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REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0009
RO Title:	Geotechnical Design Parameters
Technical Area(s)	Civil Engineering
Revision:	Rev 0
Overall RO Closure Date (Planned):	31/12/2020
Linked RQ(s)	RQ-UKHPR1000-0096
Linked RO(s)	---
Related Technical Area(s)	5. Conventional Health & Safety 8. External Hazards 21. Environmental
Other Related Documentation	---
Scope of Work	
<p><u>Background</u></p> <p>The UK HPR1000 design reference plant, Fangchenggang Unit 3 (FCG3), currently under construction in China, is located on a hard rock site; as such this will be reflected in the design of the civil structures. The Office for Nuclear Regulation (UK) (ONR) expect that the significance of differences between ground conditions at the FCG3 site and potential UK sites can be suitably considered by the Requesting Party (RP). Furthermore, the unique challenge posed by the London Clay at the Bradwell ‘B’ site also can be adequately reflected in the generic design of the UK HPR1000.</p> <p>ONR raised Regulatory Query RQ-UKHPR1000-0096 (Ref. 1) during GDA Step 2 and queried the ground bearing capacity quoted in the document Generic Site Report Rev.000 (Ref. 2). The RP’s response to RQ-UKHPR1000-0096 committed to address the issue in the updated Generic Site Report, at the end of Step 2 of GDA.</p> <p>Following a review of the updated Generic Site Report Rev.001 (Ref. 3), ONR found that the geotechnical parameters stated in RQ-UKHPR1000-0096 (Ref. 1) have not been adequately addressed. The soil bearing capacity selected to represent generic site soil properties is based on a Eurocode-specific approach, using a narrow field of parameters and assumptions which are not representative of a generic UK site, nor the Bradwell ‘B’ site. In addition, the compatibility of this Eurocode approach with the selected design codes for the UK HPR1000 has not yet been demonstrated by RP.</p> <p>In addition, the response to RQ-UKHPR1000-0096 (Ref. 1) states that the “intention [of the Generic</p>	

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Site Report] is to derive a soil bearing capacity that is more specific to the Bradwell area, so it is not intended to envelope any other potential EN6 sites”. The updated Generic Site Report Rev. 001 (Ref. 3), under Section 7.3.1 – Soil Bearing Capacity states “the potential candidate sites in the UK vary in geology from soil to rock, therefore a value for the UK HPR1000 Generic Site Envelope has been chosen using reference data to envelope the parameters”. It is unclear to ONR what is being presented due to these contradicting statements.

In summary, ONR think the currently selected geotechnical design parameters in Generic Site Report Rev.001 (Ref. 3) are not suitable to demonstrate that the plant is deployable in the UK, nor at the Bradwell ‘B’ site. ONR’s concern is how the parameters defined in the generic site envelope are going to be used to demonstrate, during GDA, that the UK HPR1000 is deployable in the UK. In order to address RO-UKHPR1000-0009 and to achieve ONR’s expectations, some actions are made to demonstrate the UK HPR1000 is deployable in the UK step by step. The work to address each action of the RO is detailed below.

Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
CGN	China General Nuclear Power Corporation
FCG3	Fangchenggang Nuclear Power Plant Unit 3
GDA	Generic Design Assessment
GNS	General Nuclear System Limited
GSR	Generic Site Report
ONR	Office for Nuclear Regulation (UK)
PCSR	Pre-Construction Safety Report
RO	Regulatory Observation
RQ	Regulatory Query
SSC	Structures, Systems and Components
UK HPR1000	UK Version of the Hua-long Pressurised Reactor

Scope of work

RP will address the Regulators’ observations (RO) on the geotechnical design parameters. For UK Version of the Hua-long Pressurised Reactor (UK HPR1000), the Generic Design Assessment (GDA) will be decoupled with BRB Project. As for GDA, a series of values of geotechnical parameters will be defined correlated to the declared shear wave velocity range in the *Generic Site Report (GSR) Rev. 001* (Ref. 3), including the stiffness and the allowable bearing capacity. Then, the civil engineering team will analyze the soil/structure system with the stiffness, check if the allowable bearing capacity is respected and calculate the response in terms of differential settlement and inclination. The Structures, Systems and Components (SSCs) team will present a solution to show that the differential settlement and inclination are capable of being accommodated.

RP will also make a commitment in the response of the RO to implement a design management

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procedure for adoption in the site licensing design for a system that will accommodate the structural response in terms of differential settlement and inclination and in accordance with the As Low As Reasonably Practicable (ALARP) principle.

In order to reply this RO, RP will update the report *Generic Design Parameters for Civil Engineering* and the *Raft Foundation Analysis and Design Method Statement* in GDA step 3. The structural analysis and design report for common raft buildings will be submitted before entering into step 4. Two new supporting documents about the differential settlement and inclination calculation and influence assessment will be submitted in GDA step 4.

Meanwhile, RP will also clearly state the RO expectations which should be out of the GDA scope.

Deliverable Description

RO-UKHPR1000-0009. Action 1 –Scope of Geotechnical Design Parameters in GDA

The RO action 1 states that:

In response to this Regulatory Observation Action, GNS should:

- *Identify explicitly whether the geotechnical parameters specified in the Generic Site Report cover the full range of candidate sites (i.e. soil to rock) or solely Bradwell ‘B’ (i.e. London Clay).*
- *Provide a scope and programme for work to be undertaken during GDA which will demonstrate that the UK HPR1000 is deployable on UK sites, and specifically Bradwell ‘B’, using the geotechnical parameters specified in the Generic Site Report.*
- *Provide an indicative scope of post GDA work that will demonstrate if the site specific geotechnical parameters are enveloped by the parameters specified in the Generic Site Report. This should describe how site specific geotechnical parameters will be determined and the subsequent comparison exercise that will be undertaken against the GDA Pre-Construction Safety Report (PCSR) and supporting documents.*

Resolution Plan

a) Identification of the geotechnical parameters

For this action, the submitted document *Generic Site Report Rev. 001* (Ref. 3) and *Generic Design Parameters for Civil Engineering Rev. A* have some relevant information. RP has already realized the significance of differences between ground conditions at the FCG3 site and potential UK sites. The geotechnical parameters of the soft, medium and hard sites condition are considered.

b) The scope and programme of the suitability study in GDA

For UK HPR1000, the GDA will be decoupled with BRB Project. RP acknowledges that there are still some gaps between the delivered submissions and regulatory expectations. Therefore, RP will update the document *Generic Design Parameters for Civil Engineering Rev. A* to respond to this

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action. The geotechnical parameters for civil engineering calculation, including bearing capacity and modulus, will be derived based on the values of shear wave velocity. The background and the detailed calculation process for these specified geotechnical parameters will be introduced comprehensively in the updated report.

c) The scope of suitability study in post-GDA

The suitability study in post-GDA is closely related to the specified site condition and belongs to site licence phase.

RO-UKHPR1000-0009.Action 2–Methodology for Use of Geotechnical Design Parameters

The RO action states that:

In response to this Regulatory Observation Action, GNS should:

- *Explain how geotechnical parameters specified in the Generic Site Report will be used during GDA to support the Civil Engineering safety case and show that they are sufficiently bounding.*
- *Develop a series of methodologies and supporting assumptions that will demonstrate how the geotechnical design parameters specified in the Generic Site Report will be used to demonstrate the deployment of the UK HPR1000 on a UK site. This should support all technical areas affected by geotechnical design parameters, including, but not limited to:*
 - *Justification for proposed nuclear island foundation and other principal structures;*
 - *Global stability of civil structures;*
 - *Deformation and settlement;*
 - *Bearing capacity;*
 - *Slope stability; and*
 - *Potential implications on construction.*
- *Develop methodologies which state how the specified geotechnical design parameters in the Generic Site Report will be used to support GDA work. Where outputs from different codes and standards are being compared, values should be justified and their mutual compatibility demonstrated as per the ONR SAPs.*
- *Develop methodologies which identify anticipated safety margins and for areas where it is likely that these margins are unable to be achieved, identify available suitable ground remedial measures or improvement techniques.*
- *Clarify how assumptions made on the site specific parameters will be checked during post-GDA work to demonstrate that the site specific design is bound by the generic site envelope.*

Resolution Plan

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a) The strategy for UK HPR1000 civil engineering design

The relevant reports have already prepared to be submitted to ONR before entering into step 4. But there are still some actions in order to satisfy the expectation of ONR.

- The document *Generic Design Parameters for Civil Engineering Rev. A* will be updated. The series of values of geotechnical parameters which are used in civil engineering design will be defined correlated to the declared shear wave velocity range in the updated version, including the stiffness and the allowable bearing capacity.
- The design and analysis for the buildings and the common raft will be conducted based on those developed geotechnical parameters. These documents will be submitted to ONR as planned.
- The document *The Inclination and Differential Settlement for the Nuclear Island Buildings* will be added in the submission list. The response in terms of differential settlement and inclination will also be developed and provided in the report. This report will be submitted in step 4.
- The assessment report *The Credible Solution for Equipment and System of UK HPR1000* will be developed by SSCs team. The preliminary assessment will be carried out to show that whether the differential settlement and inclination are capable of being accommodated and provide indicative solutions for SSCs. This report will be submitted in step 4.
- RP will implement a design management procedure for adoption in the site licensing design for a system that will accommodate the structural response in terms of differential settlement and inclination and in accordance with the ALARP principle.

b) The methodologies and supporting assumptions on demonstration of the deployment of the UK HPR1000

These documents *Structural Analysis and Design Method Statement*, *Overall Seismic Analysis Method Statement* and *Raft Foundation Analysis and Design Method Statement* have already been submitted in step 2. Some relevant information have already introduced in these documents. The methodology about the justification for proposed nuclear island foundation and other principal structures are introduced in the reports *Structural Analysis and Design Method Statement* and *Overall Seismic Analysis Method Statement*. The methodology about global stability of civil structures is stated in *Raft Foundation Analysis and Design Method Statement*.

The methodology for settlement calculation will be added in the updated version of *Raft Foundation Analysis and Design Method Statement*, and will be submitted in step 3.

The methodology about slope stability and potential implications on construction which are related to the specified site condition will be discussed in the site licence phase.

c) The methodologies on how to use the geotechnical parameters to support the GDA work

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The background and the detailed calculation process for some specified geotechnical parameters will be introduced comprehensively in the updated version for *Generic Design Parameters for Civil Engineering*. The methodologies on how to use the geotechnical parameters will be presented in the updated version of *Raft Foundation Analysis and Design Method Statement*, including the compliance study for different codes and standards (if different codes and standards are adopted).

d) The methodologies to identify anticipated safety margins

The methodology reports will identify anticipated safety margins during UK HPR1000 design. If these margins are unable to be achieved in specified site, the available ground remedial measures or improvement techniques will be considered according to the specified site condition, and these studies will be carried out in the site licence phase.

e) The suitability study for potential site during post-GDA

The suitability study for potential site will be carried out based on specified site condition, which is out of GDA scope.

RO-UKHPR1000-0009.Action 3 –Demonstration of Suitability of Geotechnical Design Parameters

The RO action states that:

In response to this Regulatory Observation Action, GNS should:

- *Provide sufficient evidence on the output of the work identified in response to Actions 1 and 2 above. The evidence should suitably demonstrate that challenges relating to ground conditions, posed by the deployment of the facility on a UK site, have been suitably addressed by the UK HPR1000.*

Resolution Plan

A series of values of geotechnical parameters will be defined correlated to the declared shear wave velocity range in the *Generic Site Report Rev. 001* (Ref. 3), including the stiffness and the allowable bearing capacity. Then, the civil engineering team will analyze the soil/structure system with the stiffness, check if the allowable bearing capacity is respected and calculate the response in terms of differential settlement and inclination. The SSCs team will present a solution to show that the differential settlement and inclination are capable of being accommodated.

The anticipated timescale to publish these documents is given in Appendix A.

Impact on the GDA Submissions

The following supporting submission documents will be involved in this RO.

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GDA Submission Document	Related ROAs	Planned schedule for submission
Generic design parameters for civil engineering(Rev. C)	ROA1	31 st August 2019
Raft foundation analysis and design method statement (Rev. C)	ROA2	23 th September 2020
Structural analysis and design report for BFX(Rev. A)	ROA2	28 th February 2020
Structural analysis and design report for common raft foundation(Rev. A)	ROA2	28 th February 2020
Structural analysis and design report for Structural analysis and design report for internal containment (Rev. A)	ROA2	30 th April 2020
The inclination and differential settlement for the nuclear island buildings(Rev. A)	ROA2	30 th June 2020
The credible solution for equipment and system of UK HPR1000(Rev. A)	ROA2	31 th October 2020
Timetable and Milestone Programme Leading to the Deliverables		
See attached Gantt Chart in APPENDIX A.		
Reference		
<p>[1] RQ-UKHPR1000-0096, Ground Bearing Capacity in Generic Site Report, 25 June 2018 - Full Response; TRIM 2018/208136.</p> <p>[2] GNS, UK HPR1000 Generic Site Report, HPR-GDA-REPO-0015, Rev: 000, 2017.</p> <p>[3] GNS, UK HPR1000 Generic Site Report, HPR-GDA-REPO-0015, Rev: 001, 2018.</p>		

