CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: MONITORING (CDM-NMM)
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SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

Reduction in the use of Ordinary Portland Cement for concrete mix preparation.

A.2. List of category(ies) of project activity to which the methodology may apply:

The project activity is applicable to 'Category 6 that relates to construction industry'. In the absence of an appropriate project sub-category definition, a new project sub-category has been considered titled *"substitution of GHG intensive materials in concrete mix preparation"*.

A.3. Conditions under which the methodology is applicable to CDM project activities:

The conditions under which this project activity would be applicable include the following:

1. project activity monitors of reduction in ordinary Portland cement (OPC) use for preparation of concrete mix in variety of construction applications;

2. project activity monitors preparation of concrete mix by substituting part of OPC content in concrete mix with alternate materials of less GHG intensity; and

3. project activity considers use of quality assurance and quality control (QA/QC) measures at the stage of concrete preparation and application.

A.4. What are the potential strengths and weaknesses of this proposed new methodology?

Potential Strengths

1. The monitoring methodology is cost effective since actual baseline and project implementation database archived during the planning and execution of a construction project can be used for calculating reduction in OPC usage and resulting CO_2 emission avoidance.

2. The monitoring methodology need not consider project emissions due to operation of concrete mix preparation machinery since the activity of concrete mix preparation is of similar scale during project activity and baseline scenarios.

Potential Weakness

1. The methodology does not directly measure quantum of CO_2 emissions from OPC production processes.

2. The methodology cannot provide a check on actual avoidance/ reduction of OPC production in the cement industry due to reduction in its requirement/ use due to the project activity.

SECTION B. Proposed new monitoring methodology

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B.1. Brief description of the new methodology:

In the preparation of concrete mix for use in various construction applications, OPC is used as a major component. The quantity of OPC to be used in any grade and application is pre-determined based on defined and accepted standards and guidelines, and has defined ratios with respect to water content in the concrete mix. A lower cement concrete technology (LCCT) is used in the project activity based on the following two approaches:

1. use of high range water reducing admixtures to decrease the OPC content in concrete mix, and

2. decrease the OPC content in the concrete mix through its partial replacement with alternate cementitious materials like fly ash or slag.

The LCCT could help in reducing the water and cement requirements in the concrete mix though not reducing the water to cement ratio in the mix. The project activity combines both these approaches mentioned above.

The savings in use of OPC could save on its production by a cement manufacturer, who normally uses a GHG emitting raw material[1]. Thus, by avoiding the production of certain quantity of OPC, emission of CO_2 is avoided.

The monitoring methodology tracks and records the project activity generated data for both baseline and project implementation scenarios as described above for use in the computation of emission reductions.

The monitoring methodology has two components:

1. determination of quantum of OPC used to prepare one tonne of concrete mix in baseline and project activity scenarios; and

2. determination of GHG emissions for a tonne of OPC produced in the cement industry.

Using 1 and 2, the GHG emissions in the preparation of one tonne of concrete, attributable to OPC content in concrete mix can be computed.

[1] The manufacturers of cements also blend alternate cementitious materials like fly ash during cement production. However, the content (%) of such material in the blended cement and the quantum of waste material that can be used as alternate materials is restricted by scale and nature of operation of cement industry. The route followed by this project activity enables use of higher % of waste material like fly ash in construction applications, and also can collect and use highly dispersed – low quantum waste materials.

The methodology suggests use of CO_2 emission factor data from National Communications of the host country for emissions due to clinker production process in OPC manufacturing, and use any authoritative national level sector-wise average for CO_2 emission due to use of fuels in OPC manufacturing process or calculate the same using plant-wise fuel consumption data and IPPC data on emissions for different fuels, for computation of emissions discussed under point number 2 as mentioned above.

The emissions due to transportation of raw materials and concrete mix preparation are included in leakage calculations.

B.2. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario:

B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
$RA_{Ci,G,Y}$	Reduced proportion of OPC in unit volume of concrete mix in application 'G' during year 'Y'	Records on relevant location for concrete mix preparation	tonnes/ cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations Ci, and for all years during the crediting period.
$RV_{Ci,G,Y}$	Gross volume of concrete produced for use in application 'G' during year 'Y'	Records on relevant location for concrete mix preparation	cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations Ci, and for all years during the crediting period.
$RAA_{Cj,G,Y}$	Reduced proportion of OPC in unit volume of concrete mix in application 'G' during year 'Y'	Records on relevant location for concrete mix preparation	tonnes/ cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations Cj, and for all years during the crediting period.
$RVA_{Cj,G,Y}$	Gross volume of concrete produced for use in application 'G' during	Records on relevant location for	cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations Cj, and for all years during the

B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
	year 'Y'	concrete mix preparation						crediting period.
$RAC_{Ck,G,Y}$	Reduced proportion of OPC in unit volume of concrete mix in application 'G' during year 'Y'	Records on relevant location for concrete mix preparation	tonnes/ cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations C_k and for all years during the crediting period.
$RVC_{Ck,G,Y}$	Gross volume of concrete produced for use in application 'G' during year 'Y'	Records on relevant location for concrete mix preparation	cubic meters	m	Annual	Daily results for entire year	electronic	For all grades G at all locations C_k and for all years during the crediting period.
Ci	All concrete mix preparation locations where the project activity is proposed during year 'Y', using only admixtures in concrete mix along with OPC and other standard constituents	Records on relevant location for concrete mix preparation	--	m	Annual	Annual	electronic	i = 1, 2,…n, and for all years during the crediting period.
Cj	All concrete mix preparation locations where the project activity is proposed during year 'Y', using both admixtures and alternate cementitious materials in	Records on relevant location for concrete mix preparation	--	m	Annual	Annual	electronic	j = 1, 2,…n, and for all years during the crediting period.

B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
	concrete mix along with OPC and other standard constituents							
C_k	All concrete mix preparation locations where the project activity is proposed during year 'Y', using only alternate cementitious material(s) in concrete mix along with OPC and other standard constituents	Records on relevant location for concrete mix preparation	--	m	Annual	Annual	electronic	k= 1, 2,…n, and for all years during the crediting period.

B.2.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

The reduction of use of OPC through the new technology could be effected under the project activity through the first stage or second stage or first stage followed by second stage, as described below.

Stage 1: Adding a high range water reducing admixture to the concrete mix thereby reducing the requirement of OPC; and/or

Stage 2: Using alternate cementitious materials to partially replace the balance requirement of OPC in the concrete mix.

For step 1 (wherein only admixture is used in the concrete mix), the requirement for OPC ($PA_{Ci,G,Y}$ *in tonnes*) at concrete mix preparation location 'Ci' for concrete mix grade 'G' during year 'Y', will be calculated as follows:

$$PA_{Ci,G,Y} = RA_{Ci,G,Y} * RV_{Ci,G,Y} \quad \text{……………………………………}(1)$$

The total quantity of OPC that would have been used for all grades of concrete mixes to be used (G = 1, 2, ……) across several applications at concrete mix preparation location 'Ci' during year 'Y' will be calculated by adding the individual usages in several grades:

$PA_{Ci,Y} = \Sigma PA_{Ci,G,Y}$……………………………………………………..(2)

For step 2 (wherein both admixture and alternate cementitious material are added in the concrete mix), the requirement for OPC ($PAA_{Cj,G,Y}$ *in tonnes*) at concrete mix preparation location 'Cj' for concrete mix grade 'G' in which admixture has already been used during year 'Y,' will be calculated as follows:

$PAA_{Cj,G,Y} = RAA_{Cj,G,Y} * RVA_{Cj,G,Y}$……………………….………………(3)

The total quantity of OPC that will be used for all grades of concrete mixes (G = 1, 2, ……) across several applications at concrete mix preparation location 'Cj' during year 'Y' will be calculated by adding the individual usages in several grades:

$PAA_{Cj,Y} = \Sigma PAA_{Cj,G,Y}$……………………………………………..(4)

For step 3 (wherein only alternate cementitious material are added in the concrete mix), the requirement for OPC ($PAC_{Ck,G,Y}$ *in tonnes*) at concrete mix preparation location 'C_k' for concrete mix grade 'G' in which admixture has already been used during year 'Y,' will be calculated as follows:

$PAC_{Ck,G,Y} = RAC_{Ck,G,Y} * RVC_{Ck,G,Y}$……………….…………(5)

The total quantity of OPC that will be used for all grades of concrete mixes (G = 1, 2, ……) across several applications at concrete mix preparation location 'C_k' during year 'Y' will be calculated by adding the individual usages in several grades:

$PAC_{Ck,Y} = \Sigma PAC_{Ck,G,Y}$……………………………………………..(6)

During any year 'Y' the gross volume of concrete produced ($V_{C,G,Y}$) for use at all concrete mix preparation locations 'C' needs to conform to the following checks in relation baseline cement reduction calculations:

$V_{C,G,Y} = RV_{Ci,G,Y} + RVA_{Cj,G,Y} + RVC_{Ck,G,Y}$ …………………………....(7)

Considering the CO_2 emission factor for OPC production to be EF_{PC} *(in tonnes CO_2 emitted per tonne of cement produced)*[2], the annual emission (PL_{PC} *in tonnes*) of CO_2 in spite of the project activity is calculated as follows, using summation over all concrete mix preparation locations considered within the project boundary:

$PL_{PC} = \sum (EF_{PC} * PA_{Ci,Y})$ ………………………………………………..(8)

[2] Calculated as per procedure shown in equation (13) under section B.2.4.

B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
$BC_{C,G,Y}$	Proportion of OPC in unit volume of concrete mix in application 'G' during year 'Y'	Project sponsors database	tonnes/ cubic meters	e	Annual	Once for all applications and grades unless additional monitoring are warranted	electronic	For all grades 'G' at all locations 'C' where reduction in use of OPC is planned for implementation, and for all years during the crediting period.
$V_{C,G,Y}$	Gross volume of concrete produced for use in application 'G' during year 'Y'	Relevant concrete mix preparation location's records	cubic meters	m	Annual	Daily results for entire year	electronic	For all grades 'G' at all locations 'C' where reduction in use of OPC is planned for implementation, and for all years during the crediting period.
C	All concrete mix preparation locations where the project activity is proposed during year 'Y', using either admixtures or alternate cementitious material(s) or both admixtures and alternate cementitious materials in concrete mix along other standard constituents	Relevant concrete mix preparation location's records	--	m	Annual	Annual	electronic	For all years during the crediting period.

B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
Q_{fuel}	Annual quantity of (all) fuel(s) used in any OPC producing plant during a year prior to start of project activity crediting period	Official/ authentic publicly available record/ data for the OPC producing plant, such as Annual Report, etc.	Tonnes	e	Annual	Annual	electronic	For year prior to start of project activity crediting period
Q_{OPC}	Annual quantity of OPC produced in the corresponding OPC producing plant (mentioned above) during a year prior to start of project activity crediting period	Official/ authentic publicly available record/ data for the OPC producing plant, such as Annual Report, etc.	Tonnes	e	Annual	Annual	electronic	For year prior to start of project activity crediting period
NCV_{fuel}	Net Calorific value of fuel (as mentioned above)	IPCC	TJ/ 10^3 tonnes	e	NA	NA	electronic	NA
CEF_{fuel}	Carbon emission factor for fuel used as above	IPCC	tonnes C/ TJ	e	NA	NA	electronic	NA
COF_{fuel}	Carbon oxidation factor for fuel used as above	IPCC	NA	e	NA	NA	electronic	NA

B.2.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>> The baseline scenario involves quantity of OPC that would have been used in a particular grade or application of concrete mix under normal concrete mix design specifications for such application. Hence, at any concrete mix preparation location 'C' during a year 'Y', the quantity of OPC ($PB_{C,G,Y}$ *in tonnes*) that would have been used in grade 'G' of concrete mix in the absence of the project activity would be calculated as follows:

$$PB_{C,G,Y} = BC_{C,G,Y} * V_{C,G,Y} \ldots\ldots (9)$$

The total quantity of OPC that would have been used for all grades of concrete mixes to be used (G = 1, 2, ……) across several applications at concrete mix preparation location 'C' during year 'Y' will be calculated by adding the individual usages in several grades:

$$PB_{C,Y} = \Sigma\ PB_{C,G,Y} \ldots\ldots (10)$$

Estimation of CO_2 Emission Factor (ex – ante) due to OPC production

For calculating the emission factor (**EF_{PC}**) for ex-ante estimation of baseline emissions, publicly available data on the same from any national level authority could be used. The same needs to be updated ex-post for each crediting year of the project activity.

Estimation of CO_2 Emission Factor (ex – post) due to OPC production

The emission factor (**EF_{PC}**) for OPC manufacturing has been calculated using process related CO_2 emissions from production of clinkers and use of fuels for energy in the total OPC manufacturing process. For each concrete mix preparation location to be identified in the project boundary, a maximum of 4 nearest located OPC producing plants will be identified for sourcing. The emission factor relevant to each concrete mix preparation location will be calculated as average emission factor for the corresponding OPC producing plants. The same procedure will be repeated all concrete mix preparation plants identified in the project boundary.

The CO_2 emission factor (**$EF_{clinker}$**) for clinker production could be used from any authentic National level official database such as National Communications by the Host Country, etc.

The CO_2 emission factor (**EF_{fuel}**) due to use of fuels in OPC manufacturing process could be used from any authoritative national level sector-wise average for CO_2 emission due to use of fuels in OPC manufacturing process or calculate the same using plant-wise fuel consumption data and IPPC data on emissions for different fuels. If calculated plant-wise, the following algorithm will be used.

$$EF_{fuel} = \Sigma\ (Q_{fuel} * NCV_{fuel} * CEF_{fuel} * COF_{fuel} * 44/12) / \Sigma\ (Q_{OPC}) \ldots\ldots (11)$$

Hence, the CO_2 emission factor (**EF_{PC}**) is calculated as:

$$EF_{PC} = EF_{clinker} + EF_{fuel} \ldots\ldots (12)$$

Using EF_{PC} *(in tonnes CO_2 emitted per tonne of OPC produced)*, the annual baseline emission (BL_{PC} *in tonnes*) of CO_2 is calculated as, using summation for all concrete mix preparation location considered within the project boundary:

$$BL_{PC} = \sum (EF_{PC} * PB_{C,Y}) \quad (13)$$

B.3. Option 2: Direct monitoring of emission reductions from the project activity:

>> Not applicable.

B.3.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

B.3.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Not applicable.

B.4. Treatment of leakage in the monitoring plan:

The leakage emissions could occur if the transportation needs for sourcing both OPC and replacement materials (in the project activity scenario) are greater than the transportation needs for sourcing only OPC (in the baseline scenario). In such an event, the leakage emissions due to additional transportation needs will be calculated as per the following provided under section B.4.2.

B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
Q_{OPC_BL}	Quantity of OPC transported from cement procuring sources to concrete mixing locations in the baseline scenario	Project proponents database	tonnes	e	Annual	Annual	electronic	To be recorded separately for each location of concrete mix preparation within project boundary, and each source of OPC for such location.
Q_{OPC_PA}	Quantity of OPC transported from cement procuring sources to concrete mixing locations in the project activity scenario	Project proponents database	tonnes	e	Annual	Annual	electronic	Same as above.
TC	Truck capacity	Project proponents database	tonnes	e	Annual	Annual	electronic	Same as above.
AVD	Average return trip distance between the	Project proponents database	km	e	Annual	Annual	electronic	Same as above.

B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
	OPC or 'Replacement Material' procuring sources and corresponding locations for concrete mix preparation							
TEF	CO_2 emission factor for the trucks	Project proponents database	tCO_2/km	e	Annual	Annual	electronic	Same as above.

B.4.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Transportation needs (number of trucks required for transportation) for OPC in the baseline scenario:

$$BL_{TRANS} = Q_{OPC\_BL} / TC \quad (14)$$

Transportation needs (number of trucks required for transportation) for OPC and 'Replacement Material in the project activity scenario':

$$PA_{TRANS} = (Q_{OPC\_PA} + Q_{RM\_PA}) / TC \quad (15)$$

If $PA_{TRANS} > BL_{TRANS}$, then leakage emissions (LE_{TRANS}) will occur, that may be calculated as per the following formula, accounting for all concrete mix preparation locations identified in the project boundary.

$$LE_{TRANS} = \sum [(PA_{TRANS} - BL_{TRANS}) * AVD * TEF] \quad (16)$$

B.5. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Based on the algorithm provided under B.2.2, B.2.4 and B.4.2, the annual emission reductions (ER_Y *in tonnes of CO_2*) due to the project activity can be calculated as follows, using formulae (8), (13) and (16):

$$ER_Y = BL_{PC} - PL_{PC} - LE_{TRANS} \quad (17)$$

B.6. Assumptions used in elaborating the new methodology:

>> The parameters and or assumptions are discussed below:

- ✓ at any concrete mix preparation location where the project activity will be implemented, the reduction of OPC usage could be effected in various grades of concrete mix in several applications;
- ✓ calibration of all monitoring equipment for parameters shown under B.2.1 and B.2.3 would be completed prior to their use for data recoding at the at the concrete mix preparation locations; and
- ✓ the equipment and processes for developing and checking the quality and reliability of the new technology would be completed prior to their use for data recoding at the concrete mix preparation location.

B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored:

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
$RA_{Ci,Gx,Y}$ (Table B.2.1)	Low	QA/QC protocols on measurement processes and equipment calibration to be used.
$RV_{Ci,Gx,Y}$ (Table B.2.1)	Low	Same as above.
$RAA_{Cj,Gy,Y}$ (Table B.2.1)	Low	Same as above.
$RVA_{Cj,Gy,Y}$ (Table B.2.1)	Low	Same as above.
$RAC_{Cj,Gy,Y}$ (Table B.2.1)	Low	Same as above.
$RVC_{Cj,Gy,Y}$ (Table B.2.1)	Low	Same as above.
$BC_{C,G,Y}$ (Table B.2.3)	Low	QA/QC not required, as this is estimated on the basis of standard published protocols.
$V_{C,G,Y}$ (Table B.2.3)	Low	QA/QC protocols on measurement processes and equipment calibration to be used.
Q_{fuel} (Table B.2.3)	Low	Official/ authentic data of OPC producer will be used, and hence no separate QA/QC is required.
Q_{OPC} (Table B.2.3)	Low	Same as above.

B.8. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

>> This is a new monitoring methodology submitted in conjunction with a corresponding new baseline methodology. The baseline and monitoring methodologies have been applied on a project activity in India that proposes "reduction in Ordinary Portland Cement consumption in concrete mix preparation *utilizing lower cement concrete technology*".

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