Građevinski materijali i konstrukcije
Building Materials and Structures

journal homepage: www.dimk.rs

doi: 10.5937/GRMK2101019D UDK: 666.972.12
Original Scientific Paper

Prediction models for high-volume fly ash concrete practical application: mechanical properties and experimental database

Jelena Dragaš*[1)], Snežana Marinković[1)], Vlastimir Radonjanin[2)]

[1)] *University of Belgrade, Faculty of Civil Engineering, Bulevar kralja Aleksandra 73, 11000 Belgrade, Serbia*
[2)] *University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, 21101 Novi Sad, Serbia*

Article history

Received: 10 January 2021
Received in revised form: 15 February 2021
Accepted: 24 February 2021
Available online: 30 March 2021

Keywords

high-volume fly ash concrete;
database;
fly ash efficiency,
compressive strength,
splitting tensile strength,
modulus of elasticity

ABSTRACT

The analysis of available experimental results of high-volume fly ash concrete mechanical properties showed that extensive amount of research had been done so far. However, a comprehensive analysis of basic high-volume fly ash concrete mechanical properties was not found in the literature. Having that in mind, the database of 440 high-volume fly ash concrete and 151 cement concrete mixtures collected from literature was made. The application of European Code EN 1992-1-1 prediction models for cement concrete mechanical properties, as well as existing proposals for high-volume fly ash concrete properties, were statistically evaluated on the results from the database. The analysis showed that the prediction models defined in EN 1992-1-1 for compressive strength, tensile strength and for modulus of elasticity can be used for high-volume fly ash concrete, in the given form or with modifications proposed in literature, with similar accuracy and variation of results as for cement concrete. Own model for fly ash efficiency prediction was developed.

1 Introduction

In the modern age, one of the main challenges on the path of preserving the environment is finding the solution for large amounts of waste or by-products generated by different industries. Recycling and reuse of these materials is currently widely investigated in order to prevent their further increase, and if possible, to reduce already generated amounts. The construction industry, and specifically its major part – concrete industry, is a potential beneficiary of this approach since large quantities of waste or by-products can be used in the production of concrete [1]. Different pozzolanic waste materials are already widely used as supplementary cementitious materials (CM) in concrete production making it more sustainable. Among them, coal fly ash (FA) is most commonly used in the production of concrete. FA is a by-product of the combustion of pulverized coal in thermal power plants. Depending on the type of coal and the production processes, FA consists of a different proportion of oxides—mostly silica, alumina and calcium—and can display pozzolanic activity. This enables it to be a substitution of cem[3]ent and fine aggregate in concrete..

If part of the cement (and eventually fine aggregate) in concrete mixture is replaced with FA, the consumption of natural aggregates and CO_2 emissions are reduced, which is clearly the environmental benefit [2]. The cement industry is responsible for more than 5% of the global CO_2 emissions in 2016, and the production rate of cement is expected to grow continuously at a rate of 10% annually to reach a historical maximum of around 5000 Mt/Year by 2021 [3], [4].

FA has been used in concrete since 1930s as a partial replacement of Portland cement to decrease the amount of early heat generation during the construction of dams. In the last few decades higher amounts of FA as a partial replacement of Portland cement or fine aggregate have been used. In 1985, the Advanced Concrete Technology Group at CANMENT, Canada, developed a high volume FA concrete (HVFAC) [5] with more than 50% of FA in total mass of CM. According to the progress in current research, the next couple of years would see the replacement of FA to a maximum of 60% by mass [6].

Up to now, a lot of research has been carried out regarding HVFAC mechanical properties. The behavior of hardened HVFAC depends upon many factors, but mostly upon FA fineness, chemical and mineralogical properties, cement type, water-to-CM mass (W/CM) ratio, amount of FA and cement etc. It can generally be concluded that HVFAC has lower compressive strength compared with the control

* Corresponding author:
E-mail address: jelenad@imk.grf.bg.ac.rs

cement concrete made with the same component materials only by partially replacing cement with FA [7]. Slower compressive strength development at early ages can be also noticed in HVFAC but greater increase at ages after 28 days compared with cement concrete [8]-[10].

Despite the fact that HVFAC has its disadvantages [6], [7], there is a great possibility for its practical application. Most industrial and commercial buildings require concrete with compressive strength of about 30 MPa in majority of their structural and non-structural elements. This compressive strength is easily achievable with HVFAC. Greater use of HVFAC in such applications could significantly reduce the amount of used cement and, therefore, the amount of emitted CO_2.

The use of HVFAC in concrete structures requires defined and standardized prediction models for mechanical properties which is not yet the case. So, the main aim of this work was to provide guidelines for practical HVFAC mix design procedure and prediction of basic mechanical properties.

However, chemical and physical properties of FA differ depending on the coal type, process methods etc. Concrete properties are affected by this FA chemical and physical heterogeneity [11] thus making general conclusions on the HVFAC ecological and economic efficiency rather unreliable. One possible way to bring this issue to a closure at the current state-of-the knowledge is to propose prediction models for HVFAC mechanical properties based on a comprehensive statistical analysis of the experimental research done so far. These models should be able to predict the basic HVFAC properties considering the FA amount and its chemical and physical heterogeneity, with a chosen reliability level. For that purpose, the database of available HVFAC experimental results from the literature was made. Firstly, the European standard EN 1992-1-1 [12] predictions for compressive strength, splitting tensile strength and modulus of elasticity of CC (cement concrete) were evaluated if they were applicable on the HVFAC mixtures from the database or new models or modifications were needed. Secondly, already proposed prediction models from literature were re-evaluated using statistical analysis on the HVFAC database and some own corrections were given.

2 Method

The analysis of experimental results of basic mechanical properties was done in two steps: (1) collection of studies with available experimental results and available information about component materials used for the production of FA concrete and (2) selection of results for further analysis based on selected criteria. The experimental results were collected from available research papers, technical reports, master and doctoral theses using content analysis. The first step was the systematic collection of all available studies on FA concrete that had own experimental results of basic mechanical properties. The search was done in the Scopus, Science Direct and Google Scholar databases, using the following key words: *fly ash, fly ash concrete, high-volume fly ash concrete, mechanical properties, compressive strength, modulus of elasticity, splitting tensile strength* and *experimental results*. Relevant studies with available experimental results found as references in previously found studies were also considered.

Further on, the selection of the results was done based on the following two criteria: only studies with class F FA were selected and the amount of FA in CM was chosen in the range between 40% and 75%. FA was classified as class F according to ASTM C618 [13] – minimum 70% of total FA mass consisted of Al_2O_3, SiO_2 and Fe_2O_3. If the selected study did not contain the FA classification, it was made based on the reported chemical and physical properties of FA.

The database of 76 research papers, project reports and theses was made [5], [9], [21]–[30], [10], [31]–[40],[14], [41]–[50], [15], [51]–[60],[16], [61]–[70], [17], [71]–[80], [18], [81]–[86], [19], [20]. Out of the total number of selected papers, 44 are papers published in journals from the Science Citation Index Thomson Reuters list, 7 are papers published by the American Concrete Institute, one is published by the American Society of Civil Engineers, 7 are master and doctoral thesis and 17 papers are from other sources.

All presented studies were carried out in the period of 31 years, from 1986 to 2018, with the total of 591 different concrete mixtures, 151 CC and 440 HVFAC mixtures, tested for different mechanical properties. In order to carry out the comprehensive analysis of the available results, import parameters which describe the concrete component materials (type of cement, FA, aggregate and water reducing admixtures), concrete mix design and physical and mechanical properties of concrete (slump, compressive strength, splitting tensile strength and modulus of elasticity) at different ages were collected from each study:

1) Cement type;
2) Cement class - 28-day compressive strength;
3) Cement early age strength (Cem. early str.);
4) % of SiO_2 in cement (CEM SiO_2);
5) % of Al_2O_3 in cement (CEM Al_2O_3);
6) % of Fe_2O_3 in cement (CEM Fe_2O_3);
7) % of CaO in cement (CEM CaO);
8) Cement specific surface - Blaine method (CEM Blaine, cm^2/g);
9) Cement density (γ_{CEM}, kg/m^3);
10) % of SiO_2in FA (FA SiO_2);
11) % of Al_2O_3in FA (FA Al_2O_3);
12) % of Fe_2O_3in FA (FA Fe_2O_3);
13) % of CaO in FA (FA CaO);
14) LOI in FA (Loss on ignition in FA, %);
15) FA fineness expressed through residue on 45μm sieve (Fine. >45μm, %);
16) FA specific surface - Blaine method (FA Blaine, cm^2/g);
17) FA density (γ_{FA}, kg/m^3);
18) Cement mass (CEM , kg/m^3);
19) FA mass (FA, kg/m^3);
20) Coarse aggregate type (Coars agg. type);
21) Coarse aggregate mass (Coars agg., kg/m^3);
22) Fine aggregate type (Fine agg. type);
23) Fine aggregate mass (Fine agg., kg/m^3);
24) Maximum aggregate size (Max agg. size, mm);
25) Plasticizer type;
26) Plasticizer amount expressed as a percentage of plasticizer mass to total CM mass (m_{pl}/CM, %);
27) FA mass in total CM (FA/CM, %);
28) W/CM ratio;

29) Curing type;
30) Slump (mm);
31) Compressive strength (f_{cm})- Sample type and size;
32)-43) Compressive strength results at 1, 3, 7, 14, 28, 56, 90, 180, 365, 1095, 1825 and 3650 days;
44) Splitting tensile strength (f_{sp}) - Sample type and size;
45)-51) Splitting tensile strength at 1, 3, 7, 28, 56, 90, 365 days;
52) Modulus of elasticity (E) - Testing procedure;
53) Modulus of elasticity - Sample type and size;
54)-60) Modulus of elasticity at 3, 7, 14, 28, 90, 180, 365 days.

All collected data were entered into an Excel spreadsheet that is reported in Appendix A (with column numbers as reported above). Although not all selected studies provided all mentioned data, information regarding concrete mix design and results of some mechanical properties were available in all of them.

In a large number of concrete mixtures (306 out of 591), ASTM Type I or CEM I cement was used, in other words cement with minimum 95% of clinker. Other types of cement like ASTM Type II, ASTM Type IP or CEM II were also used in some studies. In some studies, only provided information regarding cement type was that Ordinary Portland cement was used (182 concrete mixtures).

The cement class refers to the standard 28-day compressive strength measured according to the adequate standard for cement classification–EN 197-1 [87] and ASTM C150 and C595 [88], [89]. The early age strength is defined by the strength increase rate in the cement classification. It is usually presented with letters S, N or R referring to slow, normal or rapid strength gain, respectively [87]. In the database this column contains values of early age compressive strength at two or three days or classification S, N, R if this information is available in studies. Figure 1a shows the availability of the cement classification data in the database.

The availability of the chemical and physicals properties of FA in database is presented in Figure 1b. The range of chemical and physical properties of FA and cement used in the selected studies is shown in Table 1. Although only class F FA was used in all studies, the variety of FA chemical and physical properties was still relatively high.

Table 1. Chemical and physical properties of FA and cement

Chemical properties	FA	Cement
SiO_2 (%)	36.8 - 68.4	16.6-39.1
Al_2O_3 (%)	11.1 - 41.0	3.1-10.3
Fe_2O_3 (%)	2.7 - 39.7	2.0-6.2
CaO (%)	0.3 - 20.3	45.7-70.5
Loss on ignition - LOI (%)	0.2 - 9.7	-
Physical properties	**FA**	**Cement**
Fineness (>45 mm, %)	0.1 - 35.9	-
Specific surface area (cm^2/g)	1874 - 6780	2890-5790
Density (kg/m^3)	1900 - 2960	2890-3230

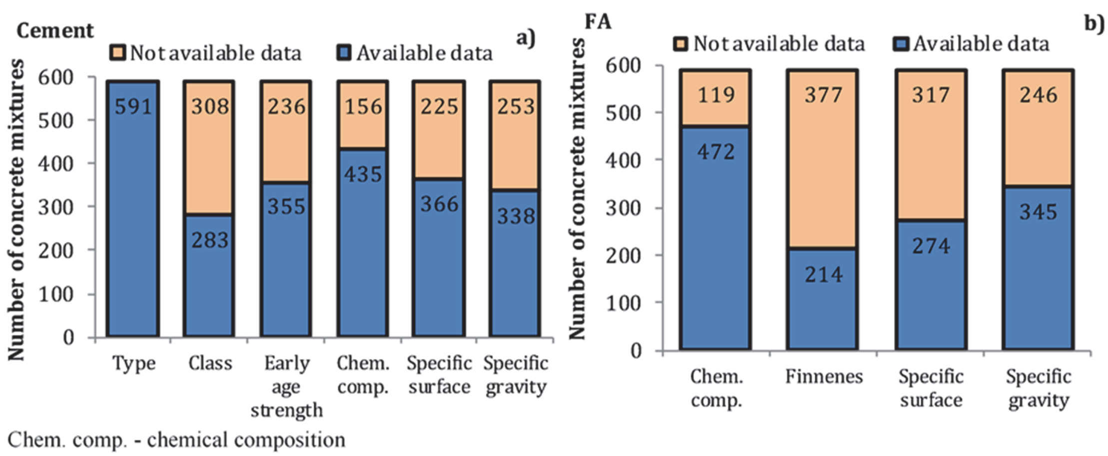

Figure 1. Number of concrete mixtures with available data regarding a) cement properties and b) FA properties

The availability of data regarding the aggregate type in database is shown in the following figures: general aggregate type in Figure 2a, maximum aggregate size in Figure 2b and aggregate stone type in Figure 3. The most frequently used aggregate type was crushed coarse (CA) and river sand aggregate (RA) with maximum aggregate size ranging from 10 mm to 32 mm.

Different types of plasticizer were used in most of the studies in different amounts ranging from no plasticizer to 9% (percent of total CM mass) in some studies. The number of studies with different plasticizer amounts is shown in Figure 4a. Plasticizers mostly used were carboxilic, melanine, naphtaline and sulphonated-naphtaleme-formaldehid based.

Figure 4b shows FA content in CM mass in all selected studies and, as it can be seen, in most studies (388 studies) FA makes 40-60% of the total CM. The curing of samples was done in different ways but mostly by standard moist/water curing. Air curing of samples was done in only two studies [29], [53]. The workability of concrete mixtures was available for most of the concrete mixtures – 470 of total 591 mixtures had available information of slump/flow values.

Testing of compressive, splitting tensile strength and modulus of elasticity was done on different samples in different studies. In order to compare these results, all compressive and splitting tensile strength results were recalculated on 150·300 mm cylinders using scaling factors reported in the literature [90], [91]. The scaling factors used for recalculation of compressive strength results were taken as:

- equal to 1 for 152·305 mm cylinder samples,
- equal to 0.975 for 100·200 mm cylinder, 102·204 mm cylinder, 110·220 mm cylinder and 100·100·200 mm prism samples,
- equal to 0.915 for 76·152 mm cylinder sample,
- equal to 0.850 for 150·150·150 mm cube sample,
- equal to 0.750 for 100·100·500 mm prism sample.

The specimen size and shape have a big influence on the splitting tensile strength of concrete [92]–[94]. The scaling factors used for recalculation of splitting tensile strength results were taken as:

- equal to 1.0 for 150·150·150 mm cube samples, 150·150 mm and 150·300 mm cylinder samples,
- equal to 0.9 for 100·100·100 mm cube and 100·200 mm cylinder samples.

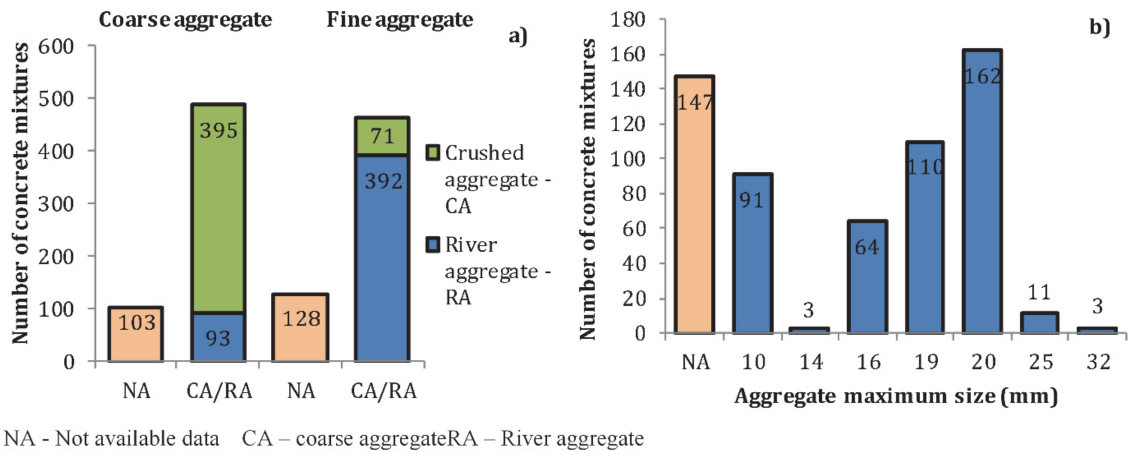

Figure 2. Number of concrete mixtures regarding a) coarse and fine aggregate type and b) aggregate maximum size

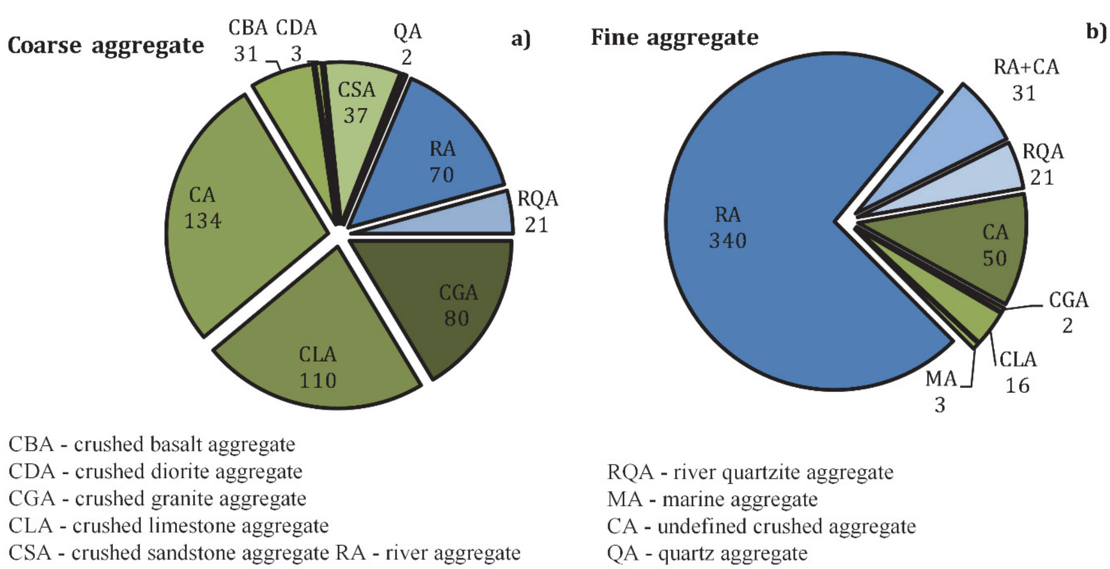

Figure 3. Number of concrete mixtures regarding a) coarse and b) fine aggregate stone type

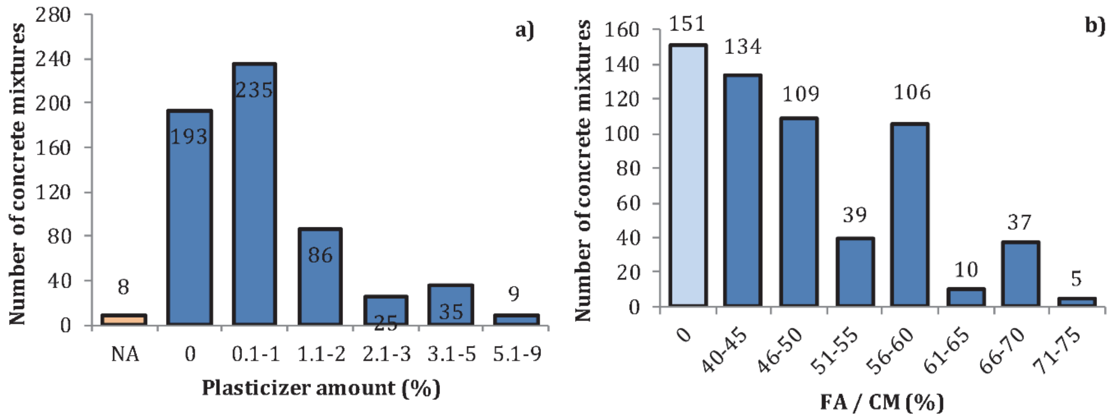

Figure 4. Number of concrete mixtures regarding a) plasticizer amount and b) FA amount in CM

As for modulus of elasticity, not only different cylinder sizes were used but also different testing methods. No corresponding factors for modulus of elasticity results recalculation were found in the literature, so this effect was neglected in this research - all modulus of elasticity testing results were used as presented in the selected study.

The compressive, splitting tensile strength and modulus of elasticity were tested at different ages in different studies. The number of concrete samples tested at a certain age regarding compressive and splitting tensile strength and modulus of elasticity are presented in Figures 5 and 6.

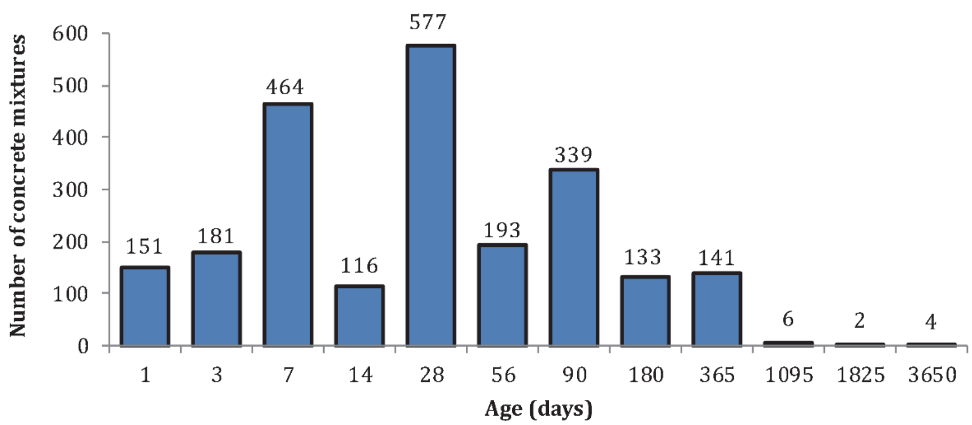

Figure 5. Number of concrete samples compressive strength tested at different ages

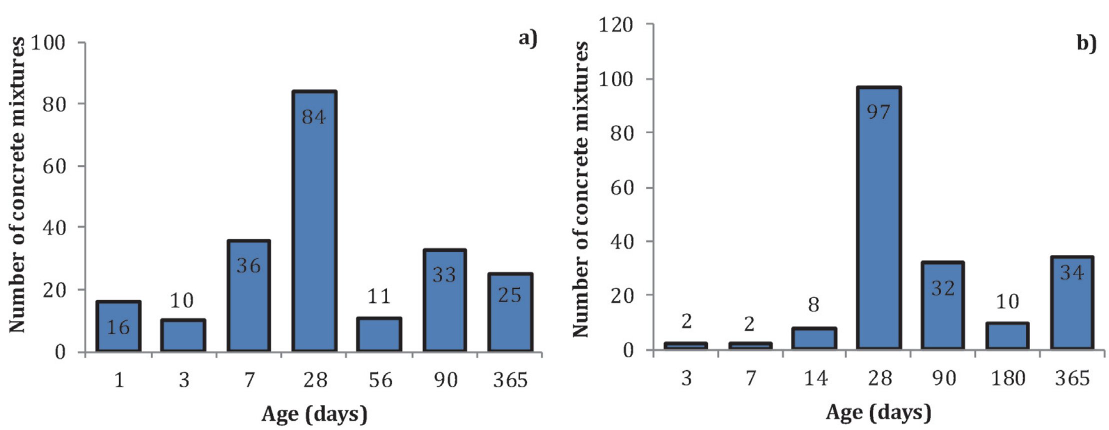

Figure 6. Number of concrete samples tested at different ages a) splitting tensile strength and b) modulus of elasticity

In most of the studies, testing was done at the age of 28 days for all mechanical properties. Different target compressive strengths were set in different studies but the largest number of concrete mixtures had 28-day compressive strength between 20 MPa and 50 MPa as shown in Figure 7.

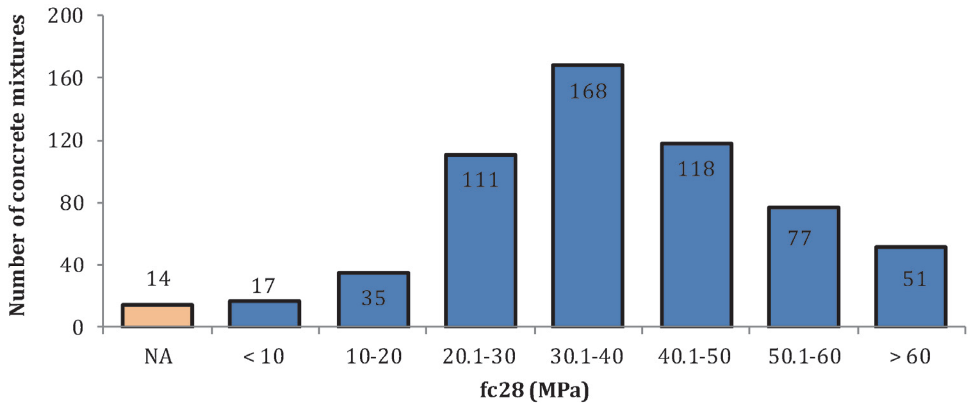

Figure 7. Number of concrete mixtures regarding 28-day compressive strength test results

3 HVFAC 28-day compressive strength evaluation

For the practical application of HVFAC it is important to establish simple quantitative way to predict the HVFAC compressive strength based on its mix design and using the empirical equations, similar as for CC. So, as a first step, the relationship between the compressive strength and W/CM ratio already established for CC was evaluated for HVFAC.

As the cement type, aggregate type and size as well as the curing conditions strongly affect the concrete strength, only commonly used cement and aggregate types and standard curing conditions were selected for this analysis. High FA content in concrete usually requires plasticizers for achieving adequate workability and it is not surprising that 67% of concrete mixtures from the database contained plasticizers. The influence of the plasticizer on physical and mechanical properties of HVFAC is not fully known. It was considered that the usual amount of plasticizer up to 2-3% of cement mass [90] will not influence the compressive strength in CC and the same assumption was adopted for the HVFAC strength. Having all this in mind, the following HVFAC mixtures were selected from the database:

Concrete mixtures with cement conforming to ASTM type I/II and CEM I/II;

- Mixtures with crushed and river coarse aggregate and maximum size ranging from 10 mm to 25 mm;
- Mixtures made and cured under standard water/moist curing conditions;
- Mixtures with up to 3% of plasticizer.

Figures 8 – 10 show the relation of compressive strength of HVFAC and CC and their W/CM ratio tested at the age of 7 days, 28 days and 90 days, respectively.

The results were plotted in three series regarding the FA/CM ratio (40-50%, 51-60% and 61-75%) and evaluated with the aid of determination coefficient (R^2). This coefficient is based on the correlation coefficient (R) which represents the degree of correlation between two variables.

Firstly, it can be seen that the FA amount has a significant influence on the HVFAC compressive strength, separating the series of results with different FA/CM ratio with relatively good correlation. Secondly, the correlation coefficient R was equal or greater than 0.7 for almost all concrete series, indicating that there is a good correlation between the compressive strength and the W/CM ratio [95]. A relatively big scatter of the results was a consequence of different cement and FA types used in different concrete mixtures. The relations in Figures 8 – 10 show that the correlation between HVFAC compressive strength at the age of 7 days, 28 days and 90 days and the W/CM ratio (R^2=0.470–0.689) is similar to that of CC (R^2=0.448–0.656). The correlation between the HVFAC compressive strength and the W/CM ratio is of the exponential type, as for CC, but it clearly depends on the FA amount – so some modifications are needed to consider the impact of the FA amount and its properties.

In order to establish an adequate relationship between the HVFAC compressive strength and the W/CM ratio, the FA efficiency factor k is often used. This concept was first proposed by Smith in 1967 [96]. He defined the FA efficiency factor in such a way that the CC compressive strength to the W/CM ratio relation was also valid for FA concrete introducing the effective W/CM ratio, given as W/(C+k·FA).

In a more general way, the FA efficiency factor can be defined as a portion of cement mass that could be replaced by one part of FA without changing the studied property [97]. Class F fly ash can be categorized as a pozzolan, mainly containing silicate, aluminum and iron oxides. In the presence of moisture it reacts with calcium hydroxide – $Ca(OH)_2$ formed by the cement hydration. First, the dissolution of FA's amorphous SiO_2 and Al_2O_3 framework by hydroxide ions and generated heat during the early hydration of cement initiates the pozzolanic reaction. Afterwards, free silicate and aluminate anions react with $Ca(OH)_2$ to form an amorphous calcium silicate aluminate phase. This reaction continues until $Ca(OH)_2$ is present in the concrete pore solution and until the hydrated gel fills in the capillary pores in concrete. The dissolution of FA is strongly influenced by the FA fineness, and can be initiated faster if FA particles are smaller in size - the pozzolanic reaction develops at higher extent if finer FA is used.

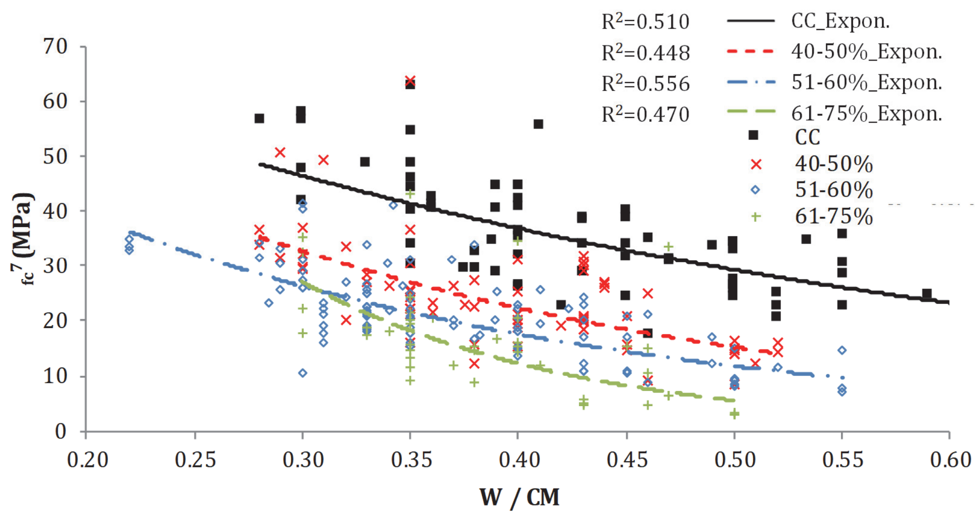

Figure 8. 7-day compressive strength of the HVFAC and CC versus the W/CM ratio

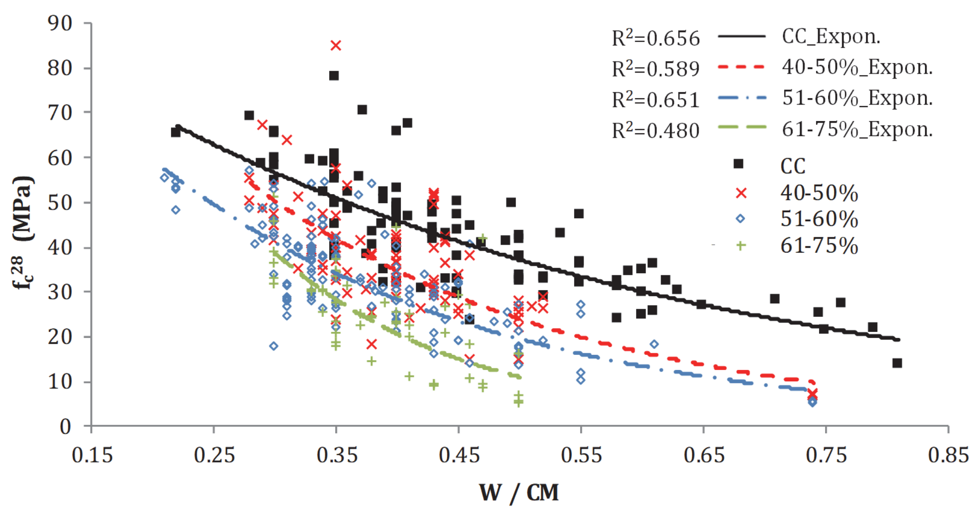

Figure 9. 28-day compressive strength of the HVFAC and CC versus the W/CM ratio

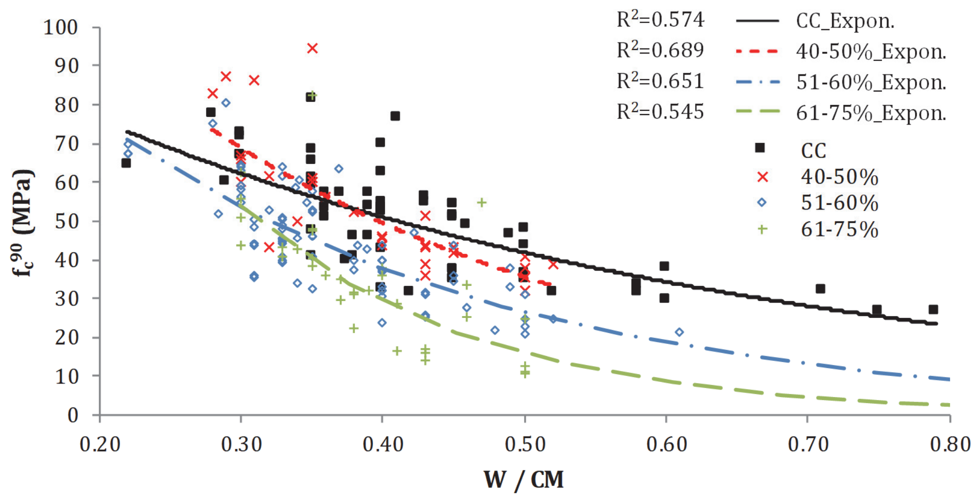

Figure 10. 90-day compressive strength of the HVFAC and CC versus the W/CM ratio

So, the capacity of FA to act as a binder equivalent to cement is influenced by many factors, but mostly by the amount, the physical and mechanical properties of FA and cement, the age of concrete and curing conditions [97]–[101]. The list of relevant research papers regarding the FA efficiency is shown in Table 2 along with all parameters analyzed in these studies. Proposed predictions for *k* factor given in Table 2 were re-evaluated using HVFAC results from the database.

Table 2. Relevant research proposals regarding efficiency factor k [102]

Study	FA class	FA/CM (%)	Parameters	Efficiency factor k
[97]	F / C	15-75	FA/CM ratio (p), concrete age.	$k_7 = 2.67 \cdot p^2 - 3.75 \cdot p + 1.45$ $k_{28} = 2.78 \cdot p^2 - 3.80 \cdot p + 1.64$ $k_{90} = 2.50 \cdot p^2 - 3.59 \cdot p + 1.73$
[101]	F / C	10-20	Activity index (AI), active silica content in FA (γ_S), silica content in C and FA, concrete age, W/C ratio.	$k = 1 + 4 \cdot (AI - 1)/(1 - 0.5a)$ a - parameter depending on time and curing; $k = \gamma_S \cdot \frac{f_{S,P}}{f_{S,C}} \cdot \left(1 - a\frac{W}{C}\right)$ $f_{S,P}$ - weight fraction of SiO_2 in FA; $f_{S,C}$ - weight fraction of SiO_2 in C.
[99]	-	10-49	FA fineness (Blaine method), FA/C ratio, concrete age.	$k_7 = 0.21 \cdot \exp\left(-0.43 \times \frac{FA}{C}\right) \cdot \alpha_2$ $k_{28} = 0.42 \cdot \exp\left(-0.72 \times \frac{FA}{C}\right) \cdot \alpha_2$ $k_{90} = 0.85 \cdot \exp\left(-1.36 \times \frac{FA}{C}\right) \cdot \alpha_2$ $\alpha_2 = 1.14 \cdot 10^{-4}(\text{Blaine} - 2500) + 1$
[103]	F	10-80	FA/CM percentage (P), concrete age.	$k_7 = 0.9 - 0.1 \cdot \log_e P$ $k_{28} = 1.2 - 0.14 \cdot \log_e P$
[104]	C	60-90	CaO, SiO_2, Al_2O_3 content in FA and cement (C, S, A), concrete age.	$k(t) = H(t) \cdot \frac{C}{S + A}$ * $H(t)$ - 0.4; 0.5; 0.6; 0.7; 0.8; 0.8; 0.8 for 7, 14, 28, 56, 84, 112 and 168 days respectively.
[105]	-	10-70	FA /CM ratio (p), concrete age (t).	$k_t = 1.25 + 0.14 \cdot \log_e t - 3.90 \cdot p + 2.75 \cdot p^2$

*C/(S+A) = CaO/(SiO_2+Al_2O_3)

One of the first research regarding the efficiency of CM (FA, silica fume and ground granulated blast-furnace slag) defined by *k* factor was performed by Babu [97], [98], [106]–[108]. Researchers assumed that the FA efficiency is mostly influenced by the W/CM ratio, FA/CM ratio and age. They re-evaluated the results from previous studies and defined the FA efficiency at different ages - 7 days, 28 days and 90 days for FA replacement levels from 15% to 75% (Table 2). The selection of the results was done in the way that only mixtures with maximum aggregate size of 20 mm, plasticizer amount less than 2%, cured under normal conditions were used for the evaluation.

The evaluation of the efficiency factor proposed by Babu and Rao [97] was done on the previously selected results from the database. Figure 11 shows the relationship between the 28-day compressive strength of CC and HVFAC experimental values and the W/(C+*k*·FA) ratio with *k* values proposed by Babu and Rao [97]. It can be seen that similar correlation between CC and HVFAC results can be obtained by applying the FA efficiency factor proposed by Babu and Rao [98] with slightly stronger correlation for HVFAC (R^2=0.656 for CC and R^2=0.704 for HVFAC).

Predictions for *k* factor given by Rajamane et al. [103] and Yeh [105] depend on the same two variables as in Babu's prediction – the FA/CM ratio and concrete age. Evaluation of their *k* factor predictions on the results from own database is shown in Figures 12 and 13. Similar correlation for HVFAC and CC compressive strength results can be seen with better correlation obtained by using Yeh [105] prediction.

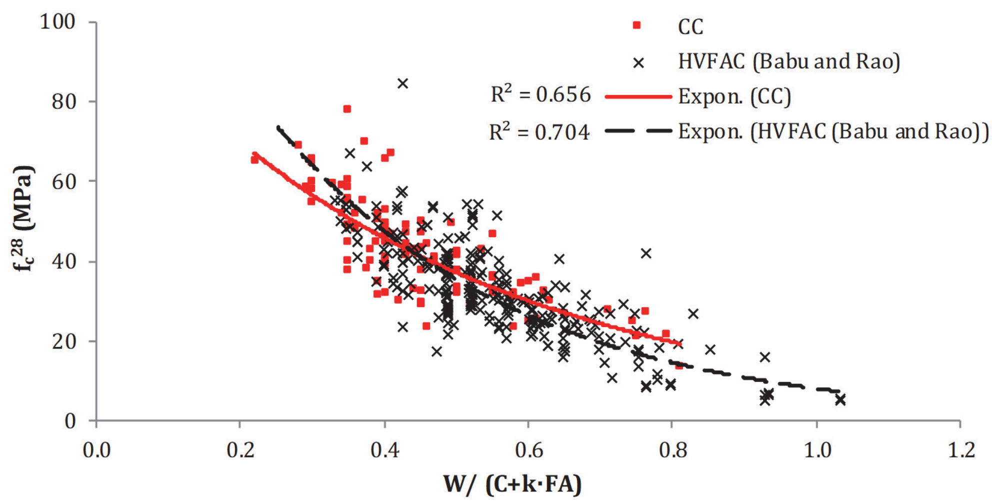

Figure 11. Relationship between 28-day compressive strength and W/(C+k·FA) [98]

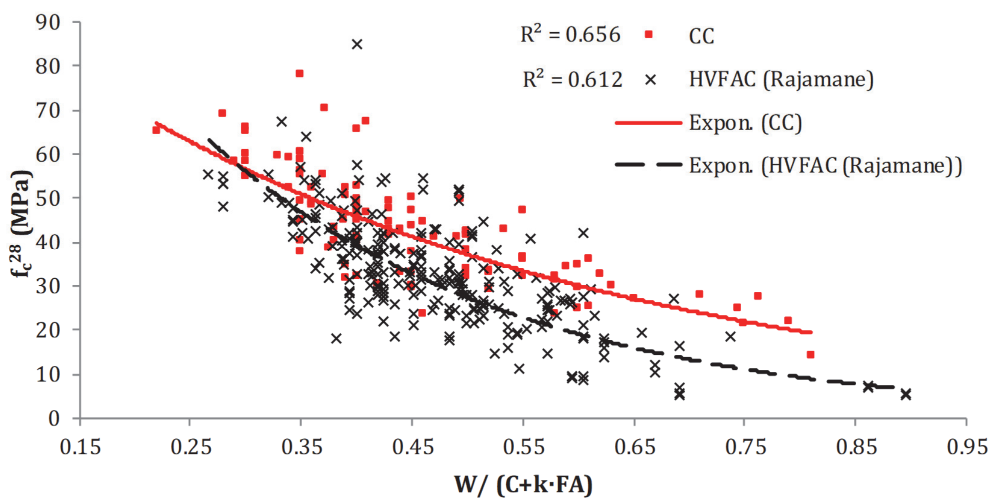

Figure 12. 28-day compressive strength versus W/(C+k·FA) [103]

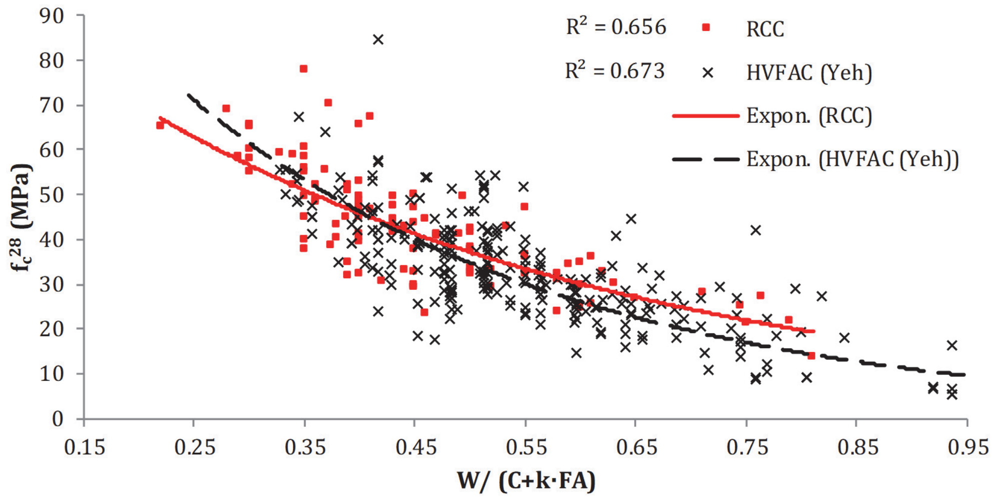

Figure 13. 28-day compressive strength versus W/(C+k·FA) [105]

To improve the correlation between the HVFAC compressive strength and W/(C+*k*·FA) factor parameters defining FA and cement properties should be included. For instance, Papadakis investigated the influence of active silica (active SiO_2) content in FA on the efficiency of FA in concrete [101], [109]–[111]. According to Papadakis et al. (2002) the activity of CM was greatly influenced by the amount of active SiO_2 in FA and cement and the FA activity index. According to the defined procedure, given in EN 450-1 [112], the FA activity index is being tested on mortars made with 25% of FA in CM mass. Papadakis et al. [101] analyzed the influence of these two parameters on the efficiency of FA in concrete mixtures made with 10% to 20% of FA in CM. Two different predictions for k factor were proposed by the authors, as shown in Table 2. The predictions proposed by Papadakis et al. [101] were not re-evaluated in this study due to the lack of available results regarding FA and cement active silica content and the FA activity index for HVFAC mixtures in the database.

Another important parameter influencing the FA efficiency is its fineness [97], [101]. A study conducted by Hwang et al. [99] evaluated the efficiency of FA as the function of the FA content, Blaine specific surface area and concrete age. The authors highlighted that the FA efficiency is strongly influenced by the FA and cement amount ratio, but suggested that the effect of the FA fineness should also be included (Table 2). In order to re-evaluate the *k* factor proposed by Hwang et al. [99] selected CC and HVFAC mixtures from the database were analyzed. Only studies with available results of FA Blaine specific surface area were chosen from the database (211 HVFAC mixtures). The relationships between the CC and HVFAC 28-day compressive strength results and the W/(C+k·FA) ratio proposed by Hwang et al. [99] are shown in Figure 14. The

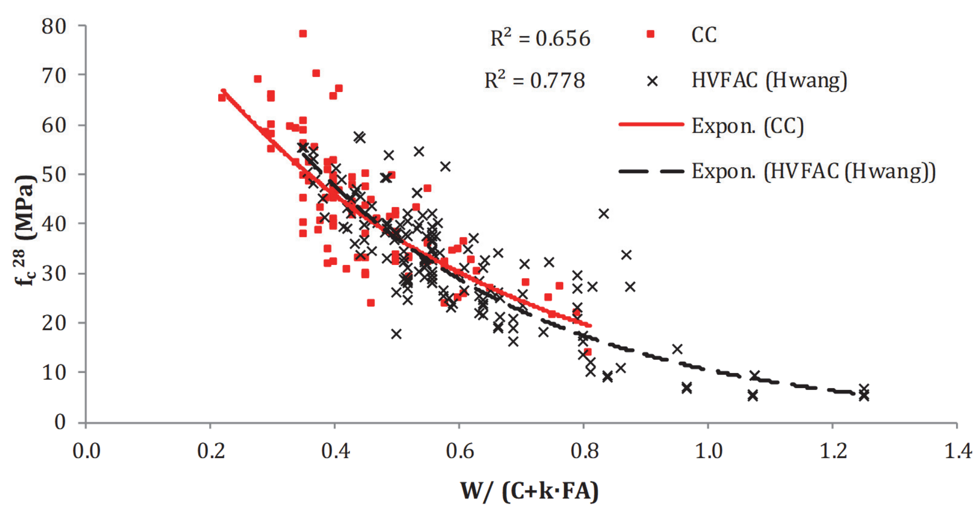

Figure 14. 28-day compressive strength versus W/(C+k·FA) [99]

strong correlation shown in Figure 14 (R^2=0.778 for HVFAC) indicates that the fineness is an important factor influencing FA efficiency.

The Blaine method is widely used for the characterization of the cement fineness and it is defined in the EN 196-6 [113]. However, this method is not included in the EN 450-1 for the use of FA in concrete [112]. One of the basic assumptions regarding the Blaine method testing is that the material particles are mostly spherical with no particles that are highly irregular in shape [114]. However, FA particles can be irregular in shape with a certain number of unburned coal residues and inter-particle heterogeneity [115]. Hence, a special attention is needed when selecting measuring techniques (which were developed for cement) in the characterization of FA [114], [116]. This can be a disadvantage of the FA efficiency method proposed by Hwang et al. [99]. Nevertheless, fineness, particularly that of its glassy phase, is considered to be an important factor influencing the FA efficiency [117].

The amount of reacted FA greatly depends on its glassy phase - reactive SiO_2 and Al_2O_3 content and on the amount of available $Ca(OH)_2$ present in the concrete matrix. Hannesson [52] conducted research in order to determine the FA efficiency as a function of FA and cement chemical composition. He concluded that the amount of CaO, SiO_2 and Al_2O_3 in the cement and FA was an important factor influencing the FA concrete compressive strength. Since these three chemical compounds are important for both early and long-term strength, the FA efficiency was presented as the function of the CaO mass to the sum of SiO_2 and Al_2O_3 mass ratio in total CM for different concrete age.

In a paper published by Kuder et al. (2012), the summary of the research done by Hannesson [52] was presented. The evaluation of the FA and granulated blast furnace slag efficiency in different concrete mixtures was done. The proposed efficiency factor (Table 2) was re-evaluated in this study on the selected results from the database. Out of all results in the database, only the ones with available data on CaO, SiO_2 and Al_2O_3 content in cement and FA were used for the analysis (334 HVFAC mixtures). The relationships between the 28-day compressive strength and the W/(C+k·FA) ratio are shown in Figure 15 for Kuder et al. [104] k factor predictions. Similar correlation was obtained for the CC and HVFAC results (R^2=0.656 for CC and R^2=0.546 for HVFAC).

The previous analysis showed that HVFAC can be defined with the same exponential type of compressive strength and W/CM ratio relationship if the FA efficiency factor was introduced. Looking at Figures 11-15, it can be concluded that Hwang et al. [99] prediction proposal provided the strongest correlation between the HVFAC compressive strength and W/(C+k·FA) ratio. This is understandable since this is the most complex prediction model reflecting the influence of FA/CM ratio, FA fineness and concrete age on the FA reactivity. On the other hand, the factor proposed by Kuder et al. (2012) introducing the CaO, SiO_2 and Al_2O_3 content in FA and cement is considered to reflect FA reactivity better than the FA/CM mass ratio. With a factor of that type, the mass ratio of the most important oxides influencing pozzolanic activity of FA is considered. Since the FA reactivity is also influenced by its fineness, the attempt was made to modify Kuder et al. [104] proposal by introducing FA fineness into the prediction model. For that purpose, the FA density was chosen because it can be determined more reliably than the Blaine specific surface area; besides, it is commonly used in the FA characterization as the fineness indicator.

To propose the modification of the C/(S+A) factor type by incorporating the FA density, the following procedure was applied:

- Evaluation of the selected empirical equations defining the relationship between the compressive strength and W/CM ratio of CC;
- Calculation of necessary coefficients for the use of these equations;
- Calculation of the experimental k factor values for the HVFAC from the database;
- Proposing the equation for k factor calculation.

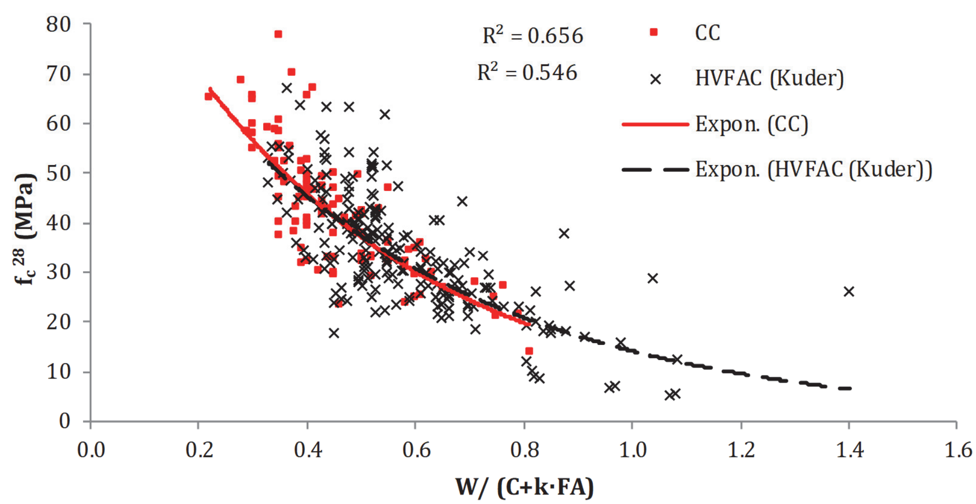

Figure 15. 28-day compressive strength versus W/(C+k·FA) [104]

One of the main reasons for analyzing the FA efficiency is the need to use the empirical equations for compressive strength predictions in order to determine the concrete mix design and component material proportion. There are few empirical equations used for the compressive strength prediction of CC and they are all the function of the W/C ratio accounting for different parameters of influence. The most commonly used empirical equations are Abrams, Bolomey, Feret and Baljejev [118]–[125]. In this study Bolomey, Baljejev and Feret equations were selected for evaluation in the following forms:

Bolomey equation:

$$f_c = A \cdot \left(\frac{1}{\frac{W}{(C + k \cdot FA)}} - 0.5 \right) \tag{1}$$

where:

W water amount (kg/m^3);
C cement amount (kg/m^3);
FA FA amount (kg/m^3);
k FA efficiency factor;
A coefficient defining cement strength and aggregate type.

Baljejev equation:

$$f_c = \frac{B}{\left(\frac{W}{C + k \cdot FA}\right)^{1.5}} \tag{2}$$

where:

B coefficient defining cement strength and aggregate type.

Feret equation:

$$f_c = \frac{K}{\left(1 + \frac{W}{C + k \cdot FA} \cdot \frac{\gamma_{sc}}{\gamma_w}\right)^2} \tag{3}$$

where:

K parameter depending on the cement class;
γ_{sc} density of cement;
γ_w density of water.

The empirical coefficients A, B and K in Bolomey, Baljejev and Feret equations were calculated based on the experimental results of the CC made with the same cement, aggregate and plasticizer type and cured under the same conditions as the HVFAC. In this way, it was further possible to apply calculated empirical coefficients when predicting the HVFAC compressive strength. Out of all studies in the database, only the ones with available data regarding concrete mix design, chemical composition of FA and cement, CC concrete mixture and 28-day compressive strength were selected. After applying these filters to the database, 41 studies with concrete mixtures remained for further analysis. The selected concrete mixtures were divided into two groups, 285 HVFAC mixtures and 88 CC mixtures. The coefficients A, B and K in Bolomey, Baljejev and Feret equations were calculated for each referent CC in each study using the following equations:

$$A_i = \frac{f_c^{RCC}}{C/_{W} - 0.5} \tag{4}$$

$$B_i = f_c^{RCC} \cdot \left(\frac{W}{C}\right)^{1.5} \tag{5}$$

$$K_i = f_c^{RCC} \cdot \left(1 + \frac{W}{C} \cdot \frac{\gamma_{sc}}{\gamma_w}\right)^2 \tag{6}$$

where:

i number of different studies;
f_c^{RCC} experimental 28-day compressive strength of CC (MPa);
C, W cement and water mass in CC;
γ_{sc} density of cement, if not available taken as 3150 kg/m^3;
γ_w = 1000 kg/m^3.

In some studies, more than one CC mixture was used and in that case A_i, B_i and K_i coefficients were taken as the mean values of all CC mixtures in that study. This procedure was justified given that all CC in one study were made with the same cement and aggregate type.

In order to choose one of these three empirical equations for further analysis the FA efficiency factor (k^{EXP}) was calculated from the experimental HVFAC compressive strength results using each of them with k=k^{EXP}.

The results of the calculated k^{EXP} for all 285 HVFAC mixtures (sample number ranging from 1 to 285) are shown in Figure 16. It can be seen that the Bolomey and Baljejev equations gave similar k^{EXP} values while the Feret equation yielded slightly higher k^{EXP} values. Bolomey equation was selected for further FA efficiency evaluation.

The next step was to propose the FA efficiency factor as a function of C/S+A ratio and FA fineness expressed with FA density. The evaluation was done on selected studies from the database that had available both chemical composition and density of FA. These criteria yielded 180 HVFAC mixtures for further evaluation. The aim was to obtain the best fit with the experimentally obtained values for *k* (k^{EXP}). The general form for the efficiency coefficient is proposed as:

$$k = a \cdot \gamma_{FA} \cdot \frac{C}{S + A} \tag{7}$$

where:

γ_{FA} FA density (kg/m^3).

The coefficient *a* was fitted in order to match as closely as possible the values of k^{EXP} and after few iterations the following equation was adopted as the best fit:

$$k = \frac{\gamma_{FA}}{3150} \cdot \frac{C}{S + A} \tag{8}$$

The compressive strength of the selected HVFAC mixtures was calculated using the Bolomey equation and the proposed *k* factor defined by Kuder et al. [104] and own modification given in the equation (8). The results are shown in Table 3 and plotted versus the experimental strength in Figure 17. Both equality and mean lines are shown in all figures of the same type as Figure 17 for visual clarity.

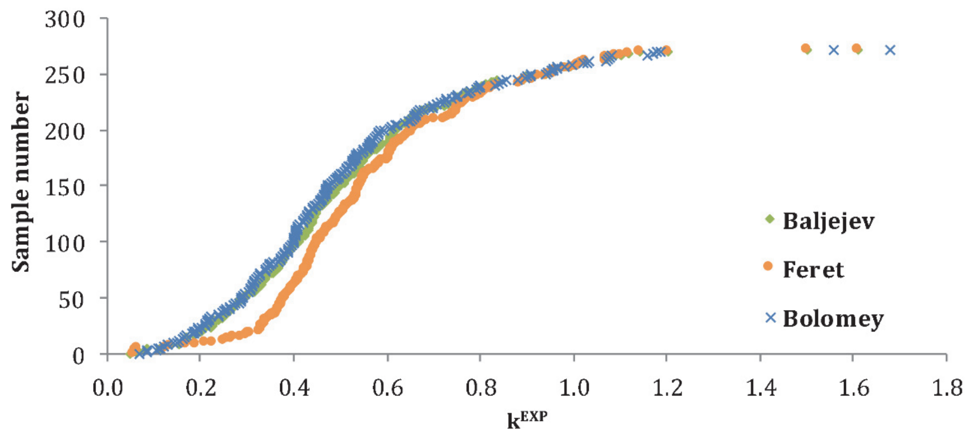

Figure 16. Experimental values of k factor for all 285 HVFAC mixtures

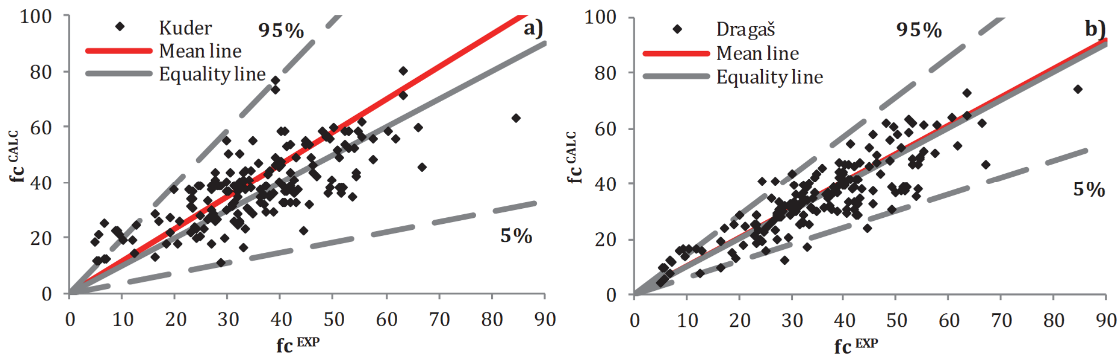

Figure 17. HVFAC compressive strength calculated using different k factor values a) Kuder et al. [104] proposal and b) own proposal

Significantly lower CoV was calculated for the application of own proposal for *k* factor compared with the k factor proposed by Kuder et al. [104] as can be seen in Table 3. So the incorporation of the FA density as a measure of FA fineness in the k factor proposed by Kuder et al. [104] led to the improvement of the compressive strength prediction, and more importantly, to the decrease of the results scattering. Equation (8) can be used to predict the 28-day compressive strength of HVFAC made with 40%-75% of class F FA and normal weight aggregate.

Table 3. Calculated-to-experimental HVFAC compressive strength predictions

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
Kuder	180	**1.17**	0.48	41.57	0.37	1.96
Dragaš	180	**1.02**	0.25	24.54	0.61	1.42

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.
#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev.

4 Compressive strength development over time

European Standard EN 1992-1-1 [12] defines the following equation for the compressive strength development of cement concrete:

$$f_{cm}(t) = f_{cm}(28) \cdot \beta_{cc}(t) = f_{cm}(28) \cdot EXP\left\{s \cdot \left(1 - \sqrt{\frac{28}{t}}\right)\right\} \quad (9)$$

where:
$f_{cm}(28)$ mean 28-day compressive strength;
t days;
s coefficient depending on the cement type and class.

The coefficient *s* is defined for three groups of cement as (32.5, 42.5 and 52.5 refer to 28-day compressive strength in MPa):

- 0.20 - cement strength classes CEM 42.5 R, CEM 52.5 N and CEM 52.5 R;
- 0.25 - cement strength classes CEM 32.5 R, CEM 42.5 N;
- 0.38 - cement strength classes CEM 32.5 N.

Application of this equation was tested on CC and HVFAC mixtures from the database with available information regarding cement strength class and early age cement strength. The compressive strengths at different ages for the selected CC and HVFAC mixtures were calculated using equation (9) and experimental value of 28-day compressive strength. The experimental versus calculated CC and HVFAC compressive strengths for 1-14 days and 56-365 days are shown in Table 4 and in Figure 18 (for HVFAC).

Looking at the statistical descriptors in Table 4 and Figure 18 it can be seen that the early age HVFAC compressive strength is overestimated and later age HVFAC compressive strength is underestimated when equation (9) is applied. This trend was expected having in mind that FA pozzolanic reaction takes place if there is available $Ca(OH)_2$ in concrete matrix – it starts after the beginning of hydration, approximately at the age of 7–14 days or later [8], [117]. So, the equation (9) defined in EN 1992-1-1 [12] should be modified for the HVFAC compressive strength development over time. The easiest way to do it is by modifying the *s* coefficient.

There are several proposals for the *s* coefficient modification in literature. The evaluation of the HVFAC compressive strength development over time was done by Yoon et al. [42] by analysing the HVFAC made with 50% and 60% of class F FA and different W/CM ratios. The researchers concluded that the W/CM ratio is also an important factor influencing the strength gain, especially in high FA content concrete made with low water amount. They proposed the modified *s* coefficients for different FA amount and W/CM ratios regardless of the cement type as follows:

- s = 0.57 ± 0.08 for FA/CM=0.5 for all W/CM;
- s = 0.56 ± 0.02 for FA/CM=0.6 for and W/CM = 0.3;
- s = 0.89 ± 0.05 for FA/CM=0.6 for all other W/CM.

Table 4. Calculated-to-experimental compressive strength ratio at different ages

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
CC_EN 1992-1-1, t <28 days	185	**1.00**	0.21	21.16	0.65	1.34
HVFAC_EN 1992-1-1, t <28 days	434	**1.39**	0.45	32.24	0.65	2.12
CC_EN 1992-1-1, t > 28 days	162	**0.99**	0.07	6.89	0.88	1.11
HVFAC_EN 1992-1-1, t >28 days	450	**0.81**	0.13	16.49	0.59	1.03

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.
#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev.

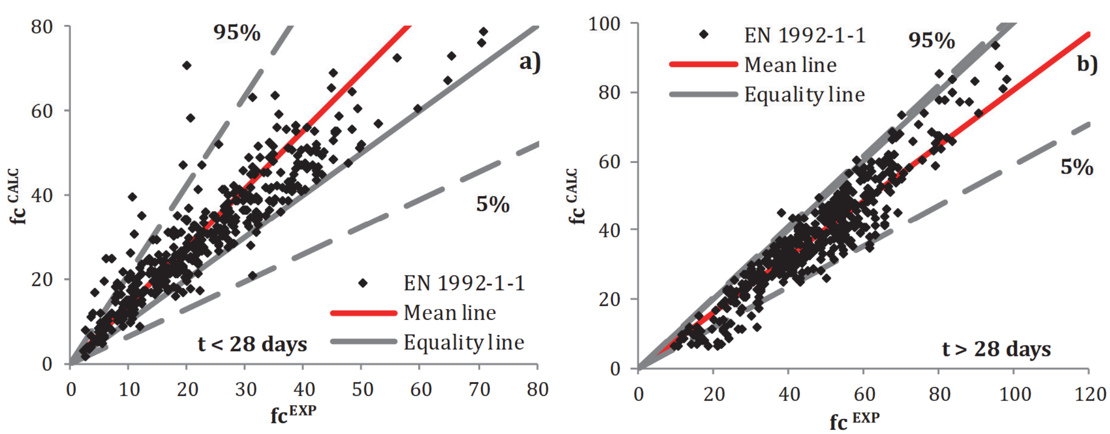

Figure 18. Relationship between the calculated (EN 1992-1-1) and experimental HVFAC compressive strength for ages a) 1-14 days and b) 56-365 days

Due to relatively wide range proposed for *s* coefficient and the fact that cement type was not included in the proposed modifications, these proposals were not tested against the test results.

Chen et al. [126] proposed the modification of the EN 1992-1-1 equation (10) by using new *s* coefficient defined as a function of the C/(S+A) ratio, mentioned before, as follows:

$$\beta_{cc}(t) = \begin{cases} EXP\left\{ s\cdot\left(-0.38\cdot\frac{C}{S+A}+2.12\right)\cdot\left(1-\sqrt{\frac{28}{t}}\right), \quad t<28\ days \right\} \\ EXP\left\{ s\cdot\left(-1.15\cdot\frac{C}{S+A}+3.70\right)\cdot\left(1-\sqrt{\frac{28}{t}}\right), \quad t>28\ days \right\} \end{cases} \tag{10}$$

where:
s coefficient defined in EN 1992-1-1 [12] in equation (10) depending on the cement type.

They concluded that the C/(S+A) ratio influenced the compressive strength development in different ways for the ages before and after 28 days. According to the authors, the increase of C/(S+A) ratio causes increase of the compressive strength before 28 days, and the decrease of strength after 28 days [126]. This can be explained by the fact that the cement hydration is dominant at early ages when more CaO is favourable. At later ages, the pozzolanic reaction takes place and more SiO_2 and Al_2O_3 is needed.

The development of FA concrete compressive strength was also studied by Bhaskara et al. [82] in their research regarding concretes containing up to 75% of FA in total mass of CM. Based on the results from literature and own experimental results they proposed the modification of coefficient *s* defined in EN 1992-1-1 (equation 10) as a function of FA amount in total CM mass as:

$$s_{mean} = 0.298e^{0.0134p} \tag{11}$$

where: $p = \frac{FA}{C+FA} \times 100$

Bhaskara et al. [82] also proposed the equations for predicting the 95% confidence limit (i.e. the lower 5% significance level of s) for obtaining a conservative estimation of mean compressive strength:

t < 28 days: $s_{mean} = 0.268e^{0.0132p}$ (12)

t > 28 days: $s_{mean} = 0.315e^{0.0135p}$ (13)

The evaluation of Chen et al. (2017) and Bhaskara et al. [82] proposal for *s* coefficient was done by comparing the calculated and experimental values of the compressive strength for the ages before and after 28 days as shown in Table 5 and in Figures 19 and 20. Chen et al. [126] proposal was evaluated on the selected results from the database that had available information regarding cement and FA chemical composition by applying the equation (10) in equation (9). Evaluation of the Bhaskara et al. proposal for *s* coefficient was done by applying equations (12) and (13) in equation (9). The HVFAC compressive strength was also calculated using s=0.38 (as for cement class S) as proposed by Bamforth et al. [127] for concretes with more than 35% of FA in total CM (Table 5 and Figure 21).

Table 5. Calculated-to-experimental HVFAC compressive strength ratio at different ages

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
Chen et al., t < 28 days	330	**0.96**	0.24	25.35	0.56	1.35
Bhaskara et al., HVFAC, t < 28 days	674	**0.85**	0.24	28.72	0.45	1.25
s=0.38, t < 28 days	674	**1.08**	0.27	24.78	0.64	1.53
Chen et al. t > 28 days	302	**1.06**	0.16	14.89	0.80	1.31
Bhaskara et al., HVFAC, t > 28 days	583	**0.99**	0.15	14.84	0.75	1.24
s=0.38, t > 28 days	583	**0.87**	0.13	15.24	0.65	1.09

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.
#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev.

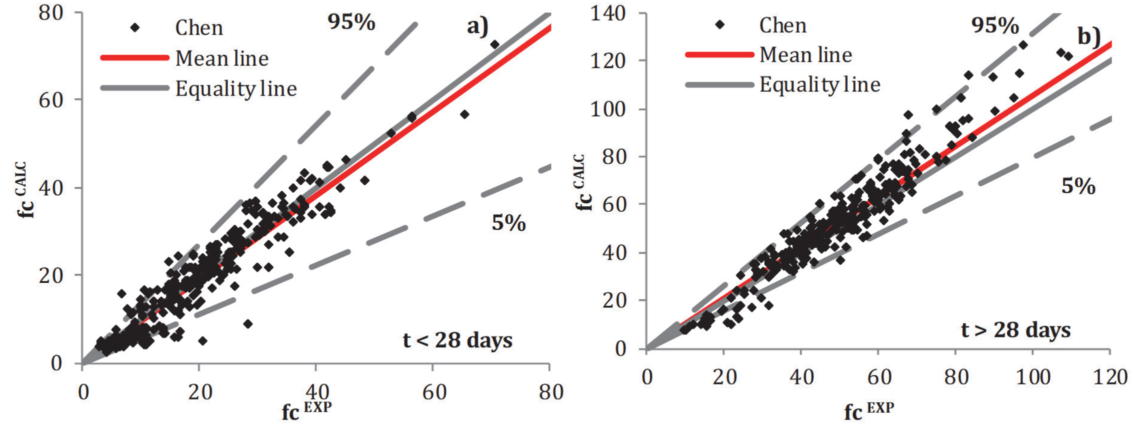

Figure 19. Relationship between the calculated [126] and experimental HVFAC compressive strength for ages a) 1-14 days and b) 56-365 days

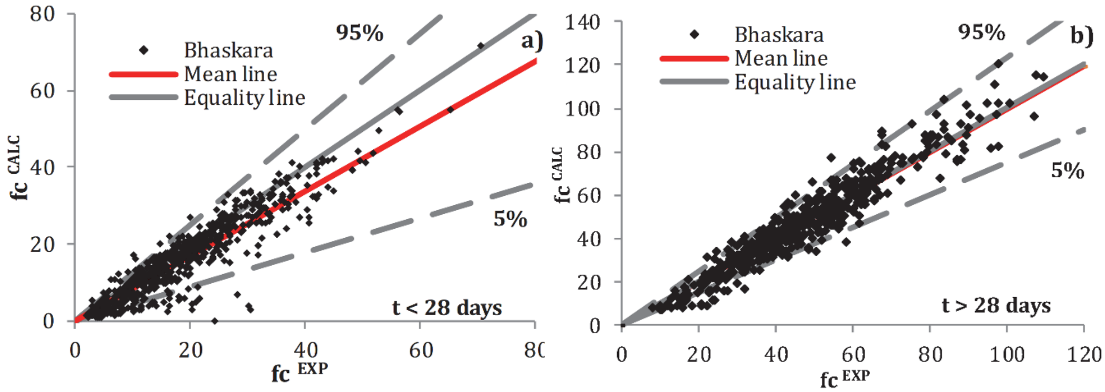

Figure 20. Relationship between the calculated (Bhaskara et al. 2018) and experimental HVFAC compressive strength for ages a) 1-14 days and b) 56-365 days

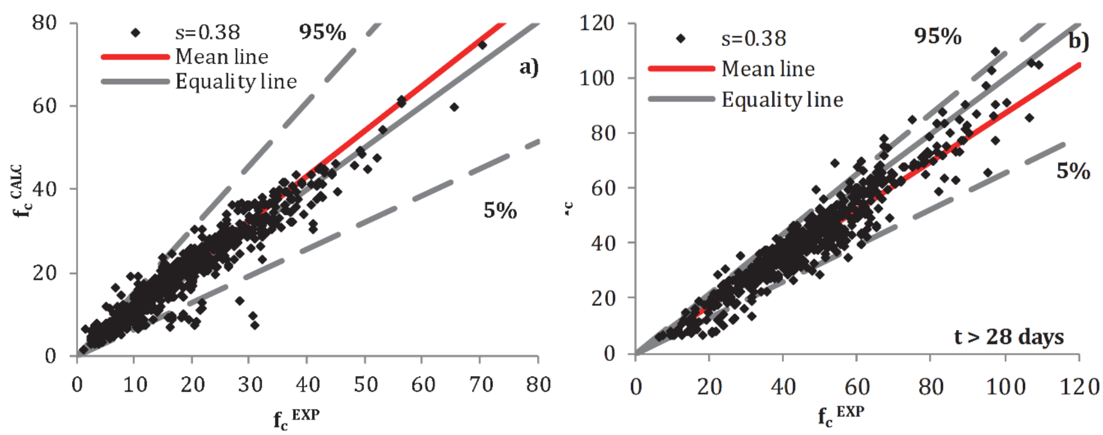

Figure 21. Relationship between the calculated (s=0.38) and experimental HVFAC compressive strength for ages a) 1-14 days and b) 56-365 days

Considering means and CoVs, the most accurate prediction of compressive strengths at ages before 28 days was obtained with Chen et al. (2017) proposal. Compressive strengths at ages after 28 days were most accurately predicted with Bhaskara et al. proposal. Looking integrally, Chen et al. prediction model (equation 10) in combination with EN 1992-1-1 equation (9) can be recommended - it provided similar accuracy and variation as for CC (Table 4 and 5) so no further modifications were needed.

5 Modulus of elasticity

Modulus of elasticity is mostly influenced by the concrete age, cement (binder) paste, aggregate type, interfacial transition zone and the porosity of concrete [90]. As already mentioned, available results regarding modulus of elasticity from different studies were obtained on cylindrical samples 100·200 mm or 150·300 mm. Different strength rates were used while testing, but all up to 40% of the ultimate strength. European standard EN 1992-1-1 [12] prescribes the CC modulus of elasticity as a function of its compressive strength. The 28-day modulus of elasticity for quartzite aggregate is defined as follows:

$$E_{cm} = 22 \cdot \left(\frac{f_{cm}}{10}\right)^{0.3} \tag{14}$$

where:

E_{cm} mean 28-day modulus of elasticity (GPa),

f_{cm} mean 28-day compressive strength obtained on a cylinder sample (MPa).

Having in mind that the concrete elastic deformation is mostly influenced by the aggregate type, recommendations for the equation (14) modification are given in EN 1992-1-1 [12]:

- for limestone aggregates modulus should be reduced by 10%;
- for sandstone aggregates modulus should be reduced by 30%;
- for basalt aggregates modulus should be increased by 20%.

In order to evaluate this equation, studies with the experimental results of the CC and HVFAC modulus of elasticity were selected from the database [14], [42], [44], [48]–[50], [128], [129]. Figure 22 shows the relationship between the experimental compressive strength and the experimental modulus of elasticity of CC and HVFAC mixtures made with granite, limestone and sandstone aggregates.

As can be seen from Figure 22, similar power relationship type was observed for both HVFAC and CC but with weaker correlation and greater scatter presented in HVFAC mixtures.

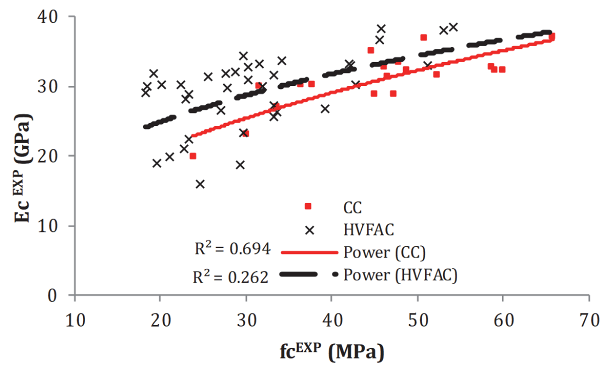

Figure 22. Relationship between experimental values of 28-day modulus of elasticity and 28-day compressive strength for CC and HVFAC

Yoon et al. [42] proposed the following modification of the EN 1992-1-1 [12] equation for the HVFAC modulus of elasticity:

- for HVFAC with 50% of FA in CM:

$$E_{cm} = (17 \pm 0.08) \cdot \left(\frac{f_{cm}}{10}\right)^{(0.45 \pm 0.10)} \tag{15}$$

- for HVFAC with 60% of FA in CM:

$$E_{cm} = (21.7 \pm 0.77) \cdot \left(\frac{f_{cm}}{10}\right)^{(0.29 \pm 0.08)} \tag{16}$$

The modulus of elasticity was calculated using the EN 1992-1-1 equation (14) for CC and HVFAC, considering different aggregate types and experimental cylinder 28-day compressive strength. Results are shown in Table 6 and Figure 23a as the calculated-to-experimental modulus ratio using descriptive statistical parameters.

The Yoon et al. proposal was evaluated for lower, average and upper values of proposed coefficients. For HVFAC mixtures with 45%-55% of FA in CM the modification proposed for 50% of FA and for HVFAC mixtures with 55%-65% of FA in CM the modification proposed for 60% of FA were used. Results are shown in Table 6 and Figure 23b as the calculated-to-experimental modulus ratio using descriptive statistical parameters.

Table 6. Calculated-to-experimental 28-day modulus of elasticity ratio

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
CC_EN 1992-1-1	22	**1.07**	0.21	19.10	0.74	1.41
HVFAC_EN 1992-1-1	75	**1.01**	0.19	19.06	0.70	1.33
Yoon et al_lower	65	**0.86**	0.16	18.35	0.59	1.12
Yoon et al_average	65	**0.99**	0.18	18.21	0.70	1.29
Yoon et al_upper	65	**1.13**	0.20	17.75	0.79	1.46

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.

#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev.

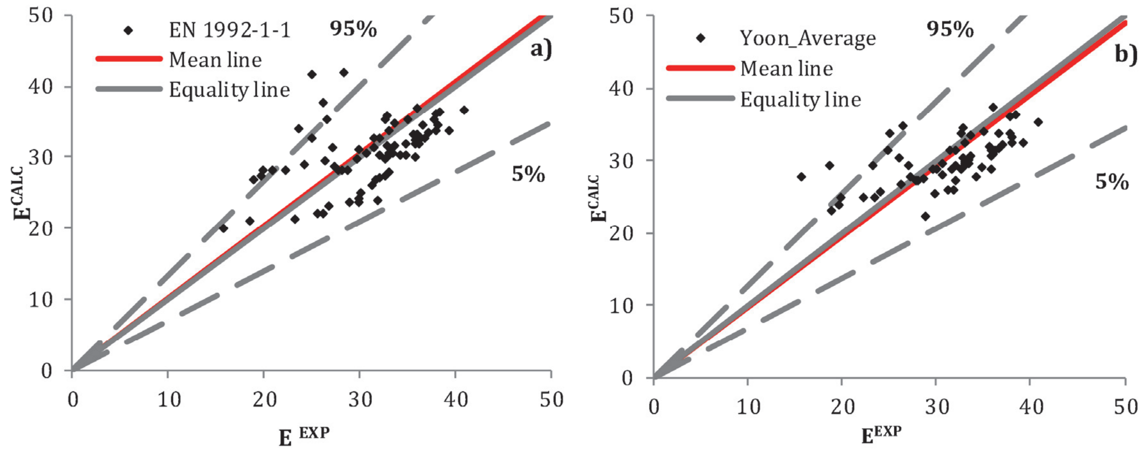

Figure 23. Relationship between calculated and experimental values of HVFAC 28-day modulus of elasticity a) EN 1992-1-1 and b) Yoon et al. prediction

Looking at Table 6, it can be seen that regarding statistical descriptors similar predictions were obtained using the EN 1992-1-1 equation and Yoon et al. (average) proposal, regardless of the FA/CM ratio. It was concluded that the EN 1992-1-1 equation (14) provided estimation of the HVFAC modulus of elasticity with similar accuracy and variation as for CC and that Yoon et al. (2014) prediction model brought no improvements.

The development of the modulus of elasticity over time for CC can be estimated using the equation given in EN 1992-1-1 as:

$$E_{cm}(t) = \left(\frac{f_{cm}(t)}{f_{cm}}\right)^{0.3} \cdot E_{cm} \quad \text{(GPa)} \qquad (17)$$

where:

$E_{cm}(t), f_{cm}(t)$ mean modulus of elasticity and mean compressive strength at the age t (GPa).

Chen et al. proposed the modification of the EN 1992-1-1 equation (17) as a function of the previously described coefficient C/(S+A) as follows:

In order to evaluate the application of equations (15) and (16) on the results from the database, studies with available experimental results of CC and HVFAC modulus of elasticity were selected at the age of 1, 3, 7, 14, 90, 180 and 365 days. The results are presented as the calculated-to-experimental modulus ratio for all ages in Table 7 using the descriptive statistical parameters. In all cases 28-day modulus of elasticity was calculated using equation (14) from experimental 28-day f_{cm}, as already concluded that it gave predictions of similar quality as for CC.

According to EN 1992-1-1, modulus of elasticity development over time is related to compressive strength development according to equation (17). Because of that, when calculating the HVFAC modulus of elasticity development according to this standard, Chen et al. proposal already recommended for compressive strength development was used (equation 10 for *s* coefficient). The graphical representation of the results is shown in Figures 24a and 24b.

Application of Chen et al. [126] proposal gave slightly better prediction of secant modulus of elasticity over time compared to EN 1992-1-1 proposal. On the basis of the evaluation on this database, it was concluded that Chen et al. prediction (equation 18) can be used for HVFAC with similar accuracy and variation of the results as for CC.

$$E_{cm}(t) = E_{cm} \cdot \beta_{cc}(t)^{0.3} = E_{cm} \cdot \left\{EXP\left[s \cdot \left(1 - \sqrt{\frac{28}{t}}\right) \cdot \left(-1.60 \cdot \frac{C}{S+A} + 5.26\right)\right]\right\}^{0.3} \quad \text{(GPa)} \qquad (18)$$

s coefficient defined in EN 1992-1-1 [12] in equation (9) depending on the cement type.

Table 7. Calculated-to-experimental modulus of elasticity ratio at ages 1-365 days

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
CC_EN 1992-1-1	22	**1.00**	0.22	22.15	0.64	1.36
HVFAC_EN 1992-1-1	55	**0.92**	0.19	20.19	0.61	1.23
Chen et al.	55	**0.94**	0.20	21.46	0.61	1.28

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.
#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev.

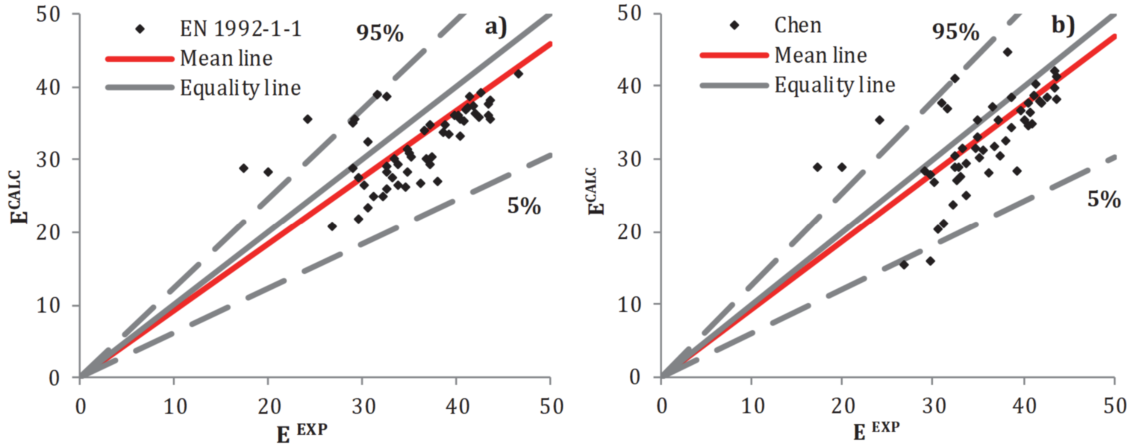

Figure 24. Relationship between the calculated and experimental HVFAC modulus of elasticity at ages 1-365 days using a) EN 1992-1-1 b) Chen et al. [126] proposal

6 Splitting tensile strength

Concrete tensile strength is an important parameter in both the serviceability and ultimate state verifications. It is used in stress analysis, the determination of crack width and spacing, deflection, minimum reinforcement, shear strength etc. European Standard EN 1992-1-1 defines the axial tensile strength of cement concrete in relation to the compressive strength as follows:

$$f_{ctm} = 0.3 \cdot \sqrt[3]{f_{ck}^{2}} \text{ (MPa) for compressive strength } f_{ck} \leq 50 \text{ MPa} \quad (19)$$

$$f_{ctm} = 2.12 \cdot \ln\left(1 + \frac{f_{ck}}{10}\right) \text{ (MPa) for compressive strength } f_{ck} > 50 \text{ MPa} \quad (20)$$

where:
f_{ctm} mean axial tensile strength of concrete,
f_{ck} characteristic compressive cylinder strength of concrete at 28 days ($f_{ck} = f_{cm} - 8$ MPa).

Axial tensile strength is rarely determined by testing, but it can be determined based on the splitting tensile strength using the equation given in EN 1992-1-1 [12] as follows:

$$f_{ct} = 0.9 \cdot f_{ct,sp} \quad \text{(MPa)} \quad (21)$$

where:
f_{ct} axial tensile strength,
$f_{ct,sp}$ splitting tensile strength.

So, the splitting tensile strength can be determined using the combination of equations as:

$$f_{ct,sp} = \frac{1}{3} \cdot \sqrt[3]{f_{ck}^{2}} \text{ (MPa) for concrete classes } \leq C50/60 \quad (22)$$

$$f_{ct,sp} = \frac{2.12}{0.9} \cdot \ln\left(1 + \frac{f_{ck}}{10}\right) \text{ (MPa) for concrete classes } > C50/60 \quad (23)$$

In order to evaluate the application of these equations on the HVFAC tensile strength, concrete mixtures with available data regarding splitting tensile strength were selected from the database [8], [10], [47], [55], [56], [71], [83], [129], [130], [22]–[24], [26], [27], [43]–[45].

The relationship between the experimental 28-day compressive and splitting tensile strength for the selected HVFAC and CC mixtures is shown in Figure 25. As can be seen, the correlation between these two variables is higher for HVFAC mixtures compared with CC results but similar trend can be noticed indicating that the same power relationship type can be used to define them both. Slightly higher splitting tensile strengths for the same 28-day compressive strength can be noticed for CC mixtures compared with the HVFAC ones.

Splitting tensile strength was then calculated for the HVFAC and CC mixtures from the database using the EN 1992-1-1 equation (22 and 23). The results are presented in Table 8 as the calculated-to-experimental splitting tensile strength ratio using the descriptive statistical parameters. The experimental versus calculated splitting tensile strengths are also shown in Figure 26.

Although the prediction of HVFAC splitting tensile strength is slightly more conservative than for CC, it is recommended that the EN 1992-1-1 [12] equation (21) can be used to predict the HVFAC splitting tensile strength at this state-of-the knowledge. Other predictions regarding splitting tensile strength were not found in the literature.

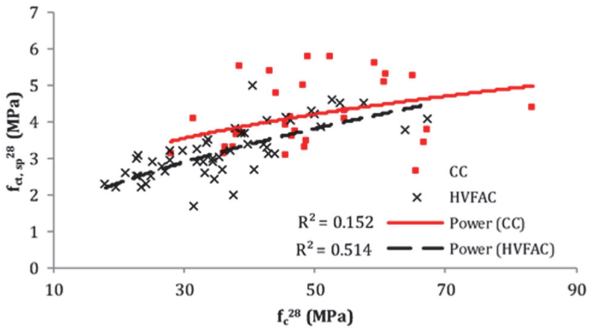

Figure 25. Relationship between 28-day compressive and splitting tensile strength for CC and HVFAC

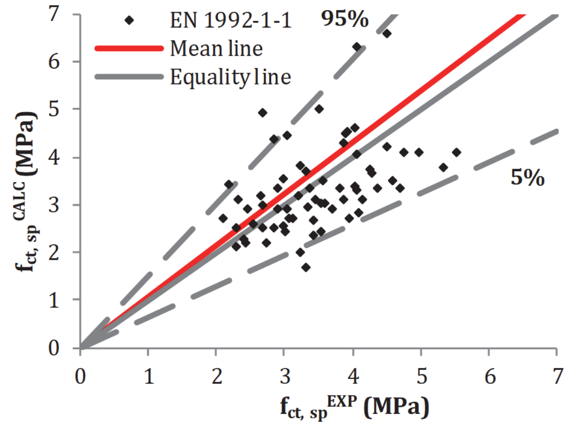

Figure 26. Relationship between the calculated (EN 1992-1-1) and experimental 28-day HVFAC splitting tensile strength

Table 8. Calculated-to-experimental splitting tensile strength using EN 1992-1-1 prediction

	Sample No.	Mean Values	St. Deviation	CoV (%)	$LCL_{5\%}$*	$UCL_{95\%}$#
CC_EN 1992-1-1	20	**0.94**	0.19	20.02	0.63	1.26
HVFAC_EN 1992-1-1	64	**0.88**	0.25	28.18	0.47	1.29

*Lover confidence limit $LCL_{5\%}$ = Mean – 1.645 St.Dev.
#Upper confidence limit $UCL_{95\%}$ = Mean + 1.645 St.Dev

7 Conclusions

The analysis of available experimental results of the HVFAC material properties showed that the extensive amount of research has been done so far. However, comprehensive analysis of HVFAC mechanical properties was not found in the literature, probably due to the great variety of FA physical and mechanical properties. Having that in mind, the database of 440 HVFAC and 151 CC mixtures collected from literature was made and analyzed. Database includes experimental results on the mechanical properties of HVFAC with class F fly ash and the amount of FA in CM in the range between 40% and 75%. Statistical analysis of the results in database enabled following conclusions:

The available empirical equations defined for CC can be used to predict the 28-day compressive strength of HVFAC based on its mixture proportions and using the FA efficiency factor.

The most important parameters influencing the FA efficiency are the amount of FA in CM, FA fineness and the FA and cement chemical composition.

Own proposal for FA efficiency (*k* factor value) as the function of FA chemical composition and its density showed good correlation with the experimental results. When HVFAC compressive strength was calculated using the Bolomey equation and own proposal for *k* factor value, the mean value of calculated-to-experimental compressive strength ratio was 1.02 with CoV of 24.5%.

The equation defined in EN 1992-1-1 for CC compressive strength development over time overestimates early age and underestimates later HVFAC compressive strengths.

The coefficient *s* influencing the compressive strength development over time proposed by Chen et al., in combination with EN 1992-1-1 equation for CC, can be used to predict the HVFAC compressive strength development.

The EN 1992-1-1 28-day modulus of elasticity prediction can be used to predict the HVFAC modulus of elasticity with similar accuracy and variation as for CC.

Chen et al. modification of EN 1992-1-1 equation for modulus of elasticity development over time can be used to predict the HVFAC modulus of elasticity with similar accuracy and variation as for CC.

The EN 1992-1-1 splitting tensile strength prediction can be used to predict the HVFAC splitting tensile strength with similar accuracy and variation as for CC.

These conclusions depend upon the database from which they were drawn and are valid only within the current range of parameters. Nevertheless, the database is freely accessible online which enables other researchers to update it, improve it, and analyse it in new and different ways compared with the ones presented in this study.

This work presented a leap forward on the road to HVAC practical application. Nevertheless, a variety of challenges regarding the use of FA in concrete still need to be overcome (heterogeneity of FA, durability of FA, behavior of structural elements made with HVFAC…).

The results and conclusions presented in this study give guidelines for practical HVFAC mix design procedure and prediction of basic mechanical properties. Greater use of HVFAC in applications where moderate compressive strength is needed could significantly reduce the amount of used cement and, therefore, the amount of emitted CO_2 compared with the traditional cement concrete. HVFAC would provide a sustainable solution to extensive growth in the construction sector and larger concrete consumption.

Acknowledgements

This work was supported by the Ministry for Education, Science and Technology, Republic of Serbia [grant number TR36017]; this support is gratefully acknowledged.

References

[1] J. Yang *et al.*, Eco-friendly treatment of low-calcium coal fly ash for high pozzolanic reactivity: A step towards waste utilization in sustainable building material, Journal of Cleaner Production, vol. 238, 2019, p. 117962, doi: 10.1016/j.jclepro.2019.117962.

[2] S. Marinković, J. Dragaš, I. Ignjatović, and N. Tošić, Environmental assessment of green concretes for structural use, Journal of Cleaner Production, vol. 154, 2017, pp. 633–649, doi: 10.1016/j.jclepro.2017.04.015.

[3] R. M. Andrew, Global CO2 emissions from cement production, 1928–2017, Earth Syst. Sci. Data, 10. [Online]. Available: https://doi.org/10.5194/essd-10-195-2018.

[4] H. Hafez, R. Kurda, W. M. Cheung, and B. Nagaratnam, Comparative life cycle assessment between imported and recovered fly ash for blended cement concrete in the UK, Journal of Cleaner Production, vol. 244, 2019, p. 118722, doi: 10.1016/j.jclepro.2019.118722.

[5] N. Bouzoubaa and V. M. Malhotra, Performance of Lab-Produced High-Volume Fly Ash Cements in Concrete, Concrete International, vol. 23, no. 4, 2001, pp. 31–35.

[6] T. Hemalatha and A. Ramaswamy, A review on fly ash characteristics – Towards promoting high volume utilization in developing sustainable concrete, Journal of Cleaner Production, vol. 147, 2017, pp. 546–559, doi: 10.1016/j.jclepro.2017.01.114.

[7] S. Marinković and J. Dragaš, Fly ash, in *Waste and Supplementary Cementitious Materials in Concrete: Characterisation, Properties and Applications*, R. Siddique and P. Cachim, Eds. Woodhead Publishing, 2018, 2018, pp. 325–360.

[8] L. Lam, Y. L. Wong, and C. S. Poon, Degree of hydration and gel/space ratio of high-volume fly ash/cement systems, Cement and Concrete Research, vol. 30, no. 5, 2000, pp. 747–756, doi: 10.1016/S0008-8846(00)00213-1.

[9] C. S. Poon, L. Lam, and Y. L. Wong, A study on high strength concrete prepared with large volumes of low calcium fly ash, Cement and Concrete Research, vol. 30, no. 3, 2000, pp. 447–455, doi: 10.1016/S0008-8846(99)00271-9.

[10] R. Siddique, Performance characteristics of high-volume Class F fly ash concrete, Cement and Concrete Research, vol. 34, no. 3, 2004, pp. 487–493, doi: 10.1016/j.cemconres.2003.09.002.

[11] C. Herath, C. Gunasekara, D. W. Law, and S. Setunge, Performance of high volume fly ash concrete incorporating additives: A systematic literature review, Construction and Building Materials, vol. 258, 2020, p. 120606, doi: 10.1016/j.conbuildmat.2020.120606.

[12] CEN, *EN 1992-1-1: Design of concrete structures - Part 1-1: General rules and rules for buildings*. Brussels: European Committee for Standardization, 2004, 2004, p.

[13] ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, West Conshohocken, Pennsylvania.

[14] S. C. Kou and C. S. Poon, Long-term mechanical and durability properties of recycled aggregate concrete prepared with the incorporation of fly ash, Cement and Concrete Composites, vol. 37, 2013, pp. 12–19, doi: 10.1016/j.cemconcomp.2012.12.011.

[15] L. Lam, Y. L. Wong, and C. S. Poon, Effect of fly ash and silica fume on compressive and fracture behaviors of concrete, Cement and Concrete Research, vol. 28, no. 2, 1998, pp. 271–283.

[16] M. J. McCarthy and R. K. Dhir, Development of high volume fly ash cements for use in concrete construction, Fuel, vol. 84, no. 11, 2005, pp. 1423–1432, doi: 10.1016/j.fuel.2004.08.029.

[17] N. Bouzoubaâ and M. Lachemi, Self-compacting concrete incorporating high volumes of class F fly ash Preliminary results, Cement and Concrete Research, vol. 31, 2001, pp. 413–420.

[18] C. H. Huang, S. K. Lin, C. S. Chang, and H. J. Chen, Mix proportions and mechanical properties of concrete containing very high-volume of Class F fly ash, Construction and Building Materials, vol. 46, 2013, pp. 71–78, doi: 10.1016/j.conbuildmat.2013.04.016.

[19] L. H. Jiang and V. M. Malhotra, Reduction in water demand of non-air-entrained concrete incorporating large volumes of fly ash, Cement and Concrete Research, vol. 30, no. 11, 2000, pp. 1785–1789, doi: 10.1016/S0008-8846(00)00397-5.

[20] H. Quan and H. Kasami, Experimental Study on Effects of Type and Replacement Ratio of Fly Ash on Strength and Durability of Concrete, The Open Civil Engineering Journal, no. 7, 2013, pp. 93–100.

[21] P. Dinakar, K. G. Babu, and M. Santhanam, Durability properties of high volume fly ash self compacting concretes, Cement and Concrete Composites, vol. 30, 2008, pp. 880–886, doi: 10.1016/j.cemconcomp.2008.06.011.

[22] P. Dinakar, M. Kartik Reddy, and M. Sharma, Behaviour of self compacting concrete using Portland pozzolana cement with different levels of fly ash, Materials and Design, vol. 46, 2013, pp. 609–616, doi: 10.1016/j.matdes.2012.11.015.

[23] M. Şahmaran, İ. Ö. Yaman, and M. Tokyay, Transport and mechanical properties of self consolidating concrete with high volume fly ash, Cement and Concrete Composites, vol. 31, no. 2, 2009, pp. 99–106, doi: 10.1016/j.cemconcomp.2008.12.003.

[24] C. D. Atis, Accelerated carbonation and testing of concrete made with fly ash, Construction and Building Materials, vol. 17, 2003, pp. 147–152.

[25] M. L. Berndt, Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate, Construction and Building Materials, vol. 23, 2009, pp. 2606–2613, doi: 10.1016/j.conbuildmat.2009.02.011.
[26] [C. D. Atis, High-Volume Fly Ash Concrete with High Strength and Low Drying Shrinkage, Journal of Materials in Civil Engineering, vol. 15, no. 2, 2003, pp. 153–156, doi: 10.1061/(ASCE)0899-1561(2003)15:2(153).
[27] A. Bilodeau and V. M. Malhotra, High-Volume Fly Ash System: Concrete Solution for Sustainable Development, ACI Materials Journal, 2000, pp. 41–47.
[28] V. Sivasundaram, G. G. Carette, and V. M. Malhotra, Selected Properties of High-Volume Fly Ash Concretes, *Concrete international*. 1990, pp. 47–50, 1990.
[29] V. M. Malhotra, Superplasticized fly ash concrete for for structural application, Concrete international, vol. 8, 1986, pp. 28–31.
[30] O. Kayali and M. Sharfuddin Ahmed, Assessment of high volume replacement fly ash concrete – Concept of performance index, Construction and Building Materials, vol. 39, 2013, pp. 71–76, doi: 10.1016/j.conbuildmat.2012.05.009.
[31] G. Li and X. Zhao, Properties of concrete incorporating fly ash and ground granulated blast-furnace slag, Cement and Concrete Composites, 2003, p., doi: 10.1016/S0958-9465(02)00058-6.
[32] A. Duran-Herrera, C. Juarez, P. Valdez, and D. . Bentz, Evaluation of sustainable high-volume fly ash concretes, Cement & Concrete Composites, vol. 33, 2011, pp. 39–45.
[33] B. Y. K. H. Obla, R. L. Hill, and R. S. Martin, HVFA Concrete – An Industry Perspective, Concrete international, no. August, 2003, pp. 29–34.
[34] M. Tokyay, Strength prediction of fly ash concretes by accelerated testing, Cement and Concrete Research, vol. 29, no. 11, 1999, pp. 1737–1741, doi: 10.1016/S0008-8846(99)00160-X.
[35] N. Bouzoubaâ and B. Fournier, Optimization of fly ash content in concrete Part I: Non-air-entrained concrete made without superplasticizer, Cement and Concrete Research, vol. 33, no. 7, 2003, pp. 1029–1037, doi: 10.1016/S0008-8846(03)00004-8.
[36] A. Mittal, M. B. Kaisare, and S. Rajenderakumar, Experimental study on use of fly ash in concrete, 2006. https://www.sefindia.org/forum/files/experimental_study_on_use_of_fly_ash_in_concrete_by_mr_amit_mittal_136.pdf (accessed Jan. 22, 2018).
[37] K. P. Keith, Characterization of the Behavior of High Volume Fly Ash Concrete, Auburn University, 2011.
[38] D. Burden, The Durability of Concrete Containing High Levels of Fly Ash, The university of New Brunswick, 2006.
[39] Inderpreet Kaur, Mechanical properties of high volume fly ash (hvfa) concrete subjected to elevated temperatures up to 120oc, Deemed University, 2005.
[40] V. K. Mathur, C. L. Verma, B. S. Gupta, S. K. Agarwal, and A. Kumar, Use of high volume fly ash in concrete for building sector, Ottawa, Ontario.
[41] H.-H. Hung, Properties of High Volume Fly Ash Concrete, Faculty of Engineering, University of Sheffield, 1997.
[42] S. Yoon, P. J. M. Monteiro, D. E. Macpheec, F. P. Glasser, and M. S.-E. Imbabi, Statistical evaluation of the mechanical properties of high-volume class F fly ash concretes, Construction and Building Materials, vol. 54, 2014, pp. 431–442.
[43] M. Soman and K. Sobha, Strength and Behaviour of High Volume Fly Ash Concrete, International Journal of Innovative Research in Science, Engineering and Technology, vol. 3, no. 5, 2014, pp. 12416–12424.
[44] N. Bouzoubaâ, M. H. Zhang, and V. M. Malhotra, Mechanical properties and durability of concrete made with high-volume fly ash blended cements using a coarse fly ash, Cement and Concrete Research, vol. 31, 2001, pp. 1393–1402.
[45] A. Mardani-Aghabaglou, Ö. Andiç-Çakir, and K. Ramyar, Freeze-thaw resistance and transport properties of high-volume fly ash roller compacted concrete designed by maximum density method, Cement and Concrete Composites, vol. 37, no. 1, 2013, pp. 259–266, doi: 10.1016/j.cemconcomp.2013.01.009.
[46] J. Zhao, G. Cai, and J. Yang, Bond-slip behavior and embedment length of reinforcement in high volume fly ash concrete, Materials and Structures, vol. 49, no. 6, 2016, pp. 2065–2082, doi: 10.1617/s11527-015-0634-2.
[47] R. M. Rao, S. Mohan, and S. K. Sekar, Shear resistance of high volume fly ash reinforced concrete beams without web reinforcement, International Journal of Civil and Structural Engineering, vol. 1, no. 4, 2011, pp. 986–993, doi: 10.6088/ijcser.00202010084.
[48] G. Carette, A. Bilodeau, R. L. Chevrier, and V. M. Malhotra, Mechanical Properties of Concrete Incorporating High Volumes of Fly Ash From Sources in the U.S., Materials Journal, vol. 90, no. 6, 1993, pp. 535–544.
[49] W. S. Langley, G. G. Carette, and V. M. Malhotra, Structural Concrete Incorporating High Volumes of ASTM Class Fly Ash, Materials Letters, vol. 86, no. 5, 1989, pp. 507–514.
[50] V. Sivasundaram, G. G. Carette, and V. M. Malhotra, Mechanical Properties, Creep, and Resistance to Diffusion of Chloride Ions of Concretes Incorporating High Volumes of ASTM Class F Fly Ashes from Seven Different Sources, ACI Materials Journal, vol. 88, 1991, pp. 407–416.
[51] D. W. S. Ho and R. K. Lewis, Effectiveness of fly ash for strength and durability of concrete, Cement and Concrete Research, vol. 15, 1985, pp. 793–800.
[52] Hannesson G., Mechanical Properties of High-Volume SCM Concretes, University of Washington Graduate School, 2010.
[53] V. M. Malhotra, M.-H. Zhang, P. H. Read, and J. Ryell, Comparative Study on Physical and Mechanical Properties of High Slump and Zero Slump

High Volume Fly Ash Concrete, ACI Materials Journal, 2000, pp. 518–525.
[54] V. M. Malhotra, Making concrete “greener” with fly ash, Concrete international, no. 5, 1999, pp. 61–66.
[55] C. D. Atis, Strength properties of high-volume fly ash roller compacted and workable concrete, and influence of curing condition, Cement and Concrete Research, vol. 35, no. 6, 2005, pp. 1112–1121, doi: 10.1016/j.cemconres.2004.07.037.
[56] T. Naik, V. Sivasundaram, and S. S. Singh, Use of high-volume class f fly ash for structural grade concrete, Transportation research record, 1991, pp. 40–47.
[57] T. Proske, S. Hainer, M. Rezvani, and C.-A. Graubner, Eco-friendly concretes with reduced water and cement content – Mix design principles and application in practice, Construction and Building Materials, vol. 67, 2014, pp. 413–421.
[58] C. Lima, A. Caggiano, C. Faella, E. Martinelli, M. Pepe, and R. Realfonzo, Physical properties and mechanical behaviour of concrete made with recycled aggregates and fly ash, Construction and Building Materials, vol. 47, 2013, pp. 547–559, doi: 10.1016/j.conbuildmat.2013.04.051.
[59] N. Bouzoubaâ, M. H. Zhang, and V. M. Malhotra, Laboratory-produced high-volume fly ash blended cements: compressive strength and resistance to the chloride-ion penetration of concrete, Cement and Concrete Research, vol. 30, no. 7, 2000, pp. 1037–1046.
[60] L. Jiang, B. Lin, and Y. Cai, A model for predicting carbonation of high-volume fly ash concrete, Cement and Concrete Research, vol. 30, no. 5, 2000, pp. 699–702, doi: 10.1016/S0008-8846(00)00227-1.
[61] Q. Zhao, X. Liu, and J. Jiang, Effect of curing temperature on creep behavior of fly ash concrete, Construction and Building Materials, vol. 96, 2015, pp. 326–333, doi: 10.1016/j.conbuildmat.2015.08.030.
[62] A. Younsi, P. Turcry, E. Rozire, A. Aït-Mokhtar, and A. Loukili, Performance-based design and carbonation of concrete with high fly ash content, Cement and Concrete Composites, vol. 33, no. 10, 2011, pp. 993–1000, doi: 10.1016/j.cemconcomp.2011.07.005.
[63] S. W. Yoo, G. S. Ryu, and J. F. Choo, Evaluation of the effects of high-volume fly ash on the flexural behavior of reinforced concrete beams, Construction and Building Materials, vol. 93, 2015, pp. 1132–1144, doi: 10.1016/j.conbuildmat.2015.05.021.
[64] V. M. Malhotra, Durability of concrete incorporating high-volume of low-calcium (ASTM Class F) fly ash, Cement and Concrete Composites, vol. 12, no. 4, 1990, pp. 271–277, doi: 10.1016/0958-9465(90)90006-J.
[65] J. H. Filho, M. H. F. Medeiros, E. Pereira, P. Helene, and G. C. Isaia, High-Volume Fly Ash Concrete with and without Hydrated Lime: Chloride Diffusion Coefficient from Accelerated Test, Journal of Materials in Civil Engineering, vol. 25, no. 3, 2013, pp. 411–418, doi: 10.1061/(ASCE)MT.1943-5533.0000596.
[66] S. Mukherjee, S. Mandal, U. B. Adhikari, and F. Ash, Comparative Study on Physical and Mechanical Properties of High Slump and Zero Slump High Volume Fly Ash Concrete (HVFAC), Global NEST Journal, vol. 15, no. 4, 2013, pp. 578–584.
[67] H. A. Alaka and L. O. Oyedele, High volume fly ash concrete: The practical impact of using superabundant dose of high range water reducer, Journal of Building Engineering, vol. 8, 2016, pp. 81–90, doi: 10.1016/j.jobe.2016.09.008.
[68] C. D. Atis, Heat evolution of high-volume fly ash concrete, Cement and Concrete Research, vol. 32, no. 5, 2002, pp. 751–756, doi: 10.1016/S0008-8846(01)00755-4.
[69] B. Balakrishnan and A. S. M. A. Awal, Durability Properties of Concrete Containing High Volume Malaysian Fly Ash, International Journal of Research in Engineering and Technology, vol. 03, no. 04, 2014, pp. 529–533.
[70] B. W. Langan, R. C. Joshi, and M. A. Ward, Strength and durability of concretes containing 50% Portland cement replacement by fly ash and other materials, Canadian Journal of Civil Engineering, vol. 17, no. 1, 1990, pp. 19–27.
[71] P. Nath, Durability of Concrete Using Fly Ash as a Partial Replacement of Cement, Curtin University of Technology, 2010.
[72] B. S. Bortz, Salt-scaling Durability of Fly Ash Concrete, Kansas State University, 2008.
[73] G. Construction, Concrete Admixture Use with High Volume Fly Ash - Technical Bulletin TB-0113.
[74] D. Ravina and P. K. Mehta, Compressive strength of low cement/high fly ash concrete, Cement and Concrete Research, vol. 18, no. 4, 1988, pp. 571–583, doi: 10.1016/0008-8846(88)90050-6.
[75] S. Naganathan *et al.*, Influence of curing on the properties of high volume fly ash concrete, International Journal of Science Technology, vol. 3, no. 2, 2017, pp. 308–315.
[76] J. Dragaš, I. Ignjatović, N. Tošić, and S. Marinković, Mechanical and time-dependent properties of high-volume fly ash concrete for structural use, Magazine of Concrete Research, vol. 68, no. 12, 2016, p., doi: 10.1680/jmacr.15.00384.
[77] A. K. Saha, Effect of class F fly ash on the durability properties of concrete, Sustainable Environment Research, vol. 28, no. 1, 2018, pp. 25–31, doi: 10.1016/j.serj.2017.09.001.
[78] A. Harison, V. Srivastava, and A. Herbert, Effect of Fly Ash on Compressive Strength of Portland Pozzolona Cement Concrete, Journal of Academia and Industrial …, vol. 2, no. 8, 2014, pp. 476–479, doi: 10.4028/www.scientific.net/AMM.754-755.447.
[79] O. Eren, Strength development of concretes with ordinary Portland cement, slag or fly ash cured at different temperatures, Materials and Structures/Materiaux et Constructions, vol. 35, no. 253, 2002, pp. 536–540, doi: 10.1617/13873.
[80] S. C. Pattanaik and A. K. Sabat, A Study of Nalco Fly Ash on Compressive Strength for Effective Use in High Volume Mass Concrete for, International

Conference on Sustainable Technologies for Concrete Constructions, 2010, p.
[81] V. A. Faseyemi, Investigation on Fly Ash As a Partial Cement Replacement in Concrete, International Journal of Scientific and Engineering Research, 2005, p.
[82] G. S. V. Bhaskara, K. B. Rao, and M. B. Anoop, Model for compressive strength development of OPC concrete and fly ash concrete with time, Magazine of Concrete Research, vol. 70, no. 11, 2018, pp. 541–557, doi: 10.1680/jmacr.17.00203.
[83] [V. Sivasundaram, G. G. Carette, and V. M. Malhotra, Long Term Strength Development of High Volume Fly Ash Concrete, Cement & Concrete Composites, vol. 12, 1990, pp. 263–270.
[84] A. Vanita, B. S. Gupta, and S. S.N., Investigations on fly ash concrete for pavements, International Journal of Civil and Structural Engineering, vol. 2, no. 3, 2012, pp. 876–883, doi: 10.6088/ijcser.00202030015.
[85] K. Turk and M. Karatas, Abrasion resistance and mechanical properties of self-compacting concrete with different dosages of fly ash/silica fume, Indian Journal of Engineering and Materials Sciences, vol. 18, no. 1, 2011, pp. 49–60.
[86] J. Pitroda, L. B. Zal, and F. S. Umrigar, Effects of the usage of fly ash as partial replacement of cement on the mechanical properties of concrete, Journal of International Academic Research for Multidisciplinary, vol. 25, no. 6, 2013, pp. 105–116.
[87] CEN, *EN 197-1: Cement - Part 1: Composition, specifications and conformity criteria for common cements*. Brussels: European Committee for Standardization, 2011, 2011, p.
[88] ASTM, ASTM C150/C150M - 17: Standard Specification for Portland Cement, West Conshohocken, Pennsylvania.
[89] ASTM, ASTM C595/C595M-14: Standard Specification for Blended Hydraulic Cements, West Conshohocken, Pennsylvania.
[90] A. M. Neville, *Properties of Concrete*. Longman Scientific and Technical, 1981, 1981, p.
[91] N. Zabihi, Effect of specimen size and shape on drying shrinkage of concrete, 2012.
[92] C. Rocco, G. V Guinea, and M. Elices, Size effect and boundary conditions in the Brazilian test : Experimental verification, vol. 32, no. April, 1999, pp. 210–217.
[93] S. Modr and V. I. Kadlecek, Size effect of test specimens on tensile splitting strength of concrete : general relation, vol. 35, no. February, 2002, pp. 28–34.
[94] N. Zabihi, Effect of Specimen Size and Shape on Strength of Concrete, Eastern Mediterranean University, Gazimağusa, North Cyprus, 2012.
[95] R. V. Silva, J. De Brito, and R. K. Dhir, Establishing a relationship between modulus of elasticity and compressive strength of recycled aggregate concrete, Journal of Cleaner Production, vol. 112, 2016, pp. 2171–2186, doi: 10.1016/j.jclepro.2015.10.064.
[96] A. I. Smith, The Design of Fly-Ash Concretes, Proceedings of the Institution of Civil Engineers, vol. 36, no. 4, 1967, pp. 769–790.
[97] K. G. Babu and G. S. N. Rao, Efficiency of fly ash in concrete with age, Cement and Concrete Research, vol. 26, no. 3, 1996, pp. 465–474.
[98] K. G. Babu and G. S. N. Rao, Efficiency of fly ash in concrete, Cement & Concrete Composites, vol. 15, 1993, pp. 223–229.
[99] K. Hwang, T. Noguchi, and F. Tomosawa, Prediction model of compressive strength development of fly-ash concrete, Cement and Concrete Research, vol. 34, 2004, pp. 2269–2276, doi: 10.1016/j.cemconres.2004.04.009.
[100] H. Yildirim, M. Sümer, V. Akyüncü, and E. Gürbüz, Comparison on efficiency factors of F and C types of fly ashes, Construction and Building Materials, vol. 25, no. 6, 2011, pp. 2939–2947, doi: 10.1016/j.conbuildmat.2010.12.009.
[101] V. G. Papadakis, S. Antiohos, and S. Tsimas, Supplementary cementing materials in concrete Part II : A fundamental estimation of the efficiency factor, Cement and Concrete Composites, vol. 32, 2002, pp. 1533–1538.
[102] J. Dragaš, I. Ignjatović, S. Marinković, V. Carević, N. Tošić, and Ivan Milićević, High-volume fly ash concrete: Mechanical properties and k-value concept, in *Natural hayards and structures*, 2017, 2017, pp. 679–690.
[103] [N. P. Rajamane, J. Annie Peter, and P. S. Ambily, Prediction of compressive strength of concrete with fly ash as sand replacement material, Cement and Concrete Composites, vol. 29, no. 3, 2007, pp. 218–223, doi: 10.1016/j.cemconcomp.2006.10.001.
[104] K. Kuder, D. Lehman, J. Berman, G. Hannesson, and R. Shogren, Mechanical properties of self consolidating concrete blended with high volumes of fly ash and slag, Construction and Building Materials, vol. 34, 2012, pp. 285–295, doi: 10.1016/j.conbuildmat.2012.02.034.
[105] I. Yeh, Modeling Efficiency Factor of Fly Ash in Concrete Using an Unification Approach Modeling Efficiency Factor of Fly Ash in Concrete Using an Unification Approach, International Journal of Engineering and Technology, vol. 5, no. January 2013, 2016, pp. 546–549, doi: 10.7763/IJET.2013.V5.615.
[106] K. G. Babu and G. S. N. Rao, Early strength behaviour of fly ash concretes, Cement and Concrete Research, vol. 24, no. 2, 1994, pp. 277–284.
[107] K. G. Babu, Efficiency of silica fume in concrete, Cement and Concrete Research, vol. 25, no. 6, 1995, pp. 1273–1283.
[108] K. G. Babu and V. S. R. Kumar, Efficiency of GGBS in concrete, Cement and Concrete Research, vol. 30, 2000, pp. 1031–1036.
[109] V. G. Papadakis and S. Tsimas, Supplementary cementing materials in concrete Part I : Efficiency and design, Cement and Concrete Research, vol. 32, 2002, pp. 1525–1532.

[110] V. G. Papadakis, Effect of fly ash on Portland cement systems: Part I. Low-calcium, Cement and Concrete Research, vol. 29, 1999, pp. 1727–1736.

[111] V. G. Papadakis, Effect of fly ash on Portland cement systems: Part II. High-calcium fly ash, Cement and Concrete Research, vol. 30, 2000, pp. 1647–1654.

[112] CEN, *EN 450-1: Fly ash for concrete — Part 1: Definition, specifications and conformity criteria*. Brussels: European Committee for Standardization, 2012, 2012, p.

[113] CEN, *EN 196-1: Methods of testing cement - Part 1: Determination of strength*. Brussels: European Committee for Standardization, 2008, 2008, p.

[114] E. C. Arvaniti *et al.*, Physical characterization methods for supplementary cementitious materials, Materials and Structures, vol. 48, no. 11, 2015, pp. 3675–3686, doi: 10.1617/s11527-014-0430-4.

[115] G. Xu and X. Shi, Characteristics and applications of fly ash as a sustainable construction material: A state-of-the-art review, Resources, Conservation and Recycling, vol. 136, no. April, 2018, pp. 95–109, doi: 10.1016/j.resconrec.2018.04.010.

[116] E. C. Arvaniti *et al.*, Determination of particle size , surface area , and shape of supplementary cementitious materials by different techniques, Materials and Structures, vol. 48, no. 11, 2014, pp. 3687–3701, doi: 10.1617/s11527-014-0431-3.

[117] K. Wesche, *Fly ash in concrete: Properties and Performance*. Teylor and Fransis Group, 2004, 2004, p.

[118] D. Abrams, Design of Concrete Mixures, Chicago.

[119] I. Yeh, Generalization of strength versus water – cementitious ratio relationship to age, Cement and Concrete Research, vol. 36, no. May, 2006, pp. 1865–1873, doi: 10.1016/j.cemconres.2006.05.013.

[120] J. Bolomey, Granulation et prévision de la résistance probable des bétons, Bulletin technique de la Suisse romande, vol. 62, no. 7, 1935, pp. 73–78.

[121] N. P. Rajamane and P. S. Ambily, Modified Bolomey equation for strengths of lightweight concretes containing fly ash aggregates, Magaz, vol. 64, no. 4, 2012, pp. 285–293.

[122] A. Oner, S. Akyuz, and R. Yildiz, An experimental study on strength development of concrete containing fly ash and optimum usage of fly ash in concrete, Cement and Concrete Research, vol. 35, no. 6, 2005, pp. 1165–1171, doi: 10.1016/j.cemconres.2004.09.031.

[123] M. K. Gopalan and M. N. Haque, Design of flyash concrete, Cement and Concrete Research, vol. 15, 1985, pp. 694–702.

[124] R. Feret, Sur la compacite des mortiers hydrauliques, Annales des ponts et chaussées, vol. 4, no. 7, 1892, pp. 5–164.

[125] M. Muravljov, *Building Materials*. Belgrade, Serbia: Građevinska knjiga, 2007, 2007, p.

[126] J. Chen, K. G. Kuder, D. Lehman, and C. W. Roeder, Creep modeling of concretes with high volumes of supplementary cementitious materials and its application to concrete-filled tubes, Materials and Structures, vol. 50, no. 1, 2017, pp. 1–20, doi: 10.1617/s11527-016-0955-9.

[127] P. Bamforth, D. Chisholm, J. Gibbs, and T. Harrison, Properties of Concrete for use in Eurocode 2.

[128] S.-W. Yoo, Y. C. Choi, and W. Choi, Compression Behavior of Confined Columns with High-Volume Fly Ash Concrete, Advances in Materials Science and Engineering, vol. 2017, 2017, p. 11, doi: http://dx.doi.org/10.1155/2017/8208079.

[129] J. Dragaš, N. Tošić, I. Ignjatović, and S. Marinković, Mechanical and time-dependent properties of high-volume fly ash concrete for structural use, Magazine of Concrete Research, vol. 68, no. 12, 2016, pp. 632–645, doi: 10.1680/jmacr.15.00384.

[130] S. C. Kou and C. S. Poon, Enhancing the durability properties of concrete prepared with coarse recycled aggregate, Construction and Building Materials, vol. 35, 2012, pp. 69–76, doi: 10.1016/j.conbuildmat.2012.02.032.

[131] J. Shekhovtsova, I. Zhernovsky, M. Kovtun, N. Kozhukhova, I. Zhernovskaya, and E. Kearsley, Estimation of fly ash reactivity for use in alkali-activated cements - A step towards sustainable building material and waste utilization, Journal of Cleaner Production, vol. 178, 2018, pp. 22–33, doi: 10.1016/j.jclepro.2017.12.270.

[132] V. Carević, I. Ignjatović, and J. Dragaš, Model for practical carbonation depth prediction for high volume fly ash concrete and recycled aggregate concrete, Construction and Building Materials, vol. 213, 2019, pp. 194–208, doi: 10.1016/j.conbuildmat.2019.03.267.

[133] C. feng Lu, W. Wang, Q. tao Li, M. Hao, and Y. Xu, Effects of micro-environmental climate on the carbonation depth and the pH value in fly ash concrete, Journal of Cleaner Production, vol. 181, 2018, pp. 309–317, doi: 10.1016/j.jclepro.2018.01.155.

[134] J. Khunthongkeaw, S. Tangtermsirikul, and T. Leelawat, A study on carbonation depth prediction for fly ash concrete, Construction and Building Materials, vol. 20, no. 9, 2006, pp. 744–753, doi: 10.1016/j.conbuildmat.2005.01.052.

[135] M. Arezoumandi, J. S. Volz, C. A. Ortega, and J. J. Myers, Effect of total cementitious content on shear strength of high-volume fly ash concrete beams, Materials and Design, vol. 46, 2013, pp. 301–309, doi: 10.1016/j.matdes.2012.10.031.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,2y}$ (MPa)	$f_{cm,3y}$ (MPa)	$f_{cm,10y}$ (MPa)	Sample size	f^{t}_{1} (MPa)	f^{t}_{3} (MPa)	f^{t}_{7} (MPa)	f^{t}_{28} (MPa)	f^{t}_{56} (MPa)	f^{t}_{90} (MPa)	f^{t}_{365} (MPa)	Test	Sample size	E_3 (GPa)	E_7 (GPa)	E_{14} (GPa)	E_{28} (GPa)	E_{56} (GPa)	E_{180} (GPa)	E_{365} (GPa)
Kou and Poon, 2013	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3520	3150	56.8	28.2	5.3	3.0	3.9	-	3960	2310	410.0	0.0	CGA	1048.0	RA	642	20.0	-	-	0	0.55	SWC	150	3					48.60				56.50	60.80	64.20	67.50	13				3.32			3.45	ASTM standard	13				30.1			32.1
	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3520	3150	56.8	28.2	5.3	3.0	3.9	-	3960	2310	184.5	225.5	CGA	1048.0	RA	530	20.0	-	-	55	0.55	SWC	190	3					36.20				48.60	57.60	62.30	67.10	13				2.66			2.89	ASTM standard	13				26.4			28.9
Poon et al., 2000	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3070	3150	56.8	28.2	5.3	3.0	3.9	6.3	3500	2100	637.0	0.0	CGA	936	RA	711	10.0	Naphtaline	2.9%	0	0.24	SWC	200-230	3		70.00	79.50		97.40		110.20																						
	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3070	3150	56.8	28.2	5.3	3.0	3.9	6.3	3500	2100	347.0	283.0	CGA	920	RA	639	10.0	Naphtaline	3.8%	45	0.24	SWC	200-230	3		42.50	56.30		89.40		107.20																						
	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3070	3150	56.8	28.2	5.3	3.0	3.9	6.3	3500	2100	702.0	0.0	CGA	949	RA	641	10.0	Naphtaline	5.0%	0	0.19	SWC	200-230	3		78.00	83.50		96.80		114.50																						
	ASTM Type I	-	N	21.0	5.9	3.4	64.7	3070	3150	56.8	28.2	5.3	3.0	3.9	6.3	3500	2100	372.0	283.0	CGA	927	RA	608	10.0	Naphtaline	5.0%	45	0.19	SWC	200-230	3		41.70	56.40		88.50		109.20																						
Lam et al., 1998	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	500.0	0.0	CGA	1086.0	RA	724	10.0	Naphtaline	1.5%	0	0.30	-	≥75	3		64.90	75.50		86.80	87.20	95.70	97.70					13				5.27	5.52											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	275.0	225.0	CGA	1086.0	RA	650	10.0	Naphtaline	2.1%	45	0.30	-	≥75	3		34.10	49.20		71.80	85.40	87.70	97.70					13				4.51	5.23											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	225.0	275.0	CGA	1086.0	RA	634	10.0	Naphtaline	2.6%	55	0.30	-	≥75	3		22.30	36.40		57.40	66.60	72.80	79.90					13				3.13	4.55											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400.0	0.0	CGA	1157.0	RA	710	20.0	Naphtaline	1.0%	0	0.40	-	≥75	3		35.00	48.40		60.70	67.10	70.50	70.60					13				3.93	3.94											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	220.0	180.0	CGA	1157.0	RA	634	20.0	Naphtaline	1.3%	45	0.40	-	≥75	3		14.50	20.30		43.90	54.10	61.20	63.70					13				2.92	3.51											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	180.0	220.0	CGA	1157.0	RA	621	20.0	Naphtaline	1.6%	55	0.40	-	≥75	3		13.60	19.80		37.30	47.10	52.90	63.20					13				2.97	3.43											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	410.0	0.0	CGA	1132.0	RA	609	20.0	-	-	0	0.50	-	≥75	3		26.10	36.90		50.80	57.10	58.10	60.60					13				3.66	4.02											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	225.5	184.5	CGA	1132.0	RA	549	20.0	-	-	45	0.50	-	≥75	3		13.40	18.40		35.60	47.00	54.10	56.60					13				2.79	3.16											
	ASTM Type I	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	184.5	225.5	CGA	1132.0	RA	536	20.0	-	-	55	0.50	-	≥75	3		7.80	11.30		24.00	33.70	41.40	48.30					13				2.32	3.16											
McCarthy and Dhir, 2005	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	225.0	0.0	CA	1745	CA	200	20.0	-	-	0	0.75	SWC	75	3		10.50	16.50	20.50	25.06	30.40	31.60	33.00																					
	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	170.0	140.0	CA	1925	CA	-	20.0	-	-	45	0.53	SWC	75	3		9.50	14.00	18.50																									
	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	385.0	0.0	CA	1680	CA	150	20.0	-	-	0	0.49	SWC	75	3		23.50	34.50	41.50	49.80	57.80	60.00	61.70																					
	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	270.0	220.0	CA	1755	CA	-	20.0	-	-	45	0.34	SWC	75	3		21.50	30.00	39.00																									
	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	510.0	0.0	CA	1675	CA	50	20.0	-	-	0	0.37	SWC	75	3		39.00	52.50	62.50	70.20	78.30	81.10	83.60																					
	CEM I 42.5 N	42.5	N	21.2	4.2	2.7	64.4	3200	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	350.0	285.0	CA	1545	CA	-	20.0	-	-	45	0.26	SWC	75	3		33.50	45.00	55.50																									
	CEM I 52.5 N	52.5	N	21.2	5.0	3.1	64.7	4900	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	160.0	135.0	CA	1935	CA	-	20.0	-	-	45	0.58	SWC	75	3		11.00	16.00	20.00	24.92	37.30	44.10	48.80																					
	CEM I 52.5 N	52.5	N	21.2	5.0	3.1	64.7	4900	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	245.0	200.0	CA	1795	CA	-	20.0	Superplasticizer BS 5075	?	45	0.38	SWC	75	3		26.00	34.50	41.50	50.39	64.11	71.20	73.00																					
	CEM I 52.5 N	52.5	N	21.2	5.0	3.1	64.7	4900	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	335.0	275.0	CA	1640	CA	-	20.0	Superplasticizer BS 5075	?	45	0.28	SWC	75	3		39.00	50.50	60.50	69.93	83.90	92.70	94.90																					
	CEM I 52.5 R	52.5	R	22.0	4.2	1.9	64.4	3600	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	150.0	125.0	CA	1945	CA	-	20.0	-	-	45	0.62	SWC	75	3		12.00	15.50	20.00	24.92	37.30	41.80	45.20																					
	CEM I 52.5 R	52.5	R	22.0	4.2	1.9	64.4	3600	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	245.0	200.0	CA	1780	CA	-	20.0	-	-	45	0.38	SWC	75	3		26.50	34.00	42.50	50.39	66.40	72.10	76.10																					
	CEM I 52.5 R	52.5	R	22.0	4.2	1.9	64.4	3600	-	47.8	30.7	3.8	7.1	1.3	7.0	-	-	320.0	265.0	CA	1640	CA	-	20.0	Superplasticizer BS 5075	?	45	0.29	SWC	75	3		40.50	51.50	61.00	69.93	86.10	91.30	95.00																					
Siddique, 2004	ASTM Type I	43.0	N	-	-	-	-	-	-	55.3	25.7	5.3	5.6	1.9	7.0	-	-	400.0	0.0	RA	1228	RA	616	10.0	Superplasticizer	0.6%	0	0.41	SWC	65	2			25.70		37.20		39.50		42.10				1			2.8	4.1		4.2	4.3	33% ultimate strength	1				29.9	31		31
	ASTM Type I	43.0	N	-	-	-	-	-	-	55.3	25.7	5.3	5.6	1.9	7.0	-	-	240.0	160.0	RA	1224	RA	614	10.0	Superplasticizer	0.6%	40	0.40	SWC	85	2			17.00		26.70		33.50		38.60				1			1.8	3		3.8	4.3	33% ultimate strength	1				20.9	22.1		24.3
	ASTM Type I	43.0	N	-	-	-	-	-	-	55.3	25.7	5.3	5.6	1.9	7.0	-	-	220.0	180.0	RA	1226	RA	610	10.0	Superplasticizer	0.7%	45	0.41	SWC	90	2			15.30		24.70		30.10		34.40				1			1.6	2.6		3.3	3.8	33% ultimate strength	1				19.8	20.9		22.2
	ASTM Type I	43.0	N	-	-	-	-	-	-	55.3	25.7	5.3	5.6	1.9	7.0	-	-	200.0	200.0	RA	1225	RA	616	10.0	Superplasticizer	0.7%	50	0.40	SWC	100	2			14.70		23.10		27.70		32.10				1			1.5	2.2		2.6	3	33% ultimate strength	1				19	19.2		20.9
Bouzoubaa and Lachemi, 2001	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	336.0	0.0	CLA	1105	RA	739	19.0	-	-	0	0.50	SMC	110	8	16.70		27.30		34.60																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	247.0	165.0	CLA	846	RA	845	19.0	Sulphonated Naphthalene	0.3%	40	0.45	SMC	240	8	8.70		21.20		34.60																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	238.0	159.0	CLA	844	RA	844	19.0	Sulphonated Naphthalene	0.7%	40	0.40	SMC	240	8	10.70		25.80		37.80																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	232.0	155.0	CLA	847	RA	846	19.0	Sulphonated Naphthalene	1.0%	40	0.35	SMC	240	8	16.60		31.30		48.30																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	207.0	207.0	CLA	843	RA	845	19.0	Sulphonated Naphthalene	0.1%	50	0.45	SMC	230	8	6.10		17.40		33.20																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	200.0	200.0	CLA	843	RA	842	19.0	Sulphonated Naphthalene	0.4%	50	0.40	SMC	240	8	7.00		19.30		34.90																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	197.0	197.0	CLA	856	RA	856	19.0	Sulphonated Naphthalene	0.7%	50	0.35	SMC	240	8	7.80		22.90		38.90																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	169.0	254.0	CLA	853	RA	853	19.0	-	-	60	0.45	SMC	230	8	5.20		15.60		30.20																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	163.0	245.0	CLA	851	RA	851	19.0	Sulphonated Naphthalene	0.5%	60	0.40	SMC	240	8	4.90		14.70		26.20																								
	ASTM Type I	-	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	0.3	16.4	-	-	161.0	241.0	CLA	864	RA	866	19.0	Sulphonated Naphthalene	0.8%	60	0.35	SMC	240	8	7.30		20.60		35.80																								
Huang et al., 2013	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	280.0	0.0	CSA	988	RA	777	19.0	-	-	0	0.72	SMC	160	13	5.30	14.60	20.90		25.00	27.60	29.00	32.40	36.50																				
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	168.0	112.0	CSA	1041	RA	802	19.0	Polycarboxylate ether polymer	0.8%	40	0.56	SMC	180	13	3.90	10.40	16.80		25.60	30.00	35.20	39.80	39.40																				
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	112.0	168.0	CSA	1106	RA	801	19.0	Polycarboxylate ether polymer	1.4%	60	0.44	SMC	210	13	2.60	9.70	14.50		23.50	25.60	30.60	37.30	41.20																				
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	112.0	448.0	CSA	1101	RA	418	19.0	Polycarboxylate ether polymer	1.1%	60	0.27	SMC	220	13	2.30	8.50	14.10		20.90	24.30	28.50	33.60	38.70																				
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	340.0	0.0	CSA	977	RA	743	19.0	Polycarboxylate ether polymer	0.1%	0	0.60	SMC	220	13	7.60	20.40	27.20		34.50	37.20	40.30	41.80	44.60												ASTM standard	13				26.9			33
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	204.0	136.0	CSA	1017	RA	752	19.0	Polycarboxylate ether polymer	0.5%	40	0.48	SMC	160	13	5.80	17.80	24.70		40.30	42.50	51.30	56.10	62.40												ASTM standard	13				26.8			40.8
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	136.0	204.0	CSA	1089	RA	756	19.0	Polycarboxylate ether polymer	1.0%	60	0.36	SMC	230	13	3.50	13.30	18.90		34.50	38.80	47.80	55.60	65.30												ASTM standard	13				26.2			41.4
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	28.4	7.0	6.0	4.6	-	-	-	136.0	544.0	CSA	1062	RA	295	19.0	Polycarboxylate ether polymer	1.4%	60	0.24	SMC	230	13	3.30	9.80	16.50		30.00	34.40	40.40	48.60	61.60												ASTM standard	13				18.7			29.8
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	23.0	7.9	6.0	7.8	-	-	-	340.0	0.0	CSA	977	RA	737	19.0	Polycarboxylate ether polymer	0.1%	0	0.60	SMC	220	13	7.60	20.40	27.20		34.50	37.20	40.30	41.80	44.60												ASTM standard	13				26.9			33
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	23.0	7.9	6.0	7.8	-	-	-	204.0	136.0	CSA	1017	RA	752	19.0	Polycarboxylate ether polymer	0.8%	40	0.48	SMC	230	13	6.00	11.30	21.50		34.10	37.40	40.80	51.50	54.30												ASTM standard	13				25.7			36.1
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	23.0	7.9	6.0	7.8	-	-	-	136.0	204.0	CSA	1089	RA	756	19.0	Polycarboxylate ether polymer	1.5%	60	0.36	SMC	220	13	2.50	12.10	17.80		30.50	33.90	39.00	47.30	55.80												ASTM standard	13				23.3			37.3
	ASTM Type I	-	N	-	-	-	-	-	-	50.0	23.0	7.9	6.0	7.8	-	-	-	136.0	544.0	CSA	1038	RA	279	19.0	Polycarboxylate ether polymer	2.6%	60	0.26	SMC	230	13	1.00	5.20	11.60		25.20	28.30	34.10	39.60	43.40												ASTM standard	13				15.9			27.5
Jiang and Malhotra, 2000	ASTM Type I	40.8	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	396.0	0.0	CLA	1110	RA	740	19.0	-	-	0	0.43	SMC	57	13	26.80	34.00	39.50		50.70	54.20	57.70																						
	ASTM Type I	40.8	N	-	-	-	-	-	-	42.7	20.3	23.7	4.2	-	-	-	-	181.0	221.0	CLA	1113	RA	742	19.0	-	-	55	0.38	SMC	57	13	10.30	17.10	22.70		34.90	43.10	48.00																						
	ASTM Type I	40.8	N	-	-	-	-	-	-	36.9	18.4	35.1	3.7	-	-	-	-	180.0	220.0	CLA	1117	RA	745	19.0	-	-	55	0.39	SMC	57	13	8.80	15.10	21.20		32.70	40.20	44.70																						
	ASTM Type I	40.8	N	-	-	-	-	-	-	52.4	23.4	4.7	13.4	-	-	-	-	180.0	220.0	CLA	1089	RA	726	19.0	-	-	55	0.37	SMC	64	13	8.70	22.40	31.80		53.00	62.10	65.20																						
	ASTM Type I	40.8	N	-	-	-	-	-	-	56.8	21.5	4.9	8.8	-	-	-	-	182.0	222.0	CLA	1090	RA	727	19.0	-	-	55	0.35	SMC	57	13	7.90	19.60	26.90		42.90	51.30	56.10																						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine. >45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)
	ASTM Type I	40.8	N	-	-	-	-	-	-	42.0	21.4	4.6	15.8	-	-	-	-	182.0	222.0	CLA	1124	RA	749	19.0	-	-	55	0.34	SMC	57
	ASTM Type I	40.8	N	-	-	-	-	-	-	53.9	16.6	20.5	0.3	-	-	-	-	181.0	222.0	CLA	1110	RA	740	19.0	-	-	55	0.38	SMC	70
	ASTM Type I	40.8	N	-	-	-	-	-	-	56.2	30.1	5.1	1.1	-	-	-	-	179.0	219.0	CLA	1097	RA	731	19.0	-	-	55	0.38	SMC	57
	ASTM Type I	40.8	N	-	-	-	-	-	-	50.5	15.4	8.8	15.6	-	-	-	-	182.0	222.0	CLA	1124	RA	749	19.0	-	-	55	0.34	SMC	64
Quan and Kasami, 2013	ASTM Type I	62.0	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	414.0	0.0	CSA	971	RA	762	20.0	-	-	0	0.43	SWC	175
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	348.0	0.0	CSA	971	RA	827	20.0	-	-	0	0.50	SWC	185
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	283.0	0.0	CSA	971	RA	892	20.0	-	-	0	0.60	SWC	175
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	233.0	0.0	CSA	955	RA	936	20.0	-	-	0	0.75	SWC	185
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	239.0	159.0	CSA	971	RA	751	20.0	-	-	40	0.43	SWC	170
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	196.0	130.0	CSA	971	RA	840	20.0	-	-	40	0.50	SWC	165
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	175.0	214.0	CSA	955	RA	770	20.0	-	-	55	0.43	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	149.0	183.0	CSA	955	RA	828	20.0	-	-	55	0.50	SWC	165
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	115.0	269.0	CSA	955	RA	765	20.0	-	-	70	0.43	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	36.1		1.2	0.9	0.1	-	-	98.0	230.0	CSA	955	RA	824	20.0	-	-	70	0.50	SWC	165
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	268.0	179.0	CSA	971	RA	698	20.0	-	-	40	0.38	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	227.0	152.0	CSA	971	RA	782	20.0	-	-	40	0.43	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	198.0	132.0	CSA	971	RA	824	20.0	-	-	40	0.50	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	198.0	242.0	CSA	955	RA	708	20.0	-	-	55	0.38	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	171.0	208.0	CSA	955	RA	780	20.0	-	-	55	0.43	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	150.0	184.0	CSA	955	RA	815	20.0	-	-	55	0.50	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	140.0	326.0	CSA	955	RA	633	20.0	-	-	70	0.38	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	112.0	260.0	CSA	955	RA	777	20.0	-	-	70	0.43	SWC	185
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	37.9		1.3	0.9	7.1	-	-	95.0	221.0	CSA	955	RA	842	20.0	-	-	70	0.50	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	251.0	167.0	CSA	971	RA	687	20.0	-	-	40	0.43	SWC	185
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	209.0	139.0	CSA	971	RA	773	20.0	-	-	40	0.50	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	195.0	238.0	CSA	955	RA	647	20.0	-	-	55	0.43	SWC	190
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	158.0	193.0	CSA	955	RA	763	20.0	-	-	55	0.50	SWC	180
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	138.0	322.0	CSA	955	RA	559	20.0	-	-	70	0.43	SWC	185
	ASTM Type I	62.0	N	-	-	-	-	-	-	-	41.0		1.6	1.7	12.5	-	-	106.0	246.0	CSA	955	RA	738	20.0	-	-	70	0.50	SWC	165
Dinakar et al., 2008	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	234.0	0.0	CGA	1874	RA	*	20.0	-	-	0	0.79	SMC	75
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	319.0	0.0	CGA	1681.0	RA	*	20.0	-	-	0	0.41	SMC	30
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	165.0	385.0	CGA	1491	RA	*	20.0	-	-	70	0.58	SMC	800
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	225.0	525.0	CGA	1107	RA	*	20.0	-	-	70	0.34	SMC	800
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	500.0	0.0	CGA	1426	RA	*	20.0	-	-	0	0.37	SMC	45
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	275.0	275.0	CGA	1571	RA	*	20.0	-	-	50	0.34	SMC	770
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	325.0	425.0	CGA	1388	RA	*	20.0	-	-	57	0.34	SMC	800
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	552.0	0.0	CGA	1465	RA	*	20.0	-	-	0	0.29	SMC	90
	ASTM Type I	53.0	N	-	-	-	-	-	-	-	31.7	5.9	2.0	0.3	-	-	-	659.0	0.0	CGA	1334	RA	*	20.0	-	-	0	0.22	SMC	120
Dinakar et al., 2013	PPC	-	-	-	-	-	-	-	-	-	26.2	4.2	1.7	1.0	-	-	-	275.0	275.0	CGA	869	RA	800	20.0	-	-	50	0.30	SWC	705
	PPC	-	-	-	-	-	-	-	-	-	26.2	4.2	1.7	1.0	-	-	-	165.0	385.0	CGA	848	RA	783	20.0	-	-	70	0.30	SWC	680
Mittal et al., 2005	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	300.0	0.0	CBA	1090	RA+CA	925	-	-	-	0	0.50	-	185
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	180.0	120.0	CBA	1063	RA+CA	902	-	-	-	40	0.50	-	180
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	150.0	150.0	CBA	1056	RA+CA	896	-	-	-	50	0.50	-	200
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	350.0	0.0	CBA	1054	RA+CA	896	-	-	-	0	0.45	-	210
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	210.0	140.0	CBA	1024	RA+CA	868	-	-	-	40	0.45	-	220
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	175.0	175.0	CBA	1016	RA+CA	861	-	-	-	50	0.45	-	210
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400.0	0.0	CBA	1064	RA+CA	833	-	-	-	0	0.40	-	210
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	240.0	160.0	CBA	1030	RA+CA	806	-	-	-	40	0.40	-	200
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	200.0	200.0	CBA	1022	RA+CA	800	-	-	-	50	0.40	-	190
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450.0	0.0	CBA	1078	RA+CA	778	-	-	-	0	0.35	-	220
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	270.0	180.0	CBA	1040	RA+CA	750	-	-	-	40	0.35	-	180
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	225.0	225.0	CBA	1030	RA+CA	743	-	-	-	50	0.35	-	210
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	500.0	0.0	CBA	1102	RA+CA	732	-	-	-	0	0.30	-	200
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	300.0	200.0	CBA	1056	RA+CA	702	-	-	-	40	0.30	-	230
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	35.0		-	0.6	-	-	-	250.0	250.0	CBA	1046	RA+CA	694	-	-	-	50	0.30	-	220
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	350.0	0.0	CBA	-	RA+CA	-	-	-	-	0	0.45	-	180
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-	CBA	-	RA+CA	-	-	-	-	40	0.45	-	175
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-	CBA	-	RA+CA	-	-	-	-	50	0.45	-	180

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	E_3 (GPa)	E_7 (GPa)	E_{14} (GPa)	E_{28} (GPa)	E_{90} (GPa)	E_{180} (GPa)	E_{365} (GPa)
	13	13.90	30.10	42.20		55.80	58.20	61.90																						
	13	6.90	15.70	20.80		31.80	39.00	43.90																						
	13	6.30	13.90	18.00		30.70	37.70	44.60																						
	13	10.30	23.40	31.10		47.50	55.70	60.00																						
Quan and Kasami, 2013	13			39.90		48.80		56.30	57.90																					
	13			35.10		38.90		49.00	52.00																					
	13			25.60		30.50		38.60	38.50																					
	13			16.10		21.90		27.40	27.20																					
	13			21.00		33.50		45.00	49.80																					
	13			16.90		28.90		38.90	44.40																					
	13			11.30		19.30		26.20	32.30																					
	13			9.60		17.80		23.60	32.20																					
	13			4.70		9.50		14.40	22.50																					
	13			3.50		6.90		11.60	16.80																					
	13			28.00		39.20		53.90	58.20																					
	13			21.30		31.70		44.30	50.90																					
	13			15.40		26.00		36.40	41.00																					
	13			17.30		27.20		38.40	43.30																					
	13			12.60		21.30		31.60	42.80																					
	13			9.30		16.40		25.50	31.50																					
	13			9.20		15.00		22.70	31.80																					
	13			6.00		9.60		17.30	26.60																					
	13			3.20		5.60		13.00	20.80																					
	13			20.80		29.90		40.00	46.00																					
	13			15.10		22.60		32.60	39.00																					
	13			11.20		16.40		26.10	31.80																					
	13			8.70		14.00		21.30	27.00																					
	13			5.20		9.40		16.40	22.70																					
	13			3.00		5.40		10.90	18.40																					
Dinakar et al., 2008	3					29.00		35.60	38.85																					
	3					43.00		44.50	45.00																					
	3					34.90		45.52	57.25																					
	3					34.80		44.96	55.81																					
	3					74.00		76.00	76.00																					
	3					57.90		66.72	79.50																					
	3					50.07		60.63	72.05																					
	3					78.00		80.00	84.00																					
	3					87.00		86.00	88.00																					
Dinakar et al., 2013	3		27.10	35.91		60.83	66.20							13				4.12	4.2			ASTM standard	1				36.63			
	3		18.14	21.77		44.21	50.21							13				2.61	2.84			ASTM standard	1				31.56			
Mittal et al., 2005	1			33.00		41.70	45.60																							
	1			13.90		24.40	30.80																							
	1			8.10		17.90	24.40																							
	1			34.20		43.70	48.80	54.20																						
	1			14.50		26.50	32.70	41.90																						
	1			10.40		19.00	25.60	34.40																						
	1			41.90		46.50	52.60	54.20															1				31.24			
	1			19.40		32.90	35.80	43.50															1				26.23			
	1			15.50		23.20	30.20	36.80															1				23.65			
	1			45.90		55.20	60.30	61.20																						
	1			25.60		42.20	51.40	59.90																						
	1			17.80		28.20	42.70	46.20																						
	1			42.00		60.00	62.70	66.70															1				32.21			
	1			29.70		47.40	61.90	66.80															1				28.36			
	1			29.00		45.60	55.80	58.90															1				25.13			
	1		25.10	31.60		37.80	45.00	51.00																						
	1		11.10	15.80		25.20	35.40	43.10																						
	1		7.30	10.90		19.20	28.10	35.90																						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine. >45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
	OPC 43 grade	60.0	-	-	-	-	-	-	-	-	28.9	3.8	-	1.5	-	-	-	-	-
Sahmaran et al., 2009	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.9	4.5	10.1	1.0	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.9	4.5	10.1	1.0	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.9	4.5	10.1	1.0	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.9	4.5	10.1	1.0	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.9	4.5	10.1	1.0	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.7	6.4	2.2	1.3	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.7	6.4	2.2	1.3	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.7	6.4	2.2	1.3	-	-	-	-	-
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	25.7	6.4	2.2	1.3	-	-	-	-	-
Atis, 2003	OPC	-	-	-	-	-	-	-	-	-	28.6	13.2	2.6	2.9	-	-	-	-	-
	OPC	-	-	-	-	-	-	-	-	-	28.6	13.2	2.6	2.9	-	-	-	-	-
	OPC	-	-	-	-	-	-	-	-	-	28.6	13.2	2.6	2.9	-	-	-	-	-
	OPC	-	-	-	-	-	-	-	-	-	28.6	13.2	2.6	2.9	-	-	-	-	-
	OPC	-	-	-	-	-	-	-	-	-	28.6	13.2	2.6	2.9	-	-	-	-	-
Berndt, 2009	ASTM Type I	-	-	-	-	-	-	-	-	-	26.4	12.2	5.5	2.2	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	26.4	12.2	5.5	2.2	-	-	-	-	-
Atis, 2003a	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
Bouzoubaa and Malhotra, 2001	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-
Bilodeau and Malhotra, 2000	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-
Malhotra et al., 2000	ASTM Type I	35.8	-	-	-	-	-	-	-	-	-	-	-	5.4	-	-	-	-	-
	ASTM Type I	35.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sivasundaram et al., 1990	ASTM Type I	38.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	38.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type I	38.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type I	38.7	-	-	-	-	-	-	-	-	22.2	15.7	3.8	9.7	-	-	-	-	-
	ASTM Type I	38.7	-	-	-	-	-	-	-	-	22.2	15.7	3.8	9.7	-	-	-	-	-
Malhotra , 1986	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
	ASTM Type II	36.7	-	-	-	-	-	-	-	-	23.0	20.4	1.2	2.9	-	-	-	-	-
Keith, 2011	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)
	CBA	-	RA+CA	-	-	-	-	0	0.40	-	200	1		26.40	35.50		45.20	50.70	54.90					
	CBA	-	RA+CA	-	-	-	-	40	0.40	-	170	1		12.20	18.90		28.70	40.30	45.70					
	CBA	-	RA+CA	-	-	-	-	50	0.40	-	180	1		7.30	13.50		23.70	32.00	37.30					
	CBA	-	RA+CA	-	-	-	-	0	0.35	-	210	1		34.20	40.30		49.50	57.00	65.40					
	CBA	-	RA+CA	-	-	-	-	40	0.35	-	210	1		19.50	24.30		36.90	52.90	61.30					
	CBA	-	RA+CA	-	-	-	-	50	0.35	-	200	1		12.50	17.70		29.20	48.50	57.90					
	CBA	-	RA+CA	-	-	-	-	0	0.30	-	185	1		32.20	47.70		58.10	61.00	67.00					
	CBA	-	RA+CA	-	-	-	-	40	0.30	-	200	1		20.50	32.20		41.30	53.20	60.30					
	CBA	-	RA+CA	-	-	-	-	50	0.30	-	200	1		16.30	25.90		33.70	49.50	56.00					
Sahmaran et al., 2009	CLA	-	RA	-	-	-	-	0	0.35	SWC	665	13			55.90		62.20		69.90	71.00	74.10			
	CLA	-	RA	-	-	-	-	40	0.35	SWC	730	13			37.40		59.10		61.50	68.30	67.30			
	CLA	-	RA	-	-	-	-	50	0.35	SWC	710	13			24.50		40.80		47.10	51.00	54.60			
	CLA	-	RA	-	-	-	-	60	0.35	SWC	740	13			21.90		38.10		48.80	51.70	56.40			
	CLA	-	RA	-	-	-	-	70	0.35	SWC	725	13			14.90		34.40		39.40	43.00	51.80			
	CLA	-	RA	-	-	-	-	40	0.32	SWC	745	13			34.50		52.30		63.20	67.20	75.60			
	CLA	-	RA	-	-	-	-	50	0.30	SWC	738	13			32.00		47.50		59.90	68.70	70.00			
	CLA	-	RA	-	-	-	-	60	0.30	SWC	770	13			22.80		39.90		52.10	62.60	65.80			
	CLA	-	RA	-	-	-	-	70	0.30	SWC	775	13			18.30		32.80		45.00	53.70	61.60			
Atis, 2003	RQA	-	RQA	-	-	-	-	0	0.55	SWC	-	3		30.70	38.20		51.20		60.40					
	RQA	-	RQA	-	-	-	-	70	0.28	SWC	-	3		17.83	24.86		43.10		63.40					
	RQA	-	RQA	-	-	-	-	70	0.29	SWC	-	3		19.80	20.09		34.10		48.75					
	RQA	-	RQA	-	-	-	-	50	0.33	SWC	-	3		32.75	40.75		63.50		81.60					
	RQA	-	RQA	-	-	-	-	50	0.30	SWC	-	3		36.90	49.60		70.30		83.70					
Berndt, 2009	RA	-	RA	-	-	-	-	0	0.40	SWC	-	8			36.50	39.00	42.00		47.00					
	RA	-	RA	-	-	-	-	50	0.40	SWC	-	8			16.40	20.00	24.00		37.00					
Atis, 2003a	RQA	-	RQA	-	-	-	-	0	0.34	SMC	-	3	12.05	38.41	49.27		60.75		65.03	69.13	71.00			
	RQA	-	RQA	-	-	-	-	0	0.32	SMC	-	3	33.51	45.27	52.63		64.95		68.10	72.29	77.08			
	RQA	-	RQA	-	-	-	-	70	0.28	SMC	-	3	1.76	16.34	24.01		33.25		40.75	42.25	45.00			
	RQA	-	RQA	-	-	-	-	70	0.29	SMC	-	3	7.09	16.64	18.60		30.55		41.10	43.00	48.05			
	RQA	-	RQA	-	-	-	-	50	0.33	SMC	-	3	5.62	31.85	38.00		57.00		60.20	67.30	67.60			
	RQA	-	RQA	-	-	-	-	50	0.30	SMC	-	3	28.25	35.30	48.30		66.55		79.90	81.60	83.60			
Bouzoubaa and Malhotra, 2001	NA	-	NA	-	-	-	-	55	0.32	-	-	1	10.00		27.00		40.00		53.00					
Bilodeau and Malhotra, 2000	NA	-	NA	-	-	-	-	40	0.32	-	-	1	8.00		20.00		35.00		43.00		55.00			
Malhotra et al., 2000	CLA	-	RA	-	-	-	-	57	0.29	AC	-	9					49.90							110.30
	CLA	-	RA	-	-	-	-	0	0.27	AC	-	9					59.90							102.30
Sivasundaram et al., 1990	NA	-	NA	-	-	-	-	0	0.49	-	-	9												
	NA	-	NA	-	-	-	-	58	0.22	-	-	9									83.40			
	NA	-	NA	-	-	-	-	58	0.31	-	-	9									52.20			
	NA	-	NA	-	-	-	-	58	0.22	-	-	9									80.60			
	NA	-	NA	-	-	-	-	58	0.31	-	-	9									42.70			
Malhotra , 1986	CLA	-	RA	-	-	-	-	56	0.33	AC	-	9		10.50			34.70		43.80					
	CLA	-	RA	-	-	-	-	56	0.33	AC	-	9		12.90	17.80		27.90		40.20					
	CLA	-	RA	-	-	-	-	56	0.33	AC	-	9		14.20	19.50		31.60		43.20					
	CLA	-	RA	-	-	-	-	56	0.33	AC	-	9		13.30	19.40		31.50		40.90					
	CLA	-	RA	-	-	-	-	56	0.33	AC	-	9		13.30	16.80		29.10		38.60					
	CLA	-	RA	-	-	-	-	56	0.28	AC	-	9		9.40	23.90		41.60		53.10					
	CLA	-	RA	-	-	-	-	56	0.28	AC	-	9		16.70	22.10		36.70		48.60					
	CLA	-	RA	-	-	-	-	56	0.28	AC	-	9		15.50	20.70		34.90		45.30					
Keith, 2011	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9	21.74		40.99	47.13	50.85	51.20						
	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9	17.87		38.16	43.13	47.06	47.33						
	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9	18.35		32.02	42.02	48.37	54.51						
	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9	18.29		36.02	44.23	50.92	60.17						
	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9	22.29		34.50	36.23	38.64	40.64						
	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9	22.36		32.50	34.16	36.43	38.99						
	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9	19.39		31.67	36.98	43.88	52.99						
	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9	18.22		32.02	36.85	45.61	52.10						
	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9					41.47							
	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9					36.09							

	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Sample size	f^s_1 (MPa)	f^s_3 (MPa)	f^s_7 (MPa)	f^s_{28} (MPa)	f^s_{56} (MPa)	f^s_{90} (MPa)	f^s_{365} (MPa)	Test	Sample size	E_3 (GPa)	E_7 (GPa)	E_{14} (GPa)	E_{28} (GPa)	E_{90} (GPa)	E_{180} (GPa)	E_{365} (GPa)
Sahmaran et al., 2009	13				5.07		5.14										
	13				4.5		4.84										
	13				3.4		4.36										
	13				3.21		3.92										
	13				3.44		3.64										
	13				3.87		4.15										
	13				4.03		4.74										
	13				3.69		4.44										
	13				3.26		3.72										
Atis, 2003	13				3.69		4.44										
	13				3.69		4.44										
	13				3.69		4.44										
	13				3.69		4.44										
	13				3.69		4.44										
Berndt, 2009																	
Atis, 2003a	1			2.55	3.1												
	1			2.96	3.48												
	1			2.07	2.53												
	1			1.81	2.51												
	1			2.99	4.06												
	1			2.32	4.2												
Bouzoubaa and Malhotra, 2001														36			
Bilodeau and Malhotra, 2000					3.5									35			
Malhotra et al., 2000																	
Sivasundaram et al., 1990																	
Malhotra , 1986																	
Keith, 2011																	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blaine (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blaine (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_p/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,2yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	$E_{,28}$ (GPa)	$E_{,90}$ (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9					48.85																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9					46.09																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9					47.75																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9					47.61																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9					47.27																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9					55.13																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9					36.85																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9					36.71																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9					41.75																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9					42.50																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.42	SMC	-	9					36.50																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.44	SMC	-	9					34.09																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	41	0.34	SMC	-	9					46.58																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	44	0.34	SMC	-	9					40.30																								
Burden, 2006	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.50	SMC	-	8					38.80				49.20																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.40	SMC	-	8					48.00				58.10																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.34	SMC	-	8					60.50				68.50																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.50	SMC	-	8					26.30				51.80																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.40	SMC	-	8					39.20				50.30																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.34	SMC	-	8					48.50				69.10																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.50	SMC	-	8					21.70				50.10																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.40	SMC	-	8					36.30				54.20																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	24.1	3.8	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.34	SMC	-	8					45.90				63.80																				
Kaur, 2005	ASTM Type I	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.50	-	-	1					23.00	29.40																							
	ASTM Type I	43.0	-	-	-	-	-	-	-	-	32.6		-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	40	0.50	-	-	1					15.40	20.40																							
	ASTM Type I	43.0	-	-	-	-	-	-	-	-	32.6		-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.50	-	-	1					10.80	13.30																							
Kayali and Ahmed, 2013	OPC	-	-	-	-	-	-	-	-	-	23.0	4.5	1.0	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.38	SMC	-	8									77.00																				
	OPC	-	-	-	-	-	-	-	-	-	23.0	4.5	1.0	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.38	SMC	-	8									38.00																				
	OPC	-	-	-	-	-	-	-	-	-	23.0	4.5	1.0	-	-	-	-	-	-	CA	-	RA	-	-	-	-	70	0.38	SMC	-	8									15.00																				
Li and Zhao, 2003	OPC	56.7	-	-	-	-	-	-	-	-	11.1	5.2	14.7	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.28	SMC	-	2	40.50	51.20	66.80		81.10	87.90	91.20		96.30																				
	OPC	56.7	-	-	-	-	-	-	-	-	11.1	5.2	14.7	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.28	SMC	-	2	21.70	32.60	43.00		65.20	86.70	97.50		107.10																				
Duran-Herrera et al., 2011	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	22.0	6.0	3.4	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	0	0.50	-	-	8	15.00	26.90	35.10	38.80	43.50	44.90																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	22.0	6.0	3.4	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	45	0.50	-	-	8	6.40	14.00	18.60	19.20	23.80	26.80																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	22.0	6.0	3.4	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	60	0.50	-	-	8	4.40	7.20	10.10	11.90	16.80	17.20																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	22.0	6.0	3.4	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	75	0.50	-	-	8	1.10	3.20	4.10	5.40	7.00	9.90																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	0	0.55	-	-	8	19.40	26.80	30.40	30.90	37.00	38.40																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	45	0.55	-	-	8	5.70	11.40	12.90	18.00	19.60	21.50																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	60	0.55	-	-	8	3.80	5.90	7.80	9.50	13.10	14.00																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	75	0.55	-	-	8		2.60	3.40	4.30	6.00	7.90																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	0	0.60	-	-	8	16.10	22.50	26.30	31.90	32.10	34.50																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	45	0.60	-	-	8	3.10	6.90	9.10	10.70	13.40	16.60																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	60	0.60	-	-	8		4.60	6.70	7.90	9.80	12.60																							
	ASTM Type IP	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	75	0.60	-	-	8			2.60	3.80	5.00	6.70																							
Obla et al., 2003	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	51	0.33	-	-	1	12.00	25.00	34.00		54.00	60.00	64.00																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	0	0.71	-	-	1		16.00	20.00		28.00		32.00																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	45	0.52	-	-	1		12.00	16.00		29.00		39.00																						
Tokyay, 1999	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.48	SMC	-	1			22.70		37.30		43.20																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.48	SMC	-	1			15.10		32.30		43.00																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.48	SMC	-	1			10.50		27.70		37.10																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.48	SMC	-	1			10.80		21.10		30.30																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.48	SMC	-	1			7.10		17.10		26.00																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	0	0.27	SMC	-	1			49.80		59.20		75.90																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	40	0.27	SMC	-	1			32.40		52.50		72.10																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	40	0.27	SMC	-	1			24.90		45.60		61.70																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	40	0.27	SMC	-	1			22.20		33.60		51.00																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	40	0.27	SMC	-	1			16.40		28.20		44.00																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	0	0.26	SMC	-	1			53.70		65.90		80.70																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.26	SMC	-	1			35.10		57.70		76.50																						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blaine (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blaine (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	$E_{,28}$ (GPa)	$E_{,90}$ (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.26	SMC	-	1			26.00		49.40		65.70																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.26	SMC	-	1			23.70		37.10		53.60																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.26	SMC	-	1			17.70		31.30		46.60																						
	OPC	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	0	0.25	SMC	-	1			54.40		69.90		82.00																						
	OPC	31.6	-	-	-	-	-	-	-	-	25.1	-	20.3	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.25	SMC	-	1			35.70		60.70		78.30																						
	OPC	31.6	-	-	-	-	-	-	-	-	17.4	-	14.0	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.25	SMC	-	1			26.90		52.50		66.60																						
	OPC	31.6	-	-	-	-	-	-	-	-	21.9	-	4.4	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.25	SMC	-	1			24.30		39.00		54.60																						
	OPC	31.6	-	-	-	-	-	-	-	-	25.8	-	2.0	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.25	SMC	-	1			18.40		33.00		47.60																						
Hung, 1997	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.40	SMC	-	3	18.00		60.00		61.90		62.90	79.40	80.00																				
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	57	0.40	SMC	-	3	6.20	12.30	20.00		33.20		42.70	49.30	55.00	62.20																			
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.40	SMC	-	3	20.20		59.50		66.20		70.00	75.20	77.70																				
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	55	0.40	SMC	-	3	6.40	14.50	24.10		31.00		43.90	53.50	57.50	62.40																			
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.40	SMC	-	3	18.00		60.00		71.00		83.00	78.80	80.60																				
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	57	0.40	SMC	-	3	6.20	12.30	20.00		28.40		41.00	42.00	46.80	47.10																			
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.40	SMC	-	3	20.20		59.50		70.50		83.20	76.50	77.10																				
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	55	0.40	SMC	-	3	6.40	14.50	24.10		28.60		42.70	51.70	47.00	45.90																			
Bouzoubaa and Fournier, 2003	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	0	0.50	SMC	-	13	19.40		32.60		40.10	43.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.46	SMC	-	13	5.90		21.80		41.80	47.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.38	SMC	-	13	12.30		34.60		55.70	62.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.43	SMC	-	13	10.50		29.70		52.70	60.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.43	SMC	-	13	10.40		30.80		53.00	59.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.43	SMC	-	13	11.00		30.80		53.40	58.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.43	SMC	-	13	10.80		31.50		50.60	59.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.50	SMC	-	13	3.40		15.30		28.00	34.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.39	SMC	-	13	8.00		25.90		43.80	51.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.44	SMC	-	13	10.30		26.50		42.00	49.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.44	SMC	-	13	10.80		27.60		42.50	49.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.46	SMC	-	13	9.00		25.50		39.00	47.00																							
	ASTM Type I	31.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.44	SMC	-	13	10.10		27.30		43.50	49.00																							
Mathur et al., 2005	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.65	SMC	-	3			20.50		36.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.58	SMC	-	3			28.00		41.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.52	SMC	-	3			19.00		35.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.52	SMC	-	3			30.50		44.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.40	SMC	-	3			27.00		43.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.40	SMC	-	3			28.20		46.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.38	SMC	-	3			30.00		44.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.36	SMC	-	3			31.00		46.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.34	SMC	-	3			35.00		48.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.33	SMC	-	3			38.00		52.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.37	SMC	-	3			27.00		44.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.35	SMC	-	3			28.00		50.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.34	SMC	-	3			29.00		51.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.33	SMC	-	3			30.00		52.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.32	SMC	-	3			32.50		53.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.43	SMC	-	3			38.50		55.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.35	SMC	-	3			29.50		53.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.33	SMC	-	3			36.00		57.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.30	SMC	-	3			39.00		60.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.29	SMC	-	3			42.00		65.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.28	SMC	-	3			45.00		67.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.33	SMC	-	3			28.50		53.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.29	SMC	-	3			34.00		56.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.29	SMC	-	3			40.50		60.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.28	SMC	-	3			42.00		65.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.61	SMC	-	3			19.50		34.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.51	SMC	-	3			16.50		35.50																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.52	SMC	-	3			27.50		44.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.43	SMC	-	3			26.50		42.50																								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blaine (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blaine (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Course agg. type	Course agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	E_3 (GPa)	E_7 (GPa)	E_{14} (GPa)	E_{28} (GPa)	E_{90} (GPa)	E_{180} (GPa)	E_{365} (GPa)
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.37	SMC	-	3			25.50		43.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.43	SMC	-	3			38.50		57.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.35	SMC	-	3			29.50		53.00																								
	OPC 53 grade	63.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.33	SMC	-	3			28.00		53.00																								
Yoon et al., 2014	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.30	SMC	-	8			41.53		54.40	64.77	66.30		78.73												ASTM standard	13				37.995			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.30	SMC	-	8			36.13		52.47	59.10	64.17		78.43												ASTM standard	13				32.865			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.30	SMC	-	8			59.40		67.50	69.50	74.67		74.80												ASTM standard	13				37.065			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.30	SMC	-	8			42.63		55.57	64.20	65.53		82.03												ASTM standard	13				38.545			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.30	SMC	-	8			33.47		46.93	53.03	57.00		70.57												ASTM standard	13				38.215			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.35	SMC	-	8			31.77		43.00	49.43	53.73		66.23												ASTM standard	13				33.06			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.35	SMC	-	8			24.83		35.07	44.33	49.43		65.23												ASTM standard	13				33.725			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.35	SMC	-	8			49.97		60.17	61.03	60.90		68.20												ASTM standard	13				32.61			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.35	SMC	-	8			25.53		34.03	39.03	41.80		53.70												ASTM standard	13				27.21			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.35	SMC	-	8			19.93		28.47	36.13	41.07		54.27												ASTM standard	13				29.77			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.40	SMC	-	8			42.00		49.10	47.77	54.03		53.73												ASTM standard	13				33.495			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.40	SMC	-	8			23.47		32.70	36.97	40.90		48.17												ASTM standard	13				30.07			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.40	SMC	-	8			16.47		23.60	31.57	38.70		45.20												ASTM standard	13				28.235			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.40	SMC	-	8			43.37		50.03	54.20	54.53		60.40												ASTM standard	13				32.285			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.40	SMC	-	8			21.00		31.10	36.93	40.53		48.93												ASTM standard	13				30.785			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.40	SMC	-	8			15.83		23.93	31.97	36.77		46.50												ASTM standard	13				28.815			
Atis, 2005	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	0	0.34	SMC	-	3	12.05	38.41	49.27		60.75		65.03	69.13	71.00				32	1.45	4.35	4.72	6.58		7.22	7.86									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	0	0.32	SMC	-	3	33.51	45.27	52.63		64.95		68.10	72.29	77.08				32	3.49	4.52	5.45	6.98		7.61	8.04									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	70	0.28	SMC	-	3	1.76	16.34	24.01		33.25		40.75	42.45	45.00				32	0.96	2.45	3.14	4.38		5.61	6.92									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	70	0.29	SMC	-	3	7.09	16.64	18.60		30.55		41.10	43.00	48.05				32	1.14	2.63	3.09	4.92		5.76	6.35									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	50	0.33	SMC	-	3	5.62	31.85	38.00		57.00		60.20	67.30	67.60				32	1.32	4.11	4.74	6.33		7.02	7.5									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	50	0.30	SMC	-	3	28.25	35.30	48.30		66.55		79.90	81.60	83.60				32	3.78	4.77	5.53	6.59		7.59	8.22									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	70	0.43	SMC	-	3		7.98	12.29		21.10		24.21	27.50	30.70				32		1.24	2.03	2.7		3.84	5.23									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	70	0.40	SMC	-	3	4.29	10.90	14.40		22.60		28.01	29.65	31.90				32	0.81	1.66	2.22	3.43		5.18	6.8									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	50	0.43	SMC	-	3	3.20	20.22	25.36		36.60		42.65	49.70	53.00				32	0.48	2.85	3.62	4.45		5.4	6.45									
	NPC BS12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RQA	-	RQA	-	-	-	-	50	0.39	SMC	-	3	15.73	26.14	34.30		45.85		54.65	55.65	60.20				32	2.12	3.35	4.52	5.01		6.86	7.43									
Soman and Sobha, 2014	OPC	53.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.40	SWC	-	2		22.22	31.11		48.29	49.11	50.22										4												
	OPC	53.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.40	SWC	-	2		17.77	25.92		47.11	50.22	51.11										4.5												
Naik et al., 1991	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.32	SMC	-	9	31.00		45.00		47.00								9	2.52		3.2	3.73				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	40	0.32	SMC	-	9	16.60		31.80		43.80								9	1.73		2.5	3.12				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.32	SMC	-	9	11.80		28.30		35.50								9	1.09		2.5	3.03				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	60	0.32	SMC	-	9	16.20		22.00		34.60								9	1		1.63	2.44				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.32	SMC	-	9	31.20		45.35		47.06								9	2.52		3.2	3.73				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.32	SMC	-	9	20.71		26.25		40.75								9	1.08		1.87	2.71				ASTM standard	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	60	0.44	SMC	-	9	3.82		15.58		31.52								9	0.31		1.46	1.69				ASTM standard	9							
Proske et al., 2014	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.58	SWC	-	2	34.60		49.40		53.90		61.20																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.36	SWC	-	2	21.80		45.10		57.00		72.90																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	56	0.36	SWC	-	2	21.30		38.50		55.00		66.50																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	62.5	0.36	SWC	-	2	11.70		29.20		42.70		54.60																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	62.5	0.30	SWC	-	2	14.30		32.20		55.30		69.60																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	68.8	0.36	SWC	-	2	8.20		26.40		39.30		44.00																						
	CEM I 52.5 R	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	75	0.36	SWC	-	2	4.80		16.90		26.30		31.90																						
Sivasundaram et al., 1990	ASTM Type II	36.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	56	0.28	SMC	-	13	9.40		23.90		41.60		53.10						13				5												
Lima et al., 2013	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	0	0.54	SWC	-	2		25.00	30.04		34.46	39.10	39.29																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	46.8	0.32	SWC	-	2		20.11	26.81		39.48	56.96	53.79																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	56	0.33	SWC	-	2		6.59	20.59		35.04	48.73	56.14																						
Bouzoubaa et al., 2001	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.40	SMC	-	8	21.40		32.50	34.40	38.60		43.30						9				3.3				ASTM standard	9				30.3			31.6
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.40	SMC	-	8					38.80								9								ASTM standard	9							
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SMC	-	8	7.70		15.90	19.60	24.00		32.70		40.30				9				2.2				ASTM standard	9				22.4			30.6
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SMC	-	8			20.90	27.10	30.50		41.60						9				3.2				ASTM standard	9				34.4			38.7
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SMC	-	8	13.10		30.50	37.50	43.80		53.70		61.90				9				3.3				ASTM standard	9				30.3			31.6
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SMC	-	8					43.30								9				3.4				ASTM standard	9				33			32.5
Bouzoubaa et al., 2000	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SWC	-	9	6.50		17.50	21.80	25.90																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	8.30		22.90	28.30	34.50																								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blaine (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blaine (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Course agg. type	Course agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	E_{28} (GPa)	E_{90} (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SWC	-	9	7.00		17.90	22.40	28.30																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	11.60		27.70	34.60	43.60																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SWC	-	9	6.60		16.90	21.20	27.30																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	10.00		29.40	34.30	41.50																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SWC	-	9	3.40		16.80	23.70	31.40																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	4.20		20.50	26.50	35.00																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	55	0.32	SWC	-	9	1.60		17.40	23.50	31.60																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	5.10		23.90	31.20	38.70																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.32	SWC	-	9	3.30		26.00	32.80	38.90																								
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	9	9.50		37.70	43.00	51.30																								
Mardani-Aghabaglou et al., 2013	CEM I 42.5 R	47.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.39	SWC	-	2			33.80		41.00		54.00	58.40					2			3.27	4.03		4.36	4.52									
	CEM I 42.5 R	47.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.43	SWC	-	2			21.80		35.60		42.20	44.10					2			2.33	3.81		3.99	4.19									
	CEM I 42.5 R	47.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	60	0.46	SWC	-	2			17.70		31.80		39.50	40.60					2			1.96	3.54		3.7	3.87									
	CEM I 42.5 R	47.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.43	SWC	-	2			37.30		46.60		60.60	64.30					2			3.45	4.31		4.71	5.12									
	CEM I 42.5 R	47.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	60	0.47	SWC	-	2			39.30		49.50		64.60	67.70					2			3.66	4.6		5.02	5.36									
Jiang et al., 2000	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.60	SMC	-	3					25.60		30.10																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	55	0.46	SMC	-	3					24.90		28.30																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	70	0.50	SMC	-	3					16.80		25.20																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.45	SMC	-	3					30.20		38.30																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	55	0.38	SMC	-	3					32.30		41.00																						
	CEM I 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	70	0.37	SMC	-	3					25.70		35.70																						
Zhao et al., 2015	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	CLA	-	-	-	-	40	0.33	SMC	-	3					52.30				54.30																				
Zhao et al., 2016	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.41	SMC	-	2					54.90																								
	OPC	-	-	-	-	-	-	-	-	57.5	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.41	SMC	-	2					28.50																								
	OPC	-	-	-	-	-	-	-	-	57.5	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	50	0.41	SMC	-	2					34.20																								
	OPC	-	-	-	-	-	-	-	-	57.5	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	60	0.41	SMC	-	2					29.50																								
	OPC	-	-	-	-	-	-	-	-	57.5	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	70	0.41	SMC	-	2					26.40																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.34	SMC	-	2					61.50																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.34	SMC	-	2					40.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	50	0.34	SMC	-	2					38.50																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	60	0.34	SMC	-	2					36.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	70	0.34	SMC	-	2					30.20																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.30	SMC	-	2					64.60																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.30	SMC	-	2					52.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	50	0.30	SMC	-	2					49.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	60	0.30	SMC	-	2					42.60																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	70	0.30	SMC	-	2					38.90																								
Younsi et al., 2011	CEM I 52.5 N	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CDA	-	MA	-	-	-	-	0	0.60	SMC	-	8		20.00	26.00		35.80																								
	CEM II 32.5 R	32.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CDA	-	MA	-	-	-	-	50	0.41	SMC	-	8		11.00	20.00		28.40																								
	CEM II 32.5 R	32.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CDA	-	MA	-	-	-	-	50	0.41	SMC	-	8		18.00	26.40		31.40																								
Yoo et al., 2015	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.58	SMC	-	8		22.40			24.40		32.30														10/30% ultimate strength	8			19.27	19.87	32.821		
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.45	SMC	-	8		28.20			30.80		35.90														10/30% ultimate strength	8			21.2	23.06	28.34		
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.35	SMC	-	8		40.20			46.20		48.80														10/30% ultimate strength	8			25.3	28.85	34.969		
	OPC	-	-	-	-	-	-	-	-	55.7	27.8	7.0	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.40	SMC	-	8		14.50			25.60		24.40														10/30% ultimate strength	8			17.329	24.27	28.981		
	OPC	-	-	-	-	-	-	-	-	55.7	27.8	7.0	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.48	SMC	-	8		12.90			23.90		22.30														10/30% ultimate strength	8			14.081	20.05	19.85		
	OPC	-	-	-	-	-	-	-	-	55.7	27.8	7.0	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.33	SMC	-	8		32.10			50.50		49.20														10/30% ultimate strength	8			24.167	26.64	29.163		
Rao et al., 2011	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.32	SWC	-	2					54.80								1				3.6												
	OPC 43 grade	43.0	-	-	-	-	-	-	-		90.5		-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.32	SWC	-	2					40.58								1				3.02												
Malhotra, 1999	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	57	0.29	-	-	8	7.80	27.10	34.00		49.90		82.50	87.00	95.60																				
Malhotra, 1990	OPC	39.3	-	-	-	-	-	-	-	47.1	23.0	20.4	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	58	0.31	SMC	-	1					39.70																								
Filho et al., 2013	OPC	39.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	CGA	-	-	-	-	0	0.52	SMC	-	13							55.50																						
	OPC	39.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	CGA	-	-	-	-	50	0.42	SMC	-	13							54.30																						
Dragas et al., 2016	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.55	SMC	-	3		22.60			41.20																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.55	SMC	-	3		9.90			31.00																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	64	0.39	SMC	-	3		11.60			36.10																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.52	SMC	-	3		31.30			50.70																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	64	0.37	SMC	-	3		15.00			45.70																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	57	0.37	SMC	-	3		18.50			47.80																								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	$E_{,28}$ (GPa)	$E_{,90}$ (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	54	0.34	SMC	-	3		19.00			54.00																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	64	0.30	SMC	-	3		25.50			63.30																								
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.49	SMC	-	3		11.10	22.70	30.40	34.20		44.20	53.10					27				2.9				33% ultimate strength	1	26.7	30.5	32.1	31.3	34.8	37.1	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	55	0.43	SMC	-	3		16.30	22.90	32.00	38.20		42.30	49.70					27				2.7				33% ultimate strength	1				32.1	33.7	37.4	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	60	0.39	SMC	-	3		15.50	22.20	32.20	36.70		42.80	42.90					27				2.9				33% ultimate strength	1				31.8	32.5	36.8	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	64	0.36	SMC	-	3		17.60	27.10	36.20	42.00		47.90	59.50					27				3.7				33% ultimate strength	1	29.6	31.1	33.7	33.2	35.1	34.7	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	67	0.33	SMC	-	3		14.80	23.30	37.20	40.20		54.20	60.60					27				2				33% ultimate strength	1				32.7	33.3	34.9	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	50	0.61	SMC	-	3		8.20	12.90	19.30	24.30		28.50	40.60					27				2.5				33% ultimate strength	1				29	35.5	38.1	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	57	0.52	SMC	-	3		8.50	15.60	20.20	25.70		32.80	41.60					27				2.3				33% ultimate strength	1				31.9	34.6	38	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	63	0.46	SMC	-	3		11.80	14.20	22.00	24.50		33.80	43.50					27				3.1				33% ultimate strength	1				30	32.6	36.2	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	67	0.41	SMC	-	3		10.00	16.10	25.30	26.80		38.00	41.40					27				2.9				33% ultimate strength	1				30.1	30.2	29.6	
	CEM II 42.5 R	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	70	0.37	SMC	-	3		9.90	16.00	25.00	29.80		39.30	46.70					27				3.2				33% ultimate strength	1				30.2	33.1	32.5	
Mukherjee et al., 2013	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	0	0.35	SWC	-	3		27.96	45.58		50.35																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.35	SWC	-	3		22.05	28.20		43.65																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.35	SWC	-	3		19.75	25.03		35.31																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.35	SWC	-	3		13.92	20.89		31.40																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	70	0.35	SWC	-	3		8.92	12.13		23.67																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	40	0.35	SWC	-	3		7.75	21.54		31.72																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	50	0.35	SWC	-	3			20.38		29.42																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	60	0.35	SWC	-	3			17.78		27.99																								
	OPC 43 grade	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	RA	-	-	-	-	70	0.35	SWC	-	3			15.20		24.72																								
Alaka and Oyedele, 2016	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	50	0.35	SMC	-	13			16.50		28.00	31.80	33.20		35.60																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	50	0.31	SMC	-	13			21.60		32.60	38.40	44.90		52.90																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	50	0.29	SMC	-	13			24.70		37.80	42.50	51.20		60.90																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	60	0.38	SMC	-	13			15.70		25.20	30.10	32.40		37.20																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	60	0.33	SMC	-	13			19.20		31.10	36.10	44.20		55.50																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	60	0.31	SMC	-	13			22.20		34.20	40.20	50.70		62.80																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	65	0.38	SMC	-	13			15.10		24.90	29.30	31.80		37.90																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	65	0.34	SMC	-	13			18.50		30.70	35.20	43.80		56.70																				
	CEM I 42.5 N	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	NA	-	-	-	-	65	0.32	SMC	-	13			21.60		32.10	39.40	50.30		63.10																				
Atis, 2002	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	0	0.55	SMC	-	13					50.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	70	0.28	SMC	-	13					40.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	70	0.29	SMC	-	13					40.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.33	SMC	-	13					65.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	-	-	-	-	50	0.30	SMC	-	13					65.00																								
Balakrishnan and Awal, 2014	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.44	-	-	13					44.00																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.44	-	-	13					37.40																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	50	0.44	-	-	13					31.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	60	0.44	-	-	13					27.60																								
Langan et al., 1990	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.47	SMC	-	1			27.10	31.50	37.40	37.40	40.70																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.47	SMC	-	1			19.80	21.80	27.20	27.80																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.47	SMC	-	1			32.60	33.00	39.50	42.70																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	0	0.47	SMC	-	1			21.60	23.60	26.40	27.20																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			18.10	25.40	32.20	33.60																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			12.30	16.90	20.50	27.80																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			19.40	25.30	34.30	39.10																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			11.00	14.10	20.70	24.80																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			17.40	25.50	31.70	37.70	42.20																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			11.30	16.10	20.40	24.80	28.30																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			14.60	22.10	27.90	34.60	39.80																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			13.50	20.10	26.70	31.30	33.80																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			18.90	24.30	31.70	35.80	35.60																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			10.50	14.60	19.70	22.40																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			13.90	17.90	22.40	28.40	35.70																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			12.30	15.20	18.80	25.40	28.70																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			14.90	18.90	24.20	28.40																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			10.80	13.90	18.20	21.10																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			13.90	18.30	24.50	28.70																							

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,2yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	$E_{,28}$ (GPa)	$E_{,90}$ (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			9.40	12.60	17.10	20.70																							
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			21.00	28.10	33.10	37.90	39.30																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			17.20	24.40	30.10	33.70	36.40																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			19.00	26.80	31.60	37.10	41.20																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			18.90	24.40	31.40	35.80	35.30																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			13.40	14.90	21.00	25.50	33.00																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			9.30	12.00	16.40	20.30	24.80																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			11.40	15.60	19.90	25.90	31.30																						
	PC Type 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	CA	-	-	-	-	50	0.47	SMC	-	1			9.20	11.90	15.60	18.80	25.20																						
Bortz, 2008	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	0	0.40	SMC	-	13					41.34																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.40	SMC	-	13					43.06																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.40	SMC	-	13					42.00																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.40	SMC	-	13					32.00																								
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLA	-	RA	-	-	-	-	40	0.40	SMC	-	13					37.20																								
Nath, 2010	OPC	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.41	SMC	-	13		47.00	57.00		69.00	77.50	78.50	78.50	79.50				1			3.4	3.8			5.1									
	OPC	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.31	SMC	-	13		41.00	50.50		65.50	80.00	88.50	90.00	97.00				1			3.5	3.8			5.9									
	OPC	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.29	SMC	-	13		67.50	70.50		85.50	96.00	101.00	101.50	102.50				1			4.3	4.4			6.3									
	OPC	60.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.29	SMC	-	13		41.00	52.00		69.00	89.00	89.50	92.50	100.50				1			3.6	4.1			5.7									
Construction, 1998	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.62	SMC	-	1		18.20	26.60		32.60																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.43	SMC	-	1		14.40	20.00		25.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.43	SMC	-	1		15.90	22.80		29.70																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.43	SMC	-	1		16.80	24.40		30.90																								
Carette et al., 1993	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	5.60		18.80		28.80		39.70		52.00													9				33	39.2		42.4
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	10.30		24.90		39.30		50.90		57.90													9				35.8	41		42.6
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	4.90		18.30		29.50		40.60		56.80													9				32.1	38.6		43.3
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	10.50		21.20		32.50		45.00		58.80													9				33.6	37.1		41.2
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	3.10		22.50		34.30		44.30		56.30													9				35.9	40.7		43.4
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	11.50		24.80		37.40		45.60		55.20													9				36.4	39.7		41.4
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	5.80		18.20		27.80		39.50		54.70													9				32.8	40.4		43.6
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	10.80		22.60		35.00		45.80		58.70													9				36.2	40.4		43.6
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	5.60		19.00		30.10		39.10															9				33.5	36.6		
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	10.30		21.90		36.90		44.70															9				35.9	40.1		
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	5.10		21.60		38.10		48.90															9				36.8	42		
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.33	SMC	-	9	8.40		26.50		42.20		50.40															9				39.4	41.7		
Langley, 1989	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	55	0.28	SMC	-	1	13.70	22.40	34.20		57.10		75.20															1				36.1			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.39	SMC	-	1	27.30	35.60	44.60		52.30		54.00															1				31.5			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.30	SMC	-	1		17.70	26.00		49.10		63.00		79.00													1				35.1			46.6
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.39	SMC	-	1	10.20	32.20	40.40		50.70		57.30		60.60													1				36.8			38.2
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.33	SMC	-	1	16.50	17.20	25.80		46.10		61.80															1				33.8			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.45	SMC	-	1	2.70	31.00	38.70		47.20		51.30															1				28.9			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.35	SMC	-	1	20.50	15.50	20.50		37.50		53.00		69.00													1				31.6			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.46	SMC	-	1	4.00	30.50	34.90		44.70		49.10		52.20													1				34.9			34.4
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.49	SMC	-	1		8.60	12.10		23.00		37.90															1				27.9			
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.30	SMC	-	1	30.50	22.00	30.00		48.50		64.00		84.10													1				32.7			46.1
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.39	SMC	-	1	5.70	42.40	49.00		59.00		59.00		66.80													1				32.2			36.3
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	56	0.35	SMC	-	1	30.70	16.70	23.80		37.50		53.70		63.70													1				32.1			43.1
	ASTM Type III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.46	SMC	-	1		37.50	41.10		46.10		51.00		53.20													1				32.6			34.8
Sivasundaram et al., 1991	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9	13.80		34.80		54.70		69.90		83.40													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.21	SMC	-	9					55.40																	9				41			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9	6.40		19.00		31.20		43.90		52.20													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9					28.90																	9				34.9			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9	14.00		33.40		53.10		67.60		78.70													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9		21.10	33.00		53.00		67.30		80.60													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9					48.20																	9				37.9			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9	4.20		15.90		26.90		35.50		42.70													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9					24.50																	9				27.4			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.30	SMC	-	9		9.10	10.40		17.00		23.20		28.00													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.32	SMC	-	9		14.00	21.00		36.40		49.10		58.70													9							

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blaine (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine.>45μm (%)	FA Blaine (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	E_{28} (GPa)	E_{90} (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.32	SMC	-	9					33.60																	9				32.9			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.23	SMC	-	9		13.50	21.90		34.80		45.40		50.80													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.23	SMC	-	9					30.00																	9				30.8			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9	2.80		17.80		28.50		35.90		39.10													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9					28.10																	9				35.9			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9		19.10	25.40		40.80		48.30		54.80													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.22	SMC	-	9					40.30																	9				37.2			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9	6.70		23.10		40.70		48.50		54.10													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9					42.00																	9				38.1			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.25	SMC	-	9		15.90	19.60		32.30		41.50		48.10													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.25	SMC	-	9					30.40																	9				33.2			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.32	SMC	-	9		12.30	15.60		27.20		32.90		36.60													9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.32	SMC	-	9					20.00																	9							
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	58	0.31	SMC	-	9		16.90	22.10		37.50		50.60															9				25			
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.49	SMC	-	9	5.60		23.40		29.90		34.90		38.50													9							
Ravina and Mehta, 1988	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.81	SMC	-	18			10.90	12.90	15.30	17.80		20.40	20.50																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	1.33	SMC	-	18			3.60	4.00	5.30	5.90		6.30																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	51	0.55	SMC	-	18			8.70	10.30	13.10	19.90		29.80																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	51	0.55	SMC	-	18			7.60	8.90	11.20	15.50		24.30																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	1.50	SMC	-	18			2.40	2.90	4.00	4.80		4.90																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	43	0.74	SMC	-	18			4.50	5.30	7.40	11.20		16.40	24.00																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	43	0.74	SMC	-	18			4.80	5.90	7.90	11.90		15.30	23.40																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	60	0.47	SMC	-	18			7.10	9.00	10.10	16.60		23.10	31.60																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	60	0.47	SMC	-	18			6.90	8.90	9.60	15.20		19.60	27.30																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.74	SMC	-	18			3.70	4.40	5.80	10.30		15.60	21.90																				
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	50	0.74	SMC	-	18				4.60	6.10	9.80		14.10	20.80																				
Hannesson, 2010	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.35	SMC	-	13			64.60	70.70	80.00	81.50	83.30	85.10																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	40	0.35	SMC	-	13			65.30	70.50	87.00	94.90	96.70	97.60																					
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	60	0.35	SMC	-	13			44.20	52.90	63.50	77.70	84.60	90.30																					
Naganathan et al., 2017	CEM I 42.5 N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	0	0.55	SMC	-	13			20.60	20.00	21.90																								
	CEM I 42.5 N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	40	0.55	SMC	-	13			18.40	10.70	20.10																								
	CEM I 42.5 N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	60	0.55	SMC	-	13			13.60	15.80	22.40																								
	CEM I 42.5 N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	RA	-	-	-	-	70	0.55	SMC	-	13			10.10	12.80	20.30																								
Ho and Lewis, 1985	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.60	SMC	-	34					25.60		30.10																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	55	0.46	SMC	-	34					24.90		28.30																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	70	0.50	SMC	-	34					16.80		25.20																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	0	0.45	SMC	-	34					30.20		38.30																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	55	0.38	SMC	-	34					32.30		41.00																						
	ASTM Type I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NA	-	NA	-	-	-	-	70	0.37	SMC	-	34					25.70		35.70																						
Saha, 2018	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	40	0.35	-	-	13			24.60																										
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	0	0.35	-	-	13			45.50		57.40				62.50																				
Harison et al., 2014	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	0	0.46	-	-	3			23.40		31.60	36.60																							
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	40	0.46	-	-	3			12.40		19.80	28.00																							
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	50	0.46	-	-	3			11.80		19.00	24.80																							
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CA	-	NA	-	-	-	-	60	0.46	-	-	3			6.20		14.40	16.20																							
Eren, 2002	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	QA	-	NA	-	-	-	-	0	0.55	-	-	3	21.76	36.95	47.45		62.77		69.65																						
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	QA	-	NA	-	-	-	-	50	0.55	-	-	3	5.08	14.45	19.61		33.35		40.85																						
Pattanaik and Sabath, 2010	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	NA	880.0	-	-	-	0	0.40	-	-	2			30.64		37.88		38.20																						
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	NA	880.0	-	-	-	40	0.38	-	-	2			18.45		30.20		28.56																						
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	NA	680.0	-	-	-	0	0.38	-	-	2			38.40		47.53		48.12																						
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CGA	-	NA	680.0	-	-	-	40	0.36	-	-	2			25.26		35.10		38.26																						
Turk and Karatas, 2011	ASTM Type I	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	800.0	-	-	-	0	0.39	-	-	2		18.00			37.50																								
	ASTM Type I	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	910.0	-	-	-	40	0.38	-	-	2		19.00			45.50																								
Faseyemi, 2005	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	760.0	-	-	-	0	0.40	-	-	2			37.50	38.90	46.50																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	760.0	-	-	-	45	0.40	-	-	2			36.50	38.00	50.50																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	760.0	-	-	-	60	0.40	-	-	2			40.50	42.30	52.50																								
	OPC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RA	-	RA	760.0	-	-	-	75	0.40	-	-	2			24.30	29.50	34.00																								
Vanita et al., 2012	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	0	0.42	-	-	3			30.50		40.70		41.80																						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Cement type	Cement class	Cem.early str.	CEM SiO_2	CEM Al_2O_3	CEM Fe_2O_3	CEM CaO	CEM Blane (cm^2/g)	γ_{CEM} (kg/m^3)	FA SiO_2	FA Al_2O_3	FA Fe_2O_3	FA CaO	FA LOI	Fine. >45μm (%)	FA Blane (cm^2/g)	γ_{FA} (kg/m^3)	CEM (kg/m3)	FA (kg/m^3)	Coarse agg. type	Coarse agg. (kg/m^3)	Fine agg. type	Fine agg. (kg/m^3)	Max agg. size (mm)	Plasticizer type	m_{pl}/CM (%)	FA/CM (%)	W/CM	Curing type	Slump (mm)
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	40	0.42	-	-
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	0	0.38	-	-
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	40	0.38	-	-
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	0	0.35	-	-
	OPC	43.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	40	0.35	-	-
Pitroda et al., 2013	OPC	53.0	-	-	-	-	-	-	3150	-	-	-	-	-	-	-	-	372.0	0.0	CBA	1251.9	RA+CA	558.6	20.0	-	-	0	0.50	-	-
	OPC	53.0	-	-	-	-	-	-	3150	-	-	-	-	-	-	-	-	473.7	0.0	CBA	1419.3	RA+CA	341.9	20.0	-	-	0	0.38	-	-
	OPC	53.0	-	-	-	-	-	-	3150	-	-	-	-	-	-	-	-	223.2	148.8	CBA	1251.9	RA+CA	558.6	20.0	-	-	40	0.50	-	-
	OPC	53.0	-	-	-	-	-	-	3150	-	-	-	-	-	-	-	-	284.2	189.5	CBA	1251.9	RA+CA	558.6	20.0	-	-	40	0.38	-	-
Bhaskara et al., 2018	OPC	53.0	-	16.6	3.7	4.8	70.5	-	3145	61.5	27.6	7.9	0.5	-	-	-	2056	367.3	0.0	CGA	1065.0	RA	871.6	20.0	-	1.0%	0	0.49	SMC	89
	OPC	53.0	-	16.6	3.7	4.8	70.5	-	3145	61.5	27.6	7.9	0.5	-	-	-	2056	289.9	193.3	CGA	967.0	RA	791.0	20.0	-	1.0%	40	0.37	SMC	85

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	Sample size	$f_{cm,1}$ (MPa)	$f_{cm,3}$ (MPa)	$f_{cm,7}$ (MPa)	$f_{cm,14}$ (MPa)	$f_{cm,28}$ (MPa)	$f_{cm,56}$ (MPa)	$f_{cm,90}$ (MPa)	$f_{cm,180}$ (MPa)	$f_{cm,365}$ (MPa)	$f_{cm,3yr}$ (MPa)	$f_{cm,5yr}$ (MPa)	$f_{cm,10yr}$ (MPa)	Sample size	$f^{sp}_{,1}$ (MPa)	$f^{sp}_{,3}$ (MPa)	$f^{sp}_{,7}$ (MPa)	$f^{sp}_{,28}$ (MPa)	$f^{sp}_{,56}$ (MPa)	$f^{sp}_{,90}$ (MPa)	$f^{sp}_{,365}$ (MPa)	Test	Sample size	$E_{,3}$ (GPa)	$E_{,7}$ (GPa)	$E_{,14}$ (GPa)	$E_{,28}$ (GPa)	$E_{,90}$ (GPa)	$E_{,180}$ (GPa)	$E_{,365}$ (GPa)
	3			25.46		34.86		45.53																						
	3			39.50		51.30		53.10																						
	3			30.70		40.90		53.20																						
	3			40.21		53.51		54.60																						
	3			33.67		44.40		56.60																						
Pitroda et al., 2013	2			28.76	32.00	38.52	40.30	42.52																						
	2			34.81	45.04	50.81	52.89	53.93																						
	2			9.93	14.81	17.33	22.22	23.56																						
	2			14.61	16.44	21.63	23.70	25.33																						
Bhaskara et al., 2018	2			39.56	43.28	48.52	49.97	54.82	57.25																					
	2			31.05	39.16	48.63	56.32	60.16	67.23																						

*Total aggregate mass is written in Coarse aggregate mass field

Annotations

- CGA Crushed granite aggregate
- RA River aggregate
- CA Crushed aggregate
- CLA Crushed limestone aggregate
- CSA Crushed sandstone aggregate
- RQA River quartzitic aggregate
- NA Natural agregate - not RCA
- RA+CA River and crushed aggregate
- CBA Crushed basalt aggregate
- QA Quartzitic aggregate
- CDA crushed diorite gravels
- MA siliceous marine sand

- SMC Standrad moist curing
- SWC Standard water curing
- AC Air curing

Specimen code	Specimen	Specimen dim. (cm)	Specimen code	Specimen	Specimen dim. (cm)	Specimen code	Specimen	Specimen dim. (cm)	Specimen code
1	cylinder	15/30	11	prism	7/7/28	21	cylinder	9.5/19	31
2	cube	15/15/15	12	prism	10/10/40	22	prism	12/12/36	32
3	cube	10/10/10	13	cylinder	10/20	23	cube	?	33
4	cylinder	7/28	14	cube	20/20/20	24	prism	?	34
5	cylinder	10/50	15	cylinder	10/?	25	beam	40/40/10	35
6	cylinder	10/30	16	beam	10/10x50	26	cube	15.8/15.8/15.8	
7	cylinder	15/45	17	cylinder	10/25	27	cylinder	15/15	
8	cylinder	10.2/20.4	18	cylinder	7.6/15.2	28	prism	7.5/7.5/30	
9	cylinder	15.2/30.5	19	prism	5/5/30.5	29	prism	7.5/7.5/28.5	
10	block	20/10/6	20	prism	15/15/45	30	cylinder	12/24	