Comparative Analysis of Conventional Concrete with Concrete Using Phosphogypsum & Thermosetting Plastics - A Literature Review

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Abstract— Concrete is a composite material composed mainly of water, aggregate, and cement. Usually there are additives and reinforcements included to achieve the desired physical properties of the finished material. For solving the disposal of large amount of recycled plastic material, reuse of plastic in concrete industry is considered as the most feasible application. The reuse of material can reduce the normal usage of ingredients in concrete and thereby reduce the cost of construction. This study is focused on the use of thermo setting plastics as a partial replacement of aggregates in concrete. The aim was to investigate the characteristics of concrete with the addition of plastic and comparing it with the control mix, thereby determining the advantages and disadvantages of doing so. One of the methods for manufacturing of such concrete involves reduction of amount of cement in the mix, which added to the reduction the total cement consumption. The use of waste materials also solves the problem of disposing the excessive amount of industrial wastes. Such Concrete is a concrete in which one or more of its constituents are replaced by a resource saving material, which ultimately has reduced environmental impacts in terms of both, resource utilization and pollution impacts together. This paper discusses the importance of such Concrete in the present day context and highlights its merits over conventional concrete which otherwise posing a serious threat to the environment through global warming.

Keywords: Conventional Concrete, Phosphogypsum, Thermosetting Plastics, Compressive Strength, Flexural Strength, Tensile Strength, Workability

I. Introduction

Concrete is the most widely used man made construction material in the world. Seeking aggregates for concrete and to dispose of the waste from various commodities is the present concern. Today sustainability has got top priority in construction industry. In this study the recycled plastics were used to prepare the fine aggregates thereby providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. The productive use of waste material represents a means of alleviating some of the problems of solid waste management .The recycle of wastes is important from different points of view. It helps to save and sustain natural resources that are not replenished, it decreases the pollution of the. Wastes and industrial by-products should be considered as potentially valuable resources merely awaiting appropriate treatment and application.

Plastic wastes are among these wastes; their disposal has harmful effects on the environment due to their long biodegradation period, and therefore one of the logical methods for reduction of their negative effects is the application of these materials in other industries. Concrete plays an important role in the beneficial use of these materials in construction. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementations binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use. The strength properties and modulus of elasticity of concrete containing various types of plastic aggregate are always lower than those of a reference concrete containing normal density natural aggregate only, and they further decrease with increasing plastic aggregate content in concrete. Concrete containing plastic aggregate can stop or divert the propagation of micro cracks and improve concrete toughness, which is of great practical significance. The use of plastic waste as a natural aggregate substitute in concrete is a relatively recent concept. One of the first significant reviews on the use of waste plastic in concrete focused on the advantages and financial benefits of such use, besides their physical and mechanical properties. And more over use of plastic as aggregate gives a solution to the problems encountered with the quarrying of natural aggregate.

Phospho-gypsum is a by-product of phosphate fertilizer plants and chemical industries. As it is contaminated with the impurities that impair the strength development of calcined products, it can be used as partial replacement of cement. above 10% replacement of phosphor-gypsum in concrete lead to drastic reduction not only in the compressive strength but in the split-tensile strength also; the flexural strength decreases as width and number of cracks increases significantly at replacement above 10% of cement with phosphor-gypsum at different water binder ratios. In India, about 6 million tons of waste gypsum such as phosphor-gypsum, flouro-gypsum etc., are being generated annually. Phospho-gypsum is a by-product in the wet process for manufacture of phosphoric acid (ammonium phosphate fertilizer) by the action of sulphuric acid on the rock phosphate. It is produced by various processes such as di-hydrate, semi hydrate or anhydrite processes. In India the majority of phosphor-gypsum is produced by the dehydrate process due to its simplicity in operation and lower maintenance as compared to other processes. The other sources of phosphor-gypsum are by-products of hydrofluoric acid and boric acid industries

II. Objectives of the Study

The main objective of this research is to compare conventional concrete and concrete with recycled plastic wastes in terms of its workability and strength. The use of

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various materials like phosphor-gypsum, fly ash, GGBS, quarry dust, broken bricks etc in concrete helps in minimizing the resources consumption used to develop the conventional concrete and provide benefits like improved strength and workability of concrete with useful disposal of by-products. This type of concrete will also used to control the energy consumption and will able to minimize the hazards caused to the environment.

III. LITERATURE REVIEW

There were various studies been conducted on the use of such recyclable materials in concrete which gives adequate strength and its durability? The studies also suggests about the difficulties arise for the use of such by-products in the proportion of concrete. Few of the data from previous studies have been discussed here along with the methodology adopted and conclusions. Many research investigations have been carried out regarding the use of such by-products to minimize the amount of energy consumed and also to reduce the damage to the surrounding environment.

1) Elzafraney *et al.* (2006) established that the incorporation of recycled plastics into concrete provides higher levels of energy efficiency and comfort in buildings compared to concretes without plastics.
2) Lakshmi and Nagan (2010) investigated the effects of e-plastic waste on the properties of concrete and found out that a significant decrease in strength occurred when the plastic content was more than 20%. They recommended that 20% of e-waste aggregate can be incorporated as replacement of coarse aggregate in concrete without any long term detrimental effects.
3) Rahman *et al.* (2010) reported that the incorporation of expanded polystyrene in concrete decreased water absorption while the compressive strength decreased with increase in polymer content due to the lower strength of expanded polystyrene.
4) Sangita *et al.* (2011) studied the use of plastics in road construction and concluded that the binding properties of polymer improved the strength of bituminous mixes.
5) Raghatate (2012) found out that 1% of plastic in concrete caused 20% reduction in compressive strength after 28 days of curing.
6) Chavan (2013) reported that the incorporation of plastic waste in bituminous mixes increased strength and performance and reduced the need for bitumen by about 10%.
7) Praveen *et al.* (2013) concluded that at a replacement of 20% of conventional coarse aggregates by recycled plastic, the compressive strength of concrete increased by about 27.4% compared to the control concrete, while at a temperature of 400oC, the compressive strengths of normal aggregate concrete and recycled plastics concrete reduced by 33% and 75% respectively.
8) *M. Kumaran, M. Nidhi, Bini P.R*
The work aims to study the possibility of disposing waste plastic as fine aggregate in concrete. In this study waste plastic mix concrete is also reinforced with polypropylene fiber to get the advantages of fiber reinforced concrete. For this, an experimental study was carried out with three different grades of concrete (M20, M25 & M30) to evaluate mechanical and durability properties of waste plastic mix concrete with and without the addition of fiber. Sand is substituted with plastic waste at a dosage of 15% by volume which is the optimum percentage without considerable reduction in strength. Results show that adding polypropylene fiber we can improve the quality of waste plastic mix concrete. The compressive strength of WPC was lowered by the addition of plastic, the reduction being in the range 4 to 7 %. But this loss was compensated to a certain extent by the addition of polypropylene fibers to WPC whereby the loss percent reduced to around 3 %. The flexural strength of WPC was lowered by the addition of plastic, the reduction being in the range 10 to 18 %. But this loss was compensated to a certain extent by the addition of polypropylene fibers to WPC. There will be an increase in flexural strength around 25 % when compared to Normal concrete. These results suggest that plastic waste mix concrete may be a useful cementitious composite with better durability characteristics than normal concrete.
9) Lakshmi and S. Nagan,
The paper presents the results of an investigation to study the performance of concrete prepared with E-plastic waste as part of coarse aggregate. An effort has been made to detail a systematic study of compressive strength of concrete with various proportions of E-waste as coarse aggregate in concrete. The test results showed that a significant improvement in compressive strength was achieved in the E-plastic concrete compared to conventional concrete. The tests were also designed to evaluate the internal pore structure, its chemical resistance to environmental agents and reactivity with some components of the cement. The results indicated that the E-plastic aggregate up to 15% weight of the coarse aggregate and replacement of cement with fly ash (10% by weight) can be used effectively in concrete and thus results in waste reduction and resources conservation.
10) *Sabarinathan. A, Dr.Suresh.S,*
This article focuses on the use of plastic fibers and m-sand as replacement materials in concrete. In this work, an attempt has been made to replace the coarse aggregate with plastic fibers and m-sand with river sand to study the behavioral changes in concrete with varying proportions. The fresh properties of concrete are studied to ensure that the workability of concrete is not affected or reduced. Specimens such as cubes, cylinders and prisms has been casted and tested at the age of 28 days to study the strength of concrete with and without replacement materials. From fresh concrete test results, it can be observed that the workability of concrete reduces as the percentage of plastic fiber increase. Ductility in concrete can be improved by the addition of plastic fibers with optimum volume content. Toughness and impact load is also increased to a greater extent.
11) *A.S.Balaji and D.Mohan Kumar*
Experimental investigation was done using M20 mix and tests were carried out as per recommended procedures by relevant codes and also Hair is used as a fibred reinforcing material in concrete as partial replacement of

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cement. Tests were conducted to determine the properties of plastic aggregate and human hair such as density, specific gravity and crushing value. Experiments were conducted on concrete cubes with various percentages of human hair i.e. 0%, 0.5%, 1%, 1.5%, 2%, and 3% by weight of cement and with constant percentage of plastic aggregate as 20%. The percentage of human hair were taken as 1%, 1.5%, 2%, 2.5%, 3%The percentage of human hair were taken as 1%, 1.5%, 2%, 2.5%, 3% it was found that the compressive strength was increased for 3% compared to normal concrete.

12) *Nabajyoti Saikia, Jorge de Brito,*
This paper presents a review on the recycling plastic waste as aggregate in cement mortar and concrete production, In the first section, types of plastics and types of methods used to prepare plastic aggregate as well as the methods of evaluation of various properties of aggregate and concrete were briefly discussed In the next two sections, the properties of plastic aggregates and the various fresh and hardened concrete properties of cement mortar and concrete in presence of plastic aggregate are discussed. The fourth section focus on the practical implications of the use of plastic waste in concrete production and future research needs. The incorporation of plastic aggregate can reduce the density of resulting concrete and cement mortar and therefore several studies were undertaken to prepare lightweight concrete by using various types of plastic aggregates.

13) *Brahimsafi Mohammed Saidi*
The work aims to study the possibility of recycling waste plastic (polyethylene terephthalate (PET) used for the bags manufacture) as a fine aggregate instead of sand in the manufacturing of the self-compacting mortars. For this, an experimental study was carried out to evaluate physical and mechanical properties of the self-compacting mortars (SCMs) with plastic wastes. The sand is substituted with the plastic waste at dosages (0%, 10%, 20%, 30% and 50% by weight of the sand).The physical (bulk density, porosity, water absorption and ultrasonic pulse velocity testing) and mechanical (bulk compressive and flexural strength) properties of SCMs were evaluated and a complementary study on micro-structural of the interface of cementations matrix and plastic waste. The measurements of physical and mechanical properties show that, in term of the density for materials, the mortars with 50% of plastic waste give better results than other proportion of the waste. Those mortars have a mechanical strength acceptable for lightweight materials. According to results obtained a reduction of 15% and 33% for mortar containing 20–50% plastic waste.

14) *Sukamal Kanta Ghosh, Ananya Chaudhury*
The paper illustrates the performance of pervious concrete with these sustainable materials replacing or partially replacing cement & aggregate. It is observed from the study that compressive strength of pervious concrete is increasing by introducing fly ash, furnace slag, and rice husk ash, silica fume, and solid waste (glass powder, ceramic waste, bottom ash). Whereas compressive strength is decreasing by addition of rubberized materials. Permeability is increasing with furnace slag, ceramic waste but glass powder, silica fume has no effect on permeability. Though rubberized materials decrease the tensile strength and compressive strength of pervious concrete, it increases the abrasion resistance & freezing–thawing resistance. Partial addition of rice husk ash, furnace slag, silica fume, glass powder also enhances tensile strength of pervious concrete.

15) *Rafat Siddique, Jamal Khatib*
This paper presents a detailed review about waste and recycled plastics, waste management options, and research published on the effect of recycled plastic on the fresh and hardened properties of concrete. The effect of recycled and waste plastic on bulk density, air content, workability, and compressive strength, splitting tensile strength, modulus of elasticity, impact resistance, permeability, and abrasion resistance is discussed in this paper. In general, the rate of reduction in strength was found to decrease with the increase in plastic aggregates content's. The use of the recycled plastic in the concrete reduced the overall concrete bulk density. When compared to conventional concrete, with the inclusion of 0.5% polypropylene fibers enhanced the impact resistance of concrete significantly.

16) *Charudatta P. Thosar, Dr.M.Husain*
Industrial wastes from polypropylene (PP) and polyethylene terephthalate (PET) were studied as alternative replacement of a part of a conventional fine sand of concrete. Four replacement levels, 20%, 40% & 60% by volume of aggregates were used for the preparation of the concretes. The results of this research suggested that PP and PET can be used in concrete containing 40% by volume of PP and PET as fine sand replacement give satisfactory result. The concrete for M20 grade has a nominal compressive strength is 20 N/mm2. Replacement of natural river sand by plastic waste material in 20% and 40% increase in the compressive strength of concrete up to acceptable limit.

17) *Arivalagan.S*
In their study, Tests were conducted to determine the properties of plastic aggregate such as density and specific gravity. As 100% replacement of natural fine aggregate with plastic fine aggregate is not feasible, partial replacement at various percentage were examined. The percentage substitution that gave higher compressive strength was used for determining the other properties such as modulus of elasticity, split tensile strength and flexural strength. Higher compressive strength was found with 10% natural fine aggregate replaced concrete.

18) Simiha Akcozoglu (2009) had made investigation by using PET plastic, concluded that use of shredded PET granules due to its low unit weight reduces the unit weight of concrete which results in reduction in dead weight of building will help to reduce the seismic risk of building the earth quake forces linearly dependent on dead weight .

19) Mariaenrica Frigione (2010) had conducted an investigation on using recycled PET bottles as fine aggregate in concrete and concluded the workability,

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compressive strength, split tensile strength is slightly lower than reference concrete and moderately higher ductility.

20) Semiha Akcaozoglu (2011) had conducted an investigation on mortars by using PET as aggregate and studied the effect of Granulated Blast Furnace Slag, Fly ash on light weight mortars and concluded that the use of fly ash has decreased compressive strength ,flexural strength , tensile strength when compared to cement specimens. Both Granulated Blast Furnace Slag and fly ash increased carbonation depths of specimens. For this reason carbonation reducing measures must be taken when using these mineral admixtures.
21) R.V.Silva (2012) had conducted an investigation on concrete containing paste waste as aggregate and influence of curing conditions on the durability related performance of concrete. He concluded that workability decreases with increasing amount of coarser, flakier and irregular shaped plastic aggregates. The gap between these values widened as all concrete specimens wore cured in progressively drier environments with reductions varying between 11.1%,28.3% of coarser plastic aggregate specimens cured.
22) Brahim Safi (2013) had conducted an investigation by using plastic waste a fine aggregate in self compacting mortars. This Concluded that this plastic waste type can be used successfully as fine aggregate in self compacting mortars (or concrete). Fluidity is significantly improved by the presence of these wastes. Reduction in Compressive strength was between 15 % and 33% for mortar containing 20 % to 50% plastic waste.
23) B.Harini and K.V.Ramana (2015) had conducted experiments on strength properties of M30 grade concrete are studied with different plastic percentage proportions. The various plastic proportions are 5%,6%,8%,10%,15%,20% by volume There is decrease in compressive strength when the ratio of plastic to aggregate was increased . For which compressive strength was least and to that mix have partially replaced cement with silica fume of 5%,10%,15% by weight. The strength properties were again studied, It was noticed that when cement was partially replaced by 10%, 15% of silica fume was higher than reference mix.

In 2018, Sanjay Thakur, et al studies fly ash concrete and the research study of silica fume concrete conclude that:

1) The use of both silica fume and fine aggregate will be overall beneficial
2) By the use of these there will be decrease in amount of cement and fine aggregate
3) The initial property of concrete like bleeding, segregation and slump will improve
4) There will be increase in the strength of concrete that is high strength performance concrete is formed.
5) The use of both fly ash and silica fume in concrete will overall enhance all the property of concrete and high strength concrete is achieved with the partial replacement of silica fume and fly ash.

24) In 2012, Ajay Verma, et al concluded in there paper that concrete is the most important engineering material and the addition of some other materials may change the properties of concrete. With increase in a trend towards the wider use of concrete for high rise buildings there is a growing demand of concrete with higher compressive strength. There are two types of materials crystalline and noncrystalline. Micro silica or silica fume is very fine non crystalline material. Silica fume is produced in electric arc furnace as a by-product of the production of elemental silicones or alloys, containing the silicon. Silica fume was initially viewed as cement replacement material and in some area it is usually used as replace by much smaller quantity of silica fume may be used as pozzolanic admixtures. Silica fume increases the strength of concrete more 25%. Silica fume is much cheaper than cement therefore it very important from economical point of view.
25) Mr.Vardhan Nagarkar, et al publishes a paper on green concrete in 2010. In which they conclude that green concrete is a very low energy and resources consuming material. And it is also reduces environmental pollution. This method is useful for saving natural resources for future generations. He also studied about the silica fume and conclude that cement is a scarce resources all over the world because the demand of cement increases day by day. At recent time the use of silica fume increases because when it mixes with cement its enhance the hardness and freshness of cement.
26) Mr.Vardhan Nagarkar, et al also studied about the emission of carbon dioxide from conventional cement and concluded that concrete is most common material used in construction field and it emits a large amount of environmental wastes. And carbon dioxide produced from concrete affects the global warming, etc.
27) Mr. Abhijeet Baikerikar studied about the factor affect on environment due to concrete from which he concluded that at recent time approximately one ton of carbon dioxide are emitted from one ton of cement. Carbon dioxide is one responsible gas for global warming. Without aggregates concrete cannot be produced.
28) WANG, H.-Y., ZENG, H.-H. & WU, J.-Y. - An experimental investigation was undertaken specifically concentrating on the mechanical and durability properties of polymer concrete. Recycled glass sand, fly ash (FA) and meta kaolin (MK) were used as fine aggregates in the concrete mix design. Five concrete mixes were prepared from which one was the control mix (no FA or MK content). The mixes were cast into moulds from which specimens in form of cylinders and prisms were prepared. These specimens were then tested to evaluate the performance of polymer concrete [3]. It is perceived that MK and FA mixes exhibited higher compressive strengths compared to the control mixes. After 28 days, the strength started to increase significantly. Mixes containing 15% FA attained the highest compressive strength after 28 days [10].
29) ZHAO, H., SUN, W., WU, X. & GAO, B - Another experimental investigation was carried out to study the properties of self-compacting concrete (SCC)

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comprising FA and ground granulated blast furnace slag (GGBFS) admixtures. Portland cement was replaced with FA and GGBFS by rates of 20%, 30% and 40%. One control mix mixture, three FA mixtures and three GGBFS mixtures were prepared [1]. The results shows that the compressive strength of FA mixes were slightly lower than the control mixes. After three days, the strength of 20% FA dropped by 5MPa. However, after 90 days the strength of all mixes was almost the same as the control mix [4].

30) KHALIL, E. A. B. & ANWAR - A laboratory investigation was performed to examine the properties of concrete comprising FA and SF. Cement was substituted with SF at portions ranging between 0-10%. Mixtures comprising both FA and SF were found to be effective in improving the strength properties of concrete. In addition, chloride resistance of concrete was also improved [5, 6].
31) ÇAKıR, Ö. & SOFYANLı, Ö. Ö. - An experimental research was performed to study the effects of SF on mechanical and physical properties of recycled aggregate (RA) concrete. Portland cement was replaced with SF by rates of 0%, 5% and 10%. Moreover, RA was replaced with natural aggregates (NA). The compressive strength results suggested that SF recycled aggregate concrete experienced reductions in early age compressive strength. However, after 28 days the strength of these mixes increased when compared to the control mix. Concrete mixes comprising 10% SF exhibited better performances in terms of mechanical and physical properties [7].
32) LONG, G., GAO, Y. & XIE, Y. - The relationship between mixing proportion parameters of self-compacting concrete (SCC) were examined in a further research. In that same research, the environmental impacts of SCC were also examined. Sixteen portions of SCC mixtures incorporating various by-products such as FA, slag and meta kaolin were created. The test results suggested that the addition of by-products reduced CO2 emissions. Furthermore, adding three mineral mixtures into SCC was more operative in reducing the environmental impact compared to the addition of single or two mineral admixtures. Therefore, addition of by-products such FA, slag and meta kaolin not only reduced CO2 emissions but also reduced environmental impacts [1].
33) RASHAD, A. M. - Laboratory study was performed to study the effects of concrete containing a combination of high volume fly ash (HVFA) and slag. Four different mixtures with various contents of HVFA and slag were prepared. After the mixes were prepared, specimens were constructed and tested. The test results suggested that the compressive strength of HVFA concrete was lower than PC concrete. Moreover, addition of slag to the concrete mix further reduced the strength. However, HVFA concrete displayed better fire performance compared to PC concrete. It was recommended not to mix slag with FA as it reduced the strength of concrete [8].
34) PANDA, K. C. & BAL, P. K. - A study was performed to examine the properties of self-compacting concrete using RA. NA was replaced with RA by rates of 10%, 20%, 30% and 40%. Six different mixes were prepared. Thereafter, specimens were created and tested. Test results suggested that an increase in RA content lead to a reduction in compressive strength, flexural strength and split tensile strength. Moreover, the properties of concrete in terms of strength were not improving when RA were used in the mix. Additionally, 30% replacement of RA helped to achieve the required compressive strength [9].
35) WANG, H.-Y., ZENG, H.-H. & WU, J.-Y. - A laboratory investigation was performed by towards macro and micro properties of concrete containing liquid crystal glass (LCD) glass. Cement was replaced with waste LCD by rates of 10%, 20%, 30%, 40% and 50%. In addition, natural sand was replaced with glass sand by rates of 10%, 20% and 30%. Various tests were performed to evaluate the performance of LCD glass. The test results suggested that addition of glass sand enhanced the compressive strength. Moreover, glass sand provided higher resistance and it improved properties of concrete with age. By utilizing glass in concrete, usage of cement and sand could be minimized which could help preserve the natural resources and reduce carbon emissions [10].
36) (Nielsen & Glavind, 2007) - In one research, the properties of concrete tactile blocks prepared with recycled tire rubber were studied. Sand was replaced with waste tire rubber by proportions of 10%, 20%, 30%, 40% and 50%. Six concrete mix designs were prepared, out of which one was the control mix. From each concrete mix, three specimens of sizes 150 x 150 x 500mm were prepared for flexural and compressive strength test. The test results revealed that rubber modified concrete obtained the same consistency as the control mix. The highest compressive strength was achieved when 10% rubber was cooperated in the mix design. This strength was also found to be higher than the control mix. It was concluded that 10% recycled tire mix could be used to make tactile paving blocks [11].The reduction in CO2 emissions can be done through: (a) the substitution of cement with flay ash, (b) the use of ground granulated blast furnace slag from steel plants, (c) use of micro silica, (d) the use of pozzolanic materials and limestone powder, (e) various kinds of ash from the burning of domestic waste and bio-fuels, and (f) crushed waste glass [12]
37) Uzal, Turanli, and Mehta reported that their initial research results with the concrete containing natural pozzolana high volume (50% of the mass of cementious material), which was named the High Volume Natural Pozzolana (HVNP) indicates achievement that promises to structural applications, reaching 14 MPa strength(aged 3 days) and 38 MPa (age 28 days). Natural pozzolana used is a low-calcium fly ash and granulated blast furnace slag. The larger portion of the fly ash can be used to substitute cement the reduction of CO2 emissions in the cement manufacturing process will also be reduced.
38) Glavind & Jepsen has prioritized taking 4 steps to go green concrete in Denmark, namely: (a) improving the utilization of residual products such as fly ash in large scale, (b) the use of residual products from concrete

plant, such as: stone dust, and concrete slurry, (c) the utilization of residual products of other industries, such as fly ash from bio-fuels and combustion of sewage sludge ash in waste processing installations, and (d) the use of a new type of cement that is more environmentally friendly, such as mineralized cement, the addition of limestone, and waste derived fuels.The comparison of CO2 emissions generated in the service life cycle of a bridge pillar located in aggressive environments (50 years, as a special case) by 4 kinds of different design principles, namely: (a) Reference column, made of conventional reinforced concrete, (b) A column made of green concrete (containing 40 ~ 50% fly ash), (c)B column made of green concrete (containing 40 ~ 50% fly ash) with stainless steel reinforcement, and (d) column C is made of green concrete (containing 40 ~ 50% fly ash) with stainless steel cladding have been investigated. It appears that the use of the three green concrete could reduce CO2 emissions by up to less than 30% compared to conventional concrete.

39) According to Mehta there are 3 structural engineer's tools for sustainability of the cement industry or reducing CO2 emissions: (a) consume less concrete for new structures, by developing innovative architectural concepts and structural design, using highly durable concrete, and using prefabricated elements for easy assembly,(b) consume less cement in concrete mixtures by using super plasticizer instead of more mixing water and cement to obtain the required consistency of fresh concrete, and optimizing the size and grading of aggregates, and (c)consume less clinker in the cementing material by selecting blended portland cements and concrete mixtures that contain high volume of coal fly ash, granulated blast-furnace slag, natural or calcined pozzolanas, silica fume, and reactive rice-husk ash.

IV. CONCLUSION

It was important to note that the quantity of by-product or waste replacement played a vital role to the properties of concrete. From all the previous studies, following points have been concluded:

1) There is significant potential in waste materials to produce such type of concrete.
2) To use phosphor gypsum as a replacement of cement in concrete.
3) To use thermosetting plastics as a replacement of fine aggregate up to certain limit in concrete.
4) To conduct experimental analysis for the strength of different grades of concrete.
5) To compare the economic feasibility of conventional concrete and such type of concrete made with recyclable materials.
6) To check the suitability of such materials in higher grade of concrete.
7) To conduct durability tests on high-performance concrete.

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