TERMS OF REFERENCE FOR R&D PROJECT

1. **Title** – Study of durability properties of composite cement (a type of hydraulic cement) currently being manufactured by the cement industry in India.

2. **Background**
   a) Composite cement is one of the varieties of hydraulic cement used in making concrete, mortar and plaster. Composite cement is made using cement clinker, fly ash and granulated slag.
   b) BIS has already formulated the Indian Standard IS 16415: 2015 'Composite Cement – Specification'. In February 2023, the first amendment to IS 16415 was issued to the standard particularly on the composition/constituent materials used in the cement including the clinker content. After release of the amendment, representations were received from the manufacturing industry regarding the change in clinker content. The Indian Standard as well as its amendment can be downloaded from https://standardsbis.bsbedge.com/
   c) Hence, in order to determine the optimum percentage of clinker to be used in composite cement so that it does not affect/harm/deteriorate the performance, durability and service life of reinforced cement concrete structures made using this variety of cement, this study is required.

3. **Objective** – To collect data/information and evidence from primary and secondary sources in regard to durability properties and requirements of composite cement.

4. **Scope**

   a) Undertake study and comparative analysis of the available literature on the subject which includes International Standards and Journals, Research Papers published on the subject, guidelines/regulations issued by the concerned Ministry/Government agency and any other study conducted by other industry/organization.
   b) Carry out factory visit to the manufacturers of composite cement, identify/collect the information regarding the manufacturing base of the product and the testing facilities available in the country. During the visit, the researcher need to observe the following activities:
      1) Variety of the products manufactured.
      2) Manufacturing process
      3) In process quality and safety checks
      4) Marking and labelling
      5) Packaging requirements
      6) Testing facilities and equipment used at the factory location
      7) Sustainability practices adopted by the manufacturer such as energy consumption, use of renewable energy resources, waste management and disposal mechanisms and reduction of carbon footprint.

c) Visit Government/NABL accredited testing laboratories (one government and one private) to identify the testing infrastructure available in the country.
d) Collect requisite samples of composite cement from the manufacturers and conduct various tests in order to obtain data on various physical, chemical and durability requirements such as RCPT, chloride induced corrosion and carbonation induced corrosion of composite cement.

5. Methodology

a) Obtain six samples of composite cement from different manufacturers based on clinker percentage (two with 45 % clinker, two with 40% clinker and two with 35 % clinker). In each of the above sample, the fly ash addition should be within the maximum permissible limit. Also, samples of PPC should be taken from the same manufacturers for comparison purpose.
b) Carry out test for physical and chemical requirements on the above samples as per relevant Indian Standards.
c) Carry out other qualitative and quantitative analysis tests such as x-ray diffraction (XRD), thermogravimetric analysis (TGA), X-Ray Fluorescence (XRF) and particle size analysis for determining comprehensive parameters.
d) For testing of concrete mix, the following should be adhered:
    i. For each of the cement sample, three concrete mixes should be prepared using the following water/binder ratio
        0.60 (usual M10 Concrete)
        0.50 (usual M20 Concrete)
        0.45 (usual M25 Concrete)
        0.40 (usual M30 Concrete)

        The target slump for the above mixes using superplasticizer should be 100-140 mm.
    ii. For each concrete mix, measure 7, 14, 28 and 90 days compressive strength.
    iii. For each concrete mix, measure carbonation depth at 3% CO_2, at 27 ± 2°C, having 40% - 60% RH.
    iv. Measure rapid chloride penetration test (RCPT) and rapid chloride migration test (RCMT) on each mix.
e) For evaluation of corrosion in beams, the following should be adhered:
    i. RC beams shall be prepared with 20 mm clear cover for each concrete mix.
    ii. The beams so cast should be exposed to accelerated carbonation for 120 days at 3 % CO_2, at 27 ± 2°C, 40% - 60% RH.
    iii. Thereafter, the beams shall be immersed 10 mm in potable water for a duration of 14 days.
    iv. Thereafter, the rate of corrosion should be measured using corrosion current (I_{corr}) measurements.
    v. Three replicates for each mix should be prepared and tested.

f) Compare the above test results with similar tests conducted on samples made using PPC at the same water to binder ratio.
g) Analyze and prepare an analytical report on comparative study on various durability parameters such as carbonation depth, RCPT and chloride induced corrosion of RCC beams with the variation in type of cement, w/b ratio and clinker content.

6. Deliverables

a) An analytical report covering all the aspects as mentioned in the scope and methodology.
b) In addition to the above report, the details of the manufacturer/laboratory visited as well as literature reviewed during the project time duration shall be suitably appended.

7. Timeline

a) The timeline for completing the study and submission of the final report is **6 months** from the date of award of the project.
b) Interim report on literature review – 1 month.
c) Collection of information from manufacturers/users – 2 months
d) Collection and testing of samples – 5 months
e) Project report shall be submitted by the end of 6 months in both hard and digital format. (*This shall not wait for the test results of samples in case it is a long duration test.*)

8. Support provided by BIS

If needed, BIS may aid with respect to available IS/ISO standards, information about manufacturing units and testing laboratories available in the country.

9. Nodal Person

Shri Jitendra Kumar Chaudhary, Sc 'B' & Member Secretary
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NOTE: All the tests as mentioned above shall be conducted as per relevant Indian Standards.

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