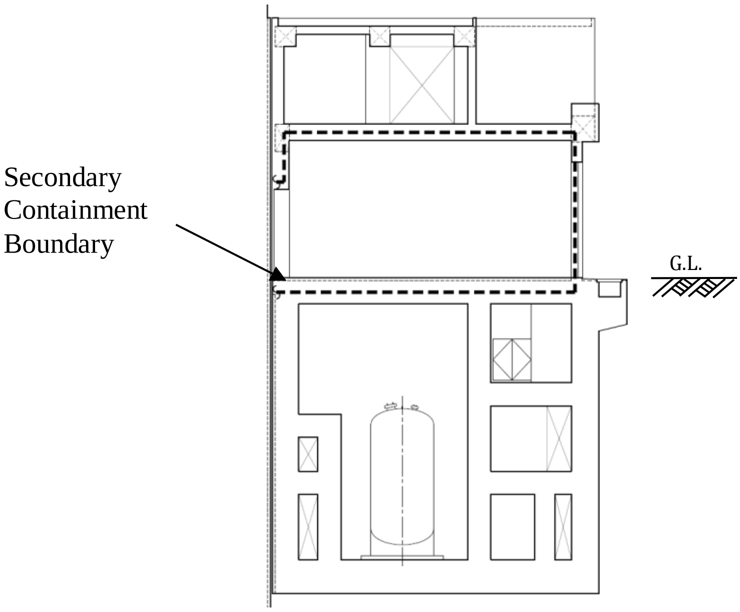

Figure 10.4.16-2: Section, FV/B

10.4.16.3 Safety Function Claims

(a) Normal Conditions

In order to meet the high level safety functions for the normal conditions the following safety functional claims are incorporated in the FV/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The FV/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [FV/B SFC 5-17.01]

The main specific normal condition loads include:

- Loads associated with the Filter Vent Tank and equipment on the lower floors.
- Vehicular loads at ground floor level.
- Loads associated with HVAC equipment on upper floors.

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The FV/B exterior building envelope maintains the internal building environment appropriate for SSCs. [FV/B SFC 5-18.01]

The Fv/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [FV/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The FV/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [FV/B SFC 5-18.01.2]

The FV/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [FV/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The FV/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce workers' exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [FV/B SFC 4-7.01]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the S/B design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The FV/B is designed to support SSCs which deliver safety functions for design base (DB) loads. [FV/B SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The FV/B exterior building envelope maintains the internal building environment appropriate for SSCs. [FV/B SFC 5-18.02]

The FV/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [FV/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The FV/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [FV/B SFC 5-18.02.2]

The FV/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [FV/B SFC 5-18.02.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.

- HLSF 4-7, Functions to confine radioactive materials, shield radiation, and reduce radioactive release

The FV/B provides low leak-rate boundaries as the secondary containment by using concrete walls and slabs, to confine radioactive material to limit release to the external environment during a fault condition. The Standby Gas Treatment System (SGTS) maintains inside of the secondary containment at negative pressure during postulated accidental conditions. [FV/B SFC 4-7.02]

The FV/B provides shielding by concrete walls and slabs. The shielding walls and slabs maintain their shielding function against postulated fault conditions. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [FV/B SFC 4-7.03]

- HLSF 5-7, Functions to limit the effect of hazard

The FV/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [FV/B SFC 5-7.01]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The FV/B layout provides safe escape routes from the inside of the building to the designated safe mustering point. [FV/B SFC 5-14.01]

10.4.16.4 Design Principles

The safety functional claims of the FV/B are described in Section 10.4.16.3 for the normal and fault conditions. To fulfil these claims, following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in “Civil Engineering Supporting Report Filter Vent Building Structural Design Report”[Ref-97].

The design method of the FV/B is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the FV/B are based on the material standards listed in Sections 10.5.6.

- Structural
  - The FV/B shall be designed to withstand the design basis external hazard conditions as defined for Class 1 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10^{-4}/y for design basis external hazard conditions.
  - All structural member of the FV/B shall be designed to remain essentially elastic under the envelope of normal conditions and the design basis external hazards.
  - Building deflections (including vibration and resonance with rotating plant and equipment) shall not exceed code limiting value, or the requirements of the plant, whichever is more onerous.
  - The FV/B shall be checked for beyond design basis resilience as described in Section 10.6.

- Design of External Envelope (External Walls and Roof)
  - The external envelope of the FV/B shall provide protection to the SSCs housed within it, which deliver the safety functions, from design basis external hazards.
  - The external envelope of the FV/B shall be designed to provide the façade permeability requirements of the HVAC systems where required.
  - The external envelope of the FV/B shall mitigate the ingress of groundwater.

- Design of Internal Walls and Slabs
  - All walls and slabs within the FV/B shall provide defence in depth segregation for plant and equipment.
  - All walls and slabs shall provide the shielding thicknesses required for radiation protection.

- Design of Basemat Slab
  - The basemat slab of the FV/B must provide an adequate foundation to the FV/B under the design loadings for normal condition and design basis fault conditions.
  - The basemat slab of the FV/B shall transfer the design vertical and lateral forces applied by the FV/B superstructure to the ground formation.
  - The basemat slab of the FV/B shall be designed to mitigate the ingress of groundwater.

The detailed design methodology is provided in “Civil Engineering Supporting Report Filter Vent Building Structural Design Report” [Ref-97].

10.4.17 Overview of the FLSS Water Storage Tank Foundation and Connecting Service Tunnel

This section provides the high level safety claims and the design principles for the civil structures associated with the Flooding System of Specific Safety facility Water Storage Tanks (FLSS WSTs), in order to demonstrate the adequacy of the generic civil engineering safety case for the UK ABWR. These structures are as follows.

- The foundation slab for supporting the water storage tanks for the FLSS system. This is referred to as the FLSS WST Foundation.
- The connecting service tunnel which conveys the FLSS water supply pipework from the FLSS WST to the Back-up Building (B/B). This is referred to as the B/B-FLSS WST Connecting Service Tunnel.

The key civil engineering reference documents for this section are:

- Basis of Safety Case on FLSS Water Storage Tank Foundation and Connecting Service Tunnel Civil Design [Ref-18].
- Civil Engineering Supporting Report FLSS Water Storage Tank Foundation and Connecting Service Tunnel Seismic Analysis Report [Ref-98].
- Civil Engineering Supporting Report FLSS Water Storage Tank Foundation and Connecting Service Tunnel Structural Design Report [Ref-99].

10.4.17.1 Safety Class and Function

The safety category and class for each UK ABWR safety function has been identified in Appendix A. Appendix A shows the high level safety functions delivered by both the FLSS WST Foundation and the B/B-FLSS WST Connecting Service Tunnel.

Accordingly the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel are both classified as :

- Safety Category A, Safety Class 2 structure.
- Seismic Category 1.

The FLSS WSTs are 10 vertical cylindrical steel tanks anchored to the FLSS WST Foundation structure. The foundation structures consist of a reinforced concrete bottom slab that supports the tanks.

The B/B-FLSS WST Connecting Service Tunnel connects the FLSS WST Foundation to the B/B. The major systems housed by this tunnel include piping for FLSS, power cables, cables trays and other related components.

10.4.17.2 Structural Form

The general arrangement of the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel for GDA are shown in Figures 10.4.17-1 and 10.4.17-2.

The FLSS WST is a vertical cylindrical steel tank and is anchored to the FLSS WST Foundation. The FLSS WST Foundation consists of a reinforced concrete bottom slab (tank foundation). The external structural size of FLSS WST Foundation is 15.5m by 3.5m height (1m for shear key).

The B/B-FLSS WST Connecting Service Tunnel is an underground reinforced concrete structure, rectangular in cross section with one internal wall, thus providing two segregated tunnels, A and B.

The major systems housed by the tunnel (as described above), are supported on cable trays and pipe support brackets attached to the inside faces of the walls. The external structural size of B/B-FLSS WST Connecting Service Tunnel in GDA is 8.3m width by 6.9m height.

The tunnel runs between the 10 FLSS WST Foundations and the B/B, so is expected to include bends to facilitate changes in direction of the piping and cable routes. The GDA design generally considers the tunnel is formed by a number of longitudinal units, with each unit isolated by seismic joints, to accommodate movement, particularly in a seismic event. However, since the final arrangement of the tanks and the tunnel will not be confirmed until site specific stage, the exact tunnel lengths are not known.

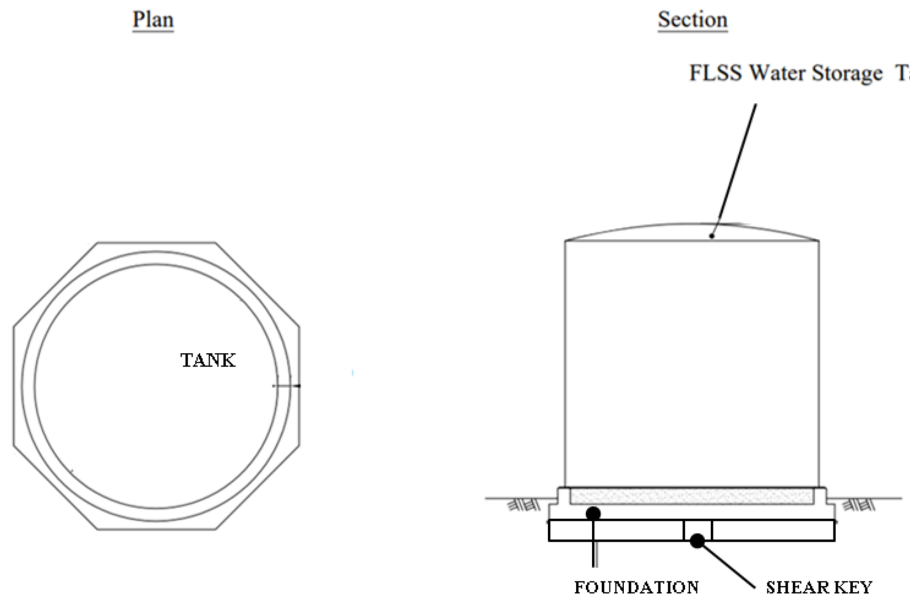

Figure 10.4.17-1: Plan and Section, FLSS WST Foundation

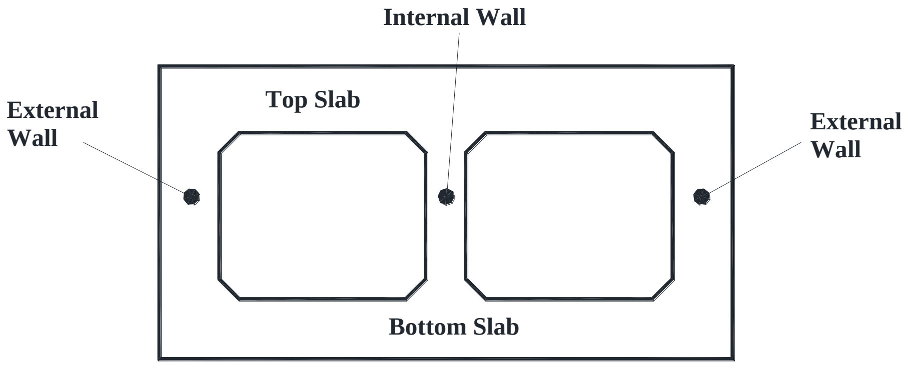

Figure 10.4.17-2: Section, B/B-FLSS WST Connecting Service Tunnel

10.4.17.3 Safety Functional Claims

(a) Normal Conditions

In order to meet the safety functions for normal conditions the following safety functional claims are incorporated in the FLSS WST Foundation and B/B-FLSS WST Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The FLSS WST Foundation and Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [FLSS WST SFC 5-17.01]

The main specific normal condition loads for the FLSS WST Foundation include:

- Loads associated with the FLSS water storage tank and the fluid it contains

The main specific normal condition loads for the B/B-FLSS WST Tunnel include:

- Loads associated with the piping and cabling between the B/B and FLSS WST

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B-FLSS WST Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [FLSS WST SFC 5-18.01]

The B/B-FLSS WST Tunnel exterior building envelope is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [FLSS WST SFC 5-18.01.1]

(b) Fault Conditions

In order to meet the safety functions for the fault conditions the following safety functional claims are incorporated in the FLSS WST Foundation and Connecting Service Tunnel design principles.

- HLSF 5-17, Function to provide structural support to SSCs

The FLSS WST Foundation and Connecting Service Tunnel are designed to support SSCs which deliver safety functions for Design Base (DB) loads. [FLSS WST SFC 5-17.02]

- HLSF 5-18, Function to maintain internal building environment appropriate for SSCs

The B/B-FLSS WST Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [FLSS WST SFC 5-18.02]

The B/B-FLSS WST Tunnel exterior building envelope is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [FLSS WST SFC 5-18.02.1]

- HLSF 5-7, Functions to limit the effect of hazard

The B/B-FLSS WST Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [FLSS WST SFC 5-7.01]

The FLSS WST is located with adequate separation from the R/B and C/B to maintain function of the accident management facilities against an extreme external hazard condition to the main structures such as R/B and C/B. [FLSS WST SFC 5-7.01.1]

The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.

- HLSF 5-14, Supporting functions for on-site emergency preparedness

The B/B-FLSS WST Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [FLSS WST SFC 5-14.01]

10.4.17.4 Design Principles

The safety functional claims of the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel are described in Chapter 10.4.17.3 for the normal conditions and the fault conditions. To fulfil these claims, the following design principles are applied to the structure with appropriate methodologies which are conservatively established for each requirement as described in "Civil Engineering Supporting Report FLSS WST Foundation and Connecting Service Tunnel Structural Design Report" [Ref-99]. The design method of the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel is carefully determined to realise those design strategies based on the codes and standards listed in Sections 10.5.2 and 10.5.3, which are internationally recognised as appropriate for the design of nuclear civil facilities. The structural materials to be used for the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel are based on the material standards listed in Chapter 10.5.6.

- Structural
  - The FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel shall be designed to withstand the design basis external hazards as defined for Class 2 structures (refer to PCSR Chapter 5). These are hazards with a loading evaluated for a frequency of occurrence of 10-3/y for design basis external hazard conditions, except for seismic category 1 structures where the seismic loading is evaluated for a frequency of occurrence of 10-4/y.
  - All structural members of the FLSS WST Foundation and B/B-FLSS WST Connecting Service Tunnel shall be designed to remain essentially elastic under the envelope of normal conditions and the design basis external hazards.
  - Structure/member deflections shall not exceed code limiting values, or the requirements of the plant, whichever is more onerous.

- Design of Walls and Slabs
  - The external walls and slabs shall provide structural protection to the SSCs, which deliver safety functions, from design basis external hazards including adequate foundation to transfer the vertical and lateral forces to the ground formation.
  - The external walls and slabs shall mitigate the ingress of groundwater.
  - The external walls and slabs shall be designed to achieve the appropriate fire resistance.

The detailed design methodology is provided in "Civil Engineering Supporting Report FLSS Water Storage Tank Foundation and Connecting Service Tunnel - Structural Design Report" [Ref-99].

10.5 Codes and Standards

10.5.1 Introduction

This section provides the Codes and Standards, which are applied to the civil structural design of the safety-related structures of the UK ABWR. They are designed based on the US codes and standards, which are recognised internationally for nuclear facilities and are considered relevant good practice in the UK nuclear industry. The UK ABWR design considering the conformity with the UK requirements.

Generally, the most current edition of codes and standards have been used. However, it is recognised that the GDA baseline of codes and standards must be revisited at site specific design to confirm the editions current at that time. The GDA design has included a major standard which is to be issued imminently (ASCE 4), and has used the draft version from the code committee in conjunction with the current published version.

10.5.2 Seismic Analysis and Design

- ASCE 4-98: ASCE Standard for Seismic Analysis of Safety Related Nuclear Structures (ASCE 4-15 (Draft) is also referred for relevant good practice)
- ASCE 43-05: Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities
- NUREG-0800: US NRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition, Revision 4, specifically sections as follows:
  Section 3.7.1, Seismic Design Parameters, Revision 4
  Section 3.7.2, Seismic System Analysis, Revision 4
  Section 3.7.3, Seismic Subsystem Analysis
- RG 1.61: Damping Values for Seismic Design of Nuclear Power Plants, Revision 1
- RG 1.92: Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 2
- EUR Volume 2: General Nuclear Island Requirements, Chapter 4 Design Basis, Revision D
- BS EN 1998-1:2004: Design of structures for earthquake resistance, with UK National Annex to Eurocode 8
- IAEA NS-G-3.6:2004: Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants

10.5.3 Civil Structural Design

Codes and Standards of civil structural design are shown as follows;

- ACI 349-13: Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary
- ANSI/AISC N690-12: Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities
- ASCE 4-98: Seismic Analysis of Safety-Related Nuclear Structures and Commentary
- ASCE 7-05: ASCE Standard for Minimum Design Loads for Buildings and Other Structures

- ACI 350.3-06: Seismic Design of Liquid-Containing Concrete Structures
- NUREG-0800: US NRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;

  Section 3.3.2 Tornado Loads, Revision 3

  Section 3.7.2 Seismic System Analysis, Revision 4

  Section 3.8.4: Other Seismic Category I Structures, Revision 4

  Section 3.8.5: Foundations, Revision 4
- RG 1.92: Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 2
- RG 1.142: Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments) , Revision 2

10.5.4 RCCV and Metal Containment (MC) Components Design

Codes and Standards of RCCV and MC Components design are shown as follows;

Refer to Section 10.4.2.3 for description of RCCV and MC components.

- ASME B&PV Code, Section II, Materials, 2013 Edition
- ASME B&PV Code, Section III, Subsection NCA: Rules for Construction of Nuclear Facility Components, General Requirements for Division 1 and Division 2, 2013 Edition
- ASME B&PV Code, Section III, Division 2, Subsection CC: Code for Concrete Containments, 2013 Edition
- ASME B&PV Code, Section III, Division 1, Subsection NE: Class MC Components, 2013 Edition
- ASME B&PV Code, Section V, Non-destructive Examination, 2013 Edition
- ASME B&PV Code, Section VIII, Rules for Construction of Pressure Vessels, Division 1, Division 2, 2013 Edition
- ASME B&PV Code, Section IX, Welding, Brazing, and Fusing Qualifications, 2013 Edition
- ASME B&PV Code, Section XI, Rules for In-service Inspection of Nuclear Power Plant Components, Subsection IWE, 2013 Edition
- NUREG-0800: US NRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;

  Section 3.8.1, Concrete Containment, Revision 4

  Section 3.8.2, Steel Containment, Revision 3
- RG 1.57: Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components, Revision 2
- RG 1.136: Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments, Revision 3

10.5.5 RCCV Internal Structures Design

Codes and Standards of RCCV Internal Structures design are shown as follows;

Refer to Section 10.4.2.3 for description of RCCV Internal Structures.

- ASME B&PV Code, Section II, Materials, 2013 Edition

- ASME B&PV Code, Section III, Subsection NCA: Rules for Construction of Nuclear Facility Components, General Requirements for Division 1 and Division 2, 2013 Edition
- ASME B&PV Code, Section III, Division 2, Subsection CC: Code for Concrete Containments, 2013 Edition
- ASME B&PV Code, Section V, Non-destructive Examination, 2013 Edition.
- ASME B&PV Code, Section IX, Welding, Brazing, and Fusing Qualifications, 2013 Edition
- ASME B&PV Code, Section XI, Rules for In-service Inspection of Nuclear Power Plant Components, Subsection IWE, 2013 Edition
- ACI 349-13: Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary
- ANSI/AISC N690-12: Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities
- NUREG-0800: USNRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;

  Section 3.8.1, Concrete Containment, Revision 4

  Section 3.8.3, Concrete and Steel Internal Structures of Steel or Concrete Containments, Revision 4

10.5.6 Material Design

The UK ABWR civil structures have been designed using the following design principles for structural materials, refer to the structural design reports for each building. Although the structural design is generally based upon the provisions of the relevant US nuclear code, the material selected and specified shall conform to UK/European requirements due to the lack of availability of ASTM material grades in the European market. Consequently, there is a requirement to substitute ASTM material grades for the equivalent UK/European grades in the specification and design.

(1) Concrete

The concrete specified is based upon the requirements of BS EN1992-1-1 and BS EN 206:2013 with Strength Class C35/45 or C30/37 with other engineering properties specified to be consistent with those provided by the US nuclear codes. The modulus of elasticity is calculated from ACI 349-13. Generally concrete grade C35 has been used for structural concrete, with the R/B basemat foundation slab using C30 concrete since it is a thick slab and the lower strength reduces the heat of hydration effects.

Concrete materials need to be compatible with the decommissioning plan and techniques. As discussed in Section 10.3.6.7, the type of aggregate used in the activation studies is based on typical UK industry standards. This will need to be confirmed at site specific stage.

(2) Steel Reinforcement

Relevant good practice in the UK is to use European reinforcing steel based on BS4449 or equivalent. B500C rebar, which has characteristic yield strength, 500 MPa and minimum yield strength, 485 MPa, is used in the design. European rebar has undergone sufficient testing and approval, such that the limits on material properties are established with the UK regulators.

The design standards used for nuclear structures in the UK are US codes, and the UK ABWR uses ACI349-13. The strength used in flexural design is reduced from BS EN to ensure compatibility with American practice, whereby minimum reinforcement strength is specified, not 95 percentile as is British practice. The yield strength for shear reinforcement is limited to 420 MPa as per ACI349-13 in the GDA design.

(3) Structural Steel

The materials used for structural steel and bolting are as follows:

- Structural steel: BS EN10025-2 or BS EN10025-4
- Preloaded bolts, studs & nuts: BS EN14399-3 or BS EN14399-10
- Non-preloaded ordinary bolts, studs & nuts: BS EN 15048-1

(4) RCCV Liner

The materials used for the liner plate and the anchors are as follows [Ref-51]:

- The Material of Liner plates shall be of the following type and grade:
  Plate (ASME SA-240 Type 304L) in wetted areas
  Plate (ASME SA-516 GR.70) in dry areas
- Stainless steel cladding to conform to ASME SA-264
- Liner anchors: ASME SA-36 or ASTM A-633 GR.C

The weld design for the liner plate shall be in accordance with ASME BPVC Sec III, Division 2 Article CC-3000.

10.6 Beyond Design Basis Conditions

10.6.1 Introduction

The design basis analysis for the UK ABWR is described in PCSR Chapter 24: Design Basis Analysis. The purpose of this is to demonstrate that the UK ABWR is tolerant to faults within the Design Basis and identify the faults in the Fault Schedule as described in the "Topic Report on Fault Assessment" [Ref-68]. The analysis also confirms that the main barriers to the release of activity remain functional during and after a design basis accident (see PCSR Chapter 24, Section 24.2.1).

The UK ABWR safety case extends the design basis analysis by summarising the results of additional fault analysis; specifically beyond design basis (BDB) assessment and Severe Accident Analysis (SAA), in accordance with NSEDP Principle BP8.11. This is described in Chapter 26: Beyond Design Basis and Severe Accident Analysis of the PCSR.

The civil structures for the UK ABWR are substantial, robust structures which provide passive withstand to plant faults and hazards. Class 1 structures are tolerant to Design Basis fault conditions, external and internal hazards and provide a margin of conservatism to allow for uncertainties [Principle BP4.1]. This therefore provides confidence that the risks associated with BDB events and SA mitigation for the UK ABWR are reduced to levels that are ALARP.

10.6.2 BDB Assessment

Beyond design basis analysis identifies and analyses credible fault sequences that have lower frequencies that those included in the design basis. The analyses presented in Chapter 26 show that no BDB faults in the GDA Fault Schedule lead to significant environmental release of any radioactive material.

The civil structures are designed to have passive withstand to the design basis faults. The DB design has confirmed that the seismic hazard is the governing structural loading. Therefore, demonstration of the BDB capability is provided by considering the bounding seismic behaviour which is captured by safety property claim CE SPC 05 (refer to Section 10.3.4). The BDB assessment of civil structures is described in the "Seismic Evaluation Methodology of Cliff-Edge Effect on Civil Structures" [Ref-69].

The beyond design basis assessment of civil structures is carried out in a deterministic way. Civil structures are designed elastically for the appropriate design basis loadings, and then the analysis is re-run for the BDB loading to confirm that there are no sudden failure mechanisms or "cliff edge" effects. The BDB loading is selected to give a reasonable margin above the design basis loading.

For Safety Class 1 structures (Seismic Category 1) the BDB loading is set at 1.5DBE (design basis earthquake) [Ref-69]. The assessment has confirmed that the critical loadcase that could cause structure failure results from the seismic external hazard, and this bounds all other external hazard loadings. For other structures of lower safety class, but with a Seismic Category 1A, similar analyses have been carried out to demonstrate that failure of the structure is gradual and not catastrophic and would not adversely affect an adjacent Class 1 building.

This BDB assessment has confirmed that there is sufficient redundancy in the civil structures such that if the loads increased above the Design Basis there would not be a sudden failure. The UK ABWR BDB assessment as a whole has also confirmed that for beyond design basis events, at least one safety division or system survives to safely shut down the reactor.

10.6.3 Aircraft Impact

The potential hazard of aircraft impact is a man-made hazard occurs in from the two sources below. Strategies for the approach to both types of aircraft impact are described in Ref-48 and Ref-49 respectively.

- Accidental AIA Strategy Document [Ref-48]
- Malicious AIA Strategy Document [Ref-49]

Characterisation of aircraft impact has been carried out within Chapter 2: Generic Site Envelope and Chapter 6: External Hazards.

For accidental aircraft crashes it is demonstrated that the crash frequency for a generic UK site is a beyond design basis event (see PCSR Chapter 6: External Hazards, Section 6.6.11.3). The hazard from malicious aircraft impact is a beyond design basis event, but in accordance with UK regulatory expectations, the UK ABWR civil structures provides sufficient protection so that the reactor can be safely shut down.

The aircraft impact assessment (AIA) carried out for the UK ABWR considers direct and indirect impacts and the potential physical damage, shock vibration and fire resulting from fuel fires. This assessment has demonstrated that the reactor building external envelope provides an aircraft impact protection shell such that aircraft cannot breach the outer walls. The AIA also confirms that the shock and fire that may affect the inside of the building is resisted such that at least one safety division always survives to shut down the reactor safely.

Assessment has also been carried out of the remaining Class 1 buildings and confirms that if any of these were impacted by an aircraft crash, there is alternative means of safely shutting down the reactor.

Therefore, the UK ABWR civil structures have enough resilience to ensure at least one safety division survives an aircraft crash with the objective to prevent core melt and avert a major radiological event. In summary, the plant is appropriately protected from the aircraft impact hazard, whether malicious or accidental.

10.6.4 Severe Accident Analysis

The severe accident analysis (SAA) for the UK ABWR is described in Chapter 26, Section 26.4 of the PCSR. It demonstrates that the UK ABWR has been designed to minimise fission product release to the environment in severe accidents. The engineered safety features, strategies and procedures have been assessed against the lessons learned from the Fukushima accident, and it is confirmed that the UK ABWR has sufficient features to support core damage prevention and mitigation.

The SAA considers faults at power, faults at shutdown, and faults in the spent fuel pool. The purposes of the SAA are to understand the severe accident progression and phenomena and show the effectiveness of countermeasures. The countermeasures include severe accident mitigation systems, described in PCSR Chapter 16, and accident management strategies. The results of the analysis evaluate the cliff edge effect in terms of radiological consequences when crossing the BDB/SA boundary, and assist in the development of the emergency preparedness described in PCSR Chapter 22. This analysis also provides information for the Probabilistic Safety Assessment, which considers risks to the public from off-site releases [Chapter 25].

The SAA assesses the integrity of the PCV due to the following failure modes:

- Overpressure and overtemperature of the containment

- Fuel Coolant Interaction (FCI) outside of the RPV (ex-vessel)
- Molten Core Concrete Interaction (MCCI)
- Direct Containment Heating (DCH)
- Direct debris interaction
- Hydrogen combustion

The failure modes which need to be resisted by the RCCV concrete structure, liner and internal structures are discussed.

(1) Overpressure and overtemperature of the containment

The RCCV structure is designed for the normal and fault conditions for internal pressure and temperature as described in Section 10.4.2 and specified in Table 13.3-1 of Chapter 13: Engineered Safety Features. In addition, it has been assessed by the SAA, for overpressure and over temperature, which is performed in a best-estimate manner. The results are presented in the "Containment Performance Analysis Report on UK ABWR" [Ref-65]. Detailed finite element modelling, using non-linear numerical analysis of the reactor building including the RCCV and internal structures, has confirmed the potential failure locations and modes of the RCCV [Ref-65, Table 3.2-9]. This modelling has been confirmed by experimental tests on scale models of the RCCV and metal containment (MC) components. Local evaluation was then carried out using more detailed models of the areas identified as the first to yield.

The initial failure of the primary containment has been identified as leakage from the steel drywell head, through the bolted flange connection and gasket. Therefore, the ultimate capacity of the RCCV concrete structure needs to be sufficiently greater than the pressure required for this initial failure mode. The containment performance analysis has demonstrated the following:

- The maximum design pressure Pd = 0.310 MPa and the maximum design temperature Td = 171℃ (See PCSR Chapter 13, Table 13.3-1).
- The estimation of failure pressure for the RCCV at 200℃ is 2.07MPa. (~4*Pd) [Ref-65].
- The estimation of failure pressure for the RCCV at 300℃ is almost same pressure level of case 200℃ (about 2.07MPa). (~3*Pd) [Ref-65].
- The estimation of failure pressure for the drywell head flange at 200℃ is ~2.6*Pd [Ref-65].

Therefore, the RCCV concrete structure has a very large margin above the failure of the drywell head flange. It is confirmed that the RCCV concrete structure remains mostly within the elastic range under the pressure level of 2.4Pd at which the initial failure of the drywell head flange occurs.

(2) Impact on Reactor Pedestal

The phenomena of Fuel-Coolant Interaction (FCI), Direct Containment Heating (DCH), or Molten Core Concrete Interaction (MCCI), could cause damage to the pedestal in the lower drywell [Ref-65]. Therefore, the impact of these on the pedestal and whether they cause failure of the structure have been investigated, and the following has been demonstrated:

- The supporting function of the reactor vessel is not lost due to the impulse load to the pedestal wall by FCI and PCV boundary does not fail due to rapid pressurisation by FCI.
- The supporting function of the reactor vessel is not lost due to the erosion of the pedestal wall by MCCI.
- RPV pressure is reduced by the time of RPV failure and an occurrence of DCH is prevented.

- Overall, the failure of the pedestal if it were to happen, would cause the RPV to sink to a lower level, but as corium melt has already occurred this effect is included.

(3) Impact on the Liner

The SAA considers RRV failure at low pressure condition and at high pressure condition. For the former the molten debris will be cooled and will remain in the lower drywell. For the latter, the future licensees have 40 hours to prevent liner failure due to direct contact by additional cooling. However, the assessment shows that the access tunnel hatches do not fail due to direct debris interaction.

10.7 Assumptions, Limits and Conditions for Operation

10.7.1 Purpose

One purpose of this generic PCSR is to identify constraints that must be applied by a future licensee of a UK ABWR plant to ensure safety during normal operation, fault and accident conditions. Some of these constraints are maximum or minimum limits on the values of system parameters, such as pressure or temperature, whilst others are conditional, such as prohibiting certain operational states or requiring a minimum level of availability of specified equipment. The LCOs, along with corresponding surveillance requirements, define the corrective actions (measures) to follow when the LCOs are not met. They are collectively described in this GDA PCSR as Assumptions, Limits and Conditions for Operation (LCOs).

10.7.2 LCOs specified for Civil Engineering

All relevant LCOs have been identified following the standard procedure for GDA that is specified in [Ref-100], and are collated in the "Generic Technical Specifications" [Ref-101].

The LCOs defined for GDA are not directly applied to civil engineering structures, but to the systems and components. However, the design requirements resulting from the LCOs are included in the civil structures' design requirements. Examples have been included in table 10.7.1.

Table 10.7-1: Examples of LCOs from Generic Technical Specifications linked to Civil Structures

Structure	Description of LCO requirement for structure
Primary Containment (RCCV)	An LCO requires the Primary containment to be Operable. Part of the surveillance is a visual examination and leakage testing of the primary containment (civil structure).
Secondary Containment	An LCO requires the secondary containment to be Operable. Part of the surveillance is to confirm the pressure vacuum requirement which is partially assured by the surrounding structure.
C/B MCR	An LCO requires two divisions of the MCR HVAC Emergency Filter Trains to be Operable. Part of the surveillance is to confirm the positive pressure which is partially assured by the surrounding structure.

10.7.3 Assumptions for Civil Engineering

Assumptions are defined in Ref-100 as "where the safety case takes for granted or presumes a specific condition exists". Almost every part of the safety case has assumptions, that is, design details, material data, operating conditions or other information that form part of the basis of the assessment but are taken for granted and presented without justification or evidence, and which are vital to the understanding and justification of the GDA. Assumptions do not have the same force as

LCOs in that they do not define the operating envelope in which the safety case is valid and do not have to be measureable.

For civil structures a number of working assumptions are made in the GDA design basis, particularly where criteria are dependent on a specific site. These assumptions provide the basis from which the PCSR demonstrates that the civil engineering will achieve all safety claims and that nuclear safety issues have been adequately considered in the GDA process. The key working assumptions for the civil engineering are given below.

- The NSEDPs apply to all civil structures with safety or environmental significance and these lead to Safety Property Claims (SPCs).
- The UK ABWR civil structures have a design life of 100 years.
- The generic site layout is based on one ABWR unit. The layout of the civil structures is shown in the typical generic plot plan described in Chapter 9 of the PCSR.
- The external hazards evaluation for the generic site for normal conditions and design basis events are as described in Chapter 2 of the PCSR.
- The protection required from design basis external hazards i.e. those arising off-site, are as described in Chapter 6 of the PCSR.
- Design basis internal hazards, i.e. those arising on site, are as described in Chapter 7 of the PCSR.
- Further to assumption 4, the soil characterisation for the generic site is assumed as described in “Supporting Document on Soil and Seismic Input for Generic Site Envelope” [Ref-44]. All seismic and structural analysis models are based on this assumed soil characterisation, and therefore the site specific design must confirm the validity of this assumption.
- The justification of building global stability is based on the following assumptions [Ref-44]:

    Buoyancy against groundwater level at ground level.

    Sliding resistance from base friction and earth side wall pressures.

    Overturning resistance from base pressure and earth sidewall pressures.

    Allowable bearing pressures are provided by the generic site formations.
- The general materials for structural concrete and steel assumed within the GDA design are as listed in Section 10.5.6.

10.8 Summary of ALARP Justification

10.8.1 Overview

This section presents a high level overview of how the ALARP principle has been applied to the civil engineering structures, and how this contributes to the overall ALARP argument for the UK ABWR.

Generic PCSR Chapter 28 (ALARP Evaluation) presents the high level approach taken for demonstrating ALARP across all aspects of the design and operation. It presents an overview of how the UK ABWR design has evolved, the further options that have been considered across all technical areas resulting in a number of design changes and how these contribute to the overall ALARP case. The approach to undertaking ALARP Assessment during GDA is described in the “GDA ALARP Methodology” [Ref-22] and “Safety Case Development Manual” [Ref-02].

Hitachi-GE has undertaken a comprehensive programme of work during GDA to demonstrate that the civil engineering structures are designed in an appropriately conservative manner to ensure that the risks to safety from failures of those structures are reduced to be as low as reasonably practicable. The demonstration starts with using an established Japanese design as the reference design. The ABWR has been built and operated successfully in Japan such that there is relevant operational experience and knowledge of performance of structures in real earthquakes. The GDA design has identified any shortfalls in the proposed facility design; any improvements required for the UK regulatory regime and confirms that safety is not unduly reliant on a small set of particular safety features.

The civil engineering design requirements are largely dependent on the requirements of the plant and equipment for normal conditions and for fault conditions and on the evaluation of internal and external hazards. The risks to civil structures result from this applied loading, which may result in large deflections, cracking and in extreme cases failure of structural elements.

The global structure of any civil engineering structure has mainly to satisfy two principal safety functions,

- Function to provide structural support to the nuclear safety related plant (HLSF 5-17) which affects every structure, system and component in the plant.
- Barrier functions across many HLSFs, namely: as protection against the outside environment (HLSFs 5-18, 5-7), to prevent release of radioactivity to the environment or spread internally (HLSFs 2-4, 4-7, 4-8) and as internal barriers for segregation of divisional safety trains (HLSF 5-7).

These two principal functions are discussed below with descriptions of the key measures provided by the generic civil engineering design to demonstrate that risks are ALARP. Reference is made to the “UK ABWR Nuclear Safety and Environmental Design Principles (NSEDPs)” [Ref-03] which set down the design basis for nuclear safety, non-radiological and radiological environmental protection.

10.8.2 Function to Provide Structural Support

10.8.2.1 Structure Classification

Each civil structure has been classified according to its safety significance and the safety function it has to support [CE SPC 01] (as described in Section 10.3). This classification will govern the design codes and standards and design methods to be used for each class of structure. This ensures that the reliability of the design matches the safety significance. The seismic category is assigned according to the safety classification of the structure, or whether its performance can affect an adjacent safety related building [CE SPC 02].

10.8.2.2 Design Loads

The margins provided by the structural design are applied at each step of the design process, as follows.

- Conservative evaluation of external hazards for generic UK sites.
- Use of European Utilities Requirements seismic design spectra for hard and medium sites.
- Plant conditions required for normal condition and fault conditions provided by the SSC designers are based on conservative design and the ALARP principle [CE SPC 03].
- Use of recognised design codes and standards for nuclear plants, supplemented by extra provisions required by UK practice.
- Seismic analysis methodology which provides conservative seismic demands.
- Structural design methodology which provides significant margin on the members in the main structural load paths.

10.8.2.3 Internal Hazards

Structural loading from potential internal hazards is defined by the plant and equipment designers, with appropriate margin. Refer to Section 10.3.3 for the civil engineering general principles for protection against internal hazards. ALARP measures where the civil structures provide segregation barriers are described below in Section 10.8.3. The structures are designed to be tolerant of hazards and provide the required barrier function [CE SPC 07].

10.8.2.4 External Hazards

Protection against external hazards is provided by civil structures, not only in the strength and robustness of the designed structure, but also in the arrangement and detailing [CE SPC 04]. Refer to Section 10.3.4 for the civil engineering general principles for protection against external hazards. For GDA the main principles are assessed, but the final arrangement will need to be determined during the site specific design. Refer to the PCSR Chapter 6: External Hazards and its supporting Topic Reports for the safety case on protection against external hazards.

10.8.2.5 Aircraft Impact Protection

The protection of the UK ABWR from potential aircraft impact has been included in the design, even though it is a beyond design basis event. This is a requirement not only for nuclear safety but also for security. Buildings have been provided with either enough strength to prevent an aircraft impact from affecting the SSCs within that building; or enough separation from other SSCs such that diversity of systems is ensured. Therefore, the aircraft impact protection provided by the UK ABWR structures has been demonstrated to reduce potential dose release to ALARP levels.

10.8.2.6 Plant Conditions and Loadings

The design criteria arising from requirements from plant and equipment are provided by the appropriate technical design teams. These include the following:

- Weights of equipment and areas of operation.
- Deflection limits for structural supports.
- Potential impact loads from moving plant items.

- Temperatures and pressures from plant processes, at both normal and fault conditions.
- Allowable leakage rates of contained material, gas or liquid (see barrier function).

These loadings, and combinations, include margin already to address the variability or uncertainties in their derivation. In addition, the civil engineering design applies the loading as part of load cases with appropriate factors of safety in accordance with the code or standard.

10.8.2.7 Structural Analysis

The structural analysis modelling, including seismic analysis methodology, is appropriately conservative to ensure that the resulting civil structure has capacity above the demand load with adequate margin [CE SPC 03]. This ensures that the generic structure has sufficient robustness such that it can withstand UK external hazards without being damaged to an extent disproportionate to the original cause.

Analysis has been by numerical modelling using finite element (FE) analysis. The “Seismic Design Methodology Report” [Ref-52] describes the models and methods used for the seismic soil structure interaction analyses and the structural stress analyses. The “Seismic Design Validation Report for R/B” [Ref-53] describes how the analyses are validated; validation of each structural model is provided in the relevant building “Structural Design Report” and justifies that the model is an appropriate representation of the structure under consideration.

Verification is provided for all computer software used in the calculations [CE SPC 09 and Principle BP8.7].

All analyses include load cases which comply with the relevant design code and which are selected by the designers to test the sensitivity of the results to variations in the input parameters. This ensures that the risk from uncertainties is kept as low as reasonably practicable.

10.8.2.8 Beyond Design Basis Assessment

Beyond design basis accident analyses (BDBAA) and Severe Accident Analyses (SAA) have been carried out and the accident scenarios identified have been used to inform the civil engineering design. This BDB evaluation provides confidence that there are no sudden failures of the structures under the BDB events [CE SPC 05]. The results are presented in the structural design report of each civil structure.

10.8.3 Barrier Function

10.8.3.1 Exterior Envelope

All civil engineering structures which enclose plant and equipment will provide protection against the outside environment by the exterior walls and roofs, known as the building weather envelope [HLSFs 5-18, 5-7 and CE SPC 04]. This ensures the HVAC systems are able to control the internal environment of the building to provide the correct conditions for plant and equipment during normal condition. For Class 1 buildings, the requirement is to design for the design basis events of meteorological, ground and manmade external hazards. The design for the seismic design basis hazard, discussed under structural design above, will ensure that the Class 1 building remains standing and serviceable and thus continues to provide a weatherproof envelope [CE SPCs 02 and 05]

The generic UK ABWR Class 1 structures provide resilience against this hazard in several ways as described in the “Topic Report on External Hazard Protection” [Ref-42]. These are summarised below:

- The site platform level (general ground level) will be at a level above the design basis flood level wherever possible, with a margin in that level.
- The design basis flood level can only be confirmed during site specific stage; however the GDA design considers the extreme combination of all of the following together.

  Design basis high tide.
  Atmospheric depression causing design basis tidal surge.
  Design basis wave height, including wind-blown effects.
  Sea water tsunami hazard.

- The Back-up Building is provided to give additional capability to safely shutdown the reactor and provide post event cooling. The back-up building is located significantly higher than the main site platform level (general ground level) for beyond design basis flood protection. This must be specified according to site specific conditions.
- To account for sites where the design basis flood level could threaten the station platform level, the exterior envelope has minimal openings through it. Ground floor will be set above the platform level such that freeboard to large openings such as doors is provided. For very low lying sites, the generic design does not preclude the option of flood barriers or water tight doors being installed.

10.8.3.2 Prevention of Release of Radioactivity

Certain structures, or parts of structures, have additional safety functions to prevent release of radioactivity to the environment, both for normal condition and for fault conditions (HLSFs 2-04, 4-07, 4-08). These comprise the following:

- Primary containment (RCCV)
- Secondary containment (R/B exterior walls and roofs)
- Spent fuel pool

The barrier functions of the civil structures are provided on the concept of multiple barriers (Principle BP4.4). These barriers also include defence in depth measures where practicable.

10.8.3.3 Avoiding Spread of Contamination

The detailing of the building internals ensures that internal spread of contamination is avoided as described in PCSR Chapter 20: Radiation Protection. Plant and equipment designers provide measures to avoid the arising in the first place. In addition, architectural features will be provided to capture and allow collection of any accidental spillage or release. These features will be defined during site specific stage, but the generic design can easily accommodate them. Typical features for liquids include:

- Provision of bounded areas around floor drains where there is potential for leakage.
- Drainage pipe details which prevent leaks spreading to other areas.
- Drainage channels and sumps as appropriate.
- Decontaminable concrete surface coatings.
- Avoidance of ledges or crevices where contamination may be trapped.

10.8.3.4 Barriers to Internal Hazards

The civil engineering structures or parts of structures provide internal barriers for segregation of divisional safety trains [HLSF 5-7 and CE SPC 07] and also non-divisional barriers to stop purgation of hazards. The barrier functions include the following:

- Fire/Explosion barrier [Ref-30].
- Internal flooding barrier [Ref-31].
- Pipe whip and jet impact barrier [Ref-32].
- Barrier to dropped or collapsed loads [Ref-33].
- Internal missile barrier [Ref-34].
- Internal blast barrier [Ref-35].
- Measures to minimise EMI effects [Ref-36].
- Miscellaneous internal hazards [Ref-37].

10.8.4 Other ALARP Measures

10.8.4.1 Reliability

The reliability of the civil structures is ensured by the following [CE SPC 10]:

- Appropriate design life being used for the structural design.
- Appropriate longevity of the materials used.
- Through life EMIT plan to ensure condition of structure remains as assumed in the design.

10.8.4.2 Decommissioning

The materials and details used for civil structures are appropriate to reduce the hazard from contamination and activation at the time of decommissioning [CE SPC 12]. Refer to PCSR Chapter 31: Decommissioning. The detailing of the civil structures will also comply with the decommissioning plan, including such items as

- Barriers to leakage of radioactive liquid e.g. SFP liner, suppression pool/RCCV liner.
- Concrete cover thickness to suit removal of potential contamination/activation.
- Provision of bounded areas around floor drains where there is potential for leakage. Appropriate concrete surface coatings and drainage pipe details would be used in the final design.
- Features to facilitate future dismantling of the plant.

The exact requirements will be defined at site specific stage. However the generic design has considered the high level principles in accordance Principles SP5.2.5 and SP8.10.1 of the NSEDPs. This ensures that the adoption of any such techniques can be easily accommodated into the generic structure.

10.8.4.3 Conventional Health and Safety

A review of the conventional hazards has been undertaken in line with relevant good practice, particularly the Construction (Design & Management) Regulations 2015 (CDM 2015) [Ref-23]. This includes the following:

- Methodology for CDM Compliance [Ref-24]
- Construction for Decommissioning [Ref-25]

This safety requirement is captured under CE SPC 13.

10.8.5 Conclusion

The design of the UK ABWR civil engineering structures and architectural details has demonstrated that it follows UK and international good practice and, following systematic and comprehensive design development, all reasonably practicable risk reduction measures have been adopted. The work undertaken in support of this topic demonstrates that the UK ABWR design has been robustly carried out, that the design reduces risks ALARP and does not preclude options for the future licensee to adopt alternative design details or construction techniques. The risks from the civil engineering structures are therefore reduced in line with the ALARP principle.

10.9 Conclusions

This chapter has provided an overview of the design of the civil works and structures. Along with its supporting references, it has shown that the civil works and structures of the UK ABWR will be designed to the highest standards consistent with their safety critical role for the UK ABWR.

This chapter has set out the following:

- Identifies and describes the buildings within the scope of GDA for the Civil Engineering structures.
- Describes the requirements of the buildings within the chapter scope – in normal condition and design basis fault conditions.
- Specifies all relevant Safety Case Claims - Safety Functional Claims (SFCs) and provides links to the relevant BSCs/TRs which identify corresponding Safety Property Claims (SPCs).
- Identifies and describe the safety functions of the Systems, Structures and Components (SSCs) within the scope of the chapter, and specifies the safety categorisation of those functions, and the safety classification of the SSCs within the scope of the chapter.
- Describes or provides pointers to where the detailed arguments and evidence can be found in the supporting BSCs, TRs and the detailed Level 3 design information.
- Provides information or provides pointers to relevant information that can be used to demonstrate compliance of the SSCs within the scope of the chapter with the relevant sections of the Nuclear Safety and Environmental Design Principles (NSEDPs).
- Provides references to the relevant evidence that demonstrates that the risks associated with the SSCs within the scope of the chapter are As Low As Reasonably Practicable (ALARP).

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[Ref-78] Hitachi-GE Nuclear Energy, Ltd., “Civil Engineering Supporting Report Backup Building Seismic Analysis Report”, GA91-9201-0003-00394 (JE-GD-0059), Rev.4, May 2017

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[Ref-80] Hitachi-GE Nuclear Energy, Ltd., Civil Engineering Supporting Report Stack Seismic Analysis Report”, GA91-9201-0003-00395 (JE-GD-0060), Rev.4, March 2017

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[Ref-85] Hitachi-GE Nuclear Energy, Ltd., “Civil Engineering Supporting Report R/B-EDG/B Connecting Service Tunnel Structural Design Report”, GA91-9201-0003-00406 (LE-GD-0068), Rev.4, June 2017

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[Ref-91] Hitachi-GE Nuclear Energy, Ltd., "Civil Engineering Supporting Report: Light Oil Storage Tank (LOT) Foundation and Connecting Service Tunnel Structural Design Report", GA91-9201-0003-00216 (LE-GD-0065), Rev.4, June 2017

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[Ref-93] Hitachi-GE Nuclear Energy, Ltd., "Civil Engineering Supporting Report R/B-B/B Connecting Service Tunnel Structural Design Report", GA91-9201-0003-00210 (LE-GD-0067), Rev.4, June 2017

[Ref-94] Hitachi-GE Nuclear Energy, Ltd., "Civil Engineering Supporting Report Service Building Seismic Analysis Report", GA91-9201-0003-01975 (JE-GD-0214), Rev.1, June 2017

[Ref-95] Hitachi-GE Nuclear Energy, Ltd., "Civil Engineering Supporting Report Service Building Structural Design Report", GA91-9201-0003-00963 (LE-GD-0167), Rev.1, June 2017

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[Ref-105] Hitachi-GE Nuclear Energy, Ltd., "Topic Report on Departures from Conventional Fire Regulation", GA91-9201-0001-00001 (LE-GD-0077), Rev 0, June 2017

[Ref-106] Hitachi-GE Nuclear Energy, Ltd., "Standard Control Procedures for Identification and Registration of Assumptions, Limits and Conditions for Operation", GA91-0512-0010-00001 (XD-GD-0042), Rev 2, March 2017

Appendix A: Safety Functional Claims Table

Table A1: Safety Functional Claims for Reactor Building (R/B)

No.	Top Claim for Mechanical System: Fundamental Safety Function (FSF) PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		High Level Safety Function (HLSF) PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claims for Mechanical System and Components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[R/B SFC 5-17.01]	The R/B is designed with the loading conditions described in section 10.3.5, to support the SSCs for the normal condition [R/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the spent fuel pools • Loads associated with the fuel transportation route • Loads from lifting equipment on the reactor deck level • Temporary loads from disassembled parts on the reactor deck	A	1
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[R/B SFC 5-18.01]	The R/B exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B SFC 5-18.01] The R/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [R/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16: Auxiliary Systems, Section 16.5. The R/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [R/B SFC 5-18.01.2] The R/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [R/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15: Electrical Power Supplies, Section 15.6.5.	A	1
3	2	Fuel Cooling	2-4	Function to cool spent fuel outside the reactor coolant system	-	No corresponding Fault	Normal Condition	[R/B SFC 2-4.01]	R/B forms SFP together with stainless liner and cooling systems, to enable fuel cooling outside the reactor coolant system. [R/B SFC 2-4.01]	A	1
4	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[R/B SFC 4-7.01]	R/B forms a part of the RCCV together with several MC components, to shield radiation from the reactor and confine the radioactive substance inside the containment. [R/B SFC 4-7.01]	A	1
5	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[R/B SFC 4-7.02]	The R/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary. The HVAC system maintains inside of the secondary containment at negative pressure, so that airflow is always from outside to inside. This negative pressure limits a potential radioactive release to the external environment during the normal condition. [R/B SFC 4-7.02]	A	1

Table A1: Safety Functional Claims for Reactor Building (R/B)

No.	Top Claim for Mechanical System: Fundamental Safety Function (FSF) — PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		High Level Safety Function (HLSF) — PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Fault Schedule (Bounding Fault) — Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claims for Mechanical System and Components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
6	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[R/B SFC 4-7.03]	The R/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [R/B SFC 4-7.03]	A	1
7	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 5-17.02]	The R/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [R/B SFC 5-17.02]	A	1
8	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 5-18.02]	The R/B exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B SFC 5-18.02] The R/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [R/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The R/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [R/B SFC 5-18.02.2] The R/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [R/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	1
9	2	Fuel Cooling	2-4	Function to cool spent fuel outside the reactor coolant system	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards. Additional faults for SFP is Event ID 14.	Fault Condition	[R/B SFC 2-4.02]	R/B forms SFP together with stainless liner and cooling systems, to enable fuel cooling outside the reactor coolant system. [R/B SFC 2-4.02]	A	1
10	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 4-7.04]	R/B forms a part of the RCCV together with several MC components, to shield radiation from the reactor and confine radioactive substances inside the containment. [R/B SFC 4-7.04]	A	1
11	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive	-	Relevant faults are listed in PCSR Chapter 6: External	Fault Condition	[R/B SFC 4-7.05]	The R/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. The	A	1

Table A1: Safety Functional Claims for Reactor Building (R/B)

No.	Top Claim for Mechanical System: Fundamental Safety Function (FSF) PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		High Level Safety Function (HLSF) PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claims for Mechanical System and Components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
				materials, shield radiation, and reduce radioactive release		Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.			Standby Gas Treatment System (SGTS) creates a negative air pressure inside the secondary containment during postulated accidental conditions, so that airflow is always from outside to inside. This negative pressure limits a potential radioactive release to the external environment during the fault condition. [R/B SFC 4-7.05]		
12	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 5-7.01]	The R/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B SFC 5-7.01] The R/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design basis internal hazards. [R/B SFC 5-7.01.1] The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3. Specific information relating to the spent fuel Transfer Cask dropped load case is included in Chapter 19. It has been identified that an impact limiter is required for the case of the spent fuel Transfer Cask drop to the ground floor. The design of the impact limiter will be performed at the site specific stage.	A	1
13	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 5-7.02]	The R/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which delivers safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B SFC 5-7.02] In addition to the design basis external hazards requirements the walls and slabs are designed to provide countermeasures against an aircraft impact and thus prevent or mitigate the physical impact, fire and vibration effects. [R/B SFC 5-7.02.1] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1
14	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B SFC 5-14.01]	The R/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B SFC 5-14.01]	C	3

Table A2: Safety Functional Claims for RCCV

A Safety Functional Claims Table for the RCCV is included in PCSR Chapter 13, Appendix A.

Table A3: Safety Functional Claims for Control Building (C/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[C/B SFC 5-17.01]	The C/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [C/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the Main Control Room • Loads associated with the electrical cabinets • Loads associated with the piping inside of the MSTR Tunnel which runs through a section of the control building	A	1
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[C/B SFC 5-18.01]	The C/B exterior building envelope maintains the internal building environment appropriate for SSCs. [C/B SFC 5-18.01] The C/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [C/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The C/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [C/B SFC 5-18.01.2] The C/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [C/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	1
3	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[C/B SFC 4-7.01]	The C/B provides shielding by concrete walls and slabs, to shield radiation from the main steam tunnel. The shielding walls and slabs are arranged around the Main Steam (MS) System and Feedwater (FDW) System piping to reduce worker's exposure within the C/B. The shielding walls and slabs also provide shielding to reduce the potential dose rate at the site boundary. [C/B SFC 4-7.01]	A	1
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[C/B SFC 5-17.02]	The C/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [C/B SFC 5-17.02]	A	1
5	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal	Fault Condition	[C/B SFC 5-18.02]	The C/B exterior building envelope maintains the internal building environment appropriate for SSCs. [C/B SFC 5-18.02] The C/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the	A	1

Table A3 : Safety Functional Claims for Control Building (C/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
						Hazards.			building internal environment, for the normal operating and fault conditions. [C/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The C/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [C/B SFC 5-18.02.2] The C/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [C/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
6	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[C/B SFC 4-7.02]	The C/B provides shielding by concrete walls and slabs, on the perimeter of the MCR, to minimise the received radiation dosage and facilitate accident management activities inside the MCR. The shielding walls and slabs maintain their shielding function against postulated fault conditions. [C/B SFC 4-7.02]	A	1
7	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[C/B SFC 5-7.01]	The C/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [C/B SFC 5-7.01] The C/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design base internal hazards. [SFC C/B 5-7.01.1] The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.	A	1
8	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[C/B SFC 5-7.02]	The C/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design base external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [C/B SFC 5-7.02] The C/B is shielded by the R/B and T/B on the north / south axis and the Rw/B and S/B on the east / west axis adding defence in depth against postulated external hazards. The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1

Table A3: Safety Functional Claims for Control Building (C/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
9	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[C/B SFC 5-14.01]	The C/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [C/B SFC 5-14.01]	C	3

Table A4: Safety Functional Claims for Heat Exchanger Building (Hx/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[Hx/B SFC 5-17.01]	The Hx/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [Hx/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the RCW and TCW heat exchangers and connecting pipework • Loads associated with the RSW, RCW, TSW and TCW pumps and connecting pipework • Crane loads and associated loading within the maintenance bay • Hydrostatic and ground pressures • Vehicular loads on top slab of intake chamber	A	1
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[Hx/B SFC 5-18.01]	The Hx/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Hx/B SFC 5-18.01] The Hx/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Hx/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The Hx/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Hx/B SFC 5-18.01.2] The Hx/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Hx/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	1
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Hx/B SFC 5-17.02]	The Hx/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [Hx/B SFC 5-17.02]	A	1
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal	Fault Condition	[Hx/B SFC 5-18.02]	The Hx/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Hx/B SFC 5-18.02] The Hx/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building	A	1

Table A4: Safety Functional Claims for Heat Exchanger Building (Hx/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
						Hazards.			internal environment, for the normal operating and fault conditions. [Hx/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The Hx/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Hx/B SFC 5-18.02.2] The Hx/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Hx/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Hx/B SFC 5-7.01]	The Hx/B provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [Hx/B SFC 5-7.01] The Hx/B provides divisional separation barriers between the safety trains, to protect SSCs, which deliver safety functions from design base internal hazards. [SFC Hx/B 5-7.01.1] The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.	A	1
6	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Hx/B SFC 5-7.02]	The Hx/B provides thick sectioned exterior walls, slabs and roof to protect SSCs inside the building which delivers safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [Hx/B SFC 5-7.02] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Hx/B SFC 5-14.01]	The Hx/B layout provides safe escape routes from inside the building to the designated safe mustering point [Hx/B SFC 5-14.01].	C	3

Table A5: Safety Functional Claims for Turbine Building (T/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) – PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Top Claim for mechanical system: High Level Safety Function (HLSF) – PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Top Claim for mechanical system: Fault Schedule (Bounding Fault) – Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety: Cat.	Safety: Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[T/B SFC 5-17.01]	The T/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [T/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the turbine generator and pedestal, including vibration, thermal expansion and condenser vacuum force. • Loads associated with the piping from the Turbine Main Steam and Condensate and Feedwater Systems. • Overhead crane and hoist loads.	B	2
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[T/B SFC 5-18.01]	The T/B exterior building envelope maintains the internal building environment appropriate for SSCs. [T/B SFC 5-18.01] The T/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [T/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The T/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [T/B SFC 5-18.01.2] The T/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [T/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	B	2
3	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[T/B SFC 4-7.01]	The T/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce the dose rate at the site boundary. [T/B SFC 4-7.01] This function relates to the shielding functions TG SFC 4-7.1, ES SFC 4-7.1, etc. in Chapter 17 Sections 17.3 to 17.11.	B	2
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[T/B SFC 5-17.02]	The T/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [T/B SFC 5-17.02]	B	2

Table A5 : Safety Functional Claims for Turbine Building (T/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
5	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[T/B SFC 5-18.02]	The T/B exterior building envelope maintains the internal building environment appropriate for SSCs. [T/B SFC 5-18.02] The T/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [T/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The T/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [T/B SFC 5-18.02.2] The T/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [T/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	B	2
6	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[T/B SFC 4-7.02]	The T/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. [T/B SFC 4-7.02]	B	2
7	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[T/B SFC 5-7.01]	The T/B provides thick sectioned exterior walls, slabs and roof to protect SSCs inside the building which delivers safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [T/B SFC 5-7.01] The T/B is categorised as Seismic Category 2/1A. Therefore, the T/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [T/B SFC 5-7.01.1]	B	2
8	5	Others	5-14	Supporting functions for on-site emergency preparedness		Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[T/B SFC 5-14.01]	The T/B layout provides safe escape routes from inside the building to the designated safe mustering point [T/B SFC 5-14.01].	C	3

Table A6: Safety Functional Claims for Radwaste Building (Rw/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[Rw/B SFC 5-17.01]	The Rw/B is designed with the loading conditions described in section 10.3.5, to support the SSCs for the normal conditions. [Rw/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the liquid storage tanks on the lower levels of the Rw/B • Loads associated with process plant and piping where known, otherwise a floor live load is used • No loads from vehicles have been included for this concept design	C	3
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[Rw/B SFC 5-18.01]	The Rw/B exterior building envelope maintains the internal building environment appropriate for SSCs. [Rw/B SFC 5-18.01] The Rw/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Rw/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The Rw/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [Rw/B SFC 5-18.01.2] The Rw/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Rw/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	C	3
3	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[Rw/B SFC 4-7.01]	The Rw/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [Rw/B SFC 4-7.01] This function relates to the dose rate function LWMS SFC 4-12.3 and SWMS SFC 4-13.2 in PCSR Chapter 18, Section 18.3.1.	C	3
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Rw/B SFC 5-17.02]	The Rw/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [Rw/B SFC 5-17.02]	C	3
5	5	Others	5-18	Function to maintain	-	Relevant faults are listed in	Fault	[Rw/B	The Rw/B exterior building envelope maintains the internal building	C	3

Table A6: Safety Functional Claims for Radwaste Building (Rw/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
				internal building environment appropriate for SSCs		PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Condition	SFC 5-18.02]	environment appropriate for SSCs. [Rw/B SFC 5-18.02] The Rw/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [Rw/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The Rw/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [Rw/B SFC 5-18.02.2] The Rw/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [Rw/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
6	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Rw/B SFC 4-7.02]	The Rw/B provides a sufficiently leak-tight boundary using concrete walls and slabs at that boundary to confine any potential radioactive release inside of the structure. [Rw/B SFC 4-7.02]	C	3
7	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Rw/B SFC 5-7.01]	The Rw/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [Rw/B SFC 5-7.01] The Rw/B is categorised as Seismic Category 2/1A. Therefore, the Rw/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [Rw/B SFC 5-7.01.1]	C	3
8	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[Rw/B SFC 5-14.01]	The Rw/B layout provides safe escape routes from the inside of the building to the designated safe mustering point. [Rw/B SFC 5-14.01]	C	3

Table A7: Safety Functional Claims for Back-up Building (B/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[B/B SFC 5-17.01]	The B/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [B/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the diesel generators including vibration and installation loads • Loads associated with heavy pumps and motors including vibration • Loads associated with the cooling water pipework	A	2
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[B/B SFC 5-18.01]	The B/B exterior building envelope maintains the internal building environment appropriate for SSCs. [B/B SFC 5-18.01] The B/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [B/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The B/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater [B/B SFC 5-18.01.2]. The B/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [B/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	2
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[B/B SFC 5-17.02]	The B/B is designed to support SSCs which deliver safety functions for design basis (DB) loads, to support accident management facilities. [B/B SFC 5-17.02]	A	2
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[B/B SFC 5-18.02]	The B/B exterior building envelope maintains the internal building environment appropriate for SSCs. [B/B SFC 5-18.02] The B/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [B/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR	A	2

Table A7: Safety Functional Claims for Back-up Building (B/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) — PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) — PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) — Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety: Cat.	Safety: Class
									Chapter 16, Section 16.5. The B/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [B/B SFC 5-18.02.2] The B/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [B/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
5	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[B/B SFC 4-7.01]	The B/B provides shielding walls and slabs, to shield radiation to lower for accident management activities inside the building. The shielding walls maintain their shielding function against postulated fault conditions. [B/B SFC 4-7.01]	A	2
6	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[B/B SFC 5-7.01]	The B/B shall provide thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazards. The walls and slabs shall retain their structural integrity against the design basis events. [B/B SFC 5-7.01] The B/B is located with adequate separation from the nuclear island to maintain function of the accident management facilities during relevant external hazard conditions which affect the R/B and C/B. [B/B SFC 5-7.01.1]	A	2
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[B/B SFC 5-14.01]	The B/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [B/B SFC 5-14.01]	C	3

Table A8: Safety Functional Claims for Main Stack

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[STACK SFC 5-17.01]	The Stack is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal conditions. [STACK SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the ducts and equipment supported by the stack. • Wind loading on the lattice frame and on the stack shell.	A	2
2	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[STACK SFC 5-17.02]	The Stack is designed to support SSCs which deliver safety functions for design basis (DB) loads. [STACK SFC 5-17.02]	A	2
3	4	Confinement/Containment of radioactive materials	4-8	Functions to minimise the release of radioactive gases	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[STACK SFC 4-8.01]	The stack provides the required height from the dispersion of exhaust gases from the ventilation of the radiation controlled area within the plant. [STACK SFC 4-8.01] The height of the top of stack duct is determined by air diffusion modelling and for GDA purpose, this is set at 75m above the nominal site ground level. The height for a specific UK site will be reassessed during the site specific stage; however this is not anticipated to vary significantly from the GDA height.	A	2
4	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[STACK SFC 5-7.01]	The stack will be designed to protect SSCs connected to the stack which deliver safety functions from design basis external hazards. The structure shall retain its structural integrity and maintain raised vent against the design basis hazards. [STACK SFC 5-7.01]	A	2

Table A9 : Safety Functional Claims for Emergency Diesel Generator Buildings (EDG/B)

<table>
<tr><th rowspan="4">No.</th><th colspan="6">Top Claim for mechanical system</th><th colspan="5" rowspan="2">Safety Functional Claim for the mechanical system and components (SFC)</th></tr>
<tr><th colspan="2">Fundamental Safety Function (FSF)</th><th colspan="2">High Level Safety Function (HLSF)</th><th colspan="2">Fault Schedule (Bounding Fault)</th></tr>
<tr><th colspan="2" rowspan="2">PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1</th><th colspan="2" rowspan="2">PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1</th><th colspan="2" rowspan="2">Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)</th><th rowspan="2">State</th><th rowspan="2">Claim ID</th><th rowspan="2">SFC Contents</th><th colspan="2">Safety</th></tr>
<tr><th>Cat.</th><th>Class</th></tr>
<tr><td>1</td><td>5</td><td>Others</td><td>5-17</td><td>Function to provide structural support to SSCs</td><td>-</td><td>No corresponding Fault</td><td>Normal Condition</td><td>[EDG/B SFC 5-17.01]</td><td>The EDG/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [EDG/B SFC 5-17.01]
The main specific normal condition loads include:
• Loads associated with the diesel generator including vibration.
• Loads associated with the fuel storage tanks including pumps and the fluids stored.
• Installation loads for the generators are also included.</td><td>A</td><td>1</td></tr>
<tr><td>2</td><td>5</td><td>Others</td><td>5-18</td><td>Function to maintain internal building environment appropriate for SSCs</td><td>-</td><td>No corresponding Fault</td><td>Normal Condition</td><td>[EDG/B SFC 5-18.01]</td><td>The EDG/B exterior building envelope maintains the internal building environment appropriate for SSCs. [EDG/B SFC 5-18.01]

The EDG/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [EDG/B SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The EDG/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [EDG/B SFC 5-18.01.2]

The EDG/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [EDG/B SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.</td><td>A</td><td>1</td></tr>
<tr><td>3</td><td>5</td><td>Others</td><td>5-17</td><td>Function to provide structural support to SSCs</td><td>-</td><td>Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.</td><td>Fault Condition</td><td>[EDG/B SFC 5-17.02]</td><td>The EDG/B is designed to support SSCs which deliver safety functions for design basis (DB) loads. [EDG/B SFC 5-17.02]</td><td>A</td><td>1</td></tr>
<tr><td>4</td><td>5</td><td>Others</td><td>5-18</td><td>Function to maintain internal building environment appropriate for SSCs</td><td>-</td><td>Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.</td><td>Fault Condition</td><td>[EDG/B SFC 5-18.02]</td><td>The EDG/B exterior building envelope maintains the internal building environment appropriate for SSCs. [EDG/B SFC 5-18.02]

The EDG/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [EDG/B SFC 5-18.02.1]

More information concerning the HVAC system can be found in PCSR Chapter</td><td>A</td><td>1</td></tr>
</table>

Table A9: Safety Functional Claims for Emergency Diesel Generator Buildings (EDG/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
									16, Section 16.5. The EDG/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [EDG/B SFC 5-18.02.2] The EDG/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [EDG/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[EDG/B SFC 5-7.01]	The EDG/B provides sufficiently thick exterior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [EDG/B SFC 5-7.01] The EDG/B provides divisional separation barriers between the safety trains to protect SSCs which deliver safety functions from design basis internal hazards. [EDG/B SFC 5-7.01.1] The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3. Since each EDG/B is one division, there are no IH claims on internal walls. The barrier requirements are given in the "Internal Hazards Barrier Substantiation Report" [Ref-102].	A	1
6	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[EDG/B SFC 5-7.02]	The EDG/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [EDG/B SFC 5-7.02] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[EDG/B SFC 5-14.01]	The EDG/B layout provides safe escape routes from the inside the building to the designated safe mustering point. [EDG/B SFC 5-14.01]	C	3

Table A10 : Safety Functional Claims for R/B-EDG/B Connecting Service Tunnels

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[R/B-EDG/B Tunnel SFC 5-17.01]	The R/B-EDG/B Connecting Service Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [R/B-EDG/B Tunnel SFC 5-17.01] The main specific normal condition loads include: • Loads associated with piping and cabling • Loads from the weight of the surrounding ground • Allowance for surcharge from vehicular loading	A	1
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[R/B-EDG/B Tunnel SFC 5-18.01]	The R/B-EDG/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-EDG/B Tunnel SFC 5-18.01] R/B-EDG/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-EDG/B Tunnel SFC 5-18.01.1]	A	1
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-EDG/B Tunnel SFC 5-17.02]	The R/B-EDG/B Connecting Service Tunnel is designed to support SSCs which deliver safety functions for design basis (DB) loads. [R/B-EDG/B Tunnel SFC 5-17.02]	A	1
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-EDG/B Tunnel SFC 5-18.02]	The R/B-EDG/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-EDG/B Tunnel SFC 5-18.02] The R/B-EDG/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-EDG/B Tunnel SFC 5-18.02.1]	A	1
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-EDG/B Tunnel SFC 5-7.01]	The R/B-EDG/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B-EDG/B Tunnel SFC 5-7.01] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1
6	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by	Fault Condition	[R/B-EDG/B Tunnel SFC 5-14.01]	The R/B-EDG/B Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B-EDG/B Tunnel SFC 5-14.01]	C	3

Table A10 : Safety Functional Claims for R/B-EDG/B Connecting Service Tunnels

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
						PCSR Chapter 7: Internal Hazards.					

Table A11 : Safety Functional Claims for Condensate Storage Tank Structure and Connecting Service Tunnel

<table>
<tr><th rowspan="4">No.</th><th colspan="6">Top Claim for mechanical system</th><th colspan="5" rowspan="2">Safety Functional Claim for the mechanical system and components (SFC)</th></tr>
<tr><th colspan="2">Fundamental Safety Function (FSF)</th><th colspan="2">High Level Safety Function (HLSF)</th><th colspan="2">Fault Schedule (Bounding Fault)</th></tr>
<tr><th colspan="2" rowspan="2">PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1</th><th colspan="2" rowspan="2">PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1</th><th colspan="2" rowspan="2">Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)</th><th rowspan="2">State</th><th rowspan="2">Claim ID</th><th rowspan="2">SFC Contents</th><th colspan="2">Safety</th></tr>
<tr><th>Cat.</th><th>Class</th></tr>
<tr><td>1</td><td>5</td><td>Others</td><td>5-17</td><td>Function to provide structural support to SSCs</td><td>-</td><td>No corresponding Fault</td><td>Normal Condition</td><td>[CST SFC 5-17.01]</td><td>The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [CST SFC 5-17.01]

The main specific normal condition loads for the CST Structure include:
• Loads associated with the tank and the fluid it contains
• Loads associated with the weight of the pumps
• Loads associated with water piping

The main specific normal condition loads for the CST Tunnel include:
• Loads associated with the pumped water pipes and cabling between the CST and buildings
• Allowance for surcharge from vehicular loading</td><td>A</td><td>2</td></tr>
<tr><td>2</td><td>5</td><td>Others</td><td>5-18</td><td>Function to maintain internal building environment appropriate for SSCs</td><td>-</td><td>No corresponding Fault</td><td>Normal Condition</td><td>[CST SFC 5-18.01]</td><td>The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel exterior building envelopes maintain the internal building environment appropriate for SSCs. [CST SFC 5-18.01]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide building envelopes which maintain the airflow into/out of the buildings suitable for the HVAC systems to be able to maintain the building internal environments, for the normal operating and fault conditions. [CST SFC 5-18.01.1]

More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5.

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel building envelopes protect the building interior from the external meteorological effects e.g. winds, precipitation, snow and are designed to mitigate ingress of groundwater by the concrete walls and slabs. [CST SFC 5-18.01.2]

The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel buildings have a lightning protection system to protect the SSCs inside the buildings from adverse effects due to lightning strike in normal operating and fault conditions. [CST SFC 5-18.01.3]

The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.</td><td>A</td><td>2</td></tr>
<tr><td>3</td><td>4</td><td>Confinement/Containment of radioactive materials</td><td>4-7</td><td>Functions to confine radioactive materials, shield</td><td>-</td><td>No corresponding Fault</td><td>Normal Condition</td><td>[CST SFC 4-7.01]</td><td>The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide shielding provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around radiation areas to reduce worker's exposure. The</td><td>A</td><td>2</td></tr>
</table>

Table A11 : Safety Functional Claims for Condensate Storage Tank Structure and Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
				radiation, and reduce radioactive release					external walls and slabs provide shielding to reduce dose rate at the site boundary. [CST SFC 4-7.01]		
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[CST SFC 5-17.02]	The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel are designed to support SSCs which deliver safety functions for design basis (DB) loads. [CST SFC 5-17.02]	A	2
5	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[CST SFC 5-18.02]	The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel exterior building envelopes maintain the internal building environment appropriate for SSCs. [CST SFC 5-18.02] The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provide building envelopes which maintain the airflow into/out of the buildings suitable for the HVAC systems to be able to maintain the building internal environments, for the normal operating and fault conditions. [CST SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel building envelopes protect the building interior from the external meteorological effects e.g. winds, precipitation, snow and are designed to mitigate ingress of groundwater by the concrete walls and slabs. [CST SFC 5-18.02.2] The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel buildings have a lightning protection system to protect the SSCs inside the buildings from adverse effects due to lightning strike in normal operating and fault conditions. [CST SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	2
6	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[CST SFC 5-7.01]	The CST Structure and R/B-CST-Rw/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [CST SFC 5-7.01] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	2

Table A11 : Safety Functional Claims for Condensate Storage Tank Structure and Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[CST SFC 5-14.01]	The CST Structure and R/B-CST Connecting Service Tunnel provide safe escape route from the inside of the building and tunnel to the safe place. [CST SFC 5-14.01]	C	3

Table A12 : Safety Functional Claims for Reactor Cooling Water (RCW) Tunnel

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[RCW Tunnel SFC 5-17.01]	The RCW Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [RCW Tunnel SFC 5-17.01] The main specific normal condition loads include: • Loads associated with piping and cabling • Loads from the weight of the surrounding ground • Allowance for surcharge from vehicular loading	A	1
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[RCW Tunnel SFC 5-18.01]	The RCW Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [RCW Tunnel SFC 5-18.01] The RCW Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [RCW Tunnel SFC 5-18.01.1]	A	1
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[RCW Tunnel SFC 5-17.02]	The RCW Tunnel is designed to support SSCs which deliver safety functions for design basis (DB) loads. [RCW Tunnel SFC 5-17.02]	A	1
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[RCW Tunnel SFC 5-18.02]	The RCW Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [RCW Tunnel SFC 5-18.02] The RCW Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [RCW Tunnel SFC 5-18.02.1]	A	1
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[RCW Tunnel SFC 5-7.01]	The RCW Tunnel provides sufficiently thick interior walls and slabs to protect SSCs inside the building which deliver safety functions from design basis internal hazards. The walls and slabs shall retain their structural integrity against the design basis hazards. [RCW Tunnel SFC 5-7.01] The RCW Tunnel provides divisional separation barriers between the safety trains, to protect SSCs which deliver safety functions from design basis internal hazards. [RCW Tunnel SFC 5-7.01.1] The internal hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.3.	A	1
6	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual	Fault Condition	[RCW Tunnel SFC 5-7.02]	The RCW Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity	A	1

Table A12 : Safety Functional Claims for Reactor Cooling Water (RCW) Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
						topic reports covered by PCSR Chapter 7: Internal Hazards.			against the design basis hazards. [RCW Tunnel SFC 5-7.02] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.		
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[RCW Tunnel SFC 5-14.01]	The RCW Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [RCW Tunnel SFC 5-14.01]	C	3

Table A13 : Safety Functional Claims for Light Oil Storage Tank Foundation and Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[LOT SFC 5-17.01]	The LOT Foundation and B/B-LOT Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [LOT SFC 5-17.01] The main specific normal condition loads for each LOT Foundation include: • Loads associated with the tank and the fluid it contains The main specific normal condition loads for the B/B-LOT Connecting Service Tunnel include: • Loads associated with the piping and cabling between the B/B and LOT • Loads from the weight of the surrounding ground • Allowance for surcharge from vehicular loading	A	2
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[LOT SFC 5-18.01]	The B/B-LOT Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [LOT SFC 5-18.01] The B/B-LOT Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [LOT SFC 5-18.01.1]	A	2
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[LOT SFC 5-17.02]	The LOT Foundation and B/B-LOT Connecting Service Tunnel are designed to support SSCs which deliver safety functions for design basis (DB) loads. [LOT SFC 5-17.02]	A	2
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[LOT SFC 5-18.02]	The B/B-LOT Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [LOT SFC 5-18.02] The B/B-LOT Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [LOT SFC 5-18.02.1]	A	2
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[LOT SFC 5-7.01]	The B/B-LOT Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [LOT SFC 5-7.01] The LOT is located with adequate separation from the R/B and C/B to maintain function of the accident management facilities against a beyond design basis external hazard to the R/B and C/B. [LOT SFC 5-7.01.1]	A	2

Table A13 : Safety Functional Claims for Light Oil Storage Tank Foundation and Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
									The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.		
6	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[LOT SFC 5-14.01]	The B/B-LOT Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [LOT SFC 5-14.01]	C	3

Table A14 : Safety Functional Claims for R/B-B/B Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[R/B-B/B Tunnel SFC 5-17.01]	The R/B-B/B Connecting Service Tunnel is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [R/B-B/B Tunnel SFC 5-17.01] The main specific normal condition loads include: • Loads associated with piping and cabling • Loads from the weight of the surrounding ground • Allowance for surcharge from vehicular loading	A	2
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[R/B-B/B Tunnel SFC 5-18.01]	The R/B-B/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-B/B Tunnel SFC 5-18.01] The R/B-B/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-B/B Tunnel SFC 5-18.01.1]	A	2
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-B/B Tunnel SFC 5-17.02]	The R/B-B/B Connecting Service Tunnel is designed to support SSCs which deliver safety functions for Design Base (DB) loads. [R/B-B/B Tunnel SFC 5-17.02]	A	2
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-B/B Tunnel SFC 5-18.02]	The R/B-B/B Connecting Service Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [R/B-B/B Tunnel SFC 5-18.02] The R/B-B/B Connecting Service Tunnel is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [R/B-B/B Tunnel SFC 5-18.02.1]	A	2
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[R/B-B/B Tunnel SFC 5-7.01]	The R/B-B/B Connecting Service Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [R/B-B/B Tunnel SFC 5-7.01] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	2
6	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR	Fault Condition	[R/B-B/B Tunnel SFC 5-14.01]	The R/B-B/B Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [R/B-B/B Tunnel SFC 5-14.01]	C	3

Table A14 : Safety Functional Claims for R/B-B/B Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
						Chapter 7: Internal Hazards.					

Table A15 : Safety Functional Claims for Service Building (S/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[S/B SFC 5-17.01]	The S/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [S/B SFC 5-17.01] The main specific normal condition loads include: • There are no large items of plant inside the S/B so there are no special building specific normal condition loads that are not already included in general live loads given in Section 10.3.5.	C	3
2	5	Others	5-18	Function to maintain environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[S/B SFC 5-18.01]	The S/B exterior building envelope maintains the internal building environment appropriate for SSCs. [S/B SFC 5-18.01] The S/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [S/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The S/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [S/B SFC 5-18.01.2] The S/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [S/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	C	3
3	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No corresponding Fault	Normal Condition	[S/B SFC 4-7.01]	The S/B provides a confinement function against radiation from radioactive materials housed within the building under normal operating and fault conditions, by means of concrete walls and slabs. The shielding walls and slabs are arranged around areas housing radioactive materials to reduce worker's exposure. The external walls and slabs also provide shielding to reduce the potential dose rate at the site boundary. [S/B SFC 4-7.01]	TBD	TBD
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[S/B SFC 5-17.02]	The S/B is designed to support SSCs which deliver safety functions for Design Base (DB) loads. [S/B SFC 5-17.02]	C	3
5	5	Others	5-18	Function to maintain environment appropriate	-	Relevant faults are listed in PCSR Chapter 6: External	Fault Condition	[S/B SFC 5-18.02]	The S/B exterior building envelope maintains the internal building	C	3

Table A15 : Safety Functional Claims for Service Building (S/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) – PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Top Claim for mechanical system: High Level Safety Function (HLSF) – PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Top Claim for mechanical system: Fault Schedule (Bounding Fault) – Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
				for SSCs		Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.			environment appropriate for SSCs. [S/B SFC 5-18.02] The S/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating conditions. [S/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The S/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) or groundwater. [S/B SFC 5-18.02.2] The S/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [S/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
6	5	Others	5-7	Function to limit the effect of Hazards	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[S/B SFC 5.7.01]	The S/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which delivers safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [S/B SFC 5-7.01] The S/B is also categorised as seismic category 1A. Therefore, the S/B is designed to maintain its structural integrity without spatial interaction or any other interaction with the C/B during the DBE, to protect SSCs which deliver safety functions inside the C/B. [S/B SFC 5-7.01.1] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	C	3
7	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[S/B SFC 5-14.01]	The S/B layout provides safe escape routes from the inside the building to the designated safe mustering point [S/B SFC 5-14.01]	C	3
8	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual	Fault Condition	[S/B SFC 5.14.02]	The S/B acts as a Forward Control Point (FCP) for Emergency Response; Emergency access to allow future licensees to monitor and control the plant in	C	3

Table A15 : Safety Functional Claims for Service Building (S/B)

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety	
										Cat.	Class
						opic reports covered by PCSR Chapter 7: Internal Hazards.			emergency situations. [S/B SFC 5-14.02]		

Table A16 : Safety Functional Claims for Filter Vent Building (FV/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[FV/B SFC 5-17.01]	The FV/B is designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [FV/B SFC 5-17.01] The main specific normal condition loads include: • Loads associated with the Filter Vent Tank and equipment on the lower floors. • Vehicular loads at ground floor level. • Loads associated with HVAC equipment on upper floors.	A	1
2	5	Others	5-18	Function to maintain environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[FV/B SFC 5-18.01]	The FV/B exterior building envelope maintains the internal building environment appropriate for SSCs. [FV/B SFC 5-18.01] The Fv/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [FV/B SFC 5-18.01.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The FV/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [FV/B SFC 5-18.01.2] The FV/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [FV/B SFC 5-18.01.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.	A	1
3	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive releases	-	No corresponding Fault	Normal Condition	[FV/B SFC 4-7.01]	The FV/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce workers' exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [FV/B SFC 4-7.01]	A	1
4	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FV/B SFC 5-17.02]	The FV/B is designed to support SSCs which deliver safety functions for design base (DB) loads. [FV/B SFC 5-17.02]	A	1
5	5	Others	5-18	Function to maintain	-	Relevant faults are listed in	Fault	[FV/B SFC 5-	The FV/B exterior building envelope maintains the internal building	A	1

Table A16 : Safety Functional Claims for Filter Vent Building (FV/B)

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)		Safety Functional Claim for the mechanical system and components (SFC)				
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
				environment appropriate for SSCs		PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Condition	18.02]	environment appropriate for SSCs. [FV/B SFC 5-18.02] The FV/B provides a building envelope which maintains the airflow into/out of the building suitable for the HVAC systems to be able to maintain the building internal environment, for the normal operating and fault conditions. [FV/B SFC 5-18.02.1] More information concerning the HVAC system can be found in PCSR Chapter 16, Section 16.5. The FV/B building envelope protects the building interior from the external environment, e.g. meteorological effects (such as winds, precipitation, snow) and groundwater. [FV/B SFC 5-18.02.2] The FV/B has a lightning protection system to protect the SSCs inside the building from adverse effects due to lightning strike in normal operating and fault conditions. [FV/B SFC 5-18.02.3] The lightning protection system is described in PCSR Chapter 15, Section 15.6.5.		
6	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive releases	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FV/B SFC 4-7.02]	The FV/B provides low leak-rate boundaries as the secondary containment by using concrete walls and slabs, to confine radioactive material to limit release to the external environment during a fault condition. The Standby Gas Treatment System (SGTS) maintains inside of the secondary containment at negative pressure during postulated accidental conditions. [FV/B SFC 4-7.02]	A	1
7	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive releases	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FV/B SFC 4-7.03]	The FV/B provides shielding by concrete walls and slabs. The shielding walls and slabs maintain their shielding function against postulated fault conditions. The external walls and slabs provide shielding to reduce dose rate at the site boundary. [FV/B SFC 4-7.03]	A	1
8	5	Others	5-7	Function to limit the effect of Hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FV/B SFC 5-7.01]	The FV/B provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design basis external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [FV/B SFC 5-7.01] The external hazards that can impose design requirements on the civil structures either in design basis or beyond design basis situations are listed in Section 10.3.4.	A	1
9	5	Others	5-14	Function important to emergency measures and monitoring of abnormal conditions	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal	Fault Condition	[FV/B SFC 5-14.01]	The FV/B layout provides safe escape routes from the inside of the building to the designated safe mustering point. [FV/B SFC 5-14.01]	C	3

Table A16 : Safety Functional Claims for Filter Vent Building (FV/B)

No.	Top Claim for mechanical system			Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)	High Level Safety Function (HLSF)	Fault Schedule (Bounding Fault)					
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1	Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)	State	Claim ID	SFC Contents	Safety	
							Cat.	Class
			Hazards.					

Table A17 : Safety Functional Claims for FLSS Water Storage Tank Foundation and Connecting Service Tunnel

No.	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	SFC Contents	Safety Cat.	Safety Class
1	5	Others	5-17	Function to provide structural support to SSCs	-	No corresponding Fault	Normal Condition	[FLSS WST SFC 5-17.01]	The FLSS WST Foundation and Connecting Service Tunnel are designed with the loading conditions described in Section 10.3.5, to support the SSCs for the normal condition. [FLSS WST SFC 5-17.01] The main specific normal condition loads for the FLSS WST Foundation include: • Loads associated with the FLSS water storage tank and the fluid it contains The main specific normal condition loads for the B/B-FLSS WST Tunnel include: • Loads associated with the piping and cabling between the B/B and FLSS WST	A	2
2	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	No corresponding Fault	Normal Condition	[FLSS WST SFC 5-18.01]	The B/B-FLSS WST Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [FLSS WST SFC 5-18.01] The B/B-FLSS WST Tunnel exterior building envelope is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [FLSS WST SFC 5-18.01.1]	A	2
3	5	Others	5-17	Function to provide structural support to SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FLSS WST SFC 5-17.02]	The B/B-FLSS WST Connecting Service Tunnel is designed to support SSCs which deliver safety functions for Design Base (DB) loads. [FLSS WST SFC 5-17.02]	A	2
4	5	Others	5-18	Function to maintain internal building environment appropriate for SSCs	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FLSS WST SFC 5-18.02]	The B/B-FLSS WST Tunnel exterior building envelope maintains the internal building environment appropriate for SSCs. [FLSS WST SFC 5-18.02] The B/B-FLSS WST Tunnel exterior building envelope is designed to mitigate ingress of groundwater by the reinforced concrete walls and slabs. [FLSS WST SFC 5-18.02.1]	A	2
5	5	Others	5-7	Functions to limit the effect of hazard	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FLSS WST SFC 5-7.01]	The B/B-FLSS WST Tunnel provides thick sectioned exterior walls and slabs to protect SSCs inside the building which deliver safety functions, from design base external hazard. The walls and slabs shall retain their structural integrity against the design basis hazards. [FLSS WST SFC 5-7.01] The FLSS WST is located with adequate separation from the R/B and C/B to maintain function of the accident management facilities against an extreme external hazard condition to the main structures such as R/B and C/B. [FLSS WST SFC 5-7.01.1] The external hazards that can impose design requirements on the civil	A	2

Table A17 : Safety Functional Claims for FLSS Water Storage Tank Foundation and Connecting Service Tunnel

No.	Top Claim for mechanical system: Fundamental Safety Function (FSF) — PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		High Level Safety Function (HLSF) — PCSR Ch.5 Categorisation and Classification of Structures, Systems and Components Table 5.6-1		Fault Schedule (Bounding Fault) — Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		Safety Functional Claim for the mechanical system and components (SFC): State	Claim ID	SFC Contents	Safety Cat.	Safety Class
									structures either in design basis or beyond design basis situations are listed in Section 10.3.4.		
6	5	Others	5-14	Supporting functions for on-site emergency preparedness	-	Relevant faults are listed in PCSR Chapter 6: External Hazards and the individual topic reports covered by PCSR Chapter 7: Internal Hazards.	Fault Condition	[FLSS WST SFC 5-14.01]	The B/B-FLSS WST Connecting Service Tunnel layout provides safe escape routes from the inside the building to the designated safe mustering point. [FLSS WST SFC 5-14.01]	C	3

Appendix B: Safety Property Claims Table

The safety properties claims defined for civil engineering (CE) structures included in the GDA scope are shown in the following table.

These SPCs apply to all CE structures within the scope of GDA.

Table D1 : SPCs applicable to Civil Structures

No.	SPC	Safety Properties Claim (SPC) Contents	SCDM SPC Guide word and NSEDPs
1	CE SPC 01	CE structures have been classified in accordance with the safety functional category of the equipment housed within them or supported by them.	• Category & Class BP4.6, SP4.6.1, SP4.6.2
2	CE SPC 02	Civil structures are seismically categorised to ensure either the SSCs contained within them can operate safely following a seismic event or such that a failure of a structure dies not have a detrimental impact on adjacent structures containing SSCs.	• Category & Class BP4.6, SP4.6.1, SP 4.6.2
3	CE SPC 03	The analysis and design of CE structures has been carried out using conservative methods and input parameters to ensure they are robust and thus achieve the required reliability to meet all relevant accident conditions, including suitable resilience to DBA, BDBA and SA events.	• Reliability BP4.10
4	CE SPC 04	CE structures are designed to be tolerant of external hazards and provide the protection to the SSCs housed within or supported by the structures. The magnitude of normal operational and design basis external hazards is given in PCSR Chapter 2, Generic Site Envelope.	• Fault tolerance BP4.1, BP4.9, SP4.9.1, SP4.10.1, SP12.2.4
5	CE SPC 05	CE structures designed to Seismic Category 1 requirements have no cliff edge effects for beyond design basis seismic events.	•
6	CE SPC 06	CE structures are designed to be tolerant of variations in the ground conditions, since GDA is not based on a specific site. This includes variations in seismic soil parameters and the assumption that the ground water level is at ground level.	• Fault tolerance BP4.1 BP4.9, SP4.9.1 SP4.10.1 SP12.2.4
7	CE SPC 07	CE structures are designed to be tolerant of internal hazards and provide the required barrier functions as specified in PCSR Chapter 7 Internal Hazards.	• Fault tolerance • Layout BP4.1 BP4.9, SP4.9.1 SP4.10.1 SP12.2.4

No.	SPC	Safety Properties Claim (SPC) Contents	SCDM SPC Guide word and NSEDPs
8	CE SPC 08	CE structures are designed using relevant good practice and complies with the appropriate internationally, recognised codes and standards.	• Relevant Good Practice BP8.1, BP 8.2, BP8.3, BP8.4 BP11.1, BP 11.3 BP15.1
9	CE SPC 09	Finite element analysis models used in the CE structures' analyses have been sufficiently validated to provide confidence in the results. The various computer codes have been sufficiently verified to prove they are used within the limits of applicability.	• Relevant Good Practice BP8.7, SP8.7.1
10	CE SPC 10	CE structures have a design life of 100 years to ensure they are robustly detailed so that they can be maintained appropriately throughout the 60 years operational life, and also for the safe decommissioning of the site.	• Reliability • Life cycle
11	CE SPC 11	The internal layouts of the CE structures and buildings provide suitable space and access in respect of safety requirements during normal operations and emergency response considerations. The layouts are derived from the Japanese reference plant and are established with relevant operator experience..	• Layout and accessibility
12	CE SPC 12	The materials and details used for civil structures are appropriate to reduce the hazard from contamination and activation at the time of decommissioning	SP5.2.5 SP8.10.1
13	CE SPC 13	The generic design of CE structures has included designers' hazard logs for recording risks for consideration by the future licensee (contractor)	

Appendix C: Document Map

Document Map for Generic PCSR Chapter 10

Relation between Level 1 document (PCSR) and Level 2 documents under PCSR Ch.10.

PCSR Ch.10:
Civil Works and Structures

Other PCSR Chapters related to Level 2 document under PCSR Ch.10

KEY LINKS
- PCSR Ch.2: Generic Site Envelope
- PCSR Ch.31: Decommissioning

KEY LINKS
- PCSR Ch.4: Safety Management
- PCSR Ch.20: Radiation Protection

KEY LINKS
- PCSR Ch.6: External Hazards
- PCSR Ch.13: Engineered Safety Features

KEY LINKS
- PCSR Ch.7: Internal Hazards
- Barrier Substantiation Report

KEY LINKS
- PCSR Ch.9: General Description of the Facility
- PCSR Ch.5: General Design Aspects

- Basis of Safety Case on Reactor Building Civil Design [Ref-04]
- Basis of Safety Case on Reinforced Concrete Containment Vessel [Ref-05]
- Basis of Safety Case on Control Building Civil Design [Ref-06]
- Basis of Safety Case on Heat Exchanger Building Civil Design [Ref-07]
- Basis of Safety Case on Turbine Building Civil Design [Ref-08]
- Basis of Safety Case on Radwaste Building Civil Design [Ref-09]
- Basis of Safety Case on Backup Building Civil Design [Ref-10]

Continue to next page.

Document Map for Generic PCSR Chapter 10 (Continued)

- Basis of Safety Case on Emergency Diesel Generator Building Civil Design [Ref-11]
- Basis of Safety Case on R/B-EDG/B Connecting Service Tunnel Civil Design [Ref-12]
- Basis of Safety Case on Condensate Storage Tank Structure and Connecting Service Tunnel Civil Design [Ref-13]
- Basis of Safety Case on RCW Tunnel Civil Design [Ref-14]
- Basis of Safety Case on Light Oil Storage Tank Basement and Connecting Service Tunnel Civil Design [Ref-15]
- Basis of Safety Case on R/B-B/B Connecting Service Tunnel Civil Design [Ref-16]
- Basis of Safety Case for Service Building Civil Design [Ref-17]
- Basis of Safety Case on FLSS Water Storage Tank Foundation and Connecting Service Tunnel Civil Design [Ref-18]

Appendix D: Internal and External Hazard Mapping

The Tables in Appendix D provide summaries of the hazards which are to be considered as applicable for each building inside the GDA civil structures' scope.

For each hazard and building pairing, there are two potential cases:

"✓"	Protection to the SSCs is provided by the civil structure in order to fulfil the fundamental safety functions. Therefore, the loading from the hazard must be included as design criteria for the civil structures.
"-"	Protection to the SSCs is provided by other means in order to fulfil the fundamental safety functions. Therefore, the loading from the hazard does not need to be taken into account for the structural design or there is no potential for the hazard to exert a loading on the structure.

Internal Hazards

Safety Class A1 structures containing Class 1 barriers require assessment against the risk of internal hazards.

Others structures with specific requirements are assessed to ensure that they will not produce any hazards which can impact A1 SSCs in other buildings.

For the turbine disintegration hazard, the UK ABWR has been shown to survive credible missile scenarios such that the fundamental safety functions are maintained. This is achieved by energy reduction from the turbine casing and certain civil structures of targeted A1 structures.

Electromagnetic interference (EMI), and Radio Frequency Interference are not included in the table because they produce no structural loads.

External Hazards

The dominant external hazard is a seismic event, therefore all buildings inside GDA scope are seismically categorised.

In some cases specific hazards are not required as strucural design critieria because the external hazards safety case specifies a screening distance value (exclusion zone), for example external missiles generated off-site will not have sufficient energy to impact buildings on the site.

Drought, Electromagnetic interference (EMI), Sea or River water temperature and Loss of Off-Site power (LOOP) are not included in the table because they produce no structural loads.

Certain requirements will be met by considering generic site position instead of structural design requirements, this is not detailed in this table.

Table D1: Internal Hazards applicable to the Design of structures in the scope of PCSR Chapter 10.

More information on specific claims is contained in the individual building sub-sections in Section 10.4.

Hazard Name	Reactor Building	RCCV Concrete Structure	Control Building	Heat Exchanger Building	Turbine Building	Radwaste Building	Back-up Building	Main Stack	Emergency Diesel Generator Building
Internal Fire and Explosion	✓	✓	✓	✓	-	-	-	-	-
Internal Flooding	✓	✓	✓	✓	-	-	-	-	-
Pipe Whip and Jet Impact	✓	✓	✓	-	-	-	-	-	-
Dropped and Collapsed Loads	✓	✓	✓	✓	-	-	-	-	-
Internal Conventional Missiles	✓	✓	✓	✓	-	-	-	-	✓
Turbine disintegration	✓	✓	✓	✓	-	-	-	-	-
Internal Blast	✓	✓	✓	✓	-	-	-	-	-
Miscellaneous Internal Hazards	✓	✓	✓	✓	-	-	-	-	-
Combined Internal Hazards	✓	✓	✓	✓	-	-	-	-	-
Combinations of Internal hazards with External hazards	✓	✓	✓	✓	-	-	-	-	-

Table D1: Internal Hazards applicable to the Design of structures in the scope of PCSR Chapter 10.

More information on specific claims is contained in the individual building sub-sections in Section 10.4.

Hazard Name	R/B-EDG/B Connecting Service Tunnels	Condensate Storage Tank Structure and Connecting Service Tunnel	Reactor Cooling Water Tunnel	Light Oil Storage Tank Foundation and Connecting Service Tunnel	R/B-B/B Connecting Service Tunnel	Service Building	Filter Vent Building	FLSS Water Storage Tank Foundation and Connecting Service Tunnel
Internal Fire and Explosion	-	-	-	-	-	-	-	-
Internal Flooding	-	-	✓	-	-	-	-	-
Pipe Whip and Jet Impact	-	-	-	-	-	-	-	-
Dropped and Collapsed Loads	-	-	-	-	-	-	-	-
Internal Conventional Missiles	-	-	-	-	-	-	-	-
Turbine Blade disintegration	-	-	-	-	-	-	-	-
Internal Blast	-	-	-	-	-	-	-	-
Miscellaneous Internal Hazards	-	-	-	-	-	-	-	-
Combined Internal Hazards	-	-	-	-	-	-	-	-
Combinations of Internal hazards with External hazards	-	-	-	-	-	-	-	-

Table D2: External Hazards applicable to the Design of structures in the scope of PCSR Chapter 10

More information on specific claims is contained in the individual building sub-sections in Section 10.4

External Hazard Group	Reactor Building	RCCV	Control Building	Heat Exchanger Building	Turbine Building	Radwaste Building	Back-up Building	Main Stack	Emergency Diesel Generator Building
Air temperature	✓	-(1)	✓	✓	✓	✓	✓	✓	✓
Wind	✓	-(1)	✓	✓	✓	✓	✓	✓	✓
Rainfall & Ice	✓	-(1)	✓	✓	✓	✓	✓	✓	✓
Snow	✓	-(1)	✓	✓	✓	✓	✓	✓	✓
External flooding	✓	-(1)	✓	✓	✓	✓	✓	-	✓
Seismic activity	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aircraft impact (2)	✓	✓	✓	-	-	-	-	-	-
External fire	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)
External missile	-(3)	-(1)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)
External explosion	-(3)	-(1)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)	-(3)

Notes:
(1) The RCCV is protected by the Reactor Building around it for these hazards. However, for the RCCV ultimate analysis it should be noted that external air temperature has been included [Ref-65].

(2) For aircraft impact, those structures noted do not require to be protected themselves, but are separated from the other buildings by distance so that the fundamental safety functions can still be met, e.g. if the Heat Exchanger Building is impacted, alternative cooling functions within the Reactor Building will survive.

(3) Protection against these external hazards is given by excluding the sources of these hazards beyond the SDV (screening distance value), i.e. provided the sources of these hazards are further away than the SDV from the site there will be no effect. Note that protection against these effects may still be provided under the CSA.

Table D2: External Hazards applicable to the Design of structures in the scope of PCSR Chapter 10.

More information on specific claims is contained in the individual building sub-sections in Section 10.4

Hazard Name	R/B-EDG/B Connecting Service Tunnels	Condensate Storage Tank Structure and Connecting Service Tunnel	Reactor Cooling Water Tunnel	Light Oil Storage Tank Foundation and Connecting Service Tunnel	R/B-B/B Connecting Service Tunnel	Service Building	Filter Vent Building	FLSS Water Storage Tank Foundation and Connecting Service Tunnel
Air temperature	-	✓	-	✓	-	✓	✓	✓
Wind	-	✓	-	✓	-	✓	✓	✓
Rainfall & Ice	-	✓	-	✓	-	✓	✓	✓
Snow	-	✓	-	✓	-	✓	✓	✓
External flooding	✓	✓	✓	✓	✓	✓	✓	✓
Seismic activity	✓	✓	✓	✓	✓	✓	✓	✓
Aircraft impact (2)	-	-	-	-	-	-	-	-
External fire	-	- (3)	-	- (3)	-	- (3)	- (3)	- (3)
External missile	-	- (3)	-	- (3)	-	- (3)	- (3)	- (3)
External explosion	-	- (3)	-	- (3)	-	- (3)	- (3)	- (3)

Notes:

(1) The RCCV is protected by the Reactor Building around it for these hazards. However, for the RCCV ultimate analysis it should be noted that external air temperature has been included [Ref-65].

(2) For aircraft impact, those structures noted do not require to be protected themselves, but are separated from the other buildings by distance so that the fundamental safety functions can still be met, e.g. if the Heat Exchanger Building is impacted, alternative cooling functions within the Reactor Building will survive.

(3) Protection against these external hazards is given by excluding the sources of these hazards beyond the SDV (screening distance value), i.e. provided the sources of these hazards are further away than the SDV from the site there will be no effect. Note that protection against these effects may still be provided under the CSA.