Review paper on material properties of high performance concrete

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Abstract:
In modern years, effective utilization of high performance concrete in construction because of their increase in durability and mechanical properties. In particular high performance concrete is made by replacing/introducing mineral admixtures and chemical admixtures with cement or replacing/introducing the fibers into the concrete. The focus of this review is to illustrate the properties of the various materials used, mix proportion of materials to make high performance concrete and observation of high performance concrete. Moreover there are three main groups which are important in manufacture of high performance concrete they are increase of workability, increase of strength and increase of durability. Finally the studies on the high performance concrete have been reviewed.

Keywords: mineral admixtures, chemical admixtures, mechanical properties, durability properties, high performance concrete

1. Introduction
Conventional concrete made by certain mix ratio gives certain strength and durability. The concrete mixture which gives high strength and durability is called High Performance Concrete (HPC). HPC contains one or more binding materials to give high properties. Reduction in water to binder (cement) ratio, addition of binding materials and plasticizers gives increase of mechanical and durability properties [1]. Three main groups are important in production of HPC they are, increase of (workability, durability and strength) (Figure 2). Mix design of producing HPC with these three groups is a hard task [2]. Many materials are introduced and replaced with binding material, such introduced materials are (fly ash, silica fume, fine fly ash) [2], (recycled concrete aggregate, waste cellular concrete powder, waste perlite powder, unprocessed waste fly ash) [3], (normal dolomite aggregate, air-cooled slag derivative, iron ore aggregates) [4], (double hooked end steel fibers, GGBS) [5], incinerated hospital wastes [6], (polycrystalline fibers, air entraining admixtures) [1], (conventional reactive pozzolanic powder of silica fume, waste glass powder) [7], copper slag [8], recycled stone slurry [9], (palm kernel shells, crushed palm kernel, palm kernel ash) [10], basalt fibers [11], (steel slag, crystallized slag, limestone aggregate) [12], [12]metaaol [13], (cold bonded lightweight aggregate, alkaline activator solution, fly ash grade class F) [14], calcined illite clay [15], black/oxidizing electric arc furnace slag [16], fabric/sheet materials [17], ceramic waste powder [18], discarded timing belts in fibers from car [19], rice husk [20], cenospheres (hollow fly ash particles) [21], shrinkage reducing admixtures [22], natural zeolite [23], rice husk ash [24], (Nano-ZrO2, Nano-Fe3O4, Nano TiO2 and Nano-Al2O3) [25], (waste foundry sand, coal cinder) [29], polluster and epoxy resin [30], marble powder [31], fine-ground ceramics [32], calcined Czech clay stone [33], siliceous limestone additions [34], pre saturated lightweight aggregate [35].

Combination of above materials by replacing with binding materials gives high performance concrete, however due to large amount of replacement of supplementary materials can cause reduction in the durability and mechanical properties. There is a certain limitation for supplementary materials to
attain HPC, such limitation for different materials can studied in this paper. There are varies types of special concrete (Figure 1). This paper discussed about properties of used materials, mix proportion and observation of high performance concrete is reviewed.

![Figure 1. Types of special concrete][36]

2. Properties

Many combination of materials has been used as replacement for binding materials(cement). Each materials have different chemical and physical properties and their replacement percentage has been limited so that it should not reduce the strength and durability of the concrete. Properties of each materials can be discussed as follows

3. Material properties and discussion:
The chemical and physical properties on CEM1, CEM2, fly ash, fine fly ash, silica fume, quartz powder, quartz sand are observed[2]. The chemical and physical properties on CEM1, Unprocessed Waste Fly Ash(UWFA), Waste Cellular Concrete Powder(WCCP), Waste Perlite Powder(WPP-c), Waste Perlite Powder(WPP-s), that is smaller and larger particles when compared binding material was observed[3]. The chemical properties on Ordinary Portland Cement(OPC), Coarse aggregates(Hematite, Dolomite, Air cooled slag, Ilmenite, sand), Silica Fume(SF) and physical properties of coarse and finer portion on coarse aggregate(Hematite, Dolomite, Air cooled slag, Ilmenite, sand) are observed[4]. The chemical and physical properties on cement and Ground Granulated Blast-furnace Slag(GGBS) are observed[5]. The pharmaceutical wastes stored for 1 year in environment having 5% calcium chloride and in drinking water are observed[6]. The chemical and physical properties on waste glass powder(used) are observed[7]. The chemical and physical properties of Ordinary Portland Cement(OPC), Silica Fume(SF), locally manufactured metakaolin are observed[11].

Chemical and material properties of cement, mineral admixture, aggregates(steel slag, limestone, sand, crystalized slag) are observed[12]. Silica fume(silica based), metakaolin(alumina-silicate based) as a replacement with cement are observed[13]. Physical and chemical composition of fly ash, ground granulated blast-furnace slag, rice husk ash, cement are observed[14]. The chemical symphony of Portland cement, silica fume, calcined clay are observed[15]. The physical properties of natural aggregate sand, natural aggregate gravel, electric arc furnace slag are observed[16]. material properties of aggregates used(fine aggregates, coarse aggregates), cement, admixtures, polypropylene fibers, metal fabric are observed[17]. Ceramic waste powder, fine aggregate(crushed stone), fine aggregate(dune sand), coarse aggregate, cement, water cement ratio are used[18].

The chemical properties of cement, silica fume are observed[19]. Cement, sand, coarse aggregate, fly ash, rice husk ash, condensed silica fume, and chemical properties of cement, silica fume, fly ash, rice husk ash are observed[20]. The chemical properties of type 1 Portland cement,
cenospheres and sand are observed[21]. Physical and chemical properties of Portland cement, silica fume, slag, fly ash, fine aggregate, coarse aggregate, high water reducing admixture(poly-naphthalene sulfonate, glycol ether) are observed[22]. The chemical properties of binding materials(cement type 2, natural zeolite, silica fume, fly ash) are observed[23]. The physical properties of Portland cement, pozzolanic materials, aggregates(crushed basalt, coarse sand, fine sand) and chemical properties of Portland cement, pozzolanic materials, super plasticizer[24]. Cement, metakaolin, super plasticizer, Nano-ZrO2, Nano-TiO2, Nano-Al2O3, Nano-Fe2O4 are observed[25]. The chemical properties of ordinary Portland cement are observed[26]. Water, cement, coarse aggregate, super plasticizer, bar chip fibers, fine aggregate are used[27].

Chemical properties of cement and silica fume. Super plasticizer (polycarboxylate ether are observed[28]. Portland cement CEM1, silica fume, granite, gravel, coal cinder, quartz sand, waste foundry sand, super plasticizer are used[29]. The physical and chemical properties of cement, properties of resins(polyester resin, epoxy resin) are observed[30]. Marble powder, Portland cement, aggregate are experimented[31].Chemical composition of cement, fine-ground ceramics and properties of fresh mixtures, basic physical properties of fresh mixtures are observed[32].The chemical composition of cement and fine fillers and pozzolans phase composition, Portland cement, silica fume, calcined Czech clay stone, aggregates, super plasticizer are observed[33]. The physical properties of white cement, chemical and mineralogical charact erizes of binding material(cement), substantial properties of used river sands, grinded dune sand, used limestone fillers were the materials used[34]. Table 1 discusses the various materials used to produce high performance concrete as evaluated in different studies.

Table 1: Various materials introduced into the concrete to produce high performance concrete.

| Researcher/Year | Materials Introduced | Outcome/Findings |
|-----------------|----------------------|------------------|
| Abd Elrahman, Mohamed Hillemeier, Bernd[2]/2014 | fine fly ash, silica fume, fly ash | Better performance of concrete |
| Abed, Mohammed Nemes, Rita[3]/2019 | Recycled concrete aggregate, waste perlite powder, waste cellular concrete powder, unprocessed waste fly ash | Better performance of concrete |
| Abo-El-Enein, Salah A. El-Sayed, Hamdy A. Ali, Ali H. Mohammed, Yasser T. Khater, Hisham M. Ouda, Ahmed S.[4]/2014 | Silica fume, iron ore aggregate, normal dolomite aggregate, air cooled slag | Better performance of concrete |
| Afroughsabet, Vahid Biolzi, Luigi Ozbakkaloglu, Togay[5]/2017 | Recycled concrete aggregate, GGBS, double hooked end steel fibers | Better performance of concrete |
| Aissa, Talah Rachid, Belaid Kharchi, Fattoum[6]/2018 | Incinerated hospital waste | Better performance of concrete |
| Akca, Abdullah Huzeyfe Özyurt Zihnioğlu, Nilüfer[1]/2013 | Polypropylene fibers, air entraining admixture | Better performance of concrete |
| Ali, Msheer Hasan Dinkha, Youkhanna Zayia Haido, James H.[7]/2017 | Pozzolanic powder of silica fume, waste glass powder | Better performance of concrete |
| Al-Jabri, Khalifa S. | Copper slag | Better performance of concrete |
| Name(s)                                                                 | Material(s)                                                                 | Result                                                                 |
|------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------|
| Hisada, Makoto Al-Oraimi, Salem K. Al-Saidy, Abdullah H.[8]/2009       | Concrete                                                                     |                                                                      |
| Almeida, Nuno Branco, Fernando de Brito, Jorge Santos, José Roberto[9]/2007 | Recycled stone slurry                                                      | Better performance of concrete                                        |
| Alsalami, Zainab Hashim Abbas Harith, Iman Kattoof Dahir, Mohammed K.[10]/2018 | Palm kernel shells, palm kernel ash, crushed palm kernel                     | Better performance of concrete                                        |
| Andreu, Gonzalez Miren, Etxeberria[37]/2014                            | Recycled concrete aggregate                                                | Better performance of concrete                                        |
| Aslani, Farhad Hamidi, Fatemeh Valizadeh, Afsaneh Dang, Anthony Thanh-Nhan[38] | Hooked end steel, polypropylene.                                           | Better performance concrete                                           |
| Ayub, Tehmina Shafiq, Nasir Nuruddin, M. Fadhil[11]/2014               | Basalt fiber                                                                | Better performance of concrete                                        |
| Biskri, Yasmina Achoura, Djamel Chelghoum, Nourredine Mouret, Michelf[12]/2017 | Silica fume, GGBS, steel slag, limestone aggregate, crystallized slag       | Better performance of concrete                                        |
| Bui, Le Anh-tuan Hwang, Chao-lung Chen, Chun-tsun Lin, Kae-long Hsieh, Meng-ying[14]/2012 | Class F fly ash, cold bonded light weight aggregate, alkaline activator | Better performance of concrete.                                      |
| Chang, Ping-Kun[39]/2004                                               | Fly ash, blast furnace slag or rice husk ash                                | Better performance of concrete                                        |
| Chen, J. J. Ng, P. L. Li, L. G. Kwan, A. K. H.[40]/2017                | Fly ash microspheres, condensed silica fume                                 | Better performance of concrete                                        |
| Dembovska, Laura Bajare, Diana Pundiene, Ina Vitola, Laura[15]/207     | Silica fume, calcined illite clay                                           | Better performance of concrete                                        |
| Dybel, Piotr Furtak, Kazimierz[41]/2017                                | Silica fume                                                                  | Better performance of concrete                                        |
| Elahi, A. Basheer, P. A. M. Nanukuttan, S. V. Khan, Q. U. Z.[42]/2010  | Silica fume, fly ash, ground granulated blast-furnace slag                 | Better performance of concrete                                        |
| Faleschini, Flora Alejandro Fernández-Ruiz, M. Zanini, Mariano Angelo Brunelli, Katya Pellegrino, Carlo Hernández-Montes, Enrique[16]/2015 | Black or oxidizing electric arc furnace slag                                | Better performance of concrete                                        |
| Authors | Year | Materials Added | Impact on Concrete Properties |
|---------|------|----------------|-----------------------------|
| Funk, Birgit Trettin, Reinhard Zoz, Henning | 2017 | GGBS | Better performance of concrete |
| Gonzalez-Corominas, Andreu Etxeberria, Miren | 2016 | Recycled concrete aggregate | Better performance of concrete |
| Han, Cheon-Goo Hwang, Yin-Seong Yang, Seong-Hwan Gowripalan, N. | 2005 | Polypropylene fibers, sheet materials or fabric | Better performance of concrete |
| Kannan, Dima M. Aboubakr, Sherif H. El-Dieb, Amr S. Reda Taha, Mahmoud M. | 2017 | Ceramic waste powder | Better performance of concrete |
| Khaloo, Ali Reza Esrafili, Amin Kalani, Masoud Mobini, Mohammad Hosein | 2015 | Discarded car timing belts fibers | Better performance of concrete |
| Khan, M. I. Lynsdale, C. J. | 2002 | Fly ash or pulverized fuel ash, silica fume | Better performance of concrete |
| Laskar, Aminul Islam Talukdar, Sudip | 2008 | Fly ash, silica fume, rice husk | Better performance of concrete |
| Liu, Fengjuan Wang, Jialai Qian, Xin Hollingsworth, Joseph | 2017 | Cenospheres or hollow fly ash particles | Better performance of concrete |
| Noumowe, Albert N. Siddique, Rafat Debricki, G. | 2009 | Silica fume, polypropylene fibers, clay lightweight aggregates | Better performance of concrete |
| Pedro, D. de Brito, J. Evangelista, L. | 2017 | densified silica fume, recycled concrete aggregates | Better performance of concrete |
| Quangphu, Nguyen Linhua, Jiang Jiaping, Liu Qian, Tian Tienquan, Do | 2008 | Fly ash, silica fume, ground granulated blast-furnace slag, shrinkage reducing admixture | Better performance of concrete |
| Sabet, Fereshteh Alsadat Libre, Nicolas Ali Shekarchi, Mohammad | 2013 | Fly ash, silica fume, natural zeolite | Better performance of concrete |
| Salas, Andres Delvasto, Silvio de Gutierrez, Ruby Mejia Lange, David | 2009 | Silica fume, rice husk ash | Better performance of concrete |
| Shekari, A. H. Razzaghi, M. S. | 2011 | Metakaolin, Nano particles | Better performance of concrete |
| Shen, Dejian Jiang, Jinliang Zhang, Mingyue Yao, Panpan | | Super absorbent polymer | Better performance of concrete |
| Authors                          | Fiber Type                          | Benefit of Concrete                        |
|---------------------------------|-------------------------------------|--------------------------------------------|
| Jiang, Guoqing[26]/2018         | Bar chip fibers                     | Better performance of concrete             |
| Shen, Dejian                    |                                     |                                            |
| Wang, Wenting                    |                                     |                                            |
| Liu, Jiwei                       |                                     |                                            |
| Zhao, Xiaoguang                  |                                     |                                            |
| Jiang, Guoqing[27]/2018         |                                     |                                            |
| Smarzewski, Piotr[28]/2019       | Polypolypropylene fiber, hybrid basalt | Better performance of concrete             |
| Barnat-Hunek, Danuta[29]/2016   |                                     |                                            |
| Tabatabaeian, Mojtaba            |                                     |                                            |
| Khaloo, Alireza                  |                                     |                                            |
| Khaloo, Hooman[30]/2019         |                                     |                                            |
| Talah, A.                        |                                     |                                            |
| Kharchi, F.                      |                                     |                                            |
| Chaid, R.[31]/2015               |                                     |                                            |
| Vejmelková, Eva                  |                                     |                                            |
| Koňáková, Dana                   |                                     |                                            |
| Doleželová, Magdalena            |                                     |                                            |
| Scheinherrová, Lenka             |                                     |                                            |
| Svora, Petr                      |                                     |                                            |
| Keppert,[33]/2018                |                                     |                                            |
| Abd Elrahman, Mohamed            |                                     |                                            |
| Hillemeier, Bernd[2]/2014        |                                     |                                            |
| Abed, Mohammed                   |                                     |                                            |
| Nemes, Rita[3]/2019              |                                     |                                            |
| Abo-El-Enein, Salah A.           |                                     |                                            |
| El-Sayed, Hamdy A.               |                                     |                                            |
| Ali, Ali H.                      |                                     |                                            |
| Mohammed, Yasser T.              |                                     |                                            |
| Khater, Hisham M.                |                                     |                                            |
| Ouda, Ahmed S.[4]/2014           |                                     |                                            |
| Afroughsabet, Vahid              |                                     |                                            |
| Biolzi, Luigi                    |                                     |                                            |
| Ozbakkaloglu, Togay[5]/2017      |                                     |                                            |
| Aissa, Talah                     |                                     |                                            |
| Rachid, Belaid                   |                                     |                                            |
| Kharchi, Fattoum[6]/2018         |                                     |                                            |
| Akca, Abdullah Huzeyfe           |                                     |                                            |
| Özyurt Zihnioğlu, Nilüfer[1]2013 |                                     |                                            |
| Ali, Msheer Hasan                 |                                     |                                            |
| Dinkha, Youkhanna Zayia          |                                     |                                            |
| Haido, James H.[7]/2017          |                                     |                                            |
| Aissa, Talah Rachid, Belaid      | Incinerated hospital waste           | Better performance of concrete             |
| Kharchi, Fattoum[6]/2018         |                                     |                                            |
| Akca, Abdullah Huzeyfe           | Polypolypropylene fibers, air        | Better performance of concrete             |
| Özyurt Zihnioğlu, Nilüfer[1]2013 | entraining admixture               |                                            |
| Ali, Msheer Hasan                 | Pozzolanic powder of silica fume,    | Better performance of concrete             |
| Dinkha, Youkhanna Zayia          | waste glass powder                  |                                            |
| Haido, James H.[7]/2017          |                                     |                                            |
4. Mix proportion

(30%) content of normal fly ash, (25%, 30%) content of fine fly ash, (8%, 10%) content of silica fume, CEM1, CEM2 having (68%) of slag content were the composition of materials used to produce high performance concrete[2]. Natural aggregate is replaced by Recycled Concrete Aggregate (0%, 25%, 50%) by mass and cement is replaced by unprocessed waste Powder Materials (0%, 15%, 30%) by mass, super plasticizer (Sika visocrete-5 Neu) were the composition of materials used to produce high performance concrete[3]. 10% Silica fume is replaced with binding material (cement) and fine aggregate is replaced by finer portion of raw materials were the composition of materials used to produce high performance concrete[4]. Binding Material (cement) is replaced by 30% of GGBS, steel fibers (volume fraction 1%), steel fibers 60mm (length) and aspect ratio (60), super plasticizer (carboxylic 110M) were the composition of materials used to produce high performance concrete[5]. 10% of waste ash (fineness modulus 8000 cm²/g) is replaced with cement is the composition of materials used to manufacture high performance concrete[6].

Silica Fume (25%) is replaced with cement, 25% waste glass powder (greyish white color) having PH (10.3) replaced with cement were the composition of materials used to manufacture high performance concrete[7]. Copper Slag from 0% to 100% (range) is replaced on the workability of the concrete were the composition of materials used to produce high performance concrete[8]. Stone dust is replaced with fine aggregate in 5%, 10%, 15%, 20%, 34%, 67%, 100% were the composition of materials used to produce high performance concrete. White cement is used for concrete mixture[9]. Palm Kernel Shells (PKS), Palm Kernel Ash (PKA), Crushed Palm Kernel (CPK) ranging from 5% to 20% were replaced separately with fine aggregate, coarse aggregate, cement were the composition of materials used to manufacture high performance concrete[10]. Basalt Fiber (1%, 2%, 3%) of volume fraction added to manufacture high performance concrete[11]. High Performance Concrete with (silica fume and steel slag), (silica fume and crystalized slag), (blast furnace slag and steel slag), (silica fume, limestone), (blast furnace slag, crystalized slag), (limestone and blast furnace slag) were the composition[12]. Silica fume (3%, 5%, 10%, 15%), met kaolin (10%, 17%, 25%, 33%), combined ratios of met kaolin and silica fume are 7/3, 12/5, 17/8, 25/8 to reach total substitution of cement ratio 10%, 17%, 25%, 33% were the composition of materials used to produce high performance concrete[13]. GGBS (25%, 50%), RHA (25%, 50%) were replaced with fly ash and combination of GGBS and RHA (13% + 12%), (25% + 25%) were replaced with fly ash to produce light weight aggregate. High performance light weight aggregate is made by above aggregates as coarse aggregate. Super plasticizer is also used[14]. Silica fume (10%, 20%, 30%) and combination of silica fume and calcined clay (10% + 20%, 20% + 10%) were the composition of materials used to produce high performance concrete[15]. By-product of steel manufacturing in electric arc furnaces plants is black or oxidizing electric arc furnace slag.

Electric arc furnace slag is replaced with natural coarse aggregate, varying amount of cement content, varying water cement ratios were the composition of materials used to produce high performance concrete[16]. Polypropylene fibers (0%, 0.05%, 0.10%), fly ash (20%), metal fabric (0.6mm, 1.6mm), carbon fiber (0.27mm), glass fiber (0.38mm), water binder ratio (30%, 40%) were the composition of materials used to produce high performance concrete[17]. Ceramic Waste powder is replaced with cement at 0%, 10%, 20%, 30%, 40% were the composition of materials used to produce high performance concrete[18]. Sand (933 Kg/m³), gravel (777 Kg/m³), water binder ratio (0.35), car timid fibers (0%, 0.2%, 0.5%, 1%, 1.5%, 2%, 0.5%, 1%, 1.5%) with super plasticizer (3.75, 5, 6.5, 9, 5, 6.5, 9) Kg/m³ were the composition of materials used to produce high performance concrete[19]. Fly ash (10%, 20%, 30%, 50%) is replaced with cement, condensed silica
fume(5%,10%,15%,20%) is replaced with cement, rice husk ash(5%,10%,15%,20%) is replaced with cement, high range water reducing admixtures(poly-carboxylic ether polymer, sulfonated-naphthalene polymer) were the composition of materials used to manufacture high performance concrete[20]. Non perforated cenospheres(0%,9%) with super plasticizer(3,3), perforated cenospheres(6%,9%) with super plasticizer(1.8,1.8) were the composition of materials used to produce high performance concrete[21]. Chemical admixture(0%,1%,2%,4%), fly ash and slag(25%,25%) with water binding ratio 0.40, silica fume and fly ash(15%,25%) with water binding ratio 0.22 were the composition of materials used to produce high performance concrete[22]. normal zeolite, silica fume, fly ash(0-20%) replaced with cement and super plasticizer%(1.3,2,1.2,0.9,0.4,0.1,0.8) were the composition of materials used to produce high performance concrete[23]. Treated rice husk ash(5%,10%,15%,20%), untreated rice husk ash(5%,10%,15%,20%),silica fume 10% were the composition of materials used to produce high performance concrete[24]. Water cement ratio(0.25/each), super plasticizer(1.5%/each), Nano particles(1.5,1.5,1.5,1.5) for respective mixtures, cement + met kaolin(580Kg/m³) were the composition of materials used to produce high performance concrete[25].

Super plasticizer (0.65%), super absorbent polymer (17%,35%,49%) were the composition of materials used to produce to high performance concrete[26]. Super plasticizer (0.6%/each), bar chip fibers/m³(0,4,8,12) were the composition of materials used to produce high performance concrete. Chemical properties of binder(cement) is experimented[27]. Super plasticizer(polyacrylate ether), straight polypropylene fiber(1%,2%), straight basalt fiber(1%,2%) were the composition of materials used to produce high performance concrete[28]. Coal cinder(10%,15%,25%,30%), waste foundry sand(5%,15%) were the composition of materials used to produce high performance concrete[29]. Polyester resin (188,220,251)kg/m³, epoxy resin(188,220,251)kg/m³. 12%,14%,16% were the amount of percentage the polymer were added to the aggregates[30]. Water cement ratio(0.5), marble powder 60Kg/m³ is replaced with cement were the composition of materials used to produce high performance concrete[31]. Fine-ground ceramics is a waste materials obtained from various brick kilns. Portland cement was replaced by fine-ground ceramics up to 60% were the composition of materials used to produce high performance concrete[32]. calcined Czech clay stone is replaced with cement and up to 30% of replacement with binding material(cement) gives the successful rate[33]. These were the composition of materials to produce high performance concrete.

5. Observation and discussion

Fine fly ash gives better durability and strength development when compared to normal fly ash [2]. The effect of waste perlite powder and unprocessed waste fly ash became more important on durability properties[3]. Environment impact has been reduced and high performance concrete has been developed[5]. Ash which are generally produced from pharmaceutical wastes are used to produce high performance concrete is better than normal usual concrete[6]. Waste glass powder is used to produce high performance concrete has better strength when comparing with normal concrete made with silica fume[7]. To produce high performance concrete having more strength and durability, copper slag can be replaced with sand up to 40% of weight[8]. 16% of high strength concrete has been improved by using industrial by-product[9]. Durability and mechanical properties of concrete is increased due to replacement of date palm kernel[10]. When cement is partially replaced with mineral admixtures and fiber is introduced with it improves concrete properties[11]. When ground granulated blast-furnace slag is obtain the place of with binding material(cement) improves the properties of the concrete when compared with silica fume replaced with binding material(cement) [12].
When metakaolin and silica fume is combined and used in the concrete it does not improves the strength of the concrete rather than using separately in the concrete[13]. Ground granulated blast-furnace slag and fly ash is good when compared with other aggregates[14]. Rate of pozzolanic reaction in silica fume combined with cement paste and portlandite consumption in silica fume combined with cement paste are higher when compared to illite clay combined with cement pastes[15]. Concrete durability and physical properties of the concrete is increased by using electric arc furnace slag[16]. Polypropylene fibers and metal structure were used at the same time, spalling does not occurred and strength(compressive) is maintained up to 90%[17]. performance is improved by using ceramic waste powder and having densely packed particles[18].

Concrete properties can be damaged when high amount of fibers is replaced[19]. Pulverized fuel ash can cause the reduction of stress(yield) up to 30%[20]. For high performance concrete internal curing agent perforated cenospheres can be preferred[21]. To reduce the drying shrinkage of concrete shrinkage reducing admixture is useful and up to 41% of shrinkage reducing admixture used in concrete to reduce shrinkage is effective[22]. When compared to natural zeolite and fly ash, silica fume increases the effect of durability properties. Natural zeolite is expensive when compared to other materials[23]. The effective supplement materials for cement is chemically treated rice husk ash and normal rice husk ash[24]. Among the Nano particles, Nano-Al$_2$O$_3$ is successful in increasing the mechanical properties of the concrete[25].

![Figure 2. Governing factors of high performance concrete.](image)

6. Conclusion

In the current study, the various materials replaced/introduced and their mix proportion to produce high performance of concrete are analyzed. In order to have a concrete with more durability and mechanical properties, high performance concrete can be preferred. Economical, safe, attractive solution for problems with more mechanical and durability properties. It was observed from the study that materials can be replaced and fibers can be introduced to produce high performance concrete(increase in mechanical and durability properties, workability). Ingredients added to make high performance concrete like mineral admixture, chemical admixture, fibers, should be of high quality. However there is a limitation for replacement/introduction of a materials to manufacture high performance concrete. Further the effect of replacing/introducing materials can affect the strength of the concrete.

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