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# Reducing $CO_2$ Emission by using Blended Cement of Mathematical Modeling

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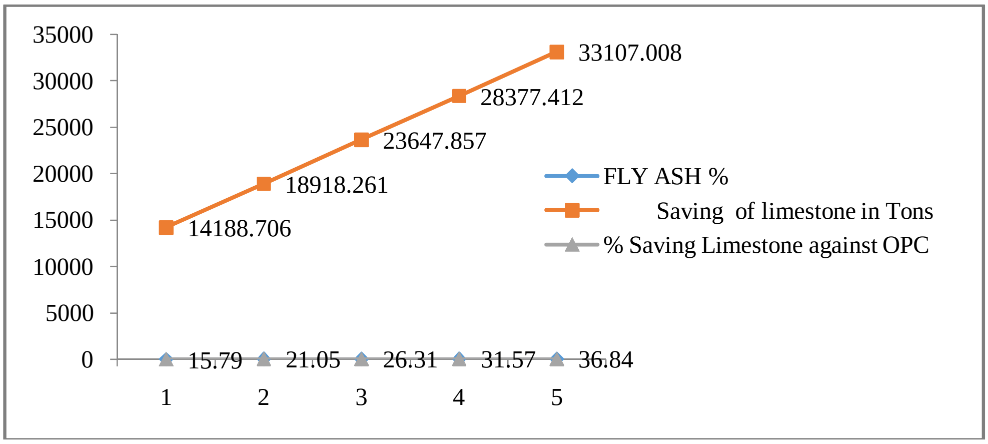
## ABSTRACT

*A Mathematical model based on the dynamic interactions among a number of system components is developed to estimate $CO_2$ emissions from the cement industry in India. The paper focuses on the problem of limestone that will be faced by cement industry in future. As per IBM survey we have limestone for 35-41 years. By using PPC and PSC we save limestone from 16% to 37% and 26% to 74% respectively. This saving increases the reserve of limestone from 14187 to 66214 million tonnes and thus extends the life of reserve limestone from 47 to 71 years.*

## Graphical Abstract




On PPC production varying fly ash % against OPC.

**Keywords:** $Co_2$ Emission, Cement Industry, Fly Ash, Green houses Gases, Fossil fuel, Carbon black, Energy Recovery.

## INTRODUCTION

Being the second largest producer of cement in the world Indian cement industry globally contributes 6% to 7% in $CO_2$ emission. In order to save our environment a lot of focus in the recent year is given on the reduction of greenhouse gases, it includes almost all industries like cement sector, power sector, steel industry etc. As the huge amount of $CO_2$ emissions cause severe environment problems, the efficient and effective utilization of energy is a major concern in Indian cement industry. Modeling and simulation of environmental impacts of coalfield: system dynamics approach [1]. Energy efficiency and environmental management options in the cement Industry, application of a system dynamics approach for assessment and mitigation of $CO_2$ emissions from the cement industry [2, 3]. Energy recovery from solid waste in cement rotary kiln and its environmental impact [4]. Evaluated energy and energy analyses of a serial flow four cyclone stages precalciner type cement plant [5]. It was analyzed Indian cement industry, annual report, New Delhi and studied modeling and forecasting the $CO_2$ emissions, energy consumption and economic growth in Brazil [4, 6]. Carried investigations on'Potential energy savings and $CO_2$ emissions reduction of China's cement industry [7]. Investigated varied potential energy savings and $CO_2$ emissions reduction of China's cement industry [7]. The prime objective is to mitigate the carbon dioxide emission without effecting our national growth. Government has set many norms for different sectors to overcome the effect of global warming but in this paper the focus is on cement industry as India is the second largest producer of cement in the world.

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## MATERIALS AND METHODS

After china we are second largest producer of cement in the world and accounts for about 6% of world's production. India is arising as a future superpower so we have to be very careful about our growth .It is well known that we are third in steel sector as well in power generation. Report tell us that we generate 600 million tons of fly ash up to 2030 from power station and presently we generate about 10-12 million tons slag from steel industry. These two figures are too big and it is not going to less but it will increase day by day.

The second problem is that for production of cement we have to produce clinker. As per IPCC default value of $CO_2$/ton clinker is 865 kg. This value is sum of 535 kg $CO_2$ ton$^{-1}$ clinker from calcination of limestone and 330 kg $CO_2$ ton$^{-1}$ clinker from fuel for heat in Kiln.

To minimize these two effects we have to find a way by which we may consume these industrial wastes and lower down the release of carbon dioxide in the atmosphere during production of cement. Cement is one of the essential building materials. To solve these two problems we produce such cement in which we utilize these waste by lowering down the clinker percentage.

International Energy Agency and Cement Sustainability set a benchmark to lower down $CO_2$ emission from 2 billion tons to 1.55 billion tons up to 2050.

For this many initiatives taken from every section, focus on reducing the use of clinker and maximizing the use of industrial wastes. Reduction in $CO_2$ emission is possible by use of composite cement. As per BIS we use fly ash and slag in mixed proportion 15-35% and 20-50% respectively by varying percentage. We use this as a base data for our calculation and study purpose.

## RESULTS AND DISCUSSION

By use of composite cement we can eliminate three stages i.e. (Raw material, grinding raw material and burning process)

We try to replace clinker and use in mix proportion the slag and fly ash as per BIS limit. By doing this we can reduce the emission of $CO_2$. We designed our model as per figure 1.

Mathematical methodology to proof that by use of composite cement reduces $CO_2$ emission.

**Case I (using clinker in the range 35 % to 65%):** As per BIS 16415-2015 we produce cement using clinker from 35% to 65% remaining part in mix proportion fly ash and slag that value will be in the range of 65 % to 35 % (min and max value of fly ash and slag is fix as per BIS)
Clinker=C, Gyp= G, Fly ash= F, Slag=S.

Let us take example of production of 100 ton composite cement keeping slag % at min value as per norms that is 20% and varying the % of Fly ash as per norms. ($CO_2$ emission per ton clinker is 865 kg as per standard value).

**Table 1.** For normal 100 ton OPC $CO_2$ released is 821.75 kg $CO_2$/Ton OPC cement

| C in Tons | G in Tons | F in Tons | S in Tons | Product = (C+G+F+S) in Tons | H= (C/Product) | H* 865 Kg $CO_2$/Ton composite cement= I | Reduction in release of $CO_2$ against OPC on same composite cement production = (821.75-I) | % Saving in reduction in release of $CO_2$ against OPC on same composite cement production= [(821.75-I) /821.75]*100 |
|---|---|---|---|---|---|---|---|---|
| 60 | 5 | 15 | 20 | 100 | 0.60 | 519 | 302.75 | 36.84% |
| 55 | 5 | 20 | 20 | 100 | 0.55 | 475.75 | 346 | 42.10% |
| 45 | 5 | 25 | 20 | 100 | 0.45 | 389.25 | 432.5 | 52.63 % |
| 45 | 5 | 30 | 20 | 100 | 0.45 | 389.25 | 432.5 | 52.63% |
| 40 | 5 | 35 | 20 | 100 | 0.40 | 346 | 475.75 | 57.89% |

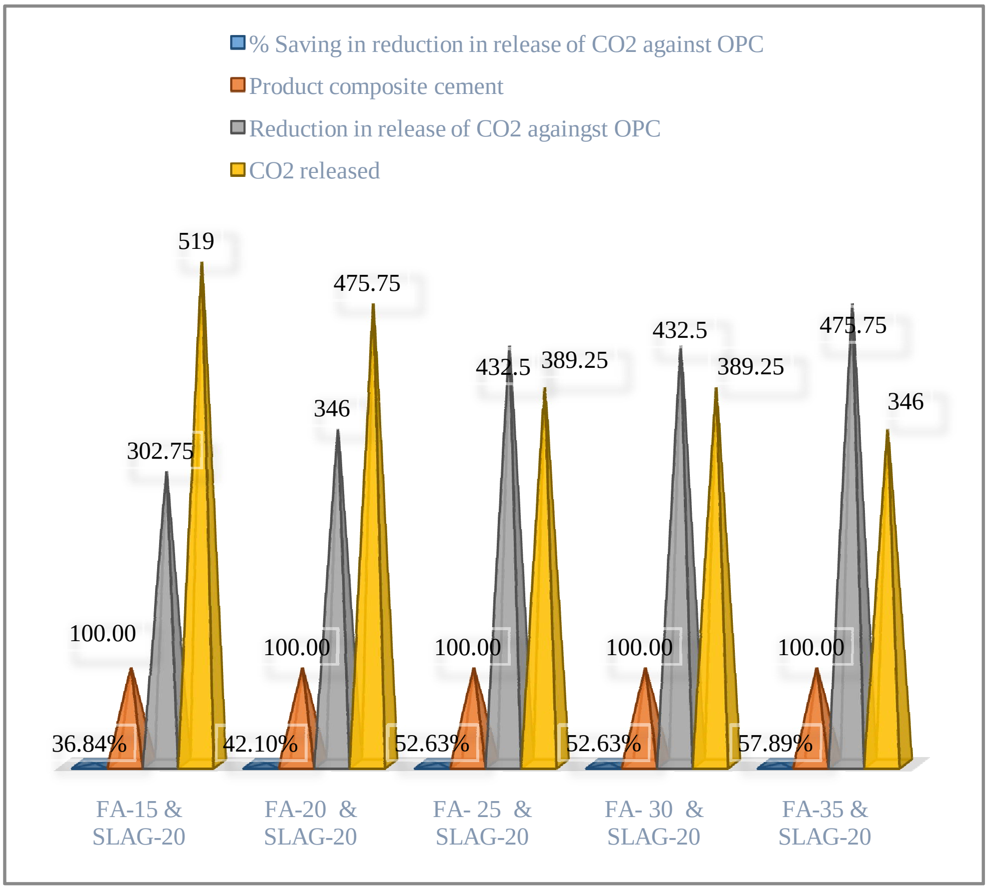


**Figure 1.** Composite Cement Saving on $CO_2$ Emission on Mix Proportion of FLY ASH and SLAG

All the above calculation is valid for use of OPC in the proportion of 35% to 65% of production of composite cement product.

Now the formula for $CO_2$ released during production of composite cement = (C % of product) × 865 kg $CO_2$/ ton clinker [value of C vary from 35 % to 65%].

Where C stands for = clinker
Product = sum of clinker, gypsum, fly ash and slag where value of fly

Ash and slag vary from 15% - 35% and slag from 20%-50% at best possible option keeping in view the value of C as per norms.

% Saving of clinker on same production= [(Clinker used in OPC –Clinker used in Composite cement)/Cement produced]×100

% Saving of $CO_2$ released against OPC=[($CO_2$ released by clinker used in OPC production-$CO_2$ released by clinker used in Composite cement)/$CO_2$released by clinker used in OPC production] ×100

Where we have to multiply in both production clinker used with 865 kg $CO_2$/ton clinker, Let us take the example of 100 ton OPC for this we have to use 95 ton clinker and suppose gypsum 5 tons.

The climate issue is today a very important issue both globally in an international perspective and nationally. Many organizations and companies are actively working on climate issues and greenhouse gas reductions are often an important goal, as well as mapping and monitoring of greenhouse gases. There is indisputable evidence that the build-up of man-made greenhouse gases in atmosphere cause changes in the global climate that will have increasingly severe human, environmental and economic impacts over the coming years. Cement manufacturers within the EU are obliged to participate in this trading scheme, due to high $CO_2$ emissions. Cement production is not only a source of combustion related $CO_2$ emissions, but it is also the largest sources of industrial process related $CO_2$ emissions in Croatia, and therefore $CO_2$ reduction measures will be required to keep cement industry emissions in line with levels set in Kyoto and post Kyoto period. It was recorded global warming impact on the cement and aggregates Industries [**12**]. It was assessed Croatian cement industry and climate changes [**10**]. Numerical modelling of calcination reaction mechanism for cement production [**9**]. Reported carbonation depth predictions in concrete bridges under changing climate conditions and increasing traffic loads [**11**]. A numerical carbonation model which deals with carbonation in fatigue-damaged concrete was introduced. reported greenhouse gas emissions from concrete can be reduced by using mix proportions, geometric aspects, and age as design factors [**13**].

Plants play an important role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, absorption and accumulation of air pollutants to reduce the pollution level in the ambiant environnent. Hence, trees act as a sink for air pollutants and this reduce their concentrations in the air [**14-21**].

## APPLICATION

Analyses of potential for achieving $CO_2$ emission reduction in the Indian cement industry. Apart from these techniques, various energy savings measures in cement industries expected to reduce indirect emissions released to the atmosphere. Based on review results it was found that sizeable amount of emission can be mitigated using different techniques and energy savings measures. The significant industrial $CO_2$ emissions released impose an immeasurable impact on the environment.

## CONCLUSION

Climate change is one of the most serious challenges facing modern society and a reduction of $CO_2$ emission in cement industry is one of the important measures for achieving the EU climate targets for 2020 and beyond. The paper analyses the potential for achieving $CO_2$ emission reduction in the Indian cement industry. Apart from these techniques, various energy savings measures in cement industries expected to reduce indirect emissions released to the atmosphere. Based on review results it was found that sizeable amount of emission can be mitigated using different techniques and energy savings measures. The significant industrial $CO_2$ emissions released impose an immeasurable impact on the environment. First of all in case of energy saving, it was indicated that shifting to more efficient process for example from wet to dry process having calciner, was the best option since potentially reduced up to 40 to 50 % of required energy and mitigated almost 10 to 20 % of $CO_2$ emissions in the process as well as increase the efficiency of the grinding process.

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