Office for Nuclear Regulation

An agency of HSE

Generic Design Assessment – New Civil Reactor Build

GDA Close-out for the EDF and AREVA UK EPR™ Reactor

GDA Issue GI-UKEPR-CE-01 Revision 1 – Hypothesis and Methodology Notes for Class 1 Structures

Assessment Report: ONR-GDA-AR-12-006
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EXECUTIVE SUMMARY

The Office for Nuclear Regulation (ONR), an agency of the Health and Safety Executive, has carried out Generic Design Assessment (GDA) of the UK EPR™ nuclear power plant. Step 4 of GDA of the UK EPR™ included an assessment of the civil engineering design and the application of external hazards. The assessment of the design process found that the basis of design for the Class 1 civil structures was contained in a large number of "hypothesis notes". The hypothesis documents were examined for all the safety class 1 structures considered in the scope of GDA, i.e. the nuclear island. These documents were found to be heavily biased towards the Flamanville 3 project, which is the reference design for GDA, and so would need to be modified to apply to a UK EPR™.

The Flamanville 3 hypothesis notes had been prepared at varying different levels by several different organisations. Therefore the design criteria, specifications and methodologies were spread across a suite of documents and ONR concluded that these did not provide sufficient clarity and so were not fully adequate for use in the design of the UK EPR™. In addition, a number of changes and additions would be required to ensure that they are suitable for use in the UK, for instance removal of references to French standards.

GDA Issue **GI-UKEPR-CE-01 Rev 1** was raised at the end of Step 4 which requested EDF and AREVA produce satisfactory hypothesis note(s) for the nuclear island structures for the UK EPR™.

In response to **GI-UKEPR-CE-01**, EDF and AREVA have produced an overarching document, the "EPR Nuclear Island Civil Engineering Design Process" note. This forms a high level basis of design document for the nuclear island buildings; and forms a platform for the individual building hypothesis notes during the site specific phase. The document includes summary descriptions of the structural philosophy for each building, design principles and marshals the design codes and standards and design methodologies to be used. The framework of roles and responsibilities for the different levels of organisations has also been clarified.

The new submission is a significant improvement in providing clarity of the overall approach to be used for the UK EPR™. I am satisfied that this document will signpost the designers to the design information necessary to achieve an acceptable civil structure design. The "EPR Nuclear Island Civil Engineering Design Process" note is an important specification document, which must be kept up to date as the detailed design progresses such that the information it contains, accurately summarises the basis of the design for safety class 1 buildings. This is required under Assessment Finding **AF-UKEPR-CE-84**. The detailed settlement analysis cannot be completed until a site is chosen and so **AF-UKEPR-CE-85** requires justification of this work and confirmation of foundation monitoring.

I have therefore found EDF and AREVA's response to **GI-UKEPR-CE-01** to be satisfactory and recommend this issue is closed.

LIST OF ABBREVIATIONS

AF	Assessment Finding
AFCEN	Association Française pour les règles de conception et de construction des matériels des Chaudières Électro Nucléaires
APC	Air Plane Crash
AREVA	AREVA NP SAS
BS	British Standard
C1	Safety class 1 for civil structures
CEEH	Civil Engineering and External Hazards
CNEN	Centre National Equipment Nucléaire (part of EDF)
COB	Coyne et Bellier
DBE	Design Basis Earthquake
EDF	Electricité de France SA
ETC-C	EPR Technical Code for Civil Works
FA3	Flamanville 3, EPR Nuclear Power Plant, France.
FE	Finite Element
FRS	Floor Response Spectra
GDA	Generic Design Assessment
GI	GDA Issue
HOW2	ONR Business Management System (HOW2)
HSE	The Health and Safety Executive
IAEA	International Atomic Energy Agency
IC	Inner Containment
NAB	Nuclear Auxiliaries Building
NI	Nuclear Island
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation (an agency of HSE)
PCER	Pre-construction Environment Report
PCSR	Pre-construction Safety Report
PSAR	Preliminary Safety Analyses Report
RFS	Règles Fondamentales de Sûreté (Basic Safety Rules)
SAB	Safety Auxiliaries Building
SAP	Safety Assessment Principles
SEPTEN	Service Etudes et Projets Thermiques et Nucléaires (part of EDF)

LIST OF ABBREVIATIONS

SLB	Steam Line Break
SSC	System, Structure and Component
TAG	(Nuclear Directorate) Technical Assessment Guide
TQ	Technical Query
TSC	Technical Support Contractor
UK CD	UK Companion Document (to the AFCEN ETC-C 2010 Edition)
WENRA	Western Europe Nuclear Regulators' Association

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1 INTRODUCTION

1.1 BACKGROUND

1 This report presents the close-out of the Office for Nuclear Regulation's (an agency of HSE) Generic Design Assessment (GDA) within the area of civil engineering and external hazards. The report specifically addresses the close-out of GDA Issue **GI-UKEPR-CE-01 Rev 1** (Ref. 1). This issue was generated as a result of the GDA Step 4 Civil Engineering and External Hazards Assessment of the UK EPR™ (Ref. 2). My assessment has focussed on the deliverables identified within the EDF and AREVA Resolution Plan (Ref. 3) published in response to the GDA Issue.

2 GDA followed a step-wise-approach in a claims-argument-evidence hierarchy. In Step 2 the claims made by EDF and AREVA were examined and in Step 3 the arguments that underpin those claims were examined. The Step 4 assessment reviewed the safety aspects of the UK EPR™ reactor in greater detail, by examining the evidence, supporting the claims and arguments made in the safety documentation.

3 The GDA Step 4 Assessment concluded that the UK EPR™ reactor was suitable for construction in the UK subject to resolution of 31 GDA Issues resulting from all assessment technical topics. GDA Issues are unresolved issues considered by regulators to be significant, but resolvable, and which require resolution before nuclear island safety related construction of such a reactor could be considered. Assessment findings are findings that are identified during the regulators' GDA assessment that are important to safety, but not considered critical to the decision to start nuclear island safety related construction of such a reactor.

4 The Step 4 Civil Engineering and External Hazards (CEEH) Assessment (Ref. 2) identified six GDA Issues and 68 Assessment Findings as part of the assessment of the evidence associated with the UK EPR™ reactor design. The purpose of this report is to provide the assessment which underpins the judgement made in closing GDA Issue **GI-UKEPR-CE-01 Rev 1** arising from the CEEH assessment. The assessments for close-out of the other five CEEH GDA Issues (Ref. 4 to Ref. 8) are detailed in separate ONR assessment reports (Ref. 9 to Ref. 12).

5 The EDF and AREVA safety case for the UK EPR™ design is contained within the Pre-construction Safety Report (PCSR) with the technical detail presented in the supporting documentation. The PCSR was originally submitted for GDA Step 4 assessment in November 2009. EDF and AREVA revised and resubmitted the PCSR in March 2011 (Ref. 13) in response to the findings of the ONR assessment and this forms the safety case for GDA Step 4. Sub-chapter 3.3 of the March 2011 PCSR describes the design of safety classified civil structures. This has required further revision in order to resolve **GI-UKEPR-CE-01** and was re-submitted in October 2012 (Ref. 14). I am satisfied that these revisions, plus the supporting documents discussed in this report reflect the additional justification required by my assessment of the response to the civil engineering GDA issue.

1.2 SCOPE

6 This report presents only the assessment undertaken as part of the resolution of this GDA Issue and it is recommended that this report be read in conjunction with the Step 4 CEEH Assessment Report (Ref. 2) in order to appreciate the totality of the assessment of the evidence undertaken as part of the GDA process.

7 This assessment report is not intended to revisit aspects of assessment already undertaken and confirmed as being adequate during previous stages of the GDA.

However, should evidence from the assessment of EDF and AREVA's responses to GDA Issues highlight shortfalls not previously identified during Step 4, there will be a need for these aspects of the assessment to be addressed as part of the close-out phase or be identified as assessment findings to be taken forward to site specific phase.

8 The possibility of further assessment findings being generated as a result of this assessment is not precluded given that resolution of the GDA Issues may leave aspects of the assessment requiring further detailed evidence when the information becomes available at a later stage.

1.3 METHODOLOGY

9 The methodology applied to this assessment is identical to the approach taken during Step 4 which followed the ONR business management system HOW2 document PI/FWD "Permissioning - Purpose and Scope of Permissioning", Issue 3 (Ref. 21), in relation to mechanics of assessment within ONR.

10 This assessment has been focussed primarily on the submissions relating to resolution of the GDA Issues as well as any further requests for information or justification derived from assessment of those specific deliverables.

11 The assessment allows ONR to judge whether the submissions provided in response to the GDA Issue are sufficient to allow it be closed. Where requirements for more detailed evidence have been identified that are appropriate to be provided at the design, construction or commissioning phases of the project these can be carried forward as assessment findings.

12 The scope of this assessment is not to undertake further assessment of the PCSR nor is it intended to extend this assessment beyond the expectations stated within the GDA Issue Actions. However, should information be identified that has an affect on the claims made for other aspects of CEEH such that the existing case is undermined, these have been addressed.

1.4 STRUCTURE OF THIS REPORT

13 This assessment report structure differs slightly from the structure adopted for the previous reports produced within GDA, most notably the Step 4 CEEH Assessment (Ref. 2). The report has been structured with the assessment of the individual GDA Issue rather than a report detailing close out of all GDA Issues associated with this technical area.

14 The reasoning behind adopting this report structure is to allow closure of GDA Issues as the work is completed rather than having to wait for the completion of all the GDA work in this technical area.

2 ONR'S ASSESSMENT STRATEGY FOR GDA ISSUE GI-UKEPR-CE-01

2.1 CLOSE-OUT PLAN

15 The intended assessment strategy for GDA close-out for the Civil Engineering and External Hazards topic area was set out in an assessment plan (Ref. 22). This identified the intended scope of the assessment and the standards and criteria that would be applied.

16 The assessment plan was based on:

- the EDF and AREVA resolutions plans for all six Civil Engineering GDA Issues;
- the project programmes contained in the resolution plans;
- the work scope for technical support contractors (TSC) commissioned by ONR to support the assessment; and
- internal ONR resources and interaction with other topic Inspectors.

17 The scope of work contained within the assessment plan comprised assessment of the following:

- technical submissions made to ONR in accordance with the resolution plans;
- whether an update was required to the March 2011 Pre-construction Safety Report (PCSR) which had been reviewed during the GDA (Ref. 13); and
- updates to the various documents supporting the PCSR.

2.2 THE APPROACH TO ASSESSMENT FOR GDA ISSUE CLOSE-OUT

18 The approach to the closure of the GDA for the UK EPR™ Project has comprised the assessment of submissions made by EDF and AREVA in response to GDA Issues identified through the GDA process. These submissions are detailed within the EDF and AREVA resolution plan for each GDA Issue.

19 During Step 4 of GDA, regular Level 4 technical meetings were held to allow discussion and clarification with EDF and AREVA on its submission documents. Since the majority of deliverables for close-out had already been identified and some GDA Issues were interrelated, points of clarification were progressed via continued dialogue of meetings. During the close-out phase, EDF and AREVA issued new or updated documents for ONR comment, and where appropriate these documents were revised again until convergence was reached on each technical point.

2.3 STANDARDS AND CRITERIA

20 The relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAP), internal ONR technical assessment guides (TAG), relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant ONR Technical Assessment Guides (TAG) have been detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.3.1 Safety Assessment Principles

21 The key SAPs applied within the assessment of GDA Issue **GI-UKEPR-CE-01** are included within Table 1 of this report. These are taken from Safety Assessment Principles for Nuclear Facilities, 2006 Edition Rev 1 (Ref. 23).

2.3.2 Technical Assessment Guides

22 The following Technical Assessment Guides have been used as the major underpinning guides for this assessment (Ref. 24).

- T/AST/013 External Hazards
- T/AST/017 Structural Integrity: civil engineering aspects

23 Other TAGs have been consulted as appropriate. These include:

- T/AST/005 ONR guidance on the demonstration of ALARP (as low as reasonably practicable)
- T/AST/004 Fundamental Principles

2.3.3 National and International Standards and Guidance

24 The following standards and guidance have been used as part of this assessment.

- International Atomic Energy Agency (IAEA) Safety Standard Series No. NS-R-1 (Ref. 25)
- Western European Nuclear Regulators' Association (WENRA) Reactor Reference Safety Levels (Ref. 26)
- BS EN 1991 – Eurocode 1 – Actions on Structures. (Ref. 27).
- BS EN 1992 – Eurocode 2 – Design of Concrete Structures (Ref. 28).
- BS EN 1997 – Eurocode 7 – Geotechnical Design (Ref. 29).

2.4 USE OF TECHNICAL SUPPORT CONTRACTORS

25 The assessment of the response to **GI-UKEPR-CE-01** has not used a technical support contractor (TSC). However, my assessment reports for the other five GDA Issues have been consulted in forming my conclusion. These other reports had support from technical support contractors ABS Consulting, Ove and Arup and Partners and Ramboll Ltd, and the individual assessment reports (Ref. 9 to Ref. 12) should be consulted for details.

2.5 OUT-OF-SCOPE ITEMS

26 There are no out of scope items. The entirety of GDA Issue **GI-UKEPR-CE-01** has been addressed. In addition, there are no changes to the scope of the GDA assessment detailed in the Step 4 report (Ref. 2).

3 GDA ISSUE

3.1 BACKGROUND TO THE GDA ISSUE

27 The civil structures in the reference design, Flamanville 3 in France, were designed using the "EPR Technical Code for Civil Works" (ETC-C) Rev B 2006 (Ref. 32). The current version, AFCEN ETC-C 2010 Edition (Ref. 33), will be used for the UK EPR™, with an accompanying UK Companion Document (Ref. 34) which has been specifically written to specify any changes to the AFCEN ETC-C 2010 that are required for the UK EPR™. The UK Companion Document (UK CD) is an important document, as its use will be mandatory and will govern over the AFCEN ETC-C 2010 in a similar way that the UK National Annexes govern Eurocodes. The AFCEN ETC-C 2010 and the UK CD were the subject of extensive discussions between ONR and EDF and AREVA during Step 4 of GDA, and one key point raised was that the AFCEN ETC-C 2010 needs to be read with the particular hypothesis notes for the building under examination.

28 EDF and AREVA have developed a series of 'hypothesis documents' for each of the buildings at FA3 to allow the designer to proceed with the detailed design. These are essentially detailed guides which extract the relevant design criteria from the PCSR, the AFCEN ETC-C 2010, specifications and methodology documents for that particular structure. This is consistent with practice in the UK civil engineering industry, where basis of design documents are written to summarise the design input information to be used.

29 The ONR Step 4 assessment considered the suite of hypothesis notes, specifications and methodologies provided by EDF and AREVA for nuclear safety class 1 (C1) civil structures. Hypothesis notes were typically prepared at three levels for FA3; Level 1 by EDF (CNEN), Level 2 by Sofinel, and Level 3, the most detailed level, by the individual design teams for the building in question (refer to Section 4.3.13 of Ref. 2). The Level 1 notes were the mechanism for the licensee's design authority to specify the design requirements to the next level of contractor. The Level 3 notes were used as confirmation of the design contractors' basis of design, both prior to work starting and updated to record the actual completed design.

30 The hypothesis documents for all the nuclear island structures were examined during Step 4 and found to be heavily biased towards the Flamanville 3 project and would need modification to apply to a UK EPR™. In addition, there were a number of changes and additions required to ensure they are suitable for use in the UK. GDA issue **GI-UKEPR-CE-01** was raised to require EDF and AREVA to provide a revised hypothesis note(s) for the nuclear island which comprises the Safety Auxiliaries Building, Fuel Building, Nuclear Auxiliaries Building and Reactor Building, and the Diesel Building structures which would clearly specify the civil engineering design process.

3.2 GDA ISSUE ACTIONS

31 There was a single action for **GI-UKEPR-CE-01**, which required a revised hypothesis note(s) to be produced for the buildings within the GDA scope. Particular observations from the Step 4 assessment of the Flamanville 3 hypothesis notes were included as bullet points within the issue action as follows.

1) The document should be UK specific including definition of ground conditions, climatic conditions and the structural classification.

2) The overall design life needs to be clarified.

3) Extensive references are made to French legislation and decrees as well as standards, which are of no relevance in the UK
4) The PSAR (Preliminary Safety Analyses Report) is constantly referred to.
5) A number of the key references have been superseded.
6) The document should reflect the latest position on load drops.
7) There are details on load combinations and replication of aspects of the ETC-C 2006. This may not fully align with the 2010 version of ETC-C and the UK companion document requirements.
8) There are no apparent requirements to consider robustness or global stability of the NI structures in accordance with the UK Building regulations part A.
9) There is no reference to the need to consider the CDM regulations.
10) The document lacks detail in a number of areas including structural philosophy, analysis methods, interfacing with adjacent structures etc.
11) The sections on the treatment of earthquakes and foundations are inconsistent with the latest methodologies.
12) The foundation conditions are limited to those of Flamanville.
13) The use of an equivalent static load method for seismic cases is suggested, which is out with the requirements of AFCEN ETC-C 2010.
14) The guidance on the construction of the finite element models for the structure is very weak without reference to other guidance.
15) The treatment of APC scenarios is unclear.
16) It is stated that there is a requirement for the reactor vessel pit to be completely dry; however there is no further guidance on how this should be achieved.
17) For a number of the accident scenarios, the loading is not clearly defined; references are made to future work-scopes. This is the case for some reactor pit thermal loads, internal missiles, and pipework rupture.
18) There is no design guidance for the treatment of gaps between the NAB and SAB or Fuel Building.
19) There are a series of vague statements over the future monitoring of foundation movements and references to “current policy”.
20) The option for using projecting bars (bent down bars) in openings is allowed, this is not a practice which is generally permitted in the UK for Nuclear structures.
21) There are a large number of references to Règles Fondamentales de Sûreté (RFS) documents for derivation of loads. These have not been benchmarked against the UK expectations.
22) The document states that long term settlement does not need to be considered, which is seen as a shortfall.
23) There is no detailed discussion on the need for some floor elements to essentially be leak-tight.

3.3 EDF AND AREVA RESOLUTION PLAN DELIVERABLES

32 EDF and AREVA proposed that a new common hypothesis note for all buildings within the GDA scope would be produced in response to **GI-UKEPR-CE-01**. This proposal was accepted by ONR at the CEEH Level 4 technical meeting on 16 March 2011. The Resolution Plan for **GI-UKEPR-CE-01** (Ref. 3) stated that "*EDF/AREVA will produce an overarching EPR Nuclear Island Civil Engineering Design Process Note for the Nuclear Island Buildings (i.e. Nuclear Island, Reactor Building, Safety Auxiliary Buildings, Fuel Building, Nuclear Auxiliary Building) and other Class 1 stand alone buildings (i.e. the Diesel Buildings). This overarching hypothesis note forms EDF/AREVA's sole response for closure of action GI-UKEPRCE01.01 and defines the interfaces with other current GDA documents, including reference to design data required from future site specific documentation."*

33 The Resolution Plan also stated that the "EPR Nuclear Island Civil Engineering Design Process" note (referred to as DPN in this report) would include detail on the following:

- applicable structures (description, and design philosophy),
- design process: main requirements (safety, codes and regulations), input data (including site data and its associated hierarchical significance in the design), main steps/activities performed in the design (including interfaces) and associated requirements,
- clarification related to general aviation (as committed in EDF and AREVA letter EPR00838N (Ref. 35), and
- identification and explanation of the necessary dedicated rules to be applied in the design of different safety classifications of civil structures (which links to cross-cutting GDA Issue GI-UKEPR-CC-01.A2 on classification).

34 It is important to note that the information within the DPN is supplementary to the information provided within the March 2011 PCSR (Ref. 13) which has already been subject to assessment during earlier stages of GDA. In addition, this deliverable is not intended to provide the complete safety case for the Civil Engineering and External Hazards topic area. Rather it forms further detailed arguments and evidence to supplement those already provided during earlier steps within the GDA Process.

3.4 INTERFACE WITH KEY DOCUMENTS

3.4.1 PCSR

35 The EDF and AREVA safety case for the UK EPR™ design is contained within the March 2011 Pre-construction Safety Report (PCSR) (Ref. 13) with the technical detail presented in supporting documentation. The sub-chapters directly relevant to civil engineering and external hazards topic area are Sub-chapter 3.3, "Design of Safety Classified Civil Structures" (Ref. 14) and Sub-chapter 13.1, "External Hazards Protection" (Ref. 15). However, certain design criteria for civil structures are stated in other sub-chapters, e.g. generic site data is given in Sub-chapter 2.1 (Ref. 16).

36 The resolution plan for **GI-UKEPR-CE-01** (Ref. 3) states that "*an update to PCSR Sub-chapter 3.3* [design of safety classified civil structures] *is programmed following finalisation of the Nuclear Island Civil Engineering Design Process Note such that it can be integrated and the existing hypothesis/methodology references can be removed from the PCSR*".

37 In summary the resolution plan proposed that the Design Process Note would become a major supporting reference to Sub-chapter 3.3 and would signpost to the detailed technical documents which comprise methodologies or design criteria. No changes to the technical content of Sub-Chapter 3.3 were proposed in order to resolve **GI-UKEPR-CE-01**.

3.4.2 ETC-C and UK Companion Document

38 The AFCEN ETC-C 2010 (Ref. 33) has been written under the auspices of AFCEN French society for design, construction and in-service inspection rules for nuclear island components) and so is a stand alone document. The accompanying UK Companion Document (UK CD) (Ref. 34) has been specifically written by EDF and AREVA to specify any changes to the AFCEN ETC-C 2010 that are required for the UK EPR™.

39 The resolution plan for **GI-UKEPR-CE-01** did not state whether any modifications would be required to the AFCEN ETC-C 2010 or its accompanying UK CD. However, during the close-out of the issue it became apparent that the DPN provides supporting information on the use and interpretation of the AFCEN ETC-C 2010 and its UK CD. The details of the revisions made to the UK CD are given in the close-out report for issue **GI-UKEPR-CE-02** (Ref. 9).

3.5 INTERFACE WITH OTHER GDA ISSUES

40 GDA Issue **GI-UKEPR-CE-01** has interfaces with deliverables for other civil engineering GDA Issues, as given in Table 2 below. This means that some of the commitments made by EDF and AREVA in order to resolve **GI-UKEPR-CE-01** are included in documents produced as deliverables for other GDA Issues. Where this is the case, details of the commitment are given in the appropriate section of this report.

Table 2: Interface of GI-UKEPR-CE-01 with other GDA Issues Deliverables

GDA Issue	Topic	Related Submissions
GI-UKEPR-CE-01 (Ref. 1)	Hypothesis and Methodology Notes	ECEIG111110 Rev C - EPR Nuclear Island Civil Engineering Design Process (Ref. 36)
GI-UKEPR-CE-02 (Ref. 4)	Use of the ETC-C	ENGSGC110015 Rev E - UK Companion Document (to the AFCEN ETC-C 2010) (Ref. 34)
GI-UKEPR-CE-03 (Ref. 5)	Beyond design basis behaviour of containment	n/a
GI-UKEPR-CE-04 (Ref. 6)	Containment analysis FE modelling	ENGSGC110015 Rev E - UK Companion Document (to the AFCEN ETC-C 2010) (Ref. 34)
GI-UKEPR-CE-05 (Ref. 7)	Reliability of the ETC-C	n/a
GI-UKEPR-CE-06 (Ref. 8)	Seismic Analysis Methodology	ENGSGC100140 Rev C - Common Foundation Raft and Seismic analysis (Ref. 37) ENGSDS100268 Rev B - UK EPR™ - Seismic Analysis of Foundation Raft, (Ref. 38) ENGSDS100269 Rev B - UK EPR™ - Methodology for Seismic Analysis of NI Buildings (Ref. 39)

4 ASSESSMENT OF RESPSONSE TO GDA ISSUE GI-UKEPR-CE-01

4.1 PROGRESS OF THE ASSESSMENT

41 The new "EPR Nuclear Island Civil Engineering Design Process" document ECEIG111110 Rev. A (Ref. 40) was submitted on 12 August 2011 in response to **GI-UKEPR-CE-01** and its single action. This submission was discussed with EDF and AREVA on 18 August 2011 and initial feedback given. Formal comments were given to EDF and AREVA via letter EPR70349N (Ref. 41). The main query was that ECEIG111110 Rev A stated that it will be supported by further hypothesis documents for each building, but these had not been submitted and so it was unclear whether this was a part response to the issue. A list of detailed questions was also enclosed with the letter.

42 EDF and AREVA's approach to resolving these comments was to use a tracking spreadsheet, ECEIG112122 Rev D (Ref. 42), in a similar fashion to that used on **GI-UKEPR-CE-02**. The purpose of this spreadsheet is to track each of the individual comments and to be used as a tool for the exchange of comments between ONR and EDF and AREVA. A staged response to the individual comments was made by issuing updated extracts of the DPN. ONR then provided comments in response to the staged changes. This process was iterated until convergence was reached on the relevant technical point.

43 The DPN was also updated to capture key commitments made in response to other CEEH GDA Issues, for example the seismic analysis methodology (**GI-UKEPR-CE-06**) or the technical clauses of the UK CD (**GI-UKEPR-CE-02)**. This reflects the fact that the DPN is an overarching document and its purpose is to summarise the civil engineering design basis.

44 Rev B of the DPN (Ref. 43) was submitted on 15 June 2012 and this revision satisfied a significant number of the ONR comments. However, one final revision of the DPN, Rev C (Ref. 36) was needed to fully address all 23 bullet points in **GI-UKEPR-CE-01.A1** and to include remnant responses resulting from the close-out of **GI-UKEPR-CE-02**. Rev C was submitted on 30 October 2012.

4.2 ASSESSMENT OF THE RESPONSE TO GI-UKEPR-CE-01

4.2.1 Overall

45 The original issue stated that *"the specification, methodology and hypothesis notes for Class 1 civil structures have not been found to be fully adequate for use in the design of the UKEPR*". There are many facets to gaining confidence in the control of the design process and that the approved design input information is actually used in the design. The GDA Step 4 review assessed the design process and this is detailed in Section 4.3.13 of Ref. 2.

46 The remnant concerns which were not fully addressed in the Step 4 assessment were that the ETC-C is an EPR™ specific design code: it is not applicable for general construction. It is not equivalent to a standard design code and needs to be read with the particular hypothesis notes for the building under examination. Its application by a designer unfamiliar with the design of this type of NPP would need much more detailed guidance than had been demonstrated.

47 Therefore, in parallel with the firming up of the UK CD clauses via resolution of **GI-UKEPR-CE-02**, an overarching hypothesis note for the nuclear safety class 1(C1) civil structures would be produced which would fully define all the design rules, methodologies

and the links between the AFCEN ETC-C 2010 and Eurocodes in a single document (Ref. 2, Section 4.3.13).

48 EDF and AREVA confirmed in response to letter EPR70349N (Ref. 41) that the Resolution Plan was based on a single document deliverable. Reference to other hypothesis notes was to the site specific documents which will be produced by the various design parties.

49 The new DPN (Ref. 36) forms a high level basis of design document for the UK EPR™ safety class 1 structures considered in the scope of GDA, i.e. the nuclear island. It also forms a platform for the individual building hypothesis notes at site specific phase. It has the following main sections.

- Scope of the generic design and design process
  - Key safety requirements of civil structures
  - Safety classification of civil structures
  - Structural philosophy of all buildings in GDA scope
  - Operating lifetime
  - Decommissioning principles
- Detailed design methodology
  - Implementation of safety requirements
  - Input design data
  - Detailed design steps

50 It includes summary descriptions of the structural philosophy for each building, key design input information, design principles and marshals the design codes and standards and design methodologies to be used. It makes a clear distinction between the generic process and the specific arrangements for FA3 which had been the basis of the Step 4 submission. Any reference to FA3 documents is given as an example, rather than as the exact methodology. The framework of roles and responsibilities for the different levels of organisations has also been clarified and made generic (refer to Section 4.2.2).

51 Information given provides an overall summary of the civil engineering design. Detailed information is referred out to the source document(s), which includes PCSR sub-chapters, codes and standards and EPR™ specific methodology documents. This avoids duplication and makes future updating of design criteria easier.

52 The safety classification of civil structures is carried out in accordance with PCSR Sub-chapter 3.2 Section 8 (Ref. 19) and methodology document NEPSF DC 557 Rev D (Ref. 44). Ref. 44 has been assessed for adequacy under resolution of GI-UKEPR-CC-01 and found to be satisfactory (Ref. 45). The DPN directs the designer to the methodology Ref. 44 and so fulfils its function as a marshalling document.

53 I am satisfied that the DPN (Ref. 36) comprises an overarching hypothesis document for the design of the C1 civil structures. It is the major underpinning reference for the civil engineering aspects of the PCSR, and summarises the overall basis of design for design contractors. However, the DPN must be a living document which is kept updated to truly summarise the civil engineering design as it progresses. This is in line with the principles of SAP SC.7. I therefore raise the following assessment finding.

AF-UKEPR-CE-84*: The licensee shall maintain the "EPR Nuclear Island Civil Engineering Design Process" document, or equivalent, as an overarching document summarising the civil engineering basis of design. This shall be the key document to signpost all the relevant specifications, methodologies and hypothesis notes for Class 1 civil structures. This document shall also form a key part of the Health and Safety File at all stages under the CDM Regulations 2007.*

Required Timescale: *Nuclear Island Safety Related Concrete.*

4.2.2 Roles and Responsibilities of Designers

54 Section 1.3 of the DPN Rev C defines the roles and responsibilities of the various design parties. These are similar to the organisational arrangements used for FA3, i.e. three levels of design responsibility which are as follows.

- Design Authority (DA) – within the licensee's organisation
- Responsible Designer (RD) – owns the processes to ensure design integrity and manages the civil works designer organisations.
- Civil Works Designer (CWD) - produces the detailed design: calculations and detail drawings to the contract technical specification instructed by the RD.

55 Section 2 "Detailed Design General Methodology" describes how the above parties interface and which party is responsible for production of the different levels of design hypothesis notes. The CWDs are responsible for the detailed design and work to the specification within the RD hypothesis notes (B hypothesis notes). The CWDs are also responsible for the technical adequacy of their work, and must alert the RD to any revisions required to the specification due to updates of codes and standards or current good practice. The CWDs are thus employed as specialists within their own field and must be competent.

56 The DPN states that "*where variations have been necessary to the original RD design intent, the hypotheses note A* [produced by the CWD] *shall clearly state what these differences are and provide justification for them. The RD shall also provide independent verification of these changes*." This therefore completes the circle of verification by requiring the RD to check any changes proposed by the CWD it its capacity as specialist designer.

57 I am satisfied that the DPN has clarified the design process management and is in line with the principles of SAPs FP.4, MS.1, MS.3 and SC.8.

58 The EDF-CNEN surveillance programme of subcontracted activities was assessed during Step 4 (Section 4.3.13 of Ref. 2) and so that aspect has not been revisited in the course of my assessment. However, it should be noted that the licensee and its Design Authority are still responsible for the adequacy of subcontracted design and the competency of its subcontractors.

4.2.3 Issue Action Comments

59 The Issue Action, **GI-UKEPR-CE-01.A1** listed 23 bullet points with specific comments on technical aspects. These had been identified during the GDA Step 4 review of the FA3 hypothesis notes for each building (Ref. 2). Therefore, some comments apply only to specific buildings or structures.

60 This section is a discussion of EDF and AREVA's responses to each of the 23 bullet points listed in **GI-UKEPR-CE-01**. They have been grouped together as comments where they refer to similar topics.

4.2.3.1 Comment 1

1) The document should be UK specific including definition of ground conditions, climatic conditions and the structural classification.

61 The current "EPR Nuclear Island Civil Engineering Design Process" note, Rev C (Ref. 36) is a major underpinning document to sub-chapter 3.3 of the GDA PCSR, which covers the design of category 1 civil structures for the UK EPR™. Section 2.2.1 of the DPN references UK legislation, regulations, codes and applicable standards to be used for the design of the UK EPR™, which makes the DPN more UK specific than the reference design hypothesis notes assessed during Step 4.

62 Section 2.2.3 of the DPN describes the technical input data required for detailed design. A table is given of the loads to be considered resulting from external hazards. It differentiates between the input data that is generic and that which needs to be decided on a site specific basis. For generic values, the PCSR sub-chapters 2.1 "Site Data Used in the Safety Analysis" (Ref. 16) and 13.1 "External Hazards Protection" (Ref. 15) are referenced, and a statement made that they are to be confirmed by site specific studies.

63 The generic analysis models for generating floor response spectra (FRS) considers six types of ground conditions as shown in Section 2.1.3 of PCSR Sub-chapter 13.1 (Ref. 15). Different analysis models are used for the generic design of the civil works (CW), and these are based on the site specific ground conditions for FA3. A range is considered: lower bound, best estimate and upper bound soil modulus for FA3. The site specific design will need to justify that the site ground conditions are bounded by these generic sites for both the FRS and the CW models. The methodologies for the seismic design are referenced in Section 2.2.7 of the DPN, and these have been assessed under **GI-UKEPR-CE-06** (Ref. 8). I am satisfied that these seismic design methodologies draw an adequate distinction between generic design requirements and site specific requirements.

64 The site geological and geotechnical data with respect to non-seismic effects such as settlement, slope stability and liquefaction are noted as site specific in the DPN table. The methodology for designing the nuclear island against these is given in Section 2.2.3.1 of the DPN, with reference to clauses in the AFCEN ETC-C 2010. Examples from the reference design have been submitted. However, FA3 is founded on a much harder site than typical in the UK, and so it is accepted that full settlement analysis etc will need to be recalculated for the site specific design.

65 The DPN describes the design approach to protection against extreme climatic conditions in Section 6. This section directs the designer to PCSR Sub-chapters 2.1 and 13.1 for specific generic values. Values for extreme external temperatures and wind blown missiles are well documented in Sub-chapter 13.1. Basic design values for wind and snow are given. Treatment of ice build up is stated as a site specific consideration.

66 The DPN has drawn together the various design values given in the different parts of the PCSR, which has fulfilled one of its purposes. The values given cannot be made more UK specific at this stage, until a site is chosen. The licensee must therefore derive hazard magnitudes on a site specific basis for all external hazards and compare directly with values used in the reference design.

67 Structural classification to UK building regulations is discussed in Section 2.2.1 of the DPN. Nuclear structures are Class 3 buildings under these regulations and so require a systematic risk assessment. The case is made in the DPN that the classification and safety case systems used for nuclear structures are more onerous than those required for

normal buildings, and hence this more than satisfies the UK building regulations. I concur that this meets regulatory expectations.

68 I am satisfied that this comment can be cleared on the basis that the Design Process Note marshals the generic design values that have been estimated but which will need to be compared with the site specific value once the site is known. Where the site specific design values are not bounded by the generic, further justification will be required at site specific phase. This satisfies SAPs ECE.5 and ECE.7.

4.2.3.2 Comment 2 – Design Life for Civil Structures

2) The overall design life needs to be clarified.

69 The values of design input data and construction detailing depend on the design life specified for a structure. During Step 4, the declared overall lifespan was given in Clause 1.1.2 of the AFCEN ETC-C 2010 (Ref. 33) as 65 years for all NI structures, based on 5 years construction +60 years assumed operational life +15 years decommissioning. ONR queried whether this equated to the structural design life and whether 65 years was sufficient for structures which may need to remain serviceable after the end of operation, such as the fuel building. The durability of concrete structures was also questioned.

70 EDF and AREVA's justification is given in Section 1.2.2 of Ref. 36. This clarifies that all NI structures will be designed for a design life of 65 years, with 75 years for the fuel building to allow for its operation past reactor shut down. The durability of reinforced concrete is detailed on a 100 year design life for the structural class in accordance with Eurocode 2 (Ref. 28). The durability of steel structures will be provided by corrosion protection and fatigue assessments for those subject to cyclic movement.

71 The justification for not having to consider the full 80 years as the design life is that the nuclear safety hazard is much reduced during the 15 year decommissioning period once the reactor has shut down. Also, the condition of the structures is appraised every 10 years so that the appropriate maintenance required is indentified.

72 I am satisfied that the durability of concrete structures is based on a 100 year design life. The design life of 65 years is acceptable for civil structures in general, since the load cases in the AFCEN ETC-C 2010 apply to conditions during construction, commissioning and reactor operation and these will be far greater than load cases occurring during decommissioning. The increased design life for the Fuel Building of 75 years applies to the loading applied and gives sufficient contingency for pools still storing fuel after reactor defueling. This approach is in line with SAPs EAD.1 and ECE.12.

4.2.3.3 Comments 3, 4, 5 and 21 – References

3) Extensive references are made to French legislation and decrees as well as standards, which are of no relevance in the UK.

4) The PSAR is constantly referred to.

5) A number of the key references have been superseded.

21) There are a large number of references to Règles Fondamentales de Sûreté (RFS) documents for derivation of loads. These have not been benchmarked against the UK expectations.

73 The DPN Rev C no longer refers to French legislation, but to the appropriate UK legislation and internationally recognised codes and standards.

74 The PSAR was a Flamanville 3 specific document called the Preliminary Safety Analyses Report which had a similar function to PCSRs in the UK. The DPN Rev C no longer refers to the PSAR, but to the PCSR.

75 The reference list given in the DPN Rev C has been updated to include the update revisions of the key underlying documents. The DPN is a signposting document and so some references which were in the March 2011 PCSR have been removed and inserted in the DPN.

76 I am satisfied that these comments can be closed.

4.2.3.4 Comment 6 – Dropped Loads

6) The document should reflect the latest position on load drops.

77 The design of civil structures to resist potential dropped loads has been assessed under GDA issue **GI-UKEPR-IH-01.A2**. The DPN Rev C includes dropped loads under internal hazards and refers to Chapter 13.2 of the PCSR (Ref. 17) for the generic definition. Section 2.2.7 of the DPN Rev C also refers the designer to the methodology for drop loads, ENGSGC100483 Rev B (Ref. 47).

78 The assessment of Ref. 47 has been carried out under GDA Issue **GI-UKEPR-CE-02** (Ref. 9) and it was found to provide satisfactory methods for assessing impact damage on civil structures from dropped loads. The schedule of internal hazards from potential dropped loads was assessed under the Internal Hazards topic area, GDA Issues **GI-UKEPR-IH-01** (Ref. 30) and **GI-UKEPR-IH-04** (Ref. 31)**.** The response to these issues provided bounding cases for dropped loads and internal missiles and these were found to be satisfactory for the definition of the generic design. The final internal hazards schedule will be compared against these bounding cases during the site specific phase. Therefore, definition of the input data for the detailed design of civil structures awaits the completion of this schedule. An assessment finding **(AF-UKEPR-CE-05)** was raised in the CEEH Step 4 report (Ref. 2) to capture this requirement.

79 The DPN points the designer to the dropped load methodology and to the internal hazard schedule and so I consider this a satisfactory response to this comment.

4.2.3.5 Comment 7 – Technical Repetition

7) There are details on load combinations and replication of aspects of the ETC-C 2006. This may not fully align with the 2010 version of ETC-C and the UK companion document requirements.

80 The DPN Rev C refers directly to the AFCEN ETC-C 2010 and its UK CD Rev E for the detailed technical clauses rather than repeating information.

81 I am satisfied this comment can be closed.

4.2.3.6 Comment 8 – UK Building Regulations

8) There are no apparent requirements to consider robustness or global stability of the NI structures in accordance with the UK Building Regulations Part A.

82 Section 2.2.1 of the DPN Rev C describes the approach to legislation, regulations, codes and applicable standards. This includes the UK Building Regulations (2010) and the Construction (Design and Management) Regulations 2007.

83 The section confirms that nuclear safety significant buildings would be considered as Class 3 buildings under the building regulations. Class 3 buildings require additional requirements to ensure robustness, stability against disproportionate collapse and should

have a systematic risk assessment performed. The UK EPR™ approach satisfies these requirements since it is based on a specific design against extreme loads.

84 I consider this section as a satisfactory response to this comment.

4.2.3.7 Comment 9 – CDM Regulations

9) There is no reference to the need to consider the CDM regulations.

85 Section 2.2.2 of the DPN Rev C describes the approach to the UK CDM Regulations. This clarifies the roles and responsibilities of the UK EPR™ design chain in terms of the CDM duties. The section also describes the similar process used in France for the Flamanville 3 NPP, which will support the UK EPR™ CDM assessment. The descriptions given provide confidence in EDF and AREVA's approach and that they recognise their duties under the CDM Regulations.

86 I consider this section as a satisfactory response to this comment.

4.2.3.8 Comments 10 and 18 – Structural Philosophy and Interfaces

10) The document lacks detail in a number of areas including structural philosophy, analysis methods, interfacing with adjacent structures etc.

18) There is no design guidance for the treatment of gaps between the NAB and SAB or Fuel Building.

87 The first submittal of the DPN included Section 1.2.3, Structural Philosophy. This was a very detailed description of the inner containment wall, but had one brief section for all other buildings. ONR commented (Ref. 41) that the latter needed to be expanded to give a more balanced document. The description was revised and the text submitted within Section 1.2.4 of the DPN Rev C satisfies regulatory expectations, with recognition that details will be given at site specific phase in the specific hypothesis notes for each structure.

88 The description of analysis methods was discussed at the Level 4 technical meeting on 26 January 2012 (Ref. 50). ONR commented that the DPN needed to an overview of the different analysis models and methods used for the different structural loadcases. For instance the hypothesis notes submitted under Step 4 were for the specific structures in the reference design, Flamanville 3, rather than for a truly generic design. The analysis methodology for the inner containment structure had been assessed during Step 4 by considering the hypothesis note for Flamanville 3, and further justified under **GI-UKEPR-CE-04.** Significant progress has also been made on definition of the seismic analysis methodology which has been revised under **GI-UKEPR-CE-06**, (Refs. 37, 38 and 39) and clarifies the generic analysis versus what needs to be done at site specific phase (Ref. 12). However, the analysis methodologies for the remaining structures needed to be summarised and the DPN was proposed as the most suitable document to do this.

89 Section 2.3 of the DPN Rev C gives descriptions of the overall analysis methods for reinforced concrete structures, inner containment, pools and steelwork structures. These descriptions are a guide to designers to signpost them to the input design data, codes and standards and UK EPR™ specific methodologies. I am satisfied that the DPN gives the level of detail required at GDA phase.

90 ONR queried during Step 4 how interfaces between structures were specified for the designer. This is particularly relevant for structures on different foundations, such as the Nuclear Auxiliaries Building (NAB) which will have a separate foundation to the NI. The parts of the NI adjacent to the NAB are the Fuel Building and the Safety Auxiliaries

Building 4 (SAB). Section 1.1.2 "Main Interfaces Between Structures" of the DPN Rev C gives a general description of what interfaces the designer must consider. I am satisfied that these are reasonable design considerations.

91 The isolation gaps between structures are described in Section 1.2.4 "Structural Philosophy" with Section 1.2.4.2 including that between the Fuel Building and the NAB. This is expanded in Section 2.2.6 "Interface Data" which states the design principle that "*gaps between structures must be sized to accommodate the predicted movements for simultaneous loadcases, with some additional margin*". The method for calculating the differential movement between structures, or interstorey drift, during an earthquake has been assessed under **GI-UKEPR-CE-06** and found to be satisfactory (Ref. 12). The calculation of movement between foundations is termed structure-soil-structure interaction. This is not considered at GDA Phase since the NAB is outside of GDA scope. An assessment finding **(AF-UKEPR-CE-020)** was raised in the Step 4 report (Ref. 2) to require the licensee to take due regard of the effects of structure-soil-structure interaction in the seismic analysis of the Class 1 and 2 structures.

92 EDF and AREVA's approach is that detailed design information shall be provided by the responsible designer to the civil work designers (CWD) through site specific hypotheses notes and associated load drawings, and this is stated in Section 2.2.6 of the DPN Rev C. The CWD then needs to confirm the actual size of isolation gap or joint required.

93 The filling of joints is specified in Clause 2.12 of the AFCEN ETC-C 2010 and states that these joints aim to "*avoid disturbances following either a temperature variation or a differential movement between two structures, or following vibrations, seismic tremors, shocks, etc.*" The clause then proceeds to specify how the joints should be detailed.

94 I am satisfied that the methodologies given in the DPN Rev C on structural philosophy, analysis methods and treatment of isolation joints between structures gives sufficient design guidance for the treatment of gaps between the NI and adjacent buildings such as the NAB. The exact magnitude of the gaps and the construction detail of the joint must be finalised at the detailed design phase.

4.2.3.9 Comments 11 and 12 - Seismic

11) The sections on the treatment of earthquakes and foundations are inconsistent with the latest methodologies.

12) The foundation conditions are limited to those of Flamanville.

95 The detail of the seismic methodologies has been submitted in response to GDA issue **GI-UKEPR-CE-06** and my assessment of them is given in ONR report ONR-GDA-12-002 (Ref. 12). The treatment of earthquakes and foundations as described in the DPN are now consistent with the seismic design methodologies (Refs. 37, 38 and 39). These methodologies are also primary references to the PCSR Sub-chapter 3.3 (Ref. 14).

96 The DPN is an overarching document and it states the approach for the site geological and geotechnical data in Section 2.2.3.1. The design of the NI foundation raft submitted during GDA is based on the reference design of Flamanville 3. However, the seismic analyses for generation of the generic floor response spectra have been undertaken considering a range of six soil types (Refer to Paragraph 63 of this report). Therefore, the foundation conditions not only include those of Flamanville 3, which is hard rock, but also include five softer soil sites. Similarly, the civil works analyses are based on a range of three ground conditions which are the lower bound, best estimate and upper bound of the soil modulus for FA3. This is an acceptable range of foundation conditions for the generic design.

97 EDF and AREVA have clarified the seismic design methodologies proposed for the UK EPR™ under **GI-UKEPR-CE-06** by differentiating between the generic parts of the foundation design and what is dependent on the ground conditions of the specific site. This has satisfactorily clarified what is included in the scope of GDA, and provides adequate methodologies for the detailed design analyses at site specific phase.

98 I consider this as a satisfactory response and regard these comments as closed.

4.2.3.10 Comment 13 – Equivalent Static Load Method

13) The use of an equivalent static load method for seismic cases is suggested, which is out with the requirements of ETC-C.

99 The reference design for FA3 used the equivalent static load method for certain structures to apply the earthquake load cases to the FE models. The justification for this was queried during Step 4, and has been investigated further under **GI-UKEPR-CE-02, GI-UKEPR-CE-04** and **GI-UKEPR-CE-06.** In order to satisfy my expectations, the following statement was added to Clause 1.A.10 bis of the UK Companion Document to AFCEN ETC-C 2010 (Ref. 34) which was assessed under **GI-UKEPR-CE-02.**

- *"A justification of the conservatism of this static approach shall be given, on a case-by-case basis*."

100 EDF and AREVA has confirmed in response to the other three GDA Issues that an equivalent static load method was used for FA3. If this method is used for any part of the UK EPR™ it will need to be justified on a case by case basis.

101 I consider this as a satisfactory response and regard this comment as closed.

4.2.3.11 Comment 14 – FE Models

14) The guidance on the construction of the finite element models for the structure is very weak without reference to other guidance.

102 The DPN Rev C (Ref. 36) provides a description of the design process of FE modelling for each of the structural groups identified; reinforced concrete structures, inner containment, pools and steelwork structures. This is a high level description and lists the aspects which the designers should consider. It describes the different global analyses and detailed analyses. I am satisfied that this is acceptable as a general design philosophy.

103 The detailed methodology for constructing the FE model for the inner containment has been the subject of **GI-UKEPR-CE-04**. My assessment of the EDF and AREVA response to this issue (Ref. 10) found that requirements for mesh sensitivity studies, boundary constraints, variation in material properties etc have been considered by EDF and AREVA in the design approach. The DPN gives the high level requirements for the FE modelling, whilst recognising that the models used for the detailed design will be justified at site specific phase. I consider this a satisfactory approach and demonstration that it will result in FE models which represent the building structures and loading adequately.

104 The DPN refers to the AFCEN ETC-C 2010 (Ref. 33) and the UK Companion Document (Ref. 34) for technical guidance on constructing FE Models. These documents have been assessed under **GI-UKEPR-CE-02** and I found them to be satisfactory guidance for the civil engineering design (Ref. 9).

105 The sections on FE analysis within PCSR Sub-chapter 3.3 (Ref. 14) have also been significantly revised, specifically to clarify the modelling process. This gives much clearer guidance of how the FE models have been constructed for the reference design, and how they interface with one another. This justification is satisfactory and is in line with SAP ECE.12.

106 I consider this as a satisfactory response and regard this comment as closed.

4.2.3.12 Comments 15 – Aeroplane Crash Scenarios

15) The treatment of APC scenarios is unclear.

107 Comment 15) was made with respect to potential accidental aeroplane impacts (also known as air plane crash or APC). The impacts considered under **GI-UKEPR-CE-01** are from general aircraft on the parts of the NI which are not within the aircraft protection shell. The treatment of these type of impacts was assessed during Step 4, and the resultant ONR query on the specifics of the computer analysis model was answered in letter EPR00838N (Ref. 35) towards the end of Step 4. Since Ref. 35 was not reviewed in detail at that time, the EDF and AREVA Resolution Plan (Ref. 3) stated that the DPN would include further clarification on general aviation.

108 The DPN Rev C describes the approach to aeroplane crash (APC) for the UK EPR™ in Section 2.2.3.3 under external hazards and under Section 2.3.2.4.3 for calculations. Ref. 35 gave the justification that the loading function curves given in the AFCEN ETC-C 2010 for accidental aircraft impact were suitable for the UK EPR™. The DPN has provided an overview of the aircraft impact analysis and refers to PCSR Sub-chapter 15.2 (Ref. 20) for the design criteria.

109 The justification given in Ref. 35 is satisfactory and confirms that the AFCEN ETC-C 2010 is an adequate specification for this load type. The DPN and the AFCEN ETC-C 2010 together provide sufficient guidance for the designer for the treatment of accidental aircraft scenarios on the NI outside the aircraft protection shell.

110 I consider the above as a satisfactory response and that it is in line with key SAPs ECE.1 and ECE.6. Therefore, this comment can be closed.

4.2.3.13 Comment 16 – Reactor Pit

16) It is stated that there is a requirement for the reactor vessel pit to be completely dry; however there is no further guidance on how this should be achieved.

111 This comment is a detailed one from Section 4.3.6.4 of the Step 4 Assessment Report (Ref. 2) on the Flamanville “Hypothesis Note on Reactor Building Containment Internals” (Ref. 46). The nuclear safety significance of why the reactor vessel pit needed to be “*completely dry*” had not been clarified sufficiently during Step 4 and so this was added to **GI-UKEPR-CE-01.**

112 EDF and AREVA has now provided additional clarification in the DPN Rev C, Section 1.2.4.2.3 “Reactor Building Other Structures”. This points to the PCSR Sub-chapter 6.2 (Ref. 18) for the safety requirements for the design of the reactor pit. It also describes the engineering features provided to achieve the dry pit as the concrete mix design for the sacrificial concrete lining to the pit and a seal ring to the top of the pit. A leak detection system is also provided to monitor the seal ring.

113 I consider this as a satisfactory response and regard this comment as closed.

4.2.3.14 Comment 17 - Accident Scenarios

17) For a number of the accident scenarios, the loading is not clearly defined; references are made to future work-scopes. This is the case for some reactor pit thermal loads, internal missiles, and pipework rupture.

114 Comment 17) refers to accident scenarios resulting from internal hazards. The loading on civil structures is defined in the Internal Hazards schedule, which has been assessed under the Internal Hazards topic area. EDF and AREVA have provided bounding cases for accident scenarios for internal missiles and pipework rupture in response to **GI-UKEPR-IH-01** (Ref. 30) and **GI-UKEPR-IH-04** (Ref. 31). These are satisfactory for justifying the limits of the generic design, and the site specific internal hazards schedule will be compared against these bounding cases. Therefore, future work scopes will be required to complete the civil engineering basis of design

115 The current Assessment Finding **AF-UKEPR-CE-05** in the Step 4 report, "*the licensee shall take account of any implications of the outcomes of the Internal Hazards GDA Issues which could affect the design of civil structures*" covers the ongoing assessment of civil structures in respect of loadings from internal hazards.

116 The reactor pit thermal loads are defined in PCSR Sub-chapter 6.2 (Ref. 18) which is referenced by the DPN Rev C. Therefore, the future site specific hypothesis notes B, which comprise the design specification from the Responsible Designer to the Civil Works Designer, will specify the exact thermal loads to be used for the design of the reactor pit structural concrete.

117 I consider the above as a satisfactory response to Comment 17) and is in line with key SAPs ECE.1 and ECE.6. Therefore, this comment can be closed.

4.2.3.15 Comments 19 and 22 - Foundation Settlement

19) There are a series of vague statements over the future monitoring of foundation movements and references to "current policy".

22) The document states that long term settlement does not need to be considered, which is seen as a shortfall.

118 The approach to the design of the foundation to control differential settlement is given in Section 2.2.3.1.3 Geotechnical Design Studies of the DPN Rev C. This confirms that settlement studies will be undertaken according to clause 1.9.1.3 of the AFCEN ETC-C 2010 . This clause covers the key principles of settlement analyses and refers to Eurocode 7 – Geotechnical Design (Ref. 29).

119 Section 2.2.3.1.3 of the DPN also states that the monitoring of settlements during construction and in the long term will be defined by the licensee based on the results of the settlement analyses.

120 I am satisfied with the above approaches, although no detail has been given to the design methodologies and EDF and AREVA maintain these will not be available until detailed design stage. In order to satisfy SAP ECE.24, I raise the following assessment finding.

> ***AF-UKEPR-CE-85****: The licensee shall justify the detailed methodologies for the settlement studies for the foundations of Class 1 civil structures and provide the resulting specification for settlement monitoring during construction and in the long term.*

Required Timescale: *Nuclear Island Safety Related Concrete.*

4.2.3.16 Comment 20 – Projecting Bars

20) The option for using projecting bars (bent down bars) in openings is allowed, this is not a practice which is generally permitted in the UK for nuclear structures.

121 This comment is a detailed one about the specification for using projecting bars being included in the Flamanville "Hypothesis Note on Reactor Building Containment Internals" (Ref. 45). The ONR queried this mainly because the use of these bars are not normally permitted in the UK nuclear industry, but also because it is more appropriate for the UK Companion Document to the AFCEN ETC-C 2010 to specify whether these bars can or cannot be used.

122 This was assessed under **GI-UKEPR-CE-02** (Ref. 9) and EDF and AREVA confirmed that Clause 2.4.5.3.3 of the AFCEN ETC-C 2010 (Ref. 33) limits the use of these bars as follows:

- *The re-straightening, even in part, of a bent reinforcement is not permitted except for reinforcements which have a certificate of conformity for re-straightening after bending, supplied by an approved and notified certification body.*

123 I consider this as a satisfactory response to this comment and so consider it closed.

4.2.3.17 Comment 23 – Leak-tight Floors

23) There is no detailed discussion on the need for some floor elements to essentially be leak-tight.

124 The structural philosophy for the civil structures is given in Section 1.2.4 of the DPN Rev C. Examples are given for various sumps, tanks and pools of the measures provided to achieve leak tight structures. Significant structures are detailed below.

125 The common raft has a requirement to be leak tight and the structural measures proposed are described in Section 1.2.4.2.1, as follows.

- Applying specific protective coatings in areas where there is potential for spillage of radioactive liquids, and a double layered stainless steel liner in sumps (example of details in Ref. [12]) which collect spillages of radioactive liquids.
- Limiting crack widths in accordance with the common raft structural class.
- Placing a membrane under the common foundation raft to protect the common raft concrete against groundwater. The membrane is not intended to serve as a final barrier against spills.

126 Therefore, the case made is that where there is potential for spillage of radioactive liquids the coatings or liners will be the primary protection to avoid leakage through concrete elements. Sumps will have double linings to provide secondary protection.

127 The Fuel Building is described in Section 1.2.4.2.4 of the DPN Rev C. Pool and tanks within the building are designed with a stainless steel liner to ensure leak tightness. The design and construction is in accordance with the Pool Liner Design Requirements and Methodology (Ref. 49) and this has been assessed under **GI-UKEPR-CE-02**.

128 I am therefore satisfied that the DPN provides a satisfactory discussion on the need for some floors and walls, to be leak tight.

4.2.4 Assessment Conclusions

129 I am satisfied that the final version of the "EPR Nuclear Island Civil Engineering Design Process" document, Rev C (Ref. 36) is a suitable overarching hypothesis document for GDA. It has clarified EDF and AREVA's organisation of the design process and the key roles and responsibilities without the need to mention the individual contractors. It brings together the civil engineering basis of design in one document and is suitable as a marshalling document for designers who are not necessarily familiar with the EPR™ design.

130 Ref. 36 has addressed each of the 23 specific points raised in action A1 of **GI-UKEPR-CE-01**. This is achieved mainly by providing high level description as a summary of the civil engineering design principles and cross referencing to sub-chapters of the PCSR or other technical supporting documents for detailed information.

131 The DPN should be seen as the starting point of the design process, and will need to be kept updated by the licensee **(AF-UKEPR-CE-84).**

5 INTERFACE OF GI-UKEPR-CE-01 WITH KEY DOCUMENTS

5.1 REVIEW OF THE PCSR

132 Information on the civil engineering design process presented for GDA Step 4 was contained in the March 2011 PCSR (Ref. 13) within Sub-chapter 3.3 Issue 03 – Design of Category 1 Civil Structures. The supporting technical information on loadings from external hazards was presented in Sub-chapters 2.1 (Ref. 16) and 13.1 (Ref. 15). The safety requirements for the reactor pit and corium spreading area were presented in Sub-Chapter 6.2 (Ref. 18).

133 The PCSR Sub-chapter 3.3 has needed revising due to the resolution of **GI-UKEPR-CE-01**, and was submitted at Issue 05 (Ref. 14) on 30 October 2012. The changes required include the following.

- Introduction of the new overarching document, the “EPR Nuclear Island Civil Engineering Design Process” document, ECEIG111110 Rev C (Ref. 24).
- Main references to ETC-C are to the AFCEN ETC-C 2010 (Ref. 33).
- Clarification of text: introduction and alignments with the "Generic UK" documents, such as the Design Process Note (DPN), such that the existing hypothesis/ methodology references can be removed from the PCSR.
- Sections on modelling of inner containment (2.3.3 and 2.4) have been re-ordered and re-titled as 2.3.3 and 2.3.4 to clarify the stages of modelling and what modelling has been done for the FA3 reference design.
- Text made consistent with the “FA3 specific" documents in the context of the GDA, which are included as examples of the FA3 EPR™ Reference Design (reference to FA3 route map document).

134 The other sub-chapters, namely 2.1, 6.2 and 13.1, have been updated since the March 2011 PCSR, however the changes required in response to **GI-UKEPR-CE-01** have been minor.

135 I am satisfied that the updates made to Sub-chapter 3.3 Issue 05 of the PCSR, along with the supporting reference documents, are sufficient to describe the civil engineering design process in the context of GDA. No changes have been required to the other sub-chapters relevant to civil engineering.

5.2 REVIEW OF UK CD TO THE ETC-C

136 The UK Companion Document Rev E (Ref. 34) comprises amended clauses from the AFCEN ETC-C 2010 (Ref. 33) for use for the UK EPR™. The UK CD therefore takes precedence over the ETC-C for the civil engineering works design.

137 No changes have been required to the UK CD for **GI-UKEPR-CE-01** since the DPN is an overarching document and the UK CD is a technical specification. However, the DPN now makes the hierarchy of civil engineering technical documents much clearer and directs the designer to the UK CD as the main technical specification.

5.3 INTERFACE WITH OTHER GDA ISSUES

138 Resolution of this issue has relied upon documents which are deliverables for other GDA Issues, as follows.

- UK Companion Document to the AFCEN ETC-C 2010 (Ref. 34) submitted under **GI-UKEPR-CE-02.**

- Specific clauses in the UK Companion Document which are relevant to **GI-UKEPR-CE-04.**
- Seismic methodology documents (Refs. 37, 38 and 39) submitted under **GI-UKEPR-CE-06.**

139 The specifics of my assessment of these deliverables with respect to each GDA issue are given in the relevant ONR assessment report (Ref. 9 to Ref. 12) which should be read in conjunction with this report.

6 ASSESSMENT FINDINGS

140 The following assessment findings, also listed in Annex 1, should be taken forward as normal regulatory business, in addition to those identified in the Step 4 Civil Engineering Assessment Report (Ref. 2).

6.1 ADDITIONAL ASSESSMENT FINDINGS FOR GI-UKEPR-CE-01

141 The following assessment findings have been raised for the resolution of **GI-UKEPR-CE-01 Rev 1.**

> ***AF-UKEPR-CE-84****: The licensee shall maintain the "EPR Nuclear Island Civil Engineering Design Process" document, or equivalent, as an overarching document summarising the civil engineering basis of design. This shall be the key document to signpost all the relevant specifications, methodologies and hypothesis notes for Class 1 civil structures. This document shall also form a key part of the Health and Safety File at all stages under the CDM Regulations 2007.*
>
> ***Required Timescale:*** *Nuclear Island Safety Related Concrete*
>
> ***AF-UKEPR-CE-85****: The licensee shall justify the detailed methodologies for the settlement studies for the foundations of Class 1 civil structures and provide the resulting specification for settlement monitoring during construction and in the long term.*
>
> ***Required Timescale:*** *Nuclear Island Safety Related Concrete*

6.2 IMPACTED STEP 4 ASSESSMENT FINDINGS

142 There are no impacted Step 4 findings for **GI-UKEPR-CE-01.**

7 ASSESSMENT CONCLUSIONS

143 I have assessed the document "EPR Nuclear Island Civil Engineering Design Process" note (DPN). I am satisfied that the final version of the DPN, Rev C (Ref. 36), provides a suitable overarching hypothesis document for GDA as required by GDA Issue **GI-UKEPR-CE-01**. It brings together the civil engineering basis of design in one document and is suitable as a marshalling document for designers at all levels of the design process.

144 The DPN gives summary descriptions of the design philosophy of the buildings within the GDA scope. It then describes the design process that is proposed for the UK EPR™. This includes EDF and AREVA's organisation of the design process and the key generic roles and responsibilities without naming the individual contractors which are likely to be different for the site specific phase. The DPN references the main civil engineering design codes and standards and the input data which was previously spread over various sub-chapters of the PCSR and other supporting documents. Generic methodologies which have been developed during GDA are also referenced as guidance to the designer.

145 Clarification is included for the impact assessment from general aviation. This is specifically for those parts of the nuclear island which are not protected by the aircraft shell structure.

146 The DPN refers to the methodology document for the classification of structures systems and components. This has been assessed separately under **GI-UKEPR-CC-01** and found to be satisfactory.

147 The DPN also addresses each of the 23 specific points raised in action A1 of **GI-UKEPR-CE-01**. This is achieved mainly by providing high level description as a summary of the civil engineering design principles and cross referencing to sub-chapters of the PCSR or other technical supporting documents for detailed information.

148 It should be seen as the starting point of the design process, and should be maintained by the licensee as a key specification document. This is required by the Assessment Finding **AF-UKEPR-CE-84**. The design process for calculating settlement of Class 1 civil structures needs to be confirmed and justified for the site specific strata. This is required by the Assessment Finding **AF-UKEPR-CE-85.**

149 My assessment of the evidence presented, taken in conjunction with the findings of my assessment for **GI-UKEPR-CE-02, GI-UKEPR-CE-04** and **GI-UKEPR-CE-06** (Refs. 9, 10 and 12), has confirmed that there is sufficient specification for the detailed design of the UK EPR™ in the context of GDA. It has also confirmed what information must be verified at site specific stage.

150 I therefore conclude that **GI-UKEPR-CE-01** can be closed.

8 REFERENCES

Ref.	Document
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2	*Step 4 Civil Engineering and External Hazards Assessment of the EDF and AREVA UK EPR™ Reactor*. ONR Assessment Report ONR-GDA-AR-11-018 Revision 0, December 2011. TRIM Ref. 2010/581513.
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6	*GDA Issue GI-UKEPR-CE-04 Revision 1, Containment Analysis.* Office for Nuclear Regulation, July 2011. TRIM Ref. 2011/385291.
7	*GDA Issue GI-UKEPR-CE-05 Revision 1, Reliability Of The ETC-C.* Office for Nuclear Regulation, July 2011. TRIM Ref. 2011/385292.
8	*GDA Issue GI-UKEPR-CE-06 Revision 1, Seismic Analysis Methodology.* Office for Nuclear Regulation, July 2011. TRIM Ref. 2011/385293.
9	*GDA Close-out for the EDF and AREVA UK EPR™ Reactor – GDA Issue GI-UKEPR-CE-02 Revision 1 – Use of the ETC-C.* ONR Assessment Report ONR-GDA-AR-12-004, Revision 0, TRIM Ref: 2012/4.
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17	*UK EPR™ PCSR – Sub-chapter 13.2 – Internal Hazards Protection,* UKEPR-0002-132 Issue 05. EDF and AREVA. October 2012. TRIM Ref. 2012/425734

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Ref. Document

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Table 1: Relevant SAPs Considered for Close-out of GI-UKEPR-CE-01 Rev 1

SAP No.	SAP Title	Description
FP.4	Fundamental principles Safety assessment	*The dutyholder must demonstrate effective understanding of the hazards and their control for a nuclear site or facility through a comprehensive and systematic process of safety assessment.*
MS.1	Leadership and management for safety Leadership	*Directors, managers and leaders at all levels should focus the organisation on achieving and sustaining high standards of safety and on delivering the characteristics of a high reliability organisation.*
MS.3	Leadership and management for safety Decision making	*Decisions at all levels that affect safety should be rational, objective, transparent and prudent.*
SC.7	The regulatory assessment of safety cases Safety case maintenance	*A safety case should be actively maintained throughout each of the life-cycle stages.*
SC.8	The regulatory assessment of safety cases Safety case ownership	*Ownership of the safety case should reside within the dutyholder's organisation with those who have direct responsibility for safety.*
EAD.1	Engineering principles Ageing and degradation	*The safe working life of structures, systems and components that are important to safety should be evaluated and defined at the design stage.*
ECE.1	Engineering principles Civil Engineering	*The required safety functional performance of the civil engineering structures under normal operating and fault conditions should be specified.*

Table 1: Relevant SAPs Considered for Close-out of GI-UKEPR-CE-01 Rev 1

SAP No.	SAP Title	Description
ECE.5	Engineering principles Civil engineering: investigations	*The design of foundations should utilise information derived from geotechnical site investigation.*
ECE.6	Engineering principles Civil engineering: design	*For safety-related structures, load development and a schedule of load combinations within the design basis together with their frequency should be used as the basis for the design against operating, testing and fault conditions.*
ECE.7	Engineering principles Civil engineering: design	*The foundations should be designed to support the structural loadings specified for normal operation and fault conditions.*
ECE.12	Engineering principles Civil engineering: structural analysis and model testing	*Structural analysis or model testing should be carried out to support the design and should demonstrate that the structure can fulfil its safety functional requirements over the lifetime of the facility.*
ECE.24	Engineering principles Civil Engineering: in-service inspection and testing	*There should be arrangements to monitor foundation settlement of major facilities during and after construction, and the information should be fed back into design reviews.*

Annex 1

GDA Assessment Findings Arising from GDA Close-out for GDA Issue GI-UKEPR-CE-01 Rev 1

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UKEPR-CE-84	The licensee shall maintain the "EPR Nuclear Island Civil Engineering Design Process" document, or equivalent, as an overarching document summarising the civil engineering basis of design. This shall be the key document to signpost all the relevant specifications, methodologies and hypothesis notes for Class 1 civil structures. This document shall also form a key part of the Health and Safety File at all stages under the CDM Regulations 2007.	*Nuclear Island Safety Related Concrete*
AF-UKEPR-CE-85	The licensee shall justify the detailed methodologies for the settlement studies for the foundations of Class 1 civil structures and provide the resulting specification for settlement monitoring during construction and in the long term.	*Nuclear Island Safety Related Concrete*

Note: It is the responsibility of the licensees / operators to have adequate arrangements to address the assessment findings. Future licensees / operators can adopt alternative means to those indicated in the findings which give an equivalent level of safety.

For assessment findings relevant to the operational phase of the reactor, the licensees / operators must adequately address the findings during the operational phase. For other assessment findings, it is the regulators' expectation that the findings are adequately addressed no later than the milestones indicated above.

Annex 2

EDF AND AREVA UK EPR™ GENERIC DESIGN ASSESSMENT

GDA ISSUE

HYPOTHESIS AND METHODOLOGY NOTES FOR CLASS 1 STRUCTURES

GI-UKEPR-CE-01 REVISION 1

Technical Area	**CIVIL ENGINEERING**		
Related Technical Areas	None		
GDA Issue Reference	**GI-UKEPR-CE-01**	**GDA Issue Action Reference**	**GI-UKEPR-CE-01.A1**
GDA Issue	The specification, methodology and hypothesis notes for Class 1 civil structures have not been found to be fully adequate for use in the design of the UKEPR.		
GDA Issue Action	ONR raised concerns over the use of ETC-C as a design code in Step 3 of GDA. One key point raised in the response was that ETC-C needs to be read with the particular hypothesis notes for the building under examination. Hypothesis notes are typically prepared at three levels, the highest level by EDF (CNEN), the second level by Sofinel, and the third and most detailed level by the individual design teams for the building in question. A revised hypothesis note(s) for the Nuclear Island, Safety Auxiliaries Building, Fuel Building, Nuclear Auxiliaries Building, Reactor Building, and the Diesel Building structures shall be produced. The following areas of concern need to be addressed in the revised document: • The document should be UK specific including definition of ground conditions, climatic conditions and the structural classification. • The overall design life needs to be clarified. • Extensive references are made to French legislation and decrees as well as standards, which are of no relevance in the UK • The PSAR is constantly referred to. • A number of the key references have been superseded. • The document should reflect the latest position on load drops. • There are details on load combinations and replication of aspects of the ETC-C. This may not fully align with the 2010 version of ETC-C and the UK companion document requirements. • There are no apparent requirements to consider robustness or global stability of the NI structures in accordance with the UK Building regulations part A. • There is no reference to the need to consider the CDM regulations. • The document lacks detail in a number of areas including structural philosophy, analysis methods, interfacing with adjacent structures etc. • The sections on the treatment of earthquakes and foundations are inconsistent with the latest methodologies. • The foundation conditions are limited to those of Flamanville. • The use of an equivalent static load method for seismic cases is suggested, which is out with the requirements of ETC-C. • The guidance on the construction of the finite element models for the structure are very weak without reference to other guidance.		

Annex 2

EDF AND AREVA UK EPR™ GENERIC DESIGN ASSESSMENT

GDA ISSUE

HYPOTHESIS AND METHODOLOGY NOTES FOR CLASS 1 STRUCTURES

GI-UKEPR-CE-01 REVISION 1

Technical Area		**CIVIL ENGINEERING**	
Related Technical Areas		None	
GDA Issue Reference	**GI-UKEPR-CE-01**	**GDA Issue Action Reference**	**GI-UKEPR-CE-01.A1**
	• The treatment of APC scenarios is unclear. • It is stated that there is a requirement for the reactor vessel pit to be completely dry, however there is no further guidance on how this should be achieved. • For a number of the accident scenarios, the loading is not clearly defined; references are made to future work-scopes. This is the case for some reactor pit thermal loads, internal missiles, and pipework rupture. • There is no design guidance for the treatment of gaps between the NAB and SAB or Fuel Building. • There are a series of vague statements over the future monitoring of foundation movements and references to “current policy”. • The option for using projecting bars (bent down bars) in openings is allowed, this is not a practice which is generally permitted in the UK for Nuclear structures. • There are a large number of references to Règles Fondamentales de Sûreté (RFS) documents for derivation of loads. These have not been benchmarked against the UK expectations. • The document states that long term settlement does not need to be considered, which is seen as a shortfall. • There is no detailed discussion on the need for some floor elements to essentially be leak-tight. With agreement from the Regulator this action may be completed by alternative means.		