Impacts of nonconventional construction materials on concrete strength development: case studies

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Abstract

Sustainable building technology is a new approach adopted in built environment, which is focused on significantly reducing impact of the construction industry on the environment. Moreover, the world is largely driving development of sustainable and smart products to mitigate global pollution issues. In this study, assessment of the impacts of using alternative constituents such as crumb rubber, coconut shell, recycled aggregate, GGBS, human hair, banana fiber, industrial sludge, saw dust, rice husk, wood waste, textile, copper slag, textile, glass powder, plastic etc., on concrete strength development using case studies has been performed. The paper explores the research work carried out towards sustainable approach in replacement of basic composition of concrete. It focuses on various waste materials used as a substitute options in concrete and characteristic strength development along with potential challenges. Leading researches relating to sustainable materials were also explored. The results show that the alternative aggregates, mostly with minimally usage of about 20% increased the compressive strength properties of concrete. Usage of fibres to about increased the flexural property of concrete and the replacement of waste sludge didn't show appreciable increased of compressive strength.

Keywords Sustainable materials · Industrial waste · strength properties · Mix proportion · Performance of concrete

1 Introduction

The use of waste materials as workable alternative to the traditional material in concrete has increased popularity in current years, which is due to the overexploitation of the natural material sources [1–3]. Waste utilization in concrete has two advantages, discarding of waste in green manner and improving strength and durability properties of concrete [4, 5]. Concrete is one of the most utilized man-made material on the planet, and is mostly used substance next to water on the planet [6]. The production of concrete has increased and consequently constituting depletion of the natural resources. Hence, various studies are focusing development of green concrete, which is a beneficially conserves natural resources and reduce carbon emission

when compared to conventional concrete [7, 8]. Concrete is essentially consist of four ingredients, i.e. coarse aggregate, fine aggregate, cement and water [9]. Green concrete may be achieved by replacement of binder or adding discarded or recycled material [10, 11].

Overall, this study presents the cases of alternative construction materials and their effects on the strength development in concrete. Available materials in the open literatures were reviewed and discussed as appropriate. Furthermore, the challenges faced by the researchers pertaining to limitations of alternative material usage are discussed.

In the most recent decade, major development in green concrete has been led to the use of discarded items in concrete. Major waste materials utilized were fly ash, GGBS

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[12], rice husk [13, 14], carbon nano tubes [15], saw dust [16], cement Kiln Dust [17], coconut shell [18, 19], recycled asphalt [20], recycled aggregate [21–24], synthetic fibres [25], Metakaolin [26], quarry dust [27], wood waste [28], textile [29], disposed tyres [30], plastic [31–34], glass powder [35–37], Copper slag [38], human hair [9], Phase Change Material [39], Kadukkai [40], ceramic [41, 42] and many more. In essence, each of the waste materials have particular impact on properties of fresh and hardened concrete. The utilization of waste items in concrete makes it cost-effective as well as takes care of a disposal issues [43].

Improvement in technology throughout the world has shown that treated or unprocessed industrial by-products can be used in concrete, which gives an sustainable solution. This alternative solution, not just benefits in recycle of the waste material, but in addition makes a cleaner and greener condition [44]. The objective of materials management is to ensure that construction materials are accessible at their place of utilization when required. Construction management framework ensures that materials are of required quality and readily available at construction site location [45]. Thus, reintegrating wastes into fresh concrete matrix remains will increase sustainability drive at the construction sites. Moreover, using these materials aid the development of lightweight concrete, which is used for adaptability and economical significance [46]. Also, geopolymer materials are broadly utilized because of the change of the conversion of the waste into the eco-friendly material [47]. While several experimental reports have shown that waste materials can be utilized for concrete production, however, in the interest of concrete users and other stakeholders in the built environment, this study presents utilization of various waste materials in concrete, resulting characteristic strength attained, and limitations in utilization of those materials. The feasibility of largescale utilization of the materials was also explored. Thus, this study is expected to serve as guide book for concrete users.

2 Eco-friendly alternative materials for concrete

Several researchers explored the possibilities to make use of industrial waste as an eco-friendly replacement in concrete production. The significant facts and findings of different authors in the above-mentioned topics are presented in Table 1. As a sustainable approach, alternative materials such as red mud, iron ore [48], human hair, rubber, ceramic, marble dust, recycled glass, fly ash, granite waste, recycled aggregate, wood waste, GGBS, bagasse ash, rice husk ash, coconut shell, treatment plant sludge, bamboo, brick waste, used PET bottles, Waste carpet fibre,

synthetic fibres, bagasse ash [49] etc., are added in different proportions as the partial replacement of cementitious material, fine aggregate, coarse aggregate or additives. Most of the researchers have conducted test on hardened concrete. The tests like Compressive Strength, Flexural Strength Water absorption test, Split tensile Strength, Modulus of rupture, Chloride diffusion, SEM, Dynamic modulus of elasticity were conducted and the results were exhibited. The study examines how the incorporation of various eco-friendly materials influences the compressive strength properties of concrete.

3 Impacts of alternative materials on concrete strength

3.1 Quarry fines

Stone waste can be utilized as substitution of concrete to accomplish extraordinary properties of cement. The utilization of the substitution materials offer cost effective, energy savings, better-quality products, and less perils in the earth [71]. The GSW (Granite Sawing Waste) is having more than 20% of silica thus it can be utilized as a additional material for cementitious substance in concrete. The primary composition of GSW which are SiO_2 , Al_2O_3 , CaO and Fe_2O_3 and minute molecule size ensure their utilization of substitution material for concrete in concrete [72]. At the point when the GSW is utilized as a replacement material for concrete by 10% it increases the compressive strength quality only up to 2.43%, represented in Fig. 1. On the other hand, upto 15% of GSW can be utilized without the loss of compressive quality on account of their molecule size distribution and potential pozzolanic activity. The hydration and void filling nature of GSW causes the increase in density of concrete [27, 41, 54, 56]. Khan utilized materials like dolomite, marble residue [73] in several portion of cement replacement with dolomite, fly ash and marble dust, the investigation is carried out for M30 grade of concrete [74] as a result compressive strength of the concrete is amplified, the optimum mix of 6% dolomite powder is shown in Fig. 2.

3.2 Ceramics

Ceramics wastes emanating from construction industry and those sourced from production sites have been used for concrete production [11, 75]. He replaced ceramic waste as coarse and fine aggregate (CCA&CFA) in the replacement of 25% to 100% and it was observed that the compressive strength gained in the later stage at 28 days [42]. As contrasted to conventional concrete, on accumulation of ceramic waste powder to concrete its characteristic

Table 1 Sustainable materials used and tests conducted

Authors	Alternate materials used	Replacement	Test conducted
Shetty et al. [48]	Red mud and iron ore	RM- 1%, 2%, 3% & 4%	Compressive strength, flexural strength split tensile strength
Tayeh et al. [50]	Iron powder	0%, 10%, 20%, 30% & 40%	Hardened density, compressive strength, flexural strength
Parul Mangal et al. [9]	Rubber	15%, 25% & 35%	Compressive strength, chloride diffusion, SEM Dynamic modulus of elasticity
Mousavimehr et al. [51] and Alaloul et al. [52]	Crumb rubber	0%, 15%, 30%	Compressive strength, split tensile strength, modulus of elasticity
Amin et al. [53]	Ceramic powder	10%, 20%, 30%	Split tensile strength, modulus of rupture
Azmi et al. [44]	Ceramic,	0%, 10%, 20%, 30%	Compressive strength, water absorption
Awoyera et al. [6]	Marble dust		Split tensile strength, modulus of rupture
Salman et al. [54]	Recycled glass	10%, 20%, 30%	Compressive strength, flexural strength split tensile strength
Yidizel et al. [55]	Glass fibre		
Aarthi K et al. [56]	Granite waste	10%, 20%, 30%	Flexural strength
Tawfik et al. [57]	Nano silica	0% to 35%	Ultrasonic pulse velocity
Jason et al. [58]	Recycled aggregate	10%, 20%, 30%	Compressive strength, split tensile strength
Safin et al. [59]	Wood waste		Compressive strength
Yogendra O. P et al. [60]	GGBS	0% to 40%	Compressive strength, flexural strength
Murthi et al. [61]	Bagasse ash	5%, 10%, 15%, 20% and 30%	Compressive strength, split tensile strength, flexural strength
Tayeh et al. [62]	Bottom ash		
Awoyera et al. [63]	Bamboo	5%, 10%, 20%, 30%	NDT, Load deflection test, flexural tests
Awoyera et al. [64]	Rice husk ash	178.93 kg/m ³	Sorptivity test, sulphate attack, Compressive split tensile and flexural strength
Murthi et al. [65]	Coconut shell	25%, 50%, 75% and 100%	Water absorption, compressive strength, SEM
Mathimalar et al. [66]	Brick waste	10%, 20%, 30%	Compressive strength
Dora Foti [67]	Waste bottles	5%, 10%, 15%	Load displacement
Abdul Awal et al. [68]	Waste carpet fiber	1% to 5%	Compressive strength, split tensile strength Flexural strength
Gobinath et al. [69]	Banana fibre	0% to 0.5%	Compressive strength, flexural strength
Azevedo et al. [70]	Natural fibre		
Teja et al. [49]	Sugarcane bagasse ash	20%	Sulfate attack test, MIP analysis, Torrent air-permeability test, surface resistivity

strength is steadily decreased. So the ceramic waste powder has been replaced by up to 30% by weight of cement without distressing the characteristic strength of M20 grade concrete [76]. Azmi et al. [44] explored the Compressive quality and water absorption of the specimens which contain Recycled aggregates (RA) in different proportions from 25% to 45% and ceramic (C) in from 5 to 15% were assessed is shown in the Fig. 3. Highly cited article related to eco-friendly replacement in concrete is shown in the Table 2.

3.3 Synthetic fibres

Synthetic fibres, such as polypropylene fibres, basalt fibres, polyester fibres, glass fibres, carbon fibres, steel fibres, Forta fibres, mineral fibre, aramid fibre, bonifibres, steel wool fibres, acrylic fibres are generally added to improve the performance of the bituminous mixes. The studies

carried out by adding these fibres are reviewed in this section. The most extreme ideal measurement of fiber in glass fiber reinforced concrete by compressive test is obtained at 0.5% glass fiber and 2% Nano silica. The normal 7 days compressive strength is 38.66MPa and 28 days compressive strength is 56.88 MPa. Up to 0.5% glass fiber and 2% nano silica, there is a slow increment in Strength at 28 days like the compressive quality of 7 days, and afterward there is a progressive abatement of compressive quality. This might be because of increment of fibrous material in concrete. From the test outcomes it shows that there is an increase of about 17% of compressive quality by usage of 0.5% glass fiber and 2% nano silica [77, 78, 79]. Awal represents results of cement holding fiber from reused carpet waste. Concrete mix containing 0.5%, 1.0%, 1.5% and 2.0% polypropylene (PP) carpet waste filaments were made and tried for compressive, tensile and flexural strength (Table 3).

Fig. 1 Effect of GSW on the compressive strength of concrete (data from [56])

Fig. 2 Effect of Dolomite Powder on the compressive strength of concrete [74]

From the results it is concluded that the compressive strength in 28 days decreased by 21 MPa even at the addition of 2% CFRC, Hence there is no advantage of adding CFRC [68]. The soil tests with banana fiber content is experimented and it shows that the strengthened soil with 0.5% banana fiber content had its Unconfined Compressive Strength expanded by 1.8 MPa over the control soil. The expansion in the Unconfined Compressive Strength of the reinforced soil was because of the shear transfer by the banana fibre [69]. Even addition

of PET bottle fibre in very small quantity reduces post cracking behaviour in concrete [67] (Fig. 4).

3.4 Ground granulated blast furnace slag

The ground granulated blast furnace slag (GGBS) is a waste from the iron assembling industry, which is utilized as partial substitution of concrete because of its natural cementing properties. In the nation like India, where the improvement of the infrastructure projects is high, such employments of waste material in concrete won't just decrease the outflow of greenhouse gases yet in addition will be the reasonable method for the management of waste [60]. Models for anticipating compressive strength, split tensile strength and flexural strength were developed dependent on various mix of materials. The R^2 of 0.9996 was obtained for compressive strength and Mean Square Error as obtained as 0.9365 [80]. Kalai-vani included fly ash and GGBS in the form of powder in the proportion of 60% and 40%. As the result the load carrying capacity of the beam increased by 28.33% when compared to standard specimen. On comparison with standard specimen the stiffness characteristics of beam also increased about 38.77% [81]. Shreyas attempted to strength characteristic study of sustainable concrete mix with GGBS incorporation as a partial replacement of cement. He made a conclusion that GGBS imparted filler effect within the concrete without detrimental to the overall strength. He also found that 28 days of compressive strength increased adding GGBS up to of 20%. The workability of concrete with GGBS addition up to 30% cement replacement in M35 grade concrete was found to be within a safer limit [82].

3.5 Rice husk ash

SCC develop somewhat higher compressive also, flexural strength than other blends. Obviously, the quality improvement was due to pozzolanic reactivity of the Rice Husk Ash. With the outcome acquired, it shows that pumice, even in spite of the fact that are more fragile in compression can be used for construction when combined with other pozzolanic material, for example, GGBS and RHA [64]. Partial replacement of granite with coconut shell from 0 to 100% in increment of 25% was considered for the mix. Rice husk ash and Silica fume were considered for creating binary and ternary mix of self-combining concrete with total powder content of 450 kg/m³ and 550 kg/m³. The 75% CSA in 28 days reflected on the compressive strength, more than 21.72 MPa as observed it satisfies the necessities of lightweight concrete [65].

Fig. 3 Impact of recycled aggregate and ceramic on the compressive strength of concrete (Data from [44])

Table 2 Leading researches relating to sustainable materials

Authors	Material used	Year	Citations
Ilker Bekir T et al.	Waste marble dust	2009	255
Dora Foti	Waste bottles PET fibers	2011	196
Moura et al.	Copper slag waste	2007	76
Wang et al.	Waste coal gangue and fly ash	2015	69
Omar et al.	Marble powder	2012	65
Swaptik et al.	Wood waste	2015	33
Omid R et al.	Crumb rubber and metakaolin	2016	29
Teja et al.	Agro-waste	2019	8
Zeyad et al.	Volcanic pumice powder and polypropylene fibers	2020	12

3.6 Recycled aggregate

A huge quantum of construction waste is spawn from progressively more number of construction activities than in the earlier period which has considerable depressing impacts on the environment if they are not suitably managed [83, 84]. The utilization of demolition and industrial waste as construction materials is attractive solution for massive disposal of waste. Recycled aggregate in 25%, 50% and 100% replacement ere tried, optimum mix was found to be at 50% replacement with compressive

strength of 30 MPa [58]. The mechanical properties of concrete pavement utilizing reused Aggregate acquired from the demolished buildings as coarse aggregate are experimentally determined. The strength properties were determined after 3, 7 and 28 days of curing period. No critical decrease of strength was seen up to the 30% substitution of recycled aggregate. From the compressive strength outcomes got right now, was presumed that the recycled aggregate could be utilized around 40% as Coarse Aggregate replacement to maintain pavement quality [85]. Earthenware (fine and coarse parts), river sand, and granite were replaced in the range of 0 and 100%, laterite between 0 and 30%, and curing was done for 3 and 91 days. Compressive strength test data were trained and validated with the regression fit of 0.998 [86]. Concrete column filled with Recycled aggregate resist 66–121% more compression load than hollow columns and 6–10% more than columns filled with plain concrete [87]. Recycled aggregate from Valnor, Vimajas, Ambilei, Europontal and Retria plant was taken for research. Compressive strength loss in 28-day those with RA from Vimajas and Europontal (44.1% and 44.6%), is higher relatively to those with RA from Ambilei (28.8%). It was likewise discovered that, in request to keep up the droop, it was important to note that to maintain the slump value water cement ratio is to be increased. One of the factors influencing the results were size of the recycled

Table 3 Properties of some common materials used in sustainable concrete

Waste materials	Source	Properties
Fibres	Optic fibre waste	Increases bending strength in concrete Increase ductile properties
Human hair	Saloon waste	Improves ductility and binding properties, micro cracking control
Rubber	Old rubber tier	Reduce stiffness of concrete, increases flexibility
Ceramic	Ceramic industry, Construction waste	Reduced the permeability of concrete
Recycled glass	Glass manufacturing	Decreased the chloride diffusion and expansion of the alkali-silica reaction
Recycled aggregate	Construction industry waste	Reduce the shrinkage of concrete
Wood waste	Municipal solid waste, wood packaging	Lightening the concrete blocks and improving thermal and acoustic properties
GGBS	Blast furnace	Later age strength and durability characteristics
Bagasse ash	Sugar industry	Enhanced Pozzolanic properties
Bamboo	Agro waste	High compressive strength and low weight
Rice husk ash	Agro waste	Porosity and water absorption
Coconut shell	Agro waste	Lightening the concrete, impact resistance
Brick Waste	Construction industry waste	Increases water absorption
PET bottles	Municipal solid waste	Cannot react with cement, stability against erosion
Banana fibre	Agro waste	Toughness and tensile strength. The cracking resistance of the concrete

Fig. 4 Compressive strength of concrete by replacing Carpet Fibre Reinforced Concrete (Data from [68])

aggregate. The compressive strength reduced greatly in fine aggregate replacement than in Coarse aggregate replacement [88].

3.7 Fly ash

Kavitha investigated impact of Fly Ash (FA) and Metakaolin (MK) on the Grade 40 High performance concrete. Ordinary Portland cement of 385 kg/m³ was used, while the Fine aggregate was supplemented up to 30% by weight of cement. Compressive strength increment is observed as

8.1% higher than controlled concrete at due to fast pozzolanic action [89, 90]. Anand kumar studied the effective utilization of fly ash as supplementary cementitious material in concrete. Class F fly ash and GGBS are used as the part replacement for cement at different mix proportions. Results show that high volume fly ash concrete developed with GGBS up to 70% as fly ash binder. Compressive strength decreased as compared to the control concrete as at binder percentage around 20%. As the GGBS increases, the workability reduces to the same water-cement ratio. With a 70% fly ash and 10% GGBS as binder promising compressive strength arrived [91]. Marthong took up the test verification of the effects of adding fly ash to the cement mantle of concrete matrix, at selected dosages of 10 to 40%. The research of the study fortified a promising results of compressive strength in 20% partial replacement of fly ash with cement, aiming at overall reductions in cement consumption and cost [92].

3.8 Steel slag

Ducman explored the potential for the usage of steel slag in the refractory concrete lining. The investigation also included in XRD for the evaluation, micro structural level. However, the investigation reported that the slag under investigation was not stable at high temperatures, exhibiting significant expansion and cracks which might lead to lower degrees of mechanical properties. It was also confirmed that between 7000C to 8000C there was an irreversible phase transformation within the slag as confirmed by an in situ XRD analysis. it has been exposed in

the examination that rice husk ash mixed [93]. Adegooye et al. explored the impacts of EAF and stabilized argon oxygen decarburization (AOD) stainless steel slag as coarse aggregate substitute in concrete. Substitution of coarse aggregate with the EAF and AOD slag aggregates amplified the compressive strength of concrete [94, 95]. The chloride penetration resistance slightly improved with EAF slag aggregates and decreased with CDW [96].

3.9 Glass fibre

Salman investigated the behavior of concrete by utilizing glass powder as a partial replacement of cement. Different mix combinations have been proposed with an equal interval of 10% as a single replacement and blended combinations for testing the mechanical properties of concrete. Test results show that when compared with conventional concrete compressive strength increases about 30% at seven days. At the age of 28 days, compressive strength value increased nearly about 32% when compared with conventional concrete with the replacement of fly ash about the addition of 10% [97]. The glass powder were added in 0.0%, 5.0%, 10.0%, 15.0%, 20.0% and 25.0% by weight of concrete. The test outcomes indicated that the glass powder had pozzolanic trademark and the utilization of glass powder had insignificant impact on setting time. The utilization of 10% glass powder as concrete substitution upgraded the mortar compressive strength by about 9.0% [98]. The ideal glass content of 20% is replaced and concrete compressive strength at 90 days was observed to be 2% higher than the controlled specimen [99] (Fig. 5).

3.10 Other materials

In spite of the way that at present there are various research and developments [100] of about the utilization of the bark, remembering for the production of construction materials, utilization of wood bark as a filler in a quantity of over 15% by weight of totally dry binder lowered the compressive strength of the concrete [59, 101]. The examination concentrated on the improvement of the quality properties of high-performance concrete utilizing ternary mixed concrete, in view of Nano-silica (NS) and bagasse Ash (BA) addition to Portland concrete [102]. As predictable, steel-reinforced beams were superior in terms of strength transversely all curing regimes; though, component reinforced with 50% bamboo, although with about 14% lesser strength but contain negligible buckle and crack dissemination, can also be a sustainable choice for construction [63]. It very well may be deduced that the usage of shades in hued concrete do not contain unconstructive impact on the quality and substantial attributes of hardened concrete [103]. It is seen that conventional

Fig. 5 Compressive Strength of concrete by replacing Glass Powder (Data from [98])

cement has more noteworthy permeability when contrasted with the concrete containing alccofine and zinc oxide. At the point when concrete is supplanted by alccofine and zinc oxide, the penetrability of cement diminished. Likewise, the elasticity, compressive quality and flexural quality are elevated [104]. Accessibility of natural sand is decreasing day by day and is seriously influencing the development of construction field. On the other side, disposal of used tyre is difficult. Right now, experimental investigation is carried out to determine the usage of crushed tyres as fine aggregate in concrete. Compressive strength is determined by replacing tyres by 0, 5, 10, 15, 20 and 25% and silica fume by 0, 5 and 10% [105]. Brick bats were added in 10%, 20% and 30%, 40% as partial replacement of coarse aggregate along with granite powder, addition of brick bat above 20% reduced the compressive strength of the concrete [66]. In the tension zone partial replacement of bamboo in the beams exhibit to be highly effective [61].

4 Discussion

Thus, this study investigates the impacts of nonconventional construction materials on concrete strength development using case studies. The following are mostly considered when using waste materials as replacement, processing and transportation, reuse, recycling and final disposal of unused materials. Findings from the 105-literature related to sustainable materials leads to the broad understanding of eco-friendly material used. The workability of the concrete reduces when the ceramic powder

is replaced with cement, Super plasticizers are added to improve the workability in such cases [43]. Analysis of fresh properties of eco-friendly material plays a vital role in selection of design mix and improving the strength property of concrete. Addition of GGBS declined the compressive strength, with minimum replacement below 20% and 90 days curing maintained the compressive strength [60]. The mechanical qualities development over the time is encouraged and the Young's modulus show that there is no damage found due to chemical reaction between the steel slag and concrete. Impregnation of steel slag also improved the density and porosity of normal concrete [95]. Replacement of crushed walnut shell for both coarse and fine aggregate up to 15% reduced both compressive and split tensile strength, it is not advisable to choose this eco-friendly material [19]. RHA and SBA was replaced for fine aggregate in concrete and found to achieve strength at 56 days in par with control mix [49]. Number of mix proportions are tried by different authors, the final aim of which is to increase the strength and durability properties of concrete. The reduction in strength is compensated with addition of fibres (banana fibre, optic fibre, steel fibre etc.,). Hence the usage of wide form of waste material in the concrete to convert it in to sustainable material by reducing carbon foot print is encourage with achieving essential strength and durability characteristics and formation of practical guidelines is essential.

5 Conclusion

Overall, the significance of alternative construction materials on strength development of concrete is has been explored by numerous researchers. This kind of research work on sustainable approach will provide awareness among the researchers and it would be motivation to develop new products on green material. Optimum addition of granite saw dust of about 10% increased the compressive strength, in replacement of about 15% to fine aggregated decreased compressive strength. Addition of Carper fibre Reinforced Concrete decreased the compressive strength of the concrete; hence it is not recommended. Steel fibres increased the compressive strength even at the addition of 2%. GGPS is replaced even up to 40% and notable increase in the strength of about 30% when compared to control mix as achieved. Rice husk ash can be replaced by cement due to its pozzalonic property and notable increase in strength was observed. Size of the recycled aggregate influenced the compressive strength of the concrete. Strength properties varied between sources of aggregate from different plants. Loss of compressive strength was observed more in fine aggregate replacement than in coarse aggregate replacement. Most

of the replacement of eco-friendly materials like ceramics, quarry dust, brick bat, ensures replacement only upto 30%. Glass fibre incorporation in concrete increased the compressive strength in minimum of 2%, for 10% replacement. If a code is developed for sustainable replacement, it would be acceptable in the people's mind and can be easily marketable.

6 Scope for further research

As the sustainable goals of India have to be reached in future, there is large scope in utilization of eco-friendly material in construction industry, which is the largest growing sector. Research on various properties of concrete is recommended.

1. Under extreme environmental condition, the durability properties of sustainable materials should be analyzed.
2. Mix design is made by the researchers according to the experience and trial mix, perfect mix design procedure is until now to be recognized.
3. Attention on utilization of feacal and sewage sludge for replacement of fine aggregate should be considered
4. Consideration of structural element for earthquake resistant buildings with seismic performance of sustainable material.

Compliance with ethical standards

Conflict of interest Authors declares that there is no conflict of interest.

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