## REVIEW ANALYSIS OF INDIAN STANDARD

*(To be submitted Online by transferring the contents)*

1. **Sectional Committee No. & Title:** CED 2 CEMENT AND CONCRETE SECTIONAL COMMITTEE

2. **IS No:** 9012 (1978)

3. **Title:** RECOMMENDED PRACTICE FOR SHOTCRETING

4. **Date of review:** 30 June 2021

5. **Review Analysis**

i) **Status of standard(s), if any from which assistance had been drawn in the formulation of this IS.**

| Standard (No. & Title) | Whether the standard has since been revised | Major changes | Action proposed |
|---|---|---|---|
| **Unnamed Standard** | | | |

ii) **Status of standards referred in the IS**

| Referred standards (No. & Title) | IS No. of this standards since revised | Changes that are of affecting the standard under review | Action proposed |
|---|---|---|---|
| Ordinary or low heat Portland cement conforming to IS: 269-1976 | IS:269-2015 Ordinary Portland Cement Specification | Will be discussed during meeting for revision | To amend clause 3.1 to refer to IS:269-2015 |
| Rapid hardening Portland cement conforming to IS : 8041-1978 | IS:8041-1990-Rapid hardening Portland cement Specification | Will be discussed during meeting for revision | To amend clause 3.1 to refer to IS:8041-1990 |
| Portland slag cement conforming to IS: 455-1976 | IS:455-2015- Portland slag cement-Specification | Will be discussed during meeting for revision | To amend clause 3.1 to refer to IS:455-2015 |
| Portland Pozzolana cement conforming to IS : 1489-1976 | IS: 1489-2015 (Part-I)-Portland Pozzolana Cement-Specification: Part-I Fly Ash Based | Will be discussed during meeting for revision | To amend clause 3.1 to refer to IS:1489-2015 |
| Hydrophobic cement conforming to IS : 8043-1978 | IS:8043-1991-Hydrophobic Portland Cement-Specification | Will be discussed during meeting for revision | To amend clause 3.1 to refer to IS:8043-1991 |
| High strength ordinary Portland cement conforming to IS : 8112-1976 | IS:269-2015 Ordinary Portland Cement Specification | Single code is now there for all three grades of OPC and this needs to be deleted from this standard. IS: 269-2015 is to be referred. | To amend / delete clause 3.1 (e) to refer to IS:269-2015 |
| IS: 383-1970-Specification for coarse and fine aggregates from natural sources for concrete | IS:383-2016-Coarse and Fine Aggregate for Concrete-Specification | Will be discussed during meeting for revision | To amend clause 3.2.1 and 3.2.2 to refer to IS: 383-2016 |

| Referred standards (No. & Title) | IS No. of this standards since revised | Changes that are of affecting the standard under review | Action proposed |
|---|---|---|---|
| IS: 456-1978-Code of practice for plain and reinforced concrete | IS: 456-2000-Code of practice for plain and reinforced concrete | Will be discussed during meeting for revision | To amend clause 3.3, 3.4, 8.3.1, 8.11 to refer to IS: 456-2000 |
| IS: 9103-1979- Specification for admixtures for concrete. | IS: 9103-1999- Specification for admixtures for concrete | Will be discussed during meeting for revision | To amend clause 3.4 to refer to IS: 9103-1999 |
| IS:432 (Part-I) 1966-&Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement : Part I Mild steel and medium tensile steel bars | IS:432 (Part-I) 1982-&Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement : Part I Mild steel and medium tensile steel bars | Will be discussed during meeting for revision | To amend clause 3.5 to refer to IS: IS:432 (Part-I) 1982 |
| IS : 1786-1966 -Specification for cold twisted steel bars for concrete reinforcement | IS: 1786-2008-High Strength Deformed Bars And Wires. For Concrete Reinforcement - Specification | Will be discussed during meeting for revision | To amend clause 3.5 to refer to IS: IS:1786-2008 |
| IS : 1566-1967- Specification for hard-drawn steel wire fabric for concrete reinforcement | IS : 1566-1982- Specification for hard-drawn steel wire fabric for concrete reinforcement | Will be discussed during meeting for revision | To amend clause 3.5 to refer to IS: IS:1566-1982 |

iii) **Any other standards available related to the subject & scope of the standard being reviewed (International/regional/other national/association/consortia, etc or of new or revision of existing Indian Standard)**

| Standard (No. & Title) | Provisions that could be relevant while reviewing the IS | Action proposed |
|---|---|---|
| ACI 506 R, EFNARC,EN 206 (BS EN 14487-1) | 1. ACI 506R suggests cementitious content range from 390 to 450 kg/m3. European standards such as EFNARC and BS EN 14487-1 refer to EN 206 for minimum cement content. EN 206 recommends minimum cement content from 260 kg/m$^3$ to 360 kg/m3 to meet the appropriate environmental exposure conditions. However, for sprayed concrete both EFNARC and EN limit the minimum content as 300 kg/m$^3$. It is inferred that the typical cementitious content specified in ACI includes the cement and pozzolona, whereas the minimum cement content mentioned in EN comprises cement and factored pozzolona (cement + k × additives). The k value varies with respect to type of pozzolana added.<br>2. As per IS 456-2000, the minimum cement content varies with respect to compressive strength and exposure conditions. The limiting values for cement content related to exposure conditions as recommended in Table I can be incorporated in IS 9012. | The limiting values for cement content related to exposure conditions needs to be recommended in IS 9012. |
| ACI-506R-Guide to shotcrete & EFNARC | 1. ACI specifies 10mm maximum aggregate size. Thus 12.5 mm and 20mm maximum aggregate size specified in IS 9012 may be omitted and the maximum aggregate size can be limited to 10mm. ACI 506R specifies total aggregate will consists of 20% to 30% coarse aggregate and 70 to 80% fine aggregate. It is recommended to incorporate the values of coarse to fine aggregate in similar line to ACI 506R in the Indian standard considering dry mix, wet mix or for mix added with fibre.<br>2. Indian standard suggests only the usage of Portland slag cement and Portland pozzolana cement with no mention of pozzolanic materials in shotcrete. ACI 506.5R suggests a typical range from 7 to 10% (Max | |

| Standard (No. & Title) | Provisions that could be relevant while reviewing the IS | Action proposed |
|---|---|---|
| | 15%) for the replacement of cement by silica fume. It also mentions that addition of fly ash and slag is acceptable only if all shotcrete performance requirements can be demonstrated during preconstruction testing. With the availability of new Indian codes on ultrafine materials and revision / formulation of new cement / supplementary cementitious material standards, it is recommended to include materials such as fly ash, GGBS, silica fume, ultrafine GGBS etc. with limits in revised IS: 9042.<br>3. Indian standard has not specified fibers for shotcrete reinforcement. Other international standards such as ACI apart from suggesting reinforcing bars and wire mesh have extensively deals with fibers also. A typical range of minimum and maximum dosages of different types of fiber used in shotcrete are there in ACI codes. Decision on type and dosage of fibre for inclusion in revised version may be taken by committee.<br>4. Minimum bond strength between concrete and rock to be included in code.<br>5. Flexural Strength, Bond strength and Energy absorption test requirement and specification needs to be included for evaluation of shotcrete especially when fibre are to be introduced.<br>6. Durability properties of shotcrete in terms on Absorption and volume of permeable voids, Permeability, Air content etc. to be included in code similar to ACI and EFNARC.<br>7. Larger aggregates and fibers show a significant rebound in shotcrete. Lower aggregate density and the addition of fine particles reduce aggregate rebound. Synthetic fibers display lower rebound than steel fibers. Also advanced application techniques have evolved in recent times which reduce rebound. Hence aggregate size, fiber type and application technique plays a key role in the percentage of rebound in shotcrete. Considering, these factors and surface of application, the values for percentage of rebound needs to be modified. EN and EFNARC have not included the criteria for percentage of rebound but ACI 506 R has percentage of rebound values. | **To be referred to CED-2 for discussion and decision** |

iv) **Technical comments on the standard received, if any: NIL.**

| Source | Clause of IS | Comment | Action proposed |
|---|---|---|---|
| | | | |

v) **Information available on technical developments that have taken place (on product/processes/practices/use or application/testing/input materials, etc)**

**NIL other than latest ACI, BS-EN and EFNARC**

| Source | Development | Relevant clause of the IS under review that is likely to be impacted (Clause & IS No.) | Action proposed |
|---|---|---|---|
| | | | |

vi) **Issues arising out of changes in any related IS or due to formulation of new Indian Standard**

**NIL**

| Related IS and its Title (revised or new) | Provision in the IS under review that would be impacted & the clause no. or addition of new clause/provision | Changes that may be necessary in the Standards under review | Action proposed |
|---|---|---|---|
| | | | |

vii) **Any consequential changes to be considered in other IS**

**NIL**

| Related IS to get impacted | Requirements to be impacted |
|---|---|
| | |

6. **Any other observation:**

   **NIL**

7. **Recommendations:**

Major areas requiring improvement in the Indian standard for shotcrete are

1. Provisions on cement, aggregate, flyash, GGBS, ultrafine materials needs to be updated keeping in view the latest revisions and formulation of Indian standards in this area.
2. Latest ACI and EN have a specific code for fiber reinforced shotcrete. Specifications and guidelines for the usage of fibers in shotcrete to be incorporated or specific code for fiber reinforced shotcrete has to be published.
3. More elaborate detail on flexural strength, bond strength, energy absorption and their testing methodology should be included.
4. Percentage of rebound of shotcrete requires to be modified.
5. Important durability factors such as absorption, volume of permeable voids, permeability and air content have to be added.

Based on the latest formulation / revision of codes in the field of cement, supplementary cementitious materials, concrete including upgradation in construction methods, It is **proposed to revise 9012 (1978) comprehensively**, with the above recommendations.

30.06.21

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