Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Aug 2024

Project Reference Number

NIA2_NGET0073

Project Registration

Project Title

Graphene Enhanced Maturity Site Trials and Optimal Network Evaluation (GEMSTONE)

Project Reference Number

NIA2_NGET0073

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2024

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Muhammad Shaban

Project Budget

£384,475.00

Summary

n alignment with National Grid Electricity Transmission's (NGET's) objectives of achieving net-zero construction, we aim to evaluate the suitability of polymer concretes as a sustainable alternative to traditional concrete for NGET's construction operations, appraise their readiness for construction trials, and support NGET in undertaking some of the required trials to demonstrate these materials' suitability. Two distinct stages are proposed, separated by a decision gate to give NGET control as the project progresses. During the initial stage, a review of polymer concrete material technology is undertaken to allow for the identification of use cases; the evaluation of the potential benefits, opportunities, risks, and constraints; and to assess the materials' readiness for construction trials. In the second stage, we will support a series of construction trials.

Nominated Contact Email Address(es)

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Problem Being Solved

Concrete industry produces 8% of global carbon dioxide emission making it the most polluting material used globally. Concrete accounts for 25% of the embodied carbon of construction in the UK. In addition to emission issue, concrete has material inefficiencies and produces large amount of waste. Mixing and pouring of concrete is a labour-intensive process and has been a core of health and safety issues. National Grid (NG) has planned to do BIG WORK in the network in expanding and upgrading the existing network requiring more than ever construction opportunities. NG has challenge of how to use concrete when it is such a significant source of greenhouse gas emissions (GHG). NGET has committed to reduce carbon emissions as much as is feasibly possible, to deliver net zero construction by 2026. NGET use Ordinary Portland Cement (OPC) for construction activities and production of OPC is a carbon intensive process which accounts for a significant portion of global CO2 emissions.

To help achieve the net zero goal, there is an incentive to reduce the carbon footprint of construction materials through the adoption of concrete alternatives, in which some or all the OPC is replaced with another material. Concrete alternatives may also offer faster curing times than OPC which provide significant operational advantages during time-critical repair or construction projects, such as

those taking place during outages.

Method(s)

During the initial stage, a review of polymer concrete material technology will be undertaken to allow for identification of usage cases, potential benefits, and readiness for construction trials, including:

- Literature review of the current state of knowledge, trends, challenges, and opportunities in utilising polymer concretes as alternatives to traditional concretes in full-scale construction applications.
- Qualitative comparison of the material's carbon footprint compared to that of OPC.
Identification/selection of two use cases for polymer concrete based on NGET's operational requirements.
- Cost-benefit analysis to assess the economic viability of adopting polymer concrete for the usage cases.
- Technology readiness review and a summary of key challenges to resolve for deployment of polymer concrete, including readiness for construction trials.

If viable use cases are identified, the second stage will undertake a series of construction trials. This includes:

- Selection of a suitable polymer concrete product.
- Development of a trial's methodology and assessment criteria.
- Execution of the trials and testing.
- Evaluation with reference to the usage cases defined in the first stage.

Scope

Polymer concretes are a family of composite materials in which the OPC is fully replaced with a polymer binder/liquid resin. For NGET, polymer concrete could be advantageous in specific cases where its increased cost may be outweighed by its superior material properties and/or the need for rapid setting (i.e., during outage work). The emergence of polymer concretes utilising recycled plastics may help to reduce their costs and contribute to towards sustainability targets by aligning with the growing emphasis on circular economy principles within the construction industry. Barriers to the widespread adoption of polymer concretes include increased cost, lack of standardisation, perception of complexity and conservative approaches within the construction industry. Studies of polymer concrete have tended to concentrate on its properties, however, there is a gap in published literature on the economic, environmental, logistical, and practical considerations related to on-site production and scalability. This project will assess the maturity of polymer concrete and evaluate its suitability for NGET's industrial applications via a series of desktop studies and site-based materials trials. The first stage of the project is a technology review into the opportunities and barriers associated with polymer concretes (as outlined above). The aim of this is to understand its potential suitability for replacing OPC in NGET's current OPC use cases. If the material demonstrates sufficient merit as a potential replacement technology, then a series of trials will be undertaken in the second stage to further assess and demonstrate the material's viability.

Final report will be published with all the learning outcomes and will be shared with all the licensees. A dissemination event will present all the results to relevant stakeholders with the recommendations of certain technologies ready to use in business as usual (BAU).

Objective(s)

The work will be delivered in discrete work packages each with a focus on different objectives linked to the overall aim to explore polymer concrete. This project is planned to take 24 months with the following major objectives:

- Develop understanding of the polymer concrete material technology to allow for identification of usage cases, potential benefits, and readiness for construction trials.
- Technology review to summarise the current state of knowledge, trends, challenges, and opportunities in utilising polymer concretes as alternatives in full-scale construction applications.
- Define a Project Mission Statement (PMS), recognising the relative novelty of polymer concretes.
- Review of current design codes and approaches to explore how they might be applied in the design of polymer concrete structures.
- Final recommendations to identify the potential benefits and implementation learning outcome.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

NGET has committed to reduce carbon emissions as much as is feasibly possible, to deliver net zero construction by 2026. To help achieve the net zero goal, there is an incentive to reduce the carbon footprint of construction materials through the adoption of new materials or existing materials deployed in novel ways. Production of Ordinary Portland Cement (OPC) is a carbon intensive process which accounts for a significant portion of global CO2 emissions. The carbon footprint of concrete can be reduced using cement replacements, in which some or all of the OPC binder is substituted for another material. Given that OPC is the most widely used construction material, the adoption of cement replacements presents a significant opportunity to progress towards NGET's net zero

construction target.

NGET is keen in exploring the use of concrete alternatives which may offer faster curing times than OPC. Such materials may be advantageous during time-critical repair or construction projects, such as those taking place during outages. Polymer concretes, which emerged in the late 1950s, are a family of composite materials in which the OPC is fully replaced with a polymer binder/liquid resin. Polymer binders typically utilise either polyester, epoxy or vinylester resins, with the choice dependent on cost and desired properties. In general, polymer concretes may offer certain performance advantages over OPC, such as faster curing times (75% of full strength can be achieved in one day of room temperature curing) and significantly higher mechanical strength (up to 5x greater than OPC, which may enable decreases in material consumption through reduction of section sizes).

Polymer concretes have found applications in specialist use cases such as repair work, precast components, and thin overlays. However, their widespread adoption has historically been limited by the relatively high cost of the polymer and hardener. Further challenges to their adoption include their absence from design codes and standards, together with logistical and supply chain considerations and recyclability.

For NGET, polymer concrete could be advantageous in specific cases where its increased cost may be outweighed by its superior material properties and/or the need for rapid setting (i.e. during outage work). Furthermore, the emergence of newer polymer concretes based on recycled plastics may help to reduce cost and contribute to towards sustainability targets by aligning with the growing emphasis on circular economy principles within the construction industry. Numerous previous studies of polymer concrete have concentrated on its properties, resulting in a well-documented understanding of its material performance. However, existing literature has given less focus to the economic, environmental, logistical, and practical considerations related to on-site production. To address this knowledge gap, this project aims to assess the maturity level of polymer concrete and evaluate its suitability for NGET's industrial applications.

This project ensures that NGET and the UK energy industry are at the forefront of global developments in asset management of transmission system, enabling the industry to make decisions that could reduce the carbon emissions and thus reduce OPEX expenditure and are supported by comprehensive research and experiments. The scale of substation development in terms of installation of assets requiring foundations is unprecedented and there is a concern that the understanding around low carbon concrete and its trials is not mature enough for future decisions. With the access to the latest development in the field, NGET will be able to manage the assets more efficiently and effectively which could deliver savings. Furthermore, the leveraged funding mechanism ensures that expensive research can be carried out at subsidised rates, thereby ensuring the best value for consumers' money. The project will not restrict benefits delivered to vulnerable consumers based on any vulnerability class.

Success Criteria

The project will be considered successful if the objectives are achieved, specifically:

- An overview of the study methodology.
- Overview of polymer concrete's key characteristics and material properties.
- Summary of identified use cases and results of the stakeholder engagement to agree selection of two of these for further study.
- Technology readiness level findings and a summary of key challenges to resolve for deployment of polymer concrete, including readiness for construction trials.
- Cost-benefit analysis for adoption of polymer concrete in the two selected use cases, framed against the 'do-nothing scenario'.
- Understand the ability and value of design requirements.
- Make clear recommendations regarding the availability and possible development of the materials to achieve net zero targets.

Sufficient knowledge would be gained for overall low carbon construction techniques like 3D printing that can be utilised to reduce the scope 3 emissions associated with the construction.

Project Partners and External Funding

The following project partners will be supporting the project:

Frazer Nash Consultancy (FNC) will conduct the feasibility study which will identify a supplier for Stage 2.
NGET is providing all the funding for the project and is the lead network.

Potential for New Learning

There is very limited amount of work being done in this area and especially the existing one focus on theoretical research and not the live product development and trial. This work will provide the basis of our understanding of the capabilities of polymer concrete for

rapid curing. The work will be valuable resource for NG and have immediate application in subsequent projects in development. The sustainability opportunities register will be used to seek our new ideas and areas of focus; these will help shape conversations with future suppliers. In addition to potential for new learning outlined above, promotion of polymer concrete will aid in facilitating compliance with legislative requirements and achieving net zero targets by 2026.

The following will be new knowledge expected from carrying out the project:

- Development of new learning around ultra-low carbon construction techniques and their efficacy.
- Operational performance data to understand design challenges.
- Like for like comparison of OPC and polymer concrete.
- The outputs created from the project will be shared with the interested parties in energy sector especially the NGET construction working group.

Scale of Project

All work is strategically linked and designed to deliver the defined objectives. Therefore, the scale of the project is as specified, and the studies will be undertaken to demonstrate the testing of the foundations developed. There will be additional field work in this project that would be undertaken at Deeside Centre for Innovation (DCI), Wales, UK to establish some recommendations for final report.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

First stage of the study will be done by FNC and will be completed remotely at various UK locations. The testing will be done at Sheffield University, UK and further field testing will be done at Deeside Centre for Innovation (DCI), Wales, UK.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£346,027

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

The project facilitates energy system transition by helping NGET to understand the environmental impact, in terms of carbon emissions arising from our construction activities. This project will conduct a feasibility study exploring polymer concrete and will run a trial to develop learnings based on the testing and monitoring of the concrete structures. This will help us identify clear opportunities to reduce emissions with fast curing ultra-low carbon concrete and assist in commitments to reduce scope 3 emissions. This project is aligned with the National Grid climate transition plan which states, “We have also identified our material hotspots for construction activities and will continue to work with partners across the industry for lower carbon alternatives”.

How the Project has potential to benefit consumer in vulnerable situations:

Developing an understanding regarding low carbon construction is important to reduce the negative impact of carbon dioxide emissions arising from construction. Reduction in emissions, material volume, and concrete used has huge societal benefit.

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter’s and/or Electricity Transmission or Electricity Distribution licensee’s network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

Research project with starting TRL of 3, hence no CBA was completed.

Please provide an estimate of how replicable the Method is across GB

The developed methodology is of generic nature and would be applicable to all electricity network Licensees across GB, this would be inclusive of transmission and distribution owners. The outcome of the project will determine how much emissions can be reduced by the implementation of such materials. The success of the project will boost the confidence on the material reliability and safety practices.

Please provide an outline of the costs of rolling out the Method across GB.

If the project is successful, the method can be further developed to roll out across GB. The estimated cost will be reviewed at the completion of the project. Conservative estimates of costs have been made for the purposes of assessing the value of this project, they are based on the cost of polymer materials. There is some cost associated to changing the technical specification to allow the use of polymer materials in the business and across GB.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee’s network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The learning will be used in the planning and designing of new substations and upgrading the existing infrastructure to reduce the carbon emissions. It is the learning that may be directly applied to other networks with similar assets at similar voltages. The disseminated results will be shared with all licensees so that the reasons for the conclusions may be understood. It will be the responsibility of others to determine to what extent it applies to other equipment types and different voltages but the underlying work from this project is likely to help.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

This project explores polymer concrete which have not been explored or implemented before. The project intends to generate evidence to change the construction activities since the technical specifications do not allow such materials now hence, they are not utilised currently. There are no other projects in development looking at polymer concrete that can help reduce the emissions. The risk of duplication will be addressed through dissemination of progress with other licensees and being open to co-operate with licensees working in this space.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

There are currently no NIA/SIF projects looking at polymer concretes with potential trials within the UK. As a responsible business, NG need to cover the knowledge gap to address the issue and manage the expectation to meet the commitments of reducing the scope 3 emissions. There is no overlap between this work focusing on foundations and the work currently under way in different trials and studies. NGET technical specifications do not allow use of any other materials now. To change the specifications, we need learning data to support the evidence of alternatives. This project originated from an existing NGET project “Use of Innovative Materials and Construction Techniques in the Substation Environment to Accelerate Transition to Net-Zero” which investigated polymer materials briefly show casing high potential in exploring polymer concrete extensively.

Relevant Foreground IPR

The foreground IPR will be the knowledge gained about the polymer concrete binders and their performance advantages over OPC. The learning will be brought together for like for like comparison and development of some of the materials to demonstrate at Deeside Centre for innovation and gather some data.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click ‘Contact Lead Network’. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

There exists no data that supports the evidence of using ultra-low carbon polymer concrete in substation environment, especially with faster curing. National Grid has done previous trials with other polymer concretes like CemFree and Earth friendly concrete however such trials were based on low carbon concrete and not ultra-low carbon concrete. A strong test data along with validation data is required to change the technical specification to utilise polymer concrete. There is a risk factor involved that may be the materials have supply chain issues or the availability is not well defined. The risk of alternatives not performing up to certain standards is also a possibility and that is why business as usual cannot fund such activities.
This project aims to update the specification based on the data obtained through a series of testing. This is not a business-as-usual activity as there is considerable risk associated with the development and implementation.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

Testing to date suggests that the work will be successful, but it cannot be guaranteed. If the feasibility study identifies more challenges than benefits, the project will not proceed to BAU and technical specifications will not be changed. The project is anticipated to generate sufficient benefit to justify the expenditure over 10 years. So, the success of the project will only become truly apparent over a longer period. During that time alternative, currently unforeseeable, solutions may arise that provide greater benefit.

There are technical risks associated with any innovation project as the proposed solution may not work. Replacing the existing materials like concrete has high risk requiring additional work like finding the unknowns about the material strength, exploring the supply chain, associated technical risks, validation, and verification of results, and identifying viable sources of relevant data and science. Therefore, considering the risks associated with the success of the project, NGET believes NIA funding is the best route for the project.

This project has been approved by a senior member of staff

☑ Yes